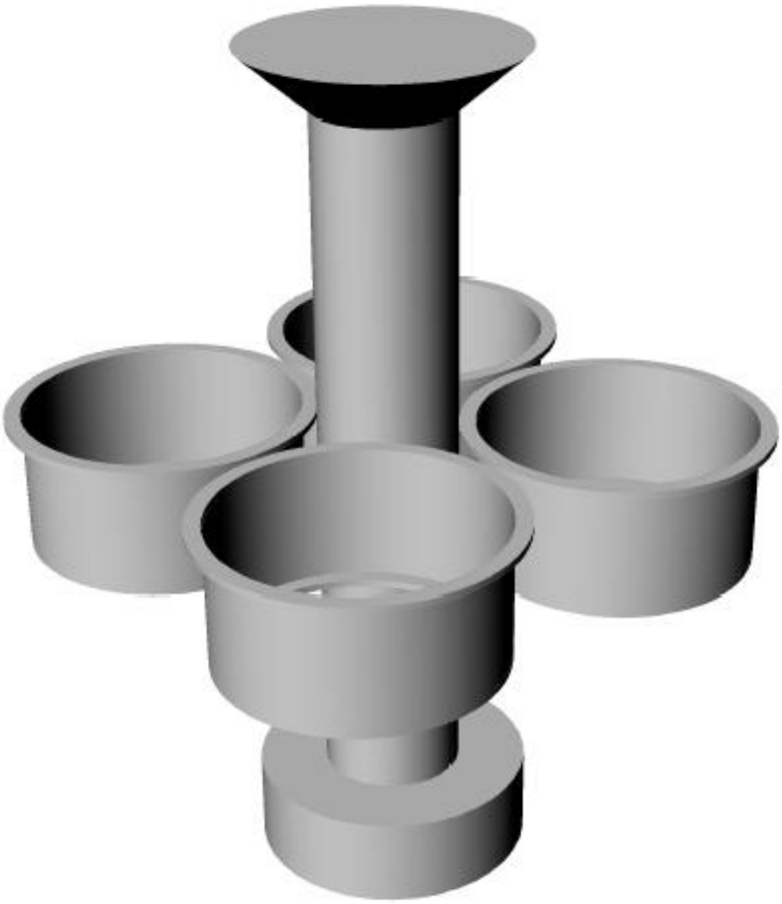
TRABAJO FIN DE MÁSTER

PLATAFORMA ACUICOLA EN MAR ABIERTO



Mónica Mª Rodríguez Lapido

Máster en Ingeniería Naval.

22/04/2016

1. INTRODUCCIÓN.

En el siglo pasado, la ingeniería naval, centraba sus conocimientos, en el diseño y construcción de buques, basándose tanto en el ahorro de los costes de construcción, operación, y el aumento de seguridad tanto para la población como para el medio ambiente, buscando tanto el aumento de velocidad, como la mejora de la maniobrabilidad, y un óptimo comportamiento ante una mala situación de mala mar, etc.

Con el paso de los años, los ingenieros influenciados por la riqueza marina, vieron que no sólo es útil como un medio de transporte o un medio de pesca; encontrando nuevos mercados como pueden ser, el aprovechamiento del mar como fuente de energía limpia, por medio de las olas y del viento que circula por encima.

Hoy en día se puede considerar la acuicultura, como un mercado en alza, y con expectativas de crecimiento. Tanto en el mar como en tierra es posible encontrar granjas, que dan un gran producto de calidad, gracias a la seguridad que poseen.

Los parámetros que nos caracterizan intrínsecamente la acuicultura son dos:

- La localización.
- La especie a criar.

Una de las propiedades que influirá en las características de las jaulas es la **localización**, que estará en la mar y en la cual existirá una determinada profundidad sobre el lecho marino. Deberá limitarse la distancia a la costa desde nuestra planta, teniendo en cuenta las condiciones ambientales, las alturas de las olas, las velocidades máximas del viento, las velocidades máximas de las corrientes, la salinidad y la temperatura, sin olvidar los organismos que ocasionan el fouling en la zona, la calidad de las aguas y su posible eutrofización, y las especies autóctonas del lugar.

Otro de los aspectos a tener en cuenta es la **especie,** para determinar el tipo de alimento, la cantidad que se necesita diariamente, su dosificación, las dimensiones de la red, el método de extracción de peces, las enfermedades que puedan afectar a la especie, el tamaño de ingreso de los alevines y el tiempo de engorde.

La cría y el engorde, es una práctica que se ha estado realizando desde hace tiempo, aunque a lo largo de la historia han cambiado los métodos, en función de la tecnología disponible. Todos los cambios que se realizan en la técnica deben tener como premisa, preservar el medio marino, y ser respetuosos con el medio ambiente, además de que sea un “negocio rentable”.

2. LA ACUICULTURA EN ESPAÑA.

2.1. LA ACUICULTURA EN EL MUNDO.

En el año 2.013, la acuicultura ha superado la producción de la pesca con 97,20 millones de toneladas a nivel mundial, frente a 93,80 toneladas de capturas. Actualmente se ha llegado a la conclusión que un 50% de los productos acuáticos proceden de la acuicultura.

En la siguiente tabla se presenta la producción acuícola mundial de tres de las especies más demandadas.

PRODUCCIÓN MUNDIAL ACUICULTURA			
	Año 2014 (t)	Año 2013 (t)	Notas
Dorada	173.024	180.464	4,3% inferior a 2013.
Lubina	153.516	153.670	0,1% inferior a 2013.
Rodaballo	11.067	6.828	38,3% superior a 2013.

Tabla 1. Producción acuícola mundial de dorada, lubina y rodaballo.

2.2. LA ACUICULTURA EN LA UNIÓN EUROPEA.

En el año 2.013 la Unión Europea puso en el mercado 1,28 millones de toneladas de productos procedentes de la acuicultura, lo que supone un aumento de un 0,73% con relación al año anterior, cuyo valor de primera venta fue de 4.000 millones de euros.

En cuanto al valor de la producción, España ocupa la quinta posición.

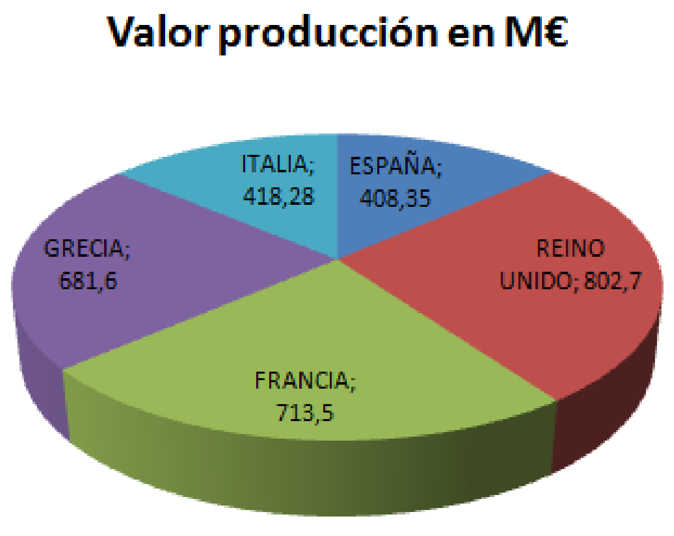


Ilustración 1. Gráfico del valor de la producción en millones de euros.

En las siguientes gráficas se puede observar la producción por especies así como la producción de las mismas por su valor en el mercado.

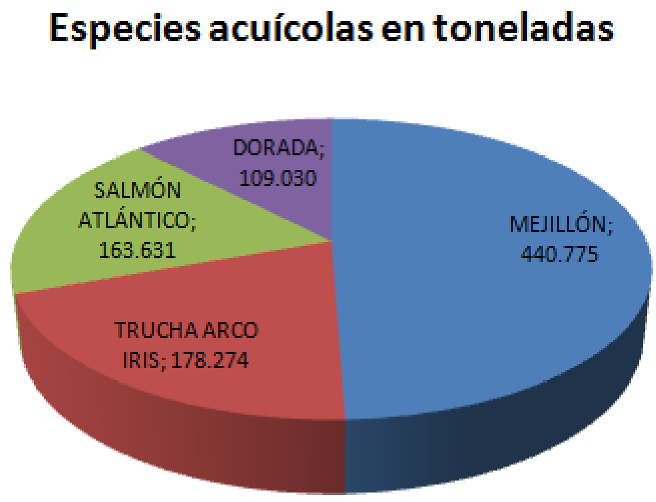


Ilustración 2 Tipos de especies acuícolas en toneladas.

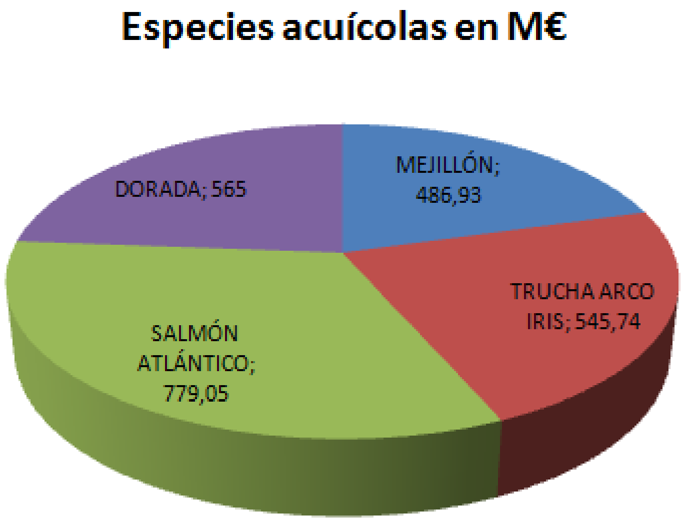


Ilustración 3. Especies acuícolas en millones de euros.

2.3. PRODUCCIÓN DE ACUICULTURA EN ESPAÑA.

El principal cultivo en España es el mejillón, del cual, en el año 2013, se produjeron unas 162.012 toneladas. Con relación a la acuicultura de peces las especies principales son, la dorada, trucha arco iris, y lubina.

En el año 2.013 existían un total de 5.025 establecimientos de acuicultura en funcionamiento, de los cuales 163 son de acuicultura continental y 4.862 de acuiculturas de aguas marinas o salobres.

Con relación al pienso, en 2014 se utilizaron unas 112.250 toneladas, siendo está cantidad un 3,9% superior a la 2013. Un 84% de este pienso fue administrado a peces marinos, como son la dorada, lubina, corvina, lenguado y anguila, y el 16% restante a peces de agua dulce como la trucha, el esturión y el salmón.

En la Tabla 2podemos ver la producción de dorada, lubina y rodaballo en España.

PRODUCCIÓN ACUICULTURA EN ESPAÑA			
	Año 2014 (t)	Año 2013 (t)	Notas
Dorada	16.230	16.782	3,4% inferior a 2013.
Lubina	17.376	15.465	11% superior a 2013.
Rodaballo	7.808	6.668	14,6% superior a 2013.

Tabla 2. Producción de dorada, lubina y rodaballo en España.

En Galicia la producción de Rodaballo es de un 99%, frente al 1% de Cantabria.

2.4. EVOLUCIÓN DE LA ACUICULTURA EN EL MUNDO.

En la Ilustración 4 se observa la evolución porcentual de producción acuática (acuicultura más pesca), mundial en el periodo 1970-2013 (fuente: FAO).

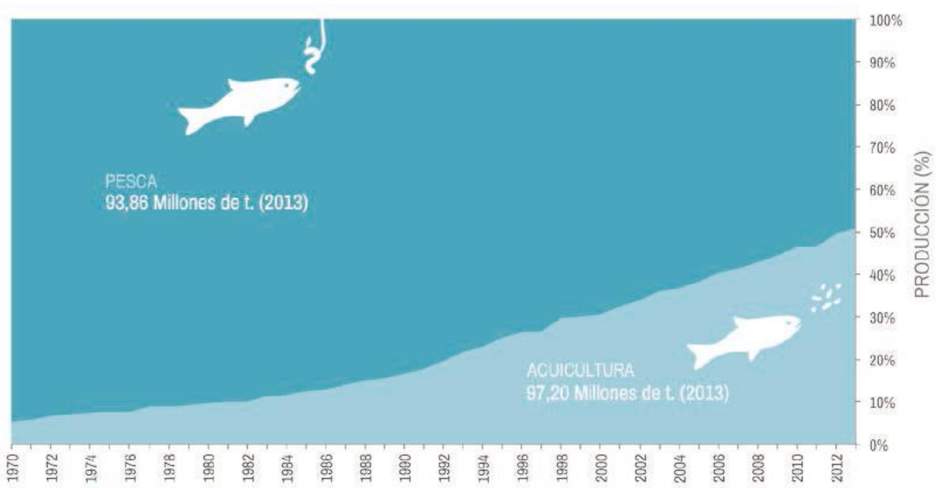


Ilustración 4. Evolución de la producción acuática mundial.

Como ya se ha dicho, más del 50% de los productos acuáticos, proceden de la acuicultura, superando por primera vez la pesca.

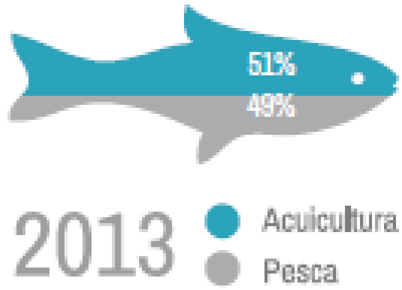


Ilustración 5. Porcentaje productos acuáticos.

La FAO estima que en el año 2.030, más de un 65% de alimentos acuáticos procederán de la acuicultura.

Hoy en día esta actividad continúa su avance y consolidación en el mundo, porque contribuye a la utilización eficaz de los recursos naturales, a la seguridad alimentaria y al desarrollo económico, con un limitado y controlado impacto sobre el medio ambiente.

2.5. TIPOS DE ESTABLECIMIENTOS DE ACUICULTURA EN ESPAÑA.

España posee una variada disponibilidad de recursos para la acuicultura, tanto en ámbito marino como continental. Posee más de 8.000km de costa, con nueve grandes ríos, y numerosos cursos fluviales, lagos y una capacidad de agua embalsada superior a los 55.000 hm^3, también posee una orografía y una diversidad de climas que proporcionan unas características ambientales y físico-químicas excelentes para el desarrollo de la acuicultura.

Los establecimientos de acuicultura deben ser diseñados para adaptarse tanto a las necesidades de las especies, como a las condiciones del medio físico.

NÚMERO DE ESTABLECIMIENTOS DE ACUICULTURA EN ESPAÑA (2013)	
UBICACIÓN	**Año 2013**
En tierra firme (agua dulce).	163
En tierra firme (agua marina).	89
En playas, zona intermareal y esteros.	1.150
En el mar bateas y long-lines.	3.579
En el mar viveros (jaulas).	44
TOTAL	**5.025**

Tabla 3. Establecimientos acuícolas por ubicación

3. REQUISITOS DEL PROYECTO (R.P.A).

UNIVERSIDADE DA CORUÑA
Escola Politécnica Superior

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22 OUT. 2015
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SOLICITUDE DE ADXUDICACIÓN DE TÍTULO E TITOR PARA O TFM
DA TITULACION MESTRADO UNIVERSITARIO EN ENXEÑARÍA NAVAL E OCEÁNICA

Don / Dona:	MONICA MARÍA RODRÍGUEZ LAPIDO
DNI:	32.678.104-A

como alumno do Mestrado Universitario en Enxeñaría Naval e Oceánica, toda vez que reúne as condicións para que se lle adxudique título e titor para o Traballo Fin de Mestrado, **SOLICITA A ADXUDICACIÓ DO TFM** que a continuación se detalla:

Ano de publicación:	
Nº de proxecto:	
Titor:	VICENTE DÍAZ CASAS
*Título en galego:	PLATAFORMA ACUÍCOLA EN MAR ABERTO
*Título en castelán:	PLATAFORMA ACUÍCOLA EN MAR ABIERTO
*Título en inglés:	AQUACULTURE INSTALATION FOR OPEN SEAS

Sinatura do/a alumno/a:	V. e Pr. do/a Titor/a:

Ferrol, a 20 de OUTUBRO de 2015

*Cubrir obrigatoriamente

Sr. Presidente da Comisión de TFM da titulación Mestrado Universitaria en Enxeñaría Naval e Oceánica.

CARACTERÍSTICAS DO TFM SOLICITADO

TÍTULO DO TFM: Plataforma acuícola en mar abierto.
TITOR/A: Vicente Díaz Casas.
OBXECTIVOS: Diseño de una plataforma de acuicultura oceánica de aguas profundas.
DESCRICIÓN DO ALCANCE DO TFM: **Alcance del trabajo:** Diseñar una plataforma offshore, para el cultivo de distintas especies de peces, que aprovechan las corrientes marinas, con un reducido mantenimiento, y protegida contra las inclemencias del tiempo. **Capacidad:** Producción por temporada de 530.000uds de rodaballo. Se contemplará la posibilidad de criar otras especies. **Profundidad de operación:** La plataforma será capaz de operar en mar abierto en una zona de hasta 80 metros de profundidad. Su ubicación se encontrará en la franja de costa comprendida entre los Cabos Prioriño Chico y Punta Frouxeira, siempre que la profundidad no supere la indicada. **Estructura**: La estructura será soldada de acero naval dimensionada de acuerdo a las cargas que debe soportar y protegida convenientemente contra la corrosión. **Maquinaria:** La plataforma será del tipo desatendido, monitorizada y actuada remotamente. Contará con alimentación eléctrica autónoma, mediante diesel generadores y energías renovables. Deberá disponer de los equipos necesarios para alimentación y cuidado de los peces, así como para la monitorización de los parámetros bioquímicos que se precisen. **Sistema de posicionamiento y fondeo:** Dispondrá de líneas de fondeo, dimensionadas de acuerdo a los esfuerzos que debe soportar. El equipo de fondeo y amarre se calculará de acuerdo a las líneas de fondeo. **Accesibilidad:** La plataforma será accesible desde el exterior, para lo cual deberá disponer de una zona de embarque.

En Ferrol, a 20 de outubro de 2015.

O titor do TFM

Asinado:

SR. PRESIDENTE DA COMISIÓN DE TFM MEST. ENXEÑARÍA NAVAL E OCEÁNICA.

4. DEFINICIÓN DE LAS POSIBLES ESPECIES A CULTIVAR

4.1. RODABALLO.

Psetta maxima Linnaeus, 1758 [Scopththalmidae.]

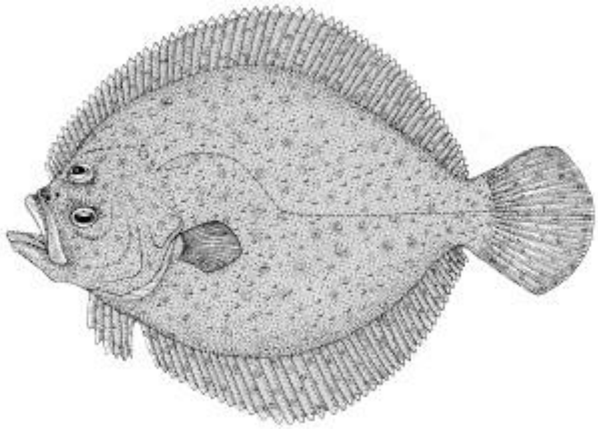


Ilustración 6.Rodaballo.

Rasgos biológicos.

Pez plano con cuerpo asimétrico y casi redondo (ojos sobre el lado izquierdo). Piel sin escamas pero con protuberancias óseas irregularmente distribuidas. Boca grande y ojos pequeños. Las aletas dorsal y anal se expanden ampliamente sobre los costados dorsal y ventral. El lado ciego (derecho) de color blanquecino y el lado del ojo con coloración variable, generalmente café-grisácea con puntos oscuros (Ilustración 6).

Perfil.

Antecedentes históricos.

La acuicultura del rodaballo comenzó en los 1970 en Escocia (Reino Unido). Fue subsecuentemente introducida en Francia y en España. Al comienzo, el número de instalaciones en España fue más bien limitado debido a la escasez de juveniles. El desarrollo tecnológico de la producción de juveniles cambió eso. Al comienzo de los 1990, ya había 16 productores en España. Una crisis significativa en el cultivo de rodaballo ocurrió en 1992; hubo un aumento de 52 por ciento en la producción pero la industria carecía de una red consolidada para la comercialización. Otro factor que contribuyó a esta crisis fue que las granjas eran pequeñas y tenían costos muy altos de producción. Esta crisis causó el cierre de algunas granjas. Desde ese momento en adelante, comenzó una reorganización del sector, la cual dio origen a un crecimiento tanto en producción como en el número de países donde se cultiva el rodaballo. España, con sus condiciones oceanográficas altamente convenientes, es ahora el mayor productor del mundo, pero el rodaballo también se cultiva actualmente en Dinamarca, Alemania, Islandia, Irlanda, Italia, Noruega, Gales (Reino Unido) y Portugal y fue criado previamente en los Países Bajos. La distribución natural del rodaballo incluye las aguas costeras de todos estos países. El rodaballo también ha sido introducido en otras regiones (notablemente Chile a fines de los 1980) y más recientemente, China.

Además de la inversión comercial en mejores instalaciones o la construcción de nuevas granjas, otros factores decisivos han asistido en la consolidación y desarrollo del sector. Estos han incluido la producción de alimentos secos y el desarrollo de vacunas para las enfermedades más importantes que afectan al rodaballo.

Principales países productores.

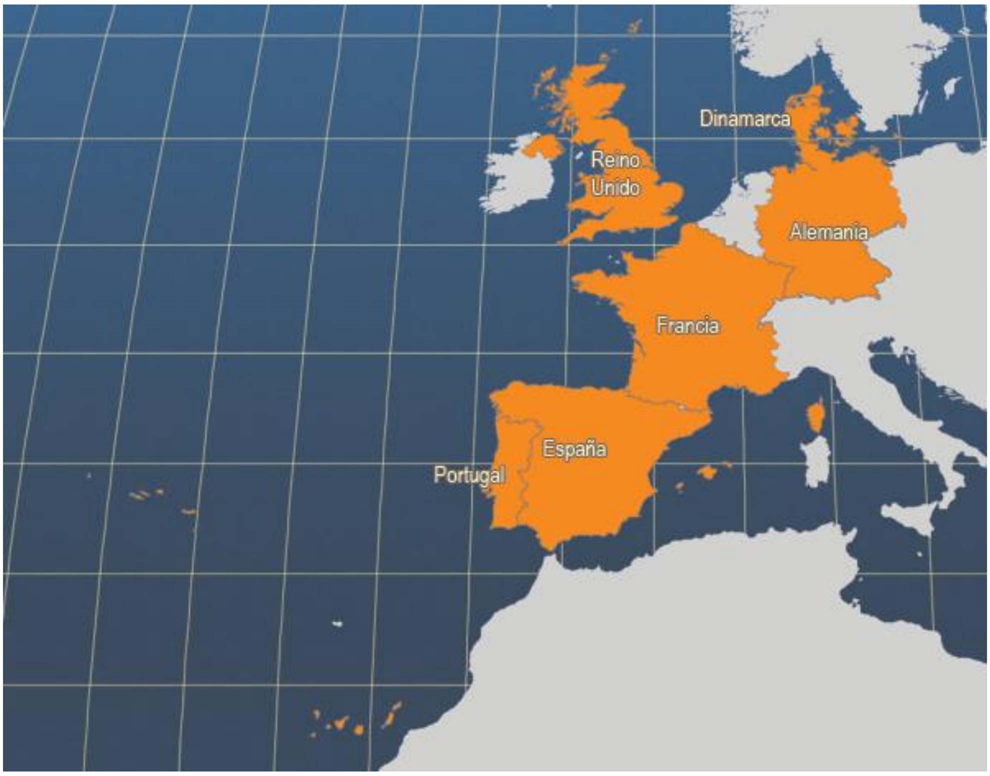


Ilustración 7. Principales países productores Rodaballo (FAO Estadística Pesquera, 2006).

Hábitat y biología.

Psetta máxima es una especie marina bentónica, que vive sobre fondos arenosos y fangosos, desde aguas someras hasta 100 m. Los individuos más jóvenes tienden a vivir en áreas menos profundas. Crípticos, imitando el color del substrato. Carnívoros, los juveniles se alimentan de moluscos y crustáceos y los adultos principalmente de peces y cefalópodos. El desove (secuencial, cada 2-4 días) usualmente ocurre en el Mediterráneo entre febrero y abril inclusive y en el Atlántico entre mayo y julio inclusive. Los huevos tienen una sola gota de grasa. Las larvas son inicialmente simétricas, pero hacia el final de la metamorfosis (día 40-50, 25 mm) el ojo derecho se ha movido a la izquierda, dando lugar a la asimetría. Antiguamente conocido como *Scophthalmus maximus*.

Producción.

Ciclos de producción.

Ilustración 8. Ciclo producción del rodaballo (Psetta máxima).

Sistemas de producción:

Suministro de semilla: *Psetta máxima* es una especie gonocórica con sexos separados. Los reproductores son mantenidos en tanques cuadrados de concreto o cemento, con volúmenes entre 20-40 m³ a densidades de 3-6 kg/m³ y alimentados con pellets húmedos. Los desoves se obtienen extrayendo los gametos (esperma y huevos) de los reproductores. Las hembras experimentan ciclos ovulatorios con un período aproximado de 70-90 horas. Los huevos son pelágicos y de forma esférica. El diámetro de los huevos varía entre 0,9 mm y 1,2 mm. El desarrollo embrionario toma 60-70 días. Después de eclosionar, las larvas de rodaballo miden 2,7-3,1 mm de longitud.

- **Producción en víveros.**

El cultivo de larvas puede ser semi-intensivo o intensivo. En los sistemas semi-intensivos, las larvas son cultivadas a baja densidad (2-5 larvas/litro) en un gran volumen (50 m³), mientras que en el cultivo intensivo la densidad de larvas es más alta (15-20/litro) y el volumen del tanque es 20-30 m³. En ambos sistemas la temperatura de crianza es 18-20 °C. Las larvas recién eclosionadas se alimentan de sus propias reservas vitelinas; la apertura de la boca ocurre al día 3. Entonces la alimentación se basa en rotíferos y artemia. Se agrega fitoplancton al medio de cultivo. La primera alimentación se proporciona en tanques cuadrados con esquinas redondeadas y bombeo de agua de mar en circuito abierto. Se emplean varios alimentos comerciales en la etapa de primera alimentación.

- **Criadero.**

La crianza de los rodaballos se realiza en tanques cuadrados o circulares (10-30 m³) con bombeo de agua de mar en circuito abierto. Usualmente se usan sistemas de aireación para mantener el agua saturada de oxígeno. Los juveniles son alimentados con dietas secas peletizadas, introducidas manualmente o automáticamente. El peso varía entre 5-10 g y 80-100 g durante el período de pre-engorde (4-6 meses de duración).

- **Técnicas de engorde.**

Los rodaballos son engordados ya sea en tanques en tierra (la técnica más común para esta especie) o en jaulas de fondo plano.

Tanques en tierra: Se usan tanques de cemento cuadrados o circulares (25-100 m³), con bombeo de agua de mar en circuito abierto. Normalmente se usan sistemas de aireación u oxigenación para mantener el agua saturada de oxígeno. La alimentación consiste de pellets extruidos, que se introducen manualmente o automáticamente. Los elementos que determinan la productividad son la temperatura y la calidad de los alevines. Las temperaturas óptimas para la alimentación varían entre 14-18 °C, mientras que la gama extrema para el cultivo del rodaballo es 11-23 °C. Los factores limitantes son patologías, tecnologías de cultivo y mercado.

Jaulas: Se usan jaulas sumergidas a varios niveles, o jaulas flotantes, en ambos casos de fondo plano. Los marcos son metálicos, con un fondo de metal o red. Los alimentos extruidos peletizados se entregan manualmente. Los elementos que determinan la productividad son localización apropiada, temperatura del agua y calidad de los alevines.

- **Suministro de alimento.**

Dietas comerciales para rodaballo están disponibles, con un costo actual (2003) de 900 EUR/tonelada. La tasa de conversión del alimento (TCA) típica es 1,1-1,2:1.

- **Técnicas de cosecha.**

Los peces son cosechados manualmente y sacrificados colocándolos en contenedores llenos con hielo y agua de mar, transportándolos luego a unidades de procesamiento.

- **Manipulación y procesamiento.**

Los peces cosechados son embalados en cajas de poliestireno, cubiertos con una capa de hielo y película plástica. En España, los rodaballos generalmente son comercializados enteros y en fresco, mientras que en el resto de Europa generalmente son eviscerados antes de la venta. España ha comenzado a producir rodaballo fileteado para satisfacer otra demanda del mercado europeo. La demanda por tamaño ha cambiado. Antes abarcaba entre 1,5-2,0 kg pero ahora tamaños más pequeños son aceptables; actualmente las ventas varían entre 0,7 kg y 2,0 kg.

- **Costes de producción.**

El costo de producción de engorde es alrededor de 5-6 EUR/kg en tanques y 5 EUR/kg en jaulas. A pesar de los costos más altos del cultivo en tanques en tierra, este sigue siendo la norma debido a que el cultivo en jaula de esta especie está aun en etapa experimental y hay pocas localizaciones que reúnen las condiciones óptimas para el engorde.

4.2. LENGUADO.

Solea solea (Quensel, 1806).

Rasgos significativos.

El cuerpo es plano, fuertemente comprimido y tiene forma ovalada. Ambos ojos se encuentran en el flanco derecho. La longitud más común oscila entre 15 y 45 cm.

La región anterior de la cabeza es redondeada. La boca es ínfera y, al igual que los ojos es pequeña. El preopérculo no es visible (Ilustración 9).

Esta especie se distingue de otras especies de lenguado porque no tiene muy dilatado el tubo nasal anterior del lado ciego. Además, la aleta pectoral del lado ciego no tiene ninguna mancha oscura. La línea lateral es recta pero sigue un recorrido más o menos curvo en su porción cefálica.

El inicio de la dorsal se sitúa por delante de los ojos y llega hasta la aleta caudal, está compuesta por entre 69 y 97 radios. La aleta anal es un poco más corta, comienza a la altura del opérculo y también llega hasta la cola; compuesta por entre 53 y 79 radios. Las aletas pectoral y ventral de la cara ocular son cortas, pero de mayor tamaño que la cara ciega. La cola está diferenciada del resto del cuerpo, pero está unida a las aletas dorsal y anal por una membrana.

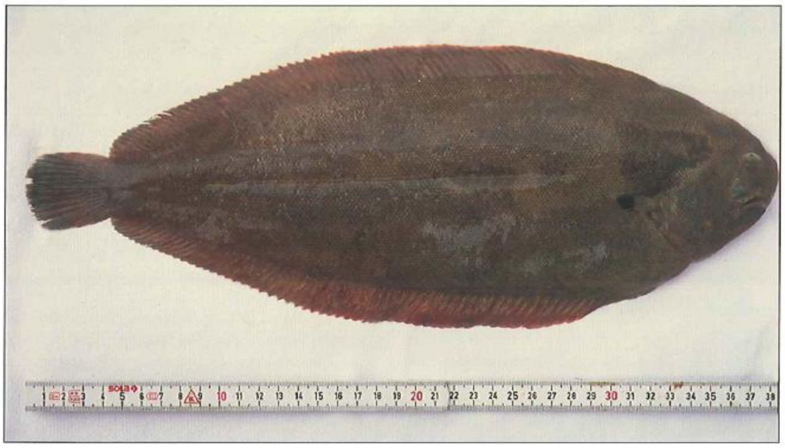


Ilustración 9. Lenguado.

Descripción general.

Lado ocular de color gris a rojo pardo, a veces con grandes y difusas manchas oscuras. La aleta pectoral del lado ocular tiene una mancha negra. El final de la cola es más oscuro que el resto. Las márgenes de las aletas dorsal y anal son claras. La cara ciega es blancuzca.

La cara ocular está cubierta de escamas cteniodeas y rectangulares que le otorgan un tanto áspero y el lado ciego sólo por vellosidades con terminaciones nerviosas. Ninguna de las aletas presenta radios espinosos.

La línea lateral sólo está presente en el lado ocular. El ojo superior se sitúa ligeramente más retrasado que el inferior. Las dos mandíbulas están dotadas de dientes pequeños, difícilmente visibles. El tubo nasal anterior del lado ocular es corto, y no sobrepasa el borde anterior del ojo inferior al rebatirlo hacia atrás. Los orificios nasales del lado ciego están separados entre sí, son de reducido tamaño y disponen de un pequeño tubo.

Hábitat y comportamiento.

Especie demersal que vive en fondos arenosos y fangosos desde el litoral hasta los 200m de profundidad. En las zonas estuáricas pueden ser muy abundantes; en ellas los juveniles prefieren las zonas de menor salinidad y con fondos dominados por sedimentos de arenas finas.

Es una especie bastante sedentaria, por lo que no realiza grandes migraciones. Sin embargo, los ejemplares adultos pueden migrar hacia aguas más frías ya que, como ocurre en la mayoría de peces planos, la temperatura óptima de la especie cambia con la talla.

Tiene hábitos nocturnos, y durante el día suele estar semienterrado en el fondo y sólo se le ven los ojos y orificios nasales.

Se alimenta principalmente de poliquetos, y en menor medida de crustáceos y moluscos. Localiza a sus presas por el fondo mediante unas barbillas con terminaciones nerviosas que tiene en el lado ciego. La actividad predadora se incrementa en primavera y verano. Es una especie cuya abundancia es muy sensible a la distribución y abundancia de sus presas, lo que explica que en años lluviosos, cuando hay muchos aportes de materia desde los ríos y los poliquetos incrementan su abundancia, repercutan positivamente en el número de juveniles de lenguado.

Distribución.

Es una especie común en el Atlántico nororiental, desde Noruega hasta Senegal, incluido el mar Mediterráneo y la parte occidental del mar Negro.

Reproducción.

La puesta del lenguado, como ocurre como muchas especies de amplia distribución geográfica, depende de la temperatura y del fotoperiodo. Por ejemplo, en mar del Norte la puesta tiene lugar entre diciembre y abril, y los huevos son viables cuando la temperatura del agua está entre 8 y 12ºC.

La madurez sexual se alcanza cuando tienen entre 3 y 5 años. La puesta siempre se realiza en aguas litorales y de poca profundidad, y cada hembra pone entre 10 y 140 huevos por gramo de peso. Los huevos y las larvas son pelágicos. Las larvas permanecen en el plancton alrededor de un mes, y se caracterizan porque inicialmente son similares a las larvas de cualquier otro pez, con un ojo situado a cada lado de la cabeza. Cuando alcanzan un tamaño de 8mm se inicia la migración del ojo izquierdo al lado derecho, pero siguen formando parte del plancton hasta que, con 15 mm finaliza la metamorfosis y comienzan la vida bentónica.

Las principales áreas de nursery están en las zonas estuáricas, en aguas poco profundas, siempre a menos de 20 m y en fondos de sedimento fino. Los juveniles llegan a ellas en varias oleadas. El crecimiento es lento y los ejemplares de mayor talla pueden alcanzar los 26 años.

4.3. DORADA.

Sparus Aurata.

Datos de interés.

Especie marina. Presenta una banda dorada entre los ojos (más patente en individuos adultos), una mancha negra en el origen de la línea lateral y una banda escarlata en el borde de la mitad inferior del opérculo.

Cuerpo ovalado, alto y comprimido. Cabeza grande con el rostro y frente convexo. Boca con labios muy gruesos, la mandíbula superior un poco más larga que la inferior Ilustración 10.

Los dientes anteriores de ambas mandíbulas son cónicos y fuertes. Aleta dorsal con una parte anterior espinosa y una posterior con radios blandos. Aletas pectorales largas, alcanzando su extremo el origen de la aleta anal.

Puede vivir más de 10 años. Se alimenta principalmente de moluscos, crustáceos y pequeños peces.

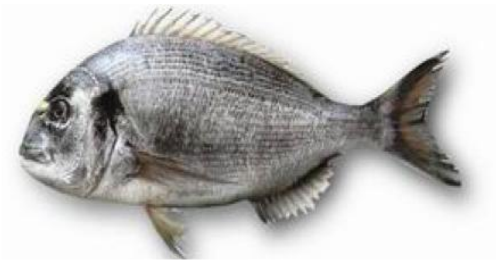


Ilustración 10. Dorada.

Valor nutricional.

VALOR NUTRICIONAL	
Aprovechamiento	54%
Proteína: 19,9 %	Grasa: 3,2 %
Calorías: 100 Kcal.	
Ácidos Omega 3 y mega-6	

Tabla 4. Valor nutricional de la dorada.

Hábitat y comportamiento.

Sparus aurata es una especie común en el mar mediterráneo, todo a lo largo de la costa este atlántica, desde Gran Bretaña a Senegal y más desconocida en el Mar Negro. Es una especie eurihalina y euriterma, por lo que puede vivir en ambientes marinos o salobres, como lagunas costeras y zonas estuáricas, particularmente durante las primeras fases de su ciclo de vida. Nace en mar abierto entre octubre y diciembre y los juveniles migran al principio de la primavera protegidos por las aguas costeras, en las que encuentran abundantes recursos y temperaturas más templadas.

Son muy sensibles a las bajas temperaturas (Tª letal a partir de 4º C), de ahí que a finales del otoño, regresen a mar abierto, donde los adultos realizan la puesta.

En mar abierto, podemos encontrar dorada en fondos rocosos y campos de algas (Posidonia oceánica), aunque también es frecuente encontrarlas en fondos arenosos. Los animales jóvenes se quedan en zonas poco profundas (hasta los 30 m), mientras que los adultos pueden habitar aguas más profundas, a partir de 50 m.

Es una especie proterándrica y hermafrodita. La madurez sexual se alcanza en los machos a los 2 años de edad y 20-30 cm. Y en las hembras entre los 2 y los 3 años. Las hembras pueden poner 20.000-80.000 huevos cada día durante un periodo superior a los 4 meses. En cautividad, la inversión sexual se produce por factores hormonales sociales.

Métodos de Cultivo.

Tradicionalmente, la dorada ha sido criada de forma extensiva en lagunas costeras y estanques de agua salada (esteros) en la práctica totalidad del mediterráneo. En la década de los 80 comienzan a desarrollarse los sistemas intensivos que han ido evolucionando hasta nuestros días. Durante los primeros años de la década de los 80 se logra con éxito la reproducción artificial de esta especie, momento en el que despega la producción de juveniles y su cría en cautividad de forma intensiva tanto en estanques como en jaulas.

Las distintas fases del ciclo de cultivo de describen a continuación:

Mantenimiento de los reproductores: normalmente cada instalación suele tener sus propias unidades de puesta, en las que los reproductores son mantenidos bajo condiciones controladas. Al principio de la época de puesta, los reproductores seleccionados son transferidos a los tanques de puesta. El control de la proporción sexual es importante en estos tanques, ya que la inversión sexual puede ser inducida por factores sociales. Normalmente, la presencia de machos jóvenes al final de la temporada de puesta, incrementa el número de machos viejos que se transforman en hembras.

Fuera de la época de puesta, esta puede inducirse manipulando las condiciones ambientales.

Cultivo Larvario: en el caso de la dorada la cría de larvas, puede realizarse a pequeña o a gran escala, en función de la capacidad de los tanques y de las densidades de cultivo. Lo más habitual es que los tanques tengan una capacidad de unos 200 m^3, y que en ellos se simulen las condiciones de un ecosistema natural, garantizando una mayor calidad de las larvas, aunque el número sea menor. Para la alimentación de las larvas se usa, normalmente, rotífero (Brachionus plicatilis) y Artemia salina. En las fases iniciales, para mejorar la calidad del agua se crea "agua verde", con distintas especies de microalgas.

Juveniles: cuando el pez alcanza los 5-10 mg. comienza a alimentarse con piensos secos altos en proteínas.

Destete: normalmente a los 45 días, los juveniles son movidos a tanques rectangulares (10-25 m^3), para ser destetados. Se les alimenta continuamente, cada dos horas, incrementando el porcentaje de alimentos seco gradualmente.

Engorde: La dorada puede ser engordada de varias formas: en estanques o lagunas costeras, con métodos extensivos o semi-extensivos. Así como en instalaciones en tierra o en jaulas en el mar, con métodos intensivos.

- **Sistemas extensivos:** en estanques o lagunas costeras. Este método se basa en la migración natural de los peces eurihalinos, durante la cual son capturados ejemplares de 2-3 g. para su "siembra" en las lagunas entre abril y mayo, alcanzando el primer tamaño comercial (350 g) en unos 20 meses. En el mismo medio de cultivo se crían también salmonetes, anguilas y lubinas. Durante el ciclo productivo los peces se alimentan de los recursos naturales de la laguna. En sistemas extensivos de densidad no suele superar los 0,2-2 kg/m^3.
- **Sistemas semi-extensivos:** también tiene lugar en estanques y lagunas costeras, con la diferencia con respecto a los anteriores de que en este tipo de sistemas se aumenta el control humano de los factores medioambientales, fertilizando el área de cultivo para incrementar la cantidad de alimento disponible. La densidad no excede 1 kg/m^3.
- **Sistemas intensivos:** en instalaciones en tierra o en jaulas en el mar. En instalaciones en tierra suelen utilizarse tanques de diversos tamaños (200-3.000 m^3), en función del tamaño de los peces y altas densidades (15-45 kg/ m^3), inyectando grandes cantidades de oxígeno. Bajo buenas condiciones (18-26 ºC) alcanzan el tamaño comercial en un año. El engorde en jaulas puede realizarse en zonas protegidas o semiexpuestas (jaulas flotantes) o bien en zonas totalmente expuestas (jaulas sumergibles o semi-sumergibles). El engorde en jaulas es más simple y

económico. Las densidades de cultivo también son menores que en los tanques, habiendo otras ventajas que los hacen más rentables (no hay gasto de energía, ni de tratamiento del agua). Doradas de 10 g. alcanzan el tamaño comercial en jaulas en un año.

En el año 2005 había en España 100 instalaciones dedicadas al cultivo de dorada, de las cuales 57 correspondían a cultivos en jaulas, 36 a instalaciones con cultivos realizados en realizados en construcciones o artefactos en tierra y 7 de ellas correspondían a cultivos realizados en enclaves naturales en la zona de Dominio Público Marítimo Terrestre.

Ilustración 11. Tipos de instalaciones.

Áreas de Producción.

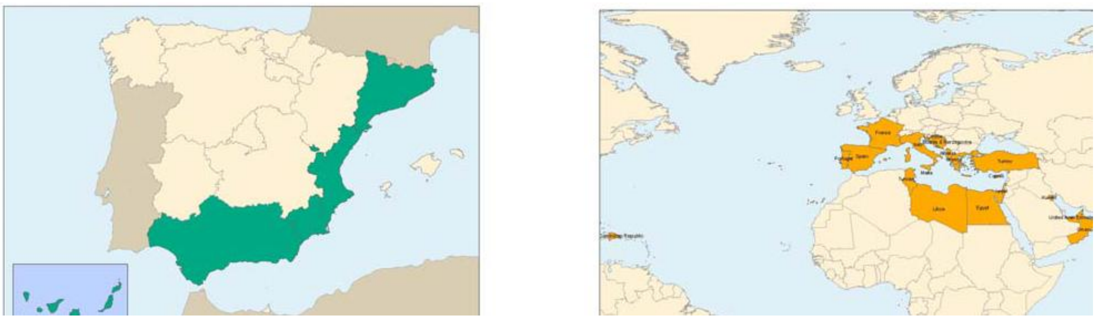
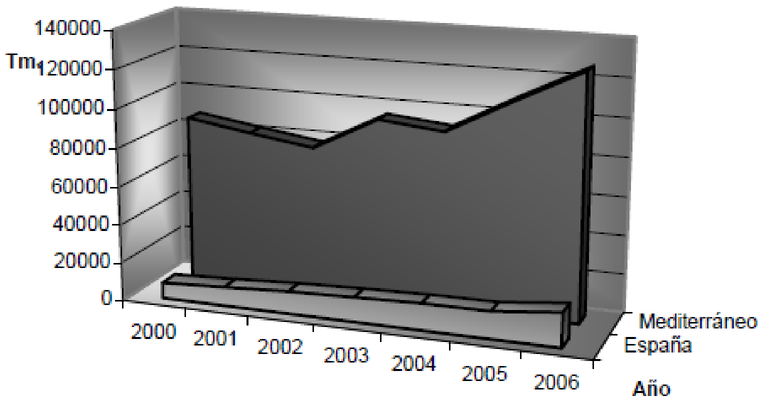


Ilustración 12. Áreas de Producción.

Países del Mediterráneo tenidos en cuenta: Chipre, Egipto, Estonia, Francia, Grecia, Croacia, Túnez, España, Portugal, Marruecos, Italia, Malta, Israel, Turquía.

Evolución Producción.



	2000	2001	2002	2003	2004	2005	2006
España	8241,9	9832,7	11653,2	12783,97	13848,29	14180,7	17836
Mediterráneo	87178	82002	77155	94730	91462	109480	126640

Ilustración 13. Evolución Producción.

En términos de producción, la Dorada (Sparus aurata) constituye la especie piscícola marina más cultivada en España.

La mayor parte de la producción mundial procede del Mediterráneo, con Grecia como principal productor (40,88 %), Turquía con un 22,46 % de la producción mundial, España con un 15,22 % e Italia, ya más alejada, con un 5,79 %. Otros países productores de cierta importancia son: Israel, Egipto, Portugal, Francia y Chipre. Podemos encontrar producción de dorada en el Mar Rojo, el golfo Pérsico y el Mar de Arabia.

Comercialización.

El rápido desarrollo de la producción en jaulas de cultivo en el mar, ha permitido el desarrollo del sector y el descenso de los precios respecto a los años en los que se inició el cultivo de esta especie. A pesar de este descenso de los precios, la actividad sigue siendo interesante para los inversores ya que garantiza un razonable beneficio. La crisis del sector en España, durante los años 2000 y 2003, debida principalmente a la entrada en los mercados de productos procedentes de otros países europeos, parece superada, situándose en 5,50 € por Kg. el precio de la dorada de 350 grs. En el mercado europeo.

Por otro lado, el cultivo de dorada en las regiones mediterráneas está sufriendo una gran transformación, pasando de ser una industria con grandes márgenes y bajos volúmenes de producción a una industria con bajos márgenes y grandes volúmenes, estrategia conocida como economía de escala.

La estrategia de los pequeños y grandes productores puede ir encaminada a aportar valor añadido al producto mediante la implantación de sistemas y/o estándares de calidad, la producción de distintos tamaños comerciales o la presentación de productos transformados.

Situación actual y líneas futuras.

Para continuar con el desarrollo de la industria acuícola de dorada en el mediterráneo, deberán fomentarse estrategias de organización de mercados, promoviendo la apertura de nuevos mercados y la ampliación de los existentes y adoptando procedimientos más exigentes en lo que respecta a calidad del producto final.

Todo ello deberá ir acompañado la mejora y optimización de los sistemas de producción y comercialización.

4.4. LUBINA.

Dicentrarchus labrax.

Datos de interés.

Cuerpo alargado, poco comprimido y esbelto. Boca grande con la mandíbula inferior algo prominente. Primera aleta dorsal de contorno triangular y la segunda trapezoidal, con el margen anterior alto. Aleta caudal ahorquillada. De color gris plateado en el dorso, más claro en los flancos y blanco en el vientre. Los peces jóvenes pueden tener manchas negras en los lados y en el dorso.

Los caracteres más significativos son: mancha negra en el borde superior del opérculo; preopérculo con el margen posterior finamente aserrado y dentículos en la parte inferior; opérculo con dos espinas puntiagudas; dos aletas dorsales separadas, la primera con 8-10 radios espinosos Ilustración 14.

Su longevidad se estima en unos 15 años, aunque en el Mediterráneo suele ser más corta. La primera maduración sexual ocurre generalmente a los 2 años en los machos y a los 3 años en las hembras en el Mediterráneo, en el Atlántico suele ser más tardía. Talla media de 40 a 65 centímetros, máxima 1 metro, excepcionalmente algo mayor. Peso medio de 5 a 7 kilos, pudiendo ocasionalmente llegar hasta los 10 ó 12 Kg.

Se distribuye por todo el Mediterráneo, Mar Negro y Atlántico nororiental (desde las costas de Noruega a las de Senegal).

Ilustración 14. Lubina.

Valor nutricional.

VALOR NUTRICIONAL	
Aprovechamiento	66%
Proteína: 18,1 %	Grasa: 4,5 %
Calorías: 97 Kcal.	
Ácidos Omega 3 y mega-6	

Tabla 5. Valor nutricional de la lubina.

Hábitat y comportamiento.

Especie que vive sobre todo tipo de fondos en la zona litoral, desde zonas superficiales hasta profundidades de unos 100 m. Es una especie eurihalina (pueden vivir en ambientes con un amplio margen de salinidad) y euritérmica (amplios rangos de temperatura, 5-28º C). Habitan en costas rocosas y arenales, bocanas de los puertos, zonas de estuarios y deltas en aguas salobres, pudiendo encontrarse ocasionalmente en ríos.

Los ejemplares jóvenes forman bancos o cardúmenes, pero los adultos son más solitarios.

Es una especie carnívora muy voraz que se alimenta de invertebrados, peces y crustáceos. Suele cazar por las noches.

Presenta una única estación reproductiva anual que tiene lugar en invierno, de diciembre a marzo, en las poblaciones mediterráneas y en primavera, hasta junio, en las atlánticas.

Los huevos son pelágicos, de 1,1 a 1,5 mm. De diámetro, con ente 1 y 5 gotas de grasa. Las larvas recién eclosionadas miden entre 3 y 4 mm., alcanzando el estado de alevín a los 40-60 días cuando se concentran en las zonas costeras poco profundas y desembocaduras de los ríos.

Su óptimo de temperatura se encuentra entre los 20-25º C.

Métodos de Cultivo.

El cultivo de la lubina se inició en Italia en la década de los 60 mediante la vallicultura tradicional y se desarrolló en Francia a partir de 1972. Desde los años 80 en que se consiguió controlar la reproducción, se fue desarrollando el cultivo intensivo de manera que en la actualidad las mayores producciones de lubina proceden de este tipo de instalaciones, pudiendo ubicarse tanto en tierra como en jaulas flotantes en el mar. Los principales sistemas de cultivo son los siguientes:

Extensivo El método más tradicional se realiza en lagunas salobres litorales, aprovechando las migraciones desde el mar de los juveniles. En esta ubicación encuentran mejores condiciones alimenticias, climatológicas y sobre todo de defensa frente a los depredadores no adaptados a los cambios de salinidad en este sistema. En España se desarrolla la acuicultura extensiva de lubina en policultivo con otras especies, como dorada y mejillón, en el Delta del Ebro en los esteros de las salinas de Cádiz. Las producciones son bajas (50-100 Kg/Ha/año), el crecimiento lento (alcanza el tamaño comercial, 400—500 gr. en unos 37 meses). La limitación de este sistema es que la lubina al ser un depredador puede reducir drásticamente los recursos naturales del ecosistema.

Una variación de este método es el semi-extensivo, que mejora sustancialmente el rendimiento y que conlleva la fertilización de las lagunas, para aumentar la producción de plancton, el suministro de alimentación artificial y el aporte controlado de alevines procedentes del medio natural o de criaderos.

Intensivos

El punto de partida de los sistemas intensivos es el manejo de los reproductores y el control de las puestas. Hoy en día son muchos los criaderos que han establecido sus propias unidades de cría, en las que grupos de reproductores de diferentes edades son mantenidos juntos durante largo tiempo. La edad óptima para las hembras es entre los 5 y los 8 años y para los machos el rango es menor, entre los 2 y los 4 años. La gestión de estos criaderos incluye la maduración natural, la inducción a la ovulación por manipulación del fotoperiodo o tratamiento hormonal, la fertilización y la incubación de las semillas en un tanque con sistema de circulación abierta de agua.

Los reproductores se mantienen en tanques (>20 m^3) con cargas inferiores a 4 Kg/m^3 y con una proporción macho: hembra de 2:1. La alimentación se hace a base de piensos comerciales especiales y de pescado fresco. La puesta natural de la lubina tiene lugar a los 10-14ºC pero modificando la temperatura y el fotoperiodo pueden mantenerse diferentes lotes de reproductores para obtener puestas a lo largo de todo el año. En determinados casos la puesta también pude ser inducida utilizando tratamientos hormonales. Hay 8 instalaciones en España, según datos del 2005, en las que se realiza en engorde de la lubina hasta la talla de madurez sexual.

La incubación de los huevos y el cultivo larvario se lleva a cabo bajo un estricto control de las condiciones de temperatura, fotoperiodo, pH, oxígeno disuelto, amonio y nitritos, para obtener una óptima calidad del agua de mar. La alimentación larvaria se basa en presas vivas-rotífero y artemia- aunque en el caso de la lubina se puede suprimir la primera fase manteniendo los tanques en completa oscuridad. A partir del día 30 de vida de las larvas se da paso a la alimentación inerte, fase conocida como destete, a base de piensos comerciales. La supervivencia en la etapa de cultivo larvario oscila entre el 30 y el 50 %.

A los 80-90 días las larvas completan la metamorfosis adquiriendo los caracteres del adulto. Se mantienen en el criadero hasta que alcanzan 1,5-2,5 g, momento en el que inician la etapa de pre-engorde, en la que alcanzan los 20g. en 3-6 meses.

El engorde tiene lugar en instalaciones en tierra o en jaulas en el mar, durante 15-18 meses, al final de los cuales la lubina alcanza su tamaño comercial (300-450 gr.), con una supervivencia del 85%. Según datos del 2005 hay en España 70 instalaciones en las que se engorda lubina, 43 de ellas son jaulas en el mar, 22 en artefactos en tierra y 5 en enclaves naturales (esteros). Las características de cada uno de estos sistemas son las siguientes:

<u>Engorde en tanques:</u> los tanques se mantienen con agua de mar en sistema de intercambio continuo con la temperatura ambiental. La densidad del stock es elevada (20-35 Kg/m^3), lo que hace esencial el correcto control de la calidad del agua y de la salud de los peces. Durante el otoño/invierno, se utiliza un sistema de recirculación para mantener la temperatura del agua entre 13-18 ºC. Esta práctica mejora el crecimiento, pero incrementa mucho los costes, por lo que cada día es empleada por un menor número de empresas.

<u>Engorde en jaulas</u>: Las jaulas tienen un diámetro de 12 a 50 m. y una profundidad de unos 10 m., lo que las permite soportar cargas de 20-30 kg/m^3 de pescado. Es fundamental, en este tipo de instalaciones, realizar 2 ó 3 clasificaciones durante cada ciclo reproductivo para evitar el crecimiento diferencial de algunos lotes y la aparición de canibalismo y deficiencias en el

aprovechamiento del alimento. Aunque las jaulas pueden ser de muy diversos tipos, todas tienen algo en común, se basan en permitir un intercambio natural de agua a su través. La calidad de la ubicación es, por lo tanto, una variable importante, dependiente de las condiciones locales y de las corrientes. Las jaulas pueden fabricarse con multitud de materiales. En la actualidad se utilizan dos tipos de estructuras, unas mantenidas en superficie y otras sumergidas. Las estructuras pueden situarse en las cercanías de la costa, siendo más accesibles, o bien en mar abierto, de forma que solo se puede acceder a ellas en barco. Otro factor importante es la estructura de los cerramientos, frecuentemente es necesario el cambio de la red, especialmente en periodos de calor. La limpieza semanal para retirar los organismos incrustados (fouling) y los tratamientos periódicos con productos antifouling son también necesarios. Aunque se encuentren en el medio natural la alimentación de los peces debe ser diaria, a base de concentrados granulados normalmente. El monitoreo de este tipo de instalaciones también es importante para el control medioambiental. Actualmente, el engorde de lubina se realiza casi mayoritariamente en instalaciones flotantes en mar abierto, que requieren una inversión menor y disminuyen considerablemente los costes de producción.

En el año 2006 hay registradas en España 107 instalaciones destinadas a la crianza de lubina, en alguna de las distintas fases de cultivo. Se distribuyen dentro del territorio nacional de la siguiente forma: 44 en Andalucía, 29 en Canarias, 16 en Valencia, 9 en Cataluña, 6 en Murcia y una instalación en las CC.AA de Cantabria, Galicia y Baleares.

Ilustración 15. Tipos de instalaciones para la cría y engorde de lubina.

Áreas de Producción.

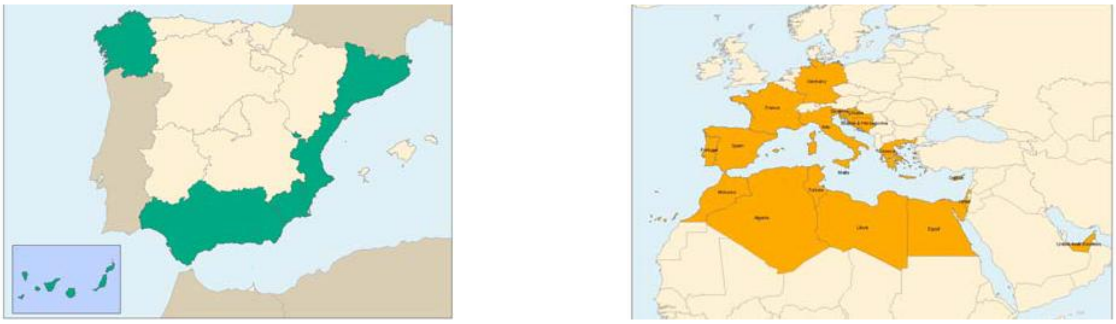


Ilustración 16. Áreas de producción de la lubina.

Evolución Producción.

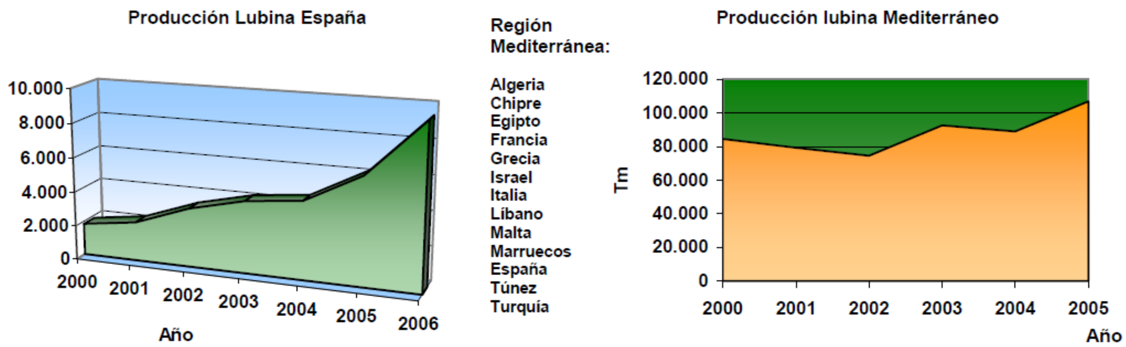


Ilustración 17. Evolución de la producción de la lubina.

La producción total de lubina en la cuenca mediterránea ascendió en 2005 a unas 106.966 Tm. (un 20 % más que en 2005). Los principales países productores son Grecia, Turquía, Italia, España y Francia. El volumen de la pesca extractiva permanece constante mientras que la lubina de crianza supone ya más del 85 % del total.

La producción acuícola de lubina en España en 2006 ha sido de 9.438 Tm, lo que supone un aumento del 50 % respecto a 2005. Andalucía es la principal productora (3.099 Tm.), seguida de la Comunidad Valenciana (2.369 Tm.), Canarias (2.229), Murcia (1.206), y Cataluña (534).

En lo que respecta a la producción de alevines en España, las cifras en 2005 amentaron de forma espectacular por tercer año consecutivo llegando a las 33.548.650 unidades producidas. Las principales Comunidades Autónomas en la producción de alevines son, por este orden: Andalucía, Cataluña, Cantabria, Valencia, Baleares y Murcia.

Comercialización.

La industria de la lubina en Europa ha crecido, en menos de 15 años, desde unas pocas miles de toneladas a las casi 50.000 Tn., que se producen en la actualidad. Cuando la lubina de cultivo empezó a entrar en el Mercado a finales de los 80 y principios de los 90, su precio era muy elevado, debido a su complementariedad con la lubina salvaje y su alta calidad, hoy en día hay una clara distinción en el mercado entre el producto salvaje y el cultivado, siendo los precios de la lubina salvaje mayores que los de la cultivada.

Comparada con muchas otras especies de pescado cultivado, la lubina ha sido comercializada siempre fresca y entera, limitándose únicamente determinados volúmenes, y evitando su procesado, lo que ha provocado que el desarrollo del sector haya sido muy limitado. Esto es debido al conservadurismo de los consumidores europeos, que están acostumbrados a ver el pescado entero al comprar, no teniendo en cuenta que el pez podría estar mejor si hubiera sido limpiado en origen.

Actualmente de la colaboración entre los productores griegos y los procesadores italianos ha surgido el envasado en una atmósfera modificada (modified atmosphere packaging, MAP), que le da al producto una vida más larga.

Situación actual y líneas futuras.

En Europa, la industria de la lubina ha crecido fuertemente en la última década. Este incremento de la oferta tan importante y continuado no podía ser digerido por la demanda sin modificaciones en los precios, lo que produjo una paulatina reducción de los mismos Esta situación desemboca, en 2001-2002, en una guerra de precios con la consiguiente caída de los resultados empresariales.

Esta situación se debe a diversos factores, en los que se debe trabajar de cara al futuro, como son: la globalización de la producción, con la entrada de nuevos países, el pequeño tamaño de las empresas productoras, la falta de formación del personal, falta de desarrollo de nuevas presentaciones del producto, la estacionalidad de la oferta, etc.

Finalmente indicar que también se debe buscar la apertura de nuevos mercados, ya que la penetración del producto es todavía muy limitada, principalmente en el norte de Europa.

4.5. ¿POR QUÉ SE HA ELEGIDO LA DORADA?

Como se indicaba en el RPA, el rodaballo se podría adaptar a nuestras costas como podemos ver en las siguientes características:

- Está demostrado que la cría de Rodaballo en Galicia es rentable.
- Es un pez que se adapta muy bien a la climatología de la costa gallega.
- El rango de temperatura tanto para la supervivencia como para el engorde es muy amplio.
- Al ser un pez plano, se puede aumentar el volumen de producción, optimizando las jaulas.

Pero se cultiva en jaulas en tierra, en jaulas flotantes todavía no hay estudios de su cultivo, al ser un pez que le gusta el fondo marino, normalmente fondos arenosos, en una jaula no podríamos tener esa posibilidad, al ser de red y no ser fondo arenoso.

Después de estudiar las otras opciones comentadas anteriormente, hemos decidido optar por la dorada, tenemos un clima y temperaturas que son aptos para su cultivo, aunque suele cultivarse más por la zona del mediterráneo porque tiene una temperatura mayor, en la zona costera gallega también es posible, de hecho existen varias plantas de acuicultura terrestre en las cuales se cultiva, como ventajas podemos enumerar:

- La producción de alevines en hatcheries está muy consolidada.
- Las granjas, están consolidadas tanto en jaulas, como en tanques como en depósitos.
- Para la etapa pre-engorde también, existen granjas de acuicultura terrestre, y a partir de ellas es cuando se llevan a las granjas de engorde que están en alta mar.
- Tienen un alto control de las enfermedades.
- Alcanzan un peso en venta en poco tiempo (unos 15 meses).
- Tiene gran demanda en el mercado.
- Densidad de cultivo (25 a 30) kg/m^3.

4.6. CANTIDAD DE DORADAS EN TONELADAS.

Para conocer los parámetros de los elementos de nuestra instalación, partimos de la cantidad de peces que queremos cultivar, nuestra capacidad de producción es de unas 530.000uds. Necesitamos saber la densidad del crecimiento del pez a criar.

Vamos a realizar unos cálculos partiendo de los siguientes datos:

La densidad de engorde hasta 0,4kg (capacidad de carga): 20 kg/m^3.

- Capacidad de carga de la dorada = 20 kg/m$^{3.}$
- Peso de la dorada en el momento de la venta = 400 gr.

$$Nº\ de\ peces = \frac{Cantidad\ de\ peces\ en\ gramos}{Peso\ Dorada\ en\ gramos}$$

De donde:

$$Cantidad\ de\ peces\ en\ gramos = Nº\ de\ peces\ \cdot Peso\ de\ la\ Dorada\ en\ gramos.$$

$$Cantidad\ de\ peces\ en\ gramos = 530.000 \cdot 400 = 212.000.000 gr = 212\ tn$$

De donde para obtener un total de 212 tn de Dorada, hemos de tener en las jaulas unas 530.000 uds de Dorada.

4.7. PROBABILIDAD DE SUPERVIVENCIA.

Usando como base el número de peces y las toneladas que acabamos de calcular, lo que haremos ahora, es por medio de una serie de cálculos adicionales calcular los peces que pueden morir a lo largo del proceso, que reducirán la producción final.

El proceso de engorde tiene lugar las jaulas que están en alta mar, tienen unos parámetros de alimentación, crecimiento y supervivencia que suelen ser mayores, que aquellos que están en tierra. Ello es debido a que las aguas tienen mayor calidad (elevado contenido en oxígeno y menor concentración de contaminantes), dando lugar a tener un mayor crecimiento de la dorada en las jaulas en alta mar. Aunque podemos comentar que tienen como inconveniente las inclemencias, que dan lugar a la perdida de pienso pero que ya se están mejorando con los nuevos sistemas de alimentación.

Las actividades tanto de pre-engorde, como las fases interiores de cultivo de la dorada se hacen en tierra o en zonas abrigadas.

Las actividades de pre-engorde en las instalaciones terrestres, donde tenemos un elevado nivel tecnológico, que actúa tanto sobre el control como la calidad del agua del cultivo, y la fase de engorde se realizará en las jaulas en alta mar, como hemos comentado anteriormente.

- Rango de mortalidad para engorde en jaulas del 5 al 10%: 10% → P(A)= 0,10.

Calcularemos el número real de peces, en función del rango de mortalidad:

$$P(TA) = 530.000 + 530.000 \cdot 0{,}10 = 583.000uds$$

4.8. VOLUMEN REQUERIDO PARA LAS JAULAS.

Tenemos el número de peces (uds), y teniendo en cuenta la mortalidad en los adultos, calcularemos las toneladas.

$$Cantidad\ de\ peces\ en\ gramos = Nº\ de\ peces\ \cdot Peso\ de\ la\ dorada\ en\ gramos.$$

$$Cantidad\ de\ peces\ en\ gramos = 583.000 \cdot 400 = 233200000gr = 233{,}2\ tn$$

Una vez que tenemos las toneladas, y con la densidad de carga, calcularemos el volumen necesario para nuestras jaulas.

$$Volumen\ de\ las\ jaulas = \frac{masa\ (kg)}{densidad} = \frac{233.200}{20} = 11.660m3$$

Vamos a suponer que tenemos 4 jaulas, por lo que el volumen mínimo por jaula será:

$$Volumen\ por\ jaula = \frac{11.660}{4} = 2.915m3$$

Si cada jaula, tiene un diámetro de 20 metros y con una altura de 10 metros, obtenemos un volumen de 3.141m^3, el cual es superior al volumen mínimo.

Por lo tanto necesitaremos:

JAULAS (unds)	DIÁMETRO (m)	ALTURA (m)
4	20	10

Tabla 6. Dimensionamiento de las jaulas.

4.9. DIMENSIONAMIENTO DE LAS REDES.

La fase de engorde se divide en dos fases, la fase de pre-engorde y la fase de engorde, la primera fase, se realizará como comentábamos antes en las zonas de tierra, que no nos interesa que estén muy lejos de nuestras jaulas de engorde, por el hecho de que no tengamos excesivos precios en el transporte.

La fase de pre-engorde, va desde 1-2 gramos hasta 15-20 gramos, suele producirse desde los días 45 – 120 dependiendo de la temperatura del agua.

El hecho de que existan estas jaulas de pre-engorde es debido, a que los cultivadores prefieren introducir peces de 20 o más gramos, porque aguantan mejor el oleaje, son más fuertes, y además los cambios de las redes son poco frecuentes.

En la fase de engorde las jaulas están a más de 30m de profundidad por lo que se denominan *Instalaciones en mar abierto (offshore).*

Para los peces que son de pre-engorde se necesitan unas mallas de luz de 4mm, en cambio para la fase de engorde las redes, tienen una luz de malla de 10mm, pudiendo sustituirse por otras mayores de 15 y 25 mm.

REDES (ud)	DIÁMETRO (m)	ALTURA (m)	LUZ (mm)
4	20	10	10

Tabla 7. Dimensionamiento de las redes.

5. PROYECTO TÉCNICO.

5.1. DESCRIPCIÓN GENERAL.

El proyecto se basa en una plataforma Spar clásica, con anclajes de fondeo, y a bordo de la cual se ubicarán todos los elementos necesarios para el funcionamiento de una instalación acuícola, es decir, el sistema de alimentación, sistema de limpieza, sistema telemático de monitorización y control, tolvas de alimentación para el pienso, sensores biométricos, planta de generación de energía, sistema de fondeo.

A lo largo de la obra viva, se instalará un anillo, unido a su vez a las 4 jaulas, para poder izarlas o sumergirlas completamente cuando sea preciso, bien sea por inclemencias meteorológicas, o bien para mantenimiento o para recoger la cosecha.

La subida y bajada de las jaulas será simultánea, ya que por estabilidad y para distribuir los esfuerzos en todo el perímetro de la zona de transición se ha optado que las cuatro jaulas sean solidarias entre sí y con el sistema de elevación.

La Spar se dividirá por cubiertas como indicaremos más adelante, y poseerá un tronco de escape, que va desde la cubierta superior hasta los tanques de lastre.

Se accederá a ella desde el exterior por medio de una escalera retráctil.

En la cubierta superior, tendremos unas escotillas por las cuales se introducirán los combustibles y consumibles, (piensos, agua, combustible…).

El interior de la zona de transición entre el tanque alto, o hard tank, y el tanque de lastre sólido, o soft tank, se dispondrá de tanques de lastre estructurales, con su respectivo sistema de lastre y achique para garantizar la estabilidad y adrizamiento de de la plataforma mediante el llenado y vaciado de los mismos.

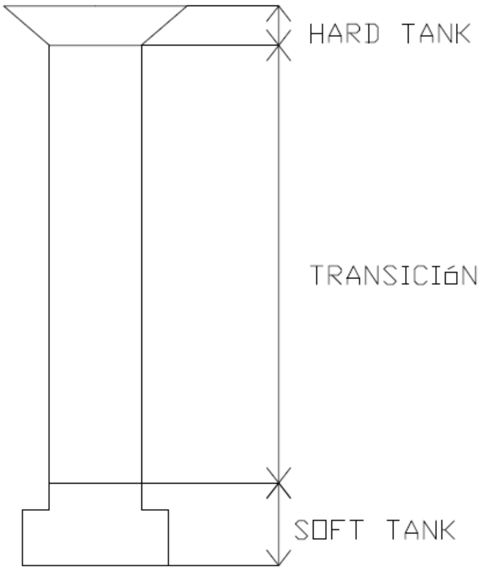


Ilustración 18. Zonas de la Spar.

5.2. NORMAS Y REGLAMENTOS.

Para la realización de la estructura de la Spar, se ha utilizado el reglamento y los estándares DNVGL para artefactos y buques.

- DNV-OS-C106.
- DNV-OS-C101.
- DNV-OS-C103.

Este reglamento en su totalidad se incluye en los anexos finales.

5.3. CARACTERIZACIÓN DEL EMPLAZAMIENTO.

En el RPA, se dice que *"La plataforma será capaz de operar en mar abierto en una zona de hasta 80 metros de profundidad. Su ubicación se encontrará en la franja de costa comprendida entre Cabos Prioriño Chico y Punta Frouxeira, siempre que la profundidad no supere la indicada".*

La caracterización meteorológica de la zona es precisa como paso previo al cálculo de las fuerzas y momentos debidos a viento, olas y corrientes sufridos por la instalación durante la operación, a 10 millas náuticas de la costa noroccidental de Galicia, es decir, en las conocidas como Rías Altas. En la Ilustración 19 se marca en amarillo la isobata de 100 m de profundidad frente a la costa de La Coruña y del Ferrol donde se podría ubicar la plataforma SPAR.

Ilustración 19. Representación de la isobata de 100m frente a la costa noroccidental de Galicia.

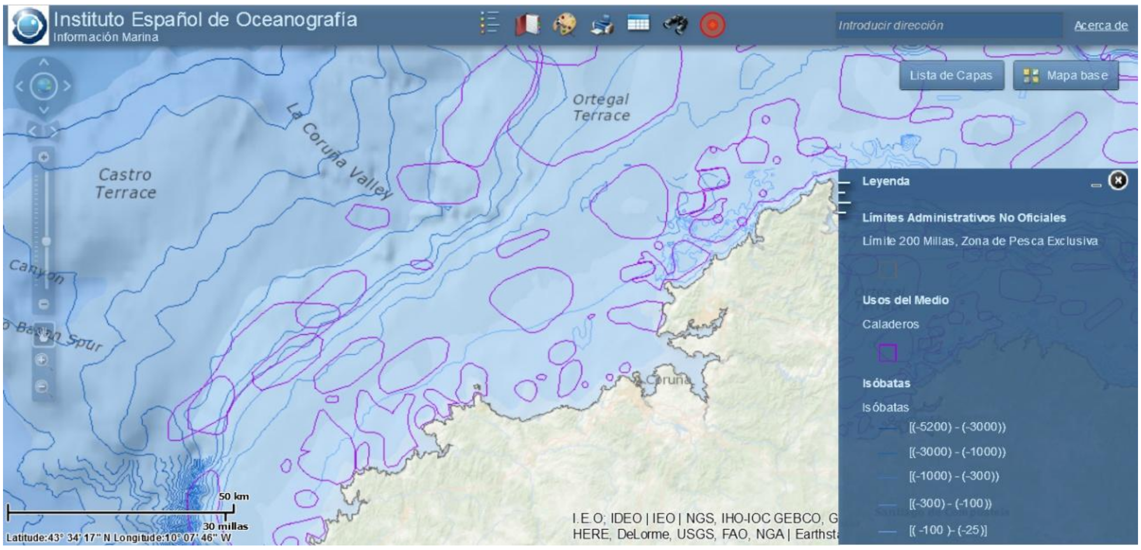


Ilustración 20. Isobatas de las Rías Altas. [Fuente: Instituto Español de Oceanografía.]

El oleaje junto con las corrientes marinas superficiales son dos de las condiciones medioambientales más importantes que van a actuar contra la plataforma. Cuando esta se encuentre en posición de mantenimiento o recolección, con las jaulas izadas en superficie los esfuerzos predominantes sobre las mismas provendrán de las olas y el viento superficial, mientras que con las jaulas sumergidas en situación de “producción”, las jaulas se verían afectadas eminentemente por las corrientes. No obstante no se deben despreciar otras fuerzas que, pese a ser pequeñas también han de ser tenidas en cuenta como por ejemplo la fuerza de los peces actuando contra las redes o el "*fouling*".

La obra muerta de la plataforma se verá invariablemente sometida a la acción de las olas y del viento superficial, mientras que la obra viva, al igual que las jaulas, se verá sometida a la acción de las corrientes marinas superficiales, el fouling y los esfuerzos debidos al sistema de fondeo.

Caracterización del oleaje.

Para establecer los parámetros más relevantes de la ola tipo se partirá de los datos históricos recabados del Instituto Español de Oceanografía y del servicio de Meteogalicia para dicha zona.

	Hs 50%	Hs 90%	Hs 99%	Hs12
Altura de ola, Hs (m)	2.08	4.07	7.02	9.93
Probabilidad de no ser superada	50.00%	90.00%	99.00%	99.86%

Tabla 8.Hs máxima en el punto SIMAO 1045074 (1958-2001) [Fuente: Proyecto ENERGYMARE - Xunta de Galicia]

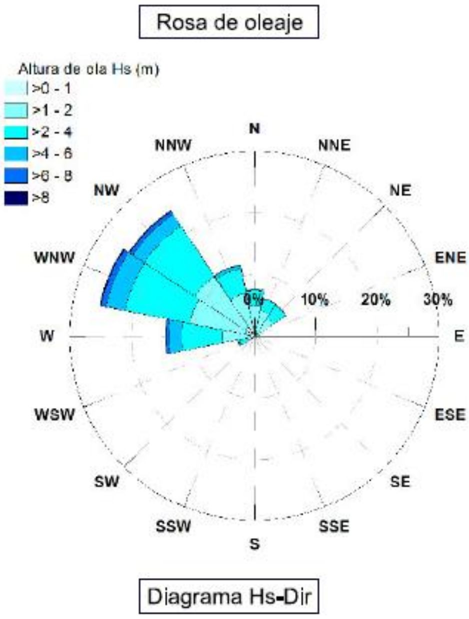


Ilustración 21. Rosa de Oleaje en el punto SIMAO 1045074 [Fuente: Proyecto ENERGYMARE - Xunta de Galicia]

De la rosa de oleaje se determina que la dirección predominante es Oeste-Noroeste (WNW) con una altura significativa de ola al alcanzar la boya (profundidad de 150 m) de 2 a 4 metros.

Punto SIMAR 1045074 1958 - 2016						
Mes	**Hs Max.**	**Tp**	**Dir**	**Año**	**Dia**	**Hora**
Enero	11,69	14,07	279	2009	24	3
Febrero	11,16	14,93	293	1989	26	0
Marzo	10,56	18,28	304	2014	3	14
Abril	7,69	12,5	326	1998	10	3
Mayo	8,27	13,33	290	1974	3	11
Junio	4,95	13,51	314	1959	7	14
Julio	7,04	12,66	308	1961	12	21
Agosto	5,53	10,38	269	2015	23	19
Septiembre	8,93	13,33	314	1991	29	5
Octubre	9,05	15,38	303	2003	31	19
Noviembre	9,8	13,51	311	2000	6	20
Diciembre	10,97	16,13	307	1982	13	9

Tabla 9. Datos Punto SIMAR 1045074.

En el periodo de 1958-2016 la altura significativa máxima fue de 11,69 m. Con los datos de dicho periodo se puede obtener la altura significativa[1] media, cuyo valor es de 8,803 m con una **Hs_{max} = 11,69 m** y un **periodo medio, Tp = 14 s**

A la hora de buscar información de la ubicación de la plataforma indicada en el RPA, sin embargo ha aparecido el inconveniente de que para esa zona no hay acceso disponible a ninguna de las boyas ni del instituto oceanográfico nacional ni de meteogalicia, datos que son necesarios, para poder calcular los efectos del medio sobre la estructura.

La boya más cercana de la cual se pueden recabar es la Boya de Langosteira II.

5.4. DISEÑO ESTRUCTURAL.

5.4.1. CALCULO FUERZAS SOBRE NUESTRA INSTALACIÓN.

5.4.1.1. OLEAJE.

ESTIMACIÓN DE OLEAJE DE VIENTO

Según la profundidad y el periodo de la ola se puede determinar si nos encontramos en una zona de aguas someras, intermedias o profundas de acuerdo al siguiente criterio:

[1] La altura significativa en un periodo determinado se define como la altura media del tercio mayor de todas las olas observadas en dicho periodo.

$$\frac{d}{L_0} > \frac{1}{2} \qquad \rightarrow \quad Aguas\ profundas \qquad (exp.1)$$

$$\frac{1}{20} < \frac{d}{L_0} < \frac{1}{2} \qquad \rightarrow \quad Aguas\ intermedias \qquad (exp.2)$$

$$\frac{d}{L_0} < \frac{1}{20} \qquad \rightarrow \quad Aguas\ poco\ profundas\ (Cnoidal) \qquad (exp.3)$$

Donde:

$$L_0 = \frac{g \cdot T^2}{2\pi} \qquad (exp.4)$$

Siendo:

g la aceleración de la gravedad en m/s^2, y

T el periodo medio en segundos.

Por lo tanto, sustituyendo en las expresiones anteriores el valor del periodo medio calculado, Tp = 14 s, y la profundidad de instalación, d = 100 m se clasificará la zona de instalación según el criterio antes descrito.

Para los parámetros establecidos, de la *exp.4* se obtiene:

$$L_0 = \frac{g \cdot T^2}{2\pi} = \frac{9{,}81 \cdot 14^2}{2\pi} = 306{,}017$$

y por lo tanto se verifica la *exp.3:*

$$\frac{d}{L_0} = \frac{100}{306{,}017} = 0{,}327 < \frac{1}{20} \qquad \rightarrow \quad Aguas\ intermedias$$

Al ser aguas intermedias puede utilizarse el método paramétrico simplificado de Bretschneider & Reid[2] (1953). Las expresiones utilizadas en el cálculo simplificado son las siguientes:

Para la ALTURA SIGNIFICATIVA:

[2] Reid, Robert O., and Charles L. Bretschneider. 1953. *Surface waves and offshore structures: the design wave in deep or shallow water, storm tide, and forces on vertical piles and large submerged objects : a technical report.* College Station, Tex: A. & M. College of Texas, Dept. of Oceanography.

$$H_S = 0{,}283 \cdot \frac{U_A^2}{g} \cdot \tanh\left[0{,}530 \cdot \left(\frac{g \cdot d}{U_A^2}\right)^{3/4}\right] \cdot \tanh\left[\frac{0{,}00565 \cdot \sqrt[2]{\frac{g \cdot L_F}{U_A^2}}}{\tanh\left[0{,}530 \cdot \left(\frac{g \cdot d}{U_A^2}\right)^{3/4}\right]}\right] \qquad (exp.5)$$

Para el PERIODO DE PICO:

$$T_p = 7{,}54 \cdot \frac{U_A}{g} \cdot \tanh\left[0{,}833 \cdot \left(\frac{g \cdot d}{U_A^2}\right)^{3/8}\right] \cdot \tanh\left[\frac{0{,}0379 \cdot \sqrt[3]{\frac{g \cdot L_F}{U_A^2}}}{\tanh\left[0{,}833 \cdot \left(\frac{g \cdot d}{U_A^2}\right)^{3/8}\right]}\right] \qquad (exp.6)$$

Para el TIEMPO MÍNIMO de acción del viento para que la altura de ola y su periodo alcancen la condición de equilibrio:

$$t_{min} = 5{,}37 \cdot 10^2 \cdot \left(\frac{g}{U_A}\right)^{4/3} \cdot T_p^{7/3} \qquad (exp.7)$$

Donde:

U_A es la velocidad del viento corregida para tener en cuenta la no-linealidad entre la velocidad del viento y el arrastre, en m/s. Su valor viene dado por la expresión

$$U_A = 0{,}71 \cdot \left(v_{V,h=10m}\right)^{1{,}23} \qquad (exp.8)$$

A su vez,

$v_{V,h=10\ m}$ es la velocidad del viento medida a 10 metros de altura durante 10 minutos sobre mar abierto ver Ilustración 22. En este caso, $v_{V,h=10\ m}$ = 7,5 m/s.

g es la aceleración de la gravedad en m/s^2.

d es la profundidad de la capa de agua en la zona elegida, en este caso 100 m.

H_S es la altura significativa de ola en metros.

T_p es el periodo de pico de la ola en segundos.

L_F es la longitud, en metros, del área de generación de oleaje, en la dirección del viento considerada. Tomamos L_F = 100.000 m (100 km) para evitar un régimen transitorio en las proximidades de la ubicación a estudiar.

Sustituyendo los valores ya conocidos en las expresiones anteriores tenemos los siguientes parámetros de la **OLA GENERADA POR EL VIENTO**:

H_S = 1,197 m.

T_p = 4,637 s.

$t_{min.}$ = 23.447 s (6,513 h).

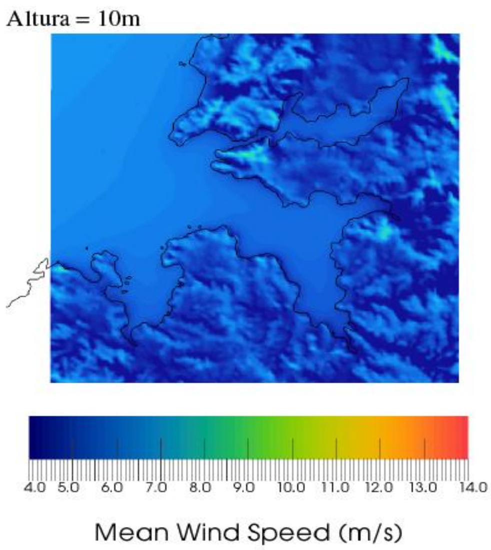


Ilustración 22. Velocidad media del viento a 10 m de altura. [Fuente: Proyecto ENERGYMARE - Xunta de Galicia]

EFECTO DE LAS OLAS SOBRE LA ESTRUCTURA.

En el caso de las jaulas, se considerará el efecto de las olas sobre la estructura superior, ya que una vez izadas hasta la superficie será esta parte la expuesta a las olas y al viento. La malla de red se considerará sometida a los efectos de las corrientes.

La propia plataforma, tal y como se ha indicado al comienzo de este estudio, se encontrará sometida a los efectos de las corrientes en su obra viva y al efecto de las olas y del viento en la obra muerta.

EFECTO DE LAS OLAS SOBRE LA ESTRUCTURA DE LAS JAULAS

Las fuerzas ejercidas sobre la estructura de las jaulas en la situación indicada, son generadas por la aceleración de las partículas de agua que impactan contra las partes sumergidas de la estructura y pueden calcularse utilizando el método propuesto por Beveridge[3]. En él se analizan las fuerzas debidas al oleaje cuando este no es rompiente, como el caso que ocupa este estudio. Es decir, se desprecia la fuerza potencial y se considera que toda la fuerza proviene de la energía cinética de la ola.

La expresión de la fuerza bajo estos supuestos es la siguiente:

$$F_0 = k \cdot \rho \cdot A \cdot u^2 \qquad (exp.9)$$

Donde:

k es un coeficiente adimensional[3], similar a C_D (coeficiente de arrastre) para mallas y redes, cuyo valor depende de la naturaleza del flotador (material, forma, construcción, etc.) y de las características del oleaje. Desafortunadamente k debe ser determinado empíricamente ya que no se haya tabulado ni existe ninguna expresión matemática que permita su cálculo. Como es similar a C_D el cual es función del número de Reynolds y este toma un valor de orden de 0,44 para zonas en régimen de Newton (1000<*Re*) se estimará dicho valor para el coeficiente *k*.

ρ es la densidad del agua de mar, tomada como 1.025 kg/m^3.

A es el área transversal a la dirección de la ola considerada, expresada en m^2.

u es la velocidad orbital horizontal de las partículas de agua, expresada en m/s.

De todos estos parámetros, la velocidad *u* deberá ser calculada a partir de la altura de la ola, su periodo, la profundidad de la ubicación considerada, y mediante la aplicación del Teorema de Stokes para olas de amplitud finita. Como altura de ola se tomará la altura máxima registrada en el periodo estudiado (1958 – 2016).

$$H_{max} = 11{,}69\ m$$

La velocidad se obtiene de la ecuación:

$$u = \pi \cdot H \left[\frac{cosh\left(\frac{2 \cdot \pi(z+h)}{\lambda}\right)}{T \cdot senh\left(\frac{2\pi \cdot h}{\lambda}\right)} \right] cos\theta \qquad (exp.10)$$

[3] Beveridge, Malcom, C. M. 2004. *Cage Aquaculture.* Blackwell Publishing Ltd., ISBN 1-4051-0842-8.

Donde:

H es la altura de la ola en metros.

T es el periodo de la ola en segundos.

z es la variación de la altura respecto al nivel del agua en metros.

λ es la longitud de la onda de la ola en metros.

h es la profundidad del emplazamiento.

θ es el ángulo de incidencia del tren de las olas sobre la estructura.

Se debe de cumplir la siguiente relación:

$$0{,}04 < \frac{h}{\lambda} < 0{,}5 \qquad (exp.\,11)$$

para poder calcular la velocidad orbital horizontal de la velocidad, la cual, para las localizaciones aptas para el cultivo marino, raramente supera los 2 m/s según Milne[4].

CÁLCULO DE LA FUERZA QUE EJERCE EL OLEAJE.

Se obtendrá la fuerza debida al oleaje como,

$$F_{o=}k \cdot \rho \cdot A \cdot u^2 \qquad (exp.\,12)$$

Se estudiará el área correspondiente a la superficie de la sección de fibra de vidrio perpendicular al tren de las olas, supondremos esta superficie totalmente emergida, y la jaula sin peso, teniendo así el caso más desfavorable posible. Se toma el diámetro perpendicular a la acción de las olas y no la longitud desarrollada de la mitad de la circunferencia de la pasarela para considerar así la variación del ángulo de incidencia de las olas contra la estructura.

$$A = D_{ext} \cdot D_{plataforma\ \ fibra\ \ vidrio} = 22{,}40m \cdot 0{,}50m = 11{,}20\ m^2.$$

Como se ha visto, para obtener la velocidad horizontal de las partículas de agua, u, deberá calcularse previamente la longitud de onda, aplicando la ecuación general para aguas someras e intermedias.

[4] Milne, Bob. Feb. 2009. "*The Selection of Sites for Aquaculture*". Article n Journal of the World Aquaculture Society 6(1-4):377 - 388

$$\left.\begin{array}{r} c^2 = \frac{g}{k} \cdot tgh(k \cdot h) \\ k = \frac{2\pi}{\lambda} \end{array}\right\} c^2 = \frac{g}{k} \cdot tgh\left(\frac{2\pi \cdot h}{\lambda}\right) \\ c = \frac{\lambda}{T} \qquad \lambda = \frac{g \cdot T^2}{2\pi} \cdot tgh\left(\frac{h \cdot 2\pi}{\lambda}\right) \quad (exp.13)$$

Aplicando el método de Newton-Raphson mediante el MatLab, se obtiene el valor de la longitud de ola para el periodo *Tp* = 14 s y la profundidad del emplazamiento, *h* = 100 m. Nótese que para el valor obtenido de $\lambda = 297{,}22\ m$ se verifica la condición

$$0{,}04 < \frac{h}{\lambda} = 0{,}336 < 0{,}5 \qquad (exp.14)$$

Y por lo tanto, utilizando la *exp.10*, la velocidad orbital horizontal de las partículas de agua será:

$$u = \pi \cdot H \left[\frac{cosh\left(\frac{2 \cdot \pi(z+h)}{\lambda}\right)}{T \cdot senh\left(\frac{2\pi \cdot h}{\lambda}\right)}\right] cos\theta = \pi \cdot 11{,}69 \cdot \left[\frac{\cosh\left(\frac{2\pi(z+100)}{297{,}22}\right)}{14 \cdot \sinh(\frac{2\pi \cdot 100}{297{,}22})}\right] \cos \pi/4$$

u = 1,974 m/s

Sustituyendo los valores calculados en la exp.12

$$F_{o=}k \cdot \rho \cdot A \cdot u^2 = 0{,}44 \cdot 1.025 \frac{kg}{m^3} \cdot 11{,}2m^2 \cdot 1{,}974^2 \frac{m^2}{s^2} = 19.683N$$

F_o = 19.683 N

5.4.1.2. VIENTO.

CARACTERIZACIÓN DEL VIENTO.

Al igual que para el cálculo de los parámetros del oleaje inducido por el viento (*fetching*) se toman los datos del proyecto ENERGYMARE de la Xunta de Galicia para la zona del emplazamiento. Según estos datos, incluidos en el anexo correspondiente, la velocidad. Se recogerán los datos donde se muestran los vientos que predominan en la zona de trabajo de la plataforma, los vientos predominantes, y lo valores de la velocidad del viento en cada mes del año, y su frecuencia.

Boya de Langosteira 2013 - 2016					
Mes	**Vm Max**	**Dir**	**Año**	**Dia**	**Hora**
Mayo	12.8	18	2015	28	18
Junio	15.9	35	2015	17	18
Julio	12.6	26	2015	15	13
Agosto	14.5	187	2015	23	11
Septiembre	15.4	227	2015	16	7
Octubre	13.4	199	2015	28	21
Noviembre	13.1	251	2015	21	0
Diciembre	14.8	202	2015	19	15

Tabla 10. Datos Boya Langosteira.

La velocidad máxima del viento durante el periodo de 2.013 a 2.016 medido en la boya de Langosteira II fue de 15,9 m/s en la dirección de 35˚, es decir NNE-NE. En general, la dirección predominante de los vientos en la zona es de 22,5˚ (NE).

ANÁLISIS DE LA ACCIÓN DEL VIENTO SOBRE LA ESTRUCTURA.

Se tomará como dato de partida, el valor del viento máximo de la caracterización media registrada en la dirección más desfavorable debido a la acción del viento. También se tomarán los coeficientes de seguridad.

El valor máximo de la velocidad del viento en el emplazamiento es de 15,9 m/s y deberá ser corregido para tener en cuenta la altura, la topografía, la rugosidad superficial y el efecto ráfaga. Los factores de corrección a aplicar son los siguientes:

F_A, factor de altura y de rugosidad superficial (tabla 2.1.4.1.2 de la ROM 0.4-95).

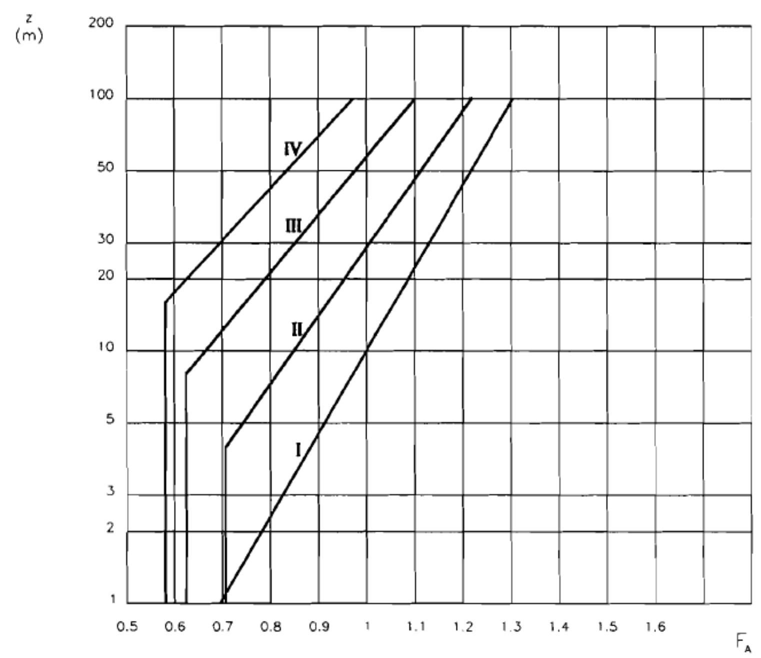
F_T, factor topográfico (apartado 2.1.4.2, tabla 2.1.4.2.1 de la ROM 0.4-95).

F_R, factor de ráfaga (tabla 2.1.4.3.1 de la ROM 0.4-95). La duración de ráfaga se determina según la tabla 3.2.1.2.1 de la ROM 0.4-95 para cada caso específico, en función del elemento a diseñar.

Factor de Altura y Rugosidad Superficial (F_A). Para velocidades básicas[5] de viento mayores de 15 m/s, F_A es creciente con la altura y decreciente con la rugosidad superficial. De los 4 estados mostrados en la gráfica de la Ilustración 23, el que afecta a la zona de emplazamiento es el Estado I, mar abierto y a una altura máxima de 1,2 metros para las jaulas (20 metros para la superestructura de la spar). De la Ilustración 23 el factor aplicable es de F_A = 0,74 para una altura de 1,6 m, que es lo que las jaulas salen por encima de la superficie de la mar.

[5] Velocidad básica es la velocidad media medida durante 10 minutos a 10 metros de altura en el lugar a caracterizar.

TABLA 2.1.4.1.2. FACTOR DE ALTURA Y DE RUGOSIDAD SUPERFICIAL *(F_A)*



NOTAS:

z: Altura efectiva sobre la superficie en las proximidades del punto considerado. El nivel cero efectivo se considerará aproximadamente coincidente con el nivel medio para el cual el volumen de obstáculos por encima del mismo es igual al volumen de huecos por debajo del mismo. *(Ver tabla 2.1.4.1.1).*
En mar abierto y zonas costeras llanas sin obstáculos se considerará como nivel cero efectivo el nivel medio del mar.

Ilustración 23. Factor de Altura y Rugosidad.

Factor Topográfico (F_T). No es de aplicación, ya que el viento viene de mar abierto donde no hay ninguna orografía que modifique su perfil de velocidades. Se toma de valor la unidad.

Factor de Ráfaga (F_R). Depende del tipo de estructura y de su altura. En el caso de las jaulas emergidas, se trata de una estructura de menos de 3 metros de altura, para la cual se recomienda estudiar una ráfaga de 15 segundos de duración por ser un valor próximo al periodo de ola y por lo tanto la situación más desfavorable. Esto equivale a un F_R = 1,45 según la gráfica de la Ilustración 24.

TABLA 2.1.4.3.1. FACTOR DE RAFAGA MAXIMA (F_R)

	CATEGORIA DE RUGOSIDAD SUPERFICIAL															
	I				II				III				IV			
z (m) \ DURACION	3s	5s	15s	1min	3s	5s	15s	1min	3s	5s	15s	1min	3s	5s	15s	1min
3	1.52	1.50	1.45	1.37	1.76	1.73	1.65	1.54	1.98	1.94	1.84	1.69	2.24	2.18	2.06	1.87
5	1.48	1.46	1.41	1.34	1.73	1.70	1.62	1.51	1.98	1.94	1.84	1.69	2.24	2.18	2.06	1.87
10	1.44	1.42	1.38	1.31	1.63	1.60	1.54	1.44	1.96	1.91	1.82	1.67	2.24	2.18	2.06	1.87
15	1.42	1.40	1.36	1.29	1.59	1.56	1.50	1.41	1.86	1.82	1.73	1.60	2.24	2.18	2.06	1.87
20	1.40	1.38	1.34	1.28	1.56	1.53	1.48	1.39	1.80	1.76	1.68	1.56	2.12	2.07	1.96	1.79
30	1.38	1.37	1.33	1.27	1.52	1.50	1.45	1.37	1.73	1.70	1.62	1.51	1.99	1.94	1.84	1.69
40	1.37	1.36	1.32	1.26	1.50	1.48	1.43	1.35	1.68	1.65	1.58	1.48	1.91	1.87	1.78	1.64
50	1.36	1.35	1.31	1.25	1.48	1.46	1.41	1.34	1.65	1.63	1.56	1.46	1.86	1.82	1.73	1.60
60	1.36	1.34	1.30	1.25	1.47	1.45	1.40	1.33	1.63	1.60	1.54	1.44	1.82	1.78	1.70	1.57
80	1.35	1.33	1.29	1.24	1.45	1.43	1.39	1.32	1.60	1.57	1.51	1.42	1.76	1.73	1.65	1.54
100	1.34	1.32	1.29	1.24	1.44	1.42	1.38	1.31	1.58	1.55	1.49	1.40	1.73	1.70	1.62	1.51

Ilustración 24. Factor de Ráfaga Máxima.

Se obtendrá el valor de la velocidad aplicando las correcciones mencionadas como

$$V_{max} = F_R \cdot F_T \cdot F_A \cdot V_B \qquad (exp. 15)$$

Y sustituyendo el valor de la velocidad (7,5 m/s) y de los factores determinados mediante la ROM 0.4-95 se obtiene la velocidad máxima

V_{max} = 8,047 m/s

CÁLCULO DE LA FUERZA DEL VIENTO.

Conocida la velocidad máxima del viento, se calculará la fuerza que soportará la instalación debido a este fenómeno. La fuerza se descompone en dos términos:

- Partes sólidas (barandilla, soportes, etc…)
- Parte de red emergida.

$$F_v = F_s + F_{red} \qquad (exp. 16)$$

Se calculará primero **la fuerza ejercida sobre la parte sólida** mediante la siguiente ecuación:

$$F_s = 0,5 \cdot C_s \cdot C_h \cdot \rho \cdot V_{max}^2 \cdot A \qquad (exp. 16a)$$

Donde:

F_s es la fuerza del viento en Newton.

C_s es el coeficiente de forma, en instalaciones de tipo cilíndrico tiene un valor de 0,5.

C_h es el coeficiente de altura, que para instalaciones entre (0-15,3)m de altura tiene un valor de 1.

ρ es la densidad aire, tomada como 1,222 kg/m^3.

V_{max} es velocidad del viento en m/s a 10 metros de altura.

A es el área proyectada de la superficie en m^2 e incluye la plataforma de fibra de vidrio, con la barandilla y sus soportes.

$$A = D_{plataforma} \cdot D_{ext.jaula} + D_{barandilla} \cdot D_{jaula} + D_{soporte} \cdot h_{soporte} \cdot nº\ de\ soportes$$

$$A = 0{,}5m \cdot 22{,}4m + 0{,}092m \cdot 20m + 0{,}080m \cdot 1{,}1m \cdot 18 = 14{,}624m^2$$

Se sustituye el valor calculado en la ecuación anterior en la (*exp.16a*):

$$F_s = 0{,}5 \cdot C_s \cdot C_h \cdot \rho \cdot V_{max}^2 \cdot A = 0{,}5 \cdot 0{,}5 \cdot 1 \cdot 1{,}222 \frac{kg}{m^3} \cdot 8{,}047^2 \frac{m^2}{s^2} \cdot 14{,}624m^2 = 289{,}298N$$

En segundo lugar calcularemos la **fuerza que ejerce el viento sobre la red**, mediante la siguiente ecuación:

$$F_{red} = 0{,}5 \cdot \rho \cdot k \cdot V^2 \cdot A' \qquad (exp.16b)$$

Donde:

k es el coeficiente de resistencia o arrastre.

ρ es la densidad aire, tomada como 1,222 kg/m^3.

V es la velocidad máxima del viento en m/s.

A' es la superficie de la red que se opone al viento.

El valor de *k* lo obtendremos de la siguiente expresión:

$$k = 0{,}5 \cdot \left[1 - \left(\frac{d}{l}\right)^2\right] \qquad (exp.17)$$

Donde:

d es el diámetro de malla de la red.

l es la luz de la malla de red.

Se tomará el valor de la malla más tupida, ya que al ser la que opone mayor resistencia proporcionará el valor máximo y por lo tanto el más desfavorable.

$$k = 0{,}5 \cdot \left[1 - \left(\frac{d}{l}\right)^2\right] = 0{,}5 \cdot \left[1 - \left(\frac{1{,}5}{10}\right)^2\right] = 0{,}4887$$

Calcularemos el área de la red, en la superficie del agua.

$$A' = 1{,}1m \cdot 20m = 22m^2$$

Se calculará con estos datos la fuerza ejercida sobre la red (*exp.16b*):

$$F_{red} = 0{,}5 \cdot \rho \cdot k \cdot V^2 \cdot A' = 0{,}5 \cdot 1{,}222 \frac{kg}{m^3} \cdot 0{,}4887 \cdot 8{,}047^2 \left(\frac{m}{s}\right)^2 \cdot 22m^2 = 425{,}377\ N.$$

Se calculará la fuerza ejercida por el viento, mediante los resultados obtenidos.

$$F_v = F_s + F_{red} = 289{,}298 + 425{,}377$$

***Fv* = 714,675 N**

5.4.1.3. CORRIENTES.

CARACTERIZACIÓN DE LAS CORRIENTES.

Las mayores fuerzas que se originan sobre nuestra estructura serán las fuerzas de las corrientes.

Para obtener la corriente local, tendremos que tener en cuenta varios componentes como son la marea, efectos locales y viento. Se sabe que la corriente generalmente, disminuye con la velocidad.

Los parámetros más importantes de las corrientes, velocidad o intensidad y dirección, se han obtenido de Puertos del Estado.

Nótese sin embargo que al igual que para las olas se ha considerado el periodo máximo del que existen registros (1958 – 2016), también se ha tomado para las corrientes y vientos, aunque los periodos de los cuales se disponen de registro en estos casos no son coincidentes. Para los valores de viento el periodo del que existe información en Puertos del Estado, es tan solo desde 2013 a 2016 mientras que para las corrientes es desde 1998 a 2016. Asimismo debe señalarse que los datos de las corrientes recogidos por la boya de Langosteira II no están disponibles por lo que se considerarán los registrados por la boya de cabo Vilano-Sisargas, que por proximidad y al no tener accidentes orográficos entre las mismas, tales como islotes o costas próximas, podrán ser considerados como equivalentes a efectos del cálculo.

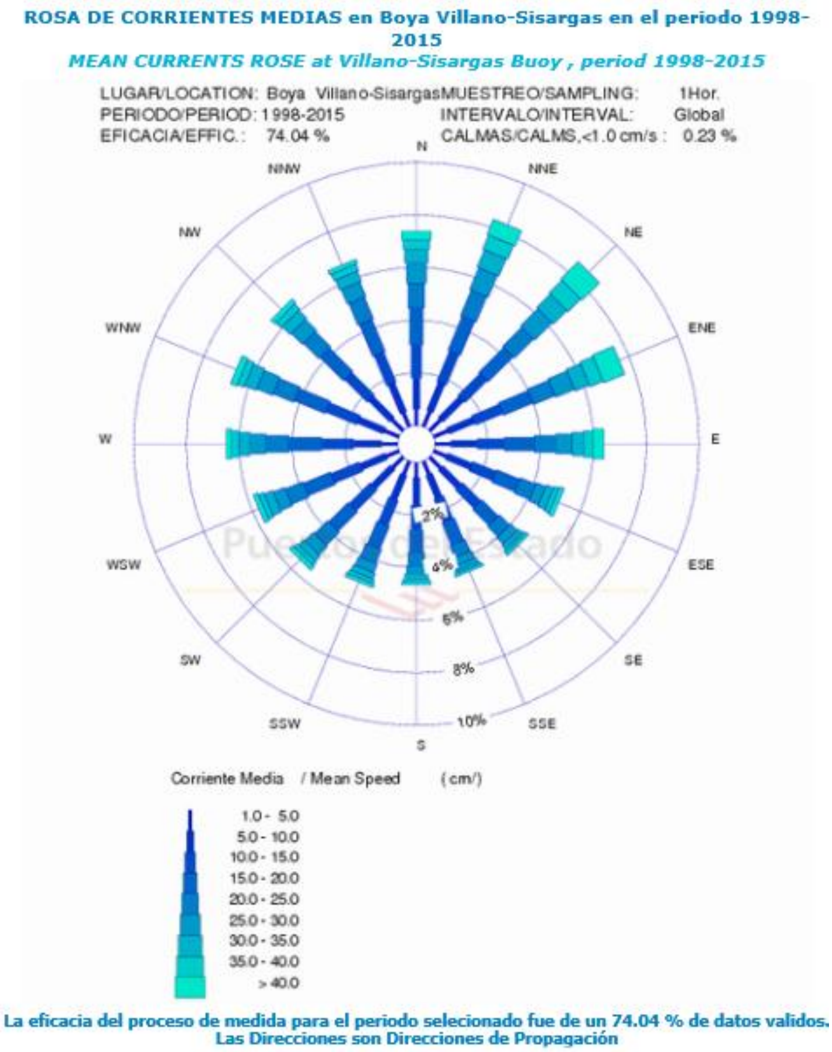


Ilustración 25. Rosa de Corrientes. Boya Vilano-Sisargas.

Co:	U media				cm/s
Dir:	Direccion media de propagación				0= Norte; 90= Este
Boya de Villano-Sisargas 1998 - 2016					
Mes	Co Max.	Dir	Año	Dia	Hora
Enero	80.8	115	2011	7	4
Febrero	82.0	231	2004	6	3
Marzo	124.2	98	2005	12	14
Abril	79.6	75	2013	11	16
Mayo	62.1	39	2006	15	18
Junio	69.1	25	2009	9	19
Julio	62.1	217	2002	26	10
Agosto	94.9	61	2013	8	10

Co:	U media				cm/s
Dir:	Direccion media de propagación				0= Norte; 90= Este
Boya de Villano-Sisargas 1998 - 2016					
Mes	Co Max.	Dir	Año	Dia	Hora
Septiembre	83.2	50	2014	10	16
Octubre	100.7	39	2015	29	15
Noviembre	72.6	25	2011	13	14
Diciembre	73.4	39	2003	25	17

Tabla 11. Datos Boya Villano-Sisargas.

CÁLCULO DE LA FUERZA DE LA CORRIENTE.

Se puede aceptar que las fuerzas de las corrientes que actúan sobre las estructuras flotantes, sumergidas son únicamente horizontales. Para calcular su valor, se tendrá en cuenta el fouling existente en la red, y el material de la misma.

La fuerza de la corriente responde a la siguiente expresión:

$$F_c = 0{,}5 \cdot \rho \cdot C_d \cdot A \cdot U^2 \qquad (exp. 18)$$

Donde:

F_c es la fuerza de la corriente sobre las jaulas, en Newton.

C_d es el coeficiente de carga del material.

ρ es la densidad de agua de mar, tomada como 1.025 kg/m^3.

U es le velocidad de la corriente en m/s.

A es el área total de presión, en m^2.

Se estimará para el coeficiente de carga de material, aquel que corresponda a la malla más tupida, que será la que oponga mayor resistencia al paso de la corriente. El valor de este coeficiente (que es adimensional), depende de la naturaleza de la red, y lo determinaremos empíricamente, mediante la siguiente expresión:

$$C_d = 3{,}12 \cdot \left(\frac{d}{l}\right)^2 + 2{,}73 \cdot \left(\frac{d}{l}\right) + 1 \qquad (exp. 19)$$

Donde:

d es el diámetro de malla de la red.

l es la luz de la malla de red.

C_d es el coeficiente de carga del material.

Se sustituyen los valores en la (*exp.19*) obteniendo el valor del coeficiente buscado:

$$C_d = 3{,}12 \cdot \left(\frac{1{,}5}{10}\right)^2 + 2{,}73 \cdot \left(\frac{1{,}5}{10}\right) + 1 = 1{,}4797$$

Se ha de considerar en el área de la red, que un 50% de la misma debido al fouling, no serán huecos. A partir de la siguiente expresión calcularemos las áreas:

$$A_T = \pi \cdot D \cdot h = \pi \cdot 20m \cdot 10m = 628{,}319\ m^2$$

$$A = 0{,}50 \cdot A_T = 0{,}50 \cdot 628{,}319 m^2 = 314{,}159\ m^2$$

Se calculará la fuerza de la corriente, para ello hemos de dividir la que actúa sobre la parte delantera, y la que actúa sobre la parte trasera. Se parte del dato de que en la parte trasera de la red, la velocidad de la corriente debido al efecto de la biomasa será de un 70%, $U_2 = 0{,}7 \cdot U_1$.

U_1, *dato obtenido de* Tabla 11*, 124,2cm/s, 1,24 m/s.*

Sustituyendo los valores anteriores en la (*exp.20*), obtendremos la fuerza de la corriente:

$$F_c = 0{,}5 \cdot \rho \cdot C_d \cdot \frac{A}{2} \cdot (U_1^2 + U_2^2) \qquad (exp.20)$$

$$F_c = 0{,}5 \cdot 1.025 \frac{kg}{m^3} \cdot 1{,}4797 \cdot \frac{314{,}159}{2} \cdot (1{,}24^2 + (1{,}24 \cdot 0{,}70)^2) \left(\frac{m}{s}\right)^2$$

F_C = 272.908 N

Hipótesis de carga.

Es un paso importante para el correcto dimensionamiento de la instalación, en estas hipótesis se considerará la actuación de múltiples cargas: tanto en intensidad, como en dirección de la actuación, combinación de las mismas.

De carga estática.

Se considera la más desfavorable de las cargas fijas y operacionales. No se consideran las cargas ambientales.

Se considerá el peso de la jaula, el peso debido al fouling…, son cargas que actúan en sentido vertical, perpendicular a la superficie del agua.

Las cargas operacionales son las constituidas por el trabajo eventual de los operarios.

De carga de diseño.

Se considera la peor combinación de las cargas siguientes:

- Cargas fijas.
- Cargas operacionales.
- Cargas ambientales más extremas.

Las cargas ambientales, son las tensiones de las líneas de fondeo.

Las cargas fijas y operacionales producen los efectos anteriormente citados.

De cargas accidentales.

Se considera la carga de la combinación de cargas fijas y operacionales, asociándolas a las cargas medioambientales, todo ello en el periodo de un mes. A estas cargas se le sumaran el efecto de un posible impacto de un buque.

De construcción.

Es la más peligrosa y exigente en la mayoría de las estructuras off-shore, debido a que es donde sufre mayores solicitaciones al encontrarse fuera del agua.

5.4.1.4. FUERZAS QUE ACTÚAN SOBRE LAS JAULAS.

Las fuerzas que actuarán sobre la estructura, serán de naturaleza estática y dinámica, se asumirá que la suma de todas las cargas parciales, será la carga final. Estas cargas serán debidas a:

- Presión hidrostática.
- Fuerzas estáticas.
- Fuerzas dinámicas.

Se calcularán solamente para una jaula, al ser todas las jaulas iguales.

LA PRESIÓN HIDROSTÁTICA.

No se tendrá en consideración está fuerza con las jaulas emergidas, debido a que comparada con las fuerzas estáticas y dinámicas es inapreciable. Esta fuerza afecta a todos los elementos que estén sumergidos.

El valor de la presión hidrostática, se calcula mediante la siguiente expresión:

$$F_H = \rho \cdot g \cdot h \qquad (exp. 21)$$

Donde:

ρ es la densidad de agua de mar, tomada como 1.025 kg/m^3.

g es la aceleración de la gravedad en m/s^2.

h es la profundidad desde la cresta de la ola en metros.

LAS FUERZAS ESTÁTICAS

Son fuerzas que actúan verticalmente, se producen por los pesos de estructura, redes, fouling, cargas adicionales, peso de los peces…

Se estimará el cálculo para las condiciones más desfavorables.

Se calcularán las fuerzas estáticas mediante la siguiente expresión:

$$F_E = P_R + P_{A.F.} + P_{A.C.} + P_E + P_P \qquad (exp. 21)$$

Donde:

P_R es el peso de la red, con los cabos y el fouling en kg.

$P_{A.F.}$ es el peso del antifouling en kg.

$P_{A.C.}$ es el peso del tubo anticorriente[6] en kg.

P_E es el peso de la estructura en kg.

P_P es el peso de de los peces apoyándose sobre la red en kg.

Se detallarán los cálculos de los sumandos de la ecuación anterior:

PESO DE LAS REDES.

Se usará una red de luz 10mm, y diámetro 2,3mm, con tratamiento antifouling, la cual se adapta al engorde de la dorada, que es la finalidad de nuestras jaulas.

Se calcula el área y el peso de la red por unidad de jaula.

Área	Área (m^2)	Peso (gr/cm3)	Peso Red (kg)
Lateral	628,32	286	179,7
Fondo	315,726	286	90,3
Techo	314,16	283	89,85
Total	1258,21		359,85

Tabla 12. Peso de la Red por Jaula.

PESO DE LAS INCRUSTACIONES.

El peso de las incrustaciones supone un incremento de peso de 1,2 a 2 veces al peso de la red.

El valor será más alto en aquellas zonas de aguas cálidas (Mediterráneo, Estrecho…), y serán más bajas en aguas más frías (Noroeste de España, Atlántico Norte…).

[6] El factor $P_{A.C.}$ peso del tubo anticorriente, únicamente se utiliza en jaulas flotantes sin estructura rígida de soporte. En el proyecto actual, la jaula estará montada sobre un bastidor de perfil de acero grado A por lo que no necesitará de dicho tubo.

Tomaremos un factor de 1,5.

$$P_I = 1{,}5 \cdot Peso\ red = 1{,}5 \cdot 359{,}85\ kg = 539{,}775\ kg \quad (exp. 22)$$

PESO DEL RECUBRIMIENTO ANTIFOULING (ANTI-INCRUSTANTE).

Conocidas las dimensiones de la malla, calculamos el área efectiva sobre la que aplicar el recubrimiento. No se puede considerar el área bruta de la jaula ya que no sería real al no considerar entonces la luz de la red.

A continuación se detalla el cálculo para la red lateral de la jaula, a partir del cual se obtendrán las áreas y pesos correspondientes al fondo y al techo de la misma.

Cada lado de una celda de la red se considerará como un cilindro de diámetro de 2,3mm. Su área lateral a ser recubierta por el antifouling se calcula entonces como:

$$a = \pi \cdot \phi \cdot h = \pi \cdot 3{,}2 \cdot 6 = 43{,}354\ mm^2\ (exp. 23)$$

El área total por celda será el área de sus cuatro lados:

$$a_t = 4 \cdot 43{,}354 = 173{,}416\ mm^2\ (exp. 24)$$

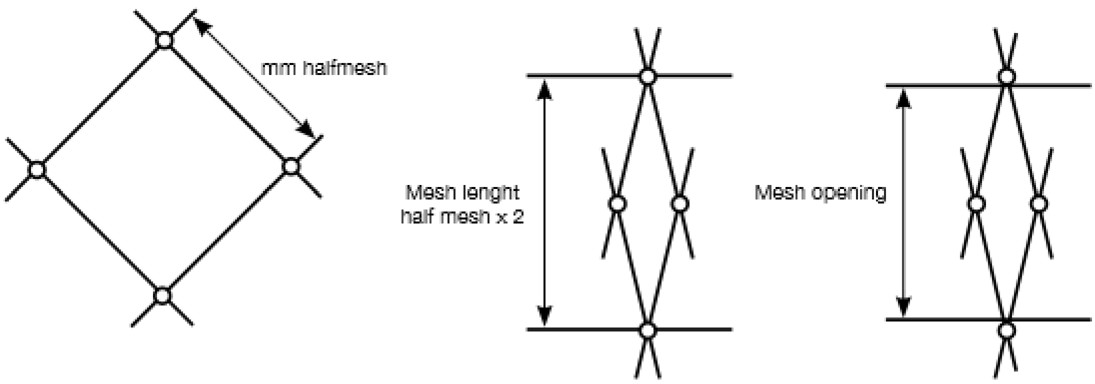


Ilustración 26. Forma de Medir una Celda según ISO 1107-1974.

Para una luz (mesh opening) de 10 mm corresponde un lado de malla (half mesh) aproximadamente de 6 mm y un diámetro de hilo de 2,3 mm según los datos del fabricante MORENOT®. La altura de la red en su estado regular (ver figura izquierda de la Ilustración 26) para un lado de 6 mm. es de 8,48 mm.

Para una columna de ancho una celda y altura la del paño de la red, es decir, 10 metros (10.000 mm), tendremos $10.000\ mm/8{,}48\ mm/celda =\ 1179$ celdas en altura.

Conocida el área de una celda según la *exp.24* el área por columna de celdas será:

$$1.179\ celdas \cdot 173{,}416\ mm^2 = 204.457\ mm^2 = (0{,}2045\ m^2)\ \ (exp.25)$$

Un diámetro de 20 m de la jaula supone una longitud de circunferencia de 62,832 metros (62.832 mm) y por lo tanto 7.409 columnas de ancho 8,48mm.

El área bruta de la red se calcula como el número total de columnas por el área por columna, es decir:

$$7.409\ celdas \cdot 0{,}2045\ m^2 = 1.515{,}14\ m^2\ \ (exp.26)$$

Sin embargo, llegados a esta punto cabe recordar que cada celda es adyacente a la siguiente y a la anterior, por lo que comparten hilos. Para eliminar este efecto se divide el área bruta por 2 obteniéndose así el área neta de la red según la *exp.27*

$$Área\ neta = Área\ bruta/2 = 1.515{,}14/2 = 757{,}57m^2\ \ (exp.27)$$

Peso del anti-fouling del cilindro:

Se ha considerado un antifouling ligero acrílico y de bajo impacto ambiental con una densidad de 0,45 kg/m^2. Considerando el área neta de la red lateral el peso del antifouling en la misma es de:

$$Peso = A_{NETA} \cdot 0{,}45 = 757{,}57 \cdot 0{,}45 = 340{,}901\ kg\ \ (exp.28)$$

Con estos datos calcularemos el peso de antifouling por kilo de red.

Área lateral (m^2)	628,32	1
Peso Anti-Fouling (kg)	340,901	**0,543**

Tabla 13. Antifouling por metro cuadrado de red.

Área	Área (m^2)	Peso (m^2/kg)	Peso A.F. (kg)
Lateral	628,32	0,543	340,901
Fondo	315,726	0,543	171,300
Techo	314,16	0,543	170,450
Total	1258,21	--	**682,651**

Tabla 14. Peso del antifouling por jaula.

Peso total del antifouling:

$$Peso_{A.F.} = Peso_{CILINDRO} + Peso_{FONDO} + Peso_{TAPA}\ \ \ (exp.28)$$

$$Peso_{A.F.} = 682{,}651\ kg$$

$$Peso_{TOTAL} = Peso\ _{RED} + Peso\ _{INCRUSTACIONES} + Peso_{A.F.}\ \ (exp.29)$$

$$Peso_{TOTAL} = 359{,}850 + 539{,}775 + 682{,}651 = 1.582{,}280\ kg\ (exp.30)$$

PESO DE LAS CARGAS ADICIONALES.

Se estima el peso de 2 operarios de unos 75kg cada uno y un peso de equipos de unos 90kg.

$$P_C = 2 \cdot 75 + 90 = 240kg\ (exp.31)$$

PESO DE LA ESTRUCTURA DE LA JAULA.

Para calcular la estructura de la jaula se tendrá en cuenta la situación de carga más demandante. En operación normal la jaula se encuentra sumergida, bien sea a 40 metros de profundidad bien con el borde superior a flor de agua. En ambos casos el peso total se ve minorado por el empuje que tanto la red como las posibles incrustaciones y el anti-incrustante suponen, además del propio empuje de la estructura a calcular. Por lo tanto como situación más demandante de carga se tomará aquella en la cual las jaulas se encuentran completamente emergidas, que se corresponderá con los periodos de instalación, desmontaje y periodos intermedios de mantenimiento como pueden ser el cambio de las redes, reparaciones del esquema de pintado etc.

Para esta situación, por lo tanto, el peso considerado será el de la red con anti-incrustante fuera del agua más el de las incrustaciones tal y como se ha obtenido en los puntos anteriores. El peso total a considerar es de 1.582,280 kg (15,517 kN) al que habrá que sumar el peso propio de los perfiles de acero utilizados para la estructura de la jaula.

Para repartir el peso calculado se ha supuesto que la red cuelga del anillo superior y apoya tanto en el central como en el anillo inferior, repartiendo el peso entre estos pudiéndose asimilar a dos paños que cuelgan del anillo superior e intermedio y que apoyan en el inmediatamente inferior. Entonces, el anillo superior y el inferior asumirán ¼ de la carga indicada y el intermedio, por ser este apoyo y soporte a la vez, ½ de la aquella. Ver Tabla 15 e Ilustración 27.

Anillo	Carga total (kN)	Longitud (m)	Carga uniforme (kN/m)
Superior	3,879	62,832	0,062
Medio	7,759	62,832	0,124
Inferior	3,879	62,832	0,062
Total	**15,517**	--	**0,248**

Tabla 15. Reparto de las Cargas en los Anillos de la Jaula.

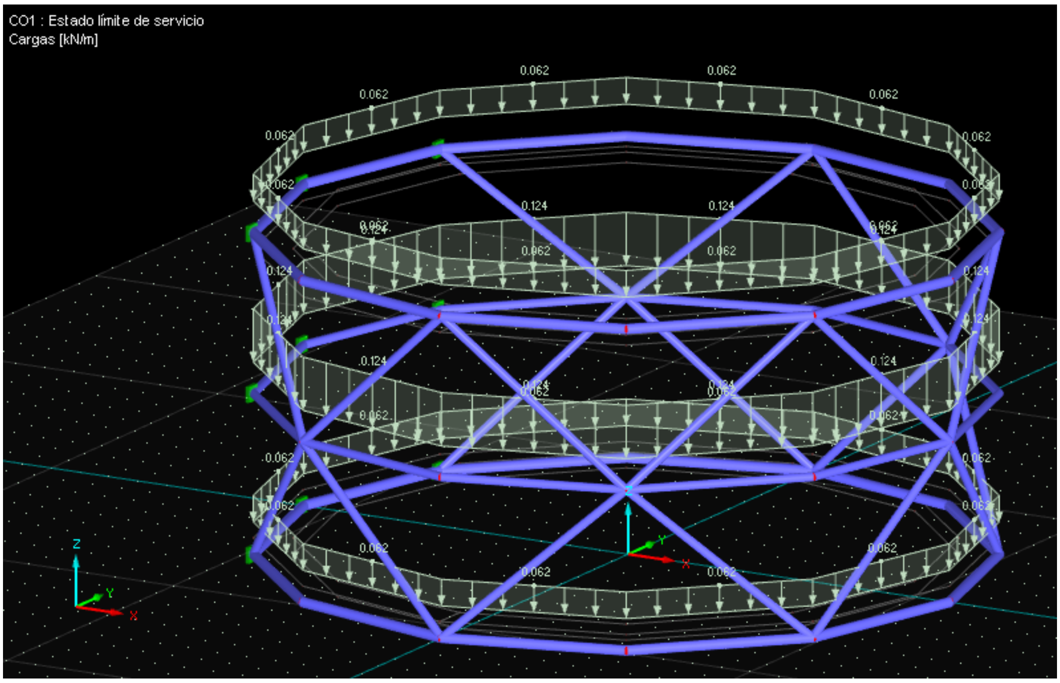


Ilustración 27. Cargas Aplicadas sobre la Estructura de la Jaula.

Los nodos correspondientes a la unión de cada jaula con los anillos deslizantes que permitirán su desplazamiento a lo largo de la spar, se modelan como empotramientos ya que esta unión no tendrá grado alguno de libertad. Las reacciones sobre estos apoyos serán posteriormente dato de entrada para el cálculo de la estructura deslizante citada.

FUERZA EJERCIDA POR LOS PECES APOYÁNDOSE SOBRE LA RED.

Se estimará un incremento de peso de un 2% de los peces soportados por la red en el fondo, debido a situaciones de estrés en los animales. Para realizar el cálculo se tomará la mayor carga de biomasa estimada.

$$F_P = \frac{233{,}2}{4}\ tn \cdot 0{,}02 = 1{,}166\ tn = 1.166\ kg$$

El valor de las Fuerzas estáticas será la suma de los componentes anteriores.

$$F_E = P_R + P_F + P_{A.F.} + P_E + P_C + F_P =$$

$$F_E = 359{,}850 + 539{,}775 + 1582{,}280 + 12.831{,}800 + 240 + 1.166 = 16.720 kg$$

FUERZAS DINÁMICAS.

El cálculo de las fuerzas dinámicas se estimará siempre para las condiciones más desfavorables, y su valor se determina por la siguiente expresión.

$$F_D = F_C + F_V + F_o$$

Siendo los valores:

F_C = 272.908 N

Fv = 714,675 N

F_o = 19.683 N

De donde **F_D= 293.306 N**

5.4.2. ESTIMACIÓN CENTRO DE GRAVEDAD INICIALES.

La estimación de peso de acero de la Spar se estima en aproximadamente unas 740 toneladas[7].

Se realizarán los cálculos preliminares sin pesos añadidos, de los centros de gravedad para la Spar, con las jaulas en tres posiciones.

Posición 1: Jaula sumergida debido al temporal, para que no le afecten las corrientes marinas.

Centro de gravedad:

	Área (m2)	Yg (m)	Mv		
Spar Zona 1	64,5	57,78	3726,81		
Spar Zona 2	507	30	15210		
Spar Zona 3	80	2,5	200		
Total Spar	**652**		**19137**	**Yg(spar)=**	**29,37**
Jaulas Altura Mínima	809,6	11	8905,6		
Total Spar + Jaula	**1461**		**28042**	**Yg(spar +jaula)=**	**19,19**

Tabla 16. Cálculo centro gravedad con las jaulas posición inferior.

[7] Soluciones flotantes para aerogeneradores. Plataforma Spar. Ponencia en el 50º Congreso de Ingeniería Naval e Industria Marítima 2011.

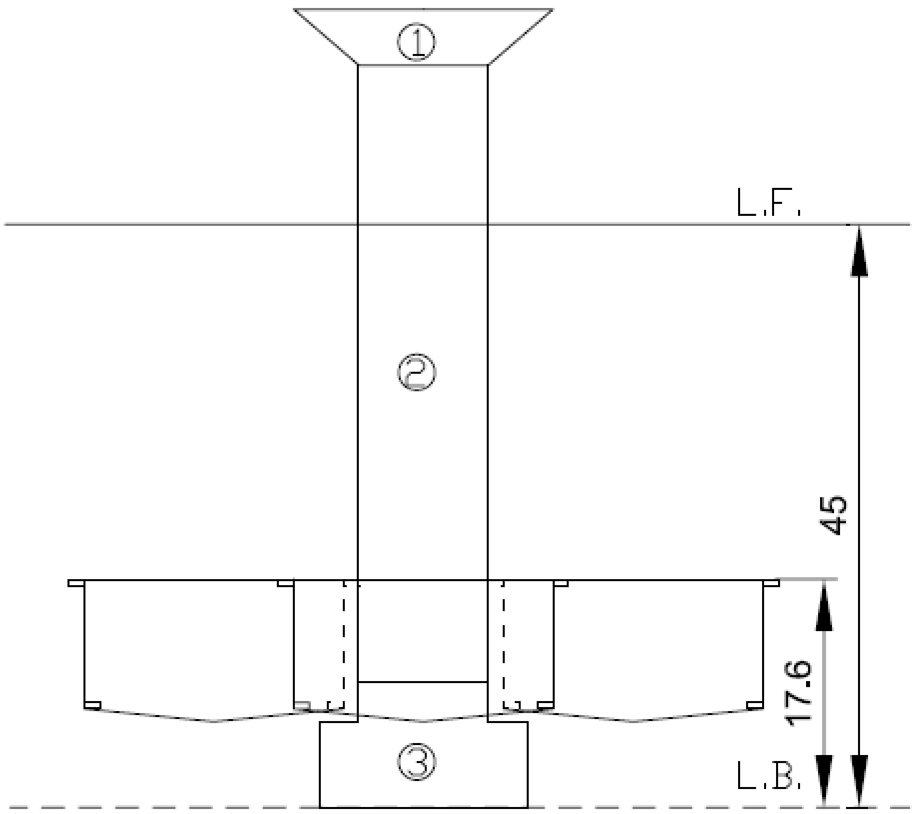


Ilustración 28. Spar con jaulas en su posición baja.

Posición 2: Jaula en posición intermedia, su ubicación habitual:

Centro de gravedad:

	Área (m2)	Yg (m)	Mv		
Spar Zona 1	64,5	57,78	3726,81		
Spar Zona 2	507	30	15210		
Spar Zona 3	80	2,5	200		
Total Spar	652		19137	Yg(spar)=	29,37
Jaulas Altura Intermedia	809,6	30	24288		
Total Spar + Jaula	1461		43425	Yg(spar +jaula)=	29,72

Tabla 17. Cálculo centro gravedad con las jaulas posición intermedia.

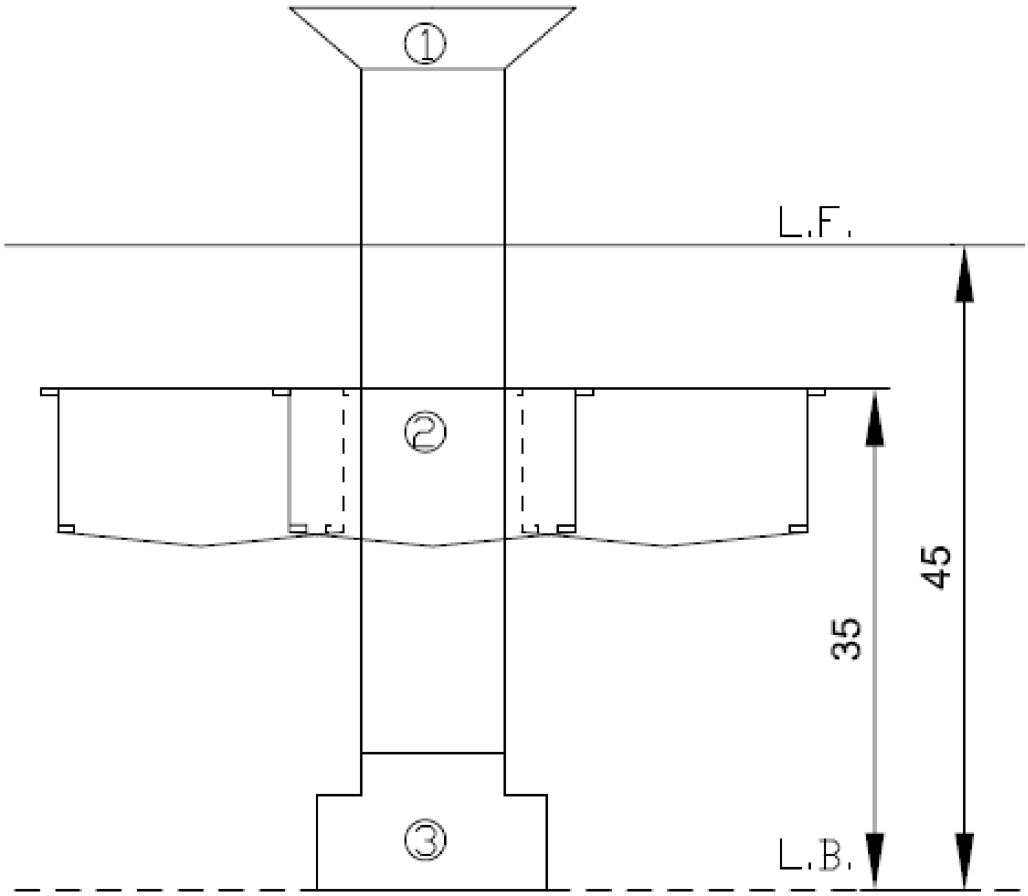


Ilustración 29. Spar con jaulas en su posición intermedia.

Posición 3: Jaula emergida, para extracción de peces y mantenimiento de la estación.

	Área (m2)	Yg (m)	Mv		
Spar Zona 1	64,5	57,78	3726,81		
Spar Zona 2	507	30	15210		
Spar Zona 3	80	2,5	200		
Total Spar	652		19137	Yg(spar)=	29,37
Jaulas Altura Superior	809,6	41	33193,6		
Total Spar + Jaula	1461		52330	Yg(spar +jaula)=	35,82

Tabla 18. Cálculo centro gravedad con las jaulas posición superior.

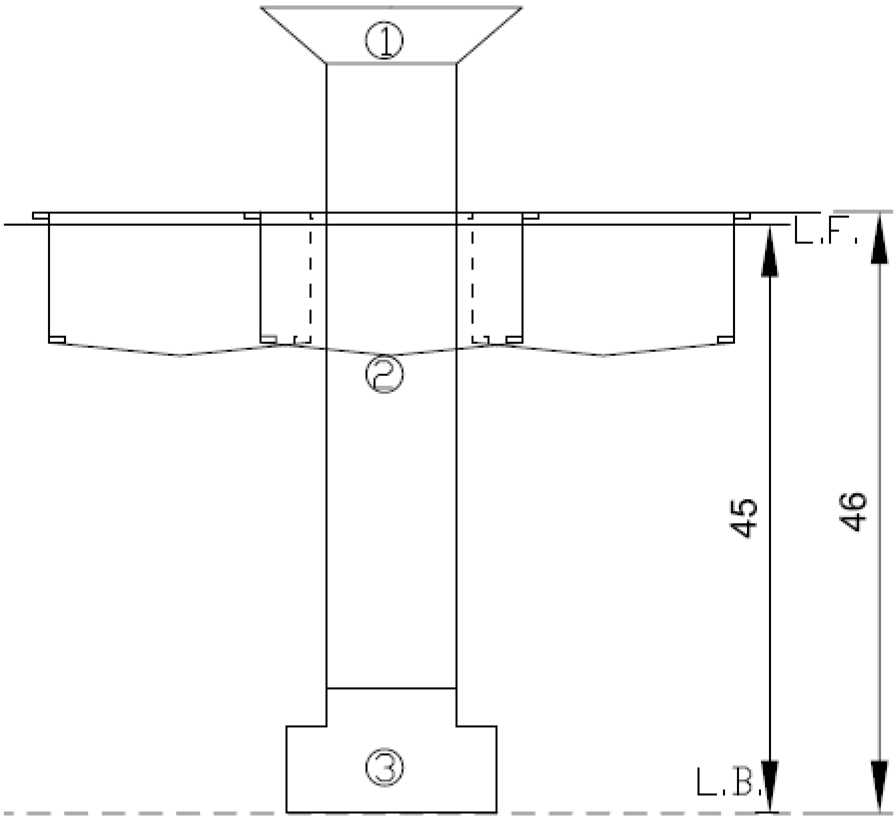


Ilustración 30. Spar con jaulas en su posición superior.

5.4.3. ESCANTILLONADO DE LA ESTRUCTURA.

Se aplicará la siguiente normativa:

Como punto de partida:

- **DNV-OS-C106**, Structural Design of Deep Draught Floating Units (LRFD Method).

Como normativa de referencia:

- **DNV-OS-C101,** Design of Offshore Steel Structures, General (LRFD Method).
- **DNV-OS-C103,** Structural Design of Column Stabilised Units (LRFD Method).

Como referencias informativas:

- **DNV-RP-F205,** Global Performance Analysis of Deepwater Floating Structures.
- **DNV-RP-C205,** Environmental Conditions and Environmental Loads.

Se definirá en este punto el escantillonado (espesores tanto de refuerzos como de acero).

Se dividirá el diseño estructural de la estructura en dos niveles principales:

- Resistencia local.
- Resistencia general o global.

El pandeo se analizará en cualquiera de los dos niveles mencionados.

La **resistencia local**, se basa en métodos empíricos y en las normas y reglamentos de las Sociedades de Clasificación. Es un método importante para las zonas críticas, como pueden ser las zonas de cargas, que están sometidas al peso de equipos, uniones estructurales, o zonas que sufren fuertes impactos, y zonas que sufren una mayor corrosión. La forma que más predomina en la carga local es la presión hidrostática. Los diseños de las estructuras, que se basan en las presiones hidrostáticas, determinarán la mayoría del peso del acero del casco más de un 80%.

La **resistencia global**, es el comportamiento del conjunto ante solicitaciones externas como pueden ser, cargas por olas, por corrientes, por vientos, gravitacionales…

Pandeo, se estudiará tanto a fenómeno global como local. Sólo podrá ser controlado en estructuras esbeltas, o localmente en zonas de entramado con refuerzos transversales, o también en cubiertas altas, siempre y cuando estén sometidas a quebranto.

Fatiga, se basa principalmente en cargas cíclicas, como las olas, éste fenómeno afecta a ciertas partes como pueden ser las uniones soldadas.

5.4.3.1. MÉTODO A APLICAR:

Se aplicará el método LRFD (Load and Resistance Factor Design), de acuerdo con la SS.CC.

Los estados límites definidos en LRFD, son los siguientes:

- **ULS (Ultimate Limit States):** Estado Límite Último, corresponde a las cargas resistentes máximas.
- **FLS (Fatigue Limit States):** Estado Límite de Fatiga, está relacionado con el fallo debido a las cargas cíclicas.
- **SLS (Serviceability Limit States):** Estado Límite de Servicio, se refiere a las condiciones normales de uso.
- **ALS (Accidental Limit States):** Estado Límite Accidental, aplicable en condiciones en las que el elemento estructural ha sido dañando.

Método LRFD[8] [9]:

(En el DNV-OS-C106, se nos indica que usemos el LRFD perteneciente al DNV-OS-C101 para el método LRFD).

Las cargas o tensiones que actúan sobre la estructura, serán menores o iguales a la resistencia estructural de fluencia del elemento. Se tendrá un factor de seguridad diferente γ_F, dependiendo de los estados límites como se puede ver en la siguiente tabla:

Table A1 Load factors – ULS

Combination of design loads	*Load categories*		
	Permanent and variable functional loads, $\gamma_{f,G,Q}$	*Environmental loads,* $\gamma_{f,E}$	*Deformation loads,* $\gamma_{f,D}$
a)	1.3 [1)]	0.7	1.0
b)	1.0	1.3	1.0
1) If the load is well defined e.g. masses or functional loads with great confidence, no possible overfilling of tanks etc. the coefficient may be reduced to 1.2.			

Tabla 19. DNV-OS-C106, Sec. [5], A 103.

Se tomará como factor de seguridad 1, para los estados límites FLS, ALS, SLS.

En la tabla que mostraremos a continuación se podrán ver para las condiciones operativas temporales y de operación.

Table B1 Basis for selection of characteristic loads for temporary design conditions

Load category	*Limit states – temporary design conditions*				
	ULS	*FLS*	*ALS*		*SLS*
			Intact structure	*Damaged structure*	
Permanent (G)	Expected value				
Variable (Q)	Specified value				
Environmental (E)	Specified value	Expected load history	Specified value	Specified value	Specified value
Accidental (A)			Specified value		
Deformation (D)	Expected extreme value				
For definitions, see Sec.1. See DNV Rules for Planning and Execution of Marine Operations.					

Table B2 Basis for selection of characteristic loads for operating design conditions

Load category	*Limit states – operating design conditions*				
	ULS	*FLS*	*ALS*		*SLS*
			Intact structure	*Damaged structure*	
Permanent (G)	Expected value				
Variable (Q)	Specified value				
Environmental (E)	Annual probability [1)] being exceeded = 10^{-2} (100 year return period)	Expected load history	Not applicable	Load with return period not less than 1 year	Specified value
Accidental (A)			Specified value, see also DNV-OS-A101		
Deformation (D)	Expected extreme value				
1) The joint probability of exceedance applies, see F.					

Tabla 20. DNV-OS-C101, Sec. [3], B102.

[8] DNV-OS-C106 Sec. [1], Parte A General.
[9] DNV-OS-C101 Sec. [2], Parte D; Design by LRFD Method.

Según el DNV-OS-C106 Sec. [2] A. Introduction, nos indica que para la caracterización estructural y categorización de las inspecciones, se debe de seguir el DNV-OS-C101.

El DNV clasifica los aceros de acuerdo con su carga y a su vez dentro de cada grupo resistente en A, B, C, D, basándose en las características de soldabilidad y temperatura de diseño[10].

Table D2 Applicable steel grades

Strength group	*Grade*		*Test temperature 3) (°C)*
	Normal weldability	*Improved weldability 2)*	
NS	A	-	Not tested
	B 1)	BW	0
	D	DW	-20
	E	EW	-40
HS	A	AW	0
	D	DW	-20
	E	EW	-40
	F	-	-60
EHS	A	-	0
	D	DW	-20
	E	EW	-40
	F	-	-60

1) Charpy V-notch tests are required for thickness above 25 mm but are subject to agreement between the contracting parties for thickness of 25 mm or less.
2) For steels with improved weldability, through-thickness properties are specified, see DNV-OS-B101.
3) Charpy V-notch impact tests, see DNV-OS-B101.

Tabla 21. DNV-OS-C101, Sec. [4], D203.

Un diseño estructural se basa en una caracterización de la misma definiéndolos:

- **Elementos primarios,** son aquellos que constituyen los elementos básicos de la estructura y un fallo podría ser importante para la integridad del conjunto.
- **Elementos secundarios,** son aquellos cuyo fallo no resultan críticos.
- **Elementos especiales,** son estructuras que bien por la configuración o por la ubicación de la carga, salen de la categorización anterior, requiriendo una inspección más cuidadosa.

[10] DNV-OS-C101 Sec. [4] D 203

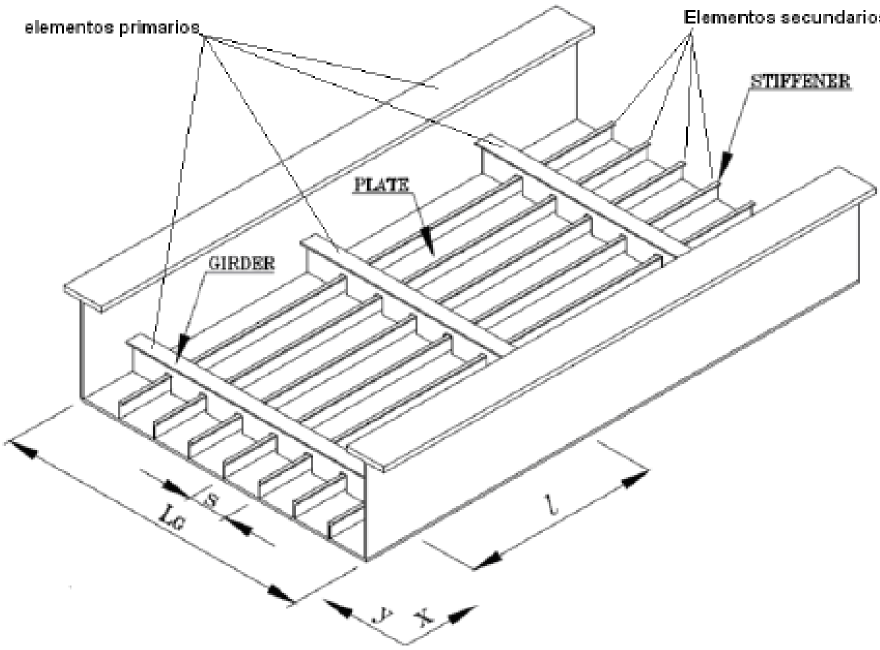


Ilustración 31: Reforzado típico de construcción naval.

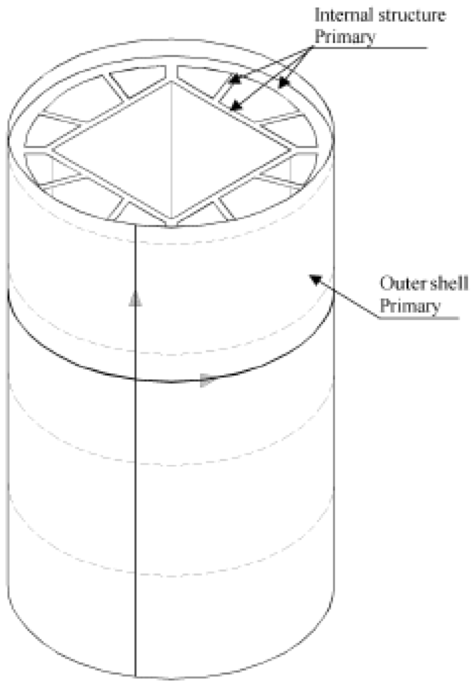


Ilustración 32: Posible reforzado típico de una Spar.

Se seleccionará el material según criterios de rigidez, densidad, peso relativo, resistencia a la corrosión, función a realizar, ciclo de vida…. Según las características mencionadas, se emplean en offshore aceros de múltiples características.

Table D1 Material designations		
Designation	*Strength group*	*Specified minimum yield stress* f_y (N/mm^2)$^{1)}$
NV	Normal strength steel (NS)	235
NV-27	High strength steel (HS)	265
NV-32		315
NV-36		355
NV-40		390
NV-420	Extra high strength steel (EHS)	420
NV-460		460
NV-500		500
NV-550		550
NV-620		620
NV-690		690
1) For steels of improved weldability the required specified minimum yield stress is reduced for increasing material thickness, see DNV-OS-B101.		

Tabla 22. DNV-OS-C101, Sec. [4], D202.

Una vez que está el material definido, se fijará la selección de temperatura más baja del emplazamiento según las siguientes tablas:

Table D3 Thickness limitations (mm) of structural steels for different structural categories and service temperatures (°C)							
Structural Category	*Grade*	*≥ 10*	*0*	*-10*	*-20*	*-25*	*-30*
Secondary	A	35	30	25	20	15	10
	B/BW	70	60	50	40	30	20
	D/DW	150	150	100	80	70	60
	E/EW	150	150	150	150	120	100
	AH/AHW	60	50	40	30	20	15
	DH/DHW	120	100	80	60	50	40
	EH/EHW	150	150	150	150	120	100
	FH	150	150	150	150	*)	*)
	AEH	70	60	50	40	30	20
	DEH/DEHW	150	150	100	80	70	60
	EEH/EEHW	150	150	150	150	120	100
	FEH	150	150	150	150	*)	*)
Primary	A	30	20	10	N.A.	N.A.	N.A.
	B/BW	40	30	25	20	15	10
	D/DW	70	60	50	40	35	30
	E/EW	150	150	100	80	70	60
	AH/AHW	30	25	20	15	12.5	10
	DH/DHW	60	50	40	30	25	20
	EH/EHW	120	100	80	60	50	40
	FH	150	150	150	150	*)	*)
	AEH	35	30	25	20	17.5	15
	DEH/DEHW	70	60	50	40	35	30
	EEH/EEHW	150	150	100	80	70	60
	FEH	150	150	150	150	*)	*)
Special	D/DW	35	30	25	20	17.5	15
	E/EW	70	60	50	40	35	30
	AH/AHW	15	10	N.A.	N.A.	N.A.	N.A.
	DH/DHW	30	25	20	15	12.5	10
	EH/EHW	60	50	40	30	25	20
	FH	120	100	80	60	50	40
	AEH	20	15	10	N.A.	N.A	N.A.
	DEH/DEHW	35	30	25	20	17.5	15
	EEH/EEHW	70	60	50	40	35	30
	FEH	150	150	100	80	70	60
*) For service temperature below -20°C the upper limit for use of this grade must be specially considered.							
N.A. = no application							

Tabla 23. DNV-OS-C101, Sec. [4], D300.

Se toma como temperatura de diseño, la temperatura más baja de diseño ≥10˚C (Tabla 23).

La SS.CC. clasifica a los aceros en función a la resistencia de fluencia y dentro de cada grupo se clasificara en A, B, C, D en base a las características de soldabilidad y la temperatura de diseño (Tabla 21).

Los materiales de construcción para la Spar serían, según (Tabla 22):

- NS Clase A para ≥10°C, Acero NV, tensión de fluencia 235N/mm^2.

Según la categoría estructural, se pueden ver las limitaciones de espesores del acero en la tabla (Tabla 23).

5.4.3.2. DISEÑO DE LA ESTRUCTURA:

La estructura dispondrá de refuerzos circulares a lo largo de todo el puntal, a los cuales denominaremos anillos. Y de una estructura primaria que será de T, y una estructura secundaria que será de bulbo.

Resistencia local, Escantillonado.

Se calcularán los espesores de los mamparos, cubiertas y chapas de forro como los mínimos para los cuales se verifiquen los requisitos de la resistencia local.

Las reglas de las SS.CC. para la determinación del escantillonado se basan en presiones hidrostáticas uniformes. Las presiones presentan dos componentes, las cargas debido a las olas, y la presión externa debida a la profundidad.

Siguiendo las indicaciones de DNV-OS-C106, Sección 5, **ULS (Ultimate Limit States):** Estado Límite Último, correspondiente a las cargas resistentes máximas, se calculará el mínimo escantillonado según el DNV-OS-C101. Sección 5.[11]

5.4.3.3. CÁLCULO DEL ESPESOR Y REFUERZOS DEL FORRO.

Criterios para el cálculo de espesores de planchas y refuerzos[12].

El espesor mínimo no ha de ser menor que el obtenido de las siguientes expresiones:

$$t = \frac{14{,}3 \cdot t_0}{\sqrt{f_{yd}}}\ (mm)$$

[11] DNV-OS-C106 Sec. [5] D 100 General.
[12] DNV-OS-C101 Sec. [5] F Special Provisions for Plating and Stiffeners

En donde:

$f_{yd} = f_y/\gamma_M$; límite elástico de diseño

f_y; es el límite elástico mínimo dado en la tabla (Tabla 22).

t_0; será 7mm para elementos estructurales primarios.

t_0; será 5mm para elementos estructurales secundarios.

γ_M; es el factor de material para el acero 1,15.

$$t = \frac{14{,}3 \cdot t_0}{\sqrt{\frac{f_y}{\gamma_M}}} = \frac{14{,}3 \cdot 7}{\sqrt{\frac{235}{1{,}15}}} = 7mm$$

El espesor de las planchas sometidas a la presión lateral no deberá ser inferior a:

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}}\ (mm)$$

De donde:

k_a; es el factor de corrección para la relación de aspecto (1,1 – 0,25 s/l)2.

valor máximo 1 cuando s/l=0,4.

valor mínimo 0,75 cuando s/l=1,0.

s ; espaciado de refuerzos (m), a lo largo del forro.

P_d; es la presión de diseño (kN/m²).[13]

$\sigma_{pd\,1}$; es diseño de tensión de flexión (kN/m2), se toma como el menor de:

- $1{,}3(f_{yd} - \sigma_{jd})$, y
- $f_{yd} = f_y/\gamma_M$

σ_{jd}; es la tensión de diseño equivalente para la tensión

$$\sigma_{jd} = \sqrt{\sigma_{xd}^2 + \sigma_{yd}^2 - \sigma_{xd} \cdot \sigma_{y\sigma d} + 3\tau_d^2}$$

k_{pp} ; parámetro de fijación de refuerzos.

13 DNV-OS-C101 Sec. [3] D 307.

- 1 para extremos fijados (soldados o similar).
- 0,5 extremos de refuerzos simplemente apoyados.

Se empezará calculando primero k_a, para ello previamente han de determinarse los valores que tomarán s y l.

Tomaremos como valor de "*s*" una medida comprendida entre 500 y 700 mm, ya que es un valor típico en la construcción naval. Se tomará *s* = 650 mm.

Se sabe que el valor de *s* y *l* , están entre valores de [0,4 – 1], según indicamos anteriormente, para un valor de *s=650mm*, obtendremos un valor de *l=1.600mm.*

$$k_a = \left(1{,}1 - 0{,}25\,{}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{650}/_{1600})^2 = \;\; 0{,}997$$

Se tomará el valor de s=650mm.

Para calcular P_d se definirán los factores de seguridad en función de la (Tabla 19).

En el reglamento[14] se indica como calcular la presión de diseño, en función de una componente fija denominada Ps, y otra componente medioambiental que engloba los factores de seguridad definidos de la (Tabla 19).

$$P_d = P_s \cdot \gamma_{f,G,Q} + P_e \cdot \gamma_{f,E}$$

Donde:

$$P_s = \rho \cdot g_0 \cdot C_W(T_E - z_b) \qquad (kNm^2) \qquad \geq 0$$

y

$$P_e = \rho \cdot g_0 \cdot C_W(D_D - z_b) \qquad (kNm^2) \quad para \quad z_b \geq T_E$$
$$P_e = \rho \cdot g_0 \cdot C_W(D_D - T_E) \qquad (kNm^2) \quad para \quad z_b < T_E$$

[14] DNV-OS-C103 Ch.1 Sec. [3] E 202

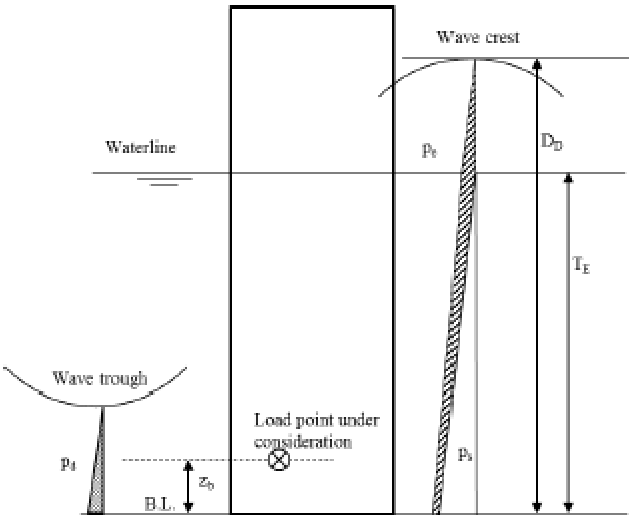


Ilustración 33: Parámetros para presiones marinas.[15]

[15] DNV-OS-J103 Sec.[4] Figure 4.2.

PARÁMETROS DE ENTRADA DEL DNV PARA OBTENCIÓN DE PRESIONES	
Factores de carga para cargas funcionales y permanentes G,Q.	1
Factor de carga para cargas medioambientales E	1,3
TE calado extremo operacional	45
Factor de efecto Smith CW	0,9

PRESIONES MARINAS ULS	Zb																				
	60	**57**	**54**	**51**	**48**	**45**	**42**	**39**	**36**	**33**	**30**	**27**	**24**	**21**	**18**	**15**	**12**	**9**	**6**	**3**	**0**
Puntal hasta la parte baja de la cubierta Dd (m)	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69	56,69
Presión del mar Permanente Ps a la cota Zb kN/m2						0	27,15	54,3	81,45	108,6	135,7	162,9	190	217,2	244,3	271,5	298,6	325,8	352,9	380,1	407,2
Pres. medioambiental del mar Pe Kn/m2 Zb > Te	-28,2	-1,71	24,78	51,26	77,75	104,2															
Pres, medioambiental del mar Pe Kn/m2 Zb < Te							105,8	105,8	105,8	105,8	105,8	105,8	105,8	105,8	105,8	105,8	105,8	105,8	105,8	105,8	105,8
Total presión del mar kN/m2	-36,7	-2,23	32,21	66,64	101,1	135,5	164,7	191,8	219	246,1	273,3	300,4	327,6	354,7	381,9	409	436,2	463,3	490,5	517,6	544,8
Total presión del mar ton/m2	-3,74	-0,23	3,284	6,795	10,31	13,82	16,79	19,56	22,33	25,1	27,87	30,63	33,4	36,17	38,94	41,71	44,48	47,25	50,01	52,78	55,55
Espesor t (mm)			4,06	5,85	7,20	8,34	9,19	9,92	10,60	11,24	11,84	12,41	12,96	13,49	14,00	14,49	14,96	15,42	15,86	16,30	16,72

Tabla 24. Tabla de Presiones marinas y de espesores de chapa de la Spar.

De donde:

T_E; calado de proyecto operativo en m medido verticalmente desde la línea de base de trazado hasta la línea de de flotación.

C_W; factor de reducción debido al movimiento de las partículas de onda (efecto Smith) C_W=0,9 a menos que este de otro modo documentado.

D_D; distancia vertical en m desde la línea base de entrada de agua, a la parte inferior de la estructura de la cubierta (la distancia relativa más grande de la línea base a la cresta de ola se puede sustituir por D_D si es demasiado pequeña.

z_b; distancia vertical en m desde la línea base de trazado y el punto de carga

P_s; presión del mar.

P_e; presión del medio ambiente marino.

$\sigma_{pd\,1}$; se tomará 235/1,15=204,348.

k_{pp}; se tomará el valor de 1.

Para los tanques donde pueden ser llenados de aire durante las operaciones de llenado, se considerarán las siguientes condiciones adicionales de la presión interna de diseño[16].

$$P_d = (\rho \cdot g_0 \cdot h_{op} + P_{dyn})\gamma_{f,G,Q} \quad (kN/m^2)$$

De donde:

P_{dyn}; presión debido al flujo de tuberías, mínimo 25 kN/m^2.

g_0; es la aceleración debido a la gravedad 9,81 m/s2.

h_{op}; es distancia vertical desde el punto de llenado a la posición de la altura máxima de llenado, pero para tanques adyacentes al mar, se tomará como punto más alto la línea de flotación.

Tanques con llenado de aire (Pd)	583,1
Espesor t (mm)	17,3

Tabla 25. Tabla de Presiones y Espesor de la Spar (para tanques llenados de aire).

[16] DNV-OS-C103 Ch.1 Sec. [3] D 305

Se tendrá en cuenta que para los espesores de las chapas aplicaremos un espesor de corrosión, por lo que se incrementaran los valores 2 mm más, como podemos ver en la tabla inferior:

	Zb										
	60	57	54	51	48	45	42	39	36	33	30
Espesor t (mm)			4,06	5,85	7,20	8,34	9,19	9,92	10,60	11,24	11,84
Espesor t (mm) +t corrosión			6	8	9	10	11	12	13	13	14

	Zb									
	27	24	21	18	15	12	9	6	3	0
Espesor t (mm)	12,41	12,96	13,49	14,00	14,49	14,96	15,42	15,86	16,30	16,72
Espesor t (mm) + t corrosión	14	15	15	16	16	17	17	18	18	19

Tabla 26. Tabla de Espesores de las chapas del forro.

Teniendo en cuenta que nuestro espesor mínimo es de 7mm, al que se le ha de sumar 2 de espesor de corrosión, obtenemos los espesores de la Tabla 27. Se ha optado como espesor mínimo 10mm, al no ser 9mm una medida comercial, al igual que en la zona de mayor profundidad, que se ha optado por un espesor de 20mm.

	Zb										
	60	57	54	51	48	45	42	39	36	33	30
Espesor t (mm) +t corrosión	10	10	10	10	10	10	11	12	13	13	14

	Zb									
	27	24	21	18	15	12	9	6	3	0
Espesor t (mm) + t corrosión	14	15	15	16	16	17	17	18	20	20

Tabla 27. Tabla de Espesores.

Cálculo de los refuerzos de la spar.

Se tomara llanta de bulbo como refuerzo vertical de nuestra Spar. Se calculará el módulo admisible y el módulo geométrico para después compararlos.

Primero calcularemos los módulos admisibles para las presiones mediante la siguiente ecuación.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [17]

De donde:

l separación entre refuerzos en (m).

s separación entre refuerzos en (m).

P_d Presión del mar en (kN/m²).

k_m factor del momento flector.[18]

$\sigma_{pd\,2}$, tensión de flexión (N/mm2).

k_{ps}, parámetro de fijación de refuerzos.

	Zb										
	60	57	54	51	48	45	42	39	36	33	30
Momento Flector Local (cm^3)	-22,4	-1,36	19,72	40,81	61,89	82,98	100,8	117,5	134,1	150,7	167,3

	Zb									
	27	24	21	18	15	12	9	6	3	0
Momento Flector Local (cm^3)	184	200,6	217,2	233,8	250,5	267,1	283,7	300,3	317	333,6

Tabla 28. Tabla de Momentos Flectores.

Se hará el bulbo pasante a lo largo de la Spar, atravesando tanto las cubiertas intermedias como los anillos:

Se pueden aplicar dos soluciones:

- En la primera se variará el bulbo, y los refuerzos primarios en función de las presiones y los espesores. Si se supone que el bulbo disminuya de sección a medida que la altura disminuye. El alma de los anillos también será menor, esto

[17] DNV-OS-C101 Sec.[5] F400
[18] DNV-OS-C101 Sec. [5] Tabla G1.

implica una disminución del peso, el inconveniente sería hacer las transiciones de los bulbos.

- En la segunda opción se tomará el bulbo y los refuerzos primarios de la sección baja, para toda la Spar. Como ventaja tenemos que la estructura estará mucho más reforzada, y como inconveniente tendrá un mayor peso la estructura, con el consiguiente mayor coste y también un aumento del KG de la partida de aceros.

Se toma la primera opción, ya que la consideramos mejor para el proyecto, disminuyendo así los pesos y evitando una disminución de la altura metacéntrica por incremento del KG.

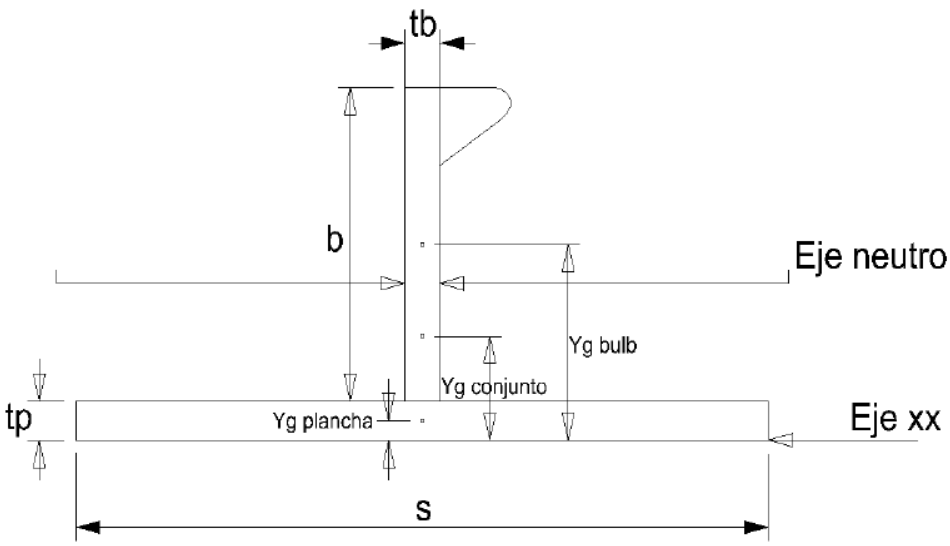


Ilustración 34: Parámetros significativos de bulbo y plancha asociada.

Se supondrá un eje paralelo al eje x-x, de la plancha, como se puede ver en la figura anterior.

Se realizarán cálculos en función de los distintos espesores del forro, y módulos requeridos, para obtener el perfil de llanta de bulbo que más se adapte a nuestras condiciones.

Dimensión nominal	Dimensiones para				Sección transversal	Masa/Ud de longitud	Superficie lateral	Distancia al centro de gravedad	Características geométricas respecto al eje x-x	
	b mm	t mm	c mm	r mm	A cm^2	G Kg/m	U m^2/m	d cm	I_x cm^4 momento de inercia	W_x cm^3 módulo elástico
80 x 5	80	5	14	4	5.41	4.25	0.189	4.9	33.87	6.91
80 x 6	80	6	14	4	6.21	4.88	0.191	4.78	38.7	8.1
100 x 7	100	7	15.5	4.5	8.74	6.68	0.236	5.87	85.3	14.5
100 x 8	100	8	15.5	4.5	9.74	7.65	0.238	5.78	94.3	16.3
120 x 6	120	6	17	5	9.32	7.32	0.276	7.21	133	18.5
120 x 7	120	7	17	5	10.52	8.26	0.278	7.07	149	21
120 x 8	120	8	17	5	11.72	9.2	0.28	6.96	165	23.6
140 x 7	140	7	19	5.5	12.43	9.75	0.32	8.32	241	29
140 x 8	140	8	19	5.5	13.83	10.85	0.322	8.18	266	32.5
140 x 10	140	10	19	5.5	16.63	13.05	0.326	7.99	315	39.5
160 x 7	160	7	22	6	14.6	11.46	0.365	9.66	373	38.6
160 x 8	160	8	22	6	16.2	12.72	0.367	9.5	411	43.3
160 x 9	160	9	22	6	17.8	13.97	0.369	9.37	449	47.9
160 x 11	160	11	22	6	21	16.49	0.373	9.16	522	57
180 x 8	180	8	25	7	18.86	14.8	0.411	10.89	609	55.9
180 x 9	180	9	25	7	20.66	16.22	0.413	10.73	664	61.8
180 x 10	180	10	25	7	22.46	17.63	0.415	10.59	717	67.7
180 x 11	180	11	25	7	24.26	19.04	0.417	10.47	770	73.5
200 x 9	200	9	28	8	23.66	18.57	0.457	12.12	942	77.7
200 x 10	200	10	28	8	25.66	20.14	0.459	11.96	1017	85.1
200 x 11	200	11	28	8	27.66	21.71	0.461	11.82	1091	92.3
200 x 12	200	12	28	8	29.66	23.28	0.463	11.69	1164	99.5
220 x 10	220	10	31	9	29	22.77	0.503	13.35	1396	105
220 x 11	220	11	31	9	31.2	24.5	0.506	13.19	1496	114
220 x 12	220	12	31	9	33.4	26.22	0.507	13.04	1595	122
240 x 10	240	10	34	10	32.49	25.5	0.547	14.77	1865	126
240 x 11	240	11	34	10	34.89	27.39	0.549	14.58	1997	137
240 x 12	240	12	34	10	37.29	29.27	0.551	14.42	2127	148
260 x 10	260	10	37	11	36.11	28.35	0.591	16.22	2434	150
260 x 11	260	11	37	11	38.71	30.39	0.593	16	2605	163
260 x 12	260	12	37	11	41.31	32.43	0.596	15.81	2774	175
280 x 11	280	11	40	12	42.68	33.5	0.637	17.44	3333	191
280 x 12	280	12	40	12	45.48	35.7	0.639	17.23	3647	206
280 x 13	280	13	40	12	48.28	37.9	0.641	17.04	3757	221
300 x 11	300	11	43	13	43.78	36.7	0.681	18.9	4192	222
300 x 12	300	12	43	13	49.79	39.09	0.683	18.7	4459	239
300 x 13	300	13	43	13	52.79	41.44	0.685	18.45	4722	256

Ilustración 35: Características del bulbo.

Se calculará el modulo total en las siguientes tablas de Excel, partiendo de las siguientes formulas:

$$Y_{GConjunto} = \frac{\sum A \cdot y}{\sum A}$$

$$I_{planc\ ha} = \frac{1}{12} \cdot s \cdot t^3$$

$$I_{bulbo} = (dato\ prontuario)$$

$$I_{xx} = \sum I_{propia} + \sum A \cdot y^2$$

$$I_{EN} = I_{xx} - A \cdot Y_G^2$$

$$Z = \frac{I_{EN}}{y_{max\,.}}$$

Los datos obtenidos con estas ecuaciones han de ser mayores a los de la Tabla 28.

Chapa	65	cm	2	cm	1	Área	130	cm2				
Bulbo	300x11	30	cm	Área	43,8	cm2	I	4192	Cm4	d	18,9	cm
Y(gconjunto)	6,01	cm										
I(plancha)	43,33	cm4										
I(bulbo)	4192	cm4				ESPESOR 20mm, Z (mínimo)= 334						
Ixx	23488,88	cm4										
Ien	17204,90	cm4										
Z	782,52	cm3										

Chapa	65	cm	1,8	cm	0,9	Área	117	cm2				
Bulbo	200x10	20	cm	Área	25,7	cm2	I	1017	cm4	d	12	cm
Y(gconjunto)	3,21	cm										
I(plancha)	31,59	cm4										
I(bulbo)	1017	cm4				ESPESOR 18mm, Z(mínimo)= 300						
Ixx	6001,76	cm4										
Ien	4528,93	cm4										
Z	302,19	cm3										

Chapa	65	cm	1,7	cm	0,85	Área	111	cm2				
Bulbo	200x10	20	cm	Área	25,7	cm2	I	1017	cm4	d	12	cm
Y(gconjunto)	3,26	cm										
I(plancha)	26,61	cm4										
I(bulbo)	1017	cm4				ESPESOR 17mm, Z(mínimo)= 284						
Ixx	5911,49	cm4										
Ien	4460,79	cm4										
Z	296,68	cm3										
Chapa	65	cm	1,6	cm	0,8	Área	104	cm2				

Bulbo	200x10	20	cm	Área	25,7	cm2	I	1017	cm4	d	12	cm
Y(gconjunto)	3,33	cm										
I(plancha)	22,19	cm4										
I(bulbo)	1017	cm4				ESPESOR 16mm, Z(mínimo)= 250						
Ixx	5823,94	cm4										
Ien	4390,27	cm4										
Z	291,23	cm3										

Chapa	65	cm	1,5	cm	0,75	Área	97,5	cm2				
Bulbo	180X10	18	cm	Área	22,5	cm2	I	717	cm4	d	10,6	Cm
Y(gconjunto)	2,87	cm										
I(plancha)	18,28	cm4										
I(bulbo)	717	cm4				ESPESOR 15mm, Z(mínimo)= 217						
Ixx	4073,06	cm4										
Ien	3082,77	cm4										
Z	226,23	cm3										

Chapa	**65**	**cm**	**1,4**	**cm**	**0,7**	**Área**	**91**	**cm2**				
Bulbo	**180X8**	**18**	**cm**	**Área**	**18,9**	**cm2**	**I**	**609**	**cm4**	**d**	**10,9**	**cm**
Y(gconjunto)	2,69	cm										
I(plancha)	14,86	cm4										
I(bulbo)	609	cm4			ESPESOR 14mm, Z(mínimo)= 184							
Ixx	3517,15	cm4										
Ien	2722,37	cm4										
Z	**195,71**	**cm3**										

Chapa	**65**	**cm**	**1,3**	**cm**	**0,65**	**Área**	**84,5**	**cm2**				
Bulbo	**160X9**	**16**	**cm**	**Área**	**17,8**	**cm2**	**I**	**449**	**cm4**	**d**	**9,37**	**cm**
Y(gconjunto)	2,39	cm										
I(plancha)	11,90	cm4										
I(bulbo)	449	cm4			ESPESOR 13mm, Z(mínimo)= 151							
Ixx	2523,11	cm4										
Ien	1937,07	cm4										
Z	**157,40**	**cm3**										

Chapa	**65**	**cm**	**1,2**	**cm**	**0,6**	**Área**	**78**	**cm2**				
Bulbo	**140X10**	**14**	**cm**	**Área**	**16,6**	**cm2**	**I**	**315**	**cm4**	**d**	**7,99**	**cm**
Y(gconjunto)	2,11	cm										
I(plancha)	9,36	cm4										
I(bulbo)	315	cm4			ESPESOR 12mm, Z(mínimo)= 117							
Ixx	1756,94	cm4										
Ien	1335,81	cm4										
Z	**124,95**	**cm3**										

Chapa	**65**	**cm**	**1**	**Cm**	**0,5**	**Área**	**65**	**cm2**				
Bulbo	**140X7**	**14**	**cm**	**Área**	**12,4**	**cm2**	**I**	**241**	**cm4**	**d**	**8,32**	**cm**
Y(gconjunto)	1,92	cm										
I(plancha)	5,42	cm4										
I(bulbo)	241	cm4			ESPESOR 10mm, Z(mínimo)= 83							
Ixx	1342,37	cm4										
Ien	1058,15	cm4										
Z	**95,47**	**cm3**										

Chapa	**65**	**cm**	**1**	**Cm**	**0,4**	**Área**	**65**	**cm2**				
Bulbo	**120X6**	**12**	**cm**	**Área**	**9,32**	**cm2**	**I**	**133**	**cm4**	**d**	**7,21**	**cm**
Y(gconjunto)	1,47	cm										
I(plancha)	5,42	cm4										
I(bulbo)	133	cm4			ESPESOR 10mm, Z(mínimo)= 41							
Ixx	782,87	cm4										
Ien	622,96	cm4										
Z	**65,35**	**cm3**										

Tabla 29. Tabla de Bulbos en función de los Momentos Flectores.

5.4.3.4. CÁLCULO DE LOS ANILLOS.

A lo largo del puntal de la Spar se dispondrán distintos anillos, debido a que no se mantiene el mismo bulbo en toda la estructura.

Para el cálculo de los anillos se usará el DNV[19] y el Chakrabarti[20].

Los anillos estarán espaciados 1600mm. Estarán formados por un alma y por un ala, mediante la cual formarán una "T".

El espesor de la bulárcama será obtenido en función del espesor de las planchas de forro, ya calculado anteriormente, no pudiendo ser el espesor de la bulárcama menor que el calculado[21].

Los anillos y las bulárcamas serán ambos de perfil en "T" y de la misma sección.

Se dispondrán de 8 T separadas 45°, que irán a lo largo del puntal de la Spar.

La altura del alma de la bulárcama y de los anillos[22] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

En donde:

d_w; es la altura del alma de la bulárcama.

d_s; es la altura del refuerzo.

Por lo tanto, en función de los espesores se dividirá la Spar en 11 zonas como se muestra en la Ilustración 36.

[19] DNV-OS-C101 y DNV-OS-C103.
[20] S.Chakrabarti. Handbook of offshore engineering.
[21] DNV-0S-C101 Sec. [5].
[22] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

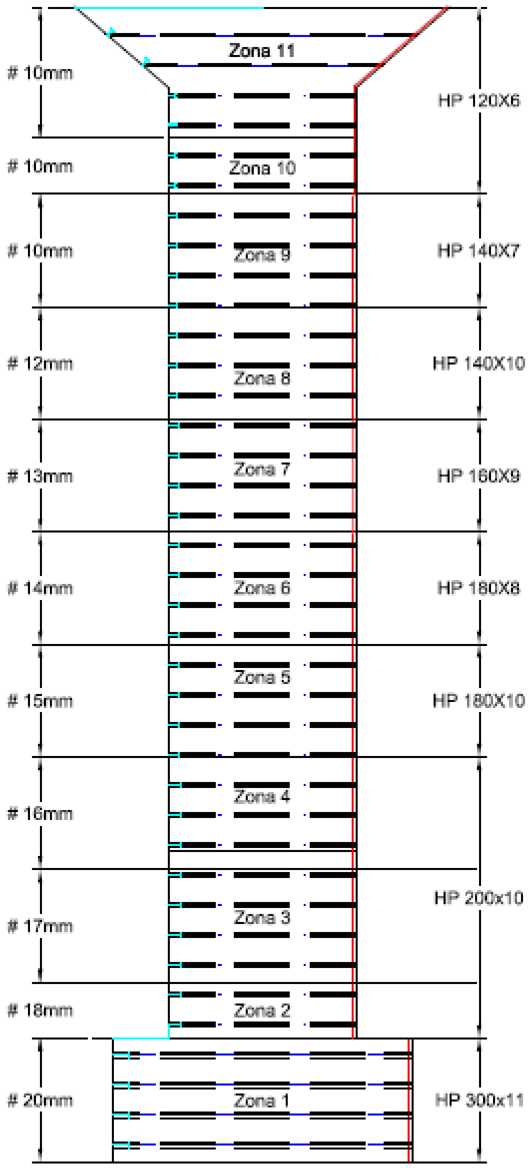


Ilustración 36: Zonas Spar.

Para cada zona se calculará la Smáx (ancho efectivo de los refuerzos primarios).

Tras definir todos estos parámetros el módulo de la sección será obtenido como:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

En donde:

S, separación entre bulárcamas.

b separación entre los anillos.

P_d presión de diseño en kN/m^2.

k_m factor del momento flector.

$\sigma_{pd\,2}$, tensión a flexión de diseño N/mm2.

	ZONA 1			ZONA 2			ZONA 3			ZONA 4		
	S (m)	1/2 S (m)	t (mm)	S (m)	1/2 S (m)	t (mm)	S (m)	1/2 S (m)	t (mm)	S (m)	1/2 S (m)	t (mm)
	10,04	5,021	20	6,223	3,112	18	6,223	3,112	17	6,223	3,112	16
Zg (cm^3)	8959,28			3098,27			2926,77			2583,77		

	ZONA 5			ZONA 6			ZONA 7			ZONA 8		
	S (m)	1/2 S (m)	t (mm)	S (m)	1/2 S (m)	t (mm)	S (m)	1/2 S (m)	t (mm)	S (m)	1/2 S (m)	t (mm)
	6,307	3,154	15	6,307	3,154	14	6,392	3,196	13	6,477	3,239	12
Zg (cm^3)	2301,67			1949,34			1640,36			1312,70		

	ZONA 9			ZONA 10			ZONA 11			ZONA 11 (Reducción Ø 16,5)		
	S (m)	1/2 S (m)	t (mm)	S (m)	1/2 S (m)	t (mm)	S (m)	1/2 S (m)	t (mm)	S (m)	1/2 S (m)	t (mm)
	6,477	3,239	10	6,562	3,281	10	6,562	3,281	10	10,91	5,456	10
Zg (cm^3)	927,29			468,08			226,22			625,57		

Tabla 30. Tabla de cálculo de módulos según DNV.

El ancho efectivo del ala es determinado por la siguiente fórmula:

$$b_e = C_e \cdot b$$ [23]

En donde:

be es el ancho efectivo de la plancha asociada.

Np, es el número de refuerzos que atraviesan las bulárcamas.

b separación entre anillos.

[23] DNV-OS-C101 Sec.[5] G 400

Ce, parámetro que se obtiene de la Ilustración 37

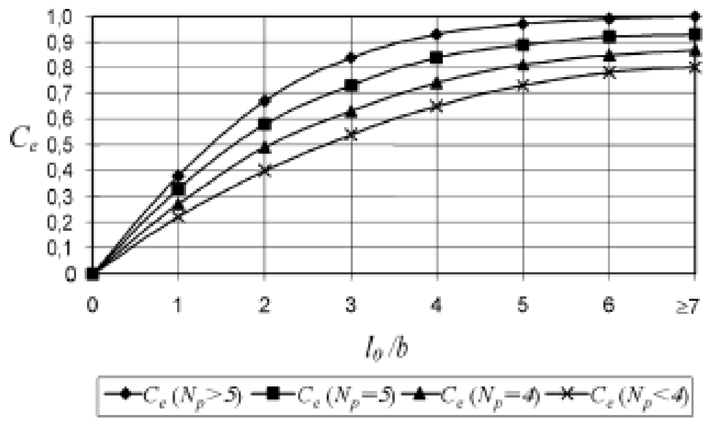


Ilustración 37.Gráfico para el parámetro Ce del ala efectivo.

l_0, es la distancia entre los puntos de momento flector 0.

s es la luz entre los refuerzos.

Se sigue el mismo proceso que en el cálculo de los bulbos. Se calcula el módulo geométrico para una sección "T", con su plancha asociada, el cual ha de ser mayor que el obtenido por el reglamento.

Basándonos en la figura del Chakrabarti de la página 600 en la cual indica la obtención de S para una sección de esquinas curvas, se puede asimilar la sección circular de la Spar a una sección con esquinas curvas como la mostrada en dicha figura, a la cual la distancia recta que une dos esquinas consecutivas se hace tender a cero. De esta forma la distancia efectiva S se reduce al cuarto del radio.

Se ha comprobado que el módulo calculado por reglamento para una distancia S=10.041mm es elevado. Por lo tanto se ha reforzado la sección introduciendo una nuevo refuerzo primario (perfil T) equidistante entre cada dos, de forma que la mencionada distancia que ahora deberemos de considerar será la mitad de aquella 5020,5mm.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Zona 1	10,041	5,0205	5,021	3,138	0,54	0,864	86,4
Zona 2	6,223	3,1115	3,112	1,945	0,38	0,608	60,8
Zona 3	6,223	3,1115	3,112	1,945	0,38	0,608	60,8
Zona 4	6,223	3,1115	3,112	1,945	0,38	0,608	60,8
Zona 5	6,307	3,1535	3,154	1,971	0,39	0,624	62,4

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Zona 6	6,307	3,1535	3,154	1,971	0,39	0,624	62,4
Zona 7	6,392	3,196	3,196	1,998	0,39	0,624	62,4
Zona 8	6,477	3,2385	3,239	2,024	0,405	0,648	64,8
Zona 9	6,477	3,2385	3,239	2,024	0,405	0,648	64,8
Zona 10	6,562	3,281	3,281	2,051	0,41	0,656	65,6
Zona 11 (cilindro)	6,562	3,281	3,281	2,051	0,41	0,656	65,6
Zona 11 (reducción)	10,912	5,456	5,456	3,41	0,6	0,96	96

Tabla 31. Cálculo plancha efectiva.

Calculo de los refuerzos primarios.

Spar Zona 1 Espesor 20mm												
Chapa	be	86,4	cm	t	2	cm	t/2	1	cm	Área	173	cm^2
Alma (web)	largo	90	cm	t	2	cm	t/2	1	cm	Área	180	cm^2
Ala (flange)	largo	30	cm	t	2	cm	t/2	1	cm	Área	60	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	172,8	1	172,80	172,80	57,60							
Alma (web)	180	47	8460,00	397620,00	121500,00							
Ala(flange)	60	93	5580,00	518940,00	20,00							
	412,80	141,00	14212,80	916732,80	121577,60							
Y(gconjunto)	34,43	cm										
Ixx	1038310,40	cm4										
Ien	548960,39	cm4			Espesor	20	mm					
y(max)	59,57	cm4			Bulbo	300	x	11	Zg	8959	cm3	
Z	9215,42	cm3										

Spar Zona 2 Espesor 18mm												
Chapa	be	60,8	cm	t	1,8	cm	t/2	0,9	cm	Área	109	cm^2
Alma (web)	largo	60	cm	t	1,8	cm	t/2	0,9	cm	Área	108	cm^2
Ala (flange)	largo	20	cm	t	1,8	cm	t/2	0,9	cm	Área	36	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	109,44	0,9	98,50	88,65	29,55							
Alma (web)	108	31,8	3434,40	109213,92	32400,00							
Ala(flange)	36	62,7	2257,20	141526,44	9,72							
	253,44	95,40	5790,10	250829,01	32439,27							
Y(gconjunto)	22,85	cm										
Ixx	283268,28	cm4										
Ien	150987,61	cm4			Espesor	18	mm		Módulo necesario			
y(max)	40,75	cm4			Bulbo	200	x	10	Zg	3098	cm3	
Z	3704,86	cm3										

Spar Zona 3 Espesor 17mm

Chapa	be	60,8	cm	t	1,7	cm	t/2	0,85	cm	Área	103	cm^2
Alma (web)	largo	60	cm	t	1,7	cm	t/2	0,85	cm	Área	102	cm^2
Ala (flange)	largo	20	cm	t	1,7	cm	t/2	0,85	cm	Área	34	cm^2

	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)
Chapa	103,36	0,85	87,86	74,68	24,89
Alma (web)	102	31,7	3233,40	102498,78	30600,00
Ala(flange)	34	62,55	2126,70	133025,09	8,19
	239,36	95,10	5447,96	235598,54	30633,08

Y(gconjunto)	22,76	cm
Ixx	266231,62	cm4
Ien	142233,36	cm4
y(max)	40,64	cm4
Z	3499,88	cm3

Espesor	17	mm		Módulo necesario
Bulbo	200	x	10	Zg 2927 cm3

Spar Zona 4 Espesor 16mm

Chapa	be	60,8	cm	t	1,6	cm	t/2	0,8	cm	Área	97,3	cm^2
Alma (web)	largo	60	cm	t	1,6	cm	t/2	0,8	cm	Área	96	cm^2
Ala (flange)	largo	20	cm	t	1,6	cm	t/2	0,8	cm	Área	32	cm^2

	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)
Chapa	97,28	0,8	77,82	62,26	20,75
Alma (web)	96	31,6	3033,60	95861,76	28800,00
Ala(flange)	32	62,4	1996,80	124600,32	6,83
	225,28	94,80	5108,22	220524,34	28827,58

Y(gconjunto)	22,68	cm
Ixx	249351,92	cm4
Ien	133522,94	cm4
y(max)	40,53	cm4
Z	3294,83	cm3

Espesor	16	mm		Módulo necesario
Bulbo	200	x	10	Zg 2584 cm3

Spar Zona 5 Espesor 15mm

Chapa	be	62,4	cm	t	1,5	cm	t/2	0,75	cm	Área	93,6	cm^2
Alma (web)	largo	54	cm	t	1,5	cm	t/2	0,75	cm	Área	81	cm^2
Ala (flange)	largo	20	cm	t	1,5	cm	t/2	0,75	cm	Área	30	cm^2

	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)
Chapa	93,6	0,75	70,20	52,65	17,55
Alma (web)	81	28,5	2308,50	65792,25	19683,00
Ala(flange)	30	56,25	1687,50	94921,88	5,63
	204,60	85,50	4066,20	160766,78	19706,18

Y(gconjunto)	19,87	cm
Ixx	180472,95	cm4
Ien	99661,70	cm4
y(max)	37,13	cm4
Z	2684,41	cm3

Espesor	15	mm		Módulo necesario
Bulbo	180	x	10	Zg 2302 cm3

Spar Zona 6 Espesor 14mm

Chapa	be	62,4	cm	t	1,4	cm	t/2	0,7	cm	Área	87,4	cm^2
Alma (web)	largo	54	cm	t	1,4	cm	t/2	0,7	cm	Área	75,6	cm^2
Ala (flange)	largo	20	cm	t	1,4	cm	t/2	0,7	cm	Área	28	cm^2

	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)
Chapa	87,36	0,7	61,15	42,81	14,27
Alma (web)	75,6	28,4	2147,04	60975,94	18370,80
Ala(flange)	28	56,1	1570,80	88121,88	4,57
	190,96	85,20	3778,99	149140,62	18389,64

Y(gconjunto)	19,79	cm
Ixx	167530,26	cm4
Ien	92746,12	cm4
y(max)	37,01	cm4
Z	2505,94	cm3

Espesor	14	mm	
Bulbo	180	x	8

Módulo necesario
Zg 1949 cm3

Spar Zona 7 Espesor 13mm

Chapa	be	62,4	cm	t	1,3	cm	t/2	0,65	cm	Área	81,1	cm^2
Alma (web)	largo	48	cm	t	1,3	cm	t/2	0,65	cm	Área	62,4	cm^2
Ala (flange)	largo	20	cm	t	1,3	cm	t/2	0,65	cm	Área	26	cm^2

	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)
Chapa	81,12	0,65	52,73	34,27	11,42
Alma (web)	62,4	25,3	1578,72	39941,62	11980,80
Ala(flange)	26	49,95	1298,70	64870,07	3,66
	169,52	75,90	2930,15	104845,95	11995,89

Y(gconjunto)	17,28	cm
Ixx	116841,84	cm4
Ien	66194,32	cm4
y(max)	33,32	cm4
Z	1986,92	cm3

Espesor	13	mm	
Bulbo	160	x	9

Módulo necesario
Zg 1640 cm3

Spar Zona 8 Espesor 12mm

Chapa	be	64,8	cm	t	1,2	cm	t/2	0,6	cm	Área	77,8	cm^2
Alma (web)	largo	42	cm	t	1,2	cm	t/2	0,6	cm	Área	50,4	cm^2
Ala (flange)	largo	20	cm	t	1,2	cm	t/2	0,6	cm	Área	24	cm^2

	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)
Chapa	77,76	0,6	46,66	27,99	9,33
Alma (web)	50,4	22,2	1118,88	24839,14	7408,80
Ala(flange)	24	43,8	1051,20	46042,56	2,88
	152,16	66,60	2216,74	70909,69	7421,01

Y(gconjunto)	14,57	cm
Ixx	78330,70	cm4
Ien	46036,28	cm4
y(max)	29,83	cm4
Z	1543,21	cm3

Espesor	12	mm	
Bulbo	140	x	10

Módulo necesario
Zg 1313 cm3

Spar Zona 9 Espesor 10mm												
Chapa	be	64,8	cm	t	1	cm	t/2	0,5	cm	Área	64,8	cm^2
Alma (web)	largo	42	cm	t	1	cm	t/2	0,5	cm	Área	42	cm^2
Ala (flange)	largo	20	cm	t	1	cm	t/2	0,5	cm	Área	20	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	64,8	0,5	32,40	16,20	5,40							
Alma (web)	42	22	924,00	20328,00	6174,00							
Ala(flange)	20	43,5	870,00	37845,00	1,67							
	126,80	66,00	1826,40	58189,20	6181,07							
Y(gconjunto)	14,40	cm										
Ixx	64370,27	cm4										
Ien	38063,19	cm4										
y(max)	29,60	cm4										
Z	1286,08	cm3										

Espesor	10	mm		Módulo necesario			
Bulbo	140	x	7	Zg	927	cm3	

Spar Zona 10 Espesor 10mm												
Chapa	be	65,6	cm	t	1	cm	t/2	0,5	cm	Área	66	cm^2
Alma (web)	largo	36	cm	t	1	cm	t/2	0,5	cm	Área	36	cm^2
Ala (flange)	largo	20	cm	t	1	cm	t/2	0,5	cm	Área	20	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	65,6	0,5	32,80	16,40	5,47							
Alma (web)	36	19	684,00	12996,00	3888,00							
Ala(flange)	20	37,5	750,00	28125,00	1,67							
	121,6	57,00	1466,80	41137,40	3895,13							
Y(gconjunto)	12,06	cm										
Ixx	45032,53	cm4										
Ien	27339,26	cm4										
y(max)	2594	cm4										
Z	1054,04	cm3										

Espesor	10	mm		Módulo necesario			
Bulbo	120	x	6	Zg	468	cm3	

Spar Zona 11 Espesor 10mm												
Chapa	be	65,6	cm	t	1	cm	t/2	0,5	cm	Área	66	cm^2
Alma (web)	largo	36	cm	t	1	cm	t/2	0,5	cm	Área	36	cm^2
Ala (flange)	largo	20	cm	t	1	cm	t/2	0,5	cm	Área	20	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	65,6	0,5	32,80	16,40	5,47							
Alma (web)	36	19	684,00	12996,00	3888,00							
Ala(flange)	20	37,5	750,00	28125,00	1,67							
	121,60	57,00	1466,80	41137,40	3895,13							
Y(gconjunto)	12,06	cm										
Ixx	45032,53	cm4										
Ien	27339,26	cm4										
y(max)	25,94	cm4										
Z	1054,04	cm3										

Espesor	10	mm		Módulo necesario			
Bulbo	120	x	6	Zg	226	cm3	

Spar Zona 11 Espesor 10mm (Reducción Diámetro 11,512mm)												
Chapa	be	96	cm	t	1	cm	t/2	0, 5	cm	Área	96	cm^2
Alma (web)	largo	36	cm	t	1	cm	t/2	0,5	cm	Área	36	cm^2
Ala (flange)	largo	20	cm	t	1	cm	t/2	0,5	cm	Área	20	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	96	0,5	48,00	24,00	8,00							
Alma (web)	36	19	684,00	12996,00	3888,0							
Ala(flange)	20	37,5	750,00	28125,00	1,67							
	152,00	57,00	1482,00	41145,00	3897,67							
Y(gconjunto)	9,75	cm										
Ixx	45042,67	cm4										
Ien	30593,17	cm4										
y(max)	28,25	cm4										
Z	1082,94	cm3										

Espesor	10	mm		Módulo necesario		
Bulbo	120	x	6	Zg	626	cm3

Tabla 32. Tabla comparativa modulo necesario y módulo estructura.

Secciones de los anillos:

Se mostrarán en función de las zonas.

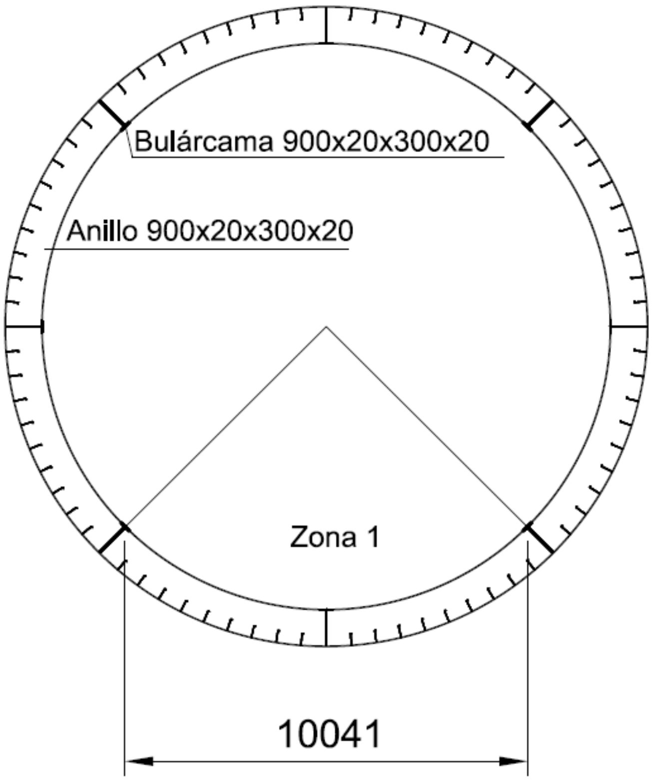


Ilustración 38.Sección Zona 1 Spar.

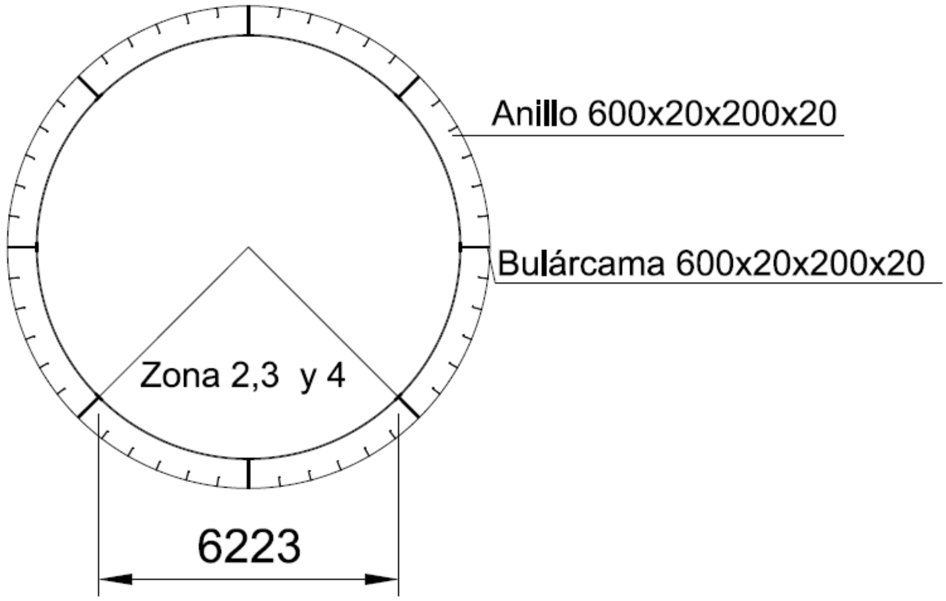


Ilustración 39.Sección Zona 2,3 y 4 Spar.

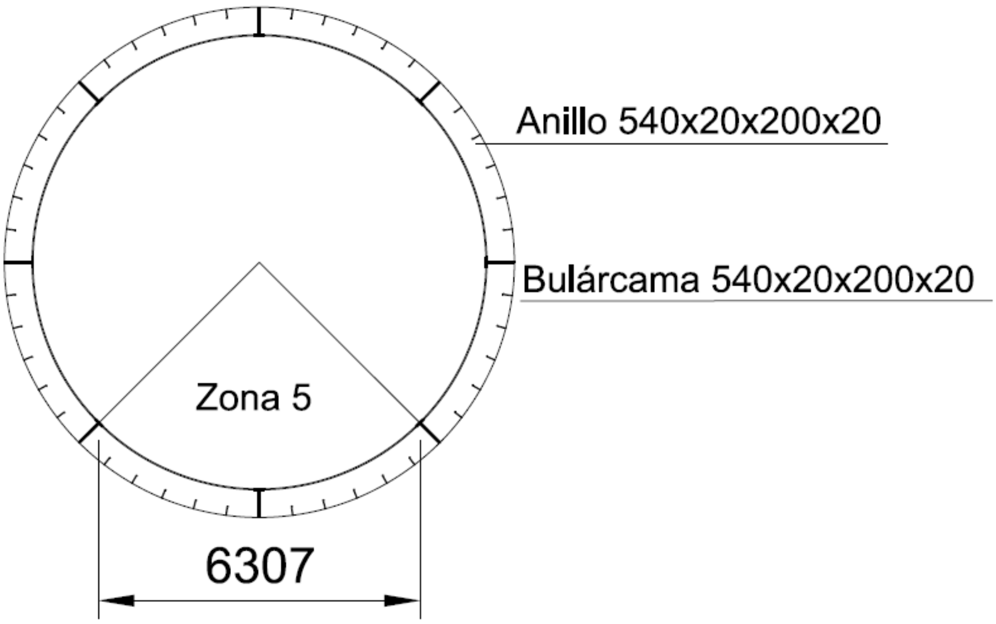


Ilustración 40.Sección Zona 5 Spar.

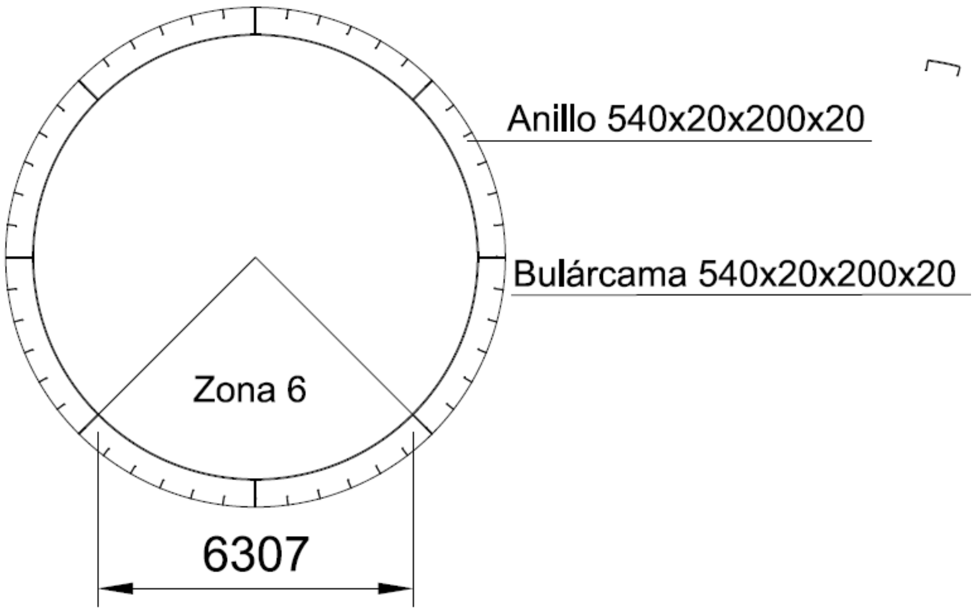


Ilustración 41.Sección Zona 6 Spar.

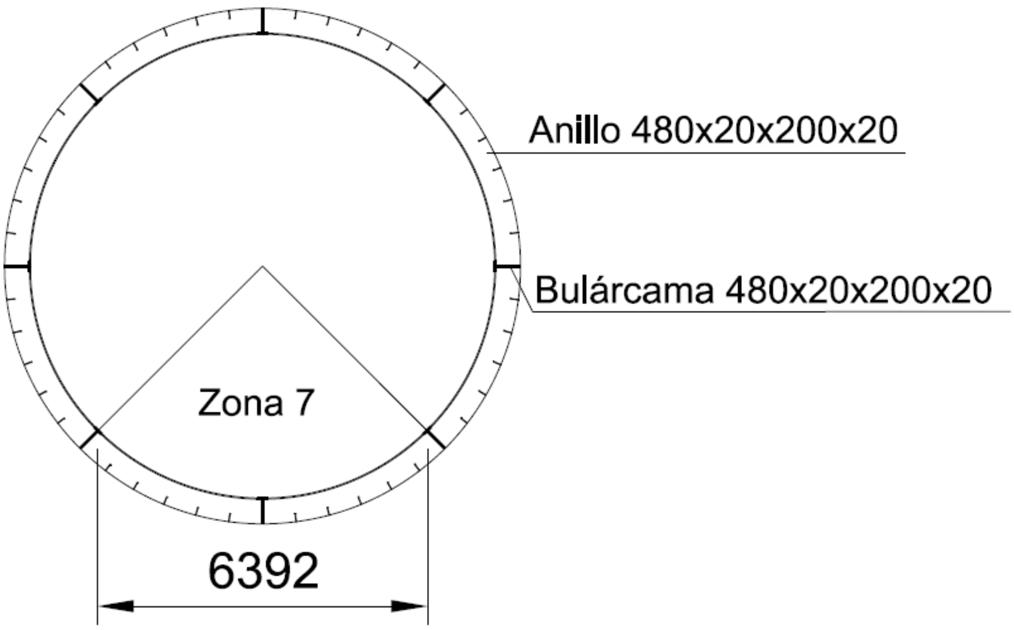


Ilustración 42.Sección Zona 7 Spar.

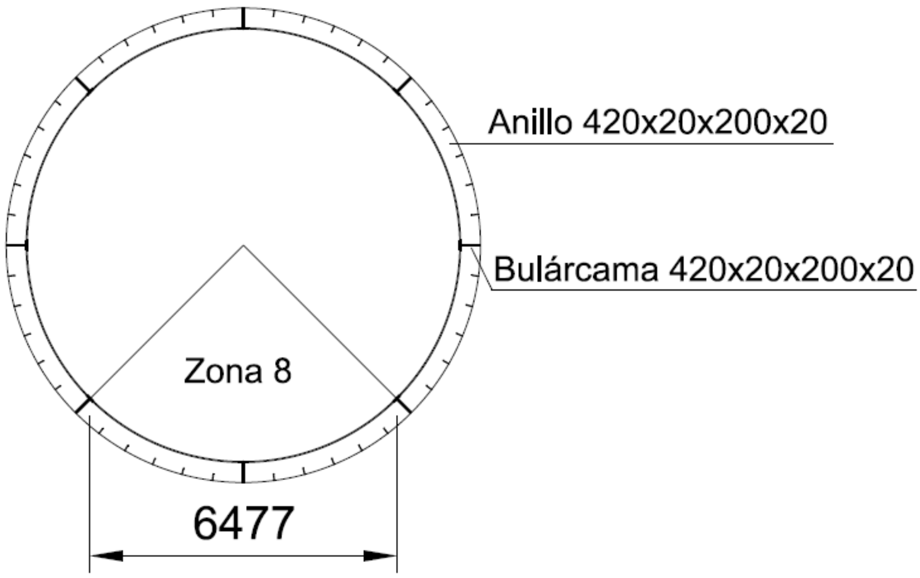


Ilustración 43.Sección Zona 8 Spar.

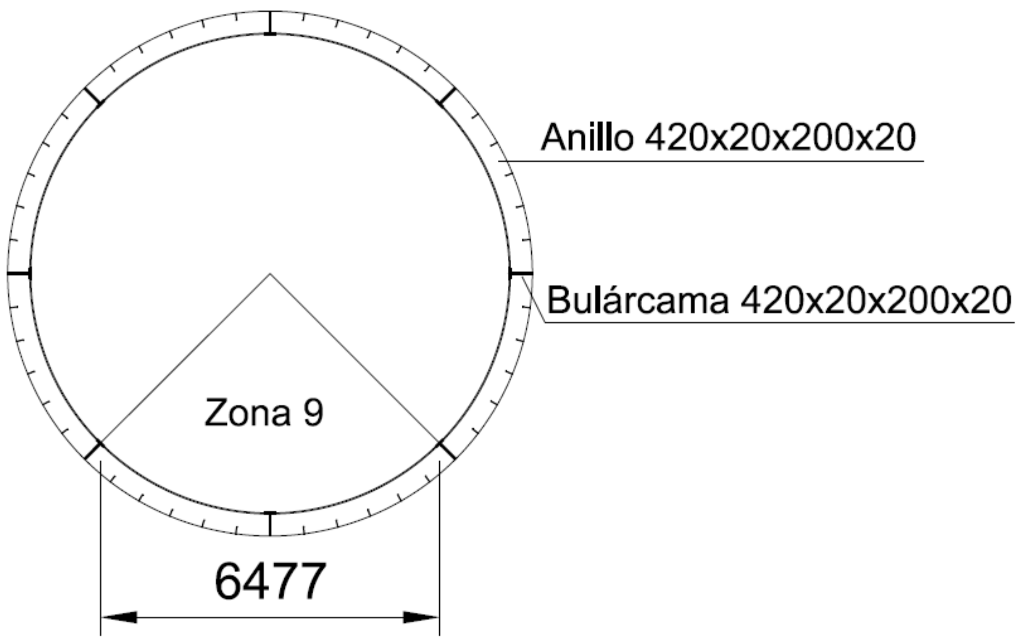


Ilustración 44.Sección Zona 9 Spar.

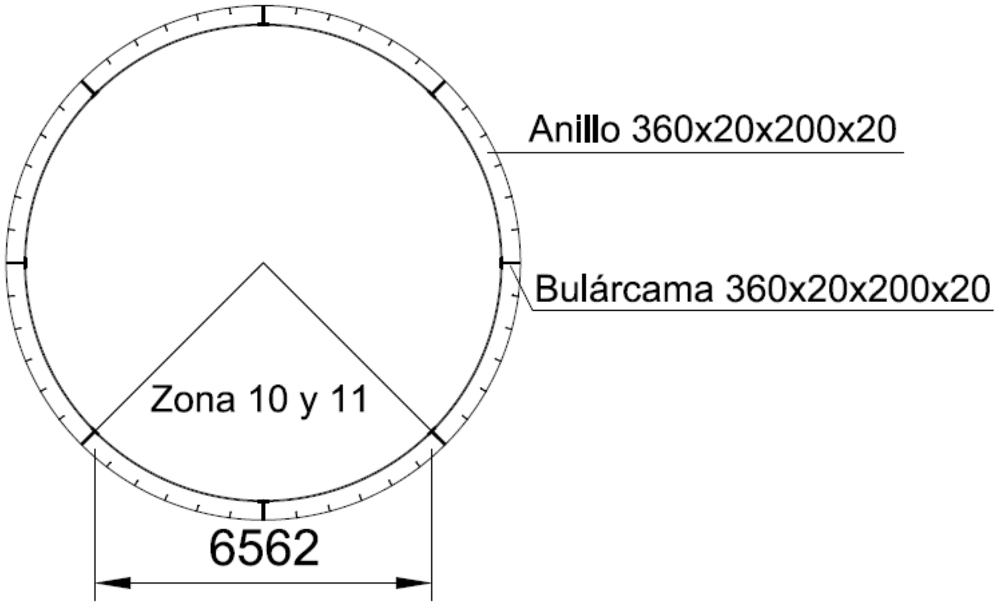


Ilustración 45.Sección Zona 10 y 11 Spar.

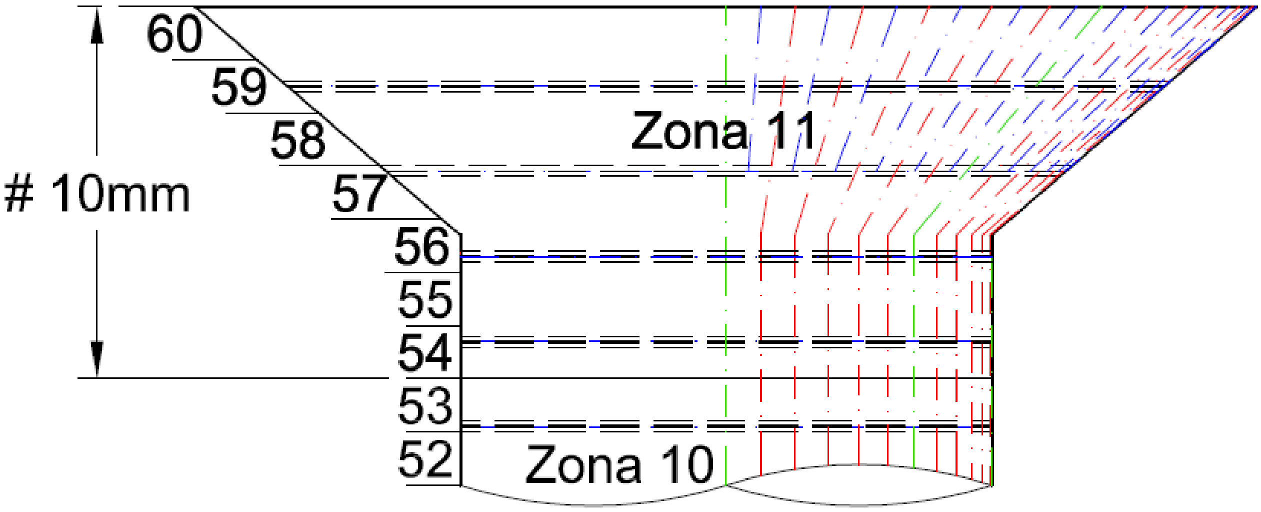


Ilustración 46.Sección Zona 11 Reducción Spar.

A continuación se calcularán los espesores de las cubiertas de la Spar, con sus reforzados, se puede ver la figura adjunta la nomenclatura de las cubiertas.

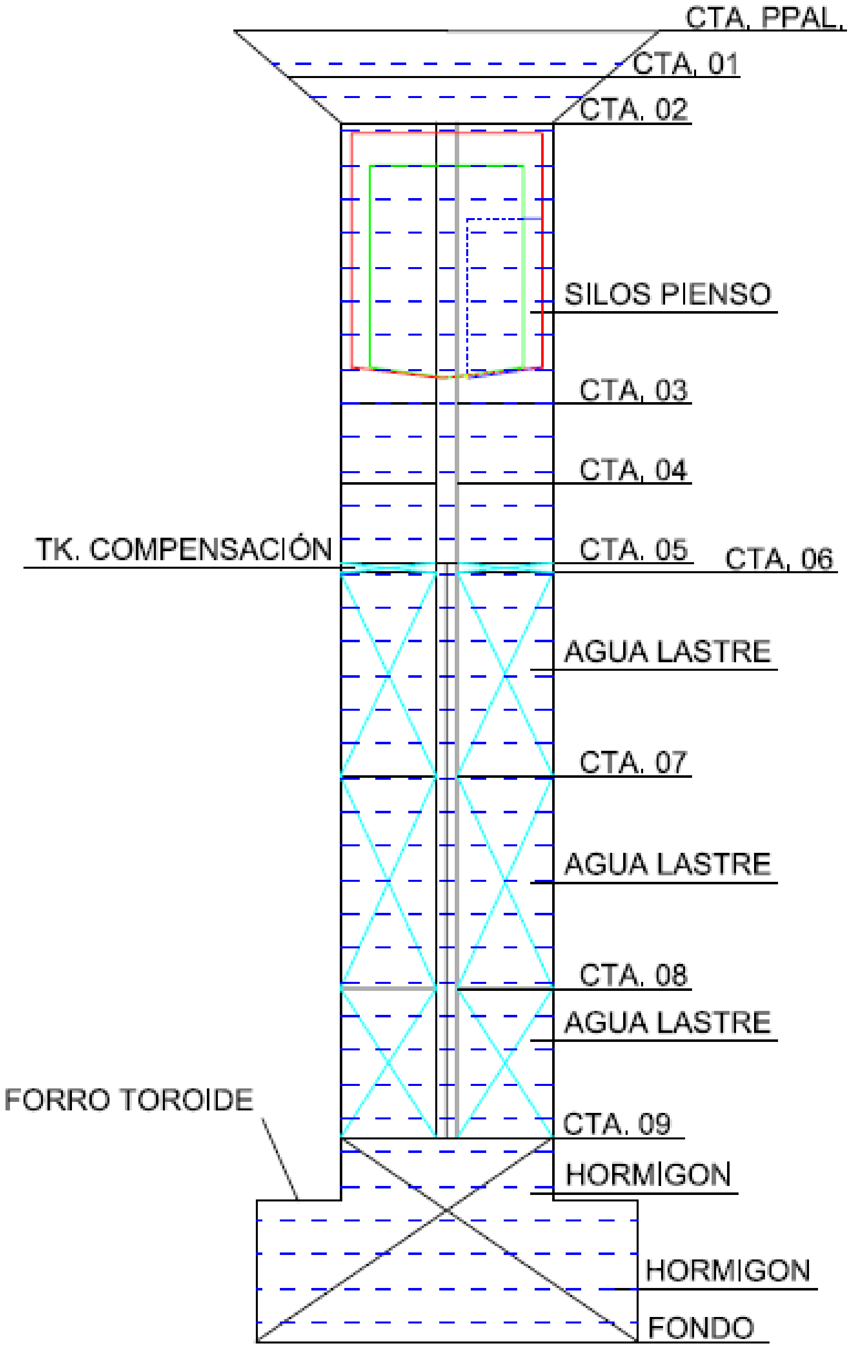


Ilustración 47.Disposición de las cubiertas.

5.4.3.5. CÁLCULO DEL ESPESOR Y REFUERZOS POR CUBIERTAS.

Cálculo del espesor y refuerzos de la cubierta principal.

Se calculará el espesor de la cubierta y el tipo de reforzado, mediante el DNV-OS-C101, siguiendo los mismos procedimientos que para el forro, tal como se nos indica en el DNV-OS-C106, Sección 5 C101.

Se calcula la carga en la cubierta mediante la siguiente tabla[24].

Table D1 Variable functional loads on deck areas

	Local design		*Primary design*	*Global design*
	Distributed load p (kN/m^2)	*Point load P (kN)*	*Apply factor to distributed load*	*Apply factor to primary design load*
Storage areas	q	1.5 q	1.0	1.0
Lay down areas	q	1.5 q	f	f
Lifeboat platforms	9.0	9.0	1.0	may be ignored
Area between equipment	5.0	5.0	f	may be ignored
Walkways, staircases and platforms, crew spaces	4.0	4.0	f	may be ignored
Walkways and staircases for inspection only	3.0	3.0	f	may be ignored
Areas not exposed to other functional loads	2.5	2.5	1.0	-

Notes:

— Wheel loads to be added to distributed loads where relevant. (Wheel loads can be considered acting on an area of 300 x 300 mm.)
— Point loads to be applied on an area 100 x 100 mm, and at the most severe position, but not added to wheel loads or distributed loads.
— q to be evaluated for each case. Lay down areas should not be designed for less than 15 kN/m^2.
— $f = \min\{1.0 ; (0.5 + 3/\sqrt{A})\}$, where A is the loaded area in m^2.
— Global load cases shall be established based upon "worst case", characteristic load combinations, complying with the limiting global criteria to the structure. For buoyant structures these criteria are established by requirements for the floating position in still water, and intact and damage stability requirements, as documented in the operational manual, considering variable load on the deck and in tanks.

Tabla 33. Calculo carga cubiertas.

Se calcula la carga en cubierta basándonos en la Tabla 33, se tomará como mínimo $15kN/m^2$, tal como se nos indica en las notas.

La máxima carga será la producida por el equipo de limpieza de redes, tal como se calcula a continuación.

$$q = \frac{2400kg}{4 \cdot 2} \cdot 0{,}01 = 3kN/m^2$$

De donde:

El peso del chigre es 2.400kg, con una huella de 4.000x2.000mm.

Se calcula el espesor de la cubierta mediante la siguiente fórmula.

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}} = \frac{15{,}8 \cdot 0{,}968 \cdot 0{,}650 \cdot \sqrt{15}}{\sqrt{204{,}31 \cdot 1}} = 2{,}7mm$$

Se toma un valor de s=650 y un valor de l=1400.

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}\!/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{650}\!/_{1400})^2 = \ 0{,}968$$

[24] DNV-OS-C101 D200.

Como el espesor obtenido es menor que el espesor mínimo definido en DNV-OS-Sec[5] F200 (espesor mínimo), 7 al que hemos de sumar 2mm, del espesor de corrosión, obteniendo así un espesor comercial de 10mm, por lo tanto el espesor de la cubierta será 10mm.

Cálculo de los refuerzos de la cubierta principal de la spar.

Se tomaran "T" como refuerzos primarios del fondo y llanta de bulbo como refuerzos secundarios.

Primero calcularemos los módulos admisibles para las presiones mediante la siguiente ecuación.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [25]

$$Z_{admisible} = \frac{1{,}40^2 \cdot 0{,}650 \cdot 15}{12 \cdot 204{,}35 \cdot 1} = 7{,}793\ cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

Chapa	65	cm	1	cm	0,5	Área	65	cm2				
Bulbo	80X6	8	cm	Área	6,21	cm2	I	38,7	cm4	d	4,78	cm
Y(gconjunto)	0,96	cm										
I(plancha)	5,42	cm4										
I(bulbo)	38,7	cm4			ESPESOR 10mm, Z(mínimo)= 7,793							
Ixx	267,83	cm4										
Ien	202,14	cm4										
Z	33,47	cm3										

Tabla 34. Tabla de Bulbos en función de los Momentos Flectores.

Bulbo resultante es de 80x6.

Calculo del módulo admisible para los refuerzos primarios:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

[25] DNV-OS-C101 Sec.[5] F400

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	CUBIERTA PRINCIPAL		
	S (m)	1/2 S(m)	t (mm)
	13,633	6,817	10
Zg (cm^3)	397,92		

Tabla 35. Calculo del módulo.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Cta. Ppal	13,633	6,817	6,817	4,87	0,72	1,008	101

Tabla 36. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[26] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

Cubierta Principal												
Chapa	be	100,8	cm	T	1	cm	t/2	0,5	Cm	Área	100,8	cm^2
Alma (web)	largo	24	cm	T	1	cm	t/2	0,5	Cm	Área	24	cm^2
Ala (flange)	largo	10	cm	T	1	cm	t/2	0,5	Cm	Área	10	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	100,8	0,5	50,40	25,20	8,40							
Alma (web)	24	13	312,00	4056,00	1152,00							
Ala(flange)	10	25,5	255,00	6502,50	0,83							
	134,80	39,00	617,40	10583,70	1161,23							

Y(gconjunto)	4,58	cm
Ixx	11744,93	cm4
Ien	8917,17	cm4
y(max)	21,42	cm4
Z	416,30	cm3

Espesor	10	mm			Módulo necesario	
Bulbo	80	x	6	Zg	398	cm3

Tabla 37. Cálculo refuerzos primarios cubierta principal.

Así obtenemos una "T" de 240x10x100x10.

[26] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

Cálculo del espesor y refuerzos de la cubierta 01.

Se calcula la carga en cubierta basándonos en la Tabla 33.

$$q = 1 \cdot 1 \cdot q = 1 \cdot 1 \cdot 4 = 4kN/m^2$$

Se calcula el espesor de la cubierta mediante la siguiente fórmula.

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}} = \frac{15{,}8 \cdot 0{,}996 \cdot 0{,}571 \cdot \sqrt{15}}{\sqrt{204{,}31 \cdot 1}} = 2{,}435mm$$

Se toma un valor de s=571 y un valor de l=1400.

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{571}/_{1400})^2 = \ 0{,}996$$

Como el espesor obtenido es menor que el espesor mínimo definido en DNV-OS-Sec[5] F200 (espesor mínimo), 7. No incluimos el espesor de corrosión al estar en el interior de la Spar, y se considera que con el tratamiento de pintura ya es suficiente.

Cálculo de los refuerzos de la cubierta 01 de la spar.

Se tomara "T" como refuerzos primarios, se calculan los módulos admisibles:

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [27]

$$Z_{admisible} = \frac{1{,}40^2 \cdot 0{,}571 \cdot 15}{12 \cdot 204{,}35 \cdot 1} = 6{,}846\ cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

Chapa	48	cm	0,7	cm	0,35	Área	33,6	cm2				
Bulbo	80X6	8	Cm	Área	6,21	cm2	I	38,7	cm4	d	4,78	cm
Y(gconjunto)	1,15	cm										
I(plancha)	1,37	cm4										
I(bulbo)	38,7	cm4			ESPESOR 7mm, Z(mínimo)= 6,846							
Ixx	230,68	cm4										
Ien	178,01	cm4										
Z	28,95	cm3										

Tabla 38. Tabla de Bulbos en función de los Momentos Flectores.

Bulbo resultante es de 80x6.

[27] DNV-OS-C101 Sec.[5] F400

Calculo del módulo admisible para los refuerzos primarios:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	CUBIERTA 01		
	S (m)	1/2 S (m)	t (mm)
	10,097	5,049	7
Zg (cm^3)	**218,27**		

Tabla 39. Calculo del módulo.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Cta 01	10,097	5,0485	5,0485	3,61	0,58	0,812	81,2

Tabla 40. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[28] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

Cubierta 01												
Chapa	be	81,2	cm	T	0,7	cm	t/2	0,35	Cm	Área	56,84	cm^2
Alma (web)	largo	24	cm	T	0,8	cm	t/2	0,4	Cm	Área	19,2	cm^2
Ala (flange)	largo	10	cm	T	0,8	cm	t/2	0,4	Cm	Área	8	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	56,84	0,35	19,89	6,96	2,32							
Alma (web)	19,2	12,7	243,84	3096,77	921,60							
Ala(flange)	8	25,1	200,80	5040,08	0,43							
	84,04	38,15	464,53	8143,81	924,35							

Y(gconjunto)	5,53	cm
Ixx	9068,16	cm4
Ien	6500,43	cm4
y(max)	19,97	cm4
Z	325,47	cm3

Espesor	7	mm			Módulo necesario	
Bulbo	80	X	6	Zg	**218**	cm3

Tabla 41. Refuerzos primarios cubierta 01.

Así obtenemos una "T" de 240x8x100x8.

[28] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

Cálculo del espesor y refuerzos de la cubierta 02.

Se calcula la carga en cubierta basándonos en la Tabla 33, se tomará como mínimo 15kN/m^2, tal como se nos indica en las notas.

La máxima carga será la producida por los chigres, tal como se calcula a continuación.

$$q = \frac{2.867kg}{2{,}155 \cdot 1{,}856} \cdot 0{,}01 = 7{,}17kN/m^2$$

De donde:

El peso del chigre es 2.867kg, con una huella de 2155x1856mm.

Se calcula el espesor de la cubierta mediante la siguiente fórmula.

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}} = \frac{15{,}8 \cdot 0{,}972 \cdot 0{,}640 \cdot \sqrt{15}}{\sqrt{204{,}31 \cdot 1}} = 2{,}663mm$$

Se toma un valor de s=640 y un valor de l=1400.

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{640}/_{1400})^2 = \ 0{,}972$$

Espesor de la chapa de cubierta 7mm.

Cálculo de los refuerzos de las cubiertas 02.

Se tomara "T" como refuerzos primarios del fondo y llanta de bulbo como refuerzos secundarios.

Primero calcularemos los módulos admisibles para las presiones mediante la siguiente ecuación.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [29]

$$Z_{admisible} = \frac{1{,}40^2 \cdot 0{,}640 \cdot 15}{12 \cdot 204{,}35 \cdot 1} = 7{,}673\ cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

[29] DNV-OS-C101 Sec.[5] F400

Chapa	64	cm	0,7	Cm	0,35	Área	44,8	cm2				
Bulbo	80X6	8	cm	Área	6,21	cm2	I	38,7	cm4	d	4,78	cm
Y(gconjunto)	0,97	cm										
I(plancha)	1,83	cm4										
I(bulbo)	38,7	cm4			ESPESOR 7mm, Z(mínimo)= 7,673							
Ixx	232,51	cm4										
Ien	184,06	cm4										
Z	29,10	cm3										

Tabla 42. Tabla de Bulbos en función de los Momentos Flectores.

Bulbo resultante es de 80x6.

Calculo del módulo admisible para los refuerzos primarios:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	Cubierta 02		
	S (m)	1/2 S (m)	t (mm)
	6,562	3,281	7
Zg (cm^3)	**92,19**		

Tabla 43. Calculo del módulo.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Cta 02	6,562	3,281	3,281	2,34	0,41	0,574	57,4

Tabla 44. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[30] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

[30] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

Spar Cubierta 02												
Chapa	be	57,4	cm	t	0,7	cm	t/2	0,35	cm	Área	40,18	cm^2
Alma (web)	largo	24	cm	t	0,8	cm	t/2	0,4	cm	Área	19,2	cm^2
Ala (flange)	largo	10	cm	t	0,8	cm	t/2	0,4	cm	Área	8	cm^2

	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)
Chapa	40,18	0,35	14,06	4,92	1,64
Alma (web)	19,2	12,7	243,84	3096,77	921,60
Ala(flange)	8	25,1	200,80	5040,08	0,43
	67,38	38,15	458,70	8141,77	923,67

Y(gconjunto)	6,81	cm
Ixx	9065,44	cm4
Ien	5942,72	cm4
y(max)	18,69	cm4
Z	317,92	cm3

					Módulo necesario	
Espesor	7	mm				
Bulbo	80	x	6	Zg	92	cm3

Tabla 45. Refuerzos primarios cubierta 02.

Así obtenemos una "T" de 240x8x100x8.

Cálculo del espesor y refuerzos de la cubierta 03.

Se calcula la carga en cubierta basándonos en la Tabla 33, se tomará como mínimo 15kN/m^2, tal como se nos indica en las notas.

La máxima carga será la producida por el compresor, tal como se calcula a continuación.

$$q = \frac{750kg}{1{,}31 \cdot 0{,}84} \cdot 0{,}01 = 6{,}815kN/m^2$$

Por lo tanto el mayor valor para la presión de la cubierta tomaremos 15.

Se calcula el espesor de la cubierta mediante la siguiente fórmula.

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}} = \frac{15{,}8 \cdot 0{,}972 \cdot 0{,}640 \cdot \sqrt{15}}{\sqrt{204{,}31 \cdot 1}} = 2{,}663mm$$

Se toma un valor de s=640 y un valor de l=1400.

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{640}/_{1400})^2 = \ 0{,}972$$

Igual que anteriormente, se toma 7mm, para el espesor de la cubierta.

Cálculo de los refuerzos de las cubiertas 03.

Se tomara "T" como refuerzos primarios del fondo y llanta de bulbo como refuerzos secundarios.

Cálculo de los módulos admisibles.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [31]

$$Z_{admisible} = \frac{1{,}40^2 \cdot 0{,}640 \cdot 15}{12 \cdot 204{,}35 \cdot 1} = 7{,}637\ cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

Chapa	64	cm	0,7	Cm	0,35	Área	44,8	cm2				
Bulbo	80X6	8	cm	Área	6,21	cm2	I	38,7	cm4	d	4,78	cm
Y(gconjunto)	0,97	cm										
I(plancha)	1,83	cm4										
I(bulbo)	38,7	cm4			ESPESOR 7mm, Z(mínimo)= 7,673							
Ixx	232,51	cm4										
Ien	184,06	cm4										
Z	29,10	cm3										

Tabla 46. Tabla de Bulbos en función de los Momentos Flectores.

Bulbo resultante es de 80x6.

Calculo del módulo admisible para los refuerzos primarios:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	Cubierta 03		
	S (m)	1/2 S (m)	t (mm)
	6,477	3,2385	7
Zg (cm^3)	**89,82**		

Tabla 47. Calculo del módulo.

[31] DNV-OS-C101 Sec.[5] F400

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Cta 03	6,477	3,2385	3,2385	2,31	0,405	0,567	56,7

Tabla 48. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[32] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

Cubierta 03.												
Chapa	be	56,7	cm	t	0,7	cm	t/2	0,35	cm	Área	39,69	cm^2
Alma (web)	largo	24	cm	t	1	cm	t/2	0,5	cm	Área	24	cm^2
Ala (flange)	largo	10	cm	t	1	cm	t/2	0,5	cm	Área	10	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	39,69	0,35	13,89	4,86	1,62							
Alma (web)	24	12,7	304,80	3870,96	1152,00							
Ala(flange)	10	25,2	252,00	6350,40	0,83							
	73,69	38,25	570,69	10226,22	1154,45							

Y(gconjunto)	7,74	cm
Ixx	11380,68	cm4
Ien	6960,96	cm4
y(max)	17,96	cm4
Z	387,68	cm3

Espesor	7	mm			Módulo necesario		
Bulbo	80	x	6	Zg	90	cm3	

Tabla 49. Refuerzos primarios cubierta 03.

Así obtenemos una "T" de 240x10x100x10.

Cálculo del espesor y refuerzos de la cubierta 04.

Se calcula la carga en cubierta basándonos en la Tabla 33, se tomará como mínimo 15kN/m^2, tal como se nos indica en las notas.

La máxima carga será la producida por el diesel generador, tal como se calcula a continuación.

$$q = \frac{1.434kg}{2,146 \cdot 0,840} \cdot 0,01 = 7,955kN/m^2$$

[32] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

De donde:

El peso del diesel generador es 1.434kg, con una huella de 2146x840mm.

Se calcula el espesor de la cubierta mediante la siguiente fórmula.

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}} = \frac{15{,}8 \cdot 0{,}972 \cdot 0{,}640 \cdot \sqrt{15}}{\sqrt{204{,}31 \cdot 1}} = 2{,}663mm$$

Se toma un valor de s=640 y un valor de l=1400.

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{640}/_{1400})^2 = \ 0{,}972$$

Espesor mínimo de la cubierta 7mm.

Cálculo de los refuerzos de las cubiertas 04.

Se tomara "T" como refuerzos primarios del fondo y llanta de bulbo como refuerzos secundarios.

Primero calcularemos los módulos admisibles para las presiones mediante la siguiente ecuación.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [33]

$$Z_{admisible} = \frac{1{,}40^2 \cdot 0{,}640 \cdot 15}{12 \cdot 204{,}35 \cdot 1} = 7{,}637\ cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

Chapa	**64**	**cm**	**0,7**	**cm**	**0,35**	**Área**	**44,8**	**cm2**				
Bulbo	**80X6**	**8**	**cm**	**Área**	**6,21**	**cm2**	**I**	**38,7**	**cm4**	**d**	**4,78**	**cm**
Y(gconjunto)	0,97	cm										
I(plancha)	1,83	cm4										
I(bulbo)	38,7	cm4			ESPESOR 7mm, Z(mínimo)= 7,673							
Ixx	232,51	cm4										
Ien	184,06	cm4										
Z	**29,10**	**cm3**										

Tabla 50. Tabla de Bulbos en función de los Momentos Flectores.

[33] DNV-OS-C101 Sec.[5] F400

Bulbo resultante es de 80x6.

Calculo del módulo admisible para los refuerzos primarios:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	Cubierta 04		
	S (m)	1/2 S (m)	t (mm)
	6,477	3,2385	7
Zg (cm^3)	**89,82**		

Tabla 51. Calculo del módulo.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Cta 04	6,477	3,2385	3,2385	2,31	0,405	0,567	56,7

Tabla 52. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[34] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

Cubierta 04												
Chapa	be	56,7	cm	t	0,7	cm	t/2	0,35	cm	Área	39,69	cm^2
Alma (web)	largo	24	cm	t	0,8	cm	t/2	0,4	cm	Área	19,2	cm^2
Ala (flange)	largo	10	cm	t	0,8	cm	t/2	0,4	cm	Área	8	cm^2

	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)
Chapa	39,69	0,35	13,89	4,86	1,62
Alma (web)	19,2	12,7	243,84	3096,77	921,60
Ala(flange)	8	25,1	200,80	5040,08	0,43
	66,89	38,15	458,53	8141,71	923,65

Y(gconjunto)	6,86	cm
Ixx	9065,36	cm4
Ien	5922,12	cm4
y(max)	18,64	cm4
Z	317,63	cm3

Espesor	7	mm		Módulo necesario			
Bulbo	80	x	6	Zg	90	cm3	

Tabla 53. Refuerzos primarios cubierta 04.

Así obtenemos una "T" de 240x8x100x8.

[34] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

Cálculo del espesor y refuerzos de la cubierta 05.

Se calcula la carga en cubierta basándonos en la Tabla 33, se tomará como mínimo 15kN/m^2, tal como se nos indica en las notas.

La máxima carga será la producida por el tanque de combustible, tal como se calcula a continuación.

$$q = \frac{18.590kg}{4,910 \cdot 2,500} \cdot 0,01 = 15,14kN/m^2$$

De donde:

El peso del tanque de combustible vacio es de 1.590kg, con una capacidad de 20m^3, tenemos un peso de combustible de 17.000kg. La huella del tanque es de 4910x2500mm.

Se calcula el espesor de la cubierta mediante la siguiente fórmula.

$$t = \frac{15,8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}} = \frac{15,8 \cdot 0,972 \cdot 0,640 \cdot \sqrt{15,14}}{\sqrt{204,31 \cdot 1}} = 2,674mm$$

Se toma un valor de s=640 y un valor de l=1400.

$$k_a = \left(1,1 - 0,25\, {s}/{l}\right)^2 = (1,1 - 0,25 \cdot {640}/{1400})^2 = \ 0,972$$

Espesor mínimo de la cubierta 7mm, pero como tenemos un tanque de lastre en la zona inferior, se le da a la chapa 2mm de espesor por corrosión, por lo que tenemos un espesor de 9mm, dejando al final un espesor comercial de 10mm.

Cálculo de los refuerzos de las cubiertas 05.

Se tomara "T" como refuerzos primarios del fondo y llanta de bulbo como refuerzos secundarios.

Cálculo de los módulos admisibles.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [35]

$$Z_{admisible} = \frac{1,40^2 \cdot 0,640 \cdot 15}{12 \cdot 204,35 \cdot 1} = 7,745\ cm^3$$

[35] DNV-OS-C101 Sec.[5] F400

Siguiendo el procedimiento anterior, obtenemos:

Chapa	64	cm	1	cm	0,5	Área	64	cm2				
Bulbo	80X6	8	cm	Área	6,21	cm2	I	38,7	cm4	d	4,78	cm
Y(gconjunto)	0,97	cm										
I(plancha)	5,33	cm4										
I(bulbo)	38,7	cm4			ESPESOR 10mm, Z(mínimo)= 7,745							
Ixx	267,50	cm4										
Ien	201,85	cm4										
Z	**33,46**	**cm3**										

Tabla 54. Tabla de Bulbos en función de los Momentos Flectores.

Bulbo resultante es de 80x6.

Calculo del módulo admisible para los refuerzos primarios:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	Cubierta 05		
	S (m)	1/2 S (m)	t (mm)
	6,392	3,196	10
Zg (cm^3)	**88,29**		

Tabla 55. Calculo del módulo.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Cta 05	6,392	3,196	3,196	2,28	0,39	0,546	54,6

Tabla 56. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[36] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

[36] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

Cta 05												
Chapa	be	54,6	cm	t	1	cm	t/2	0,5	cm	Área	54,6	cm^2
Alma (web)	largo	24	cm	t	0,8	cm	t/2	0,4	cm	Área	19,2	cm^2
Ala (flange)	largo	10	cm	t	0,8	cm	t/2	0,4	cm	Área	8	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	54,6	0,5	27,30	13,65	4,55							
Alma (web)	19,2	13	249,60	3244,80	921,60							
Ala(flange)	8	25,4	203,20	5161,28	0,43							
	81,80	38,90	480,10	8419,73	926,58							

Y(gconjunto)	5,87	cm
Ixx	9346,31	cm4
Ien	6528,51	cm4
y(max)	19,93	cm4
Z	327,56	cm3

				Módulo necesario		
Espesor	7	mm				
Bulbo	80	x	6	Zg	88	cm3

Tabla 57. Refuerzos primarios cubierta 05.

Así obtenemos una "T" de 240x8x100x8.

Cálculo del espesor y refuerzos de la cubierta 06.

Se calculará la presión ejercida en el fondo del tanque de la cubierta 6 de la Spar, mediante la siguiente fórmula[37]:

$$P_d = \rho \cdot g_0 \cdot h_{op} \cdot \left(\gamma_{f,G,Q} + \frac{a_v}{g_o} \cdot \gamma_{f,E}\right) \; (kN/m^2)$$

De donde obtenemos el siguiente valor para la presión:

$$P_d = 1{,}025 \cdot 9{,}81 \cdot 10{,}44 \cdot \left(1 + \frac{2{,}4525}{9{,}81} \cdot 1{,}3\right) = 139{,}09\; kN/m^2$$

Se calcula el espesor de la cubierta mediante la siguiente expresión:

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}} \; (mm)$$

que tomarán s y l.

Se tomará s = 605mm y l=1400mm.

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{605}/_{1400})^2 = \; 0{,}984$$

[37] DNV-OS-C101.Sec[3], D307.

Sustituyendo los valores en la expresión del espesor obtenemos:

Espesor t (mm)	8	mm
Espesor t (mm) + t corrosión	**10**	mm

Tabla 58. Espesor cubierta tanque de compensación.

Espesor de la cubierta 10mm.

Cálculo de los refuerzos del tanque cubierta 06.

Se tomara "T" como refuerzos primarios del fondo y bulbo como refuerzos secundarios.

Cálculo del módulo admisible.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [38]

$$Z_{admisible} = \frac{1{,}40^2 \cdot 0{,}605 \cdot 139{,}09}{12 \cdot 204{,}35 \cdot 1} = 67{,}262 cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

Chapa	**60,5**	**cm**	**1**	**cm**	**0,5**	**Área**	**60,5**	**cm2**				
Bulbo	**140X7**	**14**	**cm**	**Área**	**12,43**	**cm2**	**I**	**241**	**cm4**	**d**	**8,32**	**cm**
Y(gconjunto)	2,00	cm										
I(plancha)	5,04	cm4										
I(bulbo)	241	cm4			ESPESOR	10mm	10	Z	67,262	cm3		
Ixx	1340,87	cm4										
Ien	1048,20	cm4										
Z	**95,32**	**cm3**										

Tabla 59. Tabla de Bulbos en función de los Momentos Flectores.

Calculo del módulo admisible:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	CUBIERTA 06		
	S (m)	**1/2 S (m)**	**t (mm)**
	6,392	3,196	10
Zg (cm^3)	**822,73**		

Tabla 60. Calculo del módulo.

[38] DNV-OS-C101 Sec.[5] F400

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Cta 06	6,392	3,196	3,196	2,25	0,39	0,5538	55,38

Tabla 61. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[39] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

CUBIERTA 06												
Chapa	be	55,38	cm	t	1	cm	t/2	0,5	cm	Área	55,38	cm^2
Alma (web)	largo	42	cm	t	0,8	cm	t/2	0,4	cm	Área	33,6	cm^2
Ala (flange)	largo	15	cm	t	0,8	cm	t/2	0,4	cm	Área	12	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	55,38	0,5	27,69	13,85	4,62							
Alma (web)	33,6	22	739,20	16262,40	4939,20							
Ala(flange)	12	43,4	520,80	22602,72	0,64							
	100,98	65,90	1287,69	38878,97	4944,46							

Y(gconjunto)	12,75	cm
Ixx	43823,42	cm4
Ien	27402,89	cm4
y(max)	31,05	cm4
Z	882,60	cm3

Espesor	10	mm			Módulo necesario	
Bulbo	140	x	7	Zg	823	cm3

Tabla 62.Reforzado cubierta tanque compensación.

Así obtenemos una "T" de 420X8X150X8.

Cálculo del espesor y refuerzos de la cubierta 07.

Se calculará la presión ejercida en el fondo de la Spar, mediante la siguiente fórmula[40]:

$$P_d = \rho \cdot g_0 \cdot h_{op} \cdot \left(\gamma_{f,G,Q} + \frac{a_v}{g_o} \cdot \gamma_{f,E}\right) \ (kN/m^2)$$

$$P_d = 1{,}025 \cdot 9{,}81 \cdot (20) \cdot \left(1 + \frac{2{,}4525}{9{,}81} \cdot 1{,}3\right) = 266{,}46\ kN/m^2$$

Se calcula el espesor de la cubierta mediante la siguiente expresión:

[39] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).
[40] DNV-OS-C101.Sec[3], D307.

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd1} \cdot k_{pp}}}\ (mm)$$

Valor de s=605mm y l=1400mm.

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{605}/_{1400})^2 = 0{,}984$$

Sustituyendo los valores en la expresión del espesor obtenemos:

Espesor t (mm)	11	mm
Espesor t (mm) + t corrosión	**13**	mm

Tabla 63. Espesor cubierta tanque 07.

El espesor del tanque es de 13mm.

Cálculo de los refuerzos de la la cubierta 07.

Se tomara llanta de bulbo como refuerzos secundarios del fondo.

Se calculan los módulos admisibles para las presiones mediante la siguiente ecuación.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [41]

$$Z_{admisible} = \frac{1{,}40^2 \cdot 0{,}605 \cdot 266{,}46}{12 \cdot 204{,}35 \cdot 1} = 128{,}854 cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

Chapa	**60,5**	**cm**	**1,3**	**cm**	**0,65**	**Área**	**78,65**	**cm2**				
Bulbo	**160X7**	**16**	**cm**	**Área**	**14,6**	**cm2**	**I**	**373**	**cm4**	**d**	**9,66**	
Y(gconjunto)	2,26	cm										
I(plancha)	11,08	cm4										
I(bulbo)	373	cm4			ESPESOR	13mm	Z	128,854	cm3			
Ixx	2171,08	cm4										
Ien	1693,02	cm4										
Z	**136,14**	**cm3**										

Tabla 64. Tabla de Bulbos en función de los Momentos Flectores.

Así obtenemos bulbo de 160x7.

Se tomara "T" como refuerzos primarios del fondo.

[41] DNV-OS-C101 Sec.[5] F400

Calculo del módulo admisible:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	CUBIERTA07		
	S (m)	1/2 S (m)	t (mm)
	6,307	3,1535	13
Zg (cm^3)	1534,48		

Tabla 65. Calculo del módulo.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Cta 07	6,307	3,1535	3,1535	2,22	0,39	0,5538	55,38

Tabla 66. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[42] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

CUBIERTA 07												
Chapa	be	55,38	cm	t	1,3	cm	t/2	0,65	cm	Área	71,99	cm^2
Alma (web)	largo	48	cm	t	1,5	cm	t/2	0,75	cm	Área	72	cm^2
Ala (flange)	largo	15	cm	t	1,5	cm	t/2	0,75	cm	Área	22,5	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	71,994	0,65	46,80	30,42	10,14							
Alma (web)	72	25,3	1821,60	46086,48	13824,00							
Ala(flange)	22,5	50,05	1126,13	56362,56	4,22							
	166,494	76,00	2994,52	102479,45	13838,36							

Y(gconjunto)	17,99	cm
Ixx	116317,81	cm4
Ien	62459,07	cm4
y(max)	32,81	cm4
Z	1903,41	cm3

Espesor	13	mm		Módulo necesario		
Bulbo	160	x	7	Zg	1534	cm3

Tabla 67. Reforzado cubierta 07.

Así obtenemos una "T" de 480x15x150x15.

[42] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

Cálculo del espesor y refuerzos de la cubierta 08.

Se calculará la presión ejercida en el fondo de la Spar, mediante la siguiente fórmula[43]:

$$P_d = \rho \cdot g_0 \cdot h_{op} \cdot \left(\gamma_{f,G,Q} + \frac{a_v}{g_o} \cdot \gamma_{f,E}\right) \ (kN/m^2)$$

$$P_d = 1{,}025 \cdot 9{,}81 \cdot 30 \cdot \left(1 + \frac{2{,}4525}{9{,}81} \cdot 1{,}3\right) = 399{,}70\ kN/m^2$$

Se calcula el espesor de la plancha de cubierta mediante la siguiente expresión:

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}}\ (mm)$$

Valor de s=605mm y l=1400mm.

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{605}/_{1400})^2 = 0{,}984$$

Sustituyendo los valores en la expresión del espesor obtenemos:

Espesor t (mm)	13	mm
Espesor t (mm) + t corrosión	**15**	mm

Tabla 68. Espesor cubierta tanque 08.

El espesor del tanque es de 15mm.

Cálculo de los refuerzos de la cubierta 08.

Se tomara llanta de bulbo como refuerzos secundarios del fondo.

Se calculan los módulos admisibles para las presiones mediante la siguiente ecuación.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [44]

$$Z_{admisible} = \frac{1{,}40^2 \cdot 0{,}605 \cdot 399{,}70}{12 \cdot 204{,}35 \cdot 1} = 193{,}281 cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

[43] DNV-OS-C101.Sec[3], D307.
[44] DNV-OS-C101 Sec.[5] F400

Chapa	60,5	cm	1,5	cm	0,75	Área	90,75	cm2					
Bulbo	180X8	18	cm	Área	18,86	cm2	I	609	cm4	d	10,89	cm	
Y(gconjunto)	2,75	cm											
I(plancha)	17,02	cm4											
I(bulbo)	609	cm4			ESPESOR	15mm	Z	min		193,281			
Ixx	3572,30	cm4											
Ien	2741,67	cm4											
Z	199,44	cm3											

Tabla 69. Tabla de Bulbos en función de los Momentos Flectores.

Así obtenemos bulbo de 180X8.

Se tomara "T" como refuerzos primarios del fondo.

Calculo del módulo admisible:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	CUBIERTA 08		
	S (m)	1/2 S (m)	t (mm)
	6,223	3,1115	15
Zg (cm^3)	**2240,82**		

Tabla 70. Calculo del módulo.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Cta 08	6,223	3,1115	3,1115	2,19	0,38	0,5396	53,96

Tabla 71. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[45] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

[45] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

CUBIERTA 08												
Chapa	be	53,96	cm	t	1,5	cm	t/2	0,75	cm	Área	80,94	cm^2
Alma (web)	largo	54	cm	t	1,5	cm	t/2	0,75	cm	Área	81	cm^2
Ala (flange)	largo	22	cm	t	1,5	cm	t/2	0,75	cm	Área	33	cm^2
º	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	80,94	0,75	60,71	45,53	15,18							
Alma (web)	81	28,5	2308,50	65792,25	19683,00							
Ala(flange)	33	56,25	1856,25	104414,06	6,19							
	194,94	85,50	4225,46	170251,84	19704,36							

Y(gconjunto)	21,68	cm
Ixx	189956,21	cm4
Ien	98366,64	cm4
y(max)	35,32	cm4
Z	2784,67	cm3

Espesor	15	mm		Módulo necesario		
Bulbo	180	x	8	Zg	2241	cm3

Tabla 72. Reforzado cubierta 08.

Así obtenemos una "T" de 540X15X220X15.

Cálculo del espesor y refuerzos de la cubierta 09.

Se calculará la presión ejercida en el fondo de la Spar, mediante la siguiente fórmula[46]:

$$P_d = \rho \cdot g_0 \cdot h_{op} \cdot \left(\gamma_{f,G,Q} + \frac{a_v}{g_o} \cdot \gamma_{f,E}\right) \ (kN/m^2)$$

$$P_d = 1{,}025 \cdot 9{,}81 \cdot 37 \cdot \left(1 + \frac{2{,}4525}{9{,}81} \cdot 1{,}3\right) = 492{,}96\ kN/m^2$$

Se calcula el espesor de la plancha de cubierta mediante la siguiente expresión:

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd1} \cdot k_{pp}}} \ (mm)$$

Valor de s=605mm y l=1400mm.

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{605}/_{1400})^2 = 0{,}984$$

Sustituyendo los valores en la expresión del espesor obtenemos:

46 DNV-OS-C101.Sec[3], D307.

Espesor t (mm)	15	mm
Espesor t (mm) + t corrosión	**17**	mm

Tabla 73. Espesor cubierta tanque 09.

El espesor del tanque es de 17mm.

Cálculo de los refuerzos de cubierta 09.

Se tomara llanta de bulbo como refuerzos secundarios del fondo.

Se calculan los módulos admisibles para las presiones mediante la siguiente ecuación.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [47]

$$Z_{admisible} = \frac{1{,}40^2 \cdot 0{,}605 \cdot 492{,}96}{12 \cdot 204{,}35 \cdot 1} = 2438{,}380 cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

Chapa	60,5	cm	1,6	cm	0,8	Área	96,8	cm2				
Bulbo	180x11	18	cm	Área	24,26	cm2	I	770	cm4	d	10,47	cm
Y(gconjunto)	3,06	cm										
I(plancha)	20,65	cm4										
I(bulbo)	770	cm4			ESPESOR	16mm Z		min	238,380	cm3		
Ixx	4386,92	cm4										
Ien	3254,50	cm4										
Z	243,94	cm3										

Tabla 74. Tabla de Bulbos en función de los Momentos Flectores.

Así obtenemos bulbo de 180X11.

Se tomara "T" como refuerzos primarios del fondo.

Calculo del módulo admisible:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

[47] DNV-OS-C101 Sec.[5] F400

	CUBIERTA 09		
	S (m)	1/2 S (m)	t (mm)
	6,223	3,1115	17
Zg (cm^3)	2763,68		

Tabla 75. Calculo del módulo.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Cta 09	6,223	3,1115	3,1115	2,19	0,38	0,5396	53,96

Tabla 76. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[48] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

CUBIERTA 09												
Chapa	be	53,96	cm	t	1,6	cm	t/2	0,8	cm	Área	91,732	cm^2
Alma (web)	largo	54	cm	t	1,5	cm	t/2	0,75	cm	Área	81	cm^2
Ala (flange)	largo	22	cm	t	1,5	cm	t/2	0,75	cm	Área	33	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	91,732	0,85	77,97	66,28	22,09							
Alma (web)	81	28,7	2324,70	66718,89	19683,00							
Ala(flange)	33	56,35	1862,85	105157,89	6,19							
	205,732	86	4265,52	171943,05	1971,281							

Y(gconjunto)	20,73	cm
Ixx	191654,33	cm4
Ien	103215,58	cm4
y(max)	36,47	cm4
Z	2830,41	cm3

Espesor	17	mm		Módulo necesario		
Bulbo	180	x	11	Zg	2689	cm3

Tabla 77. Reforzado cubierta 08.

Así obtenemos una "T" de 540x15x220x15.

Cálculo del espesor y refuerzos, forro toroide.

Se calculará la presión ejercida en el fondo de la Spar, mediante la siguiente fórmula[49]:

[48] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).
[49] DNV-OS-C101.Sec[3], D307.

$$P_d = \rho \cdot g_0 \cdot h_{op} \cdot \left(\gamma_{f,G,Q} + \frac{a_v}{g_o} \cdot \gamma_{f,E}\right) \ (kN/m^2)$$

$$P_d = 1{,}025 \cdot 9{,}81 \cdot 40 \cdot \left(1 + \frac{2{,}4525}{9{,}81} \cdot 1{,}3\right) = 532{,}93\ kN/m^2$$

Se calcula el espesor de la plancha de cubierta mediante la siguiente expresión:

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}} \ (mm)$$

Valor de *s=770mm y l=1400mm.*

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{0{,}77}/_{1400})^2 = \ 0{,}926$$

Sustituyendo los valores en la expresión del espesor obtenemos:

Espesor t (mm)	14	mm
Espesor t (mm) + t corrosión	**16**	mm

Tabla 78. Espesor cubierta fondo toroide.

El espesor del tanque de 16mm, se compara con Tabla 27. Tabla de Espesores.(debido a las corrientes marinas), que es de espesor 18 mm, por lo que se opta por poner 20mm, para tener el mismo espesor en la denominada soft tank.

Cálculo de los refuerzos forro toroide.

Se tomara llanta de bulbo como refuerzos secundarios del fondo.

Se calculan los módulos admisibles para las presiones mediante la siguiente ecuación.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [50]

$$Z_{admisible} = \frac{1{,}40^2 \cdot 0{,}77 \cdot 532{,}93}{12 \cdot 204{,}35 \cdot 1} = 327{,}993 cm^3$$

[50] DNV-OS-C101 Sec.[5] F400

Siguiendo el procedimiento anterior, obtenemos:

Chapa	**77**	**cm**	**2**	**cm**	**1**	**Área**	**154**	**cm2**				
Bulbo	**220x10**	**22**	**cm**	**Área**	**29**	**cm2**	**I**	**1396**	**cm4**	**d**	**13,35**	**cm**
Y(gconjunto)	3,27	cm										
I(plancha)	51,33	cm4										
I(bulbo)	1396,00	cm4			ESPESOR	20mm	Z	min		327,993		
Ixx	8434,39	cm4										
Ien	6472,74	cm4										
Z	**386,988**	**cm3**										

Tabla 79. Tabla de Bulbos en función de los Momentos Flectores.

Así obtenemos bulbo de 220X10.

Se tomara "T" como refuerzos primarios del fondo.

Calculo del módulo admisible:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	FORRO TOROIDE		
	S (m)	**1/2 S (m)**	**t (mm)**
	11,43	5,715	20
Zg (cm^3)	**10079,48**		

Tabla 80. Calculo del módulo.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
FORRO TOROIDE	11,43	5,715	5,715	4,02	0,65	0,923	92,3

Tabla 81. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[51] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

[51] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

FORRO TOROIDE												
Chapa	be	92,3	cm	t	2	cm	t/2	1	cm	Área	184,6	cm^2
Alma (web)	largo	66	cm	t	3	cm	t/2	1,5	cm	Área	198	cm^2
Ala (flange)	largo	40	cm	t	3	cm	t/2	1,5	cm	Área	120	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	184,6	1	184,60	184,60	61,53							
Alma (web)	198	35	6930,00	242550,00	71874,00							
Ala(flange)	120	69,5	8340,00	579630,00	90,00							
	502,60	105,50	15454,60	822364,60	72025,53							
Y(gconjunto)	30,75	cm										
Ixx	894390,13	cm4										
Ien	419171,95	cm4			Espesor	20	mm			Módulo necesario		
y(max)	40,25	cm4			Bulbo	220	x	10	Zg	10079	cm3	
Z	10414,03	cm3										

Tabla 82. Reforzado cubierta 08.

Así obtenemos una "T" de 660X30X400X30.

Cálculo del espesor y refuerzos del fondo.

Se calculará la presión ejercida en el fondo de la Spar, mediante la siguiente fórmula[52]:

Primero calcularemos la presión y espesores debido al peso del hormigón:

$$P_d = 2{,}9 \cdot 9{,}81 \cdot 9{,}6 \cdot \left(1 + \frac{2{,}4525}{9{,}81} \cdot 1{,}3\right) = 361{,}87\ kN/m^2$$

Se calcula el espesor de la cubierta mediante la siguiente expresión:

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd1} \cdot k_{pp}}}\ (mm)$$

Se toma un valor de *s=770mm*, obtendremos un valor de *l=1.400mm.*

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{770}/_{1400})^2 = \ 0{,}926$$

Sustituyendo los valores en la expresión del espesor obtenemos:

Espesor t (mm)	15	mm
Espesor t (mm) + t corrosión	**17**	mm

Tabla 83. Espesor fondo.

[52] DNV-OS-C101.Sec[3], D307.

Se calculará la presión ejercida en el fondo de la Spar, mediante la siguiente fórmula[53]:

Obtenemos el siguiente valor de presión, hidrostática:

$$P_d = 1{,}025 \cdot 9{,}81 \cdot 45 \cdot \left(1 + \frac{2{,}4525}{9{,}81} \cdot 1{,}3\right) = 599{,}54\ kN/m^2$$

Se calcula el espesor de la cubierta mediante la siguiente expresión:

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd\,1} \cdot k_{pp}}}\ (mm)$$

Se toma un valor de *s=770mm*, obtendremos un valor de *l=1.400mm.*

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{770}/_{1400})^2 = \ 0{,}926$$

Sustituyendo los valores en la expresión del espesor obtenemos:

Espesor t (mm)	19	mm
Espesor t (mm) + t corrosión	**21**	mm

Tabla 84. Espesor fondo.

Se toma el mayor de los espesores obtenidos, que como se puede observar es 21, por lo que buscando un espesor comercial, tomaremos un espesor de 22mm.

Cálculo de los refuerzos del fondo.

Se tomara llanta de bulbo como refuerzos secundarios del fondo. Se calculará el módulo admisible y el módulo geométrico para después compararlos.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd\,2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [54]

$$Z_{admisible} = \frac{1{,}4^2 \cdot 0{,}77 \cdot 599{,}54}{12 \cdot 204{,}35 \cdot 1} = 368{,}99 cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

[53] DNV-OS-C101.Sec[3], D307.
[54] DNV-OS-C101 Sec.[5] F400

Chapa	**77,00**	**cm**	**2**	**cm**	**1**	**Área**	**154,00**	**cm2**				
Bulbo	**280x11**	**28,00**	**cm**	**Área**	**42,68**	**cm2**	**I**	**3333,00**	**cm4**	**d**	**17,44**	**cm**
Y(gconjunto)	5,00	cm										
I(plancha)	51,33	cm4										
I(bulbo)	3333,00	cm4			ESPESOR	22	Z	min		368,99		
Ixx	19667,69	cm4										
Ien	14747,69	cm4										
Z	**702,32**	**cm3**										

Tabla 85. Tabla de Bulbos en función de los Momentos Flectores.

Así obtenemos bulbo de 280x11.

Se tomara "T" como refuerzos primarios del fondo.

Calculo del módulo admisible:

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd\,2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	FONDO		
	S (m)	**1/2 S (m)**	**t (mm)**
	11,43	5,715	22
Zg (cm^3)	**11339,34**		

Tabla 86. Calculo del módulo.

	S (m)	**1/2 S(max) (m)**	**l0 (m)**	**lo/b (m)**	**Ce**	**be (m)**	**be (cm)**
FONDO	11,43	5,715	5,715	4,02	0,65	0,923	92,3

Tabla 87. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[55] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

[55] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

FONDO												
Chapa	be	92,30	cm	t	2,2	cm	t/2	1,1	cm	Área	203,06	cm^2
Alma (web)	largo	84,00	cm	t	3	cm	t/2	1,50	cm	Área	252,00	cm^2
Ala (flange)	largo	30,00	cm	t	3	cm	t/2	1,50	cm	Área	90,00	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	203,06	1,10	2223,37	245,70	81,90							
Alma (web)	252,00	44,20	11168,40	492317,28	148176,00							
Ala(flange)	90,00	87,70	7893,00	692216,10	67,50							
	545,06	133,00	19254,77	1184779,08	148325,40							

Y(gconjunto)	35,33	cm								
Ixx	133104,48	cm4								
Ien	652911,45	cm4	Espesor	22	mm			Módulo necesario		
y(max)	53,87	cm4	Bulbo	280	x	11	Zg	11339,34	cm3	
Z	12119,22	cm3								

Tabla 88. Refuerzos cubierta fondo.

Así obtenemos una "T" de 840x30x300x30.

Cálculo del espesor y refuerzos de los mamparos de los tanques de lastre agua.

Seguiremos el mismo procedimiento anterior.

Se calculará la presión ejercida en el fondo de la Spar, mediante la siguiente fórmula[56]:

$$P_d = \rho \cdot g_0 \cdot h_{op} \cdot \left(\gamma_{f,G,Q} + \frac{a_v}{g_o} \cdot \gamma_{f,E}\right) \ (kN/m^2)$$

De donde:

$$P_d = 1{,}025 \cdot 9{,}81 \cdot 10 \cdot \left(1 + \frac{2{,}4525}{9{,}81} \cdot 1{,}3\right) = 133{,}23\ kN/m^2$$

Se calcula el espesor de la plancha de forro mediante la siguiente expresión:

$$t = \frac{15{,}8 \cdot k_a \cdot s \cdot \sqrt{P_d}}{\sqrt{\sigma_{pd1} \cdot k_{pp}}} \ (mm)$$

Valor de s=560mm y l=1110mm.

$$k_a = \left(1{,}1 - 0{,}25\, {}^{s}/_{l}\right)^2 = (1{,}1 - 0{,}25 \cdot {}^{560}/_{1110})^2 = \ 0{,}951$$

[56] DNV-OS-C101.Sec[3], D307.

Sustituyendo los valores en la expresión del espesor obtenemos:

Espesor t (mm)	7	mm
Espesor t (mm) + t corrosión	**9**	mm

Tabla 89. Espesor mamparos tanque de agua de lastre.

El espesor del tanque es de 7mm, pero tomaremos el valor de10mm, ya que es un espesor comercial, e incluye 2 mm de espesor de corrosión.

Cálculo de los refuerzos de los mamparos del tanque de lastre de la spar.

Se tomara llanta de bulbo como refuerzos secundarios del fondo.

Se calculan los módulos admisibles para las presiones mediante la siguiente ecuación.

$$Z_{admisible} = \frac{l^2 \cdot s \cdot P_d}{k_m \cdot \sigma_{pd2} \cdot k_{ps}} 10^6 (mm^3), minimun\ 15 \cdot 10^3 (mm^3)$$ [57]

$$Z_{admisible} = \frac{1{,}110^2 \cdot 0{,}56 \cdot 133{,}23}{12 \cdot 204{,}35 \cdot 1} = 37{,}49 cm^3$$

Siguiendo el procedimiento anterior, obtenemos:

Chapa	**64**	**cm**	**1**	**Cm**	**0,5**	**Área**	**64**	**cm2**					
Bulbo	**120x6**	**12**	**cm**	**Área**	**9,32**	**cm2**	**I**	**133**	**cm4**	**d**	**7,21**	**cm**	
Y(gconjunto)	1,48	cm											
I(plancha)	5,33	cm4											
I(bulbo)	133	cm4			ESPESOR 10mm, Z(mínimo)= 37,49								
Ixx	782,54	cm4											
Ien	621,93	cm4											
Z	**65,33**	**cm3**											

Tabla 90. Tabla de Bulbos en función de los Momentos Flectores.

Así obtenemos bulbo de 120x6.

Se tomara "T" como refuerzos primarios del fondo.

Calculo del módulo admisible:

[57] DNV-OS-C101 Sec.[5] F400

$$Z_g = \frac{S^2 \cdot b \cdot P_d}{k_m \cdot \sigma_{pd2}} 10^6$$

Siguiendo el procedimiento anterior, obtenemos los siguientes valores:

	FORRO TANQUE LASTRE		
	S (m)	1/2 S (m)	t (mm)
		4,1638	10
Zg (cm^3)	1045,59		

Tabla 91. Calculo del módulo.

	S (m)	1/2 S(max) (m)	l0 (m)	lo/b (m)	Ce	be (m)	be (cm)
Zona Tanque Lastre		4,1638	4,1638	3,75	0,625	0,6938	69,4

Tabla 92. Calculo valor be según Ilustración 37.

La altura del alma de los refuerzos primarios[58] se obtiene mediante la siguiente fórmula:

$$d_w = 3 \cdot d_s$$

Forro de Lastre Espesor 10mm												
Chapa	be	69,375	cm	t	1	cm	t/2	0,5	cm	Área	69,375	cm^2
Alma (web)	largo	36	cm	t	1	cm	t/2	0,5	cm	Área	36	cm^2
Ala (flange)	largo	20	cm	t	1	cm	t/2	0,5	cm	Área	20	cm^2
	A (cm2)	Yg (cm)	A·y	A·y2	I (cm4)							
Chapa	69,375	0,5	34,69	17,34	5,78							
Alma (web)	36	19	684,00	12996,00	3888,00							
Ala(flange)	20	37,5	750,00	28125,00	1,67							
	125,38	57,00	1468,69	41138,34	3895,45							

Y(gconjunto)	11,71	cm
Ixx	45033,79	cm4
Ien	27829,06	cm4
y(max)	26,29	cm4
Z	1058,72	cm3

Espesor	12	mm			Módulo necesario	
Bulbo	120	x	6	Zg	1046	cm3

Tabla 93. Refuerzos forro de tanque de lastre.

[58] S.Chakrabarti. Handbook of offshore engineering. Chapter 7 (2006).

Cálculo del espesor y refuerzos de los tanques de pienso.

Para el cálculo de los tanques de pienso tendremos que usar la siguiente normativa, debido a que en la normativa referente a instalaciones off-shore no tenemos información.

- Eurocódigo 1, Parte 4. Estimación de cargas sobre las paredes.
- Eurocódigo 3, Parte 4 [3]. Normas específicas y detalladas para el cálculo estructural.

Calcularemos el espesor para el tanque de pienso de 6mm, que es el de mayor tamaño.

La densidad del pienso es 0,8595 t/m^3, en la siguiente tabla tomaremos el valor que más se acerque y tenga unas propiedades similares, la densidad del maíz es 0,82307 t/m^3.

Tabla 7.1
Propiedades de los materiales granulados

Material granular	Densidad[3] γ [kN/m^3]	Relación de presiones ($K_{s,m}$)	Coeficiente de rozamiento de la pared μ_m		Máximo coeficiente de mayoración de la presión C_0
			Acero[4]	Hormigón	
cebada[1]	8,5	0,55	0,35	0,45	1,35
cemento	16,0	0,50	0,40	0,50	1,40
clinker de cemento	18,0	0,45	0,45	0,55	1,40
arena seca[2]	16,0	0,45	0,40	0,50	1,40
harina[1]	7,0	0,40	0,30	0,40	1,45
ceniza volante[2]	14,0	0,45	0,45	0,55	1,45
maíz[1]	8,5	0,50	0,30	0,40	1,40
azúcar[1]	9,5	0,50	0,45	0,55	1,40
trigo[1]	9,0	0,55	0,30	0,40	1,30
carbón[1, 2]	10,0	0,50	0,45	0,55	1,45

1) Este material puede provocar explosiones de polvo.
2) Se debe tener cuidado por la posible variación en las propiedades del material.
3) Las densidades se dan para el cálculo de presiones, y no deben emplearse para el cálculo de volúmenes. Las densidades dadas en el capítulo 2 "Densidades de materiales de construcción y de materiales almacenados" de la ENV 1991-2-1 se pueden emplear para el cálculo de volúmenes.
4) No aplicable en paredes corrugadas.

Tabla 94. Propiedades de materiales granulados[59].

Se calculan los valores de *Ks y μ*, por aproximaciones simplificada.

Para la presión horizontal:

[59] Eurocódigo 1, Parte 4. Estimación de cargas sobre las paredes.

$$K_s = 1{,}15 \cdot K_{sm} = 1{,}15 \cdot 0{,}5 = 0{,}575$$

$$\mu = 0{,}9 \cdot \mu_m = 0{,}90 \cdot 0{,}3 = 0{,}270$$

Para la presión vertical:

$$K_s = 0{,}9 \cdot K_{sm} = 0{,}9 \cdot 0{,}5 = 0{,}450$$

$$\mu = 0{,}9 \cdot \mu_m = 0{,}90 \cdot 0{,}3 = 0{,}270$$

Para la presión rozamiento:

$$K_s = 1{,}15 \cdot K_{sm} = 1{,}15 \cdot 0{,}5 = 0{,}575$$

$$\mu = 1{,}15 \cdot \mu_m = 0{,}90 \cdot 0{,}3 = 0{,}345$$

Se calculan las presiones de llenado:

Presión de rozamiento:

$$P_{wf}(z) = \gamma \cdot \frac{A}{U} \cdot C_z(z)$$

Presión horizontal:

$$P_{hf}(z) = \frac{\gamma \cdot A}{\mu \cdot U} \cdot C_z(z)$$

Presión vertical:

$$P_v(z) = \frac{\mu \cdot A}{K_{s \cdot \mu .} U} \cdot C_z(z)$$

Con:

$$C_z(z) = 1 - e^{\left(-z/z_0\right)}$$

$$z_o = \frac{A}{K_s \cdot \mu \cdot U}$$

De donde:

ɣ; es la densidad de carga.

□; es el coeficiente de rozamiento de la pared.

K_s; es la relación de presiones horizontal y vertical.

z; es la profundidad.

U; es el perímetro interior.

Tanque de pienso de 6mm.

Se procede al cálculo de la siguiente expresión.

$$z_o = \frac{A}{K_s \cdot \mu \cdot U}$$

Para presiones horizontales:

$$z_o = \frac{27{,}318}{0{,}575 \cdot 0{,}270 \cdot 22{,}079} = 7{,}967$$

Para presiones verticales:

$$z_o = \frac{27{,}318}{0{,}450 \cdot 0{,}270 \cdot 22{,}079} = 10{,}183$$

Para presiones de rozamiento:

$$z_o = \frac{27{,}317}{0{,}575 \cdot 0{,}345 \cdot 22{,}079} = 6{,}237$$

Se procede al cálculo de la siguiente expresión.

$$C_z(z) = 1 - e^{\left(-z/z_0\right)}$$

Para presiones horizontales:

$$C_z(z) = 1 - e^{\left(-11{,}5/7{,}967\right)} = 0{,}764$$

Para presiones verticales:

$$C_z(z) = 1 - e^{\left(-11{,}5/10{,}183\right)} = 0{,}677$$

Para presiones de rozamiento:

$$C_z(z) = 1 - e^{\left(-11{,}5/6{,}237\right)} = 0{,}840$$

A partir de las expresiones anteriores, se calculan las presiones:

Presión horizontal:

$$P_{hf}(z) = \frac{\gamma \cdot A}{\mu \cdot U} \cdot C_z(z) = \frac{8{,}5 \cdot 27{,}319}{0{,}270 \cdot 22{,}079} \cdot 0{,}764 = 29{,}759 \frac{kN}{m^2} = 3034{,}573 \frac{kg}{m^2}$$

Presión de rozamiento:

$$P_{wf}(z) = \gamma \cdot \frac{A}{U} \cdot C_z(z) = 8{,}5 \cdot \frac{27{,}319}{22{,}079} \cdot 0{,}840 = 8{,}83 \frac{kN}{m^2} = 900{,}409 \frac{kg}{m^2}$$

A partir de la suma de los espesores de las siguientes expresiones se obtiene el espesor de la chapa lateral.

Para la presión horizontal:

$$t = \frac{P_h \cdot D \cdot 10}{2 \cdot \sigma_t \cdot 100} (mm)$$

De donde:

t; es el espesor de la chapa en mm.

P_h; es el valor de la presión horizontal sobre las paredes en kg/m^2.

D; es el diámetro del silo (se asimila el área del tanque de pienso al área de un cilindro).

; es el coeficiente de rozamiento de la pared.

σ_t; es el coeficiente de trabajo (minorado) de la chapa a tracción.

$$t = \frac{3034{,}573 \cdot 5{,}90 \cdot 10}{2 \cdot \frac{235}{1{,}05} \cdot 100} = 3{,}999mm$$

Para la presión de rozamiento.

$$t = \frac{900{,}409 \cdot 5{,}90 \cdot 10}{2 \cdot \frac{235}{1{,}05} \cdot 100} = 1{,}187mm$$

Suma de los dos espesores:

$$t = 3{,}999mm + 1{,}187mm = 5{,}186mm$$

Espesor de la chapa lateral 5mm.

Calculo del espesor de la tolva:

$$e = \frac{T}{100 \cdot \sigma_{fe}}$$

De donde:

e; es el espesor de la chapa en mm.

$T = \frac{P_n \cdot D}{2 \cdot \sin\,\alpha}$; Pn es la resultante de la presión normal sobre la pared de la tolva.

σ_{fe}; es el coeficiente de trabajo (minorado) de la chapa de la tolva.

$$P_{hf} = 3034{,}573 \frac{kg}{m^2}$$

Ph tiene un valor de 3034,573kg/m^2 , calculado anteriormente.

Para la presión vertical:

$$P_v(z) = \frac{\gamma \cdot A}{K_s \cdot \mu \cdot U} \cdot C_z(z) = \frac{8{,}5 \cdot 27{,}319}{0{,}575 \cdot 0{,}270 \cdot 22{,}079} \cdot 0{,}677 = 67{,}740 \frac{kN}{m^2} = 6907{,}558 \frac{kg}{m^2}$$

$$P_{vf} = C_b \cdot P_v = 1{,}2 \cdot 6907{,}558 = 8289{,}07 \frac{kg}{m^2}$$

$$P = \sqrt{(3034{,}573)^2 + (8289{,}07)^2} = 8827{,}08 \frac{kg}{m^2}$$

$$P_n = \frac{P}{\cos\beta} = \frac{8827{,}08}{\cos(13{,}727)} = 9.086{,}62 \frac{kg}{m^2}$$

$$T = \frac{P_n \cdot D}{2 \cdot \sin\alpha} = \frac{9086{,}62 \cdot 5{,}90}{2 \cdot \sin 6{,}38} = 241226$$

$$e = \frac{241226}{100 \cdot \frac{235}{1{,}05}} = 10{,}77mm$$

El espesor de la chapa de la tolva es de 12mm.

Se repite el mismo proceso para el tanque de pienso de 4mm y de 2,5mm.

Tanque de 4mm.

Para presiones horizontales:

$$z_o = \frac{16,859}{0,575 \cdot 0,270 \cdot 16,789} = 6,468$$

Para presiones verticales:

$$z_o = \frac{16,859}{0,450 \cdot 0,270 \cdot 16,789} = 8,265$$

Para presiones de rozamiento:

$$z_o = \frac{16,859}{0,575 \cdot 0,345 \cdot 16,789} = 5,062$$

Se procede al cálculo de la siguiente expresión.

$$C_z(z) = 1 - e^{\left(-z/z_0\right)}$$

Para presiones horizontales:

$$C_z(z) = 1 - e^{\left(-10/6,468\right)} = 0,787$$

Para presiones verticales:

$$C_z(z) = 1 - e^{\left(-10/8,265\right)} = 0,702$$

Para presiones de rozamiento:

$$C_z(z) = 1 - e^{\left(-10/5,062\right)} = 0,861$$

A partir de las expresiones anteriores, se calculan las presiones:

Presión horizontal:

$$P_{hf}(z) = \frac{\gamma \cdot A}{\mu \cdot U} \cdot C_z(z) = \frac{8,5 \cdot 16,859}{0,270 \cdot 16,789} \cdot 0,787 = 24,879 \frac{kN}{m^2} = 2.536,952 \frac{kg}{m^2}$$

Presión de rozamiento:

$$P_{wf}(z) = \gamma \cdot \frac{A}{U} \cdot C_z(z) = 8,5 \cdot \frac{16,859}{16,789} \cdot 0,861 = 7,349 \frac{kN}{m^2} = 749,389 \frac{kg}{m^2}$$

A partir de la suma de los espesores de las siguientes expresiones se obtiene el espesor de la chapa lateral.

Para la presión horizontal:

$$t = \frac{2.536,952 \cdot 4,63 \cdot 10}{2 \cdot \frac{235}{1,05} \cdot 100} = 2,624mm$$

Para la presión de rozamiento.

$$t = \frac{749,389 \cdot 4,63 \cdot 10}{2 \cdot \frac{235}{1,05} \cdot 100} = 0,775mm$$

Suma de los dos espesores:

$$t = 2,624mm + 0,775mm = 3,399mm$$

Espesor de la chapa lateral 4mm.

Calculo del espesor de la tolva:

$$e = \frac{T}{100 \cdot \sigma_{fe}}$$

$$P_{hf} = 2.536,952 \frac{kg}{m^2}$$

Ph tiene un valor de 2.536,952 kg/m^2 ,ya calculado anteriormente.

Para la presión vertical:

$$P_v(z) = \frac{\gamma \cdot A}{K_s \cdot \mu \cdot U} \cdot C_z(z) = \frac{8,5 \cdot 16,859}{0,575 \cdot 0,270 \cdot 16,789} \cdot 0,702 = 38,595 \frac{kN}{m^2} = 3.935,595 \frac{kg}{m^2}$$

$$P_{vf} = C_b \cdot P_v = 1,2 \cdot 3.935,595 = 4.722,71 \frac{kg}{m^2}$$

$$P = \sqrt{(2.536,952)^2 + (4.722,71)^2} = 5.360,98 \frac{kg}{m^2}$$

$$P_n = \frac{P}{\cos\beta} = \frac{5.360,98}{\cos(21,43)} = 5.759,14\frac{kg}{m^2}$$

$$T = \frac{P_n \cdot D}{2 \cdot \sin\alpha} = \frac{5.759,14 \cdot 4,63}{2 \cdot \sin 6,82} = 112.272$$

$$e = \frac{112.272}{100 \cdot \frac{235}{1,05}} = 5,01mm$$

El espesor de la chapa de la tolva es de 5mm.

Tanque de 2,5mm.

Para presiones horizontales:

$$z_o = \frac{6,5452}{0,575 \cdot 0,270 \cdot 10,923} = 3,860$$

Para presiones verticales:

$$z_o = \frac{6,5452}{0,450 \cdot 0,270 \cdot 10,923} = 4,932$$

Para presiones de rozamiento:

$$z_o = \frac{6,5452}{0,575 \cdot 0,345 \cdot 10,923} = 3,020$$

Se procede al cálculo de la siguiente expresión.

$$C_z(z) = 1 - e^{\left(-z/z_0\right)}$$

Para presiones horizontales:

$$C_z(z) = 1 - e^{\left(-7,5/3,860\right)} = 0,857$$

Para presiones verticales:

$$C_z(z) = 1 - e^{\left(-7,5/4,932\right)} = 0,781$$

Para presiones de rozamiento:

$$C_z(z) = 1 - e^{\left(-7,5/_{3,020}\right)} = 0,904$$

A partir de las expresiones anteriores, se calculan las presiones:

Presión horizontal:

$$P_{hf}(z) = \frac{\gamma \cdot A}{\mu \cdot U} \cdot C_z(z) = \frac{8,5 \cdot 6,5452}{0,270 \cdot 10,923} \cdot 0,857 = 16,167 \frac{kN}{m^2} = 1.648,575 \frac{kg}{m^2}$$

Presión de rozamiento:

$$P_{wf}(z) = \gamma \cdot \frac{A}{U} \cdot C_z(z) = 8,5 \cdot \frac{6,5452}{10,923} \cdot 0,904 = 4,604 \frac{kN}{m^2} = 469,477 \frac{kg}{m^2}$$

A partir de la suma de los espesores de las siguientes expresiones se obtiene el espesor de la chapa lateral.

Para la presión horizontal:

$$t = \frac{1.648,575 \cdot 2,88 \cdot 10}{2 \cdot \frac{235}{1,05} \cdot 100} = 1,060mm$$

Para la presión de rozamiento.

$$t = \frac{469,477 \cdot 2,88 \cdot 10}{2 \cdot \frac{235}{1,05} \cdot 100} = 0,302mm$$

Suma de los dos espesores:

$$t = 1,060mm + 0,302mm = 1,362mm$$

Espesor de la chapa lateral 2mm.

Calculo del espesor de la tolva:

$$e = \frac{T}{100 \cdot \sigma_{fe}}$$

$$P_{hf} = 1.648,575 \frac{kg}{m^2}$$

Ph tiene un valor de 1.648,575 kg/m^2 , calculado anteriormente.

Para la presión vertical:

$$P_v(z) = \frac{\gamma \cdot A}{K_s \cdot \mu \cdot U} \cdot C_z(z) = \frac{8{,}5 \cdot 6{,}5452}{0{,}575 \cdot 0{,}270 \cdot 10{,}923} \cdot 0{,}781 = 25{,}622 \frac{kN}{m^2} = 2.616{,}790 \frac{kg}{m^2}$$

$$P_{vf} = C_b \cdot P_v = 1{,}2 \cdot 2.616{,}790 = 3.140{,}150 \frac{kg}{m^2}$$

$$P = \sqrt{(1.648{,}575)^2 + (3.140{,}150)^2} = 3.546{,}6 \frac{kg}{m^2}$$

$$P_n = \frac{P}{\cos\beta} = \frac{3.546{,}6}{\cos(19{,}81)} = 3.769{,}572 \frac{kg}{m^2}$$

$$T = \frac{P_n \cdot D}{2 \cdot \sin\alpha} = \frac{3769{,}572 \cdot 2{,}88}{2 \cdot \sin 7{,}89} = 39.544{,}5$$

$$e = \frac{39.544{,}5}{100 \cdot \frac{235}{1{,}05}} = 1{,}76mm$$

Cálculo de α y β.

α; es el ángulo formado en la parte inferior de la tolva, 6,379°.

β; se muestra a continuación su cálculo.

$$\tan\mu = \frac{3034{,}57}{8289{,}07} = 0{,}336, \qquad \mu = 20{,}107°$$

$$\omega = 90 - \mu = 90 - 20{,}10 = 69{,}893°$$

De donde:

$$90 = \beta + \omega + \alpha$$

$$90 - \omega - \alpha = \beta$$

$$90 - 69{,}893 - 6{,}379 = \beta$$

$$\beta = 13{,}729°$$

(cálculo realizado para tanques de pienso de diámetro 6mm, se sigue el mismo proceso para el resto de tanques).

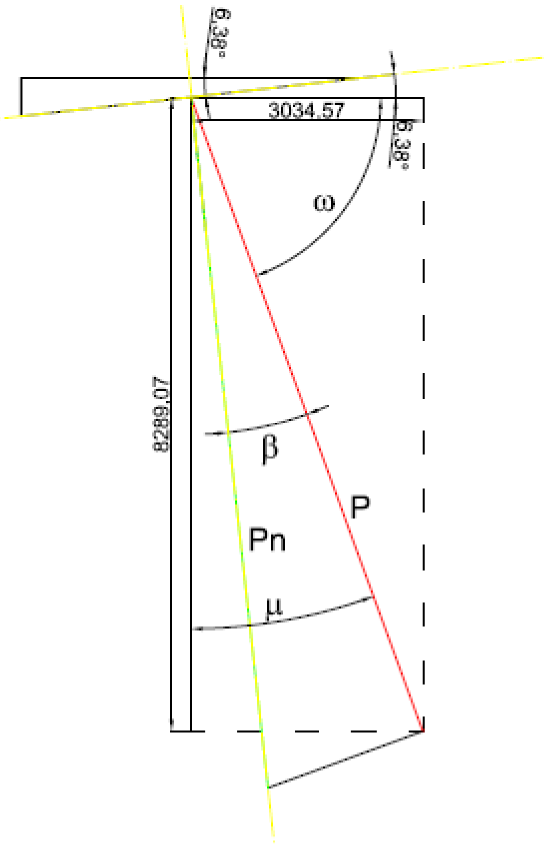


Ilustración 48. Cálculo del ángulo β.

El espesor de la chapa de la tolva es de 5mm.

	Pienso	Cilindro		Área	Espesor	Tapa	Espesor	Fondo	Espesor	Densidad	Peso
	Ø (m)	L (m)	H (m)	(m^2)	(mm)	(m^2)	(mm)	(m2)	(mm)	(kg/m3)	(kg)
Tanque	6	22,08	11,5	253,91	5	27,00	5	27,50	12	7,856	13626,75
Tanque	4	16,78	10	167,80	4	16,86	4	16,98	5	7,856	6469,73
Tanque	2,5	10,92	7,5	81,90	2	6,54	2	6,60	2	7,856	1493,27
											21.589,75

Tabla 95. Peso de los tanques de pienso.

Cálculo de la estructura soporte de los silos

Debido al elevado peso que suponen los silos de pienso cargados, estos no pueden unirse por soldadura directamente a los anillos de la estructura del costado ya que provocarían elevadas cargas locales que se transmitirían además al forro. Para liberar a los anillos de esta carga se calculará un conjunto de puntales para soportar el peso de cada silo y transmitirlo a los refuerzos bajo cubierta, y estos, mediante consolas y/o contretes transmitirlos a la estructura vertical de la spar.

Bajo cada silo, se dispondrán los puntales formados por perfiles laminados circulares de acero (235) de sección a determinar y que apoyaran, para tal cometido sobre los refuerzos primarios.

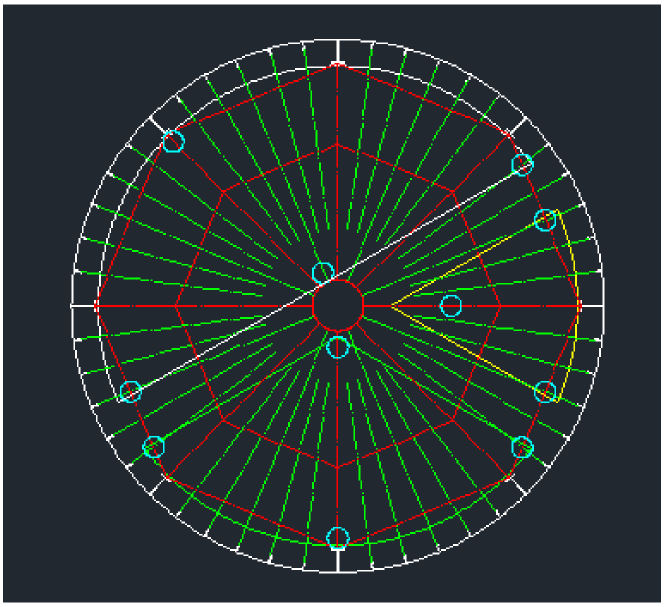


Ilustración 49. Vista en planta de los silos y los puntales sobre los refuerzos primarios.

Dimensionamiento de los puntales soporte.

Para dimensionar los puntales soporte, se han modelado las tolvas utilizando el software RFEM® de cálculo por elementos finitos, apoyándolas en los puntos donde se dispondrán los puntales. De esta forma, se obtendrán las cargas a compresión para el cálculo a pandeo según el reglamento DNV Pt.3 Ch.2 Sec.9 "*Pillars and Suporting Bulkheads*".

Las reacciones en los apoyos se pueden ver en la Ilustración 50.

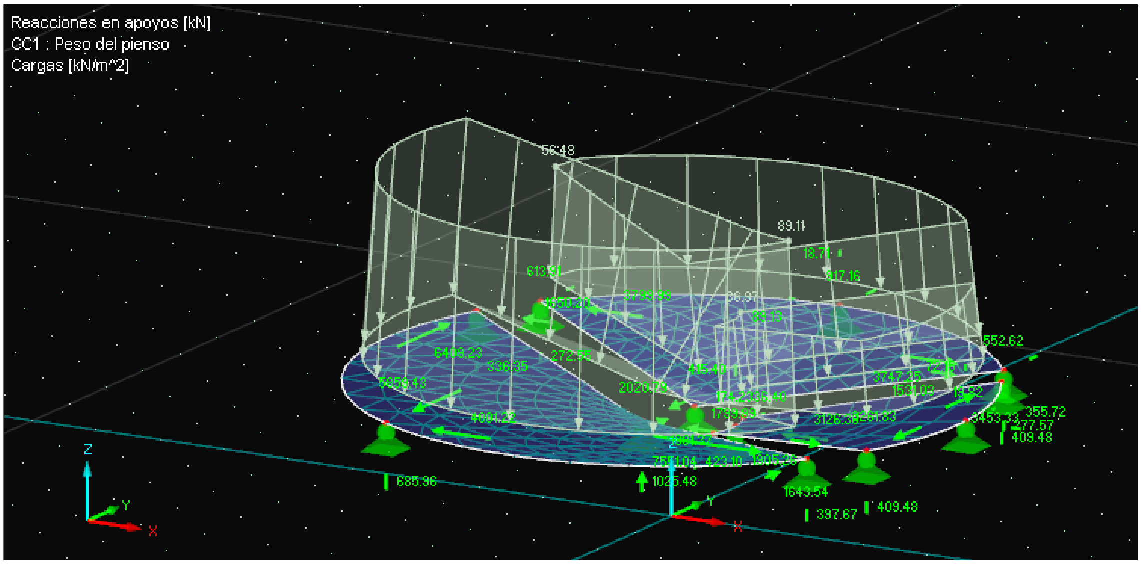


Ilustración 50. Modelo de Elementos Finitos de las Tolvas y Reacciones en los Apoyos.

Las reacciones verticales en los apoyos son las siguientes:

SILO	Reacción (kN)	SILO	Reacción (kN)	SILO	Reacción (kN)
Pienso Ø 6mm	685,86	Pienso Ø 4mm	272,55	Pienso Ø 2,5mm	415,4
	1025,48		423,1		409,48
	336,35		277,57		77,15
	397,67		18,71		409,48

Tabla 96. Reacciones en apoyos tanques.

Cálculo de los puntales

El radio de giro, para puntales de sección cuadrangular, será

$$i = 0{,}29\sqrt{(D_{ext})^2 + (D_{int})^2} \text{ en cm}$$

El área seccional requerida según A301, se calcula como

$$\mathrm{A} = \mathrm{k} \cdot \mathrm{P}$$

Donde

P es la fuerza a la que está sometido el puntal, en kN.

k es dado por la gráfica de la ilustración 2 donde *i* es el giro calculado anteriormente y *l* es la longitud (altura) del puntal en metros.

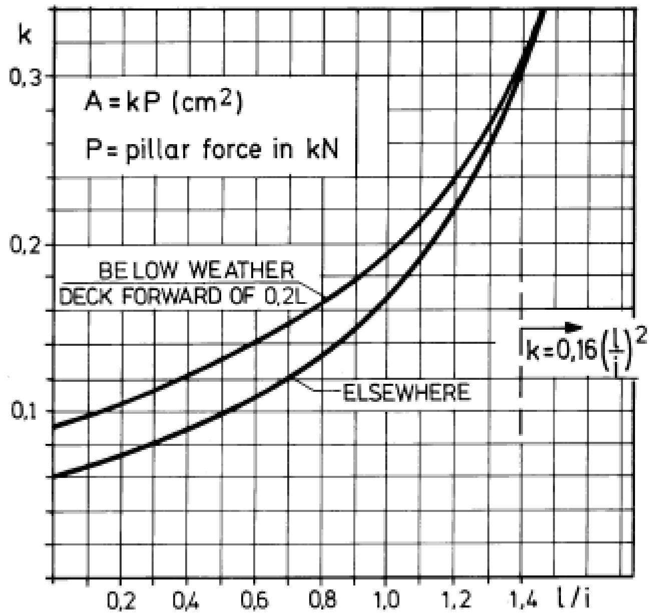


Ilustración 51. Factor k como función de l/i

Como los refuerzos primarios sobre los que apoyarán los puntales son de 240x10x100x10 ensayaremos un perfil de 100x100x10, con área seccional de 32,6 cm^2.

Para el perfil seleccionado, y para cada longitud tenemos:

SILO	Reacción (kN)	Longitud del puntal (m)	Lado perfil (mm)	Espesor (mm)	i (cm)	l/i
Pienso Ø 6mm	685,86	1,71	100	10	3,7138	0,4604
	1025,48	1,21	100	10	3,7138	0,3258
	336,35	1,71	100	10	3,7138	0,4604
	397,67	1,71	100	10	3,7138	0,4604
SILO	**Reacción (kN)**	**Longitud del puntal (m)**	**Lado perfil (mm)**	**Espesor (mm)**	**i (cm)**	**l/i**
Pienso Ø 4mm	272,55	1,71	100	10	3,7138	0,4604
	423,10	1,21	100	10	3,7138	0,3258
	277,57	1,71	100	10	3,7138	0,4604
	18,71	1,71	100	10	3,7138	0,4604
SILO	**Reacción (kN)**	**Longitud del puntal (m)**	**Lado perfil (mm)**	**Espesor (mm)**	**i (cm)**	**l/i**
Pienso Ø 2,5mm	415,40	1,21	100	10	3,7138	0,3258
	409,48	1,71	100	10	3,7138	0,4604
	77,15	1,71	100	10	3,7138	0,4604
	409,48	1,71	100	10	3,7138	0,4604

Tabla 97. Prueba puntal perfil 100x100x10.

Para cada caso, en función de *l/i* se obtendrán los siguientes valores de k (ver Ilustración 51) y por lo tanto del área seccional como *A = k·P*:

SILO	Reacción P (kN)	Longitud del puntal (m)	l/i	Área requerida (cm²)
Pienso Ø 6mm	685,86	1,71	0,4604	64,4708
	1025,48	1,21	0,3258	86,1403
	336,35	1,71	0,4604	31,6169
	397,67	1,71	0,4604	37,3810

SILO	Reacción P (kN)	Longitud del puntal (m)	l/i	Área requerida (cm²)
Pienso Ø 4mm	272,55	1,71	0,4604	25,6197
	423,10	1,21	0,3258	35,5404
	277,57	1,71	0,4604	26,0916
	18,71	1,71	0,4604	1,7587

SILO	Reacción P (kN)	Longitud del puntal (m)	l/i	Área requerida (cm²)
Pienso Ø 2,5mm	415,40	1,21	0,3258	34,8936
	409,48	1,71	0,4604	38,4911
	77,15	1,71	0,4604	7,2521
	409,48	1,71	0,4604	38,4911

Tabla 98. Cálculo del área requerida.

Sin embargo, en algunos casos, el perfil seleccionado inicialmente no verifica el requisito del área seccional por lo que para estos se ensaya un perfil mayor. Asimismo, en los casos donde el área requerida es mucho menor que el perfil seleccionado, se ensayarán perfiles de menor sección con el consiguiente ahorro de peso estructural.

SILO	Reacción (kN)	l/i	k	A (cm2)	100x100x10 ¿CUMPLE?
Pienso Ø 6mm	685,86	**0,4604**	**0,094**	**64,47084**	**NO**
	1025,48	**0,3258**	**0,084**	**86,14032**	**NO**
	336,35	**0,4604**	**0,094**	**31,6169**	**SI**
	397,67	**0,4604**	**0,094**	**37,38098**	**NO**

SILO	Reacción (kN)	l/i	k	A (cm2)	100x100x10 ¿CUMPLE?
Pienso Ø 4mm	272,55	**0,4604**	**0,094**	**25,6197**	**SI**
	423,1	**0,3258**	**0,084**	**35,5404**	**NO**
	277,57	**0,4604**	**0,094**	**26,09158**	**SI**
	18,71	**0,4604**	**0,094**	**1,75874**	**SI**

SILO	Reacción (kN)	l/i	k	A (cm2)	100x100x10 ¿CUMPLE?
Pienso Ø 2,5mm	415,4	**0,3258**	**0,084**	**34,8936**	NO
	409,48	**0,4604**	**0,094**	**38,49112**	NO
	77,15	**0,4604**	**0,094**	**7,2521**	SI
	409,48	**0,4604**	**0,094**	**38,49112**	NO

Tabla 99. Comprobación del área requerida.

Repitiendo los cálculos arriba descritos, los perfiles seleccionados para cada puntal son los siguientes:

SILO	Reacción (kN)	Longitud del puntal (m)	Área requerida (cm^2)	Perfil seleccionado	Área del perfil (cm^2)	Peso (kg)
Pienso Ø 6mm	685,86	**1,71**	**64,47084**	180x180x10	**64,6**	**86,697**
	1025,48	**1,21**	**86,14032**	200x200x12,5	**87**	**82,643**
	336,35	**1,71**	**31,6169**	100x100x10	**32,6**	**43,776**
	397,67	**1,71**	**37,38098**	120x120x10	**40,6**	**54,378**

SILO	Reacción (kN)	Longitud del puntal (m)	Área requerida (cm^2)	Perfil seleccionado	Área del perfil (cm^2)	Peso (kg)
Pienso Ø 4mm	685,86	1,71	64,47084	180x180x10	64,6	86,697
	1025,48	1,21	86,14032	200x200x12,5	87	82,643
	336,35	1,71	31,6169	100x100x10	32,6	43,776
	397,67	1,71	37,38098	120x120x10	40,6	54,378

SILO	Reacción (kN)	Longitud del puntal (m)	Área requerida (cm^2)	Perfil seleccionado	Área del perfil (cm^2)	Peso (kg)
Pienso Ø 2,5mm	415,4	**1,21**	**34,8936**	110x110x10	**36,6**	**34,727**
	409,48	**1,71**	**38,49112**	120x120x10	**40,6**	**54,378**
	77,15	**1,71**	**7,2521**	50x50x5	**8,36**	**11,218**
	409,48	**1,71**	**38,49112**	120x120x10	**40,6**	**54,378**

Tabla 100. Perfiles seleccionados.

Cálculo de la estructura de la jaula.

Se calcula la estructura de las jaulas de la Spar por medio del programa Dlubal.

Se analiza una jaula, ya que las cuatro son iguales.

La carga de partida se calcula en el punto 5.4.1.4 “Fuerzas que actúan sobre las jaulas” del Trabajo de Fin de Master.

Modelo y dimensionamiento de la estructura de la jaula.

Para calcular la estructura de la jaula se tendrá en cuenta la situación de carga más demandante. En operación normal la jaula se encuentra sumergida, bien sea a 40 metros de profundidad bien con el borde superior a flor de agua. En ambos casos el peso total se ve minorado por el empuje que tanto la red como las posibles incrustaciones y el anti-incrustante suponen, además del propio empuje de la estructura a calcular. Por lo tanto como situación más demandante de carga se tomará aquella en la cual las jaulas se encuentran completamente emergidas, que se corresponderá con los periodos de instalación, desmontaje y periodos intermedios de mantenimiento como pueden ser el cambio de las redes, reparaciones del esquema de pintado etc.

Para esta situación, por lo tanto, el peso considerado será el de la red con anti-incrustante fuera del agua más el de las incrustaciones tal y como se ha obtenido en el punto 5.4.1.4 del Trabajo Fin de Master. El peso total a considerar es de 1.582,280 kg (15,517 kN) al que habrá que sumar el peso propio de los perfiles de acero, y que el propio software ya incluye.

Por lo tanto el modelo se ensayará sometido a una combinación de cargas que resultará de la actuación simultánea del peso propio del acero y el de la carga arriba indicada.

Para repartir el peso calculado, se ha asimilado que la red está formada por dos paños que cuelgan del anillo superior e intermedio respectivamente y que apoyan en el inmediatamente inferior. Entonces, el anillo superior y el inferior asumirán ¼ de la carga indicada y el intermedio, por ser este apoyo y soporte a la vez, ½ de la aquella. Ver Tabla 15 e Ilustración 27.

Anillo	Carga total (kN)	Longitud (m)	Carga uniforme (kN/m)
Superior	3,879	62,832	0,062
Medio	7,759	62,832	0,124
Inferior	3,879	62,832	0,062
Total	**15,517**	--	**0,248**

Tabla 101. Reparto de las Cargas en los Anillos de la Jaula.

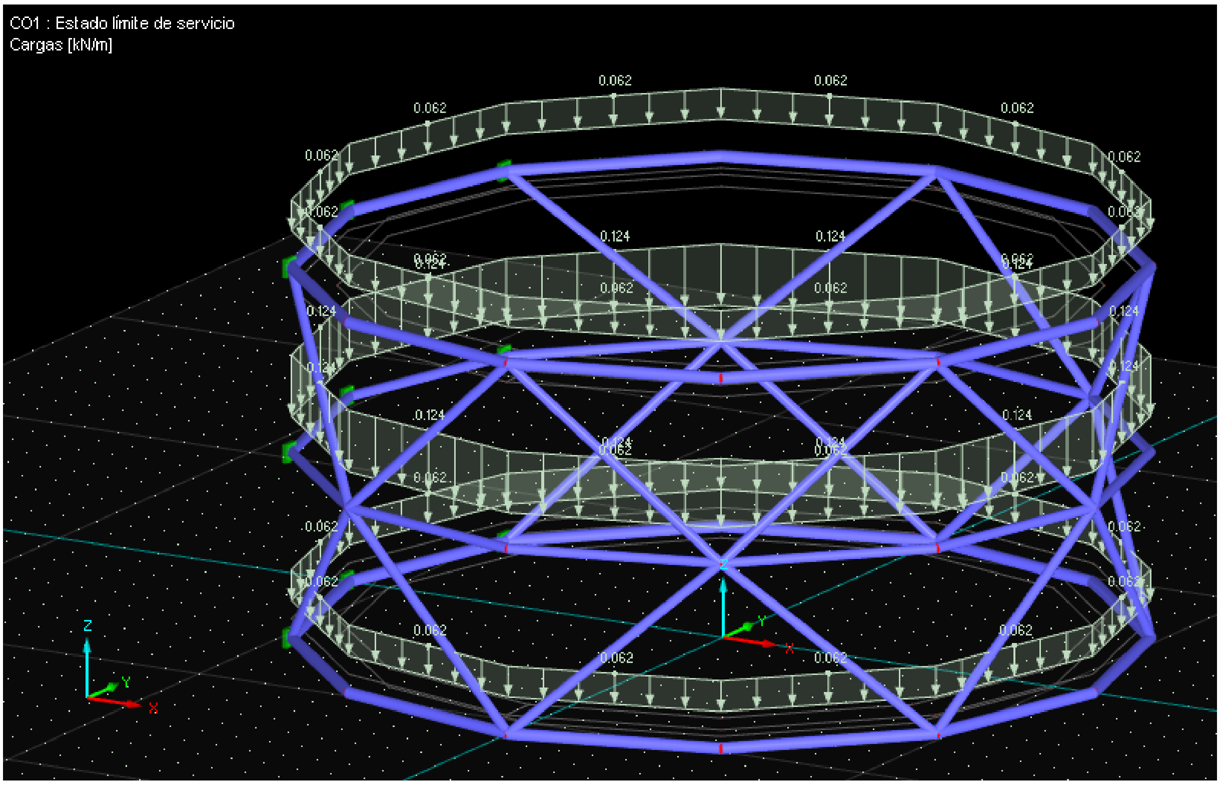


Ilustración 52. Cargas Aplicadas sobre la Estructura de la Jaula.

Los nodos correspondientes a la unión de cada jaula con los anillos deslizantes, que permitirán su desplazamiento a lo largo de la spar, se modelan como empotramientos ya que esta unión no tendrá grado alguno de libertad. Las reacciones sobre estos apoyos serán posteriormente utilizadas como dato de entrada para el cálculo de la estructura deslizante citada.

Las deformaciones de las barras y giros en los nodos se han estudiado según la normativa EUROCODE 3 para estructuras de acero, siendo la configuración que verifica este criterio la indicada a continuación:

	Diámetro		Espesor
	(mm)	(pulg)	(mm)
Anillo Superior	323,80	12"	5
Anillo intermedio	273,00	10"	5
Anillo inferior	323,80	12"	5
Tirantes	273,00	10"	5

Tabla 102. Perfiles de los anillos de las jaulas.

Características de cada jaula:

CARACTERÍSTICAS POR JAULA		
Peso jaula	12,83	ton
Longitud de las barras	361,83	m
Superficie recubrimiento	333,50	m^2

Tabla 103. Características por jaula.

Se adjuntan los resultados de salida del programa, en el que se pueden ver los distintos perfiles usados para el cálculo, y las deformaciones obtenidas.

Modelo y dimensionamiento de los anillos deslizantes.

Como se ha indicado, las cargas externas sobre esta estructura serán las reacciones correspondientes a las jaulas. A diferencia del caso anterior, en el que se modeló una única jaula por ser las cuatro iguales, en este caso se hizo el modelo completo para poder aplicar las cargas de las cuatro jaulas simultáneamente. Las reacciones de las jaulas se suman, con su signo, en aquellos nodos comunes a las mismas.

Esta estructura es cilíndrica con un diámetro interior de 10 metros de forma que rodea completamente la spar en su cuerpo de transición. Los tres anillos, superior, medio e inferior, unen a sus correspondientes de las jaulas mientras que entre ellos están unidos por puntales, como se puede ver en la Ilustración 53.

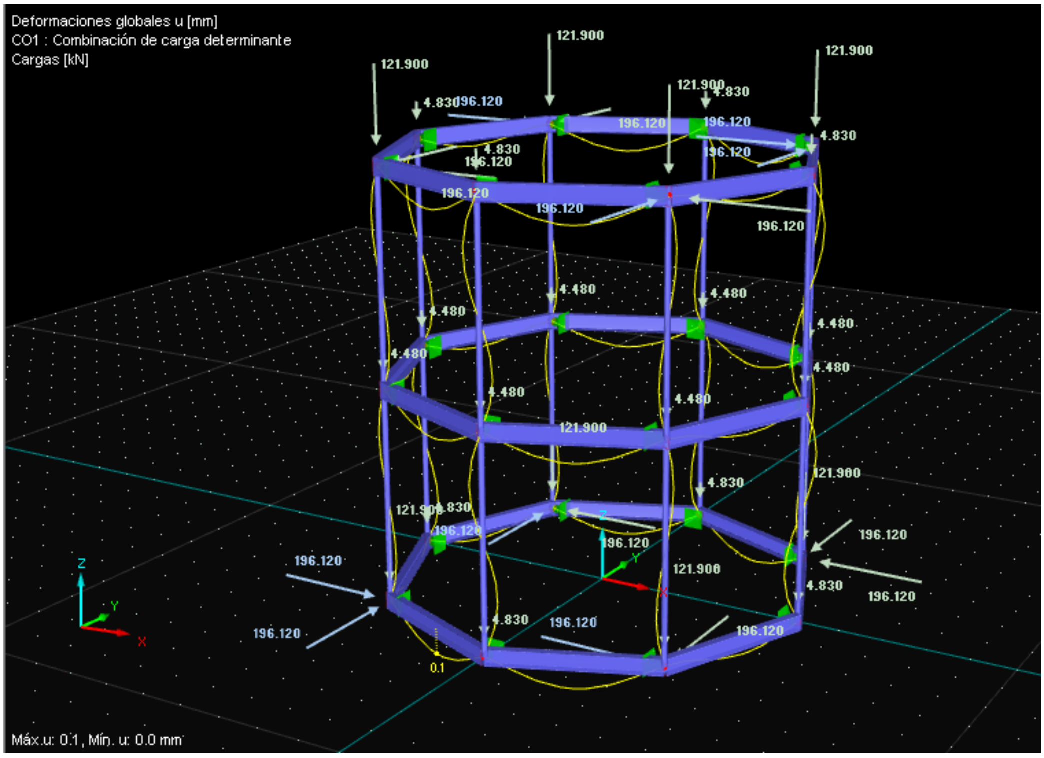


Ilustración 53. Anillos Deslizantes para la Unión de las Jaulas. (Factor de magnificación deformada: x10.000)

Las restricciones impuestas a este modelo se limitan a impedir las deformaciones hacia el interior, ya que ese será el espacio ocupado por la spar. Para ello, se han impuesto en los nodos apoyos que permiten el giro y el desplazamiento vertical y tangente a los anillos impidiendo únicamente la deformación radial de los mismos.

Las deformaciones de las barras y giros en los nodos se han estudiado según la normativa EUROCODE 3 para estructuras de acero, siendo la configuración que verifica este criterio la indicada a continuación:

	Dimensiones		Espesor
	Alto	Ancho	(mm)
Anillo Superior	400	200	8
Anillo Intermedio	400	200	8
Anillo Inferior	400	200	8

Tabla 104. Perfiles para el anillo.

	Dimensiones		Espesor
	(mm)	(pulgadas)	(mm)
Puntales	139,7	5"	4

Tabla 105. Perfiles para el anillo

Características de los anillos deslizantes:

CARACTERÍSTICAS		
Peso jaula	7,764	ton
Longitud de las barras	171,843	m
Superficie recubrimiento	143,995	m^2

Tabla 106. Características del anillo.

Se adjuntan los resultados de salida del programa, en el que se pueden ver los distintos perfiles usados para el cálculo, y los giros obtenidos (máx. 0,1 mrad).

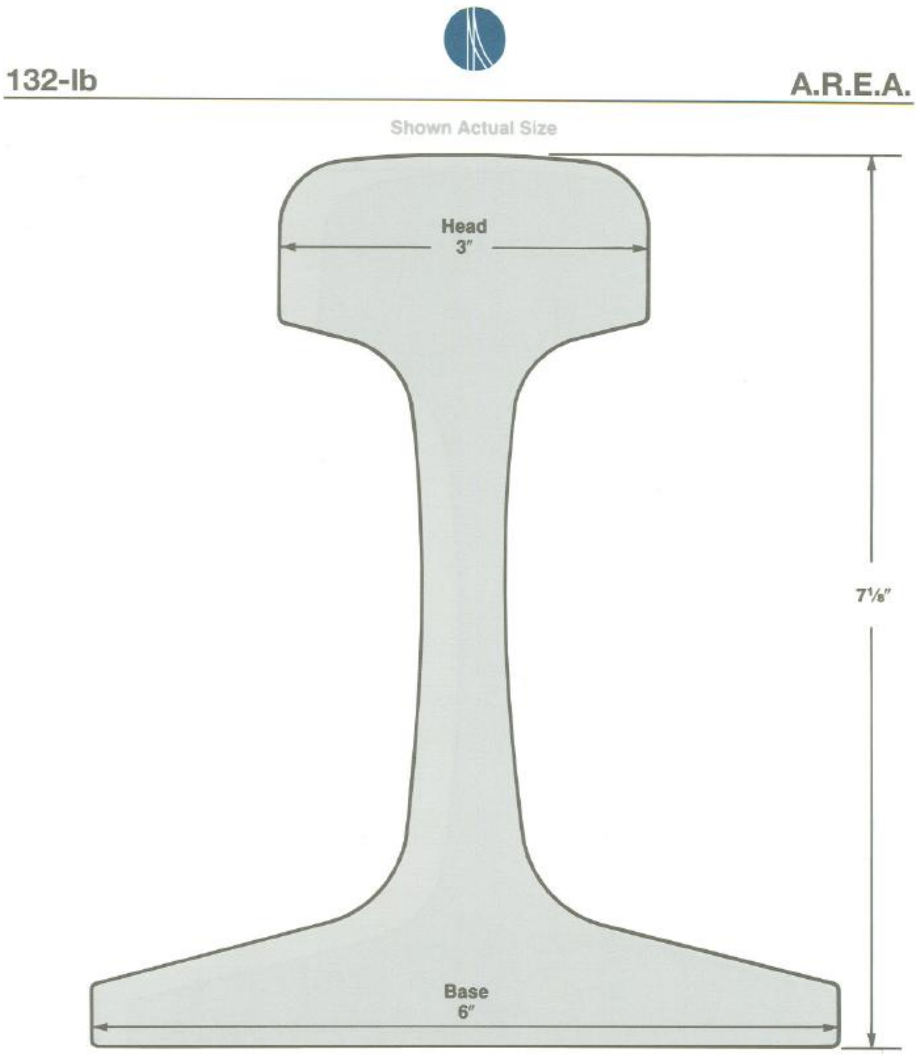
En el punto medio de cada unión con las jaulas se dispondrán cáncamos – cuatro en total – de suficiente entidad como para que el conjunto jaulas-anillos puedan ser izados por los chigres ubicados en una cubierta superior deslizándose dicho conjunto a lo largo del cuerpo de transición.

Cálculo de la estructura soporte del carril – grúa

La grúa será el modelo KN75 de TRIPLEX Cranes con movimiento sobre raíles en cubierta pudiendo de esta manera alcanzar cualquier punto de las jaulas en todo el perímetro de la plataforma.

El raíl será doble, formado por sendos perfiles paralelos del tipo indicado en la Ilustración 54.

Irá montado sobre la cubierta a la altura necesaria según indique el fabricante de la grúa y su peso y los esfuerzos generados por la grúa en operación serán transmitidos a la estructura de la SPAR mediante ocho puntales formados por perfiles laminados cuadrangulares de acero (235) de sección a determinar y que apoyaran, para tal cometido sobre los refuerzos primarios.



Specifications	
Nominal Weight	132 lbs/yd
Standard Length	39′0″
Standard Drilling	3½″ x 6″ x 6″
Joint Bar Length	36″
Joint Bar Weight	113.1 lbs/pr
With Hardware	125.7 lbs/pr
Bolt Diameter	1⅛″ or 1″

See quick reference section for all other dimensions.

Hold-Down Devices		
Standard	Single	Double
Hook Bolt	1″	—
Clip Number	62	—
Clamp & Filler	F1	F2
Welded Stud	S1	S2
Heavy Duty	Single	Double
Welded Holder	H1	H2
Welded U-Bar	—	—

Ilustración 54. Perfil del raíl de la grúa de servicio.

Dimensionamiento de los puntales soporte.

Bajo la cubierta principal e igualmente espaciados y alineados con la huella de los raíles de la grúa se dispondrán ocho puntales de acero naval con las siguientes características:

Según el reglamento, la carga a considerar para el cálculo de la estructura soporte de una grúa debe calcularse como W·SF1 siendo W la carga de trabajo de la grúa “Working Load”, y SF1 un coeficiente de seguridad que para grúas offshore tendrá el valor de 1,1.

La grúa seleccionada tiene una carga máxima de trabajo de 6 toneladas (58,84 kN) por lo que la carga a utilizar para el cálculo, incluyendo el factor de seguridad, es de 64,72 kN.

Se utilizará un software de cálculo estructural[60] en el que además de la carga de 64,72 kN indicada se incluirá el peso propio del doble carril de la grúa para obtener la fuerza máxima a soportar por cada puntal en la situación más desfavorable, esto es, cuando los esfuerzos se concentren en la vertical del propio puntal. En la Ilustración 55 se muestra el doble carril con los puntales modelizados como apoyos.

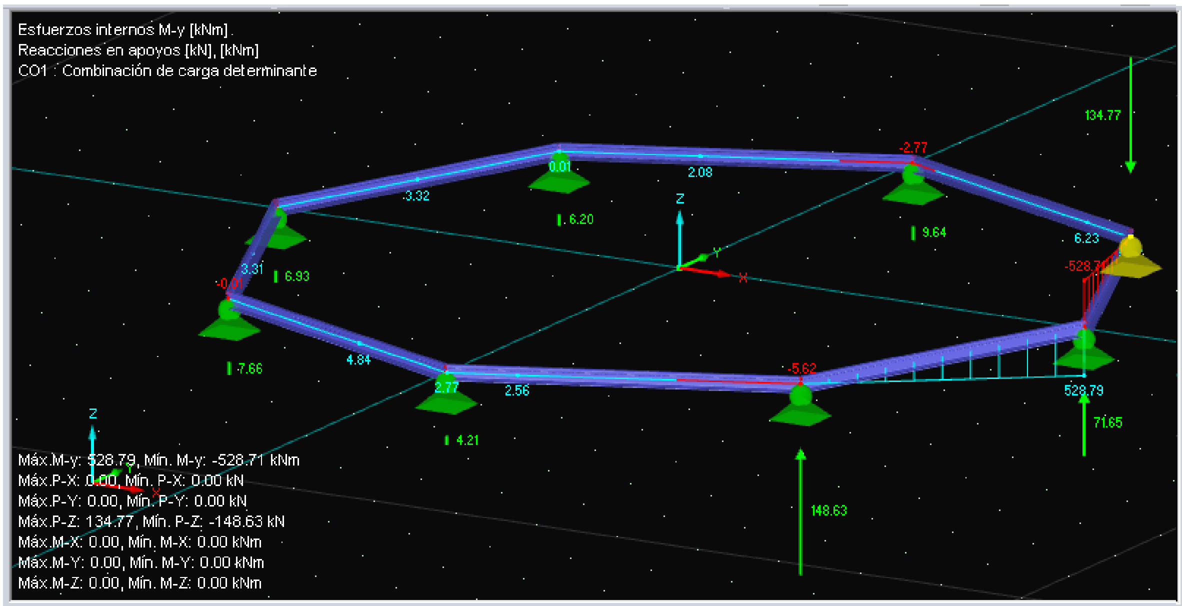


Ilustración 55. Modelización del doble carril - grúa

De la simulación realizada con ayuda del software se obtiene que la reacción máxima es de 148,63 kN.

El cálculo a pandeo de los puntales se realizará según Pt.3 Ch.2 Sec.9 del reglamento DNV 2013.

El radio de giro, para puntales de sección cuadrangular, será

$$i = 0{,}29\sqrt{(D_{ext})^2 + (D_{int})^2} \text{ en cm}$$

El área seccional requerida se calcula como

$$\mathrm{A = k \cdot P}$$

Donde

[60] RSTAB8® de Dlubal Software.

P es la fuerza a la que está sometido el puntal, en kN.

k es dado por la gráfica de la Ilustración 56 donde *i* es el giro calculado anteriormente y *l* es la longitud (altura) del puntal en metros.

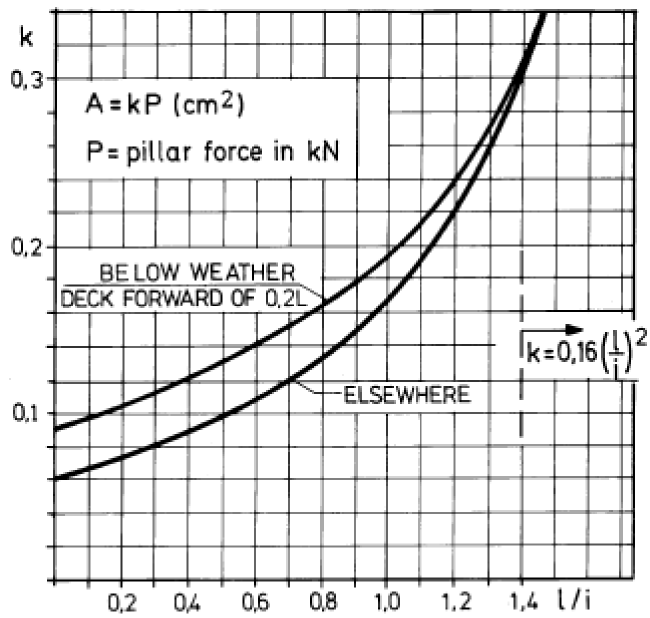


Ilustración 56. Factor k como función de l/i

Como los refuerzos primarios sobre los que apoyarán los puntales son de 360x200x20 ensayaremos un puntal de sección 200x200x10.

Para el puntal seleccionado:

$$i = 0{,}29\sqrt{(20)^2 + (20 - 2 \cdot 1)^2 =} \ 7{,}803$$

Y por lo tanto, si l = 4,3 m entonces l/i = 0,551 y el coeficiente k tomará entonces el valor de 0,12. Luego el área seccional requerida es

$$A = 0{,}11 \cdot 148{,}63 = 16{,}349 \ cm^2$$

Mientras que el área seccional del perfil seleccionado, 72,6 cm^2 supera la mínima requerida. Por lo tanto se presenta el caso de un exceso de peso, ya que un perfil de menores dimensiones y peso podrá soportar la carga solicitada.

Repitiendo los cálculos anteriores para el perfil de 160x160x3 obtenemos un Área requerida por reglamento de 17,836 cm^2 mientras que el perfil comercial seleccionado tiene un área de 18,60 cm2. Por lo tanto, se cumple el requisito del reglamento y además se tiene un considerable ahorro de peso con respecto a la primera opción seleccionada.

Se concluye entonces que los puntales serán de perfil cuadrado 160x160x3 y se situarán como se ha descrito al comienzo de este punto.

	Peso (kg)	Xg (m)	Yg (m)	Kg (m)
Conjunto Puntales	502,24	0	0	60,08
Doble Carril	4100,00	0	0	57,85

Peso de la estructura, y de las jaulas:

En la siguiente tabla se muestra un resumen de los pesos de la Spar, con relación a los espesores de chapas y tipos de refuerzos calculados anteriormente.

PESO TOTAL SPAR (T)	
FORRO FORRO TOROIDE	266,95
REFORZADO DEL FORRO	105,43
ANILLOS	170,48
CUBIERTA PRINCIPAL	35,41
CUBIERTA 01	15,28
CUBIERTA 02	6,98
CUBIERTA 03	7,46
CUBIERTA 04	6,98
CUBIERTA 05	8,83
CUBIERTA 06	10,85
CUBIERTA 07	16,46
CUBIERTA 08	19,58
CUBIERTA 09	33,29
REFORZADO FORRO TOROIDE	12,71
FONDO	128,77
MAMPAROS TK LASTRE	115,29
MAMPAROS TK PIENSO	21,59
PUNTALES GRÚA	0,50
DOBLE CARRIL	4,10
PUNTALES SILOS	0,55
	987,49

Tabla 107. Peso de la Spar.

PESOS JAULAS SPAR (T)		
ESTRUCTURA	12,83	
PECES APOYADOS RED	1,17	
ANILLO DESLIZANTE	1,94	
PESO RED PESO INCRUSTACIONES PESO ANTIFOULING	1,582	
	17,52	PESO POR JAULAS
NÚMERO DE JAULAS	4	
	70,07	PESO 4 JAULAS

Tabla 108. Peso de Jaulas.

5.4.4. CÁLCULOS DE LOS CENTROS DE GRAVEDAD.

Con los pesos de las jaulas y Spar ya conocidos, procedemos a calcular los centros de gravedad, tanto de la Spar, como de la Spar con las jaulas en las tres posiciones, abajo, en medio y arriba.

	Peso Spar t	Long. Arm m	Trans. Arm m	Vert. Arm m
FORRO y FONDO TOROIDE	266,95	0,00	0,00	25,30
REF. FORRO	105,43	0,00	0,00	25,85
ANILLO	170,48	0,00	0,00	25,06
CUBIERTA PPAL. (TECHO)	35,41	0,00	0,00	61,60
CUBIERTA 01	15,28	0,00	0,00	59,45
CUBIERTA 02	6,98	0,00	0,00	57,30
CUBIERTA 03	7,46	0,00	0,00	44,09
CUBIERTA 04	6,98	0,00	0,00	40,34
CUBIERTA 05	8,83	0,00	0,00	36,60
CUBIERTA 06	10,85	0,00	0,00	36,14
CUBIERTA 07	16,46	0,00	0,00	26,60
CUBIERTA 08	19,58	0,00	0,00	16,60
CUBIERTA 09	33,29	0,00	0,00	9,60
REF. FONDO TOROIDE	12,71	0,00	0,00	6,60
FONDO	128,77	0,00	0,00	0,00
	845,46	-	-	26,29
MROS. TK LASTRE y COMP.	115,29	0,00	0,00	21,70
MAMPAROS TK PIENSO	21,59	0,00	0,00	49,20
PUNTALES GRÚA	0,50	0,00	0,00	57,85
DOBLE CARRIL	4,10	0,00	0,00	60,18
PUNTALES SILOS	0,55	0,00	0,00	43,34
	142,03	-	-	27,20
TOTAL	987,49			

Tabla 109. Centro de gravedad de la Spar.

Se aplica a la estructura un margen de un 10% en el peso, obteniéndose así 1.086,24 t.

Centro de gravedad de la Spar de 26,42.

	Peso Spar t	Long. Arm m	Trans. Arm m	Vert. Arm m	Mom.Long. (txm)	Mom.Trans. (txm)	Mom.Vert. (txm)
ACEROS ESTRUCTURA	1.086,24	0,00	0,00	26,42	0,00	0,00	28696,33
CONJUNTO JAULAS (ABAJO)	70,12	0,00	0,00	12,60	0,00	0,00	883,51
		-	-	25,58			
TOTAL	1.156,36						

	Peso Spar t	Long. Arm m	Trans. Arm m	Vert. Arm m	Mom.Long. (txm)	Mom.Trans. (txm)	Mom.Vert. (txm)
ACEROS ESTRUCTURA	1.086,24	0,00	0,00	26,42	0,00	0,00	28696,33
CONJUNTO JAULAS (MEDIO)	70,12	0,00	0,00	30,00	0,00	0,00	2103,60
		-	-	26,64			
TOTAL	1.156,36						

	Peso Spar t	Long. Arm m	Trans. Arm m	Vert. Arm m	Mom.Long. (txm)	Mom.Trans. (txm)	Mom.Vert. (txm)
ACEROS ESTRUCTURA	1.086,24	0,00	0,00	26,42	0,00	0,00	28696,33
CONJUNTO JAULAS (ABAJO)	70,12	0,00	0,00	41,00	0,00	0,00	2874,92
		-	-	27,30			
TOTAL	1.156,36						

Tabla 110. Centro de gravedad de la Spar con las jaulas distintas alturas.

5.4.5. DISPOSICIÓN GENERAL Y PLANOS SECCIONES DE CUBIERTAS.

Se muestra una relación de los equipos que van en cada cubierta.

En los anexos se pueden ver los planos de las distintas cubiertas de la Spar.

- **Cubierta principal, dispone:**
  Compresor para el sistema de extracción de peces muertos (5.5.5SISTEMA DE EXTRACCIÓN DE PECES MUERTOS.).
  Sistema de limpieza de redes (5.5.2 SISTEMA LIMPIEZA.).
  2 balsas salvavidas (10 BALSA SALVAVIDAS.).
  2 bies.
  2 extintores.
  Grúa (6.7 GRÚA.).

Aerogenerador (8.2 AEROGENERADOR.).
Señales de posicionamiento de la Spar.

- **Cubierta 01, dispone:**
  De una sala de control y comunicaciones.
  Un pañol, por si fuese necesario realizar una pequeña reparación, o para guardar el material, que fuese necesario.
  Una zona para ubicar un módulo contraincendios.
  Un pequeño office y aseo, (en caso de que en un momento fuese necesario), aunque se supone que el barco que lleva a los obreros tiene medios propios para ello.
- **Cubierta 02, dispone:**
  Dispone de 4 chigres para la elevación de las jaulas (6.8 CHIGRES.)
  Dispone de 4, molinetes para el fondeo de la Spar.
- **Cubierta 03, dispone:**
  Sistemas de alimentación, en ella el pienso de las tolvas es enviado a las 4 jaulas, por medio de una tubería se lleva al exterior de la Spar, llegando así a las jaulas (5.5.1 SISTEMA ALIMENTACIÓN.)
- **Cubierta 04, dispone:**
  2 diesel generadores Ilustración 94. Diesel Generador.
  Cuadro eléctrico.
  Las bombas necesarias para abastecer a los equipos necesarios, y bombas de lastre (6.10 BOMBAS.)
- **Cubierta 05, dispone:**
  De los tanques de combustible para abastecer los diesel generadores, y el equipo de limpieza de redes.
  Para el consumo diario, debe de abastecerse mediante el aerogenerador, pero cuando sea necesario más consumo, o no se genere la energía necesaria, tenemos un cálculo estimado de consumo de combustible.
  Consumo del diesel generador:

$$18{,}4\frac{l}{h}\cdot\frac{24\ horas}{1\ día}\cdot\frac{30\ días}{1\ mes}\cdot 3\ meses = 39744\ litros, 39{,}7\ m^3$$

Se colocan 2 depósitos de 20.000 litros cada uno.

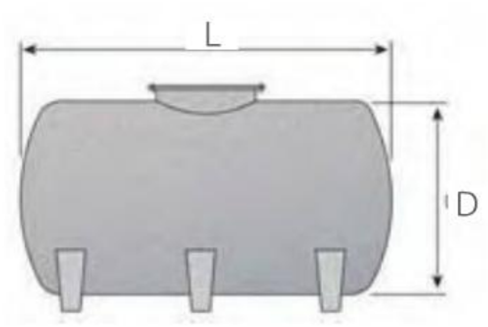


Ilustración 57. Tanque de combustible.

SUPERFICIE

REFERENCIA	VOLUMEN l	D mm	L mm	Ø BOCA DE ACCESO mm	PESO APROX. Kg
STDS 1	1.000	1.000	1.600	600	195
STDS 1.5	1.500	1.000	2.200	600	220
STDS 2	2.000	1.300	1.950	600	230
STDS 3	3.000	1.300	2.700	600	275
STDS 5	5.000	1.600	2.950	600	475
STDS 10	10.000	2.000	3.700	600	860
STDS 15	15.000	2.000	5.290	600	1.080
STDS 20	20.000	2.500	4.910	600	1.590

Tabla 111. Características tanque de combustible.

Un pequeño tanque de agua potable, de una capacidad de unos 10m^3.
(Son cálculos estimados, es una plataforma desatendida).
Embarcaciones y Tecnología marina.
Suministro de agua potable en buques y estructuras marinas.
Parte 2. Método de Cálculo, (ISO 15748-2:2002).
Anexo Tabla A1.
Plataforma “offshore” 350 l/día. (persona/cama/día).

$$350\ litros \cdot 4\ personas \cdot 7\ días = 9800\ litros \cong 10m^3$$

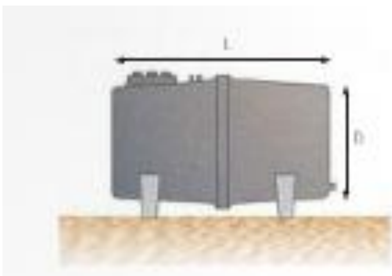


Ilustración 58. Tanque de agua potable.

SUPERFICIE

REFERENCIA	VOLUMEN l	D mm	L mm	Ø BOCA DE ACCESO mm	PESO APROX. Kg
DCHS 2200	2.200	1.150	2.720	410	70
DCHS 3500	3.500	1.600	2.140	410	90
DCHS 4500	4.500	1.600	2.660	410	125
DCHS 6000	6.000	1.750	2.930	410	170
DCHS 8000	8.000	2.120	2.900	567	205
DCHS 10000	10.000	2.120	3.620	567	250

Tabla 112. Características tanque de agua potable.

Un tanque de aguas grises[61] de unos 2m^3.
(Son cálculos estimados, es una plataforma desatendida).
Se parte de:

$$C_r \geq A \cdot N_P \cdot D_a$$

De donde:
A =0,06 m3/persona día.
N_P =número total de personas a bordo.
D_a =número máximo de días en operación (nin/día).

$$C_r \geq 0{,}06 \cdot 4 \cdot 7 = 1{,}63m^3$$

De donde obtenemos un tanque de unos 2m^3.

REFERENCIA	VOLUMEN l	D mm	L mm	Ø BOCA DE ACCESO mm	Ø TUBERÍAS mm	PESO APROX. Kg
DAF 1400	1.400	1.078	1.860	410	110	35
DAF 2200	2.200	1.150	2.720	410	110	60

Tabla 113. Características tanque de aguas grises.

- **Cubierta 06:**
  Cubierta tanque de compensación.
  Este tanque es necesario, para poder compensar, los movimientos de la grúa en cubierta.
  Entre la cubierta 5 y 6 se creará dicho tanque, que se dividirá en cuatro partes, el agua estará en tres de ellas, y cuando se mueva la grúa, el agua se trasladará de tanque, para compensar así su movimiento.
  Se sabe que para un peso de la grúa de 9 toneladas, es necesario un volumen de agua de compensación de 8,96m^3 (ya incluido permeabilidad). Con estos

[61] "Recommended Standards and Guidance for Perfomance, Application, Design and Operations & Maintenance for Holding Tank Sewage Systems, July 1, 2007"

datos se obtiene una altura del tanque de 0,460m. Con una bomba de 60m^3, se hará el traslado del agua en 8,95 minutos. Se tendrán 4 bombas de 60m^3.

Ilustración 59. Bomba para tanque de compensación.

Tipo *Type*	HP	KW	r.p.m.	"A"		Caudal m³/h / *Flow m³/h*										Ø ASP.	Ø IMP.
				230 V	400 V	20	45	60	85	100	120	150	175	200	220		
						Altura m.c.a. / *Height w.c.m.*											
CRB 300	3	2,2	2.850	9	5,2	17,2	12,5	6,8								DN 80	DN 80
CRB 400	4	3	2.850	12	6,9	20	15	10								DN 80	DN 80
CRB 550	5,5	4	2.850	16,5	9,5	19	17	15	10	6						DN 125	DN 100

Tabla 114. Características bomba tanque compensación.

La bomba seleccionada será la CRB 300, bomba centrífuga en bronce marino.

- **Cubierta 07:**
  Cubierta del tanque de lastre.
- **Cubierta 08:**
  Cubierta del tanque de agua de lastre.
- **Cubierta 09:**
  Cubierta del tanque de agua de lastre.
- **Cubierta Fondo:**
  Cubierta del tanque de lastre sólido.

5.5. SISTEMA ACUICULTURA.

5.5.1. SISTEMA ALIMENTACIÓN.

Para dimensionar el sistema de alimentación, se parte de la cantidad de pienso necesario por cosecha, para lo cual se deberá calcular el número de individuos a alimentar y durante cuánto tiempo.

Según la información obtenida[62], para alcanzar una talla comercial (350 – 400 gramos), se necesitan de 13 a 16 meses de engorde. Si la zona es de aguas frías se precisarán 18 meses, mientras que en aguas cálidas, como por ejemplo en la zona de las Canarias se puede alcanzar ese peso en 11 – 12 meses y un peso de 450 – 500 gramos, en 14 meses.

El rango de temperaturas para la supervivencia de la lubina se encuentra entre 12 y 30˚C, siendo su temperatura óptima de 23 a 25˚C.

Como la dorada, en el rango de 13 a 14 ˚C no se alimenta correctamente, podría dejar de crecer con el consiguiente retraso en la cosecha junto con un aumento de la mortalidad, en base a las temperaturas medias mensuales del agua, se ha optado por comenzar el engorde en el mes de abril y hasta el mes de junio siguiente, con un total de 15 meses para obtener un peso final de 432 gramos. No obstante, como en los tres primeros meses del año, las temperaturas medias son bajas, del orden de 13 a 14 ˚C, los individuos ingieren menos alimento y el engorde se ralentiza, por lo que se prevé llegar una talla comercial de unos 350-400.

Nunca se alcanza el límite letal para estos individuos que es de 5 – 7ºC[63], aunque en algunos artículos nos dicen por debajo de los 4ºC[64].

Los cálculos se realizan en base a las siguientes fórmulas, y en las temperaturas obtenidas, en la zona de operación de la planta.

$$Y = 0{,}0167 \cdot X^{0{,}621} \cdot e^{0{,}055 \cdot T}$$

$$C = 0{,}017 \cdot X^{0{,}71} \cdot e^{0{,}06 \cdot T}$$

Siendo:
Y = Peso ganado (g de peso/pez y día).
X = Peso (g).
C = Consumo de alimento diario (g de alimento/pez y día).
T = Temperatura (ºC).

Obteniendo así, para un periodo de quince meses la siguiente cantidad de pienso necesaria:

[62] "Cultivo de Dorada", Aurelio Ortega.
[63] "Cultivo de Dorada", Aurelio Ortega.
[64] http://www.magrama.gob.es/app/jacumar/especies/Documentos/Dorada.pdf

Total Pienso (g)/Individuo	Nº individuos	Gramos	Toneladas	Ton/jaula
728,435	583.000	424.677.518	424,678	106,169

Tabla 115. Cantidad de pienso necesaria.

En la gráfica de la Ilustración 60 se puede observar la evolución del crecimiento de la dorada. En el eje de abscisas se presenta el tiempo de engorde, y en el eje de las ordenadas el peso por unidad de dorada.

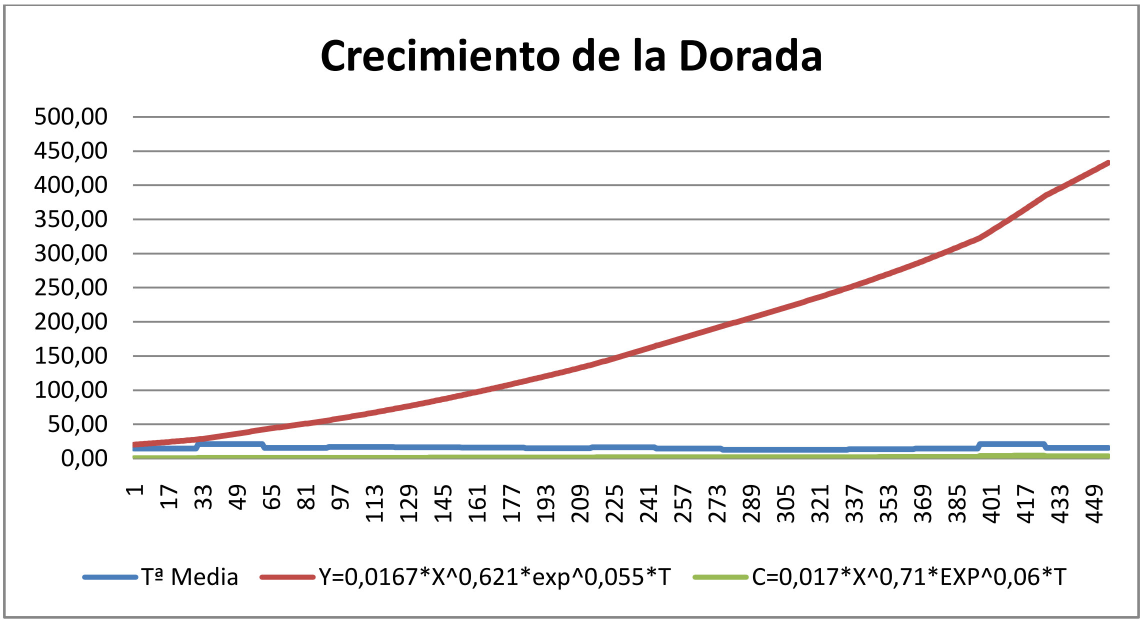


Ilustración 60. Gráfica crecimiento de la Dorada.

Se sabe que durante los 15 meses del proceso de engorde, en función del peso del pez, tendrán un pienso (pellet) cuyo diámetro será distinto, como podemos observar en la Tabla 116, en la que calcularemos un volumen total por jaula, y diámetro de pienso. Al cual aplicaremos un factor de estiba de 0,9, por ser estiba a granel.

CÁLCULO VOLUMEN PIENSO EN FUNCIÓN DIÁMETRO DEL PELLET POR JAULA					
Tamaño dorada (g)	Diámetro pellet (mm)	V unidad pellet (m3)	Vol/kg (pellet)	V. Total (m3)	F.E.=0,9
10 - 60	2,5	0,000000008	0,00104720	9,606	10,674
60 - 200	4	0,000000034	0,00104720	35,174	39,082
190 - 600	6	0,000000113	0,00104720	66,400	73,778

Tabla 116. Volumen peso función diámetro del pellet.

Para calcular el volumen por unidad de pellet, los datos de partida son del pienso “Excel” que carece de datos suficientes, por lo que se ha calculado el volumen a partir de otro tipo de pienso “Biomar”, mediante una recta de regresión.

Biomar		Excel	
Diámetro	ud/kg	Diámetro	ud/kg
3	53.000	2,5	128.000
4,5	18.000	4	31.250
6,5	5.500	6	9.259
9	2.000		

Tabla 117. Datos piensos Biomar y Excel.

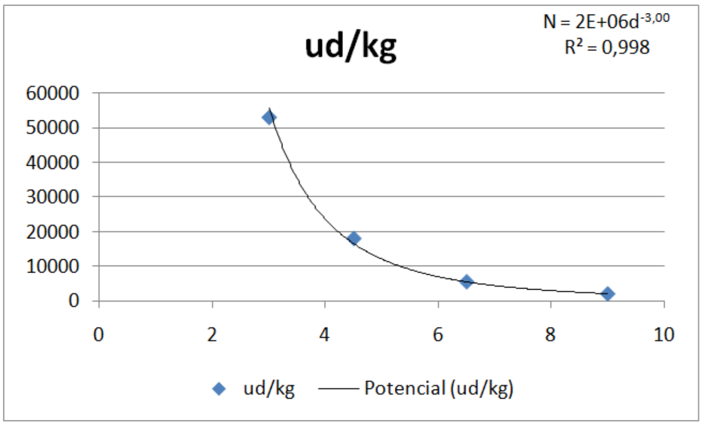


Ilustración 61. Recta de Regresión.

Los datos correspondientes a las gráficas obtenidas, se incluyen como Anexo.

Para el sistema de alimentación, se han estudiado equipos de diversos fabricantes, de los cuales se considera como más idóneo al suministrado por Akva Group debido a su modularidad y nivel de automatización.

Los sistemas de alimentación de AKVA Group están de acuerdo con las siguientes directivas europeas:

- Directiva EMC, 2004/108/CE.
- Directiva de baja tensión, 2006/95/CE.
- Directiva de máquinas, 2006/42/CE.

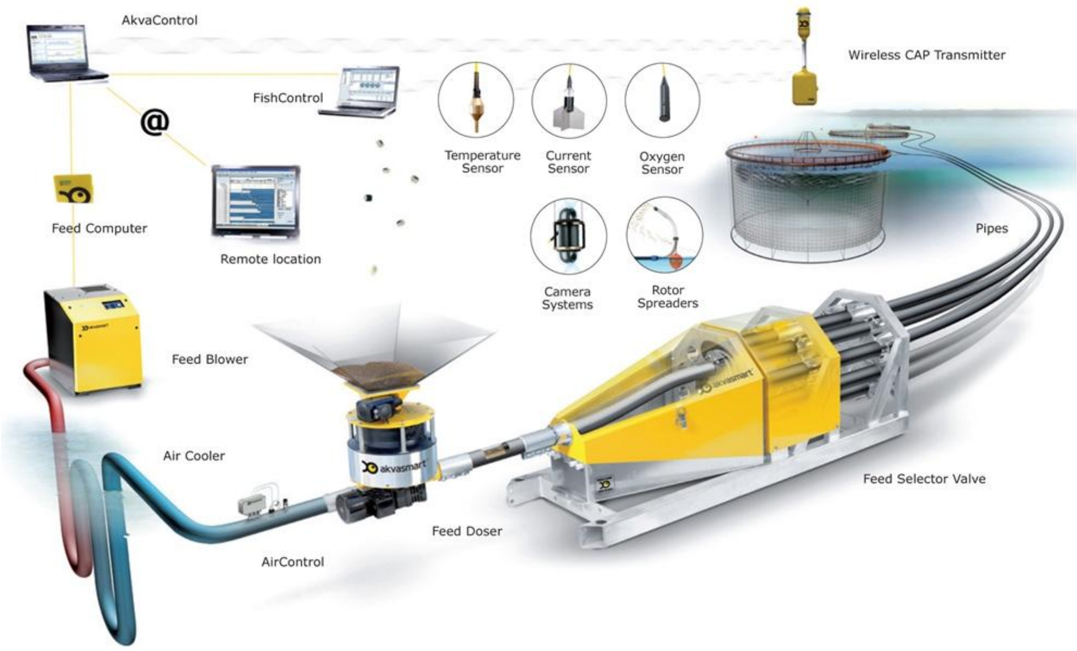


Ilustración 62. Partes del sistema de alimentación AKVA.

Los sistemas de alimentación, fueron inventados por AKVA Group en 1980, siendo hoy en día de alimentación muy usado, y fiable, siendo válido para todas las especies alimentadas por pellets. Es un sistema que está completamente integrado por cámaras y sensores ambientales, y con un software de control de producción Fishtalk. Los datos de alimentación y del medio ambiente se almacenan en la base de datos Fishtalk. Así tendremos una visión de conjunto y podemos controlar todas las actividades operativas del centro a un nivel superior.

El sistema entregará la cantidad correcta, y la tasa óptima, en el momento justo, todas las veces. Esta herramienta se ajusta al apetito de los peces, y entrega una valiosa posibilidad de optimizar el proceso de alimentación.

La nueva funcionalidad incluye un planificador de alimentación, alimentación en grupos y alimentación adaptativa. Combinando con los datos de los sensores ambientales, permite un análisis eficaz y la evaluación comparativa entre los distintos centros.

Estos sistemas pueden llegar a manejar más de 40 líneas de alimentación que funcionan en forma paralela y más de 1.000 jaulas/estanques, alimentadores centralizados, o tolva, todo operado desde un PC, iPad o Smartphone.

Akvasmart CCS es la elección perfecta para la alimentación de peces, diseñado para adaptarse a los requisitos de sistema de baja capacidad como la CCS-32, hasta sistemas de alta capacidad, como CCS-110.

Este sistema está diseñado para cumplir con todos los requisitos de alimentación, independientemente de la especie o la forma en que se desea alimentar a los peces.

La configuración del sistema se basa en los siguientes factores:

- Longitudes de Transporte.
- Biomasa.
- Número de unidades (jaulas).
- Especies.

SISTEMA CCS-32			NOTAS
Tamaño tubería alimentación	(mm/")	32/1	-
Espesor pared	(mm/")	2,9/0.11	-
ALIMENTACIÓN POR CADA LÍNEA			NOTAS
Tamaño Pellet */**	máx. (mm) min. (mm)	5-7 2	-
Capacidad máx alimentación */**/***	kg/hora kg/hora	648 -	Varidoser 1500 -
Tasa de alimentación máxima */**/***	kg/min kg/min	10.8 -	Varidoser 1500 -
Tasa de alimentación mínima */**/***	kg/min kg/min	1.2	-
Dosis de alimentación mínima */**	gramos gramos	10 -	Varidoser 1500 -
LONGITUD DE TRANSPORTE			NOTAS
Máxima longitud de tubería de alimentación.	m	300	*/**
Máxima tasa de alimentación, en función longitud tubería	kg/min	3.6	***
Máxima tasa de alimentación, en función longitud tubería	kg/min	5.4	***
Máxima tasa de alimentación en un corto, en función longitud tubería	kg/min	10.8	Varidoser 1500
CONSUMO MÁXIMO DE ENERGÍA			NOTAS
COMPRESOR DE ALIMENTACIÓN	kW	7.5	-
VÁLVULA SELECTORA	kW	0.18	-
FEEDDOSER	kW	0.37	Máxima carga/ud
VARIDOSER	kW	0.37	Máxima carga/ud
AUGER AND SLUICE	kW	0.15	-

* En función de la distancia de transporte real.

** En función del tipo de alimento, la cantidad de alimento técnica, el tamaño de pellets, velocidades de alimentación, la configuración del sistema.

*** En la alimentación continua.

Tabla 118. Sistema de alimentación de Akva

El tamaño de los pellets de pienso en función del peso del individuo, es el siguiente:

- Para un peso de la dorada entre 10-60 g diámetro del pellet 2,5mm.
- Para un peso de la dorada entre 60-200 g diámetro del pellet de 4mm.
- Para un peso de la dorada entre 190-600g diámetro del pellet de 6mm.

Una “Válvula Dosificadora de Alimento” se utiliza para transferir la alimentación al flujo del aire. Con el fin de satisfacer todas las necesidades de los clientes, se ofrece tanto alimentación por “Válvula Dosificadora” como “Tornillo Sin Fin”, con esclusa.

Ilustración 63. Válvula Dosificadora de Alimento.

La “Válvula Selectora” es el punto de conexión para las tuberías de HDPE.

Ilustración 64. Válvula Selectora.

Sistemas de Control de Aire Akvasmart, se instala entre el enfriador y el Dosficador. La regulación de aire permite garantizar un flujo óptimo de pellets, reduciendo significativamente el riesgo de bloqueo y ruptura.

- Si la velocidad del aire es demasiado baja, el riesgo de estancarse el alimento aumenta.

- Si la velocidad del aire es demasiado alta, el polvo y la ruptura de pellets aumenta.

El sistema también supervisa y registra la velocidad del aire, contrapresión y la temperatura.

Ilustración 65. Sistema de Control de aire.

Los sistemas de dispersión de alimento, poseen rodamientos diseñados para proporcionar una excelente propagación de alimento en la jaula. Los modelos tienen tubos de aluminio ligeros ajustables en el rotor, permitiendo una menor velocidad del aire par arranque y la rotación. Lo que implica es menos polvo ruptura, menos consumo de energía, menos contrapresión, menor temperatura del aire, menor ruido y menor desgaste de los tubos de alimentación

El sistema de dispersión, irá sujeto a las jaulas, así podrá subir y bajar sin problema, estará unido a las válvulas selectoras de donde tomará el pienso para hacerlo llegar a la jaula.

Ilustración 66. Sistema dispersión de alimento para jaulas de sumergidas.

Los controles remotos inteligentes proporcionan nuevas oportunidades para el acuicultor. Las Tablet permiten el acceso a todas las funciones en Akva Control y Fishtalk mientras esta fuera de la sala de control. Se puede controlar el sistema de alimentación, viendo las lecturas de los sensores ambientales y los videos de las cámaras de alimentación sólo utilizando el control remoto.

Ilustración 67. Controles remotos inteligentes.

El compresor genera una presión de aire para transportar la alimentación a cada jaula. La combinación de este sistema junto con el sistema de control de aire hace posible optimizar el transporte de pellets.

La presión dependerá de la longitud de la tubería, de la velocidad del compresor y de la necesidad de alimentación.

Ilustración 68. Compresor.

5.5.2. SISTEMA LIMPIEZA.

La limpieza de la jaula debe llevarse a cabo regularmente ya que las redes que forman la jaula son las responsables no solo de contener a los peces en ellas, sino de garantizar también un correcto flujo de agua a su través manteniendo el interior de la jaula limpio y correctamente oxigenado.

Uno de los mayores focos de suciedad, son las incrustaciones o fouling, localizadas en las redes, ocasionando los siguientes problemas.

- Disminución del intercambio de agua, el cual provocará menos aportación de oxígeno, para los peces que se encuentren en su interior.

- Incremento de las fuerzas de las corrientes sobre las redes, que influirán en la tensión de los sistemas de anclaje.
- Debido a los aumentos de las fuerzas de corrientes, las deformaciones de las jaulas también serán mayores.

Otra zona donde aparecen problemas de suciedad es en el fondo de la jaula por acumulaciones de peces muertos, restos de comidas y heces. Sin embargo, y debido a la luz de la red, los restos de comida y heces son barridos por el continuo flujo de agua que atraviesa la red reduciendo este problema únicamente a la extracción de peces muertos.

Sistema de limpieza de redes:

Para eliminar el fouling marino en las redes se utiliza agua de mar filtrada a alta presión, mediante los limpiadores de redes que usan discos giratorios montados en chasis de variadas formas y combinaciones. Mediante bombas de alta presión, para trabajos pesados y hechas a la medida para dirigir los discos de limpieza. El proceso de limpieza comienza al sumergir el dispositivo en el interior de la red, usando solamente agua de mar bombeada a alta presión. El sistema de limpieza no utiliza químicos y no actúa por refriegue. Es amigable con el medioambiente y no daña las redes.

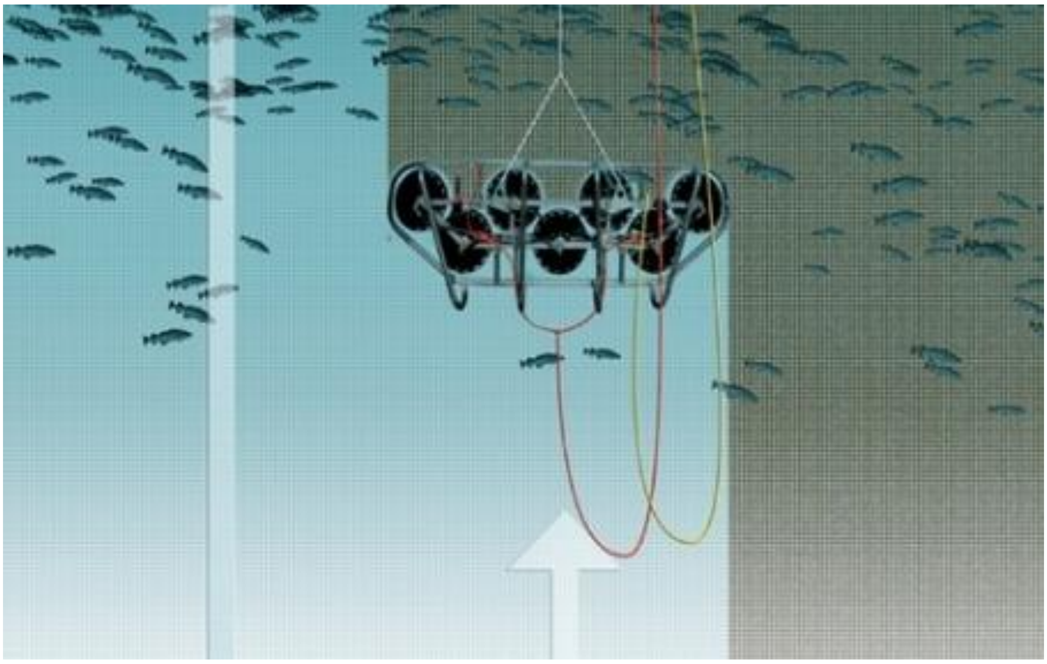


Ilustración 69. Esquema sistema de limpieza.

Tipos de discos giratorios:

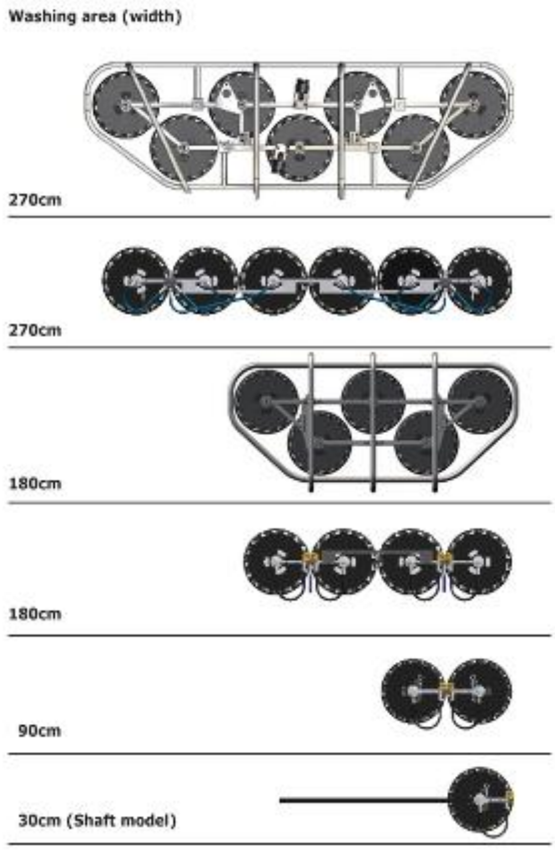


Ilustración 70. Accesorios del sistema de limpieza.

Está es una solución inteligente, flexible y de fácil manejo.

Los limpiadores de redes más grandes pueden ser operados en modo automático por dos personas utilizando una grúa. Los limpiadores de redes más pequeños pueden ser operados fácilmente desde el acceso de mantenimiento de jaula por una persona.

La limpieza efectiva de redes reduce las enfermedades y estimula el crecimiento.

La necesidad de oxígeno crece cuando la temperatura del agua aumenta. Esta curva es casi idéntica para la mayoría de las especies.

Una rotura en las redes, puede dar lugar a perder toda la producción que tengamos en la jaula.

El sistema de limpieza de las jaulas ha de ser respetuoso con el medio ambiente y con los peces.

Para realizar la limpieza se elevarán las jaulas, y desde las pasarelas de las jaulas, un operario se encargará de realizar la limpieza de las redes de las jaulas. El sistema de limpieza se alimentará de la energía generada a bordo.

El sistema de limpieza tiene las siguientes características:

Lavadores de alta presión	D-Drive K-136-3600-SD
Máquina	Jonh Deere
Máxima hp	150hp
Tamaño	400x200x200cm
Peso	aprox. 2400kg
Consumible	Diesel
Máxima cantidad de discos	10
Longitud de circunferencia	Hasta 200m
Equipo estándar	Encapsulada con cámara de acero inoxidable insonorizada y con bomba integrada
Agua litro/minuto	188
Bar	300

Tabla 119. Características Sistema de limpieza.

5.5.3. SISTEMA SANITARIO DE PECES.

El sistema sanitario de peces, llevará un control mediante los sensores de temperatura, oxígeno, y velocidad de corriente, para conocer en todo momento si el hábitat es saludable o si por el contrario las condiciones podrían dar lugar a alguna enfermedad (6.3 SENSORES AMBIENTALES.)

Además de estas mediciones, cuando se retiren los peces muertos, estos serán llevados al laboratorio para analizar las causas de la muerte y detectar cualquier enfermedad y actuar correspondientemente.

Además en las distintas visitas que se realizaran a la planta, se tomarán muestras in situ para analizar y comprobar si las condiciones son idóneas y para evitar así posibles problemas en la aparición de posibles enfermedades.

5.5.4. SISTEMAS DE EXTRACCIÓN.

A la hora de extraer los peces, se extraerán mediante copos, se ha escogido este método en lugar de un sistema de extracción que los succionase de la jaula, porque de esta manera los peces llegaran al mercado en mejores condiciones.

El barco que los venga a recoger realizará las operaciones necesarias para almacenarlos, limpiarlos y llevarlos a los puestos de venta correspondientes.

Ilustración 71. Sistema de recogida de peces muertos.

5.5.5. SISTEMA DE EXTRACCIÓN DE PECES MUERTOS.

Un requisito previo para un entorno de pescado saludable, es que todos los peces muertos se retiren de la jaula lo más rápidamente posible.

Los peces se recogen del fondo de la jaula (fondo cónico) por succión, para su posterior tratamiento.

Mediante un sistema de aire comprimido, se busca una creación de un constante y rápido caudal, y mediante un sistema de mangueras se transportarán los peces muertos de la succión, desde la cabeza hasta el dispositivo de cribado a la central de recogida.

Los compresores de tornillo tendrán una capacidad mínima de aire de 3000 litros por minuto y 10 bares de presión.

Funcionamiento.

El sistema de recolección de peces muertos funciona mediante el envío de aire presurizado a través de una manguera de aire en la entrada de succión.

Debido a que el aire tiene menor densidad que el agua, el aire se levantará en el interior de la manguera de transporte, creará un vacío y una corriente. Estas fuerzas crean un efecto de succión creando un vacío y una corriente que transportará a los peces muertos hacia arriba y fuera de la jaula.

Sistema de recogida de peces muertos.

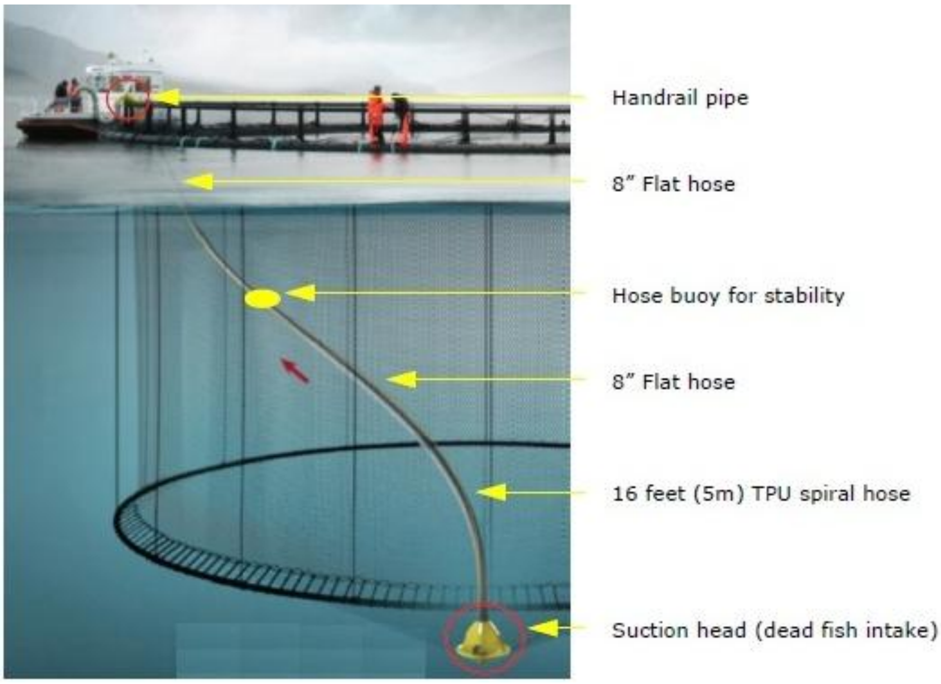


Ilustración 72. Sistema de recogida de peces muertos.

Cabeza de succión:

Ilustración 73. Cabeza de succión.

Estabilización.

Cabeza ML130 succión, tiene 700 kg de lastre, aunque el lastre estándar es de 500kg. Esta cabeza tiene un punto de fijación, que puede llevar hasta 1000 kg. El peso se fijará en función de las corrientes, profundidad y factores similares.

Cámara de lastre.

La cabeza de succión tiene una cámara de lastre que lleva 145 litros. Las bolas de acero de manganeso se utilizan como lastre, están pesan 5,5kg por litro. El cabezal de aspiración se entrega con 500kg de lastre, que equivale a 91 litros de acero al manganeso.

La cabeza de succión pesa unos 45 kg sin lastre.

El peso total de la carga es de 545kg, el lastre incluido en la construcción desplaza 145 litros, lo que significa que el peso total del agua de mar se reduce en 145 kg, dando un peso neto de 400kg en el mar.

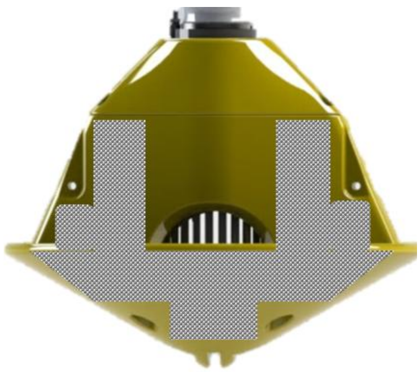


Ilustración 74. Cámara de lastre en cabeza de succión.

Distribución del aire en la cabeza de succión.

El aire se distribuye a través del tubo corto en la cámara de aire. Se sopla aire dentro que se distribuye a través de pequeños orificios de la tubería y crea un flujo de aire uniforme, la dimensión de la manguera de aire es de unos 19mm.

Ilustración 75. Distribución del aire en la cabeza de succión.

Boya de manguera.

Esta boya se instala para la flotabilidad y mantener la manguera vertical, cuando el sistema de recogida de peces muertos no se está usando y para asegurar que los peces muertos fluyen a través de este sistema, minimizando el desgarro de las mangueras y prolongando la vida operativa de todo el sistema, también asegura un rápido tiempo de inicio. Otra finalidad de esta manguera es reducir el riesgo entre las abrazaderas de manguera y la red, para no causar daños a la red.

Ilustración 76. Boya de manguera.

Sistema de aire comprimido.

El compresor es el motor del sistema, como comentamos anteriormente puede entregar 3000 litros por minuto a 10 bar de presión. La tubería tendrá un diámetro mínimo de 34mm, que nos sirve para distancias de unos 800m, para garantizar la caída de presión.

Ilustración 77. Sistema de aire comprimido.

Los peces muertos serán reemplazados, para poder mantener la producción de la planta.

Se ha de tener en cuenta que llevarán cuando tengamos algún flete, para no concurrir a mayores gastos.

6. MÁQUINAS AUXILIARES.

6.1. SISTEMAS DE CONTROL.

El Akvaconnect 2.2 es un software que controla un control óptimo de los procesos y actividades industriales. Conecta y mantiene el control desde un centro local hasta las corporaciones acuícolas, siendo un sistema compatible con todo tipo de equipamiento, sensores e instalaciones (cámaras, winches, CAP…). Basado en un sistema 3D posee funciones operativas, que hacen que tenga una manera fácil de operar.

Mediante una conexión inalámbrica puede tener conectadas hasta seis líneas al mismo tiempo, mostrando imágenes desde cada cámara por línea de alimentación, (la red inalámbrica puede tener un alcance de 50km, para vigilancia desde varios sitios como puede ser un pontón o similar).

Se pueden conectar una cantidad ilimitada de cámaras cableadas, y verse todas al mismo tiempo, sólo estarán limitadas por el número de pantallas.

Las funciones clave del Akvaconnect son.

- Visión general completa del centro a la vista.
- Planificación de la capacidad del sistema.
- Planificación de alimentación avanzada.
- Control de Tolva.
- Control de cámara de alimentación integrado.
- Aplicaciones de ayuda.
- Poderosa herramienta de informes y análisis.

6.2. CÁMARAS SUBMARINAS.

La Cámara SmartEye 360 Twin puede supervisar la actividad de los peces, así como la dispersión de alimento entregado debajo de la superficie, incluso en condiciones de poca luz.

Hoy en día es una de las mejores cámaras que existe. Mostrando una inspección avanzada de la alimentación, con cámaras a color, con características únicas y que pueden ser operadas desde la jaula, a una sala de control de la alimentación, una embarcación y vía internet. Proporciona colores vivos y/o imágenes monocromas de video bajo el agua.

Compuesta por cámara superior e inferior a color y de alta resolución, mientras que las monocromáticas, se utilizan para obtener mayor sensibilidad a la luz para mirar hacia abajo en jaulas profundas y oscuras. Las cámaras están sincronizadas para realizar movimientos verticales de 360º gira horizontal y verticalmente sin partes móviles en el agua.

Combinando la Cámara con el sistema Smart-Winch (permite posicionar de manera precisa las cámaras de manera horizontal y vertical), obtenemos una gran comprensión de la respuesta de alimentación y estado de los peces. Se conecta al transmisor CAP de video inalámbrico.

Ilustración 78. Cámara SmartEye.

Cámaras	SmartEye 360 Twin	
Tipo	Árriba: color	Abajo: monocromo
Resolución	480 TVL (Center)	570 TVL (Center)
Sensibilidad de la luz	1.5lx (@ F1.2)	0.0003lx (@ F1.4)
CCD Sensor	1/3" Sony	1/2" Sony
E. Iris/Lense	Auto / 2.8 mm	Auto / 3.5 mm
Ángulo de vista	90º en aire, 76 en agua	
Materiales	Acrilico / Bronce	
Profundidad del Cable	50 m Uretano	
Profundidad	200 m	
Alimentación	11-30VDV / 1.2 A	
Tamaño H x Ø	361mm x 171 mm	
Peso	5.4 kg	

Tabla 120. Características Cámara SmartEye.

6.3. SENSORES AMBIENTALES.

El control de datos ambientales como la temperatura, el nivel de oxígeno y velocidad de la corriente son importantes cuando se alimentan los peces. Con el sistema de alimentación Akvasmart CCS, todos estos factores se pueden configurar para controlar o ajustar la alimentación de forma automática y su velocidad. Todos los datos ambientales se registrarán y se pueden analizar posteriormente en AkvaControl o en Fishtalk.

Mediante mediciones precisas en tiempo real se muestran y registran en el programa de control y AkvaControl calculará la cantidad de alimento a entregar, basándose en tablas de alimentación y datos de los sensores.

El sistema puede ser inalámbrico y la señal se transmitirá entre el borde de la jaula y la unidad base. Por lo que los cables sólo serán necesarios desde el borde de la jaula hasta los sensores. Cada jaula se puede ajustar de forma individual, y la totalidad del sistema está conectado al sistema de alimentación Akvasmart CCS. El sistema ayuda para los operadores de alimentación, de manera que, con el uso correcto de este sistema y las especificaciones de AKVA, puede optimizar la alimentación, teniendo así un mejor crecimiento y un factor de alimentación más bajo.

Sensor de corriente:

Usaremos un sensor de corriente desde 0-50cm/seg.

SENSORES DE CORRIENTE	
Sensor de Corriente	0-50 cm/seg
Precisión	+/-1 cm/seg
Rango de Medición	0-50 cm/seg (0-1 nudos)
Principio de Medición	Sensor de inclinación electrónico
Materiales	Acrílico/POM/Aluminio
Consumo de Enegía	75mA
Cable	Cable de Poliuretano 30m
Conector	Amphenol (Impermeable, conector sellado)
Rango máximo de profundidad	30m
Tamaño L X A X H	165 X 165 X 200mm
Peso	5kg - 12 kg

Tabla 121. Sensor de Corriente.

Los sensores se colocan estratégicamente, y se puede programar la velocidad de la corriente de la máxima alimentación, así como cuales jaulas son controladas por el sensor específico. Cuando la corriente excede este límite dado, la alimentación se detiene automáticamente en las jaulas especificadas, y comienza de nuevo cuando la corriente está de nuevo por debajo del límite.

Cuando las corrientes afectan al sensor, el ángulo del péndulo cambia. El ángulo se mide electrónicamente y se convierte en cm/seg.

El sensor no tiene partes móviles. Esto le da un mantenimiento mínimo y una mayor longevidad.

Ilustración 79. Sensor de corriente.

Sensor de oxígeno:

SENSOR DE OXÍGENO	
Precisión	+/- 0.1 mg/L 0-8mg/L +/- 0.2 mg/L 8-20mg/L +/- 10% 20-50mg/L
Rango de temperatura de operación	0-50ºC
Rango de Medición	0-50 mg/L
Principio de Medición	Luminiscencia Óptica
Materiales	Polietileno
Consumo Energético	50mA at 12VDC
Cable	10m o 50m
Plug	Amphenol (Impermeable)
Profundidad máxima	210 (689') limitado por el cable
Tamaño L X Ø	203mm x 47mm
Peso	0,90 kg con 10 m de cable

Tabla 122. Sensor de Oxígeno.

Los sensores de oxígeno son una de las varias herramientas desarrolladas para la industria acuícola para optimizar la alimentación y con ello el costo beneficio. El oxígeno es un factor importante para el crecimiento y bienestar de los peces. Con este sensor conectado al sistema de alimentación, la cantidad de alimentación puede ser detenida cuando el nivel de oxígeno es demasiado bajo. El sensor de oxígeno RDO es un sensor libre de membrana robusto y confiable cuyas medidas se basan en lecturas ópticas, reduciendo así la necesidad de calibraciones, dando un alto grado de precisión y se pueden utilizar durante grandes períodos de tiempo sin pérdida de precisión para la medición.

El único mantenimiento que necesita es una limpieza regular.

Ilustración 80. Sensor de oxígeno.

Sensor de temperatura:

SENSOR DE TEMPERATURA	
Resolución	+/-0,1 ºC
Precisión	+/-0,5 ºC
Rango de Medición	0-50 ºC
Material	Bronce Maquinado
Cable	3m (100') Cable de Uretano
Profundidad	3m (100') Limitado por el cable
Tamaño L X Ø	800mm X 50mm (3.15" x 2")
Peso	3,5kg (7.7lbs)
Terminal de Conexión	Conector impermeable Amphenol (Sellado con Epoxico)

Tabla 123. Sensor de temperatura.

El sensor de temperatura es la base para todos los regímenes de alimentación y las tablas de crecimiento, Se trata de un sensor robusto y fiable para medir temperaturas a diferentes profundidades. Las mediciones en tiempo real se muestran continuamente en la pantalla del ordenador de vigilancia y se registran en AkvaControl.

Con las mediciones de temperatura y de alimentación integrada y tablas de crecimiento, AkvaControl calcula la entrega de alimento esperado diaria.

Así podremos tener una buena estimación para el control de alimentación.

El sensor se puede conectar al sistema inalámbrico a través de CSU a una estación medioambiental (EAP) o directamente al selector en el sistema de alimentación.

Estos sensores de temperatura se producen en bronce, que impide el florecimiento de algas y necesita un mantenimiento mínimo, y también da una respuesta rápida a los cambios de temperatura.

Ilustración 81. Sensor de temperatura.

Diagrama de Flujo de Sensores.

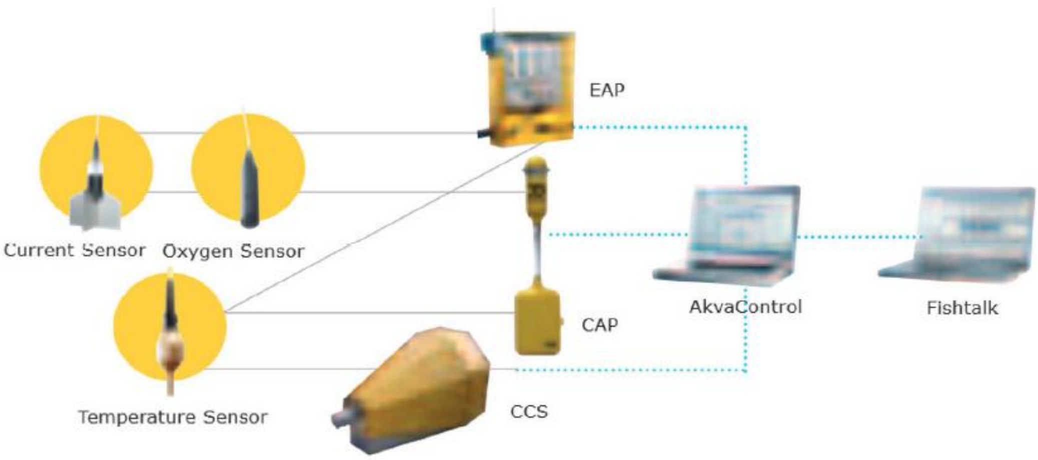


Ilustración 82. Diagrama de Flujo de Sensores.

Los sensores estarán conectados al EAP, para la transmisión de energía y señales.

6.4. CAP (Punto de Acceso en Jaula).

Es un punto de acceso inalámbrico para cámaras submarinas. Con capacidad para transmitir hasta 6 canales de video, adaptándose el sistema a cualquier centro.

Cada unidad puede ser conectada a la parte superior de la CAP.

Las imágenes de vídeo se transmiten de forma inalámbrica desde cada jaula a la base principal.

La fuente puede ser por una batería de 12V, o 230 V cableada la Spar.

Ilustración 83. CAP (Punto de acceso en jaula).

6.5. EAP (Punto de Acceso Ambiental).

Este sistema está directamente relacionado con el Sistema CCS RSS Akvasmart a través del software AkvaControl. Al recoger y registrar datos ambientales de una o varias profundidades proporciona un mejor control de la alimentación y la posibilidad de análisis de datos ambientales en comparación con los datos de alimentación.

El EAP es un módulo de conexión de sensores robusto que permite la conexión de varios sensores en un solo lugar. La comunicación de dos vías entre EAP y el sistema de alimentación puede ser por radio o cableado.

El EAP es una parte activa del sistema de alimentación, lo que permite la conexión de sensores tales como la temperatura, oxígeno y corrientes.

Los sensores ambientales dan buenas indicaciones del medio ambiente de los peces. Todas las conexiones son resistentes al agua siempre que estén debidamente conectadas.

Ilustración 84. EAP (Punto de acceso ambiental).

Información técnica y tamaño de la EAP.

INFORMACIÓN TÉCNICA	
Rango de Temperatura	-10ºC a +40ºC
Comunicación	Radio o Cableado
Conexiones	Conectores Amphenol y Conexión directa
Materiales	Fibra de vidrio, acrílico y aluminio
Equipamiento Adicional	Soporte a Jaula para la instalación en jaula de plástico o de acero

Tabla 124. Características del EAP.

TAMAÑO EAP	
L X A X H	370 x 300 x 170 mm
Peso	5kg
Conexiones	Simple
Sensor de Oxígeno	1
Sensor de Temperatura	1
Sensor de Corriente	1

Tabla 125. Tamaño EAP.

6.6. EMBARCACIÓN DE APOYO, BARCO MULTIPROPÓSITO.

Ilustración 85. Embarcación de apoyo Ocea VS815.

Barco Multipropósito de Trabajo tipo catamarán Ocea VS815. Ocea ha adquirido los derechos y los planos de la conocida marca fabricante de embarcaciones, Risnes Marine Partner AS. Los barcos están construidos y diseñados por Ocea, y remodelados y desarrollados en cooperación con Vik-Sandvik AS. Están fabricados con cascos de acero y aluminio pilot house, haciéndolos suficientemente robustos para que duren toda la vida.

Los barcos de trabajo están diseñados y construidos para entregar alta resistencia, seguridad y larga vida, teniendo en cuenta las condiciones medioambientales. Ocea pretende satisfacer las demandas del mercado otorgando soluciones ante el aumento de las exigencias de capacidad, estabilidad y velocidad. Cuenta con barcos de diferentes tamaños, de hasta 15 metros de eslora, que se fabrican conforme a la Norma de barcos nórdicos. Están construidos en acero con aluminio. Él recubrimiento de zinc en el casco de acero completa el diseño para entregar un bote de trabajo fuerte y robusto, con una larga vida útil y un mantenimiento mínimo. Los cascos responden a un diseño relativamente nuevo-realizado con Vik-Sandvik AS- y permiten alcanzar altas velocidades, de hasta 18 nudos.

Características destacadas:

- Barcos construidos en acero robusto.
- Superficie de casco recubierta de zinc.
- Cubierta con grúa.
- Proporciona un alto rendimiento y velocidad.
- Elevada cubierta de proa y la mejora de la capacidad de carga.
- Alto volumen de flotabilidad proporciona una buena estabilidad al usar la grúa.
- Construido según las normas nórdicas.

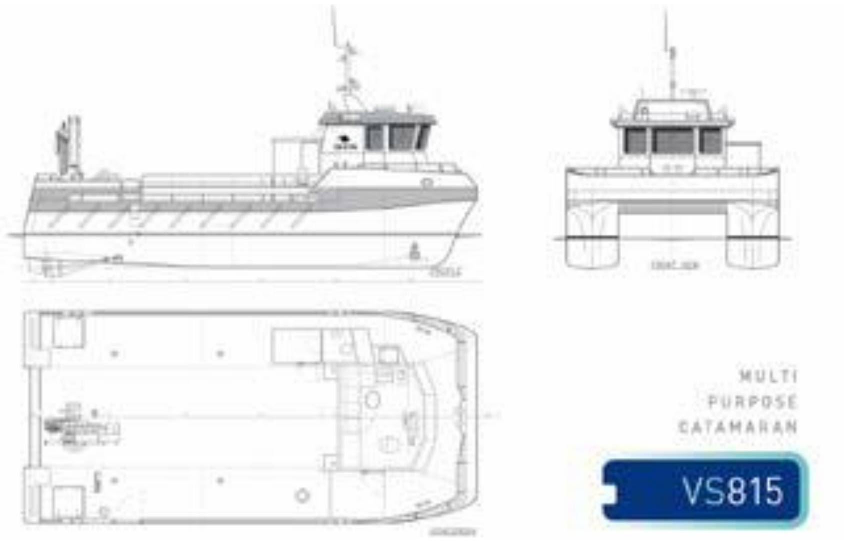


Ilustración 86. Disposición general.

Características del barco:

ESPECIFICACIONES	VS815
Longitud	14,95m
Manga	7 a 8 m
Puntal de trazado	2,2 m
Manga	0,5 m
Motor	2 x 500 HP
Grúa en cubierta, radio controlada	hasta 45 t/m
2 Cabrestantes	hasta 5t
Winche radio controlado montado en cubierta (opcional)	hasta 15t

Tabla 126. Características de la Embarcación de Apoyo.

6.7. GRÚA.

Se dispondrá de un doble carril, alrededor de la cubierta de la Spar, mediante la cual la grúa circulará para poder acceder a todas las jaulas, para las labores de mantenimiento y/o reparación necesarias.

Ilustración 87. Disposición de la Grúa.

En la siguiente ilustración podemos ver el croquis de la grúa y sus características principales.

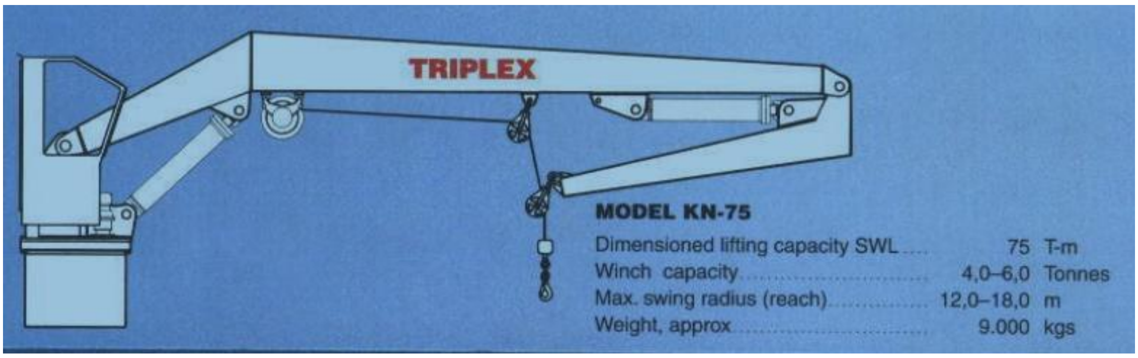


Ilustración 88. Disposición de la Grúa.

6.8. CHIGRES.

Se han de tener en cuenta los siguientes pesos para saber el tiro del chigre a usar.

- Peso de la estructura de la jaula.
- Parte proporcional del peso del anillo.
- Peso de los peces apoyándose en la red.
- Peso de la red con las incrustaciones y antifouling.
- Pesos aproximado a izar por chigre de 17,519 toneladas.

Ilustración 89. Chigre.

Line Speed Specifications (Metric)

Frame	Pulling model 15:1 D/d ratio	Lifting model 18:1 D/d ratio	Std drum length mm	hp	Line pull, layer (kg) 1st	mid	full	Std line speed, layer (mpm) 1st	mid	full	Wire rope size (mm)	Drum capacity, layer (m) 1st	mid	<2 layers[1]	full[2]
8	EP45600-18-30		762	30	20727	16909	14318	5	7	8	40	39	129	237	362
8		EL42400-20-30	762	30	19273	15955	13591	6	7	9	40	42	138	252	383

(1) <2 layers = full drum less 2 layers for working
(2) full = full drum for storage

Tabla 127. Características del chigre.

Para el ancho del chigre de *762/15=50,8* vueltas por capa.

De las *50,8X2,073=105,308* metros de cable en la primera capa.

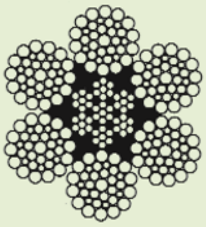
Por lo que no usaremos ni la primera capa.

Entonces es válido este modelo porque en la primera capa tenemos 19,273 ton.

El tiempo estimado para cada maniobra de subida y/o bajada de jaulas es de 7,5 minutos.

En la siguiente imagen se puede ver el tipo cable escogido para los chigres.

COMPOSICIÓN
6 x 36 + (7 x 7 + 0) WS
Negro
(180 kg/mm²)



Código T. D.	Código T. I.	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100636MNND14A	100636MNNI14A	14	0,820	12.600
100636MNND16A	100636MNNI16A	16	1,070	16.400
100636MNND18A	100636MNNI18A	18	1,350	20.800
100636MNND20A	100636MNNI20A	20	1,670	25.600
100636MNND22A	100636MNNI22A	22	2,020	31.000
100636MNND24A	100636MNNI24A	24	2,410	36.900
100636MNND25A	100636MNNI25A	25	2,620	40.039
100636MNND26A	100636MNNI26A	26	2,830	43.300
100636MNND28A	100636MNNI28A	28	3,280	50.300
100636MNND30A	100636MNNI30A	30	3,780	57.744
100636MNND32A	100636MNNI32A	32	4,280	65.700
100636MNND34A	100636MNNI34A	34	4,850	74.169
100636MNND36A	100636MNNI36A	36	5,420	83.100
100636MNND38A	100636MNNI38A	38	6,050	92.957
100636MNND40A	100636MNNI40A	40	6,690	103.000
100636MNND45A	100636MNNI45A	45	8,470	130.300
100636MNND50A	100636MNNI50A	50	10,500	160.800
100636MNND55A	100636MNNI55A	55	12,700	194.600
100636MNND60A	100636MNNI60A	60	15,100	231.600

Ilustración 90. Cable chigres.

6.9. MOLINETES.

Se instalarán en la cubierta 02, en el punto de comportamiento en la mar, se indicará como irán indicados, tipo de cadena, escoben y tipo de ancla necesario.

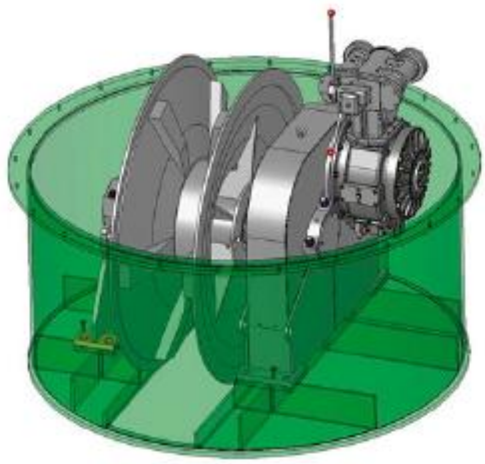


Ilustración 91. Molinetes.

En los anexos se pueden ver las características de los molinetes escogidos.

6.10. BOMBAS.

Las bombas irán situadas en la cubierta 04.

En ella irán dispuestas las siguientes bombas:

- Bombas de compensación.
  Para estas bombas suponemos un caudal de 10 l/min..

- Bombas de agua de lastre.
  Para estas bombas suponemos un caudal de 700l/min.

- Bombas de combustible y agua de lastre.
  Bomba de agua salada 80l/min.
  Bomba de agua de combustible 18,4 l/h.

(No incluimos la bomba de aguas grises, porque el mismo buque de apoyo que venga, ya tendrá la bomba para la extracción de estas aguas, en la Spar lo que tendremos es una línea de tubería que llegue a la cubierta.)

	TIPO	DIMENSIONES (mm)	PESOS (Kg)
BOMBAS COMPENSACIÓN.	CENTRIFUGAS EN BRONCE MARINO CRB 300	520X250X310	37
BOMBAS AGUA DE LASTRE.	CNX 50- 200/11	690X420X456	161
BOMBAS SERVICIO AGUA POTABLE.	CXM 60/0,37	328X213X310	14

Tabla 128. Características bombas.

En los Anexos, se pueden ver las características de las bombas.

7. MÓDULO CONTRAINCENDIOS.

Se instalará en la cubierta 01, un módulo contraincendios, como se muestra en la figura, que nos suministre el caudal para 2 lanzas, y dos bies que estén situadas en la cubierta principal.

Ilustración 92. Módulo Contraincendios.

Se pondrá un sistema de agua nebulizada de alta presión utilizado en plataformas de offshore, totalmente automatizado como el que se adjunta en los anexos MARIOFF HI-FOG®.

También se ubicarán extintores de mano de polvo ABC (2 por cubierta situados hacia la salida del tronco de escape).

En la siguiente figura podemos ver un esquema unifilar del sistema MARIOFF HI-FOG®.

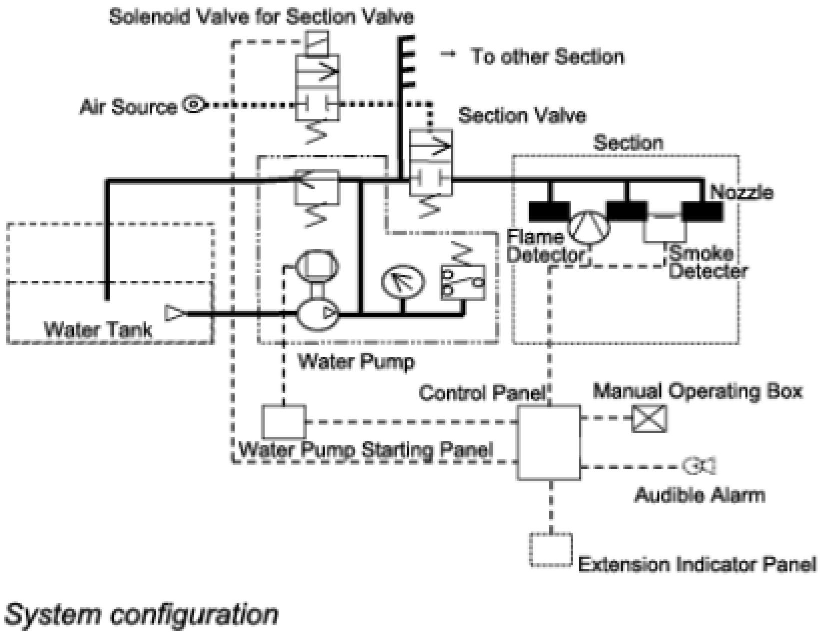


Ilustración 93. Esquema unifilar MARIOFF HI-FOG®.

8. BALANCE ELÉCTRICO Y GENERACIÓN DE ENERGÍA.

Se hará un estudio de los consumos a bordo, para calcular la potencia que necesitaremos para incluir un diesel generador.

De donde:

NI; número de unidades instaladas.

NS; número de unidades en servicio.

Kn; coeficiente de simultaneidad.

$$K_n = \frac{NS}{NI}$$

Ksr; coeficiente de servicio y régimen.

$$K_{sr} = K_s \cdot K_r$$

Ks; Coeficiente de servicio. Número de horas diarias de funcionamiento de un consumidor.

Kr; Coeficiente de régimen. Relaciona la potencia absorbida en un momento dado con la potencia total del consumidor.

Kn; coeficiente de utilización.

$$K_u = K_n \cdot K_{sr}$$

Pf; potencia eléctrica para el consumidor en la condición considerada.

$$P_f = P_C \cdot K_u$$

Los consumos de los equipos son obtenidos en los catálogos.

Para la iluminación de la Spar, se calcula del siguiente modo:

Tenemos en las distintas cubiertas una superficie total de unos 499,2m^2.

De modo que:

$$200\frac{lux}{m^2} \cdot 497{,}4m^2 = 99.480luxes$$

$$\frac{99480luxes}{630\,luxes/bombilla} = 158\ bombillas$$

$$P_E = 158bombillas \cdot \frac{60W}{bombillas} = 9480W = 9{,}48kW$$

Se reflejan en esta tabla todos los consumos.

BALANCE ELÉCTRICO								
CONSUMIDOR	NI	NS	Pu (kW)	Pc (kW)	Kn	Ksr	Ku	Pf(kW)
Compresor de alimentación	1	1	7,50	7,50	1,00	0,50	0,50	3,75
Válvula Selectora	1	1	0,18	0,18	1,00	0,50	0,50	0,09
Válvula Dosificadora de Alimento	1	1	0,37	0,37	1,00	0,50	0,50	0,19
Vari Doser	1	1	0,37	0,37	1,00	0,50	0,50	0,19
Auger and Sluice	1	1	1,50	1,50	1,00	0,50	0,50	0,75
Sistema de limpieza de redes	1	1		0,00	1,00	0,10	0,10	0,00
Sistema de extracción de peces muertos	1	1	22,00	22,00	1,00	0,20	0,20	4,40
Cámaras	4	4	0,22	0,88	1,00	0,60	0,60	0,53
Sensor de Corriente (75mA)	4	4	0,02	0,08	1,00	0,60	0,60	0,05
Sensor de Corriente (75mA)	4	4	0,02	0,08	1,00	0,60	0,60	0,05
Sensor de Temperatura	4	4	0,02	0,08	1,00	0,60	0,60	0,05
CAP	4	4	0,02	0,08	1,00	0,60	0,60	0,05
EAP	1	1	0,02	0,02	1,00	0,60	0,60	0,01
Sistema de control y comunicaciones	1	1	0,45	0,45	1,00	0,60	0,60	0,27
Tifón	1	1	3,80	3,80	1,00	0,20	0,20	0,76
Grúa	1	1	11,00	11,00	1,00	0,20	0,20	2,20
Señalización e iluminación exterior Spar			-	10,00	1,00	0,60	0,60	6,00
Sistema Elevación Jaulas (Chigres)	4	4	22,64	90,56	1,00	0,22	0,22	20,00
Microondas	1	1	1,20	1,20	1,00	0,20	0,20	0,24
Cafetera	1	1	0,70	0,70	1,00	0,20	0,20	0,14
Frigorífico	1	1	0,22	0,22	1,00	0,60	0,60	0,13
Iluminación			-	9,48	1,00	0,60	0,60	5,69
Termo eléctrico	1	1	1,50	9,48	1,00	0,30	0,30	2,84
Fondeo y amarre	4	4	29,00	116,00	1,00	0,22	0,22	25,52
Bombas de compensación	4	3	2,20	8,80	1,00	0,20	0,20	1,76
Bombas de agua de lastre	4	4	14,40	57,60	1,00	0,20	0,20	11,52
Bombas de agua potable	2	1	0,50	1,00	2,00	0,20	0,40	0,40
Bombas de servicio de DDGG	4	2	0,50	2,00	1,00	0,00	0,60	1,20
								88,77

Tabla 129. Balance eléctrico.

8.1. DIESEL GENERADOR.

Dispondrá de 2 diesel generadores.

Para las labores diarias, de alimentación, sensores y cámaras, llegaría con el aerogenerador, pero en el caso de que no hubiese la energía necesaria, usaríamos un diesel generador, además de tener el segundo diesel generador de respeto, es necesario, porque para maniobras determinadas de subida o bajada de las jaulas y para lastrar o deslastrar los taques de agua, es necesario la potencia de los dos diesel generadores.

El modelo elegido es el "Marine Generator set Quiet Diesel ™ Serise 65 QD 50Hz Model MDDCH.

Engine details

Design: 4-cycle, turbocharged, water-cooled diesel
Cylinders: 6 turbocharged
Bore: 106.5 mm (4.2 in)
Stroke: 127 mm (5.0 in)
Displacement: 6.8 L (415 in^3)
Compression ratio: 17.0:1
Max fuel lift: 3 m (10 ft)
Lube oil capacity: 19.4 L (20.5 qt)
Coolant flow rate: 116 L/min (31 Gal/min)
Raw water flow rate: 70 L/min (18 Gal/min)
Starting system: Remote 3-wire, 12 V starting battery required, 800 CCA; 24 V optional
Power (max): SAEJ1349
50 Hz at 1500 RPM 98 kW (131 hp)
Fuel injection pump: Stanadyne DE-10
Combustion chamber: Direct injection
Max raw water lift: 3 m (10 ft)

Typical fuel consumption

No. 2 diesel fuel, L/hr (Gal/hr)	1/4 load	1/2 load	3/4 load	Full load
65.0 MDDCH	5.7 (1.5)	9.9 (2.6)	14.1 (3.7)	18.4 (4.9)

Tabla 130. Características del Diesel Generador.

Ilustración 94. Diesel Generador.

A continuación se muestra un sistema unifilar del diesel generador.

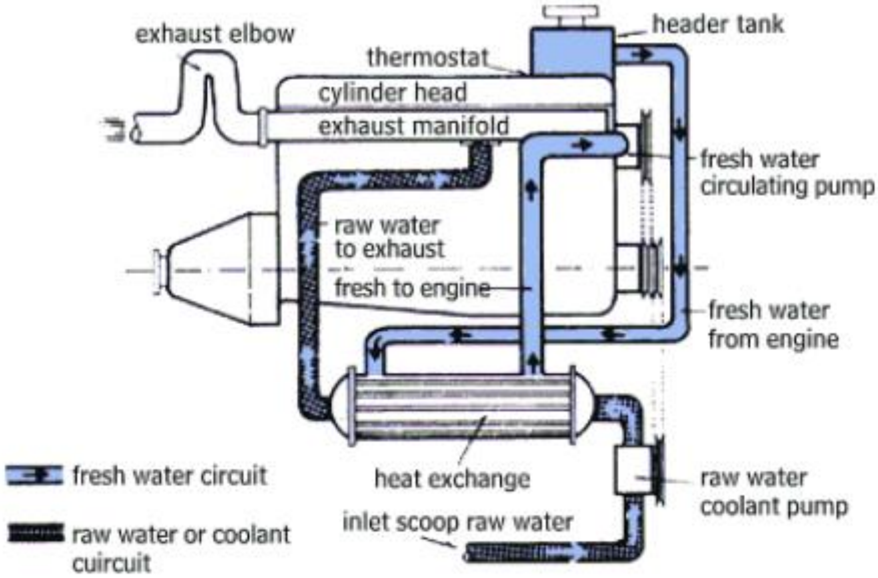


Ilustración 95. Unifilar Diesel Generador.

8.2. AEROGENERADOR.

Aeolos 10kw es un generador de eje vertical de baja velocidad de arranque del viento, silencioso, seguro y fiable. Utiliza un generador trifásico con rotor externo con una velocidad de arranque del viento de 1.5m/s. Puede ser utilizado para la aplicación 300v fuera de la red o 380v en conexión con la red. Los aerogeneradores Aeolos tienen un bajo nivel de ruido.

Las palas son hechas de aleación de aluminio con un especial diseño aerodinámico. Este diseño limitará la máxima velocidad de rotación a 260rpm incluso si la velocidad del viento es de 30m/s o 40m/s. Es más seguro y confiable que el aerogenerador tradicional de eje vertical.

Ilustración 96. Aerogenerador de 15kW.

ESPECIFICACIONES PARA AEROGENERADOR AEOLOS 10Kw	
Potencia Nominal	10 kW
Máxima Potencia de Salida	12 kW
Voltaje de Salida	300/380V
Altura del Rotor	3.6m (11.8 pies)
Diámetro del Rotor	3.0m (9.8 piesl
Velocidad de Arranque del Viento	1.5m/s (3.4 mph)
Velocidad Nominal del Viento	10m/s (22.3 mph)
Velocidad de Sobrevivencia del Viento	50m/s (111.5 mph)
Generador	Generador Magnético Permanente
Eficiencia del Generador	> 0.96
Peso de Turbina	78kg (171.6lbs)
Ruido	<45dB(A)
Rango de Temperatura	-20ºC a +50º
Vida Útil de Diseño	20 Años
Garantia	Estándar 5 años

Tabla 131. Características del Aerogenerador.

9. FONDEO Y AMARRE.

9.1. FONDEO SPAR.

Los molinetes irán ubicados en la cubierta 02, de los cuales bajarán las cadenas hasta la zona del soft tank, y de allí hasta al fondo marino.

El fondeo se detallará en el punto 11 comportamiento del buque en la .mar.

9.2. ZONA ATRAQUE BUQUE DE APOYO.

En la parte superior de la Spar, la denominada Hard Zone, tendremos un acceso a la Spar desde el buque de apoyo, mediante unas escaleras como se puede ver en el croquis adjunto., en el interior de la Spar se dispone de un tronco de escape en el eje, que alcanza desde la cubierta superior hasta la cubierta de tanques de lastre. Mediante el cual se puede acceder a todas las cubiertas, para acceder a los distintos equipos.

En las distintas cubiertas se dispondrán de escotillas de acceso.

Se dispondrá de ésta escalera, para que el personal pueda acceder a la Spar, para las labores de mantenimiento y comunicaciones.

La escalera dispone de una escalera retráctil, que será activada remotamente, ya que no puede ser fija, por el hecho de que las jaulas subirían y tropezaría con ellas.

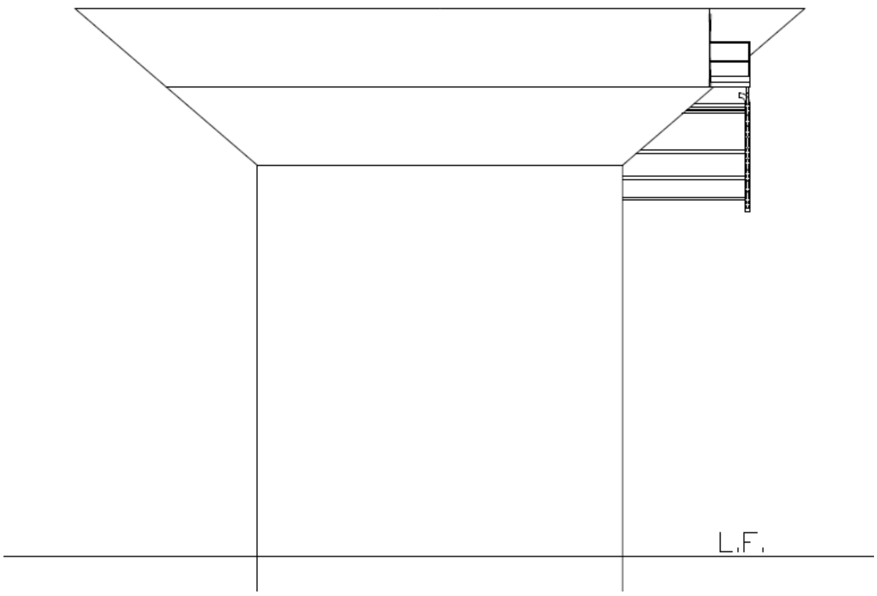


Ilustración 97. Escalera de acceso a Spar desde Buque de apoyo.

9.3. SISTEMA COMUNICACIONES Y CONTROL.

Se dispondrá de un sistema de equipos informáticos situado en la cubierta 01, mediante el cual, se mantenga la comunicación entre la Spar y la zona de tierra, para poder observar todo lo que sucede,.y acceder al lugar en caso de alguna alarma.

10. BALSA SALVAVIDAS.

Se situarán en la Spar dos balsas salvavidas, como medida de seguridad para el personal que se pueda encontrar a bordo de la Spar, a la hora de realizar las labores de mantenimiento, ya que es una plataforma desatendida.

La balsa irá en un contenedor, con una capacidad de 6 personas.

Estará diseñada y fabricada con arreglo a las exigencias de la norma ISO 9650 (norma relativa al diseño de las balsas salvavidas).

Ilustración 98. Balsa Salvavidas (Zodiac).

BALSAS SALVAVIDAS ZODIAC ISO 9650		
PERSONAS	DIMENSIONES CONTENEDOR	PESO
6	69 X 49 X 23 cm	36,5 kg

Tabla 132. Características balsa salvavidas.

11. ESTABILIDAD EN ESTADO INTACTO.

En este apartado se realizarán los cálculos de estabilidad para 4 condiciones de carga, en las tres posiciones de las jaulas en la Spar.

- Posición jaulas abajo.
- Posición jaulas medio.
- Posición jaulas arriba.

Las cuatro condiciones de carga serán las siguientes:

- Consumos 100% y piensos al 100%.
- Pienso 2,5m al 50%, resto de piensos al 100% y consumos al 90%.
- Pienso 4mm al 50%, pienso 2,5mm al 0%, pienso de 6mm al 100%, consumos al 50%.
- Pienso 4mm al 50%, pienso 2,5mm al 0%, pienso 6mm al 50% y consumos al 10%.

PESO ESTRUCTURA SPAR (10% MARGEN) ***Tabla 107. Peso de la Spar.***	1.086,24	
PESO JAULAS SPAR ***Tabla 108. Peso de Jaulas.***	70,07	
	1.156,31	**TONELADAS**

Tabla 133. Peso total aceros.

A continuación se muestran las distintas partidas:

- Se muestra la **tabla del peso en rosca**, Tabla 135. Condición de peso en rosca. con el desglose de las siguientes partidas, pesos aceros y peso jaulas (en el peso de las jaulas se supone sucia), peso de equipos y tanques no estructurales.
- Tabla de **consumos**. Tabla 134. Consumos.
- Miscelánea y habilitación, donde se incluirán (las herramientas, distintos accesorios, cadenas de respeto…).

Tabla de consumos:

CONSUMOS				
Item Name	Unit Mass tonne	Long. Arm m	Trans. Arm m	Vert. Arm m
Peso Pienso Ø6mm	253,63	-1,09	1,88	49,62
Peso Pienso Ø4mm	134,36	0,00	-2,76	48,87
Peso Pienso Ø2,5mm	36,69	3,24	0,00	47,62
Agua Potable	10,00	-2,90	0,00	36,06
Combustible	17,00	0,00	2,86	36,25
Combustible	17,00	0,00	2,86	36,25
Aguas Sucias	2,05	3,82	0,00	35,58

Tabla 134. Consumos.

CONDICIÓN PESO EN ROSCA (Lightweight)				
Item Name	Unit Mass tonne	Long. Arm m	Trans. Arm m	Vert. Arm m
Estructura y jaulas	1156,31	0,00	0,00	25,58
Diesel Generador Nº1	1,43	0,00	3,43	32,27
Diesel Generador Nº2	1,43	0,00	-3,43	32,27
Molinete Nº1	5,40	-2,64	-2,64	56,41
Molinete Nº2	5,40	2,64	2,64	56,41
Molinete Nº3	5,40	-2,64	2,64	56,41
Molinete Nº4	5,40	2,64	-2,64	56,41
Chigre Nº1 Elevación Jaulas	2,87	-3,56	0,00	56,41
Chigre Nº2 Elevación Jaulas	2,87	0,00	3,56	56,41
Chigre Nº3 Elevación Jaulas	2,87	3,56	0,00	56,41
Chigre Nº4 Elevación Jaulas	2,87	0,00	-3,56	56,41
Bombas Tanques de Compensación	0,15	-3,70	-1,50	38,91
Bombas de Lastre	0,81	-3,12	0,51	38,98
Bombas de Agua Potable	0,03	-2,11	-1,46	38,87
Bombas de Servicio de DDGG (MGO y Refrigeración)	0,06	-2,86	-1,50	38,87
Tanque Agua Potable (No Estructural)	0,25	-2,90	0,00	36,06
Tanque Combustible (MGO) (No Estructural)	1,59	0,00	2,86	36,25
Tanque Combustible (MGO) (No Estructural)	1,59	0,00	2,86	36,25
Tanque de Aguas Sucias (No Estructural)	0,06	3,82	0,00	35,58
Aerogenerador VAWT	0,30	5,30	5,30	7,00
Grúa	9,00	4,82	4,82	65,00
Balsa Salvavidas	0,07	-6,64	-6,64	60,12
Balsa Salvavidas	0,07	6,64	6,64	60,12
E.A.P.	0,03	-3,00	3,00	57,85
Compresor Alimentación	0,35	3,31	1,90	42,86
Válvula y Dosificador Ø6mm	0,05	-0,46	0,64	42,74
Válvula y Dosificador Ø4mm	0,05	1,25	0,00	42,74
Válvula y Dosificador Ø2,5mm	0,05	0,00	0,83	42,74
Sistema Dispersión Alimento	0,40	-3,22	-1,87	42,69
Sistema Limpieza Redes	2,40	-2,14	0,00	61,00
Sistemas de Extraccion Peces Muertos	0,54	1,87	0,00	60,58
CONCEPTO PESO EN ROSCA	**1210,08**	**0,03**	**0,04**	**26,87**

Tabla 135. Condición de peso en rosca.

Para las distintas posiciones de las jaulas, se calcularán las mismas condiciones, siendo el único dato que varía, la vertical del centro de gravedad.

Se utilizaran de los criterios del MaxSurf aquellos que indica el DNV-Os C106 (Sección 1 A306), que nos indica que deberemos usar el DNV-Os-C301 (Chapter 2 Section1 4.5), el cual nos lleva al Imo Code A.1023(26),(Punto 3.3.1.2) , los cuales están incluidos en los Anexos.

Con estos datos se activarán las siguientes opciones:

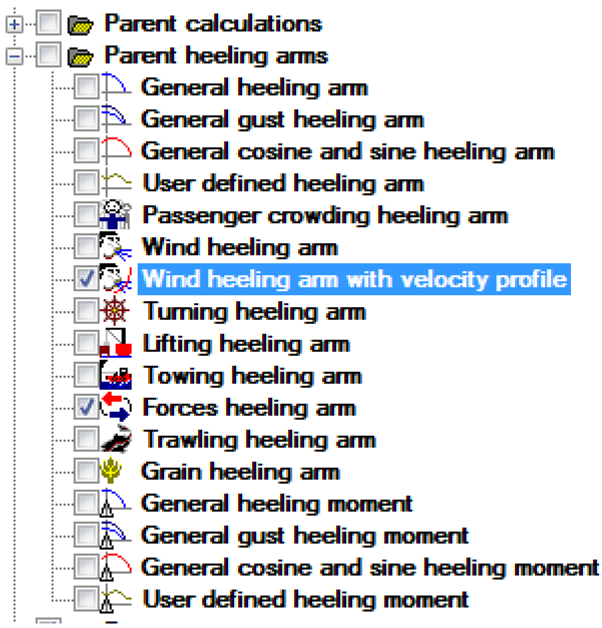


Ilustración 99. MaxSurf Parent heeling arm.

		Parent heeling arms Wind heeling arm with velocity profile	Value	Units
1	☐	*Wind arm: sin(mu) a (v f)^2 Sum_i{F*		
2	☐	constant: a (0.5 rho_air) =	0,5	tonne/m^3
3	☐	wind velocity: v =	69,900	kn
4	☐	use actual heeled projected areas		
5	☑	use upright vessel projected areas		
6	☐	cosine power: n =	2	
7	☑	height of lateral resistance: H =	21,600	m
8	☐	H = mean draft / 2		m
9	☐	H = vert. centre of projected lat. u'w		m
10	☐	H = waterline		m
11	☐	H = baseline		m
12	☐	gust ratio	1,5	
13	☐	velocity profile (f): number of heights	1	
14	☐	vel.factor above WL	1,000	factor

Ilustración 100. Max Surf wind heeling arm with velocity profile.

En este punto se define el brazo escorante por el viento, que para una velocidad mínima de 36m/s, ya que para instalaciones offshore DNV no permite una velocidad inferior, equivale a 69,9 nudos, 129,6km/h.

		Parent heeling arms Forces heeling arm	Value	Units
1	☐	*Heeling arm = (A1(h1-H)cos^n1(phi)*		
2	☐	a1 = magnitude of upper heeling forc	0,00	N
3	☐	h1 = height of upper heeling force (fr	0,000	m
4	☐	n1 = cosine power for upper heeling	0	
5	☐	a2 = magnitude of lower heeling forc	9060,00	N
6	☐	h2 = height of lower heeling force (fr	0,000	m
7	☐	n2 = cosine power for lower heeling	0	
8	☑	height of lateral resistance: H =	45,000	m
9	☐	H = mean draft / 2		m
10	☐	H = vert. centre of projected lat. u'w		m
11	☐	H = waterline		m
12	☐	H = VCG		m
13	☐	H = VCB		m

Ilustración 101. Forces heeling arms

En este apartado se definen los brazos escorantes producidos por las fuerzas. En el DNV-Os-C301 Capítulo 2, Sección 1 4.5.3, indica que deben de incluirse las corrientes en el cálculo de momentos escorantes, nos lleva a calcular la fuerza según el DNV-RP-C205, como:

$$F = \frac{1}{2} \cdot \rho \cdot C_d \cdot D \cdot U^2 = 9060N$$

De donde:

ρ, es la densidad.

Cd es el coeficiente de arrastre de un cilindro largo sumergido en un fluido 1,15.

D es el diámetro.

U velocidad de la corriente, indicada anteriormente en el punto 5.4.1.1.

Se suponen dos fuerzas opuestas en sentido superior e inferior.

Los datos de la fuerza superior los suponemos 0 ya incluidos anteriormente, y en la fuerza inferior es donde se introducen los parámetros de corriente, fuerza de corriente y altura sobre la que actua el calado.

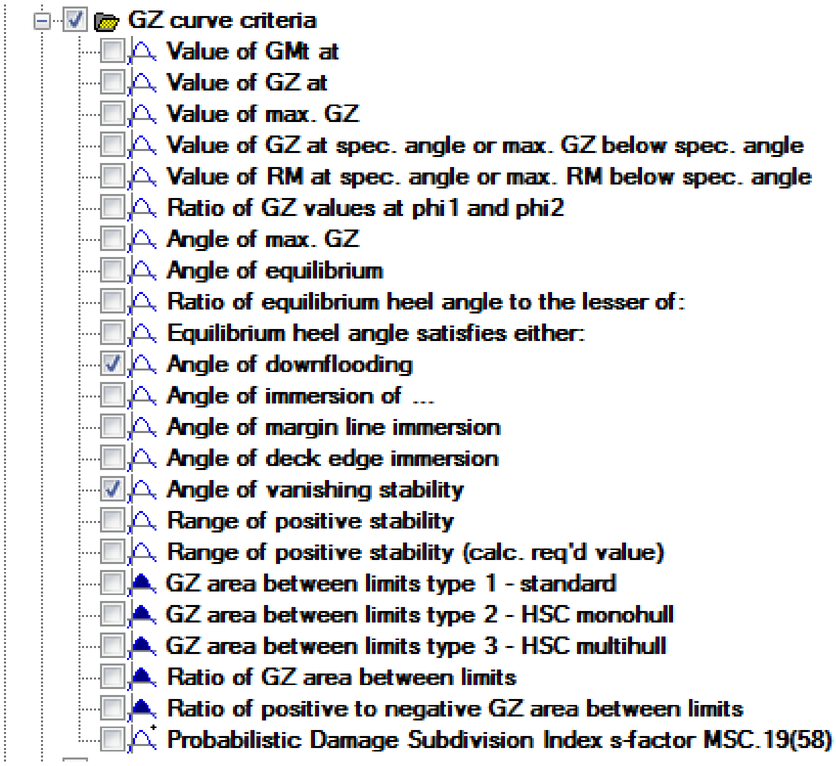


Ilustración 102. Max Surf GZ curve criteria.

En estas opciones no se varían los datos del MaxSurf.

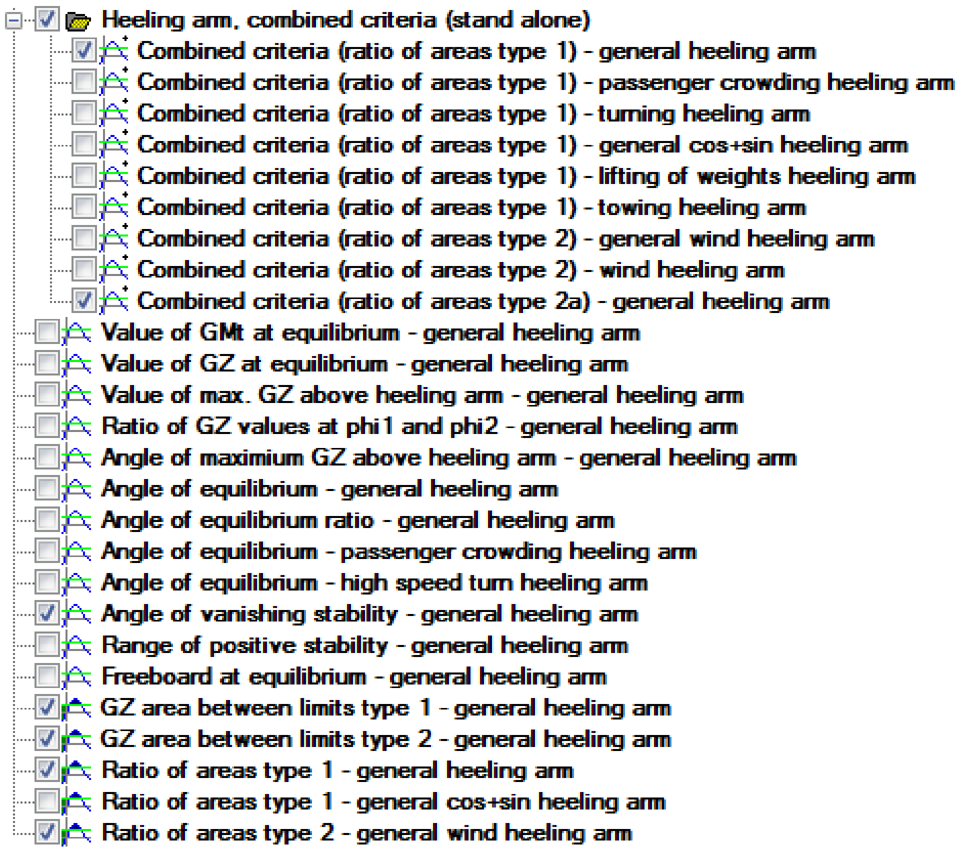


Ilustración 103. Max Surf, heeling arm, combined cirteria (stand alone).

En esta opción se varían los datos de las áreas tal como se nos indica en el Imo Code.

Los resultados de estabilidad de MaxSurf, se incluyen en el anexo.

En este apartado se mostraran las salidas del equilibrio en las 3 posiciones

Se analiza primero la posición Jaulas Abajo:

CONDICIÓN 1	
Draft Amidships m	44,356
Displacement t	9955
Heel deg	0,4
Draft at FP m	44,964
Draft at AP m	43,748
Draft at LCF m	44,356
Trim (+ve by stern) m	-1,216
WL Length m	10,002
Beam max extents on WL m	10
Wetted Area m^2	4401,406
Waterpl. Area m^2	76,053
Prismatic coeff. (Cp)	0,345
Block coeff. (Cb)	0,398
Max Sect. area coeff. (Cm)	1,158
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0,001
LCF from zero pt. (+ve fwd) m	0
KB m	14,487
KG fluid m	11,739
BMt m	0,049
BML m	0,047
GMt corrected m	2,799
GML m	2,796
KMt m	14,536
KML m	14,534
Immersion (TPc) tonne/cm	0,78
MTc tonne.m	5,08
RM at 1deg = GMt.Disp.sin(1) tonne.m	486,195
Max deck inclination deg	1,3207
Trim angle (+ve by stern) deg	-1,2717

CONDICIÓN 2	
Draft Amidships m	44,077
Displacement t	9933
Heel deg	0,4
Draft at FP m	44,631
Draft at AP m	43,524
Draft at LCF m	44,077
Trim (+ve by stern) m	-1,107
WL Length m	10,002
Beam max extents on WL m	10
Wetted Area m^2	4392,612
Waterpl. Area m^2	76,049
Prismatic coeff. (Cp)	0,346
Block coeff. (Cb)	0,399
Max Sect. area coeff. (Cm)	1,159
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0,001
LCF from zero pt. (+ve fwd) m	0
KB m	14,422
KG fluid m	11,664
BMt m	0,05
BML m	0,047
GMt corrected m	2,808
GML m	2,806
KMt m	14,471
KML m	14,469
Immersion (TPc) tonne/cm	0,78
MTc tonne.m	5,086
RM at 1deg = GMt.Disp.sin(1) tonne.m	486,807
Max deck inclination deg	1,2104
Trim angle (+ve by stern) deg	-1,1568

CONDICIÓN 3	
Draft Amidships m	42,756
Displacement t	9830
Heel deg	0,7
Draft at FP m	43,265
Draft at AP m	42,248
Draft at LCF m	42,756
Trim (+ve by stern) m	-1,017
WL Length m	10,002
Beam max extents on WL m	10,001
Wetted Area m^2	4369,404
Waterpl. Area m^2	76,052
Prismatic coeff. (Cp)	0,351
Block coeff. (Cb)	0,407
Max Sect. area coeff. (Cm)	1,162
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0,001
LCF from zero pt. (+ve fwd) m	0
KB m	14,118
KG fluid m	11,296
BMt m	0,05
BML m	0,048
GMt corrected m	2,874
GML m	2,871
KMt m	14,168
KML m	14,166
Immersion (TPc) tonne/cm	0,78
MTc tonne.m	5,15
RM at 1deg = GMt.Disp.sin(1) tonne.m	492,984
Max deck inclination deg	1,2886
Trim angle (+ve by stern) deg	-1,0632

CONDICIÓN 4	
Draft Amidships m	44,79
Displacement t	9989
Heel deg	0,5
Draft at FP m	44,715
Draft at AP m	44,865
Draft at LCF m	44,79
Trim (+ve by stern) m	0,15
WL Length m	10
Beam max extents on WL m	10
Wetted Area m^2	4410
Waterpl. Area m^2	76,036
Prismatic coeff. (Cp)	0,343
Block coeff. (Cb)	0,396
Max Sect. area coeff. (Cm)	1,156
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0
LCF from zero pt. (+ve fwd) m	0
KB m	14,589
KG fluid m	11,255
BMt m	0,049
BML m	0,047
GMt corrected m	3,384
GML m	3,381
KMt m	14,638
KML m	14,636
Immersion (TPc) tonne/cm	0,779
MTc tonne.m	6,163
RM at 1deg = GMt.Disp.sin(1) tonne.m	589,864
Max deck inclination deg	0,5421
Trim angle (+ve by stern) deg	0,1568

Tabla 136. Condiciones Jaulas Abajo.

Se analiza la posición Jaulas Medio:

CONDICIÓN 1	
Draft Amidships m	43,152
Displacement t	10324
Heel deg	0,1
Draft at FP m	43,11
Draft at AP m	43,194
Draft at LCF m	43,152
Trim (+ve by stern) m	0,084
WL Length m	10
Beam max extents on WL m	10
Wetted Area m^2	4473,614
Waterpl. Area m^2	76,033
Prismatic coeff. (Cp)	0,366
Block coeff. (Cb)	0,426
Max Sect. area coeff. (Cm)	1,164
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0
LCF from zero pt. (+ve fwd) m	0
KB m	23,148
KG fluid m	12,561
BMt m	0,048
BML m	0,045
GMt corrected m	10,636
GML m	10,633
KMt m	23,196
KML m	23,194
Immersion (TPc) tonne/cm	0,779
MTc tonne.m	20,033
RM at 1deg = GMt.Disp.sin(1) tonne.m	1916,313
Max deck inclination deg	0,1263
Trim angle (+ve by stern) deg	0,0882

CONDICIÓN 2	
Draft Amidships m	42,873
Displacement t	10302
Heel deg	0,1
Draft at FP m	42,817
Draft at AP m	42,929
Draft at LCF m	42,873
Trim (+ve by stern) m	0,112
WL Length m	10
Beam max extents on WL m	10
Wetted Area m^2	4468,071
Waterpl. Area m^2	76,033
Prismatic coeff. (Cp)	0,367
Block coeff. (Cb)	0,428
Max Sect. area coeff. (Cm)	1,165
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0
LCF from zero pt. (+ve fwd) m	0
KB m	23,107
KG fluid m	12,49
BMt m	0,048
BML m	0,046
GMt corrected m	10,664
GML m	10,662
KMt m	23,154
KML m	23,152
Immersion (TPc) tonne/cm	0,779
MTc tonne.m	20,044
RM at 1deg = GMt.Disp.sin(1) tonne.m	1917,406
Max deck inclination deg	0,1478
Trim angle (+ve by stern) deg	0,1169

CONDICIÓN 3	
Draft Amidships m	41,553
Displacement t	10199
Heel deg	0,2
Draft at FP m	41,488
Draft at AP m	41,618
Draft at LCF m	41,553
Trim (+ve by stern) m	0,13
WL Length m	10
Beam max extents on WL m	10
Wetted Area m^2	4441,72
Waterpl. Area m^2	76,033
Prismatic coeff. (Cp)	0,373
Block coeff. (Cb)	0,437
Max Sect. area coeff. (Cm)	1,17
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0
LCF from zero pt. (+ve fwd) m	0
KB m	22,914
KG fluid m	12,144
BMt m	0,048
BML m	0,046
GMt corrected m	10,819
GML m	10,816
KMt m	22,962
KML m	22,96
Immersion (TPc) tonne/cm	0,779
MTc tonne.m	20,131
RM at 1deg = GMt.Disp.sin(1) tonne.m	1925,752
Max deck inclination deg	0,23
Trim angle (+ve by stern) deg	0,1359

CONDICIÓN 4	
Draft Amidships m	38,846
Displacement t	9989
Heel deg	0,2
Draft at FP m	38,824
Draft at AP m	38,868
Draft at LCF m	38,846
Trim (+ve by stern) m	0,044
WL Length m	10
Beam max extents on WL m	10
Wetted Area m^2	4387,516
Waterpl. Area m^2	76,033
Prismatic coeff. (Cp)	0,387
Block coeff. (Cb)	0,458
Max Sect. area coeff. (Cm)	1,181
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0
LCF from zero pt. (+ve fwd) m	0
KB m	22,549
KG fluid m	11,378
BMt m	0,049
BML m	0,047
GMt corrected m	11,22
GML m	11,218
KMt m	22,598
KML m	22,596
Immersion (TPc) tonne/cm	0,779
MTc tonne.m	20,447
RM at 1deg = GMt.Disp.sin(1) tonne.m	1955,903
Max deck inclination deg	0,1576
Trim angle (+ve by stern) deg	0,0455

Tabla 137. Condiciones Jaulas Medio.

Se analiza la posición Jaulas Arriba:

CONDICIÓN 1	
Draft Amidships m	44,047
Displacement t	9960
Heel deg	0,1
Draft at FP m	44,092
Draft at AP m	44,002
Draft at LCF m	44,047
Trim (+ve by stern) m	-0,091
WL Length m	52,4
Beam max extents on WL m	38,613
Wetted Area m^2	3232,769
Waterpl. Area m^2	654,92
Prismatic coeff. (Cp)	0,387
Block coeff. (Cb)	0,116
Max Sect. area coeff. (Cm)	1,155
Waterpl. area coeff. (Cwp)	0,343
LCB from zero pt. (+ve fwd) m	0,033
LCF from zero pt. (+ve fwd) m	0
KB m	27,605
KG fluid m	11,939
BMt m	2,64
BML m	18,14
GMt corrected m	18,305
GML m	33,805
KMt m	30,245
KML m	45,745
Immersion (TPc) tonne/cm	6,713
MTc tonne.m	68,159
RM at 1deg = GMt.Disp.sin(1) tonne.m	3181,954
Max deck inclination deg	0,1184
Trim angle (+ve by stern) deg	-0,1051

CONDICIÓN 2	
Draft Amidships m	44,015
Displacement t	9938
Heel deg	0,1
Draft at FP m	44,056
Draft at AP m	43,974
Draft at LCF m	44,015
Trim (+ve by stern) m	-0,082
WL Length m	52,4
Beam max extents on WL m	38,613
Wetted Area m^2	3241,37
Waterpl. Area m^2	654,92
Prismatic coeff. (Cp)	0,386
Block coeff. (Cb)	0,115
Max Sect. area coeff. (Cm)	1,155
Waterpl. area coeff. (Cwp)	0,343
LCB from zero pt. (+ve fwd) m	0,03
LCF from zero pt. (+ve fwd) m	0
KB m	27,569
KG fluid m	11,608
BMt m	2,646
BML m	18,18
GMt corrected m	18,606
GML m	34,14
KMt m	30,215
KML m	45,749
Immersion (TPc) tonne/cm	6,713
MTc tonne.m	68,684
RM at 1deg = GMt.Disp.sin(1) tonne.m	3227,218
Max deck inclination deg	0,1092
Trim angle (+ve by stern) deg	-0,095

CONDICIÓN 3	
Draft Amidships m	43,861
Displacement t	9835
Heel deg	0,1
Draft at FP m	43,899
Draft at AP m	43,823
Draft at LCF m	43,861
Trim (+ve by stern) m	-0,076
WL Length m	52,4
Beam max extents on WL m	38,613
Wetted Area m^2	3226,346
Waterpl. Area m^2	654,92
Prismatic coeff. (Cp)	0,383
Block coeff. (Cb)	0,115
Max Sect. area coeff. (Cm)	1,155
Waterpl. area coeff. (Cwp)	0,343
LCB from zero pt. (+ve fwd) m	0,028
LCF from zero pt. (+ve fwd) m	0
KB m	27,397
KG fluid m	11,24
BMt m	2,674
BML m	18,37
GMt corrected m	18,832
GML m	34,528
KMt m	30,071
KML m	45,768
Immersion (TPc) tonne/cm	6,713
MTc tonne.m	68,745
RM at 1deg = GMt.Disp.sin(1) tonne.m	3232,463
Max deck inclination deg	0,1419
Trim angle (+ve by stern) deg	-0,0883

CONDICIÓN 4	
Draft Amidships m	44,097
Displacement t	9994
Heel deg	0,1
Draft at FP m	44,091
Draft at AP m	44,104
Draft at LCF m	44,097
Trim (+ve by stern) m	0,013
WL Length m	52,4
Beam max extents on WL m	38,613
Wetted Area m^2	3249,324
Waterpl. Area m^2	654,919
Prismatic coeff. (Cp)	0,388
Block coeff. (Cb)	0,116
Max Sect. area coeff. (Cm)	1,155
Waterpl. area coeff. (Cwp)	0,343
LCB from zero pt. (+ve fwd) m	-0,005
LCF from zero pt. (+ve fwd) m	0
KB m	27,66
KG fluid m	11,455
BMt m	2,631
BML m	18,079
GMt corrected m	18,837
GML m	34,284
KMt m	30,291
KML m	45,739
Immersion (TPc) tonne/cm	6,713
MTc tonne.m	69,359
RM at 1deg = GMt.Disp.sin(1) tonne.m	3285,419
Max deck inclination deg	0,0944
Trim angle (+ve by stern) deg	0,0155

Tabla 138. Condiciones Jaulas Arriba.

Con todas las condiciones estudiadas las jaulas se encuentran a la profundidad deseada, es decir, para cualquier carga las jaulas pueden estar sumergidas para evitar la influencia de las tormentas en los peces y en la distribución de pesos.

Al encontrarse las jaulas por debajo de la influencia de las olas no se ve alterado al entorno de los peces, y a la distribución de los pesos.

La operación normal sería con las jaulas a flor de agua, aunque depende de la especie a criar. Por ejemplo, el salmón necesita estar cerca de la superficie para respirar el oxigeno atmosférico con sus saltos, en el otro extremos podría estar el rodaballo que es un pez que busca el fondo.

En el caso de la condición estudiada de jaulas en el medio, condición 4 con el pienso consumido y próxima la visita del buque de asistencia, se pueden bajar las jaulas para que se mantengan en el rango de profundidad deseado.

Si en la condición extrema se desea aumentar el calado con este estudio, lo que se ha determinado es que existe un margen para el aumento de la densidad del hormigón del soft tank, se consideró una densidad inicial de 2,9 t/m^3, y la densidad máxima del hormigón que se puede alcanzar el 3,5 t/m^3.

12. COMPORTAMIENTO EN LA MAR.

12.1. Introducción

En este punto se estudiará el comportamiento en la mar de la plataforma de forma similar a los buques pero con sustanciales diferencias. Los buques son, en general, de forma alargada con altas relaciones L/B y que cuentan con velocidad de avance, por lo que la velocidad de encuentro con las olas es la resultante de la velocidad y dirección de estas y del buque. La operación normal de un buque es la navegación y no el fondeo en un punto.

En el caso de los buques, se utilizan teorías como la de “rebanadas” (Strip Theory) o paneles (Panels) para realizar este estudio; y los fenómenos no lineales aparecidos se deben al desprendimiento de la capa límite, el macheteo –slamming– y turbulencias en la zona del propulsor.

En el caso de las plataformas, son estructuras con una relación L/B más cercana a la unidad, es decir, no son por lo general, alargadas, están formadas por varios cascos y/o flotadores que confieren la flotabilidad necesaria. Las plataformas, además, carecen de velocidad de avance y la velocidad de encuentro con las olas únicamente dependerá de la velocidad y dirección de las mismas. Los fenómenos no lineales en este caso provienen de las líneas de fondeo, las olas rompientes contra el casco, etc.

Conceptos generales

Para el estudio del comportamiento se considerará el efecto del viento y de las olas como excitaciones de la estructura.

La situación del centro de gravedad, bajo, y el gran calado, sumado a la existencia de lastre, tanto sólido como líquido en la parte inferior de la spar, hace esperar un buen comportamiento de la misma.

Pese a estar fondeada mediante líneas de catenaria, la plataforma goza de sus seis grados de libertad y que son los estudiados durante este análisis.

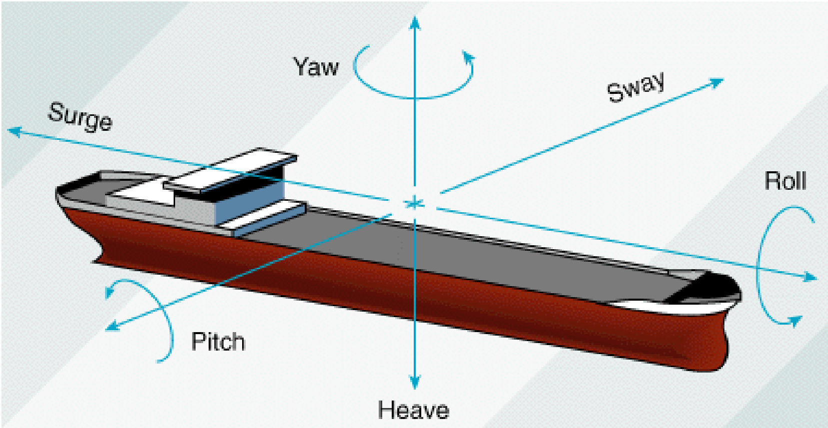


Ilustración 104. Grados de libertad y movimientos de un buque.

Las plataformas offshore responden a las excitaciones por vientos, olas y corrientes con movimientos distintos a los buques y que se ven afectados también por su propia geometría.

Con el análisis de comportamiento en la mar, se busca determinar si la estructura alcanzará la resonancia sometida a las excitaciones que encontrará durante su vida útil en la zona de operación determinada.

La resonancia paramétrica [65]es producida por la modificación de la superficie de flotación, y por tanto de los brazos adrizantes, con el paso de las olas y los movimientos de arfada (Heave) y cabeceo (Pitch). Cuando en un buque, este se encuentra con mares longitudinales de proa, la frecuencia de encuentro buque – ola se aproxima al doble de su frecuencia natural de balance, la longitud de onda es cercana a la eslora del buque y su amplitud supera un valor mínimo (función del buque), dándose entonces las condiciones para la aparición de la resonancia paramétrica. Sin embargo, el caso de una plataforma fondeada, y por lo tanto, fija con respecto al mar incidente es diferente, ya que la longitud de la onda y su velocidad o frecuencia de encuentro son independientes a la plataforma, por estar esta inmóvil.

Modelo

Se utilizará el modelo con las jaulas en posición superior por ser aquel que presenta una mayor superficie a las olas y por lo tanto es susceptible de sufrir una respuesta más acentuada a la excitación aplicada.

[65] Inteligencia artificial aplicada a la predicción del balance paramétrico autoexcitado, Marcos Míguez González 1) Vicente Díaz Casas et al. Grupo Integrado de Ingeniería, Universidade da Coruña

Espectro de ola

El espectro de ola considerado como excitación se utilizará el propuesto por DNV, ya que es el reglamento al que se sujeta este proyecto. El espectro de ola de DNV es un espectro más general que los habitualmente usados y que, en casos especiales incluye el espectro de Bretschneider cuando el factor de realce de pico (γ) es 1,0 y el de JONSWAP cuando dicho factor es 3,3. El factor γ utilizado por DNV es determinado a partir de la altura significativa de ola y el periodo modal.

$$\gamma = 5 \quad \text{para} \frac{T_0}{\sqrt{H_{1/3}}} \leq 3{,}6$$

$$\gamma = e^{\left(5{,}75 - \frac{1{,}15 T_0}{\sqrt{H_{1/3}}}\right)} \quad \text{para} \quad 3{,}6 < \frac{T_0}{\sqrt{H_{1/3}}} \leq 3{,}6$$

$$\gamma = 1 \quad \text{para} \quad 5{,}0 < \frac{T_0}{\sqrt{H_{1/3}}}$$

El espectro se define como:

$$S_{DNV}(\omega) = \frac{\alpha}{\omega^5}\, e^{\left(\frac{-\beta}{\omega^4}\right)} \cdot \gamma \uparrow \; e^{\left[\frac{-1}{2\sigma^2}\left(\frac{\omega}{\omega_0}-1\right)^2\right]}$$

Donde

$$\sigma = 0{,}07\, para\ \omega < \omega_0;\ \sigma = 0{,}09\, para\ \omega > \omega_0, y\ \ \omega_0 = \frac{2\pi}{T_0}$$

$$\sigma = 5\pi^4(1 - 0{,}287\ln(\gamma))\frac{H_{1/3}^2}{\Gamma_0^4}\ y\ \beta = \frac{20\pi^4}{\Gamma_0^4}$$

Se han aplicado los siguientes parámetros para el espectro seleccionado:

$H_{1/3}$ = 11,69 m

T = 14 s

λ = 297,22 m

Aunque la altura significativa media de la ola es de 8,80 m. para el intervalo temporal estudiado anteriormente, se ha tomado la mayor de dicho intervalo por representar la situación más desfavorable para la plataforma.

Damping factors

Como se desconocen los factores de amortiguamiento a utilizar, se realiza una simulación de decaimiento del balance (*Roll decay simulation*) para determinarlos, previamente al estudio del comportamiento.

El amortiguamiento adimensional utilizado en Maxsurf sigue la formulación utilizada pro Lloyd y Lewis, 1989, definido como:

$$\eta = \frac{b}{2\sqrt{ca}}$$

Donde

b es el amortiguamiento dimensional;

c es la rigidez en el balance

a es la inercia en el balance, incluyendo los efectos de la inercia añadida.

12.2. Análisis de los resultados RAO (Response Amplitude Operators)

Una vez que se han establecido los parámetros de entrada y cargado el modelo, se ejecuta el "Seakeeping Analysis" en el menú correspondiente y obtenemos los siguientes resultados.

MAR POR POPA (180°)

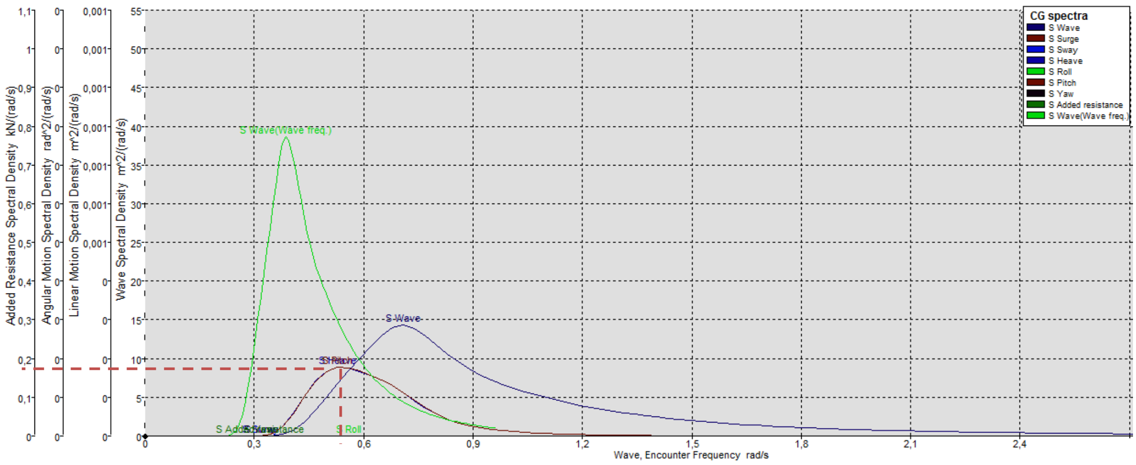


Ilustración 105. RAO con Mar por Popa.

La amplitud máxima de los movimientos Heave y Pitch se produce para una frecuencia de encuentro con la ola de 0,2763 rad/s como se puede observar en Ilustración 105.

MAR POR PROA (0°)

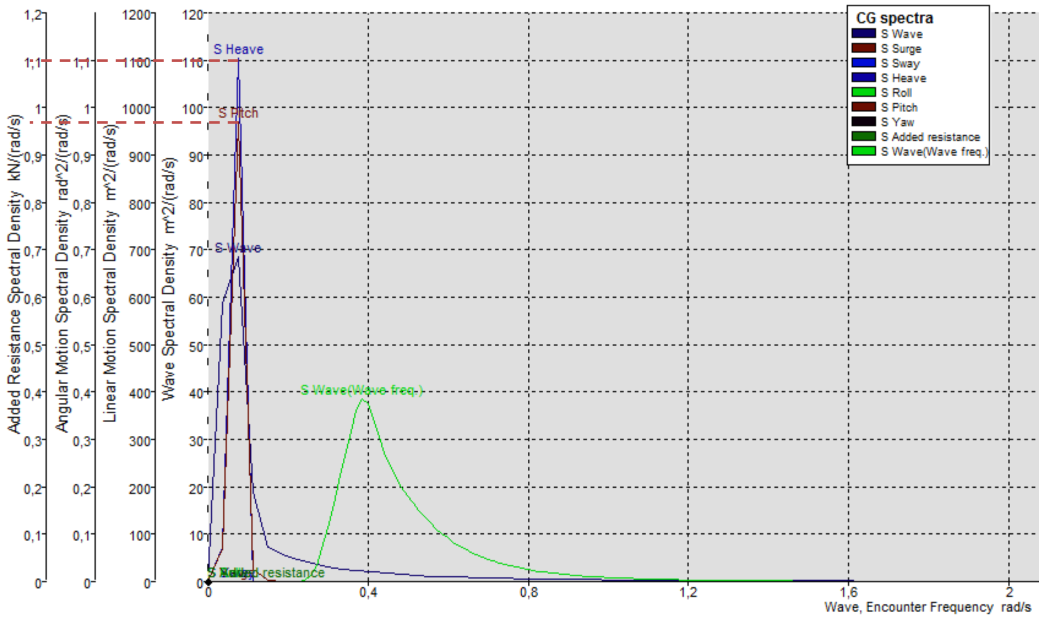


Ilustración 106. RAO con Mar por Proa

La amplitud máxima de los movimientos Heave, Pitch y Roll se produce para una frecuencia de encuentro con la ola de 0,2284 rad/s como se puede observar en la Ilustración 106, inferior a la que se obtuvo para la condición de mar por popa. Asimismo, se observa que dicha amplitud se ve acrecentada con respecto de la condición anterior. La amplitud de Heave alcanza los 1.104,28 m^2/rad·s, el Roll de 0,075 m^2/rad·s y el Pitch de 0,97 m^2/rad·s.

MAR POR "AMURA" (45°)

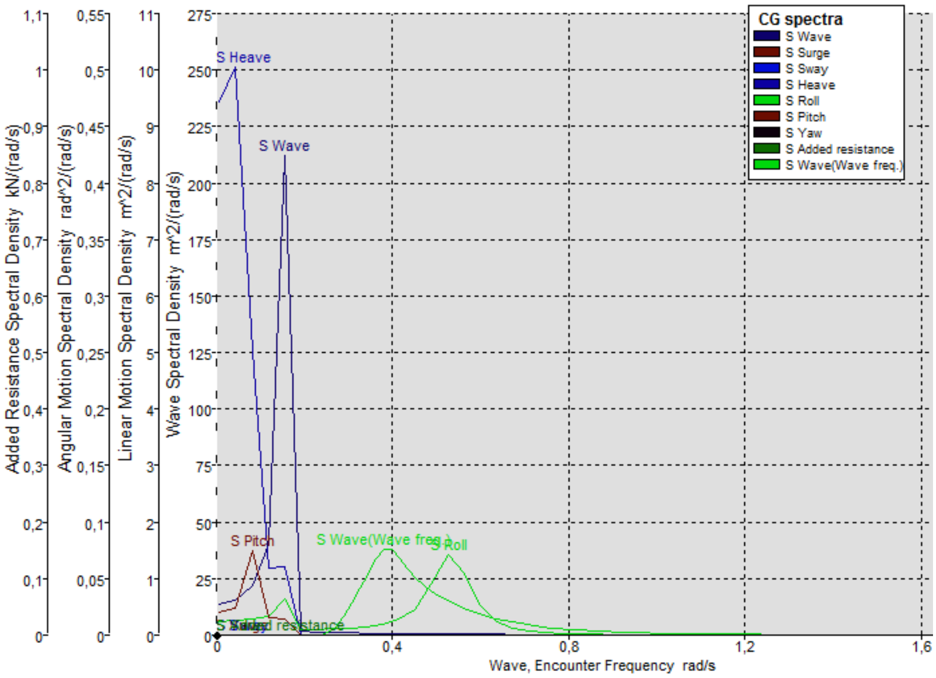


Ilustración 107. RAO con Mar por Amura.

12.3. Fuerza inducida por las olas y cálculo del fondeo

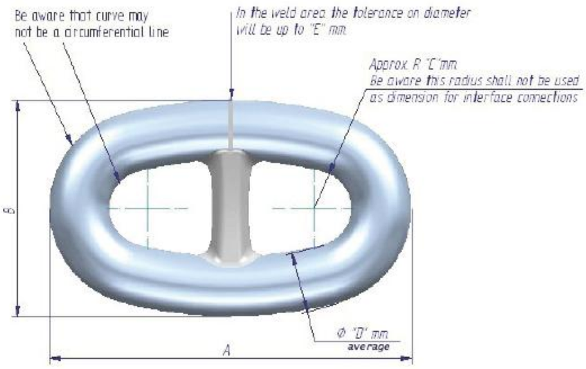
De los resultados de Maxsurf tenemos las siguientes fuerzas de excitación inducidas para cada estado de ola:

Mar Ensayado	Fuerza máxima (kN)	Fuerza máxima (ton)
Proa 0°	28.263,3	2.882
Popa 180°	392,5	40
Amura 45°	3.874,3	395

Para el dimensionamiento del sistema de fondeo se considerará una fuerza inducida de 2.882 toneladas. A esta fuerza habrá que sumarle las fuerzas inducidas por el viento y las corrientes según se ha calculado en el punto de Estabilidad en estado Intacto siguiendo el reglamento DNV: 9,06 kN para la fuerza por corrientes marinas y 5,025 kN para la fuerza por viento. Por lo tanto en total se tomará una fuerza **F = 28.277,3 kN (28.883,436 ton.).**

Esta fuerza se dividirá entre dos cadenas, ya que cuando la plataforma se encuentre sometida a ella, será debido a mares por proa, siendo por lo tanto las cadenas de esta zona las que mayor esfuerzo tendrán que soportar. De esta forma todas las cadenas serán iguales y calculadas para soportar una fuerza de trabajo de 14.216 kN.

LOADS	kN	Kips
MINIMUM LOAD BEARING CAPACITY	18033	4054
PROOF LOAD >	14216	3196



DIMENSIONS IN mm. (Approx.)

A	B	C	D	E
852	511	88.8	142	163

Ilustración 108. Eslabones de cadenas.

Para su manejo, el sistema de fondeo constará de cuatro molinetes situados según se indica en los planos de disposición general, bajo los cuales se dispondrán de cuatro tubos de acero, a modo de largo escobén. Los escobenes recorrerán el exterior de la estructura hasta la plataforma inferior (denominada "Forro toroide"). Como las jaulas han de deslizar sobre la spar, los anillos deslizantes soporte de las jaulas – calculados en la parte de "Estructura" – tendrán cuatro acanaladuras para permitir el paso de los escobenes. Ver ilustración

En la cubierta de maniobra, Cubierta 02, se dispondrán asimismo cuatro estopores (*Chain stoppers*) para cadena de 142 mm de capacidad adecuada a la carga máxima de la cadena.

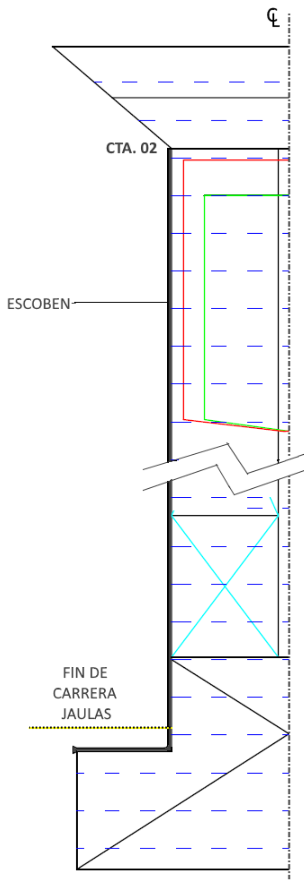


Ilustración 109. Detalle del escobén y límite de carrera de jaulas.

El ancla se selecciona utilizando la gráfica adjunta para una profundidad de 100 metros y fondo rocoso (hard clay). Por lo tanto será dotará al cada línea de fondeo de un ancla VRYHOF STEVRIS Mk.6 de 50 toneladas de peso cada una.

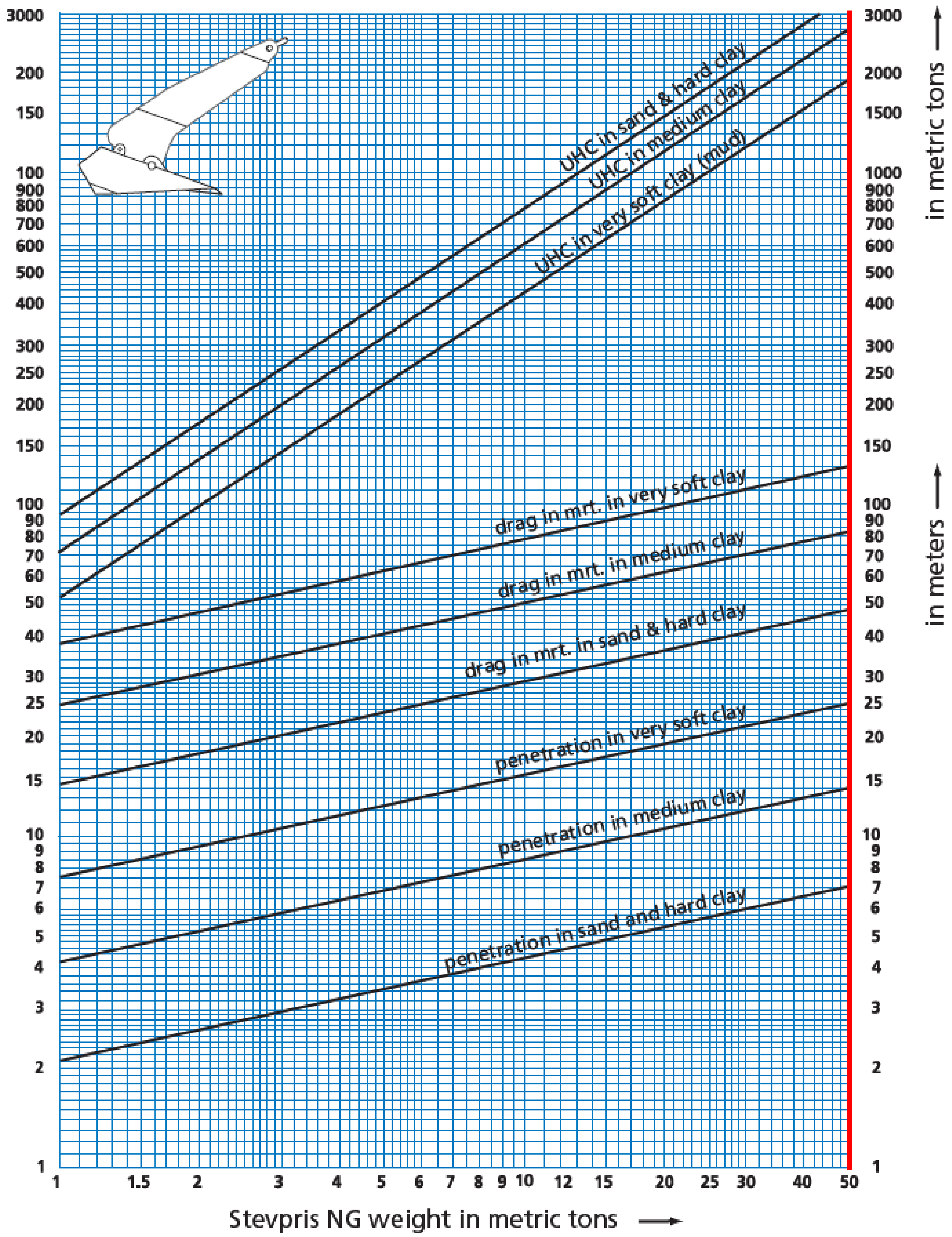


Ilustración 110. Gráfica para la selección de las anclas.

Justificación del diseño presentado.

En las siguientes ilustraciones se puede observar como el mar considerado dejaría fuera del agua las jaulas con el consiguiente daño a los peces y esfuerzos excesivos sobre las redes. A diferencia de lo que ocurre en las jaulas dispuestas al amparo de rías o fiordos, las jaulas oceánicas de superficie podrían encontrarse en algún momento fuera del agua con el consiguiente perjuicio indicado.

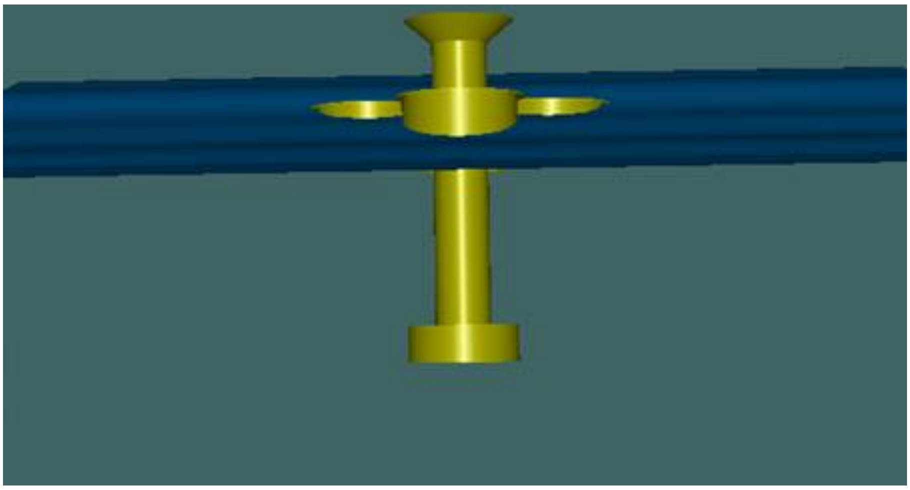


Ilustración 111. Vista desde proa. (Mar por popa).

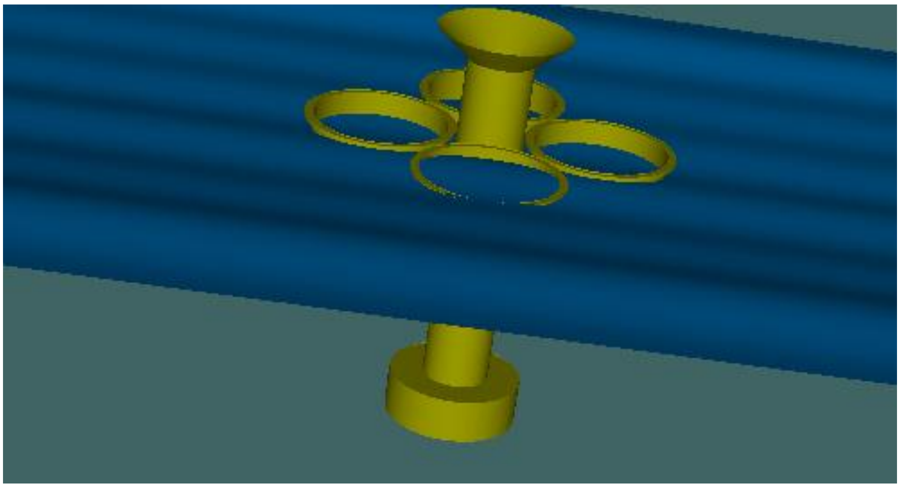


Ilustración 112. Vista desde popa. (Mar por popa).

En el diseño propuesto en este proyecto las jaulas pueden ser ajustadas en profundidad a voluntad, bien manualmente de forma remota bien automáticamente por el sistema de control en base a los parámetros oceanográficos tales como frecuencia y amplitud de las olas. En el caso del mar estudiado en los puntos anteriores, las jaulas se encontrarían a un mayor calado, bien intermedio o bien en la posición inferior, obteniéndose un doble beneficio, para la plataforma y para los peces:

1. La estructura y las redes de las jaulas sufren menos esfuerzos con el consiguiente aumento entre los intervalos de mantenimiento por daños estructurales.
2. Al reducirse la superficie expuesta a las olas, la amplitud de los movimientos será menor con respecto a las jaulas en superficie.

3. Los peces sufren menos estrés, viéndose menos afectado su engorde que si se encontrasen en la superficie. Asimismo la distribución automática de pienso por medio del sistema ya explicado, es más uniforme entre los individuos con una menor pérdida de grano hacia el exterior.

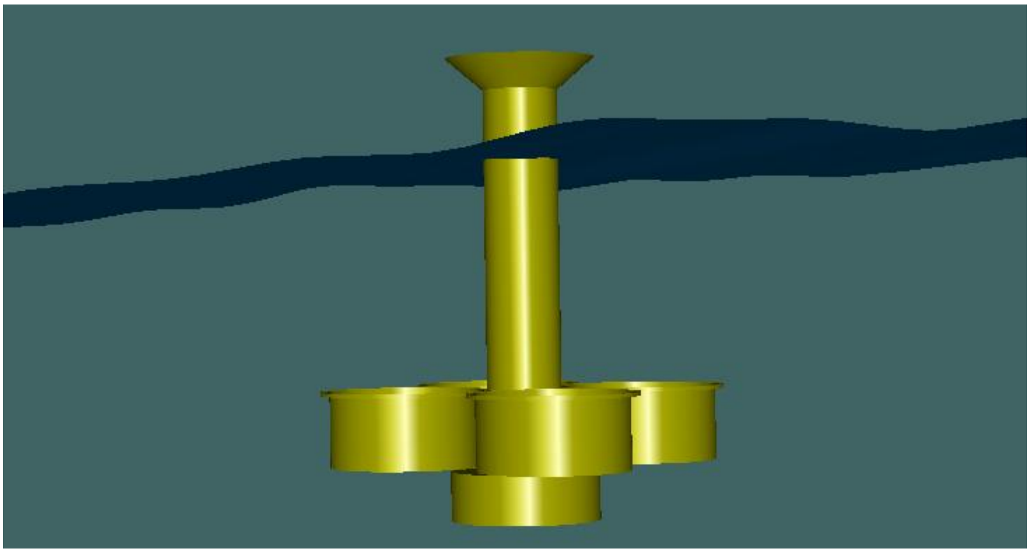


Ilustración 113. Situación de la plataforma con las jaulas en el nivel inferiro. Mismo mar.

13. CALCULO DEL PRESUPUESTO DE CONSTRUCCIÓN Y ESTUDIO DE FINANCIACION DE LA CONSTRUCCIÓN

13.1. PRESUPUESTO DEL ASTILLERO.

13.1.1. ACEROS.

En este apartado se contempla el total del coste de las horas invertidas y el material empleado por el astillero en la construcción de la estructura.

Para el acero del casco puede suponerse que el peso bruto es de aproximadamente un 8% mayor que el valor del peso neto. Este factor representa los recortes generados en el proceso de corte de acero. La cantidad de recortes será menor cuanto más eficiente sea la ingeniería realizada en el astillero constructor.

Estas horas debemos repartirlas entre los diferentes procesos, asignándoles a cada uno de ellos las horas proporcionalmente al peso que cada uno de estos procesos tiene en el buque.

Estos procesos se dividen en los siguientes:

Procesos de cabecera.

- **Corte por plasma** de chapas con espesor inferior a 20mm. En nuestro caso todas las chapas del forro, cubiertas, almas y alas de las "T", que no corresponden al cilindro inferior. pueden ser cortadas en esta instalación.

- **Oxicorte de chapas** con espesor superior o igual a 20 mm. Son la chapa de fondo, forro cilindro inferior, forro toroide y almas alas de las "T" de las zonas inferiores de la Spar.

- **Corte de perfiles**. En nuestro caso son perfiles de llanta de bulbo. En las operaciones de corte también se realizan las groeras y pasos de líquidos en las chapas y refuerzos de forma que el producto intermedio quede listo para pasar a los procesos de prefabricado.

<u>Procesos de prefabricado.</u>

Son aquellos destinados a producir las previas y paneles que formarán los subbloques que tras su unión formarán los bloques.

- **Previas simples**. Son aquellos refuerzos formados por un alma y un ala. En nuestro caso estas previas son refuerzos en "T", pertenecientes a los anillos y la los refuerzos verticales en el forro de la Spar, y longitudinales en las cubiertas de la Spar.

- **Paneles**. Formados por chapas a las que se les incorporan refuerzos longitudinales y posteriormente, se incorporan los refuerzos transversales o previas simples.

Como podemos observar es harto complejo repartir las horas de aceros entre los diferentes procesos sin realizar previamente una ingeniería de producción que de lugar a una determinada estrategia constructiva que nos permita conocer los pesos que cada proceso tiene dentro del global de la construcción de aceros.

Llegados a este punto solo podemos indicar a modo orientativo que el ratio de horas tonelada para la Spar es similar al proceso constructivo de buques por proceso en un astillero con modernas instalaciones es el siguiente:

	Corte por plasma	Oxicorte	Corte Perfiles	Previas Simples	Previas Complejas	Paneles
H/T	2,4	3,4	6,2	7,2	9,4	3,72

Tabla 139. Ratios del Astillero.

El promedio de horas que podemos considerar es de 40 h/t. incluyendo un margen por posible desviación de los valores teóricos.

Como el peso en acero de nuestra Spar es 1.153,31 toneladas el número de horas de elaborado y prefabricado es de 46.132,4h.

En estas estructuras el acero representa un 60% del total de horas al armamento, el 32% a la oficina técnica el 6,5% a gestión y control de calidad un 1,5%.

Se muestra a continuación el reparto de las horas por departamentos.

Peso de Acero Neto	1.156,31
Recortes	8%
Peso de Acero Bruto	1.248,81
H/T Acero	40

Tabla 140. Peso aceros.

	PRODUCCIÓN	OFICINA TÉCNICA	CONTROL CALIDAD
COEF. DESGLOSE DE HORAS	92%	6,5%	1,50%
DESGLOSE HORAS	70.920	5.011	1.156

	ACEROS	ARMAMENTO
COEF. DESGLOSE PRODUCCIÓN	60%	32%
DESGLOSE HORAS PRODUCIÓN	46.252	24.668

Tabla 141. Tabla desglose de horas.

HORAS TOTALES DEL BUQUE	77.087,08

Tabla 142. Horas totales de producción.

Considerando un precio por hora de 28 euros, obtenemos el siguiente coste de transformaciones.

PRECIO MEDIO/HORA	28,00 €
HORAS TOTALES	77.087,08
COSTE TRANSFORMACIONES	**2.158.438,15€**

Tabla 143. Precio coste transformaciones.

Se desglosa el coste por departamentos:

TRANSFORMACIONES	EUROS
PRODUCCIÓN ACEROS	1.295.067,20
PRODUCCION ARMAMENTO	690.696,53
OFICINA TÉCNICA	140.297,73
CONTROL CALIDAD	32.376,68
TOTAL TRANSFORMACIONES	**2.158.438,15 €**

Tabla 144. Desglose precios por departamentos.

13.1.2. MATERIALES.

Realizando una recopilación de los precios de mercado para el acero y los equipos más importantes, y teniendo en cuenta la relatividad de muchos de ellos, se obtiene el siguiente desglose:

Piezas fundidas y forjadas.

Su coste puede ser estimado por la siguiente expresión:

$$P = \frac{(4 \cdot L \cdot T)}{166,386} \text{ miles de euros}$$

Donde

L es la eslora reglamentaria (54,8)

T es el calado de escantillonado (45m)

Sustituyendo los valores en la expresión obtenemos un coste de piezas fundidas y forjadas de 59,29 miles de euros.

Materiales auxiliares para la construcción de la Spar:

$$P = 7 \cdot P_A$$

Obteniendo un valor de 7.709 euros.

Preparación y protección de superficies.

CONCEPTO	COSTE EUROS/m²	TOTAL EUROS
Obra viva	18	39.060,00 €
Obra muerta	18	10.602,00 €
Cubierta intemperie	18	5.652,00 €
Zona Interior	25	281.650,00 €
Tanques Lastre	25	28.370,25 €
	SUBTOTAL	365.334,25 €

Tabla 145 Coste tratamiento de pinturas.

Equipos diversos y protección contra la corrosión.

COSTE DE EQUIPOS Y PINTURA	
CONCEPTO	COSTE EN EUROS
ANCLAS	350.043,00 €
CADENAS Y ESTACHAS	155.267,10 €
CHALECOS Y AROS	6.000,00 €
PUERTAS DE ACERO	11.250,00 €
ESCALERAS, PASAMANOS Y CANDELEROS	15.218,00 €
ACCESORIOS DE AMARRE Y FONDEO	7.625,00 €
PREPARACIÓN SUPERFICIES Y PINTURA	365.334,25 €
PROTECCIÓN CATÓDICA	7.535,00 €
MOLINETES	142.000,00 €
CHIGRES DE MANIOBRA	123.418,00 €
TUBERÍAS	102.700,00 €
SISTEMAS DE COMUNICACIONES	50.000,00 €
SUBTOTAL	1.336.390,35 €

Tabla 146 Coste equipos y pintura.

CONCEPTO	PESO (t)	COSTE EN EUROS
ACERO	1156,31	531.902,00 €
CONSUMIBLES (2,5% del acero)	28,91	13.297,55 €
RECORTES (8% de acero)	92,50	42.552,16 €
SUBTOTAL		502.647,39 €

Tabla 147. Coste aceros.

LLAVES EN MANO	
CONCEPTO	COSTE
HABILITACIÓN	80.134,00 €
AIRE ACONDICIONADO	5.500,00 €
ELECTRICIDAD	65.585,00 €
SISTEMA CONTRAINCENDIOS	15.301,00 €
SUBTOTAL	166.520,00 €

Tabla 148. Equipos llave en mano.

AUXILIARES DE MAQUINAS	
CONCEPTO	COSTE
GRUPOS GENERADORES	162.354,00 €
SISTEMAS AKVA GROUP	534.258,00 €
AEROGENERADOR	25.000,00 €
BOMBAS	21.441,00 €
SUBTOTAL	743.053,00 €

Tabla 149. Auxiliares de máquinas.

El total de las partidas es el siguiente.

MATERIALES	
CONCEPTO	COSTE
COSTE DE ACERO Y CONSUMIBLES	502.647,39 €
COSTE DE EQUIPOS Y PINTURA	1.336.390,35 €
LLAVES EN MANO	166.520,00 €
AUXILIARES DE MÁQUINAS	743.053,00 €
TOTAL MATERIALES	2.005.557,74 €

Tabla 150. Suma de partidas.

13.1.3. Coste neto de la construcción del buque.

COSTE DE ACERO Y CONSUMIBLES	EUROS
MATERIALES	2.005.557,74 €
MANO DE OBRA DE ACEROS	1.295.067,20 €
MANO DE OBRA ARMAMENTO	690.696,53 €
OFICINA TÉCNICA	140.297,73 €
CONTROL Y GESTIÓN DE CALIDAD	32.376,68 €
TOTAL	**2.158.438,15 €**

Tabla 151. Coste neto de la producción.

13.1.4. Gastos diversos.

En esta partida se recogen los gastos achacables a la construcción y que no están incluidas en las partidas anteriores. Los más importantes son los que se enumeran a continuación.

- Seguros.
- Sociedad de Clasificación.
- Auxilios durante la construcción (andamios, radiografías…)
- Garantías.
- Varios: inspección armador.
- Avales y comisiones.
- Comisiones bróker.

Se pueden estimar estos costes entre el 3% y el 5% del valor total de la construcción de la Spar, por lo que tomaremos un valor intermedio de un 4%.

VALOR TOTAL DE LA CONSTRUCCIÓN	2.158.438,15 €
GASTOS VARIOS	4%
TOTAL GASTOS VARIOS	**86.337,53 €**

Tabla 152. Gastos varios.

13.2. Beneficio del astillero

Esta partida representa el beneficio que el astillero pretende obtener por la producción de la Spar. Normalmente se expresa con un porcentaje del coste total de la Spar que se estima en un 10%.

13.3. Precio de la Spar.

COSTE DE ACERO Y CONSUMIBLES	EUROS
MATERIALES	2.005.557,74 €
MANO DE OBRA DE ACEROS	1.295.067,20 €
MANO DE OBRA ARMAMENTO	690.696,53 €
OFICINA TÉCNICA	140.297,73 €
CONTROL Y GESTIÓN DE CALIDAD	32.376,68 €
GASTOS DIVERSOS	86.337,53 €
BENEFICIO DEL ASTILLERO	224.477,57 €
TOTAL	**4.474.810,98 €**

Tabla 153. Precio de la Spar.

13.4. Financiación.

TFM - Mónica Rodríguez Lapido - Planta Acuícola Offshore   Coste y Financiación de la SPAR

FINANCIACIÓN A 7,5 AÑOS

		Ratio diario	3.533
		Coste Op. Dia	548
Precio (eur)	4.474.811	I.R.R.	42,64%
Fin. (%)	80,0%		
Cant. Finan.	3.579.849	NPV	4.742.295,2
Ratio intereses	6,00%	Residual	

Per. Semestre	CAPEX	Financiación	Principal	Intereses	Pago total	Gastos operativos	T-Ch. Rate	Flujo caja
-4	(894.962)							(894.962)
-3	(894.962)	894.962			0			0
-2	(894.962)	894.962		(80.547)	(80.547)			(80.547)
-1	(894.962)	894.962		(53.698)	(53.698)			(53.698)
0	(894.962)	894.962		(26.849)	(26.849)			(26.849)
1			(164.503)	(107.395)	(271.899)	98.654	635.940	462.696
2			(169.438)	(102.460)	(271.899)	98.654	635.940	462.696
3			(174.521)	(97.377)	(271.899)	98.654	635.940	462.696
4			(179.757)	(92.142)	(271.899)	98.654	635.940	462.696
5			(185.150)	(86.749)	(271.899)	98.654	635.940	462.696
6			(190.704)	(81.194)	(271.899)	98.654	635.940	462.696
7			(196.425)	(75.473)	(271.899)	98.654	635.940	462.696
8			(202.318)	(69.580)	(271.899)	98.654	635.940	462.696
9			(208.388)	(63.511)	(271.899)	98.654	635.940	462.696
10			(214.639)	(57.259)	(271.899)	98.654	635.940	462.696
11			(221.078)	(50.820)	(271.899)	98.654	635.940	462.696
12			(227.711)	(44.188)	(271.899)	98.654	635.940	462.696
13			(234.542)	(37.356)	(271.899)	98.654	635.940	462.696
14			(241.578)	(30.320)	(271.899)	98.654	635.940	462.696
15	1.789.924		(248.826)	(23.073)	(271.899)	98.654	635.940	2.252.620
	(2.684.887)	3.579.849	(3.059.579)	(1.179.993)	(4.239.572)	1.479.816	9.539.100	7.674.306

Notas.-
1) El valor de la planta en el semestre 15 se estima en un 40% del precio de venta.

1. Precio de la Spar 4.474.810,98 euros aproximadamente.
2. Se financiará el 80% del precio de la Spar.
3. Cantidad de financiación 3.579.848,78 euros.
4. Se financiará en 7,5 años.

5. Tipo de intereses 6% (valor de referencia).

6. Ratio diario de time-charter: 3.533 € (mínimo necesario para que el proyecto sea viable).

7. Coste diario de la operación 548€/día, incluyen visitas a la estación, consumos de piensos, combustibles…).

8. IRR (Internal Rate of Return): es el ratio de retorno que se fija como mínimo, se tomará un 6% para un NPV de “0” (operación neutra, en break-even).

9. NPV (Net Present Value): valor actualizado neto de los flujos de caja a día de hoy, actualizado el tipo de interés del préstamo al (6%).

10. Al final del semestre 15, se deja un valor residual del 40%, del precio de la Spar, es decir se estima que la Spar después de 7,5 años tiene ese valor.

11. Periodos de tiempo son semestrales. Los primeros simestres, en negativo, indican que en el periodo de construcción. Durante este tiempo el préstamo solo será en intereses, en el principal.

12. CAPEX Son los gastos de capital que se desembolsan semestralmente, el primero es del 20% de aportación del armador y por ello no genera en intereses.

13. Financiamiento son las disposiciones de préstamo que ser irán haciento (4x20% a partir del segundo semestre). Este préstamo se desenvuelve a lo largo de los años de duración del préstamo.

14. Principal es la amortización de la cantidad prestada.

15. Intereses, son los intereses pagados por la operación, se pagarán semestralmente, a semestre vencido.

16. El pago total es la suma del principal más los intereses.

17. Los gastos operativos son un ratio diario multiplicado por 180.

18. El T.Ch. Rate es el Ratio diario multiplicado por 180.

19. El flujo de caja es la suma de todas las columnas.

14. BIBLIOGRAFÍA.

http://www.fao.org/fishery/affris/perfiles-de-las-especies/atlantic-salmon/salmon-del-atlantico-pagina-principal/es/

http://www.fao.org/fishery/culturedspecies/Psetta_maxima/es

http://www.magrama.gob.es/es/ministerio/servicios/informacion/0138Lenguado-europeo_tcm7-354360.pdf

http://www.magrama.gob.es/app/jacumar/especies/Documentos/Dorada.pdf

http://www.magrama.gob.es/app/jacumar/especies/Documentos/Lubina.pdf

http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx

http://www.magrama.gob.es/app/JACUMAR/especies/Documentos/Cultivo_Dorada.pdf

http://www.revistaaquatic.com/aquatic/art.asp?c=82

http://www2.meteogalicia.es/galego/observacion/plataformas/plataformas.asp

http://www.prona.cl/files/CatalogOceaES.pdf

https://www.palfinger.com/en/emea

http://www.cat.com/es_ES.html

http://www.sumiseran.es/contents/es/d15.html

http://www.zodiac-nautic.es/balsas/ver/2/coaster-iso-9650-4-6-y-8-plazas

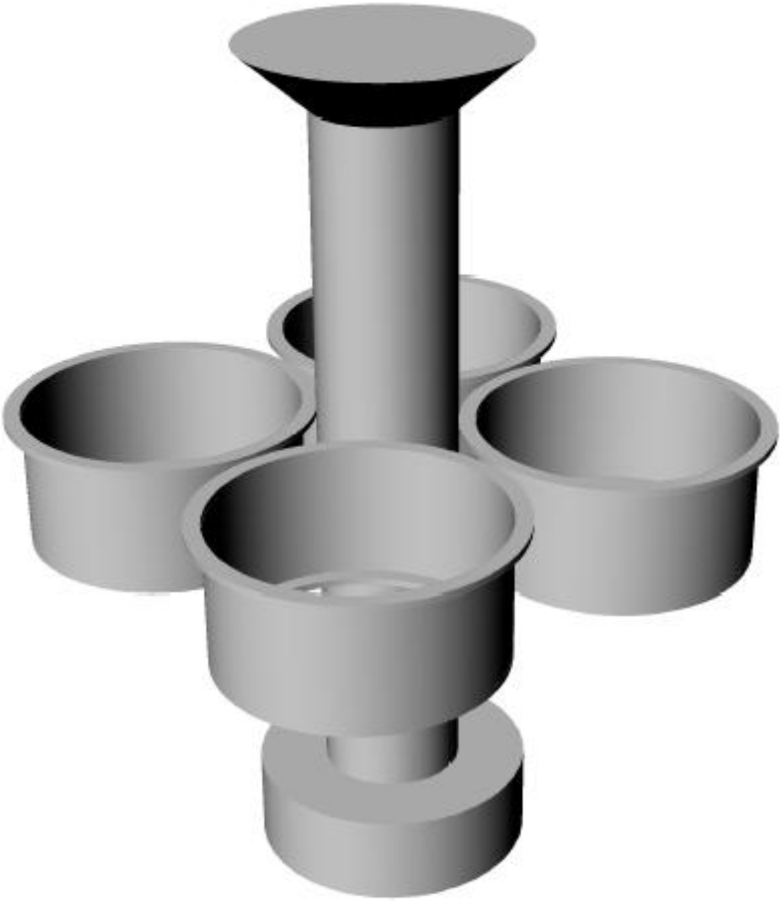
http://www.hierrossantander.com/hierros_prontuario/archivo/03-PERFILES%20COMERCIALES.pdf

https://issuu.com/flips-ele/docs/catalogo_general_remosa_2014/82?e=11810223/7683298

(Se adjunta una segunda parte donde se encuentran los Anexos)

TRABAJO FIN DE MÁSTER

PLATAFORMA ACUICOLA EN MAR ABIERTO



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22/04/2016

(Anexos)

ANEXOS

Temperatura máxima del agua, según datos de la Boya de Langosteira II:

Ts:	Temperatura Superficial Media del Agua		° C
Boya de Langosteira Año 2015			
Mes	Ts Max	Día	Hora
Enero	13,40	29	16
Febrero	13,00	1	9
Marzo	14,50	7	15
Abril	16,30	30	21
Mayo	29,10	12	17
Junio	18,70	29	17
Julio	19,40	28	19
Agosto	19,10	29	15
Septiembre	17,50	1	0
Octubre	16,30	10	0
Noviembre	17,30	11	15
Diciembre	15,90	1	23

Temperatura mínima del agua, según datos de la Boya de Langosteira II.

Ts:	Temperatura Superficial Media del Agua		° C
Boya de Langosteira Año 2015			
Mes	Ts Min.	Día	Hora
Enero	12,00	30	3
Febrero	12,00	28	23
Marzo	12,00	24	23
Abril	12,20	8	7
Mayo	12,90	27	20
Junio	12,30	10	23
Julio	13,70	31	19
Agosto	13,60	1	6
Septiembre	14,00	4	23
Octubre	13,80	3	3
Noviembre	15,60	30	11
Diciembre	13,20	29	9

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
ABRIL	1	14,25	20,00	0,34
	2	14,25	20,23	0,34
	3	14,25	20,47	0,34
	4	14,25	20,71	0,34
	5	14,25	20,95	0,35
	6	14,25	21,19	0,35
	7	14,25	21,44	0,35
	8	14,25	21,68	0,36
	9	14,25	21,93	0,36
	10	14,25	22,18	0,36
	11	14,25	22,43	0,36
	12	14,25	22,68	0,37
	13	14,25	22,93	0,37
	14	14,25	23,19	0,37
	15	14,25	23,45	0,38
	16	14,25	23,71	0,38
	17	14,25	23,97	0,38
	18	14,25	24,23	0,38
	19	14,25	24,50	0,39
	20	14,25	24,76	0,39
	21	14,25	25,03	0,39
	22	14,25	25,30	0,40
	23	14,25	25,57	0,40
	24	14,25	25,85	0,40
	25	14,25	26,12	0,41
	26	14,25	26,40	0,41
	27	14,25	26,68	0,41
	28	14,25	26,96	0,41
	29	14,25	27,24	0,42
	30	14,25	27,53	0,42
MAYO	1	21,00	27,81	0,64
	2	21,00	28,23	0,64
	3	21,00	28,65	0,65
	4	21,00	29,08	0,66
	5	21,00	29,51	0,66
	6	21,00	29,94	0,67
	7	21,00	30,38	0,68
	8	21,00	30,82	0,68
	9	21,00	31,27	0,69

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
	10	21,00	31,72	0,70
	11	21,00	32,17	0,70
	12	21,00	32,63	0,71
	13	21,00	33,09	0,72
	14	21,00	33,55	0,73
	15	21,00	34,02	0,73
	16	21,00	34,50	0,74
	17	21,00	34,98	0,75
	18	21,00	35,46	0,76
	19	21,00	35,94	0,76
	20	21,00	36,43	0,77
	21	21,00	36,93	0,78
	22	21,00	37,43	0,78
	23	21,00	37,93	0,79
	24	21,00	38,44	0,80
	25	21,00	38,95	0,81
	26	21,00	39,46	0,81
	27	21,00	39,98	0,82
	28	21,00	40,51	0,83
	29	21,00	41,03	0,84
	30	21,00	41,57	0,85
	31	21,00	42,10	0,85
JUNIO	1	15,50	42,64	0,62
	2	15,50	43,05	0,62
	3	15,50	43,45	0,63
	4	15,50	43,86	0,63
	5	15,50	44,27	0,64
	6	15,50	44,68	0,64
	7	15,50	45,10	0,64
	8	15,50	45,51	0,65
	9	15,50	45,93	0,65
	10	15,50	46,35	0,66
	11	15,50	46,78	0,66
	12	15,50	47,21	0,67
	13	15,50	47,63	0,67
	14	15,50	48,07	0,67
	15	15,50	48,50	0,68
	16	15,50	48,94	0,68
	17	15,50	49,37	0,69
	18	15,50	49,82	0,69
	19	15,50	50,26	0,70

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
	20	15,50	50,71	0,70
	21	15,50	51,15	0,70
	22	15,50	51,61	0,71
	23	15,50	52,06	0,71
	24	15,50	52,51	0,72
	25	15,50	52,97	0,72
	26	15,50	53,43	0,73
	27	15,50	53,90	0,73
	28	15,50	54,36	0,74
	29	15,50	54,83	0,74
	30	15,50	55,30	0,74
JULIO	1	16,55	55,78	0,80
	2	16,55	56,28	0,80
	3	16,55	56,79	0,81
	4	16,55	57,30	0,81
	5	16,55	57,81	0,82
	6	16,55	58,32	0,82
	7	16,55	58,84	0,83
	8	16,55	59,36	0,83
	9	16,55	59,89	0,84
	10	16,55	60,42	0,84
	11	16,55	60,95	0,85
	12	16,55	61,48	0,85
	13	16,55	62,01	0,86
	14	16,55	62,55	0,87
	15	16,55	63,09	0,87
	16	16,55	63,64	0,88
	17	16,55	64,18	0,88
	18	16,55	64,73	0,89
	19	16,55	65,29	0,89
	20	16,55	65,84	0,90
	21	16,55	66,40	0,90
	22	16,55	66,96	0,91
	23	16,55	67,53	0,91
	24	16,55	68,10	0,92
	25	16,55	68,67	0,92
	26	16,55	69,24	0,93
	27	16,55	69,82	0,94
	28	16,55	70,40	0,94
	29	16,55	70,98	0,95
	30	16,55	71,57	0,95

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
	31	16,55	72,15	0,96
AGOSTO	1	16,35	72,75	0,95
	2	16,35	73,33	0,96
	3	16,35	73,93	0,96
	4	16,35	74,52	0,97
	5	16,35	75,12	0,97
	6	16,35	75,72	0,98
	7	16,35	76,32	0,98
	8	16,35	76,92	0,99
	9	16,35	77,53	1,00
	10	16,35	78,15	1,00
	11	16,35	78,76	1,01
	12	16,35	79,38	1,01
	13	16,35	80,00	1,02
	14	16,35	80,62	1,02
	15	16,35	81,25	1,03
	16	16,35	81,88	1,03
	17	16,35	82,51	1,04
	18	16,35	83,15	1,05
	19	16,35	83,79	1,05
	20	16,35	84,43	1,06
	21	16,35	85,07	1,06
	22	16,35	85,72	1,07
	23	16,35	86,37	1,07
	24	16,35	87,03	1,08
	25	16,35	87,69	1,09
	26	16,35	88,35	1,09
	27	16,35	89,01	1,10
	28	16,35	89,68	1,10
	29	16,35	90,35	1,11
	30	16,35	91,02	1,12
	31	16,35	91,69	1,12
SEPTIEMBRE	1	15,75	92,37	1,09
	2	15,75	93,03	1,09
	3	15,75	93,70	1,10
	4	15,75	94,36	1,10
	5	15,75	95,03	1,11
	6	15,75	95,70	1,12
	7	15,75	96,38	1,12
	8	15,75	97,05	1,13
	9	15,75	97,74	1,13

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
	10	15,75	98,42	1,14
	11	15,75	99,11	1,14
	12	15,75	99,79	1,15
	13	15,75	100,49	1,15
	14	15,75	101,18	1,16
	15	15,75	101,88	1,17
	16	15,75	102,58	1,17
	17	15,75	103,29	1,18
	18	15,75	103,99	1,18
	19	15,75	104,70	1,19
	20	15,75	105,42	1,19
	21	15,75	106,13	1,20
	22	15,75	106,85	1,21
	23	15,75	107,58	1,21
	24	15,75	108,30	1,22
	25	15,75	109,03	1,22
	26	15,75	109,76	1,23
	27	15,75	110,50	1,23
	28	15,75	111,23	1,24
	29	15,75	111,97	1,25
	30	15,75	112,72	1,25
OCTUBRE	1	15,05	113,46	1,21
	2	15,05	114,19	1,21
	3	15,05	114,91	1,22
	4	15,05	115,64	1,22
	5	15,05	116,37	1,23
	6	15,05	117,10	1,23
	7	15,05	117,84	1,24
	8	15,05	118,58	1,24
	9	15,05	119,32	1,25
	10	15,05	120,06	1,26
	11	15,05	120,81	1,26
	12	15,05	121,56	1,27
	13	15,05	122,31	1,27
	14	15,05	123,07	1,28
	15	15,05	123,83	1,28
	16	15,05	124,59	1,29
	17	15,05	125,35	1,30
	18	15,05	126,12	1,30
	19	15,05	126,89	1,31
	20	15,05	127,67	1,31

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
	21	15,05	128,44	1,32
	22	15,05	129,22	1,32
	23	15,05	130,00	1,33
	24	15,05	130,79	1,33
	25	15,05	131,58	1,34
	26	15,05	132,37	1,35
	27	15,05	133,16	1,35
	28	15,05	133,96	1,36
	29	15,05	134,76	1,36
	30	15,05	135,56	1,37
	31	15,05	136,37	1,37
NOVIEMBRE	1	16,45	137,18	1,50
	2	16,45	138,05	1,51
	3	16,45	138,93	1,52
	4	16,45	139,82	1,52
	5	16,45	140,70	1,53
	6	16,45	141,59	1,54
	7	16,45	142,49	1,54
	8	16,45	143,39	1,55
	9	16,45	144,29	1,56
	10	16,45	145,19	1,56
	11	16,45	146,10	1,57
	12	16,45	147,01	1,58
	13	16,45	147,93	1,58
	14	16,45	148,85	1,59
	15	16,45	149,77	1,60
	16	16,45	150,70	1,61
	17	16,45	151,62	1,61
	18	16,45	152,56	1,62
	19	16,45	153,49	1,63
	20	16,45	154,43	1,63
	21	16,45	155,38	1,64
	22	16,45	156,33	1,65
	23	16,45	157,28	1,65
	24	16,45	158,23	1,66
	25	16,45	159,19	1,67
	26	16,45	160,15	1,68
	27	16,45	161,12	1,68
	28	16,45	162,09	1,69
	29	16,45	163,06	1,70
	30	16,45	164,03	1,70

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
DICIEMBRE	1	14,55	165,01	1,53
	2	14,55	165,90	1,53
	3	14,55	166,79	1,54
	4	14,55	167,68	1,55
	5	14,55	168,57	1,55
	6	14,55	169,47	1,56
	7	14,55	170,37	1,56
	8	14,55	171,28	1,57
	9	14,55	172,18	1,57
	10	14,55	173,09	1,58
	11	14,55	174,00	1,59
	12	14,55	174,92	1,59
	13	14,55	175,84	1,60
	14	14,55	176,76	1,60
	15	14,55	177,68	1,61
	16	14,55	178,61	1,62
	17	14,55	179,54	1,62
	18	14,55	180,48	1,63
	19	14,55	181,41	1,63
	20	14,55	182,35	1,64
	21	14,55	183,29	1,65
	22	14,55	184,24	1,65
	23	14,55	185,19	1,66
	24	14,55	186,14	1,66
	25	14,55	187,09	1,67
	26	14,55	188,05	1,68
	27	14,55	189,01	1,68
	28	14,55	189,98	1,69
	29	14,55	190,94	1,69
	30	14,55	191,91	1,70
	31	14,55	192,89	1,71
ENERO	1	12,70	193,86	1,53
	2	12,70	194,75	1,54
	3	12,70	195,63	1,54
	4	12,70	196,52	1,55
	5	12,70	197,41	1,55
	6	12,70	198,31	1,56
	7	12,70	199,21	1,56
	8	12,70	200,11	1,57
	9	12,70	201,01	1,57
	10	12,70	201,91	1,58

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
	11	12,70	202,82	1,58
	12	12,70	203,73	1,59
	13	12,70	204,64	1,59
	14	12,70	205,55	1,60
	15	12,70	206,47	1,60
	16	12,70	207,39	1,61
	17	12,70	208,31	1,61
	18	12,70	209,24	1,62
	19	12,70	210,17	1,62
	20	12,70	211,10	1,63
	21	12,70	212,03	1,63
	22	12,70	212,96	1,64
	23	12,70	213,90	1,64
	24	12,70	214,84	1,65
	25	12,70	215,78	1,65
	26	12,70	216,73	1,66
	27	12,70	217,68	1,66
	28	12,70	218,63	1,67
	29	12,70	219,58	1,67
	30	12,70	220,53	1,68
	31	12,70	221,49	1,68
FEBRERO	1	12,50	222,45	1,67
	2	12,50	223,40	1,68
	3	12,50	224,36	1,68
	4	12,50	225,32	1,69
	5	12,50	226,28	1,69
	6	12,50	227,24	1,70
	7	12,50	228,21	1,70
	8	12,50	229,17	1,71
	9	12,50	230,14	1,71
	10	12,50	231,12	1,72
	11	12,50	232,09	1,72
	12	12,50	233,07	1,73
	13	12,50	234,05	1,73
	14	12,50	235,03	1,74
	15	12,50	236,02	1,74
	16	12,50	237,01	1,75
	17	12,50	238,00	1,75
	18	12,50	238,99	1,76
	19	12,50	239,99	1,76
	20	12,50	240,99	1,77

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
	21	12,50	241,99	1,77
	22	12,50	242,99	1,78
	23	12,50	244,00	1,78
	24	12,50	245,01	1,79
	25	12,50	246,02	1,79
	26	12,50	247,03	1,80
	27	12,50	248,05	1,80
	28	12,50	249,07	1,81
MARZO	1	13,25	250,09	1,90
	2	13,25	251,16	1,90
	3	13,25	252,23	1,91
	4	13,25	253,30	1,92
	5	13,25	254,38	1,92
	6	13,25	255,46	1,93
	7	13,25	256,54	1,93
	8	13,25	257,62	1,94
	9	13,25	258,71	1,94
	10	13,25	259,80	1,95
	11	13,25	260,90	1,96
	12	13,25	261,99	1,96
	13	13,25	263,09	1,97
	14	13,25	264,19	1,97
	15	13,25	265,30	1,98
	16	13,25	266,40	1,99
	17	13,25	267,51	1,99
	18	13,25	268,63	2,00
	19	13,25	269,74	2,00
	20	13,25	270,86	2,01
	21	13,25	271,99	2,01
	22	13,25	273,11	2,02
	23	13,25	274,24	2,03
	24	13,25	275,37	2,03
	25	13,25	276,50	2,04
	26	13,25	277,64	2,04
	27	13,25	278,78	2,05
	28	13,25	279,92	2,06
	29	13,25	281,06	2,06
	30	13,25	282,21	2,07
	31	13,25	283,36	2,07

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
ABRIL	1	14,25	284,52	2,21
	2	14,25	285,74	2,22
	3	14,25	286,96	2,22
	4	14,25	288,19	2,23
	5	14,25	289,42	2,24
	6	14,25	290,66	2,24
	7	14,25	291,90	2,25
	8	14,25	293,14	2,26
	9	14,25	294,38	2,26
	10	14,25	295,63	2,27
	11	14,25	296,88	2,28
	12	14,25	298,14	2,28
	13	14,25	299,40	2,29
	14	14,25	300,66	2,30
	15	14,25	301,92	2,30
	16	14,25	303,19	2,31
	17	14,25	304,46	2,32
	18	14,25	305,74	2,32
	19	14,25	307,02	2,33
	20	14,25	308,30	2,34
	21	14,25	309,58	2,35
	22	14,25	310,87	2,35
	23	14,25	312,16	2,36
	24	14,25	313,45	2,37
	25	14,25	314,75	2,37
	26	14,25	316,05	2,38
	27	14,25	317,36	2,39
	28	14,25	318,67	2,39
	29	14,25	319,98	2,40
	30	14,25	321,29	2,41
MAYO	1	21,00	322,61	3,62
	2	21,00	324,52	3,64
	3	21,00	326,45	3,65
	4	21,00	328,38	3,67
	5	21,00	330,31	3,68
	6	21,00	332,26	3,70
	7	21,00	334,21	3,71
	8	21,00	336,16	3,73
	9	21,00	338,13	3,74
	10	21,00	340,10	3,76
	11	21,00	342,08	3,77

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
	12	21,00	344,07	3,79
	13	21,00	346,06	3,81
	14	21,00	348,06	3,82
	15	21,00	350,07	3,84
	16	21,00	352,08	3,85
	17	21,00	354,10	3,87
	18	21,00	356,13	3,88
	19	21,00	358,17	3,90
	20	21,00	360,21	3,92
	21	21,00	362,26	3,93
	22	21,00	364,32	3,95
	23	21,00	366,39	3,96
	24	21,00	368,46	3,98
	25	21,00	370,54	4,00
	26	21,00	372,63	4,01
	27	21,00	374,72	4,03
	28	21,00	376,82	4,04
	29	21,00	378,93	4,06
	30	21,00	381,05	4,08
	31	21,00	383,17	4,09
JUNIO	1	15,50	385,31	2,95
	2	15,50	386,89	2,96
	3	15,50	388,47	2,97
	4	15,50	390,06	2,98
	5	15,50	391,65	2,99
	6	15,50	393,25	3,00
	7	15,50	394,85	3,00
	8	15,50	396,45	3,01
	9	15,50	398,06	3,02
	10	15,50	399,67	3,03
	11	15,50	401,29	3,04
	12	15,50	402,91	3,05
	13	15,50	404,54	3,06
	14	15,50	406,16	3,07
	15	15,50	407,80	3,07
	16	15,50	409,43	3,08
	17	15,50	411,08	3,09
	18	15,50	412,72	3,10
	19	15,50	414,37	3,11
	20	15,50	416,02	3,12
	21	15,50	417,68	3,13

		Tª Media	Y=0,0167*X^0,621*exp^0,055*T Y (consumo ganado pez/día)	C=0,017*X^0,71*EXP^0,06*T C (consumo alimento diario)
	22	15,50	419,34	3,14
	23	15,50	421,01	3,14
	24	15,50	422,68	3,15
	25	15,50	424,35	3,16
	26	15,50	426,03	3,17
	27	15,50	427,71	3,18
	28	15,50	429,40	3,19
	29	15,50	431,09	3,20
	30	15,50	432,78	3,21
			Total Pienso (g)/Individuo	**728,435**

OFFSHORE STANDARD

DNV-OS-C106

Structural Design of Deep Draught Floating Units (LRFD Method)

APRIL 2012

The electronic pdf version of this document found through http://www.dnv.com is the officially binding version

DET NORSKE VERITAS AS

FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

DNV service documents consist of among others the following types of documents:

— *Service Specifications.* Procedural requirements.
— *Standards.* Technical requirements.
— *Recommended Practices.* Guidance.

The Standards and Recommended Practices are offered within the following areas:

A) Qualification, Quality and Safety Methodology
B) Materials Technology
C) Structures
D) Systems
E) Special Facilities
F) Pipelines and Risers
G) Asset Operation
H) Marine Operations
J) Cleaner Energy
O) Subsea Systems

Any comments may be sent by e-mail to *rules@dnv.com*

CHANGES

General

This document supersedes DNV-OS-C106, October 2008.

Text affected by the main changes in this edition is highlighted in red colour. However, if the changes involve a whole chapter, section or sub-section, normally only the title will be in red colour.

Main changes:

- **General**

— Changed name of DNV-OS-106 to: Structural Design of Deep Draught Floating Units (LRFD Method).
— General update from "Spar" to DDF (Deep Draught Floater) for more generic description throughout document.

- **Section 1**

— updated description of DDF to include both Spar and DDS shaped units
— adding D207: "Heave Damping Structure: Structure to increase added mass in heave and reduce the vertical motions of the Deep Draught Semi units (DDS)"
— Table D1: adding "DDS - Deep draught semi-submersible unit".

- **Section 2**

— B101: included examples specific to Deep Draught Semi (DDS) units for Structural categorization
— E: "Guidance to Minimum Requirements": updated Figures 1 to 4 to include examples specific to Deep Draught Semi units (added Figure 5).

- **Section 3**

— C100: "Hydrostatic Pressure":

a) 101: changed to be specific to Spars
b) 102: added requirements specific to DDS units
c) 103: added ballasting sequence to include DDS units.

— D300: "Hydrodynamic loads":

a) 306: added "Air gap is measured to the bottom of deck structure".

- **Section 4**

— B103: regarding "Eigen modes" has been deleted
— C: "Load Effect Analysis in the Non Operational Phases":

a) C102: added "Relevant model testing should be considered for novel installation procedures".
b) C103: added "Stability check and ballast capacity design shall include assessment of relevant load conditions during transport and installation".
c) moved C400 in previous edition of document to C500 and changed to be specific to Spar installation sequence.

- **Section 5**

— B: "Hull"

a) B102: added typical DDS connection and guidance for DDS referencing OS-C103.
b) B204: changed text to be specific for Spars.
c) B205: added "For DDS units, the finite element analysis shall cover all critical transient phases during installation".

— E: "Weld Connections" in previous edition of document moved to Section 9.

- **Section 6**

a) B104: included DDS specific connections.
b) B107: added "For mooring fairlead/riser porch analysis, the effect of disturbed wave field due to the presence of columns etc. should also be taken into account".
c) B110: changed Table B1 to be in line with API requirements.

CHANGES

- **Section 7**

— G: “Unintended Flooding”:

a) added G105: “The structure should be designed to withstand one compartment flooding under reduced environment (e.g. 10-yr. return probability)”.

— added H: “Riser Damage”
— I: “Abnormal Wave and Wind Events”: included tensioner system.

- **Section 9:**

a) A102: moved text from Section 5 in previous edition of document to Section 9
b) A201: included DDS specific connections
c) A202: added “Special connections, for example, grouted connections shall be fully qualified. The process as presented in DNV-RP-A203 Qualification of New Technology can be used”.

- **Section 12:**

— “Dynamic Riser Design and Global Performance”: added section.

CONTENTS

SECTION 1 INTRODUCTION

A. General

A 100 Introduction

101 This document provides requirements for the structural design of Deep Draught Floater (DDF) units, fabricated in steel, in accordance with the provisions of DNV-OS-C101 utilizing the LRFD design Method. For WSD methodology, reference is made to DNV-OS-C201.

102 A DDF platform is categorised as having a relatively large draught when compared to ship shaped, semi-submersible or TLP type units. This large draught is mainly introduced to obtain sufficiently high "Eigen period" in heave and reduced wave excitation in heave such that resonant responses in heave can be omitted or minimised.

103 A DDF can include a Spar, deep draught semi (DDS) or other deep draught floating units. Spar can consist of multi-vertical columns, single column with or without moonpool (e.g. classic, truss and cell spar). A DDS can consist of multi-vertical columns with ring pontoon with or without a heave damping structure.

104 The unit is usually kept in position by a passive mooring system. The mooring system may also be activated in case of horizontal movements above wells (drilling riser placed vertically above well), or other needed operational adjustments (e.g. reduction in VIM responses).

105 The deck or topside solution may be modular, or integrated type.

106 The standard has been written for general world-wide application. Governmental regulations may include requirements in excess of the provisions of this standard depending on size, type, location and intended service of the offshore unit/installation.

A 200 Objectives

The objectives of the standard are to:

— provide an internationally acceptable standard for structural design of DDF's
— serve as a contractual reference document for suppliers, yards and owners
— serve as guidance for designers, suppliers, owners and regulators
— specify procedures and requirements for units and installations subject to DNV verification and classification services.

A 300 Scope and application

301 The DDF unit may be applied for drilling, production, export and storage.

302 A DDF unit may be designed to function in different modes, typically operational (inclusive horizontal movement above wells) and survival. Limiting design criteria when going from one mode of operation to another shall be established.

303 The DDF unit should also be designed for transit relocation, if relevant.

304 For novel designs, or unproven applications of designs where limited, or no direct experience exists, relevant analyses and model testing shall be performed which clearly demonstrate that an acceptable level of safety can be obtained, i.e. safety level is not inferior to that obtained when applying this standard to traditional designs.

305 Requirements concerning mooring are given in DNV-OS-E301 and riser systems are given in DNV-OS-F201.

306 Requirements related to floating stability are given in DNV-OS-C301.

A 400 Classification

401 For use of this standard as technical basis for offshore classification as well as descriptions of principles, procedures and applicable class notations related to classification services see, DNV Offshore Service Specification given in Table B1.

402 Documentation for classification shall be in accordance with the NPS DocReq (i.e. DNV's Nauticus Production System for documentation requirements) and DNV-RP-A201.

B. Normative References

B 100 General

101 The standards given in Table B1 and Table B2 include provisions, which through reference in this text constitute provisions for this standard.

B 200 Offshore service specifications and rules

The offshore service specifications and rules given in Table B1 are referred to in this standard.

Table B1 DNV Offshore Service Specifications and rules

Reference	*Title*
DNV-OSS-101	Rules for Classification of Offshore Drilling and Support Units
DNV-OSS-102	Rules for Classification of Floating Production, Storage and Loading Units
DNV VMO (See Table D1)	Rules for Planning and Execution of Marine Operations

B 300 Offshore Standards

301 The offshore standards given in Table B2 are referred to in this standard.

Table B2 DNV Offshore Standards

Reference	*Title*
DNV-OS-A101	Safety Principles and Arrangement
DNV-OS-B101	Metallic Materials
DNV-OS-C101	Design of Offshore Steel Structures, General (LRFD method)
DNV-OS-C103	Structural Design of Column Stabilised Units (LRFD method)
DNV-OS-C301	Stability and Watertight Integrity
DNV-OS-C401	Fabrication and Testing of Offshore Structures
DNV-OS-E301	Position Mooring
DNV-OS-E401	Helicopter Decks
DNV-OS-F201	Dynamic Risers

C. Informative References

C 100 General

101 The documents listed in Table C1 include acceptable methods for fulfilling the requirements in the standard and may be used as a source of supplementary information.

Table C1 DNV Recommended Practices, Classification Notes and other references

Reference	*Title*
DNV-RP-C201	Buckling Strength of Plated Structures
DNV-RP-C202	Buckling Strength of Shells
DNV-RP-C203	Fatigue Strength Analysis of Offshore Steel Structures
DNV Classification Note 30.1	Buckling Strength Analysis of Bars an Frames, and Spherical Shells
DNV-RP-C205	Environmental Conditions and Environmental Loads
DNV Classification Note 30.6	Structural Reliability Analysis of Marine Structures
DNV-RP-F205	Global Performance Analysis of Deepwater Floating Structures
SNAME 5-5A	Site Specific Assessment of Mobile Jack-Up Units
API RP 2T	Planning, Designing and Constructing Tension Leg Platforms
API RP 2FPS	Recommended Practice for Planning, Designing and Constructing Floating Production Systems
API RP 2SK	Design and Analysis of Station keeping Systems for Floating Structures
API RP 2A	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design
API BUL 2TD	Guidelines for Tie-downs on Offshore Production Facilities for Hurricane Season
ISO 19904-1	Petroleum and natural gas industries – Floating Offshore Structures Part 1: Monohulls, Semi-submersibles and Spars
N-004	NORSOK - Design of Steel Structures

D. Definitions

D 100 Verbal forms

101 *Shall:* Indicates a mandatory requirement to be followed for fulfilment or compliance with the present standard. Deviations are not permitted unless formally and rigorously justified, and accepted by all relevant contracting parties.

102 *Should:* Indicates a recommendation that a certain course of action is preferred or particularly suitable. Alternative courses of action are allowable under the standard where agreed between contracting parties but shall be justified and documented.

103 *May:* Indicates a permission, or an option, which is permitted as part of conformance with the standard.

104 *Can:* Can-requirements are conditional and indicate a possibility to the user of the standard.

D 200 Terms

201 *Cell spar:* A classic spar with main column composed of several cylinders (cells).

202 *Classic spar:* A deep draft floater (DDF) with shell type cylindrical hull structure.

203 *Collision ring:* Inner bulkhead in the splash zone area with the purpose of providing a second barrier in case of damage or rupture to outer hull skin.

204 *Damping plates*: Horizontal decks or plates introduced in the truss area of e.g. a truss spar with the purpose of creating additional heave damping and increased added mass in heave.

205 *Dynamic up-ending:* A process where seawater is filled or flooded into the bottom section of a horizontally floating DDF/Spar hull and creating a trim condition and subsequent water filling of hull or moonpool and dynamic upending to bring the hull in vertical position.

206 *Hard tank area:* Usually upper part of the hull providing sufficient buoyancy for a DDF/Spar unit.

207 *Heave Damping Structure:* Structure to increase added mass in heave and reduce the vertical motions of the Deep Draught Semi units (DDS).

208 *Heave plates:* Horizontal stiffened plates in the truss area to increase added mass in heave and reduce the vertical motions of the spar.

209 *High frequency (HF) response:* Response at frequency higher than the wave frequency.

210 *Launching:* Similar to a traditional launching of a jacket. Applicable for a truss or classic spar.

211 *Low frequency (LF) responses:* Defined as DDF/Spar rigid body motions at, or near system "Eigen periods" which are normally well below the dominant wave frequency.

212 *Pre-upending:* The phase prior to dynamic upending.

213 *P-delta effect:* Global bending or shear effects in DDF/Spar units due to relatively high roll or pitch angles in harsh environment.

214 *Riser frame:* Framed steel structures installed at different vertical elevations along the hull or moonpool in order to separate the different risers.

215 *Roll, pitch, yaw:* Rotational modes around surge, sway and heave axes, respectively.

216 *Skirt area:* Stiffened single shell area below hard tank for a classic spar.

217 *Soft tank area:* Bottom section of a spar concept. Flooded during upending and used as storage of potential fixed ballast.

218 *Spar:* A deep draught floater consisting of a single column type structure which may be either classic, truss, or cell spar.

219 *Strake:* Usually helical triangular shaped section plated structures welded to outer hull with the purpose of reducing the VIM motion of DDF/Spar hull due to current (mainly).
Also the term *VIV suppression strake* is used sometimes.

220 *Surge, sway, heave:* Translatory displacements of DDF/Spar in horizontal planes (surge, sway) and vertical plane (heave).

221 *Truss spar:* Spar with a truss structure below the hard tank and above the soft tank areas.

222 *Vortex induced motions (VIM)):* The rigid body global motion of the DDF/Spar due to vortex shedding.

223 *Vortex induced vibrations (VIV)):* The in-line and transverse (cross) oscillation of slender structures like risers, umbilicals, mooring lines, or other tubular structure in a current, induced by the periodic shedding of vortices.

224 *Wave frequency (WF) response:* DDF/Spar linear rigid body motions at the dominating wave periods.

D 300 Abbreviations

301 The abbreviations given in Table D1 are used in this standard.

Table D1 Abbreviations

Abbreviation	*In full*
ALS	Accidental Limit States
DDF	Deep Draught Floater
DDS	Deep Draught Semi-submersible unit
DFF	Design Fatigue Factors
DNV	Det Norske Veritas
FLS	Fatigue Limit States
GOM	Gulf of Mexico
HF	High Frequency
OS	Offshore Standard
OSS	Offshore Service Specification
LF	Low Frequency
LRFD	Load and Resistance Factor Design
NDT	Non-Destructive Testing
QTF	Quadratic Transfer Function
RAO	Response Amplitude Operator
ROV	Remote Operated Vehicle
RP	Recommended Practice
SCR	Steel Catenary Riser
TTR	Top Tensioned Risers
ULS	Ultimate Limit States
VIM	Vortex Induced Motions
VIV	Vortex Induced Vibrations
VMO	Veritas Marine Operations Rules
WF	Wave Frequency
WSD	Working Stress Design

D 400 Symbols

401 The following Latin symbols are used:

x_D load effect
D number of years
$F_X(x)$ long-term peak distribution
H_s significant wave height
N_D total number of load effect maxima during D years
T_p wave period

402 The following Greek symbols are used:

$\gamma_{f,D}$ load factor for deformation loads
$\gamma_{f,E}$ load factor for environmental loads
$\gamma_{f,G,Q}$ load factor for permanent and functional loads
γ_m material factor

E. Non-Operational Phases

E 100 General

101 In general the unit shall be designed to resist relevant loads associated with conditions that may occur during all phases of the life-cycle of the unit. Such phases may include:

— fabrication
— load-out and sea fastening
— sea transportation (wet or dry)
— assembly of hull main sections including lifting
— installation (dynamic upending, launching, deck mating, jacking)

— relocation (drilling mode, new site)
— de-commissioning.

102 Structural design covering marine operations and construction sequences shall be undertaken in accordance with DNV-OS-C101 for LRFD method or DNV-OS-C201 for WSD method.

103 Marine operations may be undertaken in accordance with the requirements stated in “Rules for Planning and Execution of Marine Operations” (VMO).

104 All marine operations shall, as far as practicable, be based upon well proven principles, techniques, systems and equipment and shall be undertaken by qualified, competent personnel possessing relevant experience.

105 Structural responses resulting from one temporary phase condition (e.g. construction or assembly, or transportation) that may influence design criteria in another phase shall be clearly documented and considered in all relevant design workings.

E 200 Fabrication

201 The planning of fabrication sequences and the methods of fabrication shall be performed. Loads occurring in fabrication phases shall be assessed and, when necessary, the structure and the structural support arrangement shall be evaluated for structural adequacy.

202 Major lifting operations shall be evaluated to ensure that deformations are within acceptable levels, and that relevant strength criteria are satisfied.

203 Fabrication residual; stresses due to welding and fitting must be within acceptable tolerance (see DNV-OS-C401) or otherwise accounted for in design analysis.

E 300 Mating

301 All relevant load effects incurred during mating operations shall be considered in the design process. Particular attention should be given to hydrostatic loads imposed during mating sequences.

E 400 Sea transportation

401 A detailed transportation assessment shall be undertaken which includes determination of the limiting environmental criteria, evaluation of intact and damage stability characteristics, motion response of the global system and the resulting, induced load effects. The occurrence of slamming loads on the structure and the effects of fatigue during transport phases shall be evaluated when relevant. Wind induced vortex shedding should be evaluated for truss and deck tubular members.

Guidance note:

Guidance on sea transportation is available in the DNV VMO rules.

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

402 Satisfactory compartmentation and stability during all floating operations shall be ensured.

403 All aspects of the transportation, including planning and procedures, preparations, sea-fastenings and marine operations should comply with the requirements of the warranty authority.

E 500 Installation

501 Installation procedures of foundations (e.g. piles, suction anchor or gravity based structures) shall consider relevant static and dynamic loads, including consideration of the maximum environmental conditions expected for the operations.

502 For novel installation activities, relevant model testing should be considered.

503 The loads induced by the marine spread mooring involved in the operations, and the forces exerted on the structures utilised in positioning the unit, such as fairleads and pad-eyes, shall be considered for local strength checks.

Guidance note:

Guidance on offshore installation is available in the DNV VMO rules.

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

E 600 Decommissioning

601 Abandonment of the unit shall be planned for in the design stage.

SECTION 2 STRUCTURAL CATEGORISATION, SELECTION OF MATERIAL AND EXTENT OF INSPECTION

A. Introduction

A 100 General

101 Selection of materials and inspection principles shall be based on a systematic categorisation of the structure according to the structural significance and the complexity of the joints or connections as given in DNV-OS-C101 Sec.4.

102 In addition to in-service operational phases, consideration shall be given to structural members and details utilised for temporary conditions, e.g. fabrication, lifting arrangements, towing and installation arrangements, etc.

103 The structural application categories are determined based on the structural significance, consequences of failure and the complexity of the joints. The structural application category set the selection of steel quality and the extent of inspection for the welds.

104 The steel grades selected for structural components are to be related to calculated stresses and requirements for toughness properties and are to be in compliance with the requirements given in the DNV-OS-B101.

105 Special consideration shall be given to ensure the appropriate inspection category for welds with high utilisation in fatigue if the coverage with standard local area allocation is insufficient.

106 Examples of typical structural categories applicable to DDF are stated in B. These examples provide minimum requirements and are not intended to restrict the designer in applying more stringent requirements should such requirements be desirable.

B. Structural Categorisation

B 100 General

101 Application categories for structural components are defined in DNV-OS-C101 Sec.4. Structural members of a DDF unit are grouped as follows: However if a special design warrants redefining the categories, the same shall be discussed and agreed.

Special category

a) Portions of deck plating, heavy flanges, and bulkheads within the structure which receive major concentrated loads.
b) External shell structure (plating and stiffeners) in way of highly stressed connections (higher than 85% of the allowable i.e. at 0.85 usage factor) to the deck structure.
c) Major intersections of bracing members.
d) External brackets, portions of bulkheads, and frames which are designed to receive concentrated loads at intersections of major structural members.
e) Highly stressed elements of anchor line fairleads, crane pedestals, flare boom, etc. and their supporting structure.

For Spars, these special structural categories include the hard tank to deck leg and to truss leg connections, the truss to soft tank connections, the heave plate to truss leg connections, truss tubular joints, the fairlead and chain jack foundations, and the riser frame to hard tank connections.

For DDS units, these special structural categories include “through” material used at connections of vertical columns, upper platform decks and upper or lower hulls which are designed to provide alignment and adequate load transfer, i.e. the pontoon to column connection, column to deck connection, any brace to column connections and connection of heave damping structure to main hull structure.

Primary category

a) Deck plating, heavy flanges, transverse frames, stringers, and bulkhead structure that do not receive major concentrated loads (not categorized as special).
b) Moonpool shell.
c) External shell structure of vertical columns, lower and upper hulls, and diagonal and horizontal braces.
d) Bulkheads, decks, stiffeners and girders that provide local reinforcement or continuity of structure in way of intersections, except areas where the structure is considered special application.

e) Main support structure of heavy substructures and equipment, e.g. anchor line fairleads, cranes, drill floor substructure, lifeboat platform, thruster well and helicopter deck.

For Spars, primary structures include hull shell, top spar deck and bottom deck structures, hull ring frames, longitudinal stringers and web frames, all radial bulkheads, truss chords and brace members, heave plate and soft tank structures.

For DDS units, the heave damping structure is considered primary structure.

Secondary category

a) Upper platform decks, or decks of upper hulls except areas where the structure is considered primary or special application.
b) Bulkheads, stiffeners, flats or decks and girders, diagonal and horizontal bracing, which are not considered as primary or special application.
c) Non-watertight bulkheads internal outfitting structure in general, and other non-load bearing components.
d) Deckhouses.

For Spars, secondary structures include; e.g., all internal hull flats, soft tank shell and internal bulkheads with no pressure differential, and hull and heave plate stiffeners and soft tank stiffeners.

C. Material Selection

C 100 General

101 Material specifications shall be established for all structural materials utilised in a DDF unit. Such materials shall be suitable for their intended purpose and have adequate properties in all relevant design conditions. Material selection shall be undertaken in accordance with the principles given in DNV-OS-C101.

102 When considering criteria appropriate to material grade selection, adequate consideration shall be given to all relevant phases in the life cycle of the unit. In this connection there may be conditions and criteria, other than those from the in-service, operational phase, that may govern the design requirements with respect to the selection of material. (Such criteria may, for example, be design temperature and/or stress levels during marine operations.)

103 In structural cross-joints essential for the overall structural integrity where high tensile stresses are acting normal to the plane of the plate, the plate material shall be tested to prove the ability to resist lamellar tearing (Z-quality).

104 Material designations are defined in DNV-OS-C101.

C 200 Design temperature

201 External structures above the inspection waterline are to be designed for service temperatures down to the lowest mean daily temperature for the area(s) where the unit is to operate.

202 External structures below the inspection waterline need normally not be designed for service temperatures lower than 0°C.

203 Internal structures are assumed to have the same service temperature as the adjacent external structure if not otherwise documented.

204 Internal structures in way of permanently heated rooms need normally not be designed for service temperatures lower than 0°C.

D. Inspection Categories

D 100 General

101 Welding, and the extent of non-destructive examination during fabrication, shall be in accordance with the requirements stipulated for the structural categorisation designation as defined in DNV-OS-C101 Sec.4.

102 Inspection categories determined in accordance with DNV-OS-C101 provide requirements for the minimum extent of required inspection. When considering the economic consequence that repair during in-service operation may entail, for example, in way of complex connections with limited or difficult access, it may be considered prudent engineering practice to require more demanding requirements for inspection than the required minimum.

103 When determining the extent of inspection and the locations of required NDT, in additional to evaluating design parameters (for example fatigue utilisation), consideration should be given to relevant fabrication parameters including:

— location of block (section) joints

— manual versus automatic welding
— start and stop of weld etc.

E. Guidance to Minimum Requirements

E 100 General

101 Figures 1, 2, 3, 4 and 5 illustrates minimum requirements for selection of the structural category for one example of structural configurations of a DDF unit. The indicated structural categorisation should be regarded as guidance of how to apply the recommendations in DNV-OS-C101.

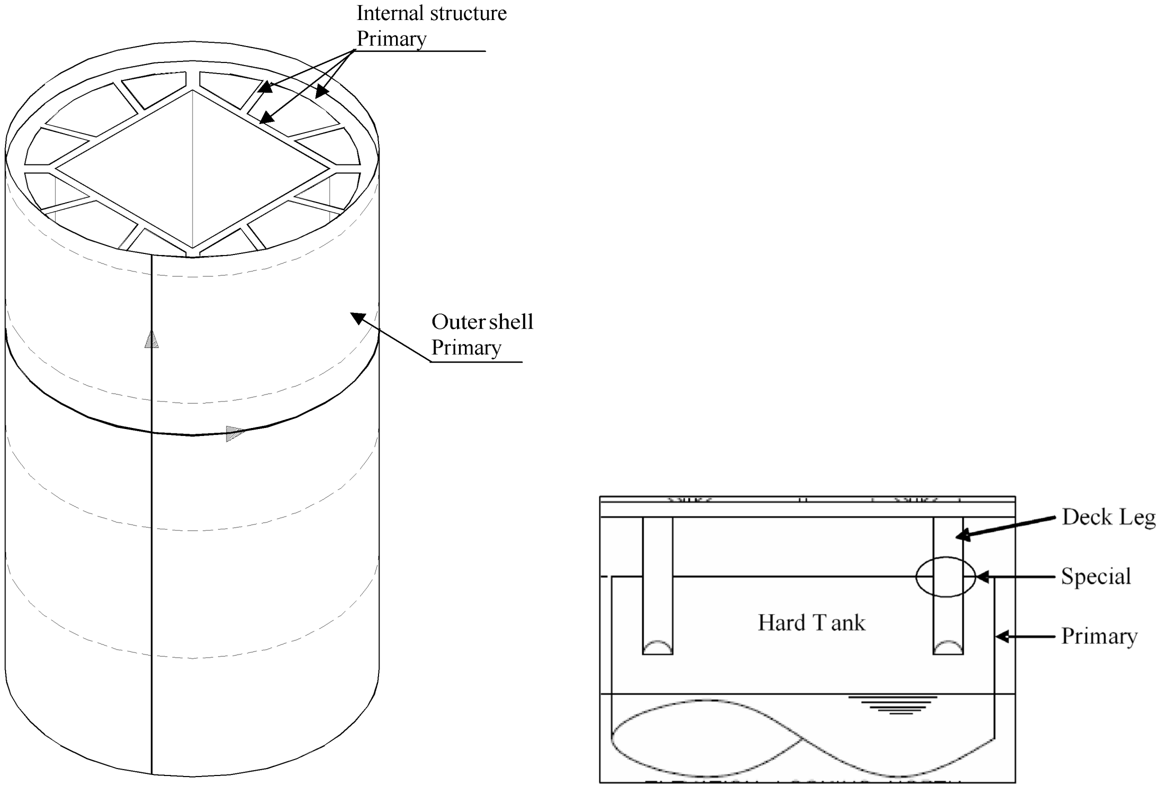

Figure 1
Example of structural categorisation (Special and Primary Steel) in the hard tank area of a typical Spar

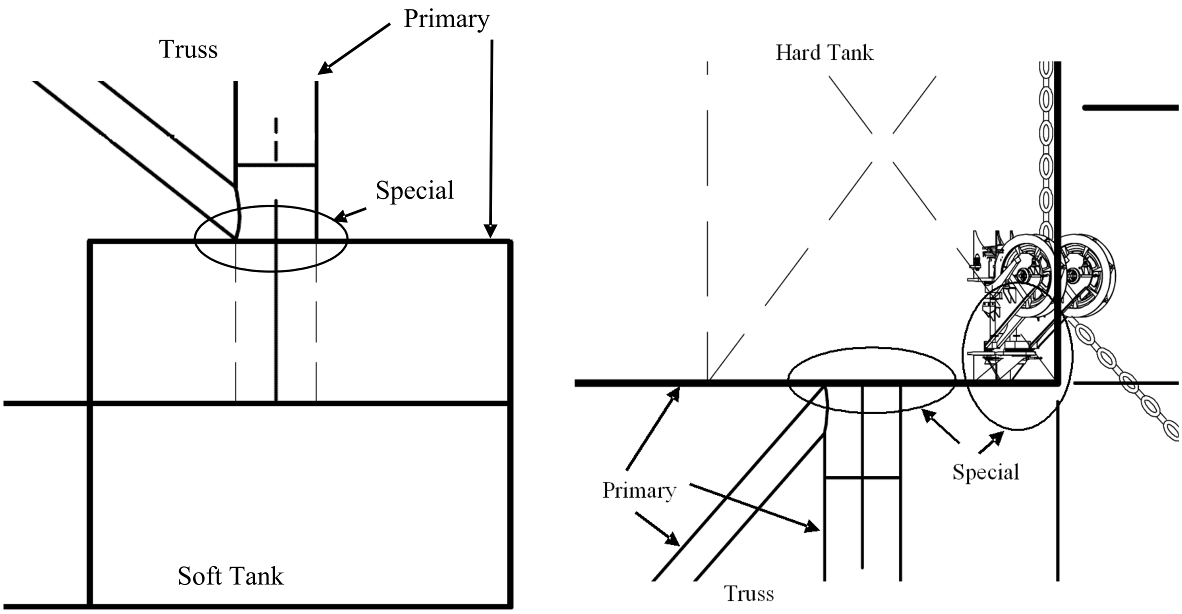

Figure 2
Example of structural categorisation (Special and Primary Steel) in the soft tank/hard tank and Truss interface of a typical Spar

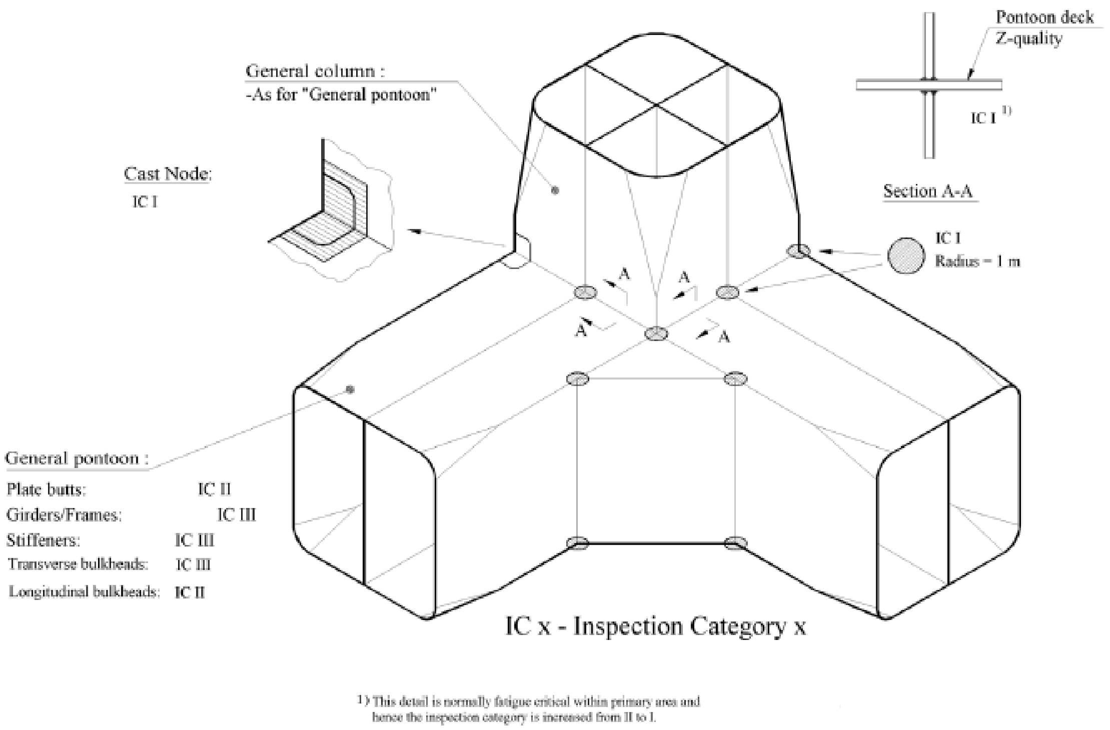

Figure 3
Example of structural categorisation of a column and pontoon connection of a typical Deep Draught Semi

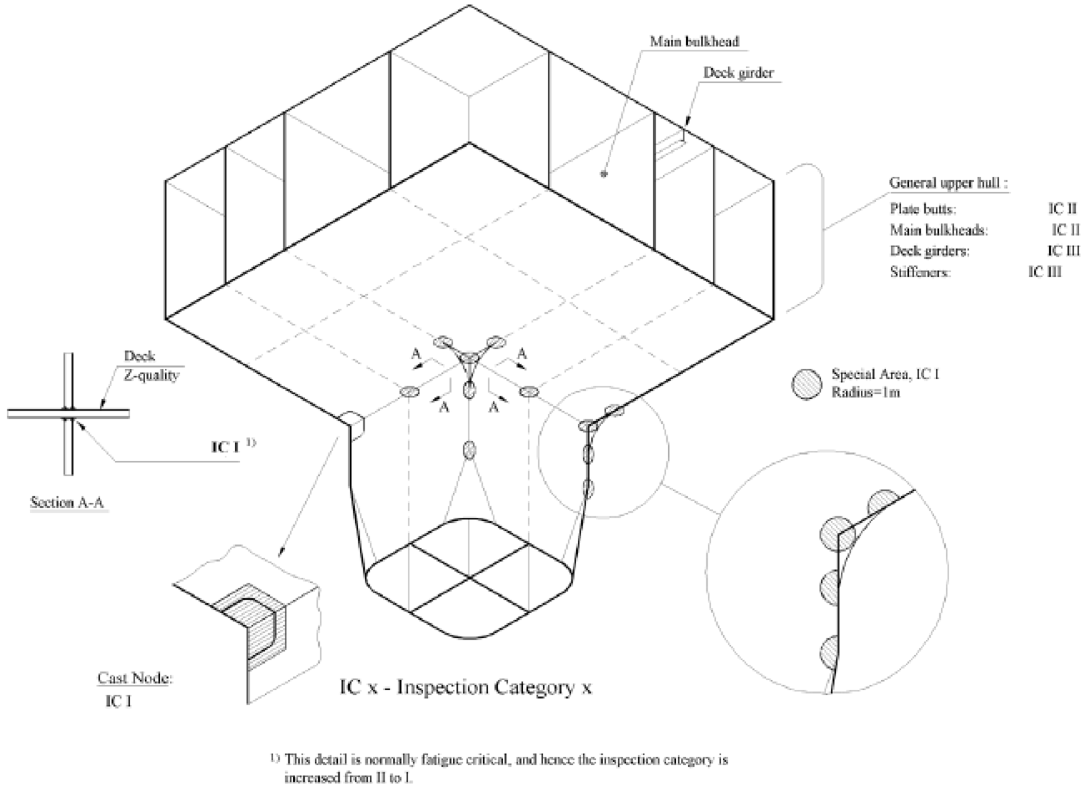

Figure 4
Example of structural categorisation of deck and column connection of a typical Deep Draught Semi

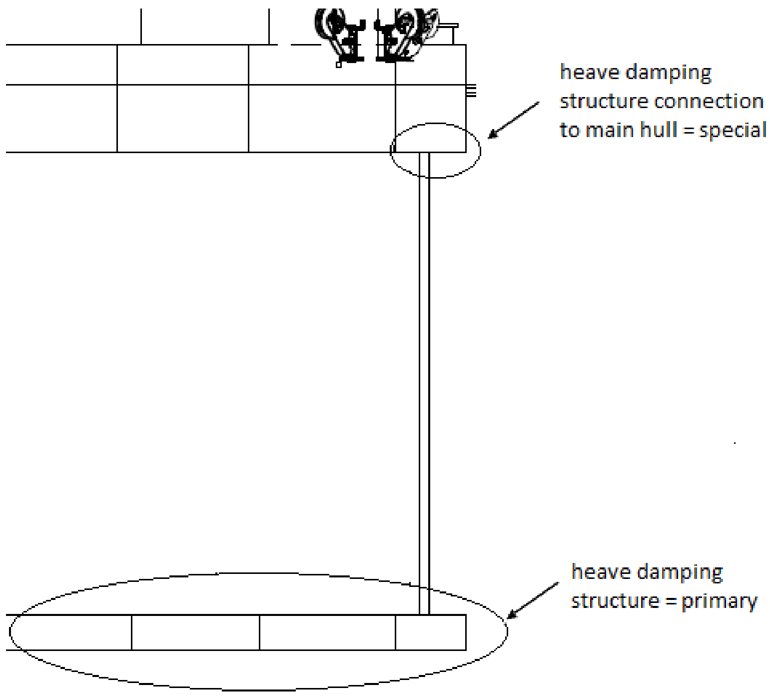

Figure 5
Example of structural categorisation of heave damping structure of a typical DDF

SECTION 3
DESIGN LOADS

A. General

A 100 Objective

101 The objective of this section is to provide additional load provisions to DDF units not covered within DNV-OS-C101.

A 200 Application

201 Load descriptions are intended to cover operational as well as non-operational phases for the three limit states (ULS, FLS and ALS).

B. Permanent Loads

B 100 Permanent ballast

101 The type and use of permanent ballast (e.g. within soft tank of DDF units) for stability reasons must be carefully evaluated with respect to long term effects related to corrosion, wash out etc.

C. Variable Functional Loads

C 100 Hydrostatic pressures

101 *For Spars*, all relevant combinations of tank filling in the hard tank for the installation and operational phases shall be taken into account in design.

102 *For Deep Draught Semis*, all relevant combinations of tank filling in the columns, pontoons and/or heave damping structure in the installation and operational phases shall be taken into account in design.

103 Hydrostatic or hydrodynamic differential pressures acting on the hull or buoyancy tanks during launch and upending sequences, mating, ballasting sequences, whichever is relevant, shall be analysed or determined and taken into account in design of the hull.

C 200 Differential pressures

201 All relevant combinations of differential pressures due to filling of ballast tanks, produced fluids, compressed air etc. shall be taken into account in design.

D. Environmental Loads

D 100 Environmental conditions

101 If sufficient environmental data is available, environmental joint probability models may be developed and applied in the design of DDF units. This is especially important in regions with e.g. high loop current and frequently occurring hurricanes.

102 In geographical areas with hurricane activity, special considerations have to be made with respect to the selection of relevant sea states to be applied in design of the unit. (E.g. new Meteocean criteria (API BUL.INT 2/- MET) with updated GOM criteria published in May 2007).

103 Due to the geometry (deep draught and large volume) of DDF units the current loading may be of high importance for design of mooring or riser systems in relation to vortex induced vibrations (VIV) for e.g. hull and risers. Hence attention must be given to the description of magnitude and direction of current with depth.

D 200 Determination of characteristic loads

201 Calculation of characteristic hydrodynamic loads may be carried out according to DNV-RP-C205.

202 Hydrodynamic model tests should be carried out to:

— confirm that no important hydrodynamic features have been overlooked (for new type of units, environmental conditions, adjacent structures, Mathieu instability etc.)
— support theoretical calculations when available analytical methods are susceptible to large uncertainties (e.g. in evaluating the need for VIM suppression strakes, on DDF hull)
— verify theoretical methods or models on a general basis.

203 Wind tunnel tests should be performed when:

— wind loads are significant for overall stability, motions or structural response
— there is a danger of dynamic instability.

204 Models applied in model tests shall be sufficient (reasonable scale and controllable scaling effects) to represent the actual unit. The test set-up and registration system shall provide a sound basis for reliable and repeatable interpretations.

205 A correlation report (tests and calculations) shall be prepared for validation purposes (design documentation).

D 300 Hydrodynamic loads

301 Resonant excitation (e.g. internal moonpool resonance, sloshing and roll/pitch resonance) shall be carefully evaluated. Wave on deck via moonpool has to be considered for DDF concepts with relatively short distances between moonpool and the outer wave active zone.

302 If hydrodynamic analyses of a DDF are performed with the moonpool 'sealed' at the keel level it must be validated that the results are equivalent to 'open' DDF hydrodynamic analyses. Special focus should be placed on the heave motion prediction (important for riser system) by using consistent added mass, total damping and excitation forces such that the Eigen period and response in heave can be determined correctly.

303 In case of a DDF with damping and added mass heave plates and where it is possible that resonant, or near resonant heave motion may occur, the theoretical predictions should be validated against model test results.

304 If VIM suppression devices (e.g. spiral strakes) are attached to the hull, the increased loads (drag, inertia) must be taken into account. This applies to the operational as well as non-operational phases.

305 Air gap and green water (Wave-on-Deck) are to be considered. (See DNV-OS-C101 or DNV-OS-C201).

306 Air gap is measured to the bottom of the deck structure.

307 Simulation of loads and responses on risers in the moonpool area shall be carried out according to a recognised code.

Guidance note:
DNV-OS-F201 may be applied for this purpose.

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D 400 Combination of environmental loads

401 In areas with high current (e.g. loop current, or high subsurface current) special attention must be given to the joint occurrence of wind, waves and current. Joint probability models (loads and load effects) are recommended.

402 If more accurate data are not available, the combination of environmental loads may be taken according to DNV-OS-C101 Sec.3.

SECTION 4
LOAD EFFECTS

A. General

A 100 Objective

101 The objective of this section is to provide additional load effect provisions to DDF units not covered within DNV-OS-C101.

A 200 Application

201 Load effect descriptions are intended to cover operational as well as non-operational phases for the three limit states (ULS, FLS and ALS).

B. Load Effect Analysis in the Operational Phase

B 100 General

101 Global dynamic motion response analysis taking into account loads from wind (static and gust), waves (wave frequency and low frequency) and current shall be performed. Time domain analysis is the preferred option as opposed to frequency domain type analysis. However, frequency domain analysis may be acceptable if proper justification is demonstrated. Reference is made to DNV-RP-F205 for detailed description of global performance analysis procedures.

102 Coupled analyses may be performed for DDF units in order to determine the coupling effects due to the presence of mooring and risers. These coupled analyses mainly provide viscous damping estimates for slowly varying motions (all six degrees of freedom). When utilising viscous damping estimates from coupled analyses the actual riser installation program must be taken into consideration.

103 The simulation length for determination of the different load effects must be sufficient such that reliable extreme response statistics can be obtained.

Guidance note:

Combined loading.

Common practice to determine extreme responses has been to expose the dynamic system to multiple stationary design environmental conditions. Each design condition is then described in terms of a limited number of environmental parameters (e.g. H_s, T_p) and a given seastate duration (3 to 6 hours). Different combinations of wind, wave and current with nearly the same return period for the combined environmental condition are typically applied.

The main problem related to design criteria based on environmental statistics is that the return period for the characteristic load effect is unknown for non-linear dynamic systems. This will in general lead to an inconsistent safety level for different design concepts and failure modes.

A more consistent approach is to apply design based on response statistics. Consistent assessment of the D-year load effect will require a probabilistic response description due to the long-term environmental loads on the system. The load effect with a return period of D-year, denoted x_D, can formally be found from the long-term load effect distribution as:

$F_X(x_D)$ = 1 - 1/N_D
N_D = total number of load effect maxima during *D* years
$F_X(x)$ = long-term peak distribution of the (generalised) load effect

The main challenge related to this approach is to establish the long-term load effect distribution due to the non-linear behaviour. Design based on response statistics is in general the recommended procedure and should be considered whenever practicable for consistent assessment of characteristic load effects. Further details may be found in Appendices to DNV-OS-F201.

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B 200 Global bending effects

201 Global bending and shear forces along the length of the structure due to environmental load effects shall be determined. This applies to first order wave effects, as well as P-delta effects due to platform heel or tilt.

202 Global bending and shear forces in the hull will be influenced by the non-linear restoring effect from the mooring system. This additional load effect shall be analysed and taken into account in design of the hull structure.

C. Load Effect Analysis in the Non Operational Phases

C 100 General

101 All temporary phases shall be carefully evaluated and sufficient level and amount of analyses shall be performed according to this standard. Further details regarding non-operational conditions may be found in DNV "Rules for Planning and Execution of Marine Operations".

102 Relevant model testing should be considered for novel installation procedures.

103 Stability check and ballast capacity design shall include assessment of relevant load conditions during transport and installation.

C 200 Load-out and Transportation

201 Hull/deck stresses during load-out are to be evaluated and accounted for in the design. Possible skid beam foundation settlement should be minimized or avoided. Local sea fastening stresses are to be kept within acceptable design limits.

202 In case of wet tow in harsh environment (e.g. overseas), model tests shall be performed as a supplement to motion response analyses. Non-linear effects (e.g. slamming, global bending or shear, green seas) shall be taken into account.

203 Motion response analyses shall be performed for dry transports on e.g. heavy lift vessel, or barge. Special attention shall be made to:

— roll motions (roll angles, accelerations, viscous roll damping)
— slamming pressures and areas and structural responses due to slamming
— global strength (vessel, DDF/Spar unit)
— strength of sea-fastening
— wind VIV of slender truss members.
— stability, overhang.

C 300 Launching

301 Launching may be an alternative way of installation or upending a Spar (e.g. truss spar). Model testing of the launch process may be required if there is limited or no experience with such operations for similar concepts.

C 400 Deck mating

401 Offshore installation of deck structure and modules will require refined analyses in order to determine the governing responses. This applies to lifting operations as well as float-over operations with barge. Important factors are limiting environmental criteria, impact responses and floating stability requirements.

402 Floating concepts ("jack-up") utilising jacking of legs to desired draught and subsequent deballasting to obtain sufficient air-gap, shall be carefully evaluated or analysed with respect to limiting environmental criteria.

C 500 Upending

501 Pre-upending phases shall be analysed with respect to global bending moments and shear forces in the hull. In case that wave load effects in this pre-upending phase may be relevant, this shall be analysed and taken into account.

502 In case of dynamic upending, analyses shall be performed in order to determine global and local load effects in the DDF/Spar unit and its appurtenances.

503 Hydrostatic or hydrodynamic differential (outside/inside) pressures during dynamic upending shall be determined and further used in design of the hull structure.

504 Model testing of the dynamic upending may be avoided if the applied simulation software has been validated against similar or relevant operations demonstrating good correlation.

505 In case of lift assisted upending offshore, the limiting environmental criteria must be carefully selected. Dynamic analyses of the system (i.e. lift vessel, lifting gear, Spar unit) will be required in order to determine responses in lifting gear and DDF/Spar unit.

SECTION 5
ULTIMATE LIMIT STATES (ULS)

A. General

A 100 Objective

101 General considerations in respect to methods of analysis and capacity checks of structural elements are given in DNV-OS-C101 for LRFD and DNV-OS-C201 for WSD.

102 This section applies for the hull and deck or modules and operational as well as non-operational phases.

103 The LRFD format shall be used when the ULS capacity of the structure is checked. Two combinations shall be checked, a) and b). The load factors are defined in DNV-OS-C101 Sec.2 D400 and values are given in Table A1.

Table A1 Load factors – ULS

Combination of design loads	*Load categories*		
	Permanent and variable functional loads, $\gamma_{f,G,Q}$	*Environmental loads,* $\gamma_{f,E}$	*Deformation loads,* $\gamma_{f,D}$
a)	1.3 [1)]	0.7	1.0
b)	1.0	1.3	1.0

1) If the load is well defined e.g. masses or functional loads with great confidence, no possible overfilling of tanks etc. the coefficient may be reduced to 1.2.

104 The loads shall be combined in the most unfavourable way, provided that the combination is physically feasible and permitted according to the load specifications. For permanent loads, a load factor of 1.0 in load combination a) shall be used where this gives the most unfavourable response. Other considerations for the partial coefficients and design loads are given in DNV-OS-C101 Sections 2 and 3, respectively.

105 The material factor γ_m for ULS yield check should be 1.15 for steel. The material factor γ_m for ULS buckling check is given in DNV-OS-C101 Sec.5.

A 200 Methodology and Acceptance Criteria

201 **The LRFD methodo**logy and the acceptance criteria for the ULS check are given in DNV-OS-C101.

B. Hull

B 100 Operational phase

101 For global structural analysis, a complete three-dimensional structural model of the unit is required. This may be a complete shell type model, or a combined shell or space-frame model.

102 Additional detailed finite element analyses may be required for complex joints and other complicated structural parts especially at interfaces and connections to determine the local stress distribution more accurately. Typical examples being: hull interface with mooring system, hard tank area, column and brace connections, strake terminations or interactions, deck and hull connections, hull interface with riser system, pontoon to column connection, brace to column connection, column to deck connection.

Guidance note:

For Spars, in order to be able to assess the effect of all possible tank filling configurations, a local finite element model covering the hard tank area may be utilised. Only those tanks used in the normal operation of the platform shall as a minimum be modelled. The stresses from a local finite element model should be superimposed to global stresses.

For DDS units, reference is made to DNV-OS-C103.

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103 The additional global bending and shear due to P-delta and mooring restoring effects are to be combined with first order wave effects in a consistent way.

104 The same applies to combining the loads from the risers on riser frames in the moonpool and transfer into the hull structure. Horizontal forces as well as vertical (friction from riser system) shall be taken into account.

105 If VIV suppression devices (e.g. strakes) are installed, both local (direct wave or current loads) and global bending effects should be considered in design of the suppression devices.

B 200 Non-operational phases

201 Finite element analyses are to be performed for long international water wet tow and dry tow in harsh environment.

202 For dry tow this implies that the complete structural system (hull sections, sea-fastening, transport vessel) shall be modelled such that reliable stress-distributions can be obtained.

203 For wet tow in harsh environment special emphasis must be put on the simulation or modelling of the hydrodynamic wave pressures or accelerations acting on the wet hull structure. Further, the non-linear hogging and sagging bending or shear effects due to the shape of the hull should be properly simulated or accounted for in the design.

204 *For Spars*, the level or amount of finite element analyses for the upending process needs to be evaluated. As a minimum, the following considerations shall be made:

a) Operational Global bending moments and shear forces are to be compared (location and level) with those for pre-upending and dynamic upending.
b) Possibilities for local and global buckling (e.g. skirt area for a classic spar) due to global load effects and lateral differential pressures needs to be assessed/analysed.

205 *For DDS units*, the finite element analysis shall cover all critical transient phases during installation.

C. Deck or Topside

C 100 Operation phase

101 Structural analysis of deck structure shall, in general, follow the same principles as outlined for the hull.

102 Horizontal accelerations at deck level due to wave loading will be high for some DDF units in harsh environment. Detailed finite element analyses of the deck and hull connections shall be performed in such instances.

C 200 Non-operational phases

201 Typical non-operational phases as fabrication, transportation and installation of deck and topside modules shall be assessed and analysed to a sufficient level such that the actual stress level can be determined and used in the design checks.

D. Minimum Scantlings

D 100 General

101 Minimum scantlings for plate, stiffeners and girders are given in DNV-OS-C101 Sec.5.

SECTION 6
FATIGUE LIMIT STATES (FLS)

A. General

A 100 General

101 The objective of this section is to provide supplemental guidance related to FLS design as outlined in DNV-OS-C101 Sec.6.

102 This section applies for the hull and deck or modules and major structural interfaces for operational as well as non-operational phases.

103 In general, all significant stress fluctuations (operational and temporary phases) which contribute to fatigue damage in parts of the unit shall be taken into account for the FLS condition.

104 Criteria related to DFF's are given in DNV-OS-C101 Sec.6.

105 DNV-RP-C203 presents recommendations in relation to fatigue analyses based on fatigue tests and fracture mechanics.

B. Hull

B 100 Operation phase

101 First order wave loads will usually be the dominating fatigue component for the hull. The long term distribution of wave induced stress fluctuations need to be determined with basis in the same type of load effect and finite element analyses as for ULS.

Guidance note:

Early phase evaluation or analysis of fatigue may incorporate modelling the hull as a beam with associated mass distribution and simulation of wave loads according to Morison formulation, or preferably, performing a radiation or diffraction analysis.

Final documentation related to first order wave induced fatigue damage should incorporate a stochastic approach. This implies establishing stress transfer functions, which are combined with relevant wave spectra (scatter diagram) in order to obtain long-term distribution of stresses. The stress transfer functions should be obtained from finite element analyses with appropriate simulation of wave loads (radiation/diffraction analysis). The P-delta effect due to platform roll and pitch shall be taken into account.

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102 As for ULS, the P-delta effect due to platform roll or pitch shall be taken into account. This implies that both first order and second order, slowly varying roll or pitch motions need to be considered and taken into account if contributing to fatigue damage in the hull.

103 For special fatigue sensitive areas, local stress concentrations shall be determined by detailed finite element analyses.

104 Typical fatigue sensitive areas for DDF units include:

— hull and deck connections
— collision ring area
— hull and deck and stiffener connections at location of peak wave induced global bending moments
— hull and mooring system interface
— hard tank area
— column and brace connections
— strake and hull connections and strake terminations
— riser frame/support and hull connections
— openings in main hull
— flare tower
— mooring and export/import SCR connections
— hard tank and truss connections
— tubular joints
— column to deck connections
— column to pontoon connections
— tensioner support structure.

105 Fatigue analyses shall be performed to check that the hull strakes have sufficient fatigue lives. Relative motions between the hull and disturbed wave kinematics around strakes must be properly taken into account. Hydrodynamic pressures from a radiation/diffraction analysis in combination with a Morison formulation (inertia and drag) will be sufficient to describe the environmental loads on the strakes.

106 VIM load effects from mooring system (global hull in-line and cross-flow motions) into the fairlead or hull areas shall be outlined and taken into account if significant. The same applies to VIV load effects from riser system into the riser frame or hull areas.

107 For mooring fairlead/riser porch analysis, the effect of disturbed wave field due to the presence of columns, etc. should also be taken into account.

108 Allowance for wear and tear shall be taken into account in areas exposed to for example friction and abrasion. For a DDF unit this will typically be interfaces between hull and risers (keel level, intermediate riser-frames, deck level). These relative motions are caused by movements of the unit and risers and subsequent pullout and push-up of the risers in the moonpool.

109 The fatigue analysis of riser / keel guide frames shall account for the interaction between risers and guide frames where relevant.

110 The design fatigue factors or fatigue life safety factors depend on the consequence of failure and the accessibility for inspection as given in Table B1.

Table B1 Design Fatigue Factors for Hull and Topside (DFF's) – FLS

Consequence of failure	*Accessibility for inspection*		
	In-accessible	*Underwater access*	*Accessible*
Unacceptable[1)]	10	3	2
Acceptable	3	2	1

1) The acceptability of the consequence of failure involves the owner, the flag state authorities, as well as DNV. Refer to DNV-OS-C101 Sec.6 for further guidance.

B 200 Non-operational phases

201 Wet, overseas transports in harsh environment will require quite detailed analyses to determine the fatigue damage during this temporary phase. Both global and local wave load effects shall be taken into account. Some level of monitoring of weather and load effects during towage will be required such that it is possible to recalculate the actual fatigue contribution during wet tow.

202 Dry, overseas transports will usually be less exposed to fatigue damages. It however, requires almost the same level of finite element analyses as for wet tow in order to determine the stress fluctuations in hull, sea-fastenings and transport vessel.

B 300 Splash zone

301 The definition of 'splash zone' as given DNV-OS-C101 Sec.10 B200, relates to a highest and lowest tidal reference. For DDF units, for the evaluation of the fatigue limit state, reference to the tidal datum should be substituted by reference to the draught that is intended to be utilised when condition monitoring is to be undertaken. The requirement that the extent of the splash zone is to extend 5 m above and 4 m below this draught may then be applied. The splash zone is to be considered in-accessible with respect to the required DFF (Table B1).

Guidance note:

If significant adjustment in draught is possible in order to provide for satisfactory accessibility in respect to inspection, maintenance and repair, a sufficient margin in respect to the minimum inspection draught should be considered when deciding upon the appropriate DFF's. As a minimum this margin is to be at least 1 m, however it is recommended that a larger value is considered especially in the early design stages where sufficient reserve should be allowed for to account for design changes (mass and centre of mass of the unit). Consideration should further be given to operational requirements that may limit the possibility for ballasting and deballasting operations.

When considering utilisation of remotely operated vehicle (ROV) inspection, consideration should be given to the limitations imposed on such inspection by the action of water particle motion (e.g. waves). The practicality of such a consideration may be that effective underwater inspection by ROV, in normal sea conditions, may not be achievable unless the inspection depth is at least 10 m below the sea surface.

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C. Deck or Topside

C 100 Operation phase

101 Wave induced horizontal accelerations and P-delta effects will usually be governing for FLS design of deck structure and topside modules and shall be duly taken into account.

102 A stochastic approach is the preferred option for determination of final fatigue damage for the deck or topside. See Guidance note to B101 for the hull. For Design Fatigue Factor (DFF) refer to Table B 1 in Section 6.

103 Deck and hull connections, joints in deck structure, module supports etc. will typically be fatigue sensitive areas. The amount or level of detailed finite element analyses for these joints needs to be considered. For the deck and hull connection some level or amount of detailed finite element analyses shall be performed, at least for units located in harsh environment.

C 200 Non-operational phases

201 Fatigue damage of deck structure and topside modules shall be documented if the stress fluctuations in the different phases are significant.

SECTION 7
ACCIDENTAL LIMIT STATES (ALS)

A. General

A 100 Objective

101 The objective of this section is to provide supplemental guidance related to ALS design as outlined in DNV-OS-A101 and in DNV-OS-C101 Sec.7.

102 This section applies for the hull and deck or modules and operational as well as non-operational phases.

103 General requirements concerning accidental events are given in DNV-OS-C101.

B. General Requirements

B 100 General

101 Units shall be designed to be damage tolerant, i.e. credible accidental damages, or events, should not cause loss of global structural integrity or stability. The capability of the structure to redistribute loads should be considered when designing the structure. Hull compartmentation should not allow loss of unit with one or more compartments flooded (see DNV-OS-A101).

C. Fire

C 100 General

101 Deck area will be limited for some DDF/Spar concepts. Potential fire scenarios shall therefore be carefully considered and taken into account in design and layout planning.

D. Explosion

D 100 General

101 As for fire, the limiting deck space and protected moon-pool area (potential gas or oil leakage) for some DDF units require that explosions are carefully considered in the design process.

102 In respect to design considering loads resulting from explosions, or a combination of the following main design philosophies are relevant:

- ensure that the probability of explosion is reduced to a level where it is not required to be considered as a relevant design load case
- ensure that hazardous areas are located in unconfined (open) locations and that sufficient shielding mechanisms (e.g. blast walls) are installed
- locate hazardous areas in partially confined locations and design utilising the resulting, relatively small overpressures
- locate hazardous areas in enclosed locations and install pressure relief mechanisms (e.g. blast panels) and design for the resulting overpressure.

103 As far as practicable, structural design accounting for large plate field rupture resulting from explosion loads should normally be avoided due to the uncertainties of the loads and the consequence of the rupture itself.

104 Structural support of blast walls, and the transmission of the blast load into main structural members shall be evaluated when relevant. Effectiveness of connections and the possible outcome from blast, such as flying debris, shall be considered.

E. Collision

E 100 General

101 Safety assessments will be the basis for determination of type and size of colliding vessel and impact speed.

102 Collision impact shall be considered for all elements of the unit, which may be impacted by supply vessel on sideways, bow or stern collision. The vertical extent of the collision zone shall be based on the depth and draught of attending vessels and the relative motion between the attending vessels and the unit.

103 Resistance to unit collisions may be accounted for by indirect means, such as, using redundant framing configurations, collision ring in splash zone and materials with sufficient toughness in affected areas.

104 Boat landings are to be designed to withstand probable impact loads depending on the design service vessels and the operational criteria. (see DNV-RP-C204).

F. Dropped Objects

F 100 General

101 Critical areas for dropped objects shall be determined on the basis of the actual movement of potential dropped objects (e.g. crane actions) relative to the structure of the unit itself. Where a dropped object is a relevant accidental event, the impact energy shall be established and the structural consequences of the impact assessed.

102 Generally, dropped object assessment will involve the following considerations:

a) Assessment of the risk and consequences of dropped objects impacting topside, wellhead, riser system in moon-pool and safety systems and equipment. The assessment shall identify the necessity of any local structural reinforcement or protections to such arrangements.

b) Assessments of the risk and consequences of dropped objects impacting externally on the hull structure (shell, or bracings) and hull attachments such as strakes, fairleads and pipes. The structural consequences are normally fully accounted for by the requirements for watertight compartmentation and damage stability and the requirement for structural redundancy of slender structural members.

G. Unintended Flooding

G 100 General

101 A procedure describing actions to be taken after relevant unintended flooding shall be prepared. Unintended filling of hard tanks, collision ring and bracings for a DDF will be the most relevant scenarios for the operation phase.

102 It must be ensured that counter-filling of tanks and righting up the unit can be performed safely and without delays.

103 Structural aspects related to the tilted condition and counter-flooding (if relevant) shall be investigated. This applies to the complete unit including risers and mooring system.

104 If the unit can not be brought back to the design draught and verticality by counter-ballasting and redistribution of ballast water, this must be taken into account in design of the unit.

105 The structure should be designed to withstand one compartment flooding under reduced environment (e.g. 10-yr return probability).

H. Riser Damage

H 100 General

101 Provisions for accidental limit state design of risers, in general, are provided in DNV-OS-F201. Special considerations for risers on DDF/Spar include, but are not limited to:

— The structural and global performance design should account for one tensioner cylinder out of service.
— Loss of buoyancy, e.g. air cans for spar units.
— Loss of station keeping, e.g. mooring line failure, or tendon failure.
— Clashing between risers and/or umbilicals, and interaction between risers and surrounding structures.

I. Abnormal Wave and Wind Events

I 100 General

101 Abnormal wave effects are partly related to air-gap and wave exposure of deck or topside structures as well as tensioner system. Consequences from such wave impacts shall be evaluated and taken into account in design of the relevant structural parts.

102 In hurricane environments the derrick tie down to the substructure and the top deck should be carefully designed. (see API Bulletin 2TD). The use of LRFD method for the design against uplift loads at the clamped footing connections is recommended.

103 In areas with hurricanes, special considerations have to be made with respect to effects of load hysteresis and high cycle fatigue especially for moorings and deck mounted tall structures (e.g., derricks).

104 Hurricane loading is considered abnormal only in cases where the occurrence probability is consistent with 10^{-4} annual level or if the unit is designed to be evacuated ahead of hurricanes and the damage is considered acceptable.

SECTION 8
SERVICEABILITY LIMIT STATES (SLS)

A. General

A 100 Objective

101 The objective of this section is to provide supplemental guidance related to SLS design as outlined in DNV-OS-C101 Sec.8. Since all partial load and material factors are equal to unity, the methodology as described is also a WSD design procedure.

A 200 Criteria

201 The SLS calculations should include expected values of permanent and variable loads and specific design environmental conditions and deformation extreme expected values.

202 The maximum allowable deflections or hull displacements or motions are to be assessed as given in DNV-OS-C101 Sec.8 and any additional relevant operational limitations for essential systems / equipment.

SECTION 9
WELD CONNECTIONS

A. General

A 100 Objective

101 The objective of this section is to provide supplemental guidance related to weld connections design as outlined in DNV-OS-C101 Sec.9 and DNV-OS-C201 Sec.9 for LRFD- or WSD-method, respectively.

102 The weld material factor γ_{Mw} shall be taken as 1.3 in the LRFD design method.

A 200 Special Connections

201 Special DDF/Spar welded connections that should receive more detailed scrutiny include the TTR foundations in the centre well, the deck leg connections to the top of the spar deck, the hard tank bottom connection to the truss legs, the heave plates connections to the truss, the soft tank to truss connections, deck to column, column to pontoon and heave damping structure to main hull.

202 Special connections, for example, grouted connections shall be fully qualified. The process as presented in *DNV-RP-A203 Qualification of New Technology* can be used.

SECTION 10 CORROSION CONTROL

A. General

A 100 Venue

101 Design Requirements for Corrosion Protection and Control system are outlined in DNV-OS-C101 Sec.10 or DNV-OS-C201 Sec.10 for LRFD- or WSD-method, respectively. The two documents are equivalent in this regard.

SECTION 11
MOORING AND FOUNDATION DESIGN

A. General

A 100 Venue

101 Mooring design is detailed in DNV-OS-E301 and the foundations design requirements are outlined in DNV-OS-C101 Sec.11 or DNV's Classification Notes 30.4. Approaches for LRFD and WSD design methods are provided in these documents. For DDF, in particular, the strength and fatigue damage of the mooring lines due to the vortex induced motions of the DDF itself, should be fully assessed.

SECTION 12
DYNAMIC RISER DESIGN AND GLOBAL PERFORMANCE

A. Dynamic Riser Design

A 100 General

101 Design of dynamic risers is detailed in DNV-OS-F201, with additional provisions in DNV-RP-F201 for titanium risers, DNV-RP-F202 for composite risers, DNV-RP-F203 for riser interference and DNV-RP-F204 for riser fatigue. Approaches for both LRFD and WSD design methods are provided in the above listed documents.

102 For DDS units, or other units where the risers are exposed to the dynamics of the wave splash zone, the effects of disturbed kinematics of the wave field due to the presence of the vessel should be fully assessed. This disturbance may be determined by the use of radiation/diffraction analysis. See DNV-RP-F205 for further details.

103 For vessels with moonpools, the kinematics of the water entrapped in the moonpool should be adequately addressed to ensure correct response of risers and/or tensioner buoys inside the moonpool. Kinematics of the entrapped water in the moonpool area can, in principle, be treated in the same way as the disturbed wave kinematics. See DNV-RP-F205 for further details.

104 For dry tree units, the riser tension system is a critical component and issues such as available stroke and tension variation due to stroke variation should be addressed.

105 Possible friction load effects due to keel guides should be accounted for in the riser design.

106 For DFFs and Spars, special attention should be paid to the influence of vortex induced motions of the DDF/Spar unit itself on the riser system.

B. Global Performance

B 100 General

101 Global performance analyses are detailed in DNV-RP-F205. As the water depth increases, the interaction/coupling between the slender structures and the large volume floater becomes more important. In this case, a coupled analysis is required to capture the interaction between the two in order to accurately predict the individual responses of floater, risers and mooring.

102 For DDFs and Spars, special attention should be paid to the influence of vortex induced motions (VIM) on the global performance, and VIM induced fatigue on hull, mooring and risers.

103 Heave eigen period and cancellation period of DDS units tend to be close. Global performance is sensitive to viscous effects (both excitation and damping). Differences between model tests and analysis may be significant. Viscous effects at cancellation/resonance area should be carefully checked, so as not to take advantage from the cancellation effect.

OFFSHORE STANDARD
DNV-OS-C101

DESIGN OF OFFSHORE STEEL STRUCTURES, GENERAL (LRFD METHOD)

APRIL 2011

DET NORSKE VERITAS

FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

DNV service documents consist of amongst other the following types of documents:

— *Service Specifications.* Procedual requirements.
— *Standards.* Technical requirements.
— *Recommended Practices.* Guidance.

The Standards and Recommended Practices are offered within the following areas:

A) Qualification, Quality and Safety Methodology
B) Materials Technology
C) Structures
D) Systems
E) Special Facilities
F) Pipelines and Risers
G) Asset Operation
H) Marine Operations
J) Cleaner Energy
O) Subsea Systems

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CHANGES

- **General**

This document supersedes DNV-OS-C101, October 2008.
This update is based on experience and feedback gained during 10 years since first edition of document.

Main changes in April 2011

- **General**

— A number of editorial corrections and clarifications have been made.

- **Sec.4 Structural Categorisation, Material Selection and Inspection Principles**

— In sub-section element D500 a new paragraph has been added concerning PWHT.

- **Sec.9 Weld Connections**

— Item B203 has been amended, mainly list-item a) concerning full penetration weld.

CONTENTS

SECTION 1 INTRODUCTION

A. General

A 100 Introduction

101 This offshore standard provides principles, technical requirements and guidance for the structural design of offshore structures.

102 DNV-OS-C101 is the general part of the DNV offshore standards for structures. The design principles and overall requirements are defined in this standard. The standard is primarily intended to be used in design of a structure where a supporting object standard exists, but may also be used as a stand-alone document for objects where no object standard exist.

103 When designing a unit where an object standard exists, the object standard *(DNV-OS-C10x)* for the specific type of unit shall be applied. The object standard gives references to this standard when appropriate.

104 In case of deviating requirements between this standard and the object standard, requirements of this standard shall be overruled by specific requirements given in the object standard.

105 This standard has been written for general world-wide application. Governmental regulations may include requirements in excess of the provisions by this standard depending on size, type, location and intended service of the offshore unit or installation.

A 200 Objectives

201 The objectives of this standard are to:

- provide an internationally acceptable level of safety by defining minimum requirements for structures and structural components (in combination with referred standards, recommended practices, guidelines, etc.)
- serve as a contractual reference document between suppliers and purchasers
- serve as a guideline for designers, suppliers, purchasers and regulators
- specify procedures and requirements for offshore structures subject to DNV certification and classification.

A 300 Scope and application

301 The standard is applicable to all types of offshore structures of steel.

302 For other materials, the general design principles given in this standard may be used together with relevant standards, codes or specifications.

303 The standard is applicable to the design of complete structures including substructures, topside structures, vessel hulls and foundations.

304 This standard gives requirements for the following:

- design principles
- structural categorisation
- material selection and inspection principles
- design loads
- load effect analyses
- design of steel structures and connections
- corrosion protection
- foundation design.

A 400 Other than DNV codes

401 In case of conflict between the requirements of this standard and a reference document other than DNV documents, the requirements of this standard shall prevail.

402 Where reference is made to codes other than DNV documents, the latest revision of the documents shall be applied, unless otherwise specified.

403 When code checks are performed according to other than DNV codes, the resistance or material factors as given in the respective code shall be used.

A 500 Classification

501 Classification principles, procedures and applicable class notations related to classification services of offshore units are specified in the DNV Offshore Service Specifications given in Table A1.

Table A1 DNV Offshore Service Specifications	
Reference	*Title*
DNV-OSS-101	Rules for Classification of Offshore Drilling and Support Units
DNV-OSS-102	Rules for Classification of Floating Production, Storage and Loading Units
DNV-OSS-103	Rules for Classification of LNG/LPG Floating Production and Storage Units or Installations
DNV-OSS-121	Classification Based on Performance Criteria Determined by Risk Assessment Methodology

502 Documentation for classification shall be in accordance with the NPS DocReq (DNV Nauticus Production System for documentation requirements) and DNV-RP-A201.

503 In case of classification, the Limit States ULS, FLS, and ALS apply. Technical requirements given in Sec.8, related to Serviceability Limit States (SLS), are not required to be fulfilled as part of classification.

B. References

B 100 General

101 The DNV documents in Tables B1 and B2 and recognised codes and standards in Table B3 are referred to in this standard.

102 The latest valid revision of the DNV reference documents in Tables B1 and B2 applies. These include acceptable methods for fulfilling the requirements in this standard. See also current DNV List of Publications.

103 When designing a unit where an object standard exists, the object standard for the specific type of unit shall be applied, see Table B2. The object standard gives references to this standard when appropriate, see also A103 and A104.

104 Other recognised codes or standards may be applied provided it is shown that they meet or exceed the level of safety of the actual DNV Offshore Standard.

Table B1 DNV Reference Documents	
Reference	*Title*
DNV-OS-A101	Safety Principles and Arrangement
DNV-OS-B101	Metallic Materials
DNV-OS-C401	Fabrication and Testing of Offshore Structures
DNV-OS-E301	Position Mooring
	Rules for Planning and Execution of Marine Operations
DNV-RP-A201	Plan Approval Documentation Types – Definitions
DNV-RP-B401	Cathodic Protection Design
DNV-RP-C201	Buckling Strength of Plated Structures
DNV-RP-C202	Buckling Strength of Shells
DNV-RP-C203	Fatigue Strength Analysis of Offshore Steel Structures
DNV-RP-C204	Design against Accidental Loads
DNV-RP-C205	Environmental Conditions and Environmental Loads
DNV-RP-E301	Design and Installation of Fluke Anchors in Clay
DNV-RP-E302	Design and Installation of Plate Anchors in Clay
DNV-RP-E303	Geotechnical Design and Installation of Suction Anchors in Clay
Classification Note 30.1	Buckling Strength Analysis of Bars and Frames, and Spherical Shells, Sec.2 Bars and Frames
Classification Note 30.4	Foundations
Classification Note 30.6	Structural Reliability Analysis of Marine Structures
Classification Note 30.7	Fatigue Assessments of Ship Structures

Table B2 DNV Offshore Object Standards for Structural Design	
Reference	*Title*
DNV-OS-C102	Structural Design of Offshore Ships
DNV-OS-C103	Structural Design of Column-stabilised Units (LRFD method)
DNV-OS-C104	Structural Design of Self-elevating Units (LRFD method)
DNV-OS-C105	Structural Design of TLP (LRFD method)
DNV-OS-C106	Structural Design of Deep Draught Floating Units
DNV-OS-C107	Structural Design of Ship-shaped Drilling and Well Service Units

Table B3 Other references	
Reference	*Title*
AISC	LRFD Manual of Steel Construction
API RP 2A LRFD	Planning, Designing, and Constructing Fixed Offshore Platforms - Load and Resistance Factor Design
BS 7910	Guide on methods for assessing the acceptability of flaws in fusion welded structures
Eurocode 3	Design of Steel Structures
NACE TPC	Publication No. 3. The role of bacteria in corrosion of oil field equipment
NORSOK	N-003 Actions and Action Effects
NORSOK	N-004 Design of Steel Structures

C. Definitions

C 100 Verbal forms

101 *Shall:* Indicates a mandatory requirement to be followed for fulfilment or compliance with the present standard. Deviations are not permitted unless formally and rigorously justified, and accepted by all relevant contracting parties.

102 *Should:* Indicates a recommendation that a certain course of action is preferred or particularly suitable. Alternative courses of action are allowable under the standard where agreed between contracting parties but shall be justified and documented.

103 *May:* Indicates a permission, or an option, which is permitted as part of conformance with the standard.

C 200 Terms

201 *Accidental Limit States (ALS):* Ensures that the structure resists accidental loads and maintain integrity and performance of the structure due to local damage or flooding.

202 *Atmospheric zone:* The external surfaces of the unit above the splash zone.

203 *Cathodic protection:* A technique to prevent corrosion of a steel surface by making the surface to be the cathode of an electrochemical cell.

204 *Characteristic load:* The reference value of a load to be used in the determination of load effects. The characteristic load is normally based upon a defined fractile in the upper end of the distribution function for load.

205 *Characteristic resistance:* The reference value of structural strength to be used in the determination of the design strength. The characteristic resistance is normally based upon a 5% fractile in the lower end of the distribution function for resistance.

206 *Characteristic material strength:* The nominal value of material strength to be used in the determination of the design resistance. The characteristic material strength is normally based upon a 5% fractile in the lower end of the distribution function for material strength.

207 *Characteristic value:* The representative value associated with a prescribed probability of not being unfavourably exceeded during the applicable reference period.

208 *Classification Note:* The Classification Notes cover proven technology and solutions which is found to represent good practice by DNV, and which represent one alternative for satisfying the requirements stipulated in the DNV Rules or other codes and standards cited by DNV. The classification notes will in the same manner be applicable for fulfilling the requirements in the DNV offshore standards.

209 *Coating:* Metallic, inorganic or organic material applied to steel surfaces for prevention of corrosion.

210 *Corrosion allowance:* Extra wall thickness added during design to compensate for any anticipated reduction in thickness during the operation.

211 *Design brief:* An agreed document where owners requirements in excess of this standard should be given.

212 *Design temperature:* The design temperature for a unit is the reference temperature for assessing areas where the unit can be transported, installed and operated. The design temperature is to be lower or equal to the *lowest mean daily temperature* in air for the relevant areas. For seasonal restricted operations the *lowest mean daily temperature* in air for the season may be applied.

213 *Design value:* The value to be used in the deterministic design procedure, i.e. characteristic value modified by the resistance factor or load factor.

214 *Driving voltage:* The difference between closed circuit anode potential and the protection potential.

215 *Expected loads and response history:* Expected load and response history for a specified time period, taking into account the number of load cycles and the resulting load levels and response for each cycle.

216 *Expected value:* The most probable value of a load during a specified time period.

217 *Fatigue:* Degradation of the material caused by cyclic loading.

218 *Fatigue critical:* Structure with calculated fatigue life near the design fatigue life.

219 *Fatigue Limit States (FLS):* Related to the possibility of failure due to the effect of cyclic loading.

220 *Foundation:* A device transferring loads from a heavy or loaded object to the vessel structure.

221 *Guidance note:* Information in the standard added in order to increase the understanding of the requirements.

222 *Hindcasting:* A method using registered meteorological data to reproduce environmental parameters. Mostly used for reproducing wave parameters.

223 *Inspection:* Activities such as measuring, examination, testing, gauging one or more characteristics of an object or service and comparing the results with specified requirements to determine conformity.

224 *Limit State:* A state beyond which the structure no longer satisfies the requirements. The following categories of limit states are of relevance for structures:

— ULS = ultimate limit states
— FLS = fatigue limit states
— ALS = accidental limit states
— SLS = serviceability limit states.

225 *Load and Resistance Factor Design (LRFD):* Method for design where uncertainties in loads are represented with a load factor and uncertainties in resistance are represented with a material factor.

226 *Load effect:* Effect of a single design load or combination of loads on the equipment or system, such as stress, strain, deformation, displacement, motion, etc.

227 *Lowest mean daily temperature:* The lowest value on the annual mean daily average temperature curve for the area in question. For temporary phases or restricted operations, the lowest mean daily temperature may be defined for specific seasons.

Mean daily average temperature: the statistical mean average temperature for a specific calendar day.

Mean: statistical mean based on number of years of observations.

Average: average during one day and night.

228 *Lowest waterline:* Typical light ballast waterline for ships, wet transit waterline or inspection waterline for other types of units.

229 *Non-destructive testing (NDT):* Structural tests and inspection of welds with radiography, ultrasonic or magnetic powder methods.

230 *Object Standard:* The standards listed in Table B2.

231 *Offshore Standard:* The DNV offshore standards are documents which presents the principles and technical requirements for design of offshore structures. The standards are offered as DNV's interpretation of engineering practice for general use by the offshore industry for achieving safe structures.

232 *Offshore installation:* A general term for mobile and fixed structures, including facilities, which are intended for exploration, drilling, production, processing or storage of hydrocarbons or other related activities or fluids. The term includes installations intended for accommodation of personnel engaged in these activities. Offshore installation covers subsea installations and pipelines. The term does not cover traditional shuttle tankers, supply boats and other support vessels which are not directly engaged in the activities described above.

233 *Operating conditions:* Conditions wherein a unit is on location for purposes of production, drilling or other similar operations, and combined environmental and operational loadings are within the appropriate design limits established for such operations (including normal operations, survival, accidental).

234 *Potential:* The voltage between a submerged metal surface and a reference electrode.

235 *Recommended Practice (RP):* The recommended practice publications cover proven technology and solutions which have been found by DNV to represent good practice, and which represent one alternative for satisfy the requirements stipulated in the DNV offshore standards or other codes and standards cited by DNV.

236 *Redundancy:* The ability of a component or system to maintain or restore its function when a failure of a member or connection has occurred. Redundancy may be achieved for instance by strengthening or introducing alternative load paths.

237 *Reference electrode:* Electrode with stable open-circuit potential used as reference for potential measurements.

238 *Reliability:* The ability of a component or a system to perform its required function without failure during a specified time interval.

239 *Risk:* The qualitative or quantitative likelihood of an accidental or unplanned event occurring considered in conjunction with the potential consequences of such a failure. In quantitative terms, risk is the quantified probability of a defined failure mode times its quantified consequence.

240 *Service temperature:* Service temperature is a reference temperature on various structural parts of the unit used as a criterion for the selection of steel grades.

241 *Serviceability Limit States (SLS):* Corresponding to the criteria applicable to normal use or durability.

242 *Shakedown:* A linear elastic structural behaviour is established after yielding of the material has occurred.

243 *Slamming:* Impact load on an approximately horizontal member from a rising water surface as a wave passes. The direction of the impact load is mainly vertical.

244 *Specified Minimum Yield Strength (SMYS):* The minimum yield strength prescribed by the specification or standard under which the material is purchased.

245 *Specified value:* Minimum or maximum value during the period considered. This value may take into account operational requirements, limitations and measures taken such that the required safety level is obtained.

246 *Splash zone:* The external surfaces of the unit that are periodically in and out of the water. The determination of the splash zone includes evaluation of all relevant effects including influence of waves, tidal variations, settlements, subsidence and vertical motions, see Sec.10 B200.

247 *Submerged zone:* The part of the unit which is below the splash zone, including buried parts.

248 *Supporting structure:* Strengthening of the vessel structure, e.g. a deck, in order to accommodate loads and moments from a heavy or loaded object.

249 *Survival condition:* A condition during which a unit may be subjected to the most severe environmental loadings for which the unit is designed. Drilling or similar operations may 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.

250 *Target safety level:* A nominal acceptable probability of structural failure.

251 *Temporary conditions:* Design conditions not covered by *operating conditions*, e.g. conditions during fabrication, mating and installation phases, transit phases, accidental.

252 *Tensile strength:* Minimum stress level where strain hardening is at maximum or at rupture.

253 *Transit conditions:* All unit movements from one geographical location to another.

254 *Unit:* is a general term for an offshore installation such as ship shaped, column stabilised, self-elevating, tension leg or deep draught floater.

255 *Utilisation factor:* The fraction of anode material that can be utilised for design purposes.

256 *Verification:* Examination to confirm that an activity, a product or a service is in accordance with specified requirements.

257 *Ultimate Limit States (ULS):* Corresponding to the maximum load carrying resistance.

D. Abbreviations and Symbols

D 100 Abbreviations

101 Abbreviations as shown in Table D1 are used in this standard.

Table D1 Abbreviations

Abbreviation	*In full*
AISC	American Institute of Steel Construction
ALS	accidental limit states
API	American Petroleum Institute
BS	British Standard (issued by British Standard Institute)
CN	classification note
CTOD	crack tip opening displacement
DDF	deep draught floaters
DFF	design fatigue factor
DNV	Det Norske Veritas
EHS	extra high strength
FLS	fatigue limit state
FM	Fracture mechanics
HAT	highest astronomical tide
HISC	hydrogen induced stress cracking
HS	high strength
ISO	international organisation of standardisation
LAT	lowest astronomic tide
LRFD	load and resistance factor design
MPI	magnetic particle inspection
MSL	mean sea level
NACE	National Association of Corrosion Engineers
NDT	non-destructive testing
NS	normal strength
PWHT	post weld heat treatment
RP	recommended practise
RHS	rectangular hollow section
SCE	saturated calomel electrode
SCF	stress concentration factor
SLS	serviceability limit state
SMYS	specified minimum yield stress
SRB	sulphate reducing bacteria
TLP	tension leg platform
ULS	ultimate limit states
WSD	working stress design

D 200 Symbols

201 *Latin characters*

α_0 connection area
a_v vertical acceleration
b full breadth of plate flange
b_e effective plate flange width
c detail shape factor
d bolt diameter
f load distribution factor
f_E elastic buckling stress
f_r strength ratio
f_u nominal lowest ultimate tensile strength
f_{ub} ultimate tensile strength of bolt

f_w strength ratio
f_y specified minimum yield stress
g, g_o acceleration due to gravity
h height
h_{op} vertical distance from the load point to the position of maximum filling height
k_a correction factor for aspect ratio of plate field
k_m bending moment factor
k_{pp} fixation parameter for plate
k_{ps} fixation parameter for stiffeners
k_s hole clearance factor
k_t shear force factor
l stiffener span
l_o distance between points of zero bending moments
n number
p pressure
p_d design pressure
r root face
r_c radius of curvature
s distance between stiffeners
t_0 net thickness of plate
t_k corrosion addition
t_w throat thickness
A_s net area in the threaded part of the bolt
C weld factor
C_e factor for effective plate flange
D deformation load
E environmental load
F_d design load
F_k characteristic load
F_{pd} design preloading force in bolt
G permanent load
M moment
M_p plastic moment resistance
M_y elastic moment resistance
N_p number of supported stiffeners on the girder span
Ns number of stiffeners between considered section and nearest support
P load
P_{pd} average design point load from stiffeners
Q variable functional load
R radius
R_d design resistance
R_k characteristic resistance
S girder span as if simply supported
S_d design load effect
S_k characteristic load effect
SZ_l lower limit of the splash zone
SZ_u upper limit of the splash zone
W steel with improved weldability
Z steel grade with proven through thickness properties with respect to lamellar tearing.

202 *Greek characters*

α	angle between the stiffener web plane and the plane perpendicular to the plating
β_w	correlation factor
δ	deflection
ϕ	resistance factor
γ_f	load factor
γ_M	material factor (material coefficient)
γ_{Mw}	material factor for welds
λ	reduced slenderness
θ	rotation angle
μ	friction coefficient
ρ	density
σ_d	design stress
σ_{fw}	characteristic yield stress of weld deposit
σ_{jd}	equivalent design stress for global in-plane membrane stress
σ_{pd1}	design bending stress
σ_{pd2}	design bending stress
τ_d	design shear stress.

203 *Subscripts*

d	design value
k	characteristic value
p	plastic
y	yield.

SECTION 2
DESIGN PRINCIPLES

A. Introduction

A 100 General

101 This section describes design principles and design methods including:

— load and resistance factor design method
— design assisted by testing
— probability based design.

102 General design considerations regardless of design method are also given in B101.

103 This standard is based on the load and resistance factor design method referred to as the LRFD method.

104 As an alternative or as a supplement to analytical methods, determination of load effects or resistance may in some cases be based either on testing or on observation of structural performance of models or full-scale structures.

105 Direct reliability analysis methods are mainly considered as applicable to special case design problems, to calibrate the load and resistance factors to be used in the LRFD method and for conditions where limited experience exists.

A 200 Aim of the design

201 Structures and structural elements shall be designed to:

— sustain loads liable to occur during all temporary, operating and damaged conditions, if required
— maintain acceptable safety for personnel and environment
— have adequate durability against deterioration during the design life of the structure.

B. General Design Considerations

B 100 General

101 The design of a structural system, its components and details shall, as far as possible, account for the following principles:

— resistance against relevant mechanical, physical and chemical deterioration is achieved
— fabrication and construction comply with relevant, recognised techniques and practice
— inspection, maintenance and repair are possible.

102 Structures and elements thereof, shall possess ductile resistance unless the specified purpose requires otherwise.

103 The overall structural safety shall be evaluated on the basis of preventive measures against structural failure put into design, fabrication and in-service inspection as well as the unit's residual strength against total collapse in the case of structural failure of vital elements.

104 Structural connections are, in general, to be designed with the aim to minimise stress concentrations and reduce complex stress flow patterns.

105 Fatigue life improvements with methods such as grinding or hammer peening of welds should not provide a measurable increase in the fatigue life at the design stage. The fatigue life should instead be extended by means of modification of structural details. Fatigue life improvements based on mean stress level should not be applied for welded structures, ref. DNV-RP-C203.

106 Transmission of high tensile stresses through the thickness of plates during welding, block assembly and operation shall be avoided as far as possible. In cases where transmission of high tensile stresses through thickness occur, structural material with proven through thickness properties shall be used. Object standards may give examples where to use plates with proven through thickness properties.

107 Structural elements may be fabricated according to the requirements given in DNV-OS-C401.

C. Limit States

C 100 General

101 A limit state is a condition beyond which a structure or a part of a structure exceeds a specified design requirement.

102 The following limit states are considered in this standard:

- *Ultimate limit states (ULS)* corresponding to the ultimate resistance for carrying loads.
- *Fatigue limit states (FLS)* related to the possibility of failure due to the effect of cyclic loading.
- *Accidental limit states (ALS)* corresponding to damage to components due to an accidental event or operational failure.
- *Serviceability limit states (SLS)* corresponding to the criteria applicable to normal use or durability.

103 Examples of limit states within each category:

Ultimate limit states (ULS)

- loss of structural resistance (excessive yielding and buckling)
- failure of components due to brittle fracture
- loss of static equilibrium of the structure, or of a part of the structure, considered as a rigid body, e.g. overturning or capsizing
- failure of critical components of the structure caused by exceeding the ultimate resistance (in some cases reduced by repeated loads) or the ultimate deformation of the components
- transformation of the structure into a mechanism (collapse or excessive deformation).

Fatigue limit states (FLS)

- cumulative damage due to repeated loads.

Accidental limit states (ALS)

- structural damage caused by accidental loads
- ultimate resistance of damaged structures
- maintain structural integrity after local damage or flooding
- loss of station keeping (free drifting).

Serviceability limit states (SLS)

- deflections that may alter the effect of the acting forces
- deformations that may change the distribution of loads between supported rigid objects and the supporting structure
- excessive vibrations producing discomfort or affecting non-structural components
- motion that exceed the limitation of equipment
- temperature induced deformations.

D. Design by LRFD Method

D 100 General

101 Design by the LRFD method is a design method by which the target safety level is obtained as closely as possible by applying load and resistance factors to characteristic reference values of the basic variables. The basic variables are, in this context, defined as:

- loads acting on the structure
- resistance of the structure or resistance of materials in the structure.

102 The target safety level is achieved by using deterministic factors representing the variation in load and resistance and the reduced probabilities that various loads will act simultaneously at their characteristic values.

D 200 The load and resistance factor design format (LRFD)

201 The level of safety of a structural element is considered to be satisfactory if the design load effect (S_d) does not exceed the design resistance (R_d):

$$S_d \leq R_d$$

The equation: $S_d = R_d$, defines a limit state.

202 A design load is obtained by multiplying the characteristic load by a given load factor:

$$F_d = \gamma_f F_k$$

F_d = design load
γ_f = load factor
F_k = characteristic load, see Sec.3.

The load factors and combinations for ULS, ALS, FLS and SLS shall be applied according to 300 to 700.

203 A design load effect is the most unfavourable combined load effect derived from the design loads, and may, if expressed by one single quantity, be expressed by:

$$S_d = q(F_{d1},....,F_{dn})$$

S_d = design load effect
q = load effect function.

204 If the relationship between the load and the load effect is linear, the design load effect may be determined by multiplying the characteristic load effects by the corresponding load factors:

$$S_d = \sum_{i=1}^{n} (\gamma_{fi} S_{ki})$$

S_{ki} = characteristic load effect.

205 In this standard the values of the resulting material factor are given in the respective sections for the different limit states.

206 The resistance for a particular load effect is, in general, a function of parameters such as structural geometry, material properties, environment and load effects (interaction effects).

207 The design resistance (R_d) is determined as follows:

$$R_d = \phi R_k$$

R_k = characteristic resistance
ϕ = resistance factor.

The resistance factor relate to the material factor γ_M as follows:

$$\phi = \frac{1}{\gamma_M}$$

γ_M = material factor.

208 R_k may be calculated on the basis of characteristic values of the relevant parameters or determined by testing. Characteristic values should be based on the 5^{th} percentile of the test results.

209 Load factors account for:

— possible unfavourable deviations of the loads from the characteristic values
— the reduced probability that various loads acting together will act simultaneously at their characteristic value
— uncertainties in the model and analysis used for determination of load effects.

210 Material factors account for:

— possible unfavourable deviations in the resistance of materials from the characteristic values
— possible reduced resistance of the materials in the structure, as a whole, as compared with the characteristic values deduced from test specimens.

D 300 Characteristic load

301 The representative values for the different groups of limit states in the operating design conditions shall be based on Sec.3:

— for the ULS load combination, the representative value corresponding to a load effect with an annual probability of exceedance equal to, or less than, 10^{-2} (100 years).

— for the ALS load combination for damaged structure, the representative load effect is determined as the most probable annual maximum value.
— for the FLS, the representative value is defined as the expected load history.
— for the SLS, the representative value is a specified value, dependent on operational requirements.

302 For the temporary design conditions, the characteristic values may be based on specified values, which shall be selected dependent on the measurers taken to achieve the required safety level. The value may be specified with due attention to the actual location, season of the year, weather forecast and consequences of failure.

D 400 Load factors for ULS

401 For analysis of ULS, two sets of load combinations shall be used when combining design loads as defined in Table D1.

The combinations denoted a) and b) shall be considered in both operating and temporary conditions.

The load factors are generally applicable for all types of structures, but other values may be specified in the respective object standards.

Table D1 Load factors γ_f for ULS

Combination of design loads	*Load categories*			
	G	*Q*	*E*	*D*
a)	1.3	1.3	0.7	1.0
b)	1.0	1.0	1.3	1.0

Load categories are:
G = permanent load
Q = variable functional load
E = environmental load
D = deformation load
For description of load categories see Sec.3.

402 When permanent loads (G) and variable functional loads (Q) are well defined, e.g. hydrostatic pressure, a load factor of 1.2 may be used in combination a) for these load categories.

403 If a load factor γ_f = 1.0 on G and Q loads in combination a) results in higher design load effect, the load factor of 1.0 shall be used.

404 Based on a safety assessment considering the risk for both human life and the environment, the load factor γ_f for environmental loads may be reduced to 1.15 in combination b) if the structure is unmanned during extreme environmental conditions.

D 500 Load factor for FLS

501 The structure shall be able to resist expected fatigue loads, which may occur during temporary and operation design conditions. Where significant cyclic loads may occur in other phases, e.g. wind excitation during fabrication, such cyclic loads shall be included in the fatigue load estimates.

502 The load factor γ_f in the FLS is 1.0 for all load categories.

D 600 Load factor for SLS

601 For analyses of SLS the load factor γ_f is 1.0 for all load categories, both for temporary and operating design conditions.

D 700 Load factor for ALS

701 The load factors γ_f in the ALS is 1.0.

E. Design Assisted by Testing

E 100 General

101 Design by testing or observation of performance is in general to be supported by analytical design methods.

102 Load effects, structural resistance and resistance against material degradation may be established by means of testing or observation of the actual performance of full-scale structures.

E 200 Full-scale testing and observation of performance of existing structures

201 Full-scale tests or monitoring on existing structures may be used to give information on response and load effects to be utilised in calibration and updating of the safety level of the structure.

F. Probability Based Design

F 100 Definition

101 Reliability, or structural safety, is defined as the probability that failure will not occur or that a specified criterion will not be exceeded.

F 200 General

201 This section gives requirements for structural reliability analysis undertaken in order to document compliance with the offshore standards.

202 Acceptable procedures for reliability analyses are documented in the Classification Note 30.6.

203 Reliability analyses shall be based on level 3 reliability methods. These methods utilise probability of failure as a measure and require knowledge of the distribution of all basic variables.

204 In this standard, level 3 reliability methods are mainly considered applicable to:

— calibration of level 1 method to account for improved knowledge. (Level 1 methods are deterministic analysis methods that use only one characteristic value to describe each uncertain variable, i.e. the LRFD method applied in the standards)
— special case design problems
— novel designs where limited (or no) experience exists.

205 Reliability analysis may be updated by utilisation of new information. Where such updating indicates that the assumptions upon which the original analysis was based are not valid, and the result of such non-validation is deemed to be essential to safety, the subject approval may be revoked.

206 Target reliabilities shall be commensurate with the consequence of failure. The method of establishing such target reliabilities, and the values of the target reliabilities themselves, should be agreed in each separate case. To the extent possible, the minimum target reliabilities shall be based on established cases that are known to have adequate safety.

207 Where well established cases do not exist, e.g. in the case of novel and unique design solution, the minimum target reliability values shall be based upon one or a combination of the following considerations:

— transferable target reliabilities similar existing design solutions
— internationally recognised codes and standards
— Classification Note 30.6.

SECTION 3
LOADS AND LOAD EFFECTS

A. Introduction

A 100 General

101 The requirements in this section define and specify load components and load combinations to be considered in the overall strength analysis as well as design pressures applicable in formulae for local design.

102 Impact pressure caused by the sea (slamming, bow impact) or by liquid cargoes in partly filled tanks (sloshing) are not covered by this section.

103 For structural arrangement of mooring equipment and arrangement/devices for towing, see DNV-OS-E301 Ch.2 Sec.4 N-O. The mooring and towing equipment, including the support to main structure, shall be designed for the loads and acceptance criteria specified in DNV-OS-E301 Ch.2 Sec.4.

B. Basis for Selection of Characteristic Loads

B 100 General

101 Unless specific exceptions apply, as documented within this standard, the characteristic loads documented in Table B1 and Table B2 shall apply in the temporary and operating design conditions, respectively.

102 Where environmental and accidental loads may act simultaneously, the characteristic loads may be determined based on their joint probability distribution.

Table B1 Basis for selection of characteristic loads for temporary design conditions

Load category	*Limit states – temporary design conditions*				
	ULS	*FLS*	*ALS*		*SLS*
			Intact structure	*Damaged structure*	
Permanent (G)	Expected value				
Variable (Q)	Specified value				
Environmental (E)	Specified value	Expected load history	Specified value	Specified value	Specified value
Accidental (A)			Specified value		
Deformation (D)	Expected extreme value				
For definitions, see Sec.1. See DNV Rules for Planning and Execution of Marine Operations.					

Table B2 Basis for selection of characteristic loads for operating design conditions

Load category	*Limit states – operating design conditions*				
	ULS	*FLS*	*ALS*		*SLS*
			Intact structure	*Damaged structure*	
Permanent (G)	Expected value				
Variable (Q)	Specified value				
Environmental (E)	Annual probability[1)]being exceeded $= 10^{-2}$ (100 year return period)	Expected load history	Not applicable	Load with return period not less than 1 year	Specified value
Accidental (A)			Specified value, see also DNV-OS-A101		
Deformation (D)	Expected extreme value				
1) The joint probability of exceedance applies, see F.					

C. Permanent Loads (G)

C 100 General

101 Permanent loads are loads that will not vary in magnitude, position or direction during the period considered. Examples are:

— mass of structure
— mass of permanent ballast and equipment
— external and internal hydrostatic pressure of a permanent nature
— reaction to the above e.g. articulated tower base reaction.

102 The characteristic load of a permanent load is defined as the expected value based on accurate data of the unit, mass of the material and the volume in question.

D. Variable Functional Loads (Q)

D 100 General

101 Variable functional loads are loads which may vary in magnitude, position and direction during the period under consideration, and which are related to operations and normal use of the installation.

102 Examples are:

— personnel
— stored materials, equipment, gas, fluids and fluid pressure
— crane operational loads
— loads from fendering
— loads associated with installation operations
— loads associated with drilling operations
— loads from variable ballast and equipment
— variable cargo inventory for storage vessels
— helicopters
— lifeboats.

103 The characteristic value of a variable functional load is the maximum (or minimum) specified value, which produces the most unfavourable load effects in the structure under consideration.

104 The specified value shall be determined on the basis of relevant specifications. An expected load history shall be used in FLS.

D 200 Variable functional loads on deck areas

201 Variable functional loads on deck areas of the topside structure shall be based on Table D1 unless specified otherwise in the design basis or the design brief. The intensity of the distributed loads depends on local or global aspects as shown in Table D1. The following notations are used:

Local design: e.g. design of plates, stiffeners, beams and brackets
Primary design: e.g. design of girders and columns
Global design: e.g design of deck main structure and substructure.

Table D1 Variable functional loads on deck areas				
	Local design		*Primary design*	*Global design*
	Distributed load p (kN/m^2)	*Point load P (kN)*	*Apply factor to distributed load*	*Apply factor to primary design load*
Storage areas	q	1.5 q	1.0	1.0
Lay down areas	q	1.5 q	f	f
Lifeboat platforms	9.0	9.0	1.0	may be ignored
Area between equipment	5.0	5.0	f	may be ignored
Walkways, staircases and platforms, crew spaces	4.0	4.0	f	may be ignored
Walkways and staircases for inspection only	3.0	3.0	f	may be ignored
Areas not exposed to other functional loads	2.5	2.5	1.0	-

Notes:

- Wheel loads to be added to distributed loads where relevant. (Wheel loads can be considered acting on an area of 300 x 300 mm.)
- Point loads to be applied on an area 100 x 100 mm, and at the most severe position, but not added to wheel loads or distributed loads.
- q to be evaluated for each case. Lay down areas should not be designed for less than 15 kN/m^2.
- $f = \min\{1.0\ ;\ (0.5 + 3/\sqrt{A})\}$, where A is the loaded area in m^2.
- Global load cases shall be established based upon "worst case", characteristic load combinations, complying with the limiting global criteria to the structure. For buoyant structures these criteria are established by requirements for the floating position in still water, and intact and damage stability requirements, as documented in the operational manual, considering variable load on the deck and in tanks.

D 300 Tank pressures

301 The structure shall be designed to resist the maximum hydrostatic pressure of the heaviest filling in tanks that may occur during fabrication, installation and operation.

302 Hydrostatic pressures in tanks should be based on a minimum density equal to that of seawater, $\rho = 1.025\ t/m^3$. Tanks for higher density fluids, e.g. mud, shall be designed on basis of special consideration. The density, upon which the scantlings of individual tanks are based, shall be given in the operating manual.

303 Pressure loads that may occur during emptying of water or oil filled structural parts for condition monitoring, maintenance or repair shall be evaluated.

304 Hydrostatic pressure heads shall be based on tank filling arrangement by e.g. pumping, gravitational effect, accelerations as well as venting arrangements.

305 Pumping pressures may be limited by installing appropriate alarms and auto-pump cut-off system (i.e. high level and high-high level with automatic stop of the pumps). In such a situation the pressure head may be taken to be the cut-off pressure head.

Descriptions and requirements related to different tank arrangements are given in DNV-OS-D101 Ch.2 Sec.3 C300.

306 Dynamic pressure heads due to flow through pipes shall be considered, see 308.

307 All tanks shall be designed for the following internal design pressure:

$$p_d = \rho \cdot g_0 \cdot h_{op} \cdot \left(\gamma_{f,G,Q} + \frac{a_v}{g_0} \cdot \gamma_{f,E}\right) \quad (kN/m^2)$$

a_v	=	maximum vertical acceleration (m/s^2), being the coupled motion response applicable to the tank in question
h_{op}	=	vertical distance (m) from the load point to the position of maximum filling height. For tanks adjacent to the sea that are situated below the extreme operational draught, the maximum filling height should not be taken lower than the extreme operational draught.
ρ	=	density of liquid (t/m^3)
g_0	=	9.81 m/s^2
$\gamma_{f,G,Q}$	=	load factor for ULS, permanent and functional loads
$\gamma_{f,E}$	=	load factor for ULS, environmental loads.

308 For tanks where the air pipe may be filled during filling operations, the following additional internal design pressure conditions shall be considered:

$$p_d = (\rho \cdot g_0 \cdot h_{op} + p_{dyn}) \cdot \gamma_{f,G,Q} \ \ (kN/m^2)$$

h_{op} = vertical distance (m) from the load point to the position of maximum filling height. For tanks adjacent to the sea that are situated below the extreme operational draught, the maximum filling height should not be taken lower than the extreme operational draught

p_{dyn} = Pressure (kN/m^2) due to flow through pipes, minimum 25 kN/m^2

$\gamma_{f,G,Q}$ = load factor for ULS, permanent and functional loads.

309 In a situation where design pressure head might be exceeded, should be considered as an ALS condition.

D 400 Lifeboat platforms

401 Lifeboat platforms shall be checked for the ULS and ALS condition if relevant. A dynamic factor of $0.2 \cdot g_0$ due to retardation of the lifeboats when lowered shall be included in both ULS and ALS condition.

E. Environmental Loads (E)

E 100 General

101 Environmental loads are loads which may vary in magnitude, position and direction during the period under consideration, and which are related to operations and normal use of the installation. Examples are:

— hydrodynamic loads induced by waves and current
— inertia forces
— wind
— earthquake
— tidal effects
— marine growth
— snow and ice.

102 Practical information regarding environmental loads and conditions are given in DNV-RP-C205.

E 200 Environmental loads for mobile offshore units

201 The design of mobile offshore units shall be based on the most severe environmental loads that the structure may experience during its design life. The applied environmental conditions shall be defined in the design basis or design brief, and stated in the unit's Operation Manual.

202 The North Atlantic scatter diagram should be used in ULS, ALS and FLS for unrestricted world wide operation.

E 300 Environmental loads for site specific units

301 The parameters describing the environmental conditions shall be based on observations from or in the vicinity of the relevant location and on general knowledge about the environmental conditions in the area. Data for the joint occurrence of e.g. wave, wind and current conditions should be applied.

302 According to this standard, the environmental loads shall be determined with stipulated probabilities of exceedance. The statistical analysis of measured data or simulated data should make use of different statistical methods to evaluate the sensitivity of the result. The validation of distributions with respect to data should be tested by means of recognised methods.

303 The analysis of the data shall be based on the longest possible time period for the relevant area. In the case of short time series the statistical uncertainty shall be accounted for when determining design values. Hindcasting may be used to extend measured time series, or to interpolate to places where measured data have not been collected. If hindcasting is used, the model shall be calibrated against measured data, to ensure that the hindcast results comply with available measured data.

E 400 Determination of characteristic hydrodynamic loads

401 Hydrodynamic loads shall be determined by analysis. When theoretical predictions are subjected to significant uncertainties, theoretical calculations shall be supported by model tests or full scale measurements of existing structures or by a combination of such tests and full scale measurements.

402 Hydrodynamic model tests should be carried out to:

— confirm that no important hydrodynamic feature has been overlooked by varying the wave parameters (for new types of installations, environmental conditions, adjacent structure, etc.)
— support theoretical calculations when available analytical methods are susceptible to large uncertainties
— verify theoretical methods on a general basis.

403 Models shall be sufficient to represent the actual installation. The test set-up and registration system shall provide a basis for reliable, repeatable interpretation.

404 Full-scale measurements may be used to update the response prediction of the relevant structure and to validate the response analysis for future analysis. Such tests may especially be applied to reduce uncertainties associated with loads and load effects which are difficult to simulate in model scale.

405 In full-scale measurements it is important to ensure sufficient instrumentation and logging of environmental conditions and responses to ensure reliable interpretation.

406 Wind tunnel tests should be carried out when:

— wind loads are significant for overall stability, offset, motions or structural response
— there is a danger of dynamic instability.

407 Wind tunnel test may support or replace theoretical calculations when available theoretical methods are susceptible to large uncertainties, e.g. due to new type of installations or adjacent installation influence the relevant installation.

408 Theoretical models for calculation of loads from icebergs or drift ice should be checked against model tests or full-scale measurements.

409 Proof tests of the structure may be necessary to confirm assumptions made in the design.

410 Hydrodynamic loads on appurtenances (anodes, fenders, strakes etc,) shall be taken into account, when relevant.

E 500 Wave loads

501 Wave theory or kinematics shall be selected according to recognised methods with due consideration of actual water depth and description of wave kinematics at the surface and the water column below.

502 Linearised wave theories, e.g. Airy, may be used when appropriate. In such circumstances the influence of finite amplitude waves shall be taken into consideration.

503 Wave loads should be determined according to DNV-RP-C205.

504 For large volume structures where the wave kinematics is disturbed by the presence of the structure, typical radiation or diffraction analyses shall be performed to determine the wave loads, e.g. excitation forces or pressures.

505 For slender structures (typically chords and bracings, tendons, risers) where the Morison equation is applicable, the wave loads should be estimated by selection of drag and inertia coefficients as specified in DNV-RP-C205.

506 In the case of adjacent large volume structures disturbing the free field wave kinematics, the presence of the adjacent structures may be considered by radiation and diffraction analyses for calculation of the wave kinematics.

E 600 Wave induced inertia forces

601 The load effect from inertia forces shall be taken into account in the design. Examples where inertia forces can be of significance are:

— heavy objects
— tank pressures
— flare towers
— drilling towers
— crane pedestals.

602 The accelerations shall be based on direct calculations or model tests unless specified in the object standards.

E 700 Wind loads

701 The wind velocity at the location of the installation shall be established on the basis of previous measurements at the actual and adjacent locations, hindcast predictions as well as theoretical models and other meteorological information. If the wind velocity is of significant importance to the design and existing wind data are scarce and uncertain, wind velocity measurements should be carried out at the location in question.

702 Characteristic values of the wind velocity should be determined with due account of the inherent uncertainties.

Guidance note:
Wind loads may be determined in accordance with DNV-RP-C205.

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703 The pressure acting on vertical external bulkheads exposed to wind shall not be taken less than 2.5 kN/m^2 unless otherwise documented.

704 For structures being sensitive to dynamic loads, for instance tall structures having long natural period of vibration, the stresses due to the gust wind pressure considered as static shall be multiplied by an appropriate dynamic amplification factor.

E 800 Vortex induced oscillations

801 Consideration of loads from vortex shedding on individual elements due to wind, current and waves may be based on DNV-RP-C205. Vortex induced vibrations of frames shall also be considered. The material and structural damping of individual elements in welded steel structures shall not be set higher than 0.15% of critical damping.

E 900 Current

901 Characteristic current design velocities shall be based upon appropriate consideration of velocity or height profiles and directionality.

Guidance note:
Further details regarding current design loads are given in DNV-RP-C205.

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E 1000 Tidal effects

1001 For floating structures constrained by tendon mooring systems, tidal effects can significantly influence the structure's buoyancy and the mean loads in the mooring components. Therefore the choice of tide conditions for static equilibrium analysis is important. Tidal effects shall be considered in evaluating the various responses of interest. Higher mean water levels tend to increase maximum mooring tensions, hydrostatic loads, and current loads on the hull, while tending to decrease under deck wave clearances.

1002 These effects of tide may be taken into account by performing a static balance at the various appropriate tide levels to provide a starting point for further analysis, or by making allowances for the appropriate tide level in calculating extreme responses.

E 1100 Marine growth

1101 Marine growth is a common designation for a surface coating on marine structures, caused by plants, animals and bacteria. In addition to the direct increase in structure weight, marine growth may cause an increase in hydrodynamic drag and added mass due to the effective increase in member dimensions, and may alter the roughness characteristics of the surface.

1102 Effect of marine growth shall be considered, where relevant.

E 1200 Snow and ice accumulation

1201 Ice accretion from sea spray, snow, rain and air humidity shall be considered, where relevant.

1202 Snow and ice loads may be reduced or neglected if a snow and ice removal procedures are established.

1203 When determining wind and hydrodynamic load, possible increases of cross-sectional area and changes in surface roughness caused by icing shall be considered, where relevant.

1204 For buoyant structures the possibility of uneven distribution of snow and ice accretion shall be considered.

E 1300 Direct ice load

1301 Where impact with sea ice or icebergs may occur, the contact loads shall be determined according to relevant, recognised theoretical models, model tests or full-scale measurements.

1302 When determining the magnitude and direction of the loads, the following factors shall be considered:

— geometry and nature of the ice
— mechanical properties of the ice
— velocity and direction of the ice
— geometry and size of the ice and structure contact area
— ice failure mode as a function of the structure geometry
— environmental forces available to drive the ice
— inertia effects for both ice and structure.

E 1400 Water level, settlements and erosion

1401 When determining water level in the calculation of loads, the tidal water and storm surge shall be taken into account. Calculation methods that take into account the effects that the structure and adjacent structures have on the water level shall be used.

1402 Uncertainty of measurements and possible erosion shall be considered.

E 1500 Earthquake

1501 Relevant earthquake effects shall be considered for bottom fixed structures.

1502 Earthquake excitation design loads and load histories may be described either in terms of response spectra or in terms of time histories. For the response spectrum method all modes of vibration which contribute significantly to the response shall be included. Correlation effects shall be accounted for when combining the modal response maximum.

1503 When performing time-history earthquake analysis, the response of the structure and foundation system shall be analysed for a representative set of time histories. Such time histories shall be selected and scaled to provide a best fit of the earthquake motion in the frequency range where the main dynamic response is expected.

1504 The dynamic characteristics of the structure and its foundation should be determined using a three-dimensional analytical model. A two-dimensional or axis-symmetric model may be used for the soil and structure interaction analysis provided compatibility with the three-dimensional structural model is ensured.

1505 Where characteristic ground motions, soil characteristics, damping and other modelling parameters are subject to great uncertainties, a parameter sensitivity study should be carried out.

1506 Consideration shall be given to the possibility that earthquakes in the local region may cause other effects such as subsea earthslides, critical pore pressure built-up in the soil or major soil deformations affecting foundation slabs, piles or skirts.

F. Combination of Environmental Loads

F 100 General

101 Where applicable data are available joint probability of environmental load components, at the specified probability level, may be considered. Alternatively, joint probability of environmental loads may be approximated by combination of characteristic values for different load types as shown in Table F1.

102 Generally, the long-term variability of multiple loads may be described by a scatter diagram or joint density function including information about direction. Contour curves may then be derived which give combination of environmental parameters, which approximately describe the various loads corresponding to the given probability of exceedance.

103 Alternatively, the probability of exceedance may be referred to the load effects. This is particularly relevant when direction of the load is an important parameter.

104 For bottom founded and symmetrical moored structures it is normally conservative to consider co-linear environmental loads. For certain structures, such as moored ship shaped units, where the colinear assumption is not conservative, non colinear criteria should be used.

105 The load intensities for various types of loads may be selected to correspond to the probabilities of exceedance as given in Table F1.

106 In a short-term period with a combination of waves and fluctuating wind, the individual variations of the two load processes should be assumed uncorrelated.

Table F1 Proposed combinations of different environmental loads in order to obtain ULS combinations with 10^{-2} annual probability of exceedance and ALS loads with return period not less than 1 year

Limit state	*Wind*	*Waves*	*Current*	*Ice*	*Sea level*
ULS	10^{-2}	10^{-2}	10^{-1}		10^{-2}
	10^{-1}	10^{-1}	10^{-2}		10^{-2}
	10^{-1}	10^{-1}	10^{-1}	10^{-2}	Mean water level
ALS	Return period not less than 1 year	Return period not less than 1 year	Return period not less than 1 year		Return period not less than 1 year

G. Accidental Loads (A)

G 100 General

101 Accidental loads are loads related to abnormal operations or technical failure. Examples of accidental loads are loads caused by:

— dropped objects
— collision impact
— explosions
— fire

— change of intended pressure difference
— accidental impact from vessel, helicopter or other objects
— unintended change in ballast distribution
— failure of a ballast pipe or unintended flooding of a hull compartment
— failure of mooring lines
— loss of DP system causing loss of heading.

102 Relevant accidental loads should be determined on the basis of an assessment and relevant experiences. With respect to planning, implementation, use and updating of such assessment and generic accidental loads, reference is given to DNV-OS-A101.

103 For temporary design conditions, the characteristic load may be a specified value dependent on practical requirements. The level of safety related to the temporary design conditions is not to be inferior to the safety level required for the operating design conditions.

H. Deformation Loads (D)

H 100 General

101 Deformation loads are loads caused by inflicted deformations such as:

— temperature loads
— built-in deformations
— settlement of foundations
— tether pre-tension on a TLP.

H 200 Temperature loads

201 Structures shall be designed for the most extreme temperature differences they may be exposed to. This applies to, but is not limited to:

— storage tanks
— structural parts that are exposed to radiation from the top of a flare boom. For flare born radiation a one hour mean wind with a return period of 1 year may be used to calculate the spatial flame extent and the air cooling in the assessment of heat radiation from the flare boom
— structural parts that are in contact with pipelines, risers or process equipment.

202 The ambient sea or air temperature is calculated as an extreme value with an annual probability of exceedance equal to 10^{-2} (100 years).

H 300 Settlements and subsidence of sea bed

301 Settlement of the foundations into the sea bed shall be considered for permanently located bottom founded units

302 The possibility of, and the consequences of, subsidence of the seabed as a result of changes in the subsoil and in the production reservoir during the service life of the installation, shall be considered.

303 Reservoir settlements and subsequent subsidence of the seabed shall be calculated as a conservatively estimated mean value.

I. Load Effect Analysis

I 100 General

101 Load effects, in terms of motions, displacements, or internal forces and stresses of the structure, shall be determined with due regard for:

— spatial and temporal nature, including:

  — possible non-linearities of the load
  — dynamic character of the response

— relevant limit states for design check
— desired accuracy in the relevant design phase

102 Permanent-, functional-, deformation-, and fire-loads should be treated by static methods of analysis. Environmental (wave, wind and earthquake) loads and certain accidental loads (impacts, explosions) may require dynamic analysis. Inertia and damping forces are important when the periods of steady-state loads are close to natural periods or when transient loads occur.

103 In general, three frequency bands need to be considered for offshore structures:

High frequency (HF)	Rigid body natural periods below dominating wave periods (typically ringing and springing responses in TLP’s).
Wave frequency (WF)	Area with wave periods in the range 4 to 25 s typically. Applicable to all offshore structures located in the wave active zone.
Low frequency (LF)	This frequency band relates to slowly varying responses with natural periods above dominating wave energy (typically slowly varying surge and sway motions for column-stabilised and ship-shaped units as well as slowly varying roll and pitch motions for deep draught floaters).

104 A global wave motion analysis is required for structures with at least one free mode. For fully restrained structures a static or dynamic wave-structure-foundation analysis is required.

105 Uncertainties in the analysis model are expected to be taken care of by the load and resistance factors. If uncertainties are particularly high, conservative assumptions shall be made.

106 If analytical models are particularly uncertain, the sensitivity of the models and the parameters utilised in the models shall be examined. If geometric deviations or imperfections have a significant effect on load effects, conservative geometric parameters shall be used in the calculation.

107 In the final design stage theoretical methods for prediction of important responses of any novel system should be verified by appropriate model tests. (See Sec.2 E200).

108 Earthquake loads need only be considered for restrained modes of behaviour. See object standards for requirements related to the different objects.

I 200 Global motion analysis

201 The purpose of a motion analysis is to determine displacements, accelerations, velocities and hydrodynamic pressures relevant for the loading on the hull and superstructure, as well as relative motions (in free modes) needed to assess airgap and green water requirements. Excitation by waves, current and wind should be considered.

I 300 Load effects in structures and soil or foundation

301 Displacements, forces or stresses in the structure and foundation, shall be determined for relevant combinations of loads by means of recognised methods, which take adequate account of the variation of loads in time and space, the motions of the structure and the limit state which shall be verified. Characteristic values of the load effects shall be determined.

302 Non-linear and dynamic effects associated with loads and structural response shall be accounted for whenever relevant.

303 The stochastic nature of environmental loads shall be adequately accounted for.

304 Description of the different types of analyses are covered in the various object standards.

SECTION 4
STRUCTURAL CATEGORISATION, MATERIAL SELECTION AND INSPECTION PRINCIPLES

A. General

A 100 Scope

101 This section describes the structural categorisation, selection of steel materials and inspection principles to be applied in design and construction of offshore steel structures.

B. Temperatures for Selection of Material

B 100 General

101 The design temperature for a unit is the reference temperature for assessing areas where the unit can be transported, installed and operated.

The design temperature is to be lower or equal to the *lowest mean daily temperature* in air for the relevant areas. For seasonal restricted operations the *lowest mean daily temperature* in air for the season may be applied.

102 The service temperatures for different parts of a unit apply for selection of structural steel.

103 The service temperature for various structural parts is given in B200 and B300. In case different service temperatures are defined in B200 and B300 for a structural part the lower specified value shall be applied. Further details regarding service temperature for different structural elements are given in the various object standards.

104 In all cases where the temperature is reduced by localised cryogenic storage or other cooling conditions, such factors shall be taken into account in establishing the service temperatures for considered structural parts.

B 200 Floating units

201 External structures above the lowest waterline shall be designed with service temperature not higher than the *design temperature* for the area(s) where the unit is to operate.

202 External structures below the lowest waterline need not be designed for service temperatures lower than 0°C.

A higher service temperature may be accepted if adequate supporting data can be presented relative to *lowest mean daily temperature* applicable to the relevant actual water depths.

203 Internal structures in way of permanently heated rooms need not be designed for service temperatures lower than 0°C.

B 300 Bottom fixed units

301 External structures above the lowest astronomical tide (LAT) shall be designed with service temperature not higher than the *design temperature*.

302 Materials in structures below the lowest astronomical tide (LAT) need not be designed for service temperatures lower than 0°C.

A higher service temperature may be accepted if adequate supporting data can be presented relative to *lowest mean daily temperature* applicable to the relevant actual water depths.

C. Structural Category

C 100 General

101 The purpose of the structural categorisation is to assure adequate material and suitable inspection to avoid brittle fracture. The purpose of inspection is also to remove defects that may grow into fatigue cracks during service life.

Guidance note:

Conditions that may result in brittle fracture are sought avoided. Brittle fracture may occur under a combination of:

- presence of sharp defects such as cracks
- high tensile stress in direction normal to planar defect(s)
- material with low fracture toughness.

Sharp cracks resulting from fabrication may be found by inspection and repaired. Fatigue cracks may also be discovered during service life by inspection.

High stresses in a component may occur due to welding. A complex connection is likely to provide more restraint and larger residual stress than a simple one. This residual stress may be partly removed by post weld heat treatment if necessary. Also a complex connection shows a more three-dimensional stress state due to external loading than simple connections. This stress state may provide basis for a cleavage fracture.

The fracture toughness is dependent on temperature and material thickness. These parameters are accounted for separately in selection of material. The resulting fracture toughness in the weld and the heat affected zone is also dependent on the fabrication method.

Thus, to avoid brittle fracture, first a material with suitable fracture toughness for the actual service temperature and thickness is selected. Then a proper fabrication method is used. In special cases post weld heat treatment may be performed to reduce crack driving stresses, see D501 and DNV-OS-C401. A suitable amount of inspection is carried out to remove planar defects larger than that are acceptable. In this standard selection of material with appropriate fracture toughness and avoidance of unacceptable defects are achieved by linking different types of connections to different structural categories and inspection categories.

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C 200 Selection of structural category

201 Components are classified into structural categories according to the following criteria:

— significance of component in terms of consequence of failure
— stress condition at the considered detail that together with possible weld defects or fatigue cracks may provoke brittle fracture.

Guidance note:

The consequence of failure may be quantified in terms of residual strength of the structure when considering failure of the actual component.

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202 Structural category for selection of materials shall be determined according to principles given in Table C1.

Table C1 Structural categories for selection of materials 1)

Structural category	*Principles for determination of structural category*
Special	Structural parts where failure will have substantial consequences and are subject to a stress condition that may increase the probability of a brittle fracture.2)
Primary	Structural parts where failure will have substantial consequences.
Secondary	Structural parts where failure will be without significant consequence.

1) Examples of determination of structural categories are given in the various object standards.

2) In complex joints a triaxial or biaxial stress pattern will be present. This may give conditions for brittle fracture where tensile stresses are present in addition to presence of defects and material with low fracture toughness.

C 300 Inspection of welds

301 Requirements for type and extent of inspection are given in DNV-OS-C401 dependent on assigned inspection category for the welds. The requirements are based on the consideration of fatigue damage and assessment of general fabrication quality.

302 The inspection category is by default related to the structural category according to Table C2.

Table C2 Inspection categories

Inspection category	*Structural category*
I	Special
II	Primary
III	Secondary

303 The weld connection between two components shall be assigned an inspection category according to the highest of the joined components. For stiffened plates, the weld connection between stiffener and stringer and girder web to the plate may be inspected according to inspection category III.

304 If the fabrication quality is assessed by testing, or well known quality from previous experience, the extent of inspection required for elements within structural category *primary* may be reduced, but not less than for inspection category III.

305 Fatigue critical details within structural category *primary* and *secondary* shall be inspected according to requirements in category I.

306 Welds in fatigue critical areas not accessible for inspection and repair during operation shall be inspected according to requirements in category I during construction.

307 The extent of NDT for welds in block joints and erection joints transverse to main stress direction shall not be less than for IC II.

D. Structural Steel

D 100 General

101 Where the subsequent requirements for steel grades are dependent on plate thickness, these are based on the nominal thickness as built.

102 The requirements in this subsection deal with the selection of various structural steel grades in compliance with the requirements given in DNV-OS-B101. Where other, agreed codes or standards have been utilised in the specification of steels, the application of such steel grades within the structure shall be specially considered.

103 The steel grades selected for structural components shall be related to calculated stresses and requirements to toughness properties. Requirements for toughness properties are in general based on the Charpy V-notch test and are dependent on service temperature, structural category and thickness of the component in question.

104 The material toughness may also be evaluated by fracture mechanics testing in special cases, see D401 and DNV-OS-C401.

105 In structural cross-joints where high tensile stresses are acting perpendicular to the plane of the plate, the plate material shall be tested to prove the ability to resist lamellar tearing, Z-quality, see 203.

106 Requirements for forging and castings are given in DNV-OS-B101.

D 200 Material designations

201 Structural steel of various strength groups will be referred to as given in Table D1.

202 Each strength group consists of two parallel series of steel grades:

— steels of normal weldability
— steels of improved weldability.

The two series are intended for the same applications. However, the improved weldability grades have in addition to leaner chemistry and better weldability, extra margins to account for reduced toughness after welding. These grades are also limited to a specified minimum yield stress of 500 N/mm^2.

Table D1 Material designations

Designation	*Strength group*	*Specified minimum yield stress* f_y (N/mm^2)$^{1)}$
NV	Normal strength steel (NS)	235
NV-27	High strength steel (HS)	265
NV-32		315
NV-36		355
NV-40		390
NV-420	Extra high strength steel (EHS)	420
NV-460		460
NV-500		500
NV-550		550
NV-620		620
NV-690		690

1) For steels of improved weldability the required specified minimum yield stress is reduced for increasing material thickness, see DNV-OS-B101.

203 Different steel grades are defined within each strength group, depending upon the required impact toughness properties. The grades are referred to as A, B, D, E, and F for normal weldability, and AW, BW, DW, and EW for improved weldability, as shown in Table D2.

Additional symbol:

Z = steel grade of proven through-thickness properties. This symbol is omitted for steels of improved weldability although improved through-thickness properties are required.

Table D2 Applicable steel grades			
Strength group	*Grade*		*Test temperature3) (ºC)*
	Normal weldability	*Improved weldability2)*	
NS	A	-	Not tested
	B 1)	BW	0
	D	DW	-20
	E	EW	-40
HS	A	AW	0
	D	DW	-20
	E	EW	-40
	F	-	-60
EHS	A	-	0
	D	DW	-20
	E	EW	-40
	F	-	-60

1) Charpy V-notch tests are required for thickness above 25 mm but are subject to agreement between the contracting parties for thickness of 25 mm or less.
2) For steels with improved weldability, through-thickness properties are specified, see DNV-OS-B101.
3) Charpy V-notch impact tests, see DNV-OS-B101.

D 300 Selection of structural steel

301 The grade of steel to be used shall in general be related to the service temperature and thickness for the applicable structural category as shown in Table D3.

Table D3 Thickness limitations (mm) of structural steels for different structural categories and service temperatures (ºC)

Structural Category	*Grade*	*≥ 10*	*0*	*-10*	*-20*	*-25*	*-30*
Secondary	A	35	30	25	20	15	10
	B/BW	70	60	50	40	30	20
	D/DW	150	150	100	80	70	60
	E/EW	150	150	150	150	120	100
	AH/AHW	60	50	40	30	20	15
	DH/DHW	120	100	80	60	50	40
	EH/EHW	150	150	150	150	120	100
	FH	150	150	150	150	*)	*)
	AEH	70	60	50	40	30	20
	DEH/DEHW	150	150	100	80	70	60
	EEH/EEHW	150	150	150	150	120	100
	FEH	150	150	150	150	*)	*)
Primary	A	30	20	10	N.A.	N.A.	N.A.
	B/BW	40	30	25	20	15	10
	D/DW	70	60	50	40	35	30
	E/EW	150	150	100	80	70	60
	AH/AHW	30	25	20	15	12.5	10
	DH/DHW	60	50	40	30	25	20
	EH/EHW	120	100	80	60	50	40
	FH	150	150	150	150	*)	*)
	AEH	35	30	25	20	17.5	15
	DEH/DEHW	70	60	50	40	35	30
	EEH/EEHW	150	150	100	80	70	60
	FEH	150	150	150	150	*)	*)
Special	D/DW	35	30	25	20	17.5	15
	E/EW	70	60	50	40	35	30
	AH/AHW	15	10	N.A.	N.A.	N.A.	N.A.
	DH/DHW	30	25	20	15	12.5	10
	EH/EHW	60	50	40	30	25	20
	FH	120	100	80	60	50	40
	AEH	20	15	10	N.A.	N.A	N.A.
	DEH/DEHW	35	30	25	20	17.5	15
	EEH/EEHW	70	60	50	40	35	30
	FEH	150	150	100	80	70	60

*) For service temperature below -20°C the upper limit for use of this grade must be specially considered.

N.A. = no application

302 Selection of a better steel grade than minimum required in design shall not lead to more stringent requirements in fabrication.

303 Grade of steel to be used for thickness less than 10 mm and/or service temperature above 10 °C may be specially considered.

304 Welded steel plates and sections of thickness exceeding the upper limits for the actual steel grade as given in Table D3 shall be evaluated in each individual case with respect to the fitness for purpose of the weldments. The evaluation should be based on fracture mechanics testing and analysis, e.g. in accordance with BS 7910.

305 For structural parts subjected to compressive and/or low tensile stresses, consideration may be given to the use of lower steel grades than stated in Table D3.

306 The use of steels with specified minimum yield stress greater than 550 N/mm^2 (NV550) shall be subject to special consideration for applications where anaerobic environmental conditions such as stagnant water, organically active mud (bacteria) and hydrogen sulphide may predominate.

307 Predominantly anaerobic conditions can for this purpose be characterised by a concentration of sulphate reducing bacteria, SRB, in the order of magnitude $>10^3$ SRB/ml (method according to NACE TPC Publication No.3).

308 The steels' susceptibility to hydrogen induced stress cracking (HISC) shall be specially considered when used for critical applications (such as jack-up legs and spud cans). See also Sec.10.

D 400 Fracture mechanics (FM) testing

401 For units which are intended to operate continuously at the same location for more than 5 years, FM testing shall be included in the qualification of welding procedures for joints which all of the following apply:

— the design temperature is lower than +10ºC
— the joint is in special area
— at least one of the adjoining members is fabricated from steel with a SMYS larger than or equal to 420 MPa.

For details on FM testing methods, see DNV-OS-C401 Ch.2 Sec.1 C900.

D 500 Post weld heat treatment (PWHT)

501 For units which are intended to operate continuously at the same location for more than 5 years, PWHT shall be applied for joints in C-Mn steels in special areas when the material thickness at the welds exceeds 50mm. For details, see DNV-OS-C401 Ch.2 Sec.2 F200.

If, however, satisfactory performance in the as-welded condition can be documented by a fitness-for-purpose assessment applying fracture mechanics testing, fracture mechanics and fatigue crack growth analyses, PWHT may be omitted.

SECTION 5
ULTIMATE LIMIT STATES

A. General

A 100 General

101 This section gives provisions for checking of ultimate limit states for typical structural elements used in offshore steel structures.

102 The ultimate strength capacity (yield and buckling) of structural elements shall be assessed using a rational, justifiable, engineering approach.

103 Structural capacity checks of all structural components shall be performed. The capacity checks shall consider both excessive yielding and buckling.

104 Simplified assumptions regarding stress distributions may be used provided the assumptions are made in accordance with generally accepted practice, or in accordance with sufficiently comprehensive experience or tests.

105 Gross scantlings may be utilised in the calculation of hull structural strength, provided a corrosion protection system in accordance with Sec.10 is installed and maintained.

106 In case corrosion protection in accordance with Sec.10 is not installed (and maintained) corrosion additions as given in Sec.10 B407 shall be used. The corrosion addition shall not be accounted for in the determination of stresses and resistance for local capacity checks.

A 200 Structural analysis

201 The structural analysis may be carried out as linear elastic, simplified rigid-plastic, or elastic-plastic analyses. Both first order or second order analyses may be applied. In all cases, the structural detailing with respect to strength and ductility requirement shall conform to the assumption made for the analysis.

202 When plastic or elastic-plastic analyses are used for structures exposed to cyclic loading, e.g. wave loads, checks shall be carried out to verify that the structure will shake down without excessive plastic deformations or fracture due to repeated yielding. A characteristic or design cyclic load history needs to be defined in such a way that the structural reliability in case of cyclic loading, e.g. storm loading, is not less than the structural reliability for ULS for non-cyclic loads.

203 In case of linear analysis combined with the resistance formulations set down in this standard, shakedown can be assumed without further checks.

204 If plastic or elastic-plastic structural analyses are used for determining the sectional stress resultants, limitations to the width thickness ratios apply. Relevant width thickness ratios are found in the relevant codes used for capacity checks.

205 When plastic analysis and/or plastic capacity checks are used (cross section type I and II, according to Appendix A), the members shall be capable of forming plastic hinges with sufficient rotation capacity to enable the required redistribution of bending moments to develop. It shall also be checked that the load pattern will not be changed due to the deformations.

206 Cross sections of beams are divided into different types dependent of their ability to develop plastic hinges. A method for determination of cross sectional types is found in Appendix A.

A 300 Ductility

301 It is a fundamental requirement that all failure modes are sufficiently ductile such that the structural behaviour will be in accordance with the anticipated model used for determination of the responses. In general all design procedures, regardless of analysis method, will not capture the true structural behaviour. Ductile failure modes will allow the structure to redistribute forces in accordance with the presupposed static model. Brittle failure modes shall therefore be avoided or shall be verified to have excess resistance compared to ductile modes, and in this way protect the structure from brittle failure.

302 The following sources for brittle structural behaviour may need to be considered for a steel structure:

- unstable fracture caused by a combination of the following factors: brittle material, low temperature in the steel, a design resulting in high local stresses and the possibilities for weld defects
- structural details where ultimate resistance is reached with plastic deformations only in limited areas, making the global behaviour brittle
- shell buckling
- buckling where interaction between local and global buckling modes occurs.

A 400 Yield check

401 Structural members for which excessive yielding are possible modes of failure shall be investigated for yielding.

Individual design stress components and the von Mises equivalent design stress for plated structures shall not exceed the design resistance (Sec.2 D200).

Guidance note:

a) For plated structures the von Mises equivalent design stress is defined as follows:

$$\sigma_{jd} = \sqrt{\sigma_{xd}^2 + \sigma_{yd}^2 - \sigma_{xd}\sigma_{yd} + 3\tau_d^2}$$

where σ_{xd} and σ_{yd} are design membrane stresses in x- and y-direction respectively, τ_d is design shear stress in the x-y plane (i.e. local bending stresses in plate thickness not included).

b) In case local plate bending stresses are of importance for yield check, e.g for lateral loaded plates, yield check may be performed according to DNV-RP-C201 Part 1 Sec.5.

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402 Local peak stresses from linear elastic analysis in areas with pronounced geometrical changes, may exceed the yield stress provided the adjacent structural parts has capacity for the redistributed stresses.

Guidance note:

a) Areas above yield determined by a linear finite element method analysis may give an indication of the actual area of plastification. Otherwise, a non-linear finite element method analysis may need to be carried out in order to trace the full extent of the plastic zone.

b) The yield checks do not refer to local stress concentrations in the structure or to local modelling deficiencies in the finite element model.

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403 For yield check of welded connections, see Sec.9.

A 500 Buckling check

501 Elements of cross sections not fulfilling requirements to cross section type III shall be checked for local buckling.

Cross sectional types are defined in Appendix A.

502 Buckling analysis shall be based on the characteristic buckling resistance for the most unfavourable buckling mode.

503 The characteristic buckling strength shall be based on the 5^{th} percentile of test results.

504 Initial imperfections and residual stresses in structural members shall be accounted for.

505 It shall be ensured that there is conformity between the initial imperfections in the buckling resistance formulas and the tolerances in the applied fabrication standard.

Guidance note:

If buckling resistance is calculated in accordance with DNV-RP-C201 for plated structures, DNV-RP-C202 for shells, or Classification Note 30.1 for bars and frames, the tolerance requirements given in DNV-OS-C401 should not be exceeded, unless specifically documented.

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B. Flat Plated Structures and Stiffened Panels

B 100 General

101 The material factor γ_M for plated structures is 1.15.

B 200 Yield check

201 Yield check of plating and stiffeners may be performed as given in F.

202 Yield check of girders may be performed as given in G.

B 300 Buckling check

301 The buckling stability of plated structures may be checked according to DNV-RP-C201.

B 400 Capacity checks according to other codes

401 Stiffeners and girders may be designed according to provisions for beams in recognised standards such as Eurocode 3 or AISC LRFD Manual of Steel Construction.

Guidance note:

The principles and effects of cross section types are included in the AISC LRFD Manual of Steel Construction.

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402 Material factors when using Eurocode 3 are given in Table B1.

Table B1 Material factors used with Eurocode 3

Type of calculation	*Material factor* [1)]	*Value*
Resistance of Class 1, 2 or 3 cross sections	γ_{M0}	1.15
Resistance of Class 4 cross sections	γ_{M1}	1.15
Resistance of members to buckling	γ_{M1}	1.15

1) Symbols according to Eurocode 3.

403 Plates, stiffeners and girders may be designed according to NORSOK N-004.

C. Shell Structures

C 100 General

101 The buckling stability of cylindrical and un-stiffened conical shell structures may be checked according to DNV-RP-C202.

102 For interaction between shell buckling and column buckling, DNV-RP-C202 may be used.

103 If DNV-RP-C202 is applied, the material factor for shells shall be in accordance with Table C1.

Table C1 Material factors γ_M for buckling

Type of structure	$\lambda \leq 0.5$	$0.5 < \lambda < 1.0$	$\lambda \geq 1.0$
Girder, beams stiffeners on shells	1.15	1.15	1.15
Shells of single curvature (cylindrical shells, conical shells)	1.15	$0.85 + 0.60\,\lambda$	1.45

Note that the slenderness is based on the buckling mode under consideration.

λ	=	reduced slenderness parameter
	=	$\sqrt{\frac{f_y}{f_E}}$
f_y	=	specified minimum yield stress
f_E	=	elastic buckling stress for the buckling mode under consideration.

D. Tubular Members, Tubular Joints and Conical Transitions

D 100 General

101 Tubular members may be checked according to Classification Note 30.1, API RP 2A - LRFD or NORSOK N-004.

For interaction between local shell buckling and column buckling, and effect of external pressure, DNV-RP-C202 may be used.

102 Cross sections of tubular member are divided into different types dependent of their ability to develop plastic hinges and resist local buckling. Effect of local buckling of slender cross sections shall be considered.

Guidance note:

a) Effect of local buckling of tubular members without external pressure (i.e. subject to axial force and/or bending moment) are given in Appendix A, cross section type IV. Section 3.8 of DNV-RP-C202 may be used, see C100.

b) Effect of local buckling of tubular members with external pressure need not be considered for the following diameter (D) to thickness (t) ratio:

$$\frac{D}{t} \leq 0.5\sqrt{\frac{E}{f_y}}$$

where

E = modulus of elasticity, and
f_y = specified minimum yield stress.

In case of local shell buckling, see C100, section 3.8 of DNV-RP-C202, API RP 2A - LRFD or NORSOK N-004 may be used.

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103 Tubular joints and conical transitions may be checked according to API RP 2A - LRFD or NORSOK N-004.

104 The material factor γ_M for tubular structures is 1.15.

E. Non-Tubular Beams, Columns and Frames

E 100 General

101 The design of members shall take into account the possible limits on the resistance of the cross section due to local buckling.

Guidance note:

Cross sections of member are divided into different types dependent of their ability to develop plastic hinges and resist local buckling, see Appendix A. In case of local buckling, i.e. for cross sectional type IV, DNV-RP-C201 may be used.

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102 Buckling checks may be performed according to Classification Note 30.1.

103 Capacity check may be performed according to recognised standards such as Eurocode 3 or AISC LRFD Manual of Steel Construction.

104 The material factors according to Table B1 shall be used if Eurocode 3 is used for calculation of structural resistance.

F. Special Provisions for Plating and Stiffeners

F 100 Scope

101 The requirements in F will normally give minimum scantlings to plate and stiffened panels with respect to yield. Dimensions and further references with respect to buckling capacity are given in B.

F 200 Minimum thickness

201 The thickness of plates should not to be less than:

$$t = \frac{14.3 t_0}{\sqrt{f_{yd}}} \quad \text{(mm)}$$

f_{yd} = design yield strength f_y/γ_M
f_y is the minimum yield stress (N/mm^2) as given in Sec.4 Table D1
t_0 = 7 mm for primary structural elements
= 5 mm for secondary structural elements
γ_M = material factor for steel
= 1.15.

F 300 Bending of plating

301 The thickness of plating subjected to lateral pressure shall not be less than:

$$t = \frac{15{,}8 k_a s \sqrt{p_d}}{\sqrt{\sigma_{pd1} k_{pp}}} \quad (mm)$$

k_a = correction factor for aspect ratio of plate field
= $(1.1 - 0.25\ s/l)^2$
= maximum 1.0 for $s/l = 0.4$
= minimum 0.72 for $s/l = 1.0$
s = stiffener spacing (m), measured along the plating
p_d = design pressure (kN/m^2) as given in Sec.3
σ_{pd1} = design bending stress (N/mm^2), taken as the smaller of:

- 1.3 ($f_{yd} - \sigma_{jd}$), and
- $f_{yd} = f_y / \gamma_M$

σ_{jd} = equivalent design stress for global in-plane membrane stress:

$$\sigma_{jd} = \sqrt{\sigma_{xd}^2 + \sigma_{yd}^2 - \sigma_{xd}\sigma_{yd} + 3\tau_d^2}$$

k_{pp} = fixation parameter for plate
= 1.0 for clamped edges
= 0.5 for simply supported edges.

Guidance note:

The design bending stress σ_{pd1} is given as a bi-linear capacity curve for the plate representing the remaining capacity of plate when reduced for global in-plane membrane stress.

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F 400 Stiffeners

401 The section modulus Z_s for longitudinals, beams, frames and other stiffeners subjected to lateral pressure shall not be less than:

$$Z_s = \frac{l^2 s p_d}{k_m \sigma_{pd2} k_{ps}} 10^6 (mm^3),\ \text{minimum } 15 \cdot 10^3\ (mm^3)$$

l = stiffener span (m)
k_m = bending moment factor, see Table G1
σ_{pd2} = design bending stress (N/mm^2)
= $f_{yd} - \sigma_{jd}$
k_{ps} = fixation parameter for stiffeners
= 1.0 if at least one end is clamped
= 0.9 if both ends are simply supported.

Guidance note:

The section modulus Z_s will typically be calculated for plate side and stiffener flange side.

The design bending stress σ_{pd2} for plate side is given as a linear capacity curve for the plate representing the remaining capacity of plate when reduced for global in-plane membrane stress (longitudinal, transverse and shear stresses).

The design bending stress for stiffener flange side is given as a linear capacity curve for the stiffener flange representing the remaining capacity of stiffener when reduced for global longitudinal membrane stress.

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402 The requirement in 401 applies to an axis parallel to the plating. For stiffeners at an oblique angle with the plating an approximate requirement to standard section modulus may be obtained by multiplying the section modulus from 401 with the factor:

$$\frac{1}{\cos\alpha}$$

α = angle between the stiffener web plane and the plane perpendicular to the plating.

403 Stiffeners with sniped ends may be accepted where dynamic stresses are small and vibrations are considered to be of small importance, provided that the plate thickness supported by the stiffener is not less than:

$$t \geq 16 \sqrt{\frac{(l - 0.5s)sp_d}{f_{yd}}} \quad (mm)$$

In such cases the section modulus of the stiffener calculated as indicated in 401 is normally to be based on the following parameter values:

k_m = 8
k_{ps} = 0.9

The stiffeners should normally be snipped with an angle of maximum 30º.

Guidance note:
For typical sniped end detail as described above, a stress range lower than 30 MPa can be considered as a small dynamic stress.

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G. Special Provisions for Girder and Girder Systems

G 100 Scope

101 The requirements in G give minimum scantlings to simple girders with respect to yield. Further, procedures for the calculations of complex girder systems are indicated.

102 Dimensions and further references with respect to buckling capacity are given in B.

G 200 Minimum thickness

201 The thickness of web and flange plating shall not be less than given in F200 and F300.

G 300 Bending and shear

301 The requirements for section modulus and web area are applicable to simple girders supporting stiffeners or other girders exposed to linearly distributed lateral pressure. It is assumed that the girder satisfies the basic assumptions of simple beam theory, and that the supported members are approximately evenly spaced and has similar support conditions at both ends. Other loads will have to be specially considered.

302 When boundary conditions for individual girders are not predictable due to dependence of adjacent structures, direct calculations according to the procedures given in 700 shall be carried out.

303 The section modulus and web area of the girder shall be taken in accordance with particulars as given in 400 and 500. Structural modelling in connection with direct stress analysis shall be based on the same particulars when applicable.

G 400 Effective flange

401 The effective plate flange area is defined as the cross sectional area of plating within the effective flange width. The cross section area of continuous stiffeners within the effective flange may be included. The effective flange width b_e is determined by the following formula:

$$b_e = C_e b$$

C_e = parameter given in Fig.1 for various numbers of evenly spaced point loads (N_p) on the girder span
b = full breadth of plate flange (m), e.g. span of the supported stiffeners, or distance between girders, see also 602.
l_0 = distance between points of zero bending moments (m)
= S for simply supported girders
= 0.6 S for girders fixed at both ends
S = girder span as if simply supported, see also 602.

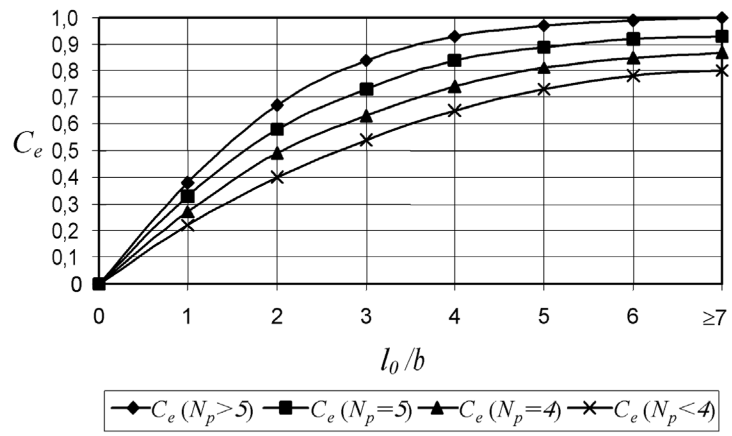


Figure 1
Graphs for the effective flange parameter C_e

G 500 Effective web

501 Holes in girders will generally be accepted provided the shear stress level is acceptable and the buckling capacity and fatigue life is documented to be sufficient.

G 600 Strength requirements for simple girders

601 Simple girders subjected to lateral pressure and which are not taking part in the overall strength of the structure, shall comply with the following minimum requirements:

— section modulus according to 602
— web area according to 603.

602 *Section modulus Z_g*

$$Z_g = \frac{S^2 b p_d}{k_m \sigma_{pd2}} 10^6 \quad (mm^3)$$

S = girder span (m). The web height of in-plane girders may be deducted. When brackets are fitted at the ends, the girder span S may be reduced by two thirds of the bracket arm length, provided the girder ends may be assumed clamped and provided the section modulus at the bracketed ends is satisfactory

b = breadth of load area (m) (plate flange), b may be determined as:
= 0.5 ($l_1 + l_2$), l_1 and l_2 are the spans of the supported stiffeners on both sides of the girder, respectively, or distance between girders

p_d = design pressure (kN/m^2) as given in Sec.3

k_m = bending moment factor, see 604

σ_{pd2} = design bending stress (N/mm^2), see F401

σ_{jd} = equivalent design stress for global in-plane membrane stress.

$$\sigma_{jd} = \sqrt{\sigma_{xd}^2 + \sigma_{yd}^2 - \sigma_{xd}\sigma_{yd} + 3\tau_d^2}$$

603 *Web area A_w*

$$A_w = \frac{k_\tau S b p_d - N_s P_{pd}}{\tau_{pd}} 10^3 \quad (mm^2)$$

k_τ = shear force factor, see 604.

N_s = number of stiffeners between considered section and nearest support
The N_s-value shall in no case be taken greater than $(N_p+1)/4$.

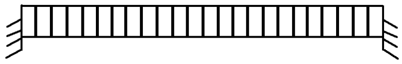
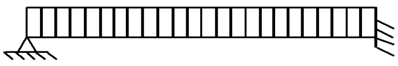
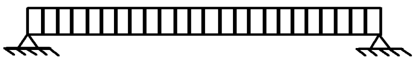
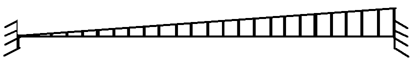
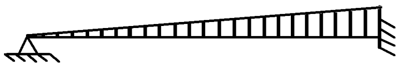
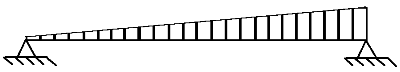
N_p = number of supported stiffeners on the girder span

P_{pd} = average design point load (kN) from stiffeners between considered section and nearest support

τ_{pd} = 0.5 f_{yd} (N/mm^2).

604 The k_m- and k_τ-values referred to in 602 and 603 may be calculated according to general beam theory. In Table G1 k_m- and k_τ-values are given for some defined load and boundary conditions. Note that the smallest k_m-value shall be applied to simple girders. For girders where brackets are fitted or the flange area has been partly increased due to large bending moment, a larger k_m-value may be used outside the strengthened region.

Table G1 Values of k_m and k_τ

Load and boundary conditions			*Bending moment and shear force factors*		
Positions			1	2	3
1 Support	2 Field	3 Support	k_{m1} $k_{\tau 1}$	k_{m2} -	k_{m3} $k_{\tau 3}$
			12 0.5	24	12 0.5
			0.38	14.2	8 0.63
			0.5	8	0.5
			15 0.3	23.3	10 0.7
			0.2	16.8	7.5 0.8
			0.33	7.8	0.67

G 700 Complex girder system

701 For girders that are parts of a complex 2- or 3-dimensional structural system, a complete structural analysis shall be carried out.

702 Calculation methods or computer programs applied shall take into account the effects of bending, shear, axial and torsional deformation.

703 The calculations shall reflect the structural response of the 2- or 3-dimensional structure considered, with due attention to boundary conditions.

704 For systems consisting of slender girders, calculations based on beam theory (frame work analysis) may be applied, with due attention to:

— shear area variation, e.g. cut-outs
— moment of inertia variation
— effective flange
— lateral buckling of girder flanges.

705 The most unfavourable of the loading conditions given in Sec.3 shall be applied.

706 For girders taking part in the overall strength of the unit, stresses due to the design pressures given in Sec.3 shall be combined with relevant overall stresses.

H. Slip Resistant Bolt Connections

H 100 General

101 The requirements in H give the slip capacity of pre-tensioned bolt connections with high-strength bolts.

102 A high strength bolt is defined as bolts that have ultimate tensile strength larger than 800 N/mm^2 with yield strength set as minimum 80% of ultimate tensile strength.

103 The bolt shall be pre-tensioned in accordance with international recognised standards. Procedures for measurement and maintenance of the bolt tension shall be established.

104 The design slip resistance R_d may be specified equal or higher than the design loads F_d.

$$R_d \geq F_d$$

105 In addition, the slip resistant connection shall have the capacity to withstand ULS and ALS loads as a bearing bolt connection. The capacity of a bolted connection may be determined according to international recognised standards which give equivalent level of safety such as Eurocode 3 or AISC LRFD Manual of Steel Construction.

106 The design slip resistance of a preloaded high-strength bolt shall be taken as:

$$R_d = \frac{k_s n \mu}{\gamma_{Ms}} F_{pd}$$

k_s = hole clearance factor
= 1.00 for standard clearances in the direction of the force
= 0.85 for oversized holes
= 0.70 for long slotted holes in the direction of the force
n = number of friction interfaces
μ = friction coefficient
γ_{Ms} = 1.25 for standard clearances in the direction of the force
= 1.4 for oversize holes or long slotted holes in the direction of the force
= 1.1 for design shear forces with load factor 1.0.
F_{pd} = design preloading force.

107 For high strength bolts, the controlled design pre-tensioning force in the bolts used in slip resistant connections are:

$$F_{pd} = 0.7 f_{ub} A_s$$

f_{ub} = ultimate tensile strength of the bolt
A_s = tensile stress area of the bolt (net area in the threaded part of the bolt).

108 The design value of the friction coefficient μ is dependent on the specified class of surface treatment. The value of μ shall be taken according to Table H1.

Table H1 Friction coefficient μ

Surface category	μ
A	0.5
B	0.4
C	0.3
D	0.2

109 The classification of any surface treatment shall be based on tests or specimens representative of the surfaces used in the structure, see also DNV-OS-C401 Ch.2 Sec.6.

110 The surface treatments given in Table H2 may be categorised without further testing.

Table H2 Surface treatment

Surface category	*Surface treatment*
A	Surfaces blasted with shot or grit, - with any loose rust removed, no pitting - spray metallised with aluminium - spray metallised with a zinc-based coating certified to prove a slip factor of not less than 0.5
B	Surfaces blasted with shot or grit, and painted with an alkali-zinc silicate paint to produce a coating thickness of 50 to 80 mm
C	Surfaces cleaned by wire brushing or flame cleaning, with any loose rust removed
D	Surfaces not treated

111 Normal clearance for fitted bolts shall be assumed if not otherwise specified. The clearances are defined in Table H3.

Table H3 Clearances in bolt holes		
Clearance type	*Clearance mm*	*Bolt diameter d (maximum) mm*
Standard	1	12 and 14
	2	16 to 24
	3	27 and larger bolts
Oversized	3	12
	4	14 to 22
	6	24
	8	27

112 Oversized holes in the outer ply of a slip resistant connection shall be covered by hardened washers.

113 The nominal sizes of short slotted holes for slip resistant connections shall not be greater than given in Table H4.

Table H4 Short slotted holes	
Maximum size mm	*Bolt diameter d (maximum) mm*
(d + 1) by (d + 4)	12 and 14
(d + 2) by (d + 6)	16 to 22
(d + 2) by (d + 8)	24
(d + 3) by (d + 10)	27 and larger

114 The nominal sizes of long slotted holes for slip resistant connections shall not be greater than given in Table H5.

Table H5 Long slotted holes	
Maximum size mm	*Bolt diameter d (maximum) mm*
(d + 1) by 2.5 d	12 and 14
(d + 2) by 2.5 d	16 to 24
(d + 3) by 2.5 d	27 and larger

115 Long slots in an outer ply shall be covered by cover plates of appropriate dimensions and thickness. The holes in the cover plate shall not be larger than standard holes.

SECTION 6
FATIGUE LIMIT STATES

A. General

A 100 General

101 In this standard, requirements are given in relation to fatigue analyses based on fatigue tests and fracture mechanics. Reference is made to DNV-RP-C203 and Classification Note 30.7 for practical details with respect to fatigue design of offshore structures. See also Sec.2 B105.

102 The aim of fatigue design is to ensure that the structure has an adequate fatigue life. Calculated fatigue lives should also form the basis for efficient inspection programmes during fabrication and the operational life of the structure.

103 The resistance against fatigue is normally given as S-N curves, i.e. stress range (S) versus number of cycles to failure (N) based on fatigue tests. Fatigue failure should be defined as when the crack has grown through the thickness.

104 The S-N curves shall in general be based on a 97.6% probability of survival, corresponding to the mean-minus-two-standard-deviation curves of relevant experimental data.

105 The design fatigue life for structural components should be based on the specified service life of the structure. If a service life is not specified, 20 years should be used.

106 To ensure that the structure will fulfil the intended function, a fatigue assessment shall be carried out for each individual member which is subjected to fatigue loading. Where appropriate, the fatigue assessment shall be supported by a detailed fatigue analysis. It shall be noted that any element or member of the structure, every welded joint and attachment or other form of stress concentration is potentially a source of fatigue cracking and should be individually considered.

107 The analyses shall be performed utilising relevant site specific environmental data for the area(s) in which the unit will be operated. The restrictions shall be described in the Operation Manual for the unit.

108 For world wide operation the analyses shall be performed utilising environmental data (e.g. scatter diagram, spectrum) given in DNV-RP-C205. The North Atlantic scatter diagram shall be utilised.

A 200 Design fatigue factors

201 Design fatigue factors (DFF) shall be applied to reduce the probability for fatigue failures.

202 The DFFs are dependent on the significance of the structural components with respect to structural integrity and availability for inspection and repair.

203 DFFs shall be applied to the design fatigue life. The calculated fatigue life shall be longer than the design fatigue life times the DFF.

204 The design requirement may alternatively be expressed as the cumulative damage ratio for the number of load cycles of the defined design fatigue life multiplied with the DFF shall be less or equal to 1.0.

205 The design fatigue factors in Table A1 are valid for units with low consequence of failure and where it can be demonstrated that the structure satisfies the requirement to damaged condition according to the ALS with failure in the actual element as the defined damage.

Table A1 Design fatigue factors (DFF)

DFF	*Structural element*
1	Internal structure, accessible and not welded directly to the submerged part.
1	External structure, accessible for regular inspection and repair in dry and clean conditions.
2	Internal structure, accessible and welded directly to the submerged part.
2	External structure not accessible for inspection and repair in dry and clean conditions.
3	Non-accessible areas, areas not planned to be accessible for inspection and repair during operation.

Guidance note:

Units intended to follow normal inspection schedule according to class requirements, i.e. the 5-yearly inspection interval in sheltered waters or drydock, may apply a Design Fatigue Factor (DFF) of 1. Units that are planned to be inspected afloat at a sheltered location the DFF for areas above 1 m above lowest inspection waterline should be taken as 1, and below this line the DFF is 2 for the outer shell. Splash zone is defined as non-accessible area (see splash zone definition in Sec.10 B200).

Where the likely crack propagation develops from a location which is accessible for inspection and repair to a structural element having no access, such location should itself be deemed to have the same categorisation as the most demanding category when considering the most likely crack path. For example, a weld detail on the inside (dry space) of a submerged shell plate should be allocated the same DFF as that relevant for a similar weld located externally on the plate.

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206 The design fatigue factors shall be based on special considerations where fatigue failure will entail substantial consequences such as:

— danger of loss of human life, i.e. not compliance with ALS criteria
— significant pollution
— major economical consequences.

Guidance note:
Evaluation of likely crack propagation paths (including direction and growth rate related to the inspection interval), may indicate the use of a different DFF than that which would be selected when the detail is considered in isolation. E.g. where the likely crack propagation indicates that a fatigue failure starting in a non critical area grows such that there might be a substantial consequence of failure, such fatigue sensitive location should itself be deemed to have a substantial consequence of failure.

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207 Welds beneath positions 150 m below water level should be assumed inaccessible for in-service inspection.

208 The various object standards define the design fatigue factors to be applied for typical structural details.

A 300 Methods for fatigue analysis

301 The fatigue analysis should be based on S-N data, determined by fatigue testing of the considered welded detail, and the linear damage hypothesis. When appropriate, the fatigue analysis may alternatively be based on fracture mechanics.

302 In fatigue critical areas where the fatigue life estimate based on simplified methods is below the acceptable limit, a more accurate investigation or a fracture mechanics analysis shall be performed.

303 For calculations based on fracture mechanics, it should be documented that the in-service inspections accommodate a sufficient time interval between time of crack detection and the time of unstable fracture. See DNV-RP-C203 for more details.

304 All significant stress ranges, which contribute to fatigue damage in the structure, shall be considered. The long term distribution of stress ranges may be found by deterministic or spectral analysis. Dynamic effects shall be duly accounted for when establishing the stress history.

SECTION 7
ACCIDENTAL LIMIT STATES

A. General

A 100 General

101 The ALS shall in principle be assessed for all units. Safety assessment is carried out according to the principles given in DNV-OS-A101.

102 The material factor γ_M for the ALS is 1.0.

103 Structures shall be checked in ALS in two steps:

a) Resistance of the structure against design accidental loads.
b) Post accident resistance of the structure against environmental loads should only be checked when the resistance is reduced by structural damage caused by the design accidental loads.

104 The overall objective of design against accidental loads is to achieve a system where the main safety functions are not impaired by the design accidental loads.

105 The design against accidental loads may be done by direct calculation of the effects imposed by the loads on the structure, or indirectly, by design of the structure as tolerable to accidents. Examples of the latter are compartmentation of floating units which provides sufficient integrity to survive certain collision scenarios without further calculations.

Guidance note:
Recommendations for design of structures exposed to accidental events can be found in DNV-RP-C204.

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106 The inherent uncertainty of the frequency and magnitude of the accidental loads, as well as the approximate nature of the methods for determination of accidental load effects, shall be recognised. It is therefore essential to apply sound engineering judgement and pragmatic evaluations in the design.

107 If non-linear, dynamic finite element analysis is applied for design, it shall be verified that all local failure mode, e.g. strain rate, local buckling, joint overloading, joint fracture, are accounted for implicitly by the modelling adopted, or else subjected to explicit evaluation.

Typical accidental loads are:

— impact from ship collisions
— impact from dropped objects
— fire
— explosions
— abnormal environmental conditions
— accidental flooding.

108 The different types of accidental loads require different methods and analyses to assess the structural resistance.

SECTION 8
SERVICEABILITY LIMIT STATES

A. General

A 100 General

101 Serviceability limit states for offshore steel structures are associated with:

— deflections which may prevent the intended operation of equipment
— deflections which may be detrimental to finishes or non-structural elements
— vibrations which may cause discomfort to personnel
— deformations and deflections which may spoil the aesthetic appearance of the structure.

A 200 Deflection criteria

201 For calculations in the serviceability limit states $\gamma_M = 1.0$

202 Limiting values for vertical deflections should be given in the design brief. In lieu of such deflection criteria limiting values given in Table A1 may be used.

Table A1 Limiting values for vertical deflections

Condition	*Limit for* δ_{max}	*Limit for* δ_2
Deck beams	$\frac{L}{200}$	$\frac{L}{300}$
Deck beams supporting plaster or other brittle finish or non- flexible partitions	$\frac{L}{250}$	$\frac{L}{350}$
L is the span of the beam. For cantilever beams L is twice the projecting length of the cantilever.		

203 The maximum vertical deflection is:

$$\delta_{max} = \delta_1 + \delta_2 - \delta_0$$

δ_{max} = the sagging in the final state relative to the straight line joining the supports
δ_0 = the pre-camber
δ_1 = the variation of the deflection of the beam due to the permanent loads immediately after loading
δ_2 = the variation of the deflection of the beam due to the variable loading plus any time dependent deformations due to the permanent load

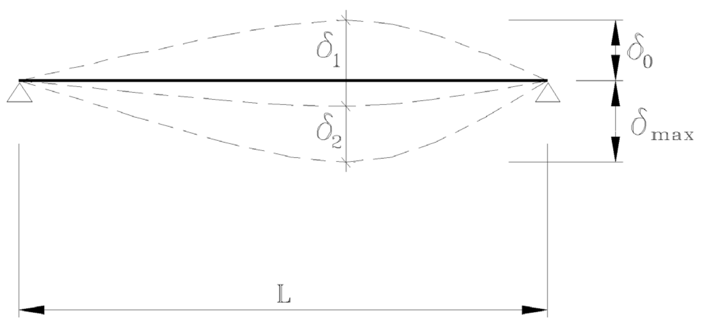

Figure 1
Definitions of vertical deflections

204 Shear lag effects need to be considered for beams with wide flanges.

A 300 Out of plane deflection of local plates

301 Check of serviceability limit states for slender plates related to out of plane deflection may be omitted if the smallest span of the plate is less than 150 times the plate thickness.

SECTION 9
WELD CONNECTIONS

A. General

A 100 General

101 The requirements in this section are related to types and size of welds.

B. Types of Welded Steel Joints

B 100 Butt joints

101 All types of butt joints should be welded from both sides. Before welding is carried out from the second side, unsound weld metal shall be removed at the root by a suitable method.

B 200 Tee or cross joints

201 The connection of a plate abutting on another plate may be made as indicated in Fig.1.

202 The throat thickness of the weld is always to be measured as the normal to the weld surface, as indicated in Fig.1d.

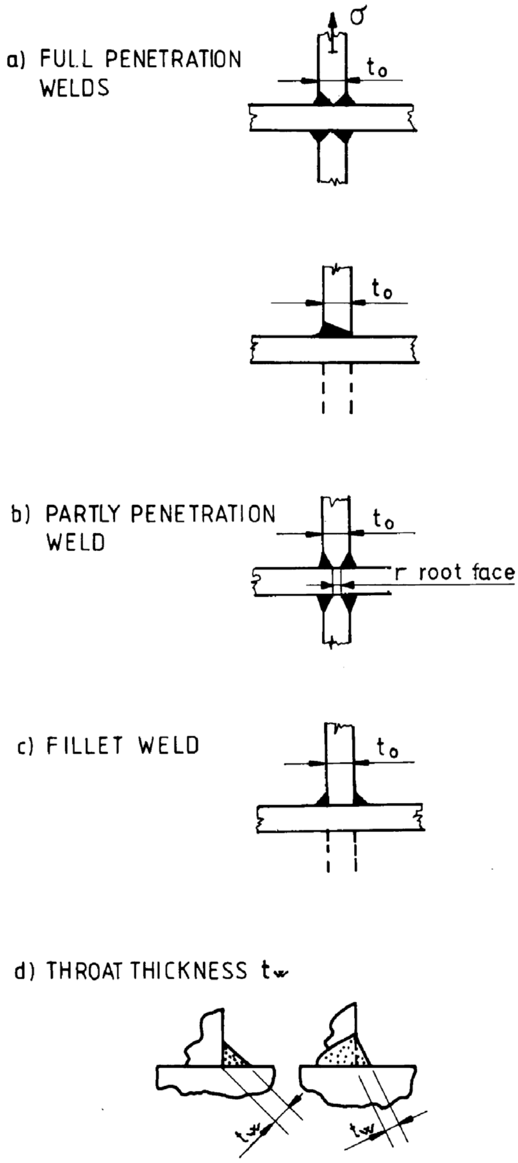

Figure 1
Tee and cross joints

203 The type of connection shall be adopted as follows:

a) *Full penetration weld*

— Important cross connections in structures exposed to high stress, especially dynamic, e.g. for special areas and fatigue utilised primary structure.
— All welds with abutting plate panels forming boundaries to open sea.
— All external welds in way of opening to open sea e.g. pipes, seachests or tee-joints.

b) *Partly penetration weld*
Connections where the static stress level is high. Acceptable also for dynamically stressed connections, provided the equivalent stress is acceptable, see C300.

c) *Fillet weld*
Connections where stresses in the weld are mainly shear, or direct stresses are moderate and mainly static, or dynamic stresses in the abutting plate are small.

204 Double continuous welds are required in the following connections, irrespective of the stress level:

— oiltight and watertight connections
— connections at supports and ends of girders, stiffeners and pillars
— connections in foundations and supporting structures for machinery
— connections in rudders, except where access difficulties necessitate slot welds.

205 Intermittent fillet welds may be used in the connection of girder and stiffener webs to plate and girder flange plate, respectively, where the connection is moderately stressed. With reference to Fig.2, the various types of intermittent welds are as follows:

— chain weld
— staggered weld
— scallop weld (closed).

206 Where intermittent welds are accepted, scallop welds shall be used in tanks for water ballast or fresh water. Chain and staggered welds may be used in dry spaces and tanks arranged for fuel oil only.

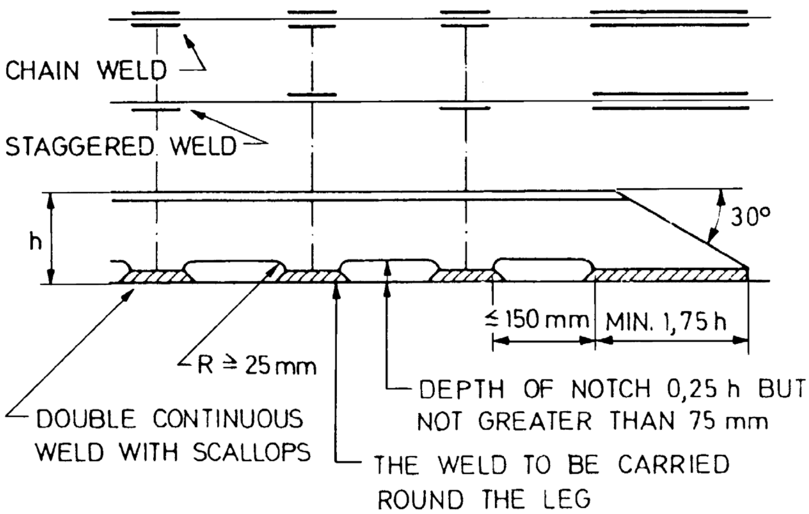

Figure 2
Intermittent welds

B 300 Slot welds

301 Slot weld, see Fig.3, may be used for connection of plating to internal webs, where access for welding is not practicable, e.g. rudders. The length of slots and distance between slots shall be considered in view of the required size of welding.

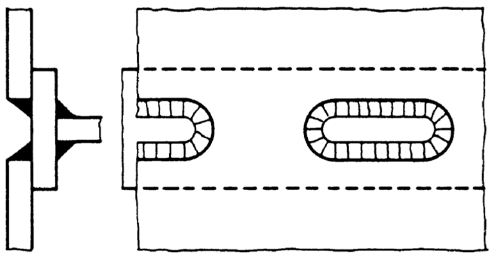

Figure 3
Slot welds

B 400 Lap joint

401 Lap joint as indicated in Fig.4 may be used in end connections of stiffeners. Lap joints should be avoided in connections with dynamic stresses.

Figure 4
Lap joint

C. Weld size

C 100 General

101 The material factors γ_{Mw} for welded connections are given in Table C1.

Table C1 Material factors γ_{Mw} for welded connections	
Limit states	*Material factor*
ULS	1.3
ALS	1.0

102 If the yield stress of the weld deposit is higher than that of the base metal, the size of ordinary fillet weld connections may be reduced as indicated in 104.

The yield stress of the weld deposit is in no case to be less than given in DNV-OS-C401.

103 Welding consumables used for welding of normal steel and some high strength steels are assumed to give weld deposits with characteristic yield stress σ_{fw} as indicated in Table C2. If welding consumables with deposits of lower yield stress than specified in Table C2 are used, the applied yield strength shall be clearly informed on drawings and in design reports.

104 The size of some weld connections may be reduced:

— corresponding to the strength of the weld metal, f_w:

$$f_w = \left(\frac{\sigma_{fw}}{235}\right)^{0,75} \quad \text{or}$$

— corresponding to the strength ratio value f_r, base metal to weld metal:

$$f_r = \left(\frac{f_y}{\sigma_{fw}}\right)^{0,75} \quad \text{minimum 0.75}$$

f_y = characteristic yield stress of base material, abutting plate (N/mm^2)
σ_{fw} = characteristic yield stress of weld deposit (N/mm^2).

Ordinary values for f_w and f_r for normal strength and high strength steels are given in Table C2. When deep penetrating welding processes are applied, the required throat thicknesses may be reduced by 15% provided that sufficient weld penetration is demonstrated.

Table C2 Strength ratios, f_w and f_r

Base metal		*Weld deposit*	*Strength ratios*	
Strength group	Designation	Yield stress σ_{fw} (N/mm²)	Weld metal $f_w = \left(\frac{\sigma_{fw}}{235}\right)^{0,75}$	Base metal/weld metal $f_r = \left(\frac{f_y}{\sigma_{fw}}\right)^{0,75}$
Normal strength steels	NV NS	355	1.36	0.75
High strength steels	NV 27	375	1.42	0.75
	NV 32	375	1.42	0.88
	NV 36	375	1.42	0.96
	NV 40	390	1.46	1.00

C 200 Fillet welds

201 Where the connection of girder and stiffener webs and plate panel or girder flange plate, respectively, are mainly shear stressed, fillet welds as specified in 202 to 204 should be adopted.

202 Unless otherwise calculated, the throat thickness of double continuous fillet welds should not be less than:

$$t_w = 0{,}43 f_r t_0 \ \ (\text{mm}), \ \text{minimum 3 mm}$$

f_r = strength ratio as defined in 104
t_0 = net thickness (mm) of abutting plate.
For stiffeners and for girders within 60% of the middle of span, t_0 need normally not be taken greater than 11 mm, however, in no case less than 0.5 times the net thickness of the web.

203 The throat thickness of intermittent welds may be as required in 202 for double continuous welds provided the welded length is not less than:

— 50% of total length for connections in tanks
— 35% of total length for connections elsewhere.

Double continuous welds shall be adopted at stiffener ends when necessary due to bracketed end connections

204 For intermittent welds, the throat thickness is not to exceed:

— for chain welds and scallop welds:

$$t_w = 0{,}6 f_r t_0 \ \ (\text{mm})$$

t_0 = net thickness abutting plate.

— for staggered welds:

$$t_w = 0{,}75 f_r t_0 \ \ (\text{mm})$$

If the calculated throat thickness exceeds that given in one of the equations above, the considered weld length shall be increased correspondingly.

C 300 Partly penetration welds and fillet welds in cross connections subject to high stresses

301 In structural parts where dynamic stresses or high static tensile stresses act through an intermediate plate, see Fig.1, penetration welds or increased fillet welds shall be used.

302 When the abutting plate carries dynamic stresses, the connection shall fulfil the requirements with respect to fatigue, see Sec.6.

303 When the abutting plate carries design tensile stresses higher than 120 N/mm², the throat thickness of a double continuous weld is not to be less than:

$$t_w = \frac{1{,}36}{f_w}\left[0{,}2 + \left(\frac{\sigma_d}{320} - 0{,}25\right)\frac{r}{t_0}\right] t_0 \ \ (\text{mm})$$

minimum 3 mm.

f_w = strength ratio as defined in 104
σ_d = calculated maximum design tensile stress in abutting plate (N/mm²)

r = root face (mm), see Fig.1b

t_0 = net thickness (mm) of abutting plate.

C 400 Connections of stiffeners to girders and bulkheads etc.

401 Stiffeners may be connected to the web plate of girders in the following ways:

— welded directly to the web plate on one or both sides of the stiffener
— connected by single- or double-sided lugs
— with stiffener or bracket welded on top of frame
— a combination of the ways listed above.

In locations where large shear forces are transferred from the stiffener to the girder web plate, a double-sided connection or stiffening should be required. A double-sided connection may be taken into account when calculating the effective web area.

402 Various standard types of connections between stiffeners and girders are shown in Fig.5.

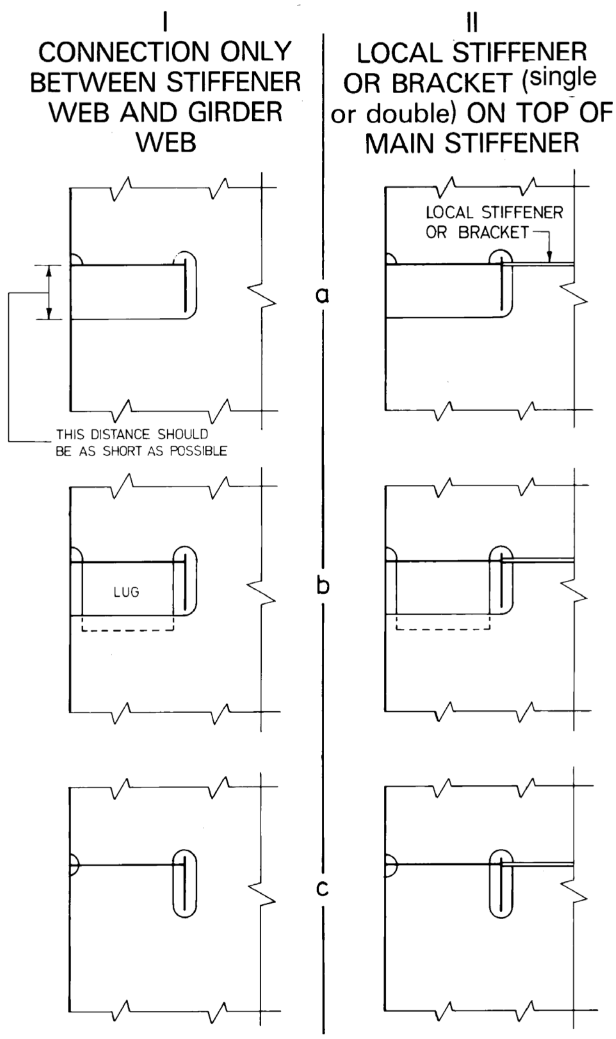

Figure 5
Connections of stiffeners

403 Connection lugs should have a thickness not less than 75% of the web plate thickness.

404 The total connection area (parent material) at supports of stiffeners should not to be less than:

$$a_0 = \sqrt{3}\,\frac{c}{f_{yd}}10^3(l - 0.5s)sp_d \quad (mm^2)$$

c = detail shape factor as given in Table C3

f_{yd} = design yield strength f_y/γ_M.
f_y is the minimum yield stress (N/mm^2) as given in Sec.4 Table D1
l = span of stiffener (m)
s = distance between stiffeners (m)
p_d = design pressure (kN/m^2).

Table C3 Detail shape factor c			
Type of connection (see Fig.5)	*I Web to web connection only*	*II Stiffener or bracket on top of stiffener*	
		Single-sided	*Double-sided*
a	1.00	1.25	1.00
b	0.90	1.15	0.90
c	0.80	1.00	0.80

405 Total weld area a is not to be less than:

$$a = f_r a_0 \quad (mm^2)$$

f_r = strength ratio as defined in 104
a_0 = connection area (mm^2) as given in 404.

The throat thickness is not to exceed the maximum for scallop welds given in 204.

406 The weld connection between stiffener end and bracket is principally to be designed such that the design shear stresses of the connection correspond to the design resistance.

407 The weld area of brackets to stiffeners which are carrying longitudinal stresses or which are taking part in the strength of heavy girders etc., is not to be less than the sectional area of the longitudinal.

408 Brackets shall be connected to bulkhead by a double continuous weld, for heavily stressed connections by a partly or full penetration weld.

C 500 End connections of girders

501 The weld connection area of bracket to adjoining girders or other structural parts shall be based on the calculated normal and shear stresses. Double continuous welding shall be used. Where large tensile stresses are expected, design according to 300 shall be applied.

502 The end connections of simple girders shall satisfy the requirements for section modulus given for the girder in question.

Where the design shear stresses in web plate exceed 90 N/mm^2, double continuous boundary fillet welds should have throat thickness not less than:

$$t_w = \frac{\tau_d}{260 f_w} f_r t_0 \quad (mm)$$

τ_d = design shear stress in web plate (N/mm^2)
f_w = strength ratio for weld as defined in 104
f_r = strength ratio as defined in 104
t_0 = net thickness (mm) of web plate.

C 600 Direct calculation of weld connections

601 The distribution of forces in a welded connection may be calculated on the assumption of either elastic or plastic behaviour.

602 Residual stresses and stresses not participating in the transfer of load need not be included when checking the resistance of a weld. This applies specifically to the normal stress parallel to the axis of a weld.

603 Welded connections shall be designed to have adequate deformation capacity.

604 In joints where plastic hinges may form, the welds shall be designed to provide at least the same design resistance as the weakest of the connected parts.

605 In other joints where deformation capacity for joint rotation is required due to the possibility of excessive straining, the welds require sufficient strength not to rupture before general yielding in the adjacent parent material.

Guidance note:
In general this will be satisfied if the design resistance of the weld is not less than 80 % of the design resistance of the weakest of the connected parts.

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606 The design resistance of fillet welds is adequate if, at every point in its length, the resultant of all the forces per unit length transmitted by the weld does not exceed its design resistance.

607 The design resistance of the fillet weld will be sufficient if both the following conditions are satisfied:

$$\sqrt{\sigma_{\perp d}^2 + 3(\tau_{\|d}^2 + \tau_{\perp d}^2)} \leq \frac{f_u}{\beta_w \gamma_{Mw}}$$

and

$$\sigma_{\perp d} \leq \frac{f_u}{\gamma_{Mw}}$$

$\sigma_{\perp d}$	=	normal design stress perpendicular to the throat (including load factors)
$\tau_{\perp d}$	=	shear design stress (in plane of the throat) perpendicular to the axis of the weld
$\tau_{\|d}$	=	shear design stress (in plane of the throat) parallel to the axis of the weld, see Fig.6
f_u	=	nominal lowest ultimate tensile strength of the weaker part joined
β_w	=	appropriate correlation factor, see Table C4
γ_{Mw}	=	material factor for welds

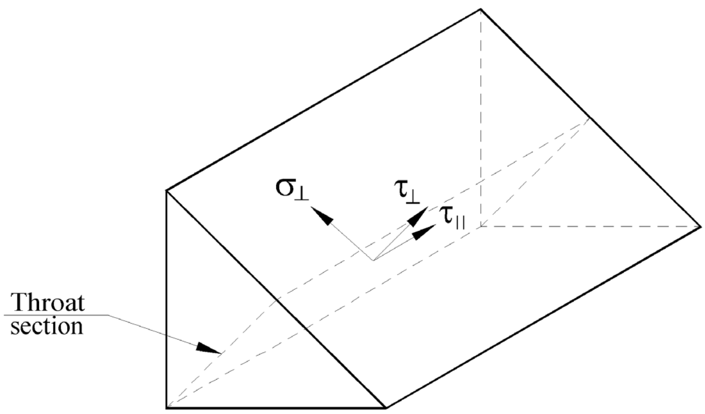

Figure 6
Stresses in fillet weld

Table C4 The correlation factor βw

Steel grade	*Lowest ultimate tensile strength* f_u	*Correlation factor* β_w
NV NS	400	0.83
NV 27	400	0.83
NV 32	440	0.86
NV 36	490	0.89
NV 40	510	0.9
NV 420	530	1.0
NV 460	570	1.0

SECTION 10 CORROSION CONTROL

A. General

A 100 General

101 Corrosion control of structural steel for offshore structures comprises:

- coatings and/or cathodic protection
- use of a corrosion allowance
- inspection/monitoring of corrosion
- control of humidity for internal zones (compartments).

102 This section gives technical requirements and guidance for the design of corrosion control of structural steel associated with offshore steel structures. The manufacturing / installation of systems for corrosion control and inspection and monitoring of corrosion in operation are covered in DNV-OS-C401.

B. Techniques for Corrosion Control Related to Environmental Zones

B 100 Atmospheric zone

101 Steel surfaces in the atmospheric zone shall be protected by a coating system (see D100) proven for marine atmospheres by practical experience or relevant testing.

Guidance note:

The “Atmospheric Zone” is defined as the areas of a structure above the Splash Zone (see B201) being exposed to sea spray, atmospheric precipitation and/or condensation.

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B 200 Splash zone

201 Steel surfaces in the splash zone shall be protected by a coating system (see D100) proven for splash zone applications by practical experience or relevant testing. A corrosion allowance should also be considered in combination with a coating system for especially critical structural items.

202 Steel surfaces in the splash zone, below the mean sea level (MSL) for bottom fixed structures or below the normal operating draught for floating units, shall be designed with cathodic protection in addition to coating.

203 The splash zone is that part of an installation, which is intermittently exposed to air and immersed in the sea. The zone has special requirements to fatigue for bottom fixed units and floating units that have constant draught.

Guidance note:

Constant draught means that the unit is not designed for changing the draught for inspection and repair for the splash zone and other submerged areas.

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204 For floating units with constant draught, the extent of the splash zone shall extend 5 m above and 4 m below this draught.

205 For bottom fixed structures, such as jackets and TLPs, the definitions given in 205 to 207 apply.

The wave height to be used to determine the upper and lower limits of the splash zone shall be taken as 1/3 of the wave height that has an annual probability of being exceeded of 10^{-2}.

206 The upper limit of the splash zone (SZ_U) shall be calculated by:

$$SZ_U = U_1 + U_2 + U_3 + U_4 + U_5$$

where:

U_1 = 60% of the wave height defined in 205
U_2 = highest astronomical tide level (HAT)
U_3 = foundation settlement, if applicable
U_4 = range of operation draught, if applicable
U_5 = motion of the structure, if applicable.

The variables (U_i) shall be applied, as relevant, to the structure in question, with a sign leading to the largest or larger value of SZ_U.

207 The lower limit of the splash zone (SZ_L) shall be calculated by:

$$SZ_L = L_1 + L_2 + L_3 + L_4$$

where:

L_1 = 40% of the wave height defined in 205
L_2 = lowest astronomical tide level (LAT)
L_3 = range of operating draught, if applicable
L_4 = motions of the structure, if applicable.

The variables (L_i) shall be applied, as relevant, to the structure in question, with a sign leading to the smallest or smaller value of SZ_L.

B 300 Submerged zone

301 Steel surfaces in the submerged zone shall have a cathodic protection system. The cathodic protection design shall include current drain to any electrically connected items for which cathodic protection is not considered necessary (e.g. piles).

The cathodic protection shall also include the splash zone beneath MSL (for bottom fixed structures) and splash zone beneath normal operating draught (for floating units), see B202.

Guidance note:
The 'Submerged Zone' is defined as the zone below the splash zone.

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302 For certain applications, cathodic protection is only practical in combination with a coating system. Any coating system shall be proven for use in the submerged zone by practical experience or relevant testing demonstrating compatibility with cathodic protection.

Guidance note:
Cathodic protection may cause damage to coatings by blistering or general disbondment (“cathodic disbondment”).

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B 400 Internal zones

401 Internal zones exposed to seawater for a main period of time (e.g. ballast tanks) shall be protected by a coating system (see D100) proven for such applications by practical experience or relevant testing. Cathodic protection should be considered for use in combination with coating (see also 402).

Guidance note:
'Internal Zones' are defined as tanks, voids and other internal spaces containing a potentially corrosive environment, including seawater.

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402 Internal zones that are empty (including those occasionally exposed to seawater for a short duration of time) shall have a coating system and/or corrosion allowance. For internal zones with continuous control of humidity, no further corrosion control is required. Further, no coating is required for zones that do not contain water and that are permanently sealed.

403 Tanks for fresh water shall have a suitable coating system. Special requirements will apply for coating systems to be used for potable water tanks.

404 To facilitate inspection, light coloured and hard coatings shall be used for components of internal zones subject to major fatigue forces requiring visual inspection for cracks. Regarding restrictions for use of coatings with high content of aluminium, see D101.

405 Only anodes on aluminium or zinc basis shall be used. Due to the risk of hydrogen gas accumulation, anodes of magnesium or impressed current cathodic protection are prohibited for use in tanks.

406 For cathodic protection of ballast tanks that may become affected by hazardous gas from adjacent tanks for storage of oil or other liquids with flash point less than 60 °C, anodes on zinc basis are preferred. Due to the risk of thermite ignition, any aluminium base anodes shall in no case be installed such that a detached anode could generate an energy of 275 J or higher (i.e. as calculated from anode weight and height above tank top). For the same reason, coatings containing more than 10% aluminium on dry weight basis shall not be used for such tanks.

407 A corrosion allowance shall be implemented for internal compartments without any corrosion protection (coating and/or cathodic protection) but subject to a potentially corrosive environment such as intermittent exposure to seawater, humid atmosphere or produced/cargo oil.

Any corrosion allowance for individual components (e.g. plates, stiffeners and girders) shall be defined taking into account:

— design life
— maintenance philosophy
— steel temperature
— single or double side exposure.

As a minimum, any corrosion allowance (t_k) to be applied as alternative to coating shall be as follows:

— one side unprotected: t_k = 1.0 mm
— two sides unprotected: t_k = 2.0 mm

C. Cathodic Protection

C 100 General

101 Cathodic protection of offshore structures may be effected using galvanic anodes (also referred to as "sacrificial anodes") or impressed current from a rectifier. Impressed current is almost invariably used in combination with a coating system.

Guidance note:

The benefits of a coating system (e.g. by reducing weight or friction to seawater flow caused by excessive amounts of anodes) should also be considered for systems based on galvanic anodes.

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102 Cathodic protection systems in marine environments are typically designed to sustain a protection potential in the range -0.80 V to -1.10 V relative to the Ag/AgCl/seawater reference electrode. More negative potentials may apply in the vicinity of impressed current anodes.

Guidance note:

The use of galvanic anodes based on aluminium and zinc limits the most negative potential to -1.10 V relative to Ag/AgCl/seawater.

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103 Design of cathodic protection systems for offshore structures shall be carried out according to a recognised standard.

Guidance note:

Recommendations for cathodic protection design may be found in DNV-RP-B401.

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104 Cathodic protection may cause hydrogen induced stress cracking (HISC) of components in high strength steels that are exposed to severe straining in service

It is recommended that the welding of high strength structural steels is qualified to limit the hardness in the weld zone to max. 350 HV (Vicker hardness). The use of coatings reduces the risk of hydrogen embrittlement further and is recommended for all critical components in high strength structural steel.

Guidance note:

There is no evidence in the literature that structural steels with SMYS up to 550 N/mm^2 have suffered any cracking when exposed to cathodic protection in marine environments at the protection potential range given in 102.

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C 200 Galvanic anode systems

201 Unless replacement of anodes is allowed for in the design, galvanic anode cathodic protection systems shall have a design life at least equal to that of the offshore installation. For ballast tanks with access for replacement of anodes and any other such applications, the minimum design life should be 5 years.

202 Anode cores shall be designed to ensure attachment during all phases of installation and operation of the structure. Location of anodes in fatigue sensitive areas shall be avoided.

203 The documentation of cathodic protection design by galvanic anodes shall contain the following items as a minimum:

— reference to design code and design premises
— calculations of surface areas and cathodic current demand (mean and initial/final) for individual sections of the structure
— calculations of required net anode mass for the applicable sections based on the mean current demands
— calculations of required anode current output per anode and number of anodes for individual sections based on initial/final current demands
— drawings of individual anodes and their location.

204 Requirements to the manufacturing of anodes (see 205) shall be defined during design, e.g. by reference to a standard or in a project specification.

205 Galvanic anodes shall be manufactured according to a manufacturing procedure specification (to be prepared by manufacturer) defining requirements to the following items as a minimum:

— chemical compositional limits
— anode core material standard and preparation prior to casting
— weight and dimensional tolerances
— inspection and testing
— marking, traceability and documentation.

206 The needs for a commissioning procedure including measurements of protection potentials at pre-defined locations should be considered during design. As a minimum, recordings of the general protection level shall be performed by lowering a reference electrode from a location above the water level.

207 Manufacturing and installation of galvanic anodes are addressed in DNV-OS-C401, Sec.5

C 300 Impressed current systems

301 Impressed current anodes and reference electrodes for control of current output shall be designed with a design life at least equal to that of the offshore installation unless replacement of anodes (and other critical components) during operation is presumed. It is recommended that the design in any case allows for replacement of any defective anodes and reference electrodes (see 304) during operation.

302 Impressed current anodes shall be mounted flush with the object to be protected and shall have a relatively thick non-conducting coating or sheet ("dielectric shield") to prevent any negative effects of excessively negative potentials such as disbondment of paint coatings or hydrogen induced damage of the steel. The sizing of the sheet shall be documented during design. Location of impressed current anodes in fatigue sensitive areas shall be avoided.

303 Impressed current cathodic protection systems shall be designed with a capacity of minimum 1.5 higher than the calculated final current demand of the structure.

Guidance note:
Impressed current cathodic protection provide a more non-uniform current distribution and are more vulnerable to mechanical damage which requires a more conservative design than for galvanic anode systems.

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304 A system for control of current output based on recordings from fixed reference electrodes located close to and remote from the anodes shall be included in the design. Alarm functions indicating excessive voltage/current loads on anodes, and too negative or too positive protection potential should be provided. A failure mode analysis should be carried out to ensure that any malfunction of the control system will not lead to excessive negative or positive potentials that may damage the structure or any adjacent structures.

305 Cables from rectifier to anodes and reference electrodes should have steel armour and shall be adequately protected by routing within a dedicated conduit (or internally within the structure, if applicable). Restriction for routing of anode cables in hazardous areas may apply.

306 The documentation of cathodic protection design by impressed current shall contain the following items as a minimum:

— reference to design code and design premises
— calculations of surface areas and cathodic current demand (mean and initial/final) for individual sections

of the structure
- general arrangement drawings showing locations of anodes, anode shields, reference electrodes, cables and rectifiers
- detailed drawings of anodes, reference electrodes and other major components of the system
- documentation of anode and reference electrode performance to justify the specified design life
- documentation of rectifiers and current control system
- documentation of sizing of anode shields
- specification of anode shield materials and application
- commissioning procedure, incl. verification of proper protection range by independent potential measurements
- operational manual, including procedures for replacement of anodes and reference electrodes.

307 Manufacturing and installation of impressed current cathodic protection systems are addressed in DNV-OS-C401, Sec.5

D. Coating systems

D 100 Specification of coating

101 Requirements to coatings for corrosion control (including those for any impressed current anode shields) shall be defined during design (e.g. by reference to a standard or in a project specification), including as a minimum:

- coating materials (generic type)
- surface preparation (surface roughness and cleanliness)
- thickness of individual layers
- inspection and testing.

For use of aluminium containing coatings in tanks that may become subject to explosive gas, the aluminium content is limited to maximum 10% on dry film basis.

Guidance note:

It is recommended that supplier specific coating materials are qualified by relevant testing or documented *performance* in service.

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102 Coating materials and application of coatings are addressed in DNV-OS-C401, Sec.5.

SECTION 11
FOUNDATION DESIGN

A. General

A 100 Introduction

101 The requirements in this section apply to pile foundations, gravity type foundations, anchor foundations and stability of sea bottom.

102 Foundation types not specifically covered by this standard shall be specially considered.

103 Design of foundations shall be based on site specific information, see 200.

104 The partial coefficient method is the selected method in these standards for foundation design (see Sec.2). The application of this method is documented in this section. Alternative methods or safety checking together with general design principles are given in Sec.2.

105 In the case where allowable stress methods are used for design, central safety factors shall be agreed upon in each case, with the aim of achieving the same safety level as with the design by the partial coefficient method.

106 The design of foundations shall consider both the strength and deformations of the foundation structure and of the foundation soils.

This section states requirements for:

— foundation soils
— soil reactions upon the foundation structure
— soil-structure interaction.

The foundation structure itself (anchor), including the anchor padeye, shall be designed for the loads and acceptance criteria specified in DNV-OS-E301 Ch.2 Sec.4. See also design requirements in this standard Sec.4 to Sec.10, as relevant for steel anchor design.

107 A foundation failure mode is defined as the mode in which the foundation reaches any of its limit states. Examples of such failure modes are:

— bearing failure
— sliding
— overturning
— anchor pull-out
— large settlements or displacements.

108 The definition of limit state categories as given in Sec.2 is valid for foundation design with the exception that failure due to effect of cyclic loading is treated as an ULS limit state, alternatively as an ALS limit state, using load and material coefficients as defined for these limit state categories. The load coefficients are in this case to be applied to all cyclic loads in the design history. Lower load coefficients may be accepted if the total safety level can be demonstrated to be within acceptable limits.

109 The load coefficients to be used for design related to the different groups of limit states are given in Sec.2. Load coefficients for anchor foundations are given in E200.

110 Material coefficients to be used are specified in B to E. The characteristic strength of the soil shall be assessed in accordance with 300.

111 Material coefficients shall be applied to soil shear strength as follows:

— for effective stress analysis, the tangent to the characteristic friction angle shall be divided by the material coefficient (γ_M)
— for total shear stress analysis, the characteristic undrained shear strength shall be divided by the material coefficient (γ_M).

For soil resistance to axial pile load, material coefficients shall be applied to the characteristic resistance as described in C106.

For anchor foundations, material coefficients shall be applied to the characteristic anchor resistance, as described for the respective types of anchors in E.

112 Settlements caused by increased stresses in the soil due to structural weight shall be considered for structures with gravity type foundation. In addition, subsidence, e.g. due to reservoir compaction, shall be considered for all types of structures.

113 Further elaborations on design principles and examples of design solutions for foundation design are given in Classification Note 30.4.

A 200 Site investigations

201 The extent of site investigations and the choice of investigation methods shall take into account the type, size and importance of the structure, uniformity of soil and seabed conditions and the actual type of soil deposits. The area to be covered by site investigations shall account for positioning and installation tolerances.

202 For anchor foundations the soil stratigraphy and range of soil strength properties shall be assessed within each anchor group or per anchor location, as relevant.

203 Site investigations shall provide relevant information about the soil to a depth below which possible existence of weak formations will not influence the safety or performance of the structure.

204 Site investigations are normally to comprise of the following type of investigations:

- site geology survey
- topography survey of the seabed
- geophysical investigations for correlation with borings and in-situ testing
- soil sampling with subsequent laboratory testing
- in-situ tests, e.g. cone penetrations tests.

205 The site investigations shall provide the following type of geotechnical data for the soil deposits as found relevant for the design:

- data for soil classification and description
- shear strength parameters including parameters to describe the development of excess pore-water pressures
- deformation properties, including consolidation parameters
- permeability
- stiffness and damping parameters for calculating the dynamic behaviour of the structure.

Variations in the vertical, as well as, the horizontal directions shall be documented.

206 Tests to determine the necessary geotechnical properties shall be carried out in a way that accounts for the actual stress conditions in the soil. The effects of cyclic loading caused by waves, wind and earthquake, as applicable, shall be included.

207 Testing equipment and procedures shall be adequately documented. Uncertainties in test results shall be described. Where possible, mean and standard deviation of test results shall be given.

A 300 Characteristic properties of soil

301 The characteristic strength and deformation properties of soil shall be determined for all deposits of importance.

302 The characteristic value of a soil property shall account for the variability in that property based on an assessment of the soil volume governing for the limit state being considered.

303 The results of both laboratory tests and in-situ tests shall be evaluated and corrected as relevant on the basis of recognised practice and experience. Such evaluations and corrections shall be documented. In this process account shall be given to possible differences between properties measured in the tests and the soil properties governing the behaviour of the in-situ soil for the limit state in question. Such differences may be due to:

- soil disturbance due to sampling and samples not reconstituted to in-situ stress history
- presence of fissures
- different loading rate between test and limit state in question
- simplified representation in laboratory tests of certain complex load histories
- soil anisotropy effects giving results which are dependent on the type of test.

304 Possible effects of installation activities on the soil properties should be considered.

305 The characteristic value of a soil property shall be a cautious estimate of the value affecting the occurrence of the limit state, selected such that the probability of a worse value is low.

306 A limit state may involve a large volume of soil and it is then governed by the average of the soil property within that volume. The choice of the characteristic value shall take due account for the number and quality of tests within the soil volume involved. Specific care should be made when the limit state is governed by a narrow zone of soil.

307 The characteristic value shall be selected as a lower value, being less than the most probable value, or an upper value being greater, depending on which is worse for the limit state in question.

Guidance note:
When relevant statistical methods should be used. If such methods are used, the characteristic value should be derived such that the calculated probability of a worse value governing the occurrence of the limit state is not greater than 5%.

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A 400 Effects of cyclic loading

401 The effects of cyclic loading on the soil properties shall be considered in foundation design, where relevant.

402 Cyclic shear stresses may lead to a gradual increase in pore pressure. Such pore pressure build-up and the accompanying increase in cyclic and permanent shear strains may reduce the shear strength of the soil. These effects shall be accounted for in the assessment of the characteristic shear strength for use in design within the applicable limit state categories.

403 In the SLS design condition the effects of cyclic loading on the soil's shear modulus shall be corrected for as relevant when dynamic motions, settlements and permanent (long-term) horizontal displacements shall be calculated. See also D300.

404 The effects of wave induced forces on the soil properties shall be investigated for single storms and for several succeeding storms, where relevant.

405 In seismically active areas, where the structure foundation system may be subjected to earthquake forces, the deteriorating effects of cyclic loading on the soil properties shall be evaluated for the site specific conditions and considered in the design where relevant. See also 500.

A 500 Soil-structure interaction

501 Evaluation of structural load effects shall be based on an integrated analysis of the soil and structure system. The analysis shall be based on realistic assumptions regarding stiffness and damping of both the soil and structural members.

502 Due consideration shall be given to the effects of adjacent structures, where relevant.

503 For analysis of the structural response to earthquake vibrations, ground motion characteristics valid at the base of the structure shall be determined. This determination shall be based on ground motion characteristics in free field and on local soil conditions using recognised methods for soil-structure interaction analysis. See Sec.3 I100.

B. Stability of Seabed

B 100 Slope stability

101 Risk of slope failure shall be evaluated. Such calculations shall cover:

- natural slopes
- slopes developed during and after installation of the structure
- future anticipated changes of existing slopes
- effect of continuous mudflows
- wave induced soil movements.

The effect of wave loads on the sea bottom shall be included in the evaluation when such loads are unfavourable.

102 When the structure is located in a seismically active region, the effects of earthquakes on the slope stability shall be included in the analyses.

103 The safety against slope failure for ULS design shall be analysed using material coefficients (γ_M):

γ_M = 1.2 for effective stress analysis
= 1.3 for total stress analysis.

104 For ALS design the material coefficients γ_M may be taken equal to 1.0.

B 200 Hydraulic stability

201 The possibility of failure due to hydrodynamic instability shall be considered where soils susceptible to erosion or softening are present.

202 An investigation of hydraulic stability shall assess the risk for:

- softening of the soil and consequent reduction of bearing capacity due to hydraulic gradients and seepage forces
- formation of piping channels with accompanying internal erosion in the soil

— surface erosion in local areas under the foundation due to hydraulic pressure variations resulting from environmental loads.

203 If erosion is likely to reduce the effective foundation area, measures shall be taken to prevent, control and/or monitor such erosion, as relevant, see 300.

B 300 Scour and scour protection

301 The risk for scour around the foundation of a structure shall be taken into account unless it can be demonstrated that the foundation soils will not be subject to scour for the expected range of water particle velocities.

302 The effect of scour, where relevant, shall be accounted for according to at least one of the following methods:

a) Adequate means for scour protection is placed around the structure as early as possible after installation.
b) The foundation is designed for a condition where all materials, which are not scour resistant are assumed removed.
c) The seabed around the platform is kept under close surveillance and remedial works to prevent further scour are carried out shortly after detection of significant scour.

303 Scour protection material shall be designed to provide both external and internal stability, i.e. protection against excessive surface erosion of the scour protection material and protection against transportation of soil particles from the underlying natural soil.

C. Design of Pile Foundations

C 100 General

101 The load carrying capacity of piles shall be based on strength and deformation properties of the pile material as well as on the ability of the soil to resist pile loads.

102 In evaluation of soil resistance against pile loads, the following factors shall be amongst those to be considered:

— shear strength characteristics
— deformation properties and in-situ stress conditions of the foundation soil
— method of installation
— geometry and dimensions of pile
— type of loads.

103 The data bases of existing methods for calculation of soil resistance to axial and lateral pile loads are often not covering all conditions of relevance for offshore piles. This especially relates to size of piles, soil shear strength and type of load. When determining soil resistance to axial and lateral pile loads, extrapolations beyond the data base of a chosen method shall be made with thorough evaluation of all relevant parameters involved.

104 It shall be demonstrated by a driveability study or equivalent that the selected solution for the pile foundation is feasible with respect to installation of the piles.

105 Structures with piled foundations shall be assessed with respect to stability for both operation and temporary design conditions, e.g. prior to and during installation of the piles. See Sec.3 for selection of representative loads.

106 For determination of design soil resistance against axial pile loads in ULS design, a material coefficient γ_M = 1.3 shall be applied to all characteristic values of soil resistance, e.g. to skin friction and tip resistance.

Guidance note:

This material coefficient may be applied to pile foundation of multilegged jacket or template structures. The design pile load shall be determined from structural analyses where the pile foundation is modelled with elastic stiffness, or non-linear models based on characteristic soil strength.

If the ultimate plastic resistance of the foundation system is analysed by modelling the soil with its design strength and allowing full plastic redistribution until a global foundation failure is reached, higher material coefficients should be used.

For individual piles in a group lower material coefficients may be accepted, as long as the pile group as a whole is designed with the required material coefficient. A pile group in this context shall not include more piles that those supporting one specific leg.

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107 For pile foundations of structures where there are no or small possibilities for redistribution of loads from one pile to another, or from one group of piles to another group of piles, larger material coefficients than those given in 106 shall be used. This may for example apply to pile foundations for TLPs or to deep draught floaters. In such cases the material coefficient shall not be taken less than γ_M = 1.7 for ULS design.

108 For calculation of design lateral resistance according to 300, the following material coefficients shall be applied to characteristic soil shear strength parameters for ULS design:

γ_M = 1.2 for effective stress analysis
= 1.3 for total stress analysis.

109 For ALS and SLS design, the material coefficient γ_M may be taken equal to 1.0.

110 For conditions where large uncertainties are attached to the determination of characteristic shear strength or characteristic soil resistance, e.g. pile skin friction or tip resistance, larger material factors are normally to be used. Choice of material coefficients is, in such cases, to be in accordance with the determination of characteristic values of shear strength or soil resistance.

C 200 Soil resistance against axial pile loads

201 Soil resistance against axial pile loads shall be determined by one, or a combination of, the following methods:

— load testing of piles
— semi-empirical pile capacity formulae based on pile load test data.

202 The soil resistance in compression shall be taken as the sum of accumulated skin friction on the outer pile surface and resistance against pile tip. In case of open-ended pipe piles, the resistance of an internal soil plug shall be taken into account in the calculation of resistance against pile tip. The equivalent tip resistance shall be taken as the lower value of the plugged (gross) tip resistance or the sum of the skin resistance of the internal soil plug and the resistance against the pile tip area. The soil plug may be replaced by a grout plug or equivalent in order to achieve fully plugged tip resistance.

203 For piles in tension, no resistance from the soil below pile tip shall be accounted for, if the pile tip is in sandy soils.

204 Effects of cyclic loading shall be accounted for as far as possible. In evaluation of the degradation of resistance, the influence of flexibility of the piles and the anticipated loading history shall be accounted for.

205 For piles in mainly cohesive soils, the skin friction shall be taken equal to or smaller than the undrained shear strength of undisturbed clay within the actual layer. The degree of reduction depends on the nature and strength of clay, method of installation, time effects, geometry and dimensions of pile, load history and other factors.

206 The unit tip resistance of piles in mainly cohesive soils may be taken as 9 times the undrained shear strength of the soil near the pile tip.

207 For piles in mainly cohesionless soils the skin friction may be related to the effective normal stresses against the pile surface by an effective coefficient of friction between the soil and the pile element. It shall be noticed that a limiting value of skin friction may be approached for long piles.

208 The unit tip resistance of piles in mainly cohesionless soils may be calculated by means of conventional bearing capacity theory, taken into account a limiting value, which may be approached, for long piles.

C 300 Soil resistance against lateral pile loads

301 When pile penetrations are governed by lateral soil resistance, the design resistance shall be checked within the limit state categories ULS and ALS, using material coefficients as prescribed in 108.

302 For analysis of pile stresses and lateral pile head displacement, the lateral soil reaction shall be modelled using characteristic soil strength parameters, with the soil material coefficient γ_M = 1.0.

Non-linear response of soil shall be accounted for, including the effects of cyclic loading.

C 400 Group effects

401 When piles are closely spaced in a group, the effect of overlapping stress zones on the total resistance of the soil shall be considered for axial, as well as, lateral loads on the piles. The increased displacements of the soil volume surrounding the piles due to pile-soil-pile interaction and the effects of these displacements on interaction between structure and pile foundation shall be considered.

402 In evaluation of pile group effects, due consideration shall be given to factors such as:

— pile spacing
— pile type
— soil strength
— soil density
— pile installation method.

D. Design of Gravity Foundations

D 100 General

101 Failure modes within the categories of limit states ULS and ALS shall be considered as described in 200.

102 Failure modes within the SLS, i.e. settlements and displacements, shall be considered as described in 200 using material coefficient $\gamma_M = 1.0$.

D 200 Stability of foundations

201 The risk of shear failure below the base of the structure shall be investigated for all gravity type foundations. Such investigations shall cover failure along any potential shear surface with special consideration given to the effect of soft layers and the effect of cyclic loading. The geometry of the foundation base shall be accounted for.

202 The analyses shall be carried out for fully drained, partially drained or undrained conditions, whatever represents most accurately the actual conditions.

203 For design within the applicable limit state categories ULS and ALS, the foundation stability shall be evaluated by one of the following methods:

- effective stress stability analysis
- total stress stability analysis.

204 An effective stress stability analysis shall be based on effective strength parameters of the soil and realistic estimates of the pore water pressures in the soil.

205 A total stress stability analysis shall be based on total shear strength values determined from tests on representative soil samples subjected to similar stress conditions as the corresponding element in the foundation soil.

206 Both effective stress and total stress methods shall be based on laboratory shear strength with pore pressure measurements included. The test results should preferably be interpreted by means of stress paths.

207 Stability analyses by conventional bearing capacity formulae are only acceptable for uniform soil conditions.

208 For structures where skirts, dowels or similar foundation members transfer loads to the foundation soil, the contributions of these members to the bearing capacity and lateral resistance may be accounted for as relevant. The feasibility of penetrating the skirts shall be adequately documented.

209 Foundation stability shall be analysed in ULS applying the following material coefficients to the characteristic soil shear strength parameters:

γ_M = 1.2 for effective stress analysis
= 1.3 for total stress analysis.

For ALS design $\gamma_M = 1.0$ shall be used.

210 Effects of cyclic loads shall be included by applying load coefficients in accordance with A108.

211 In an effective stress analysis, evaluation of pore pressures shall include:

- initial pore pressure
- build-up of pore pressures due to cyclic load history
- the transient pore pressures through each load cycle
- the effect of dissipation.

212 The safety against overturning shall be investigated in ULS and ALS.

D 300 Settlements and displacements

301 For SLS design conditions, analyses of settlements and displacements are, in general, to include calculations of:

- initial consolidation and secondary settlements
- differential settlements
- permanent (long term) horizontal displacements
- dynamic motions.

302 Displacements of the structure, as well as of its foundation soil, shall be evaluated to provide basis for the design of conductors and other members connected to the structure which are penetrating or resting on the seabed.

303 Analysis of differential settlements shall account for lateral variations in soil conditions within the foundation area, non-symmetrical weight distributions and possible predominating directions of environmental loads. Differential settlements or tilt due to soil liquefaction shall be considered in seismically active areas.

D 400 Soil reaction on foundation structure

401 The reactions from the foundation soil shall be accounted for in the design of the supported structure for all design conditions.

402 The distribution of soil reactions against structural members seated on, or penetrating into the sea bottom, shall be estimated from conservatively assessed distributions of strength and deformation properties of the foundation soil. Possible spatial variation in soil conditions, including uneven seabed topography, shall be considered. The stiffness of the structural members shall be taken into account.

403 The penetration resistance of dowels and skirts shall be calculated based on a realistic range of soil strength parameters. The structure shall be provided with sufficient capacity to overcome maximum expected penetration resistance in order to reach the required penetration depth.

404 As the penetration resistance may vary across the foundation site, eccentric penetration forces may be necessary to keep the platform inclination within specified limits.

D 500 Soil modelling for dynamic analysis

501 Dynamic analysis of a gravity structure shall consider the effects of soil and structure interaction. For homogeneous soil conditions, modelling of the foundation soil using the continuum approach may be used. For more non-homogeneous conditions, modelling by finite element techniques or other recognised methods accounting for non-homogenous conditions shall be performed.

502 Due account shall be taken of the strain dependency of shear modulus and internal soil damping. Uncertainties in the choice of soil properties shall be reflected in parametric studies to find the influence on response. The parametric studies should include upper and lower boundaries on shear moduli and damping ratios of the soil. Both internal soil damping and radiation damping shall be considered.

D 600 Filling of voids

601 In order to assure sufficient stability of the structure or to provide a uniform vertical reaction, filling of the voids between the structure and the seabed, e.g. by underbase grouting, may be necessary.

602 The foundation skirt system and the void filling system shall be designed so that filling pressures do not cause channelling from one compartment to another, or to the seabed outside the periphery of the structure.

603 The filling material used shall be capable of retaining sufficient strength during the lifetime of the structure considering all relevant forms of deterioration such as:

— chemical
— mechanical
— placement problems such as incomplete mixing and dilution.

E. Design of Anchor Foundations

E 100 General

101 Subsection E applies to the following types of anchor foundations:

— pile anchors (300)
— gravity anchors (400)
— suction anchors (500)
— fluke anchors (600)
— plate anchors (700).

102 The analysis of anchor resistance shall be carried out for the ULS and the ALS, in accordance with the safety requirements given in 200. Due consideration shall be given to the specific aspects of the different anchor types and the current state of knowledge and development.

103 Determination of anchor resistance may be based on empirical relationships and relevant test data. Due consideration shall be given to the conditions under which these relationships and data are established and the relevance of these conditions with respect to the actual soil conditions, shape and size of anchors and loading conditions.

104 When clump weight anchors are designed to be lifted off the seabed during extreme loads, due consideration shall be paid to the suction effects that may develop at the clump weight and soil interface during a rapid lift-off. The effect of possible burial during the subsequent set-down shall be considered.

E 200 Safety requirements for anchor foundations

201 The safety requirements are based on the limit state method of design, where the anchor is defined as a load bearing structure. For geotechnical design of the anchors this method requires that the ULS and ALS categories must be satisfied by the design.

The ULS is intended to ensure that the anchor can withstand the loads arising in an intact mooring system under extreme environmental conditions. The ALS is intended to ensure that the mooring system retains adequate capacity if one mooring line or anchor should fail for reasons outside the designer's control.

202 Two consequence classes are considered, both for the ULS and for the ALS, defined as follows:

Consequence class 1 (CC1): Failure is unlikely to lead to unacceptable consequences such as loss of life, collision with an adjacent platform, uncontrolled outflow of oil or gas, capsize or sinking.

Consequence class 2 (CC2): Failure may well lead to unacceptable consequences of these types.

203 Load coefficients for the two alternative methods to calculate line tension are given in Table E1 and Table E2 for ULS and ALS, respectively. For mooring in deep water (i.e. water depth exceeding 200m, see DNV-OS-E301 Ch.2 Sec.2 B100) a dynamic analysis is required.

Table E1 Load coefficients for ULS [1)]

Consequence class	*Type of analysis*	γ_{mean}	γ_{dyn}
1	Dynamic	1.10	1.50
2	Dynamic	1.40	2.10
1	Quasi-static	1.70	
2	Quasi-static	2.50	

1) If the characteristic mean tension exceeds 2/3 of the characteristic dynamic tension, when applying a dynamic analysis in ULS consequence class 1, then a common value of 1.3 shall be applied on the characteristic tension instead of the partial load factors given in Table E1, ref. DNV-OS-E301. This is intended to ensure adequate safety in cases dominated by a mean tension component. The partial safety factor on the characteristic anchor resistance given in Table E1 is applicable in such cases provided that the effects of creep and drainage on the shear strength under the long-term load are accounted for.

Table E2 Load coefficients for ALS

Consequence class	*Type of analysis*	γ_{mean}	γ_{dyn}
1	Dynamic	1.00	1.10
2	Dynamic	1.00	1.25
1	Quasi-static	1.10	
2	Quasi-static	1.35	

204 The design line tension T_d at the touch-down point is the sum of the two calculated characteristic line tension components $T_{C\text{-mean}}$ and $T_{C\text{-dyn}}$ at that point multiplied by their respective load coefficients γ_{mean} and γ_{dyn}, i.e.:

$$T_d = T_{C-mean} \cdot \gamma_{mean} + T_{C-dyn} \cdot \gamma_{dyn}$$

$T_{C\text{-mean}}$ = the characteristic mean line tension due to pretension (T_{pre}) and the effect of mean environmental loads in the environmental state

$T_{C\text{-dyn}}$ = the characteristic dynamic line tension equal to the increase in tension due to oscillatory low-frequency and wave-frequency effects.

205 Material coefficients for use in combination with the load coefficients in Table E1 and Table E2 are given specifically for the respective types of anchors in 300 to 700.

E 300 Pile anchors

301 Pile anchors shall be designed in accordance with the relevant requirements given in C.

302 The soil material coefficients to be applied to the resistance of pile anchors shall not be taken less than:

γ_M = 1.3 for ULS Consequence Class 1 (CC1) and 2 (CC2)
= 1.0 for ALS CC1 and CC2.

See also requirements to tension piles in C107.

E 400 Gravity anchors

401 Gravity anchors shall be designed in accordance with the relevant requirements given in D. The capacity against uplift of a gravity anchor shall not be taken higher that the submerged mass. However, for anchors supplied with skirts, the contribution from friction along the skirts may be included. In certain cases such anchors may be able to resist cyclic uplift loads by the development of temporary suction within their skirt compartments. In relying on such suction one shall make sure, that there are no possibilities for leakage, e.g. through pipes or leaking valves or channels developed in the soil, that could prevent the development of suction.

402 The soil material coefficients to be applied to the resistance of gravity anchors shall not be taken less than:

γ_M = 1.3 for ULS Consequence Class 1 (CC1) and 2 (CC2)
= 1.0 for ALS CC1 and CC2.

E 500 Suction anchors

501 Suction anchors are vertical cylindrical anchors with open or (normally) closed top, which are installed initially by self-weight penetration followed by application of underpressure (suction) in the closed compartment.

The failure mechanism in the clay around an anchor will depend on various factors, like the load inclination, the anchor depth to diameter ratio, the depth of the load attachment point, the shear strength profile, and whether the anchor has an open or a closed top.

502 If the load inclination is close to vertical, the anchor will tend to move out of the ground, mainly mobilising the shear strength along the outside skirt wall and the inverse bearing capacity of the soil at skirt tip level. If the anchor has an open top, the inverse bearing capacity will not be mobilised if the inside skirt friction is lower than the inverse bearing capacity at skirt tip level.

503 If the load inclination is more towards the horizontal, the resistance at the upper part of the anchor will consist of passive and active resistances against the front and back of the anchor, and side shear along the anchor sides. Deeper down, the soil may flow around the anchor in the horizontal plane, or underneath the anchor.

504 The coupling between vertical and horizontal resistances occurs when the failure mechanism is a combination between vertical and horizontal translation modes. The coupling may reduce the vertical and horizontal resistance components at failure, and the resulting resistance will be smaller than the vector sum of the uncoupled maximum vertical and horizontal resistance. This is illustrated in Fig.1.

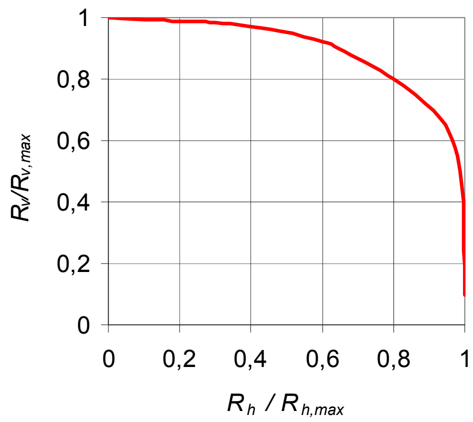


Figure 1
Schematic resistance diagram for suction anchor.

505 DNV recommendations for geotechnical design and installation of suction anchors in clay are provided in DNV-RP-E303. The design method outlined in the code makes use of a relatively detailed resistance analysis, and it is concluded that many existing analytical methods will meet the analysis requirements in this code. For details, see DNV-RP-E303.

506 If a less detailed resistance analysis is applied, the designer should be aware of the limitations of the method and make sure that the effects of any simplifications are conservative in comparison with the results from the more advanced methods.

507 The soil material coefficients to be applied to the resistance of suction anchors shall be:

γ_M = 1.20 for ULS Consequence Class 1 (CC1) and 2 (CC2)
= 1.20 for ALS CC2, and
= 1.00 for ALS CC1

In the calculation of the anchor resistance, strength anisotropy and the effects of cyclic loading on the undrained shear strength shall be accounted for. The characteristic undrained shear strength shall be taken as the mean value with due account of the quality and complexity of the soil conditions.

508 Seabed impact landing and subsequent penetration by self weight shall be addressed in terms of required water evacuation areas to avoid excessive channelling and/or global instability during installation.

509 Load factors for loads associated with impact landing, suction to target penetration depth and possible retrieval by means of overpressure shall be taken according to Sec.2 D400. For loads associated with permanent removal after service life the load factors may be taken according to Sec.2 D700.

510 The soil material coefficients to be applied for a potential soil plug failure during suction assisted penetration shall not be taken less than 1.5.

E 600 Fluke anchors

601 Design of fluke anchors shall be based on recognised principles in geotechnical engineering supplemented by data from tests performed under relevant site and loading conditions.

602 The penetration resistance of the anchor line shall be taken into considerations where deep penetration is required to mobilise reactions forces.

603 Fluke anchors are normally to be used only for horizontal and unidirectional load application. However, some uplift may be allowed under certain conditions both during anchor installation and during operating design conditions. The recommended design procedure for fluke anchors is given in the DNV-RP-E301.

604 The required installation load of the fluke anchor shall be determined from the required design resistance of the anchor, allowing for the inclusion of the possible contribution from post installation effects due to soil consolidation and storm induced cyclic loading. For details, see DNV-RP-E301. For fluke anchors in sand the same load coefficients as given in 200 should be applied, and the target installation load should normally not be taken less than the design load.

605 Provided that the uncertainty in the load measurements is accounted for and that the target installation tension T_i is reached and verified by reliable measurements the main uncertainty in the anchor resistance lies then in the predicted post-installation effects mentioned above.

The soil material coefficient γ_M on this predicted component of the anchor resistance shall then be:

γ_M = 1.3 for ULS Consequence Class 1 (CC1) and 2 (CC2)
= 1.0 for ALS CC1
= 1.3 for ALS CC2.

E 700 Plate anchors

701 Design methodologies for plate anchors like drag-in plate anchors, push-in plate anchors, drive-in plate anchors, suction embedment plate anchors, etc. should be established with due consideration of the characteristics of the respective anchor type, how the anchor installation affects the in-place conditions, etc.

702 Recipes for calculation of characteristic line tension and characteristic anchor resistance are given in DNV-RP-E302, together with their partial safety factors for each combination of limit state and consequence class. Requirements for measurements during installation are also provided.

APPENDIX A
CROSS SECTIONAL TYPES

A. Cross Sectional Types

A 100 General

101 Cross sections of beams are divided into different types dependent of their ability to develop plastic hinges as given in Table A1.

Table A1 Cross sectional types	
I	Cross sections that can form a plastic hinge with the rotation capacity required for plastic analysis
II	Cross sections that can develop their plastic moment resistance, but have limited rotation capacity
III	Cross sections where the calculated stress in the extreme compression fibre of the steel member can reach its yield strength, but local buckling is liable to prevent development of the plastic moment resistance
IV	Cross sections where it is necessary to make explicit allowances for the effects of local buckling when determining their moment resistance or compression resistance

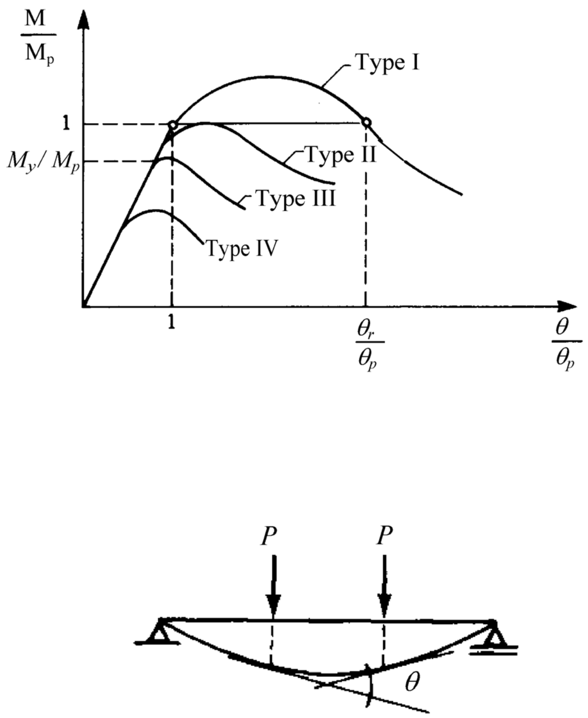


Figure 1
Relation between moment M and plastic moment resistance M_p, and rotation θ for cross sectional types. M_y is elastic moment resistance

102 The categorisation of cross sections depends on the proportions of each of its compression elements, see Table A3.

103 Compression elements include every element of a cross section which is either totally or partially in compression, due to axial force or bending moment, under the load combination considered.

104 The various compression elements in a cross section such as web or flange, can be in different classes.

105 The selection of cross sectional type is normally quoted by the highest or less favourable type of its compression elements.

A 200 Cross section requirements for plastic analysis

201 At plastic hinge locations, the cross section of the member which contains the plastic hinge shall have an axis of symmetry in the plane of loading.

202 At plastic hinge locations, the cross section of the member which contains the plastic hinge shall have a rotation capacity not less than the required rotation at that plastic hinge location.

A 300 Cross section requirements when elastic global analysis is used

301 When elastic global analysis is used, the role of cross section classification is to identify the extent to which the resistance of a cross section is limited by its local buckling resistance.

302 When all the compression elements of a cross section are type III, its resistance may be based on an elastic distribution of stresses across the cross section, limited to the yield strength at the extreme fibres.

Table A2 Coefficient related to relative strain

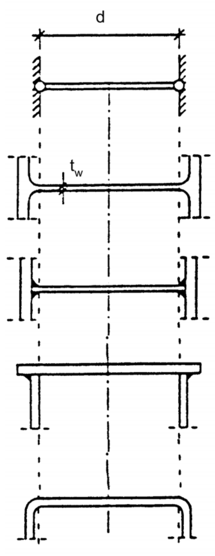
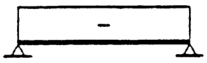
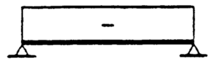
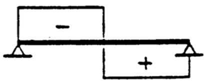
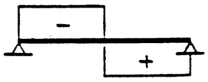
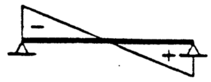
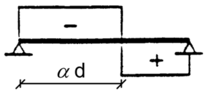
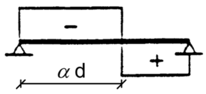
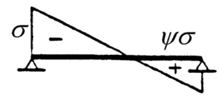
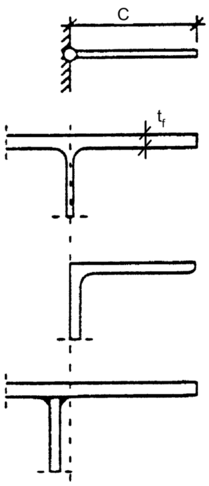
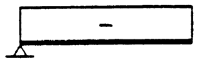
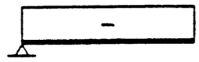
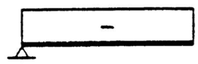
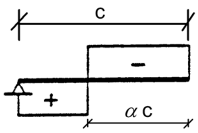
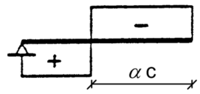
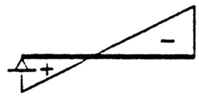
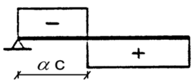
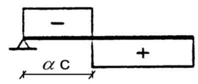
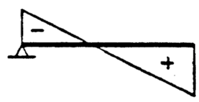
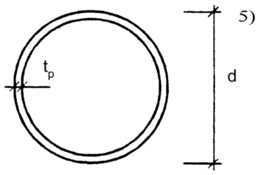
NV Steel grade 1)	ε 2)
NV-NS	1
NV-27	0.94
NV-32	0.86
NV-36	0.81
NV-40	0.78
NV-420	0.75
NV-460	0.72
NV-500	0.69
NV-550	0.65
NV-620	0.62
NV-690	0.58

1) The table is not valid for steel with improved weldability. See Sec.4, Table D1, footnote 1).

2)

$$\varepsilon = \sqrt{\frac{235}{f_y}} \quad \text{where } f_y \text{ is yield strength}$$

Table A3 Maximum width to thickness ratios for compression elements

Cross section part	*Type I*	*Type II*	*Type III*
 $d = h - 3\,t_w$ 3)	 1) $d / t_w \le 33\,\varepsilon$ 2)	 $d / t_w \le 38\,\varepsilon$	 $d / t_w \le 42\,\varepsilon$
	 $d / t_w \le 72\,\varepsilon$	 $d / t_w \le 83\,\varepsilon$	 $d / t_w \le 124\,\varepsilon$
	 when $\alpha > 0.5$: $d/t_w \le \frac{396\varepsilon}{13\alpha-1}$ when $\alpha \le 0.5$: $d/t_w \le \frac{36\varepsilon}{\alpha}$	 when $\alpha > 0.5$: $d/t_w \le \frac{456\varepsilon}{13\alpha-1}$ when $\alpha \le 0.5$: $d/t_w \le \frac{41.5\varepsilon}{\alpha}$	 when $\psi > -1$: $d/t_w \le \frac{126\varepsilon}{2+\psi}$ when $\psi \le -1$: $d/t_w \le 62\varepsilon(1-\psi)\sqrt{\lvert\psi\rvert}$
	 Rolled: $c/t_f \le 10\varepsilon$ Welded: $c/t_f \le 9\varepsilon$	 Rolled: $c/t_f \le 11\varepsilon$ Welded: $c/t_f \le 10\varepsilon$	 Rolled: $c/t_f \le 15\varepsilon$ Welded: $c/t_f \le 14\varepsilon$
	Tip in compression  Rolled: $c/t_f \le 10\varepsilon/\alpha$ Welded: $c/t_f \le 9\varepsilon/\alpha$	Tip in compression  Rolled: $c/t_f \le 11\varepsilon/\alpha$ Welded: $c/t_f \le 10\varepsilon/\alpha$	Tip in compression  4) Rolled: $c/t_f \le 23\varepsilon\sqrt{C}$ Welded: $c/t_f \le 21\varepsilon\sqrt{C}$
	Tip in tension  Rolled: $c/t_f \le \frac{10\varepsilon}{\alpha\sqrt{\alpha}}$ Welded: $c/t_f \le \frac{9\varepsilon}{\alpha\sqrt{\alpha}}$	Tip in tension  Rolled: $c/t_f \le \frac{11\varepsilon}{\alpha\sqrt{\alpha}}$ Welded: $c/t_f \le \frac{10\varepsilon}{\alpha\sqrt{\alpha}}$	Tip in tension  Rolled: $c/t_f \le 23\varepsilon\sqrt{C}$ Welded: $c/t_f \le 21\varepsilon\sqrt{C}$
 5)	$d / t_p \le 50\,\varepsilon^2$	$d / t_p \le 70\,\varepsilon^2$	$d / t_p \le 90\,\varepsilon^2$

1) Compression negative
2) ε is defined in Table A2
3) Valid for rectangular hollow sections (RHS) where h is the height of the profile
4) C is the buckling coefficient. See Eurocode 3 Table 5.3.3 (denoted k_σ)
5) Valid for axial and bending, not external pressure.

OFFSHORE STANDARD
DNV-OS-C103

STRUCTURAL DESIGN OF COLUMN STABILISED UNITS (LRFD METHOD)

APRIL 2004

DET NORSKE VERITAS

FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

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— *Offshore Service Specifications*. Provide principles and procedures of DNV classification, certification, verification and consultancy services.
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— *Recommended Practices*. Provide proven technology and sound engineering practice as well as guidance for the higher level Offshore Service Specifications and Offshore Standards.

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C) Structures

D) Systems

E) Special Facilities

F) Pipelines and Risers

G) Asset Operation

H) Marine Operations

Amendments and Corrections

This document is valid until superseded by a new revision. Minor amendments and corrections will be published in a separate document on the DNV web-site; normally updated twice per year (April and October). To access the web-site, select short-cut options "Technology Services" and "Offshore Rules and Standards" at http://www.dnv.com/

The electronic web-versions of the DNV Offshore Codes will be regularly updated to include these amendments and corrections.

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Main changes

- **General**

The present edition supersedes the October 2000 edition.

- **Main changes**

The main changes are:

— Sec.1 has been aligned with other relevant structural standards (e.g. references, terminology, definitions, etc.) and with DNV-OS-C101.
— Definition and application of *design temperature* have been updated. The term *service temperature* has been introduced.
— Formulations relating to *tank pressures* have been simplified and clarified.
— Amendments have been introduced in connection with the selection of load factors, contingency factors and the selection of *design waves*.

Corrections and Clarifications

In addition to the above mentioned changes, a number of corrections and clarifications have been made to the existing text.

Errata

2004-06-01

The equation for p_s in Sec.3 E202, page 14, has been corrected to include C_w - reduction factor due to wave particle motion.

$$p_s = \rho g_0 C_w (T_E - z_b) \quad (\mathrm{kNm}^2) \quad \geq 0$$

CONTENTS

SECTION 1 INTRODUCTION

A. General

A 100 General

101 This offshore standard provides requirements and guidance for the structural design of column-stabilised units, constructed in steel.

102 The standard has been written for general world-wide application. Governmental regulations may include requirements in excess of the provisions given by this standard depending on the size, type, location and intended service of an offshore unit or installation.

A 200 Objectives

201 The objectives of this standard are to:

- provide an internationally acceptable standard of safety by defining minimum requirements for design of column-stabilised units
- serve as a contractual reference document between suppliers and purchasers
- serve as a guideline for designers, suppliers, purchasers and regulators
- specify procedures and requirements for column-stabilised units subject to DNV verification.

A 300 Assumptions and applications

301 The requirements and guidance documented in this standard are generally applicable to all configurations of column-stabilised units, including those with:

- ring pontoons
- twin pontoons.

302 A column-stabilised unit is a floating structure that can be relocated. A column-stabilised unit normally consists of a deck box with a number of widely spaced, large diameter, supporting columns that are attached to submerged pontoons.

303 Column-stabilised unit may be kept on station by either a passive mooring system, e.g. anchor lines, or an active mooring system, e.g. thrusters, or a combination of these methods.

304 Requirements concerning mooring and riser systems are not considered in this standard.

305 A column-stabilised unit may be designed to function in a number of modes, e.g. transit, operational and survival. Limiting design criteria modes of operation shall be clearly established and documented. Such limiting design criteria shall include relevant consideration of the following items:

- intact condition, structural strength
- damaged condition, structural strength
- air gap
- watertight integrity and hydrostatic stability.

306 For novel designs, or unproved applications of designs where limited or no direct experience exists, relevant analyses and model testing, shall be performed to clearly demonstrate that an acceptable level of safety is obtained.

A 400 Classification

401 Classification principles, procedures and applicable class notations related to classification services of offshore units are specified in the DNV Offshore Service Specifications given in Table A1.

Table A1 DNV Offshore Service Specifications	
Reference	*Title*
DNV-OSS-101	Rules for Classification of Drilling and Support Units
DNV-OSS-102	Rules for Classification of Production and Storage Units

402 Documentation requirements for classification are given by DNV-RP-A202.

403 Technical requirements given in DNV-OS-C101, section 8, related to Serviceability Limit States, are not mandatory as part of classification.

B. References

B 100 General

101 The Offshore Standards, Recommended Practices and Classification Notes given in Table B1 are referred to in this standard.

Table B1 DNV Offshore Standards, Classification Notes and Recommended Practices	
Reference	*Title*
DNV-OS-A101	Safety Principles and Arrangement
DNV-OS-B101	Metallic Materials
DNV-OS-C101	Design of Offshore Steel Structures, General (LRFD method)
DNV-OS-C301	Stability and Watertight Integrity
DNV-OS-C401	Fabrication and Testing of Offshore Structures
DNV-OS-D101	Marine and Machinery Systems and Equipment
DNV-OS-D301	Fire Protection
DNV-OS-E301	Position Mooring
DNV-RP-C103	Column-stabilised Units
DNV-RP-C201	Buckling of Plated Structures
DNV-RP-C202	Buckling Strength of Shells
DNV-RP-C203	Fatigue Strength Analysis
Classification Note 30.1 Sec. 2	Buckling Strength Analysis (Bars and Frames)
Classification Note 30.5	Environmental Conditions and Environmental Loads
Classification Note 30.6	Structural Reliability Analysis of Marine Structures
	Rules for Planning and Execution of Marine Operations

C. Definitions

C 100 Verbal forms

101 *Shall:* Indicates a mandatory requirement to be followed for fulfilment or compliance with the present standard. Deviations are not permitted unless formally and rigorously justified, and accepted by all relevant contracting parties.

102 *Should:* Indicates a recommendation that a certain course of action is preferred or particularly suitable. Alternative courses of action are allowable under the standard where agreed between contracting parties but shall be justified and documented.

103 *May:* Indicates a permission, or an option, which is permitted as part of conformance with the standard.

C 200 Terms

201 *Transit conditions:* All unit movements from one geographical location to another.

202 Standard terms are given in DNV-OS-C101.

D. Symbols

D 100 Symbols

101 *Latin characters*

$\bar{a}$	=	the intercept of the design S-N curve with the log N axis
a_h	=	horizontal acceleration
a_v	=	vertical acceleration
g_0	=	9.81 m/s^2 acceleration due to gravity
h	=	Weibull shape parameter
h_{op}	=	vertical distance from the load point to the position of maximum filling height
M	=	mass of cargo, equipment or other components
m	=	the inverse slope of the S-N curve
n_0	=	total number of stress fluctuations during the lifetime of the structure
n_i	=	number of stress fluctuations in *i* years
p_d	=	design pressure
p_{dyn}	=	pressure head due to flow through pipes
z_b	=	vertical distance in m from the moulded baseline to the load point
C_w	=	reduction factor due to wave particle motion (Smith effect)
D_D	=	vertical distance from the moulded baseline to the underside of the deck structure
DFF	=	Design Fatigue Factor
P_{Hd}	=	horizontal design force
P_{Vd}	=	vertical design force
T_E	=	extreme operational draught measured vertically from the moulded baseline to the assigned load waterline.

102 *Greek characters*

Γ	=	gamma function
α	=	angle
ρ	=	density
γ_c	=	contingency factor
τ_d	=	nominal design shear stress in the girder adjusted for cut-outs
γ_f	=	partial load factor
$\gamma_{f,E}$	=	partial load factor for environmental loads
$\gamma_{f,G,Q}$	=	partial load factor for functional and variable loads.

D 200 Abbreviations

201 Abbreviations used in this standard are given in DNV-OS-C101.

SECTION 2
STRUCTURAL CATEGORISATION, MATERIAL SELECTION AND INSPECTION PRINCIPLES

A. General

A 100 Scope

101 This section describes the structural categorisation, selection of steel materials and inspection principles to be applied in design and construction of column-stabilised units.

102 The structural application categories are determined based on the structural significance, consequences of failure and the complexity of the joints. The structural application category set the selection of steel quality and the inspection extent of the welds.

103 The steel grades selected for structural components shall be related to weldability and requirements for toughness properties and shall be in compliance with the requirements given in the DNV-OS-B101.

B. Structural Categorisation

B 100 Structural categorisation

101 Application categories for structural components are defined in DNV-OS-C101 Sec.4. Structural members of column-stabilised units are grouped as follows:

Special category

a) Portions of deck plating, heavy flanges, and bulkheads within the upper hull or platform which form «box» or «I» type supporting structure which receive major concentrated loads.

b) External shell structure in way of intersections of vertical columns, decks and lower hulls.

c) Major intersections of bracing members.

d) «Through» material used at connections of vertical columns, upper platform decks and upper or lower hulls which are designed to provide proper alignment and adequate load transfer.

e) External brackets, portions of bulkheads, and frames which are designed to receive concentrated loads at intersections of major structural members.

f) Highly utilised areas supporting anchor line fairleads and winches, crane pedestals, flare etc.

Guidance note:
Highly stressed areas are normally considered to be areas utilised more than 85% of the allowable yield capacity.

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Fig.1 to Fig.4 show typical examples of special structures.

Primary category

a) Deck plating, heavy flanges, and bulkheads within the upper hull or platform which form «box» or «I» type supporting structure which do not receive major concentrated loads.

b) External shell structure of vertical columns, lower and upper hulls, and diagonal and horizontal braces.

c) Bulkheads, decks, stiffeners and girders which provide local reinforcement or continuity of structure in way of intersections, except areas where the structure is considered for special application.

d) Main support structure of heavy substructures and equipment, e.g. anchor line fairleads, cranes, drillfloor substructure, life boat platform, thruster foundation and helicopter deck.

Secondary category

a) Upper platform decks, or decks of upper hulls except areas where the structure is considered primary or special application.

b) Bulkheads, stiffeners, flats or decks and girders in vertical columns, decks, lower hulls, diagonal and horizontal bracing, which are not considered as primary or special application.

c) Deckhouses.

d) Other structures not categorised as special or primary.

C. Material Selection

C 100 General

101 Material specifications shall be established for all structural materials. Such materials shall be suitable for their intended purpose and have adequate properties in all relevant design conditions. Material selection shall be undertaken in accordance with the principles given in DNV-OS-C101.

102 When considering criteria appropriate to material grade selection, adequate consideration shall be given to all relevant phases in the life cycle of the unit. In this connection there may be conditions and criteria, other than those from the in-service operational phase that provide the design requirements in respect to the selection of material. (Such criteria may, for example, be design temperature and/or stress levels during marine operations.)

103 In structural cross-joints essential for the overall structural integrity where high tensile stresses are acting normal to the plane of the plate, the plate material shall be tested to prove the ability to resist lamellar tearing (Z-quality).

104 Material designations are defined in DNV-OS-C101.

C 200 Design and service temperatures

201 The design temperature for a unit is the reference temperature for assessing areas where the unit can be transported, installed and operated. The design temperature shall be lower or equal to the lowest mean daily temperature in air for the relevant areas. For seasonal restricted operations the lowest mean daily temperature in air for the season may be applied.

202 The service temperatures for different parts of a unit apply for selection of structural steel. The service temperatures are defined as presented in 203 to 206. In case different service temperatures are defined in 203 to 206 for a structural part the lower specified value shall be applied.

203 External structures above the light transit waterline shall not be designed for a service temperature higher than the design temperature for the unit.

However, for column-stabilised units of conventional type, the pontoon deck need not be designed for service temperatures lower than 0ºC.

204 External structures below the light transit waterline need not be designed for service temperatures lower than 0ºC.

205 Internal structures of columns, pontoons and decks shall have the same service temperature as the adjacent external structure, if not otherwise documented.

206 Internal structures in way of permanently heated rooms need not to be designed for service temperatures lower than 0ºC.

D. Inspection Categories

D 100 General

101 Welding and the extent of non-destructive testing during fabrication, shall be in accordance with the requirements stipulated for the appropriate inspection category as defined in DNV-OS-C101, Sec.4.

102 Inspection categories determined in accordance with DNV-OS-C101, Sec.4 provide requirements for the minimum extent of required inspection. When considering the economic consequence that repair during in-service operation may entail, for example, in way of complex connections with limited or difficult access, it may be considered prudent engineering practice to require more demanding requirements for inspection than the required minimum.

103 When determining the extent of inspection and the locations of required NDT, in additional to evaluating design parameters (for example fatigue utilisation), consideration should be given to relevant fabrication parameters including:

— location of block (section) joints
— manual versus automatic welding
— start and stop of weld, etc.

E. Categorisation and Inspection Level for Typical Column-Stabilised Unit Details

E 100 General

101 Fig.1 to Fig.4 illustrate minimum requirements for structural categorisation and extent of inspection for typical column-stabilised unit configurations.

102 In way of the pontoon and column connection as indicated in Fig.1 and Fig.2, the pontoon deckplate should be the continuous material. These plate fields should be of material with through-thickness properties (Z-quality material).

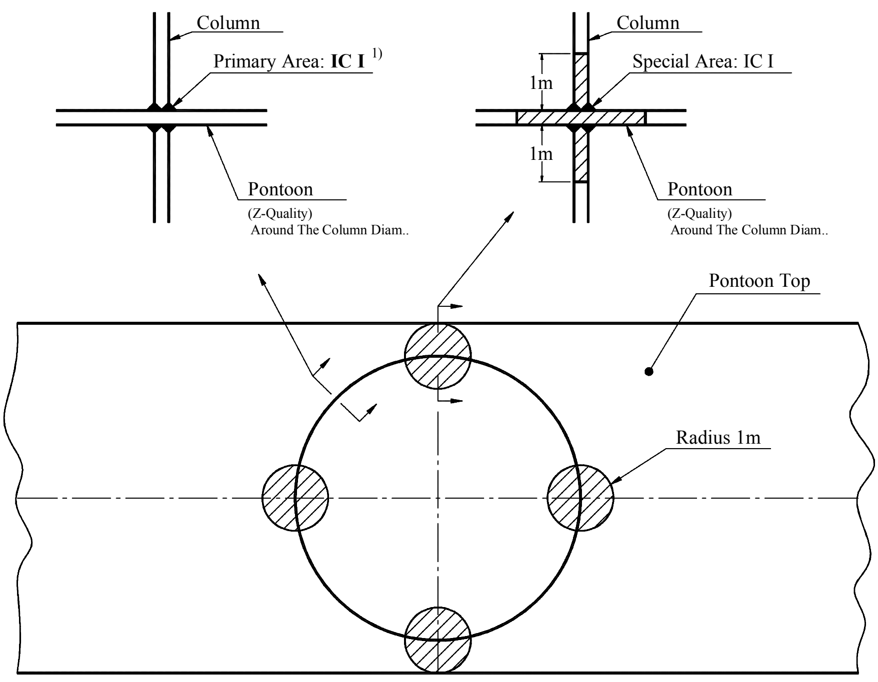
103 Shaded areas indicated in the figures are intended to be three-dimensional in extent. This implies that, in way of these locations, the shaded area is not only to apply to the outer surface of the connection, but is also to extend into the structure. However, stiffeners and stiffener brackets within this area should be of primary category and the bracket toe locations on the stiffeners should be designated with mandatory MPI.

104 Stiffeners welded to a plate categorised as special area should be welded with full penetration welds and no notches should be used.

105 The inspection categories for general pontoon, plate butt welds and girder welds to the pontoon shell are determined based upon, amongst others, accessibility and fatigue utilisation.

106 Major bracket toes should be designated as locations with a mandatory requirement for MPI. In way of the brace connections as indicated Fig.3, the brace and brace bracket plate fields should be the continuous material. These plate fields should be material with through-thickness properties (Z-quality material).

107 In way of the column and upper hull connection as indicated in Fig.4 the upper hull deckplate should be the continuous material. These plate fields should be material with through-thickness properties (Z-quality material).



1) This is normally fatigue critical, an hence the inspection category is increased from II to I, see DNV-OS-C101, Sec.4 C305

Figure 1
Pontoon and column connection, twin pontoon design

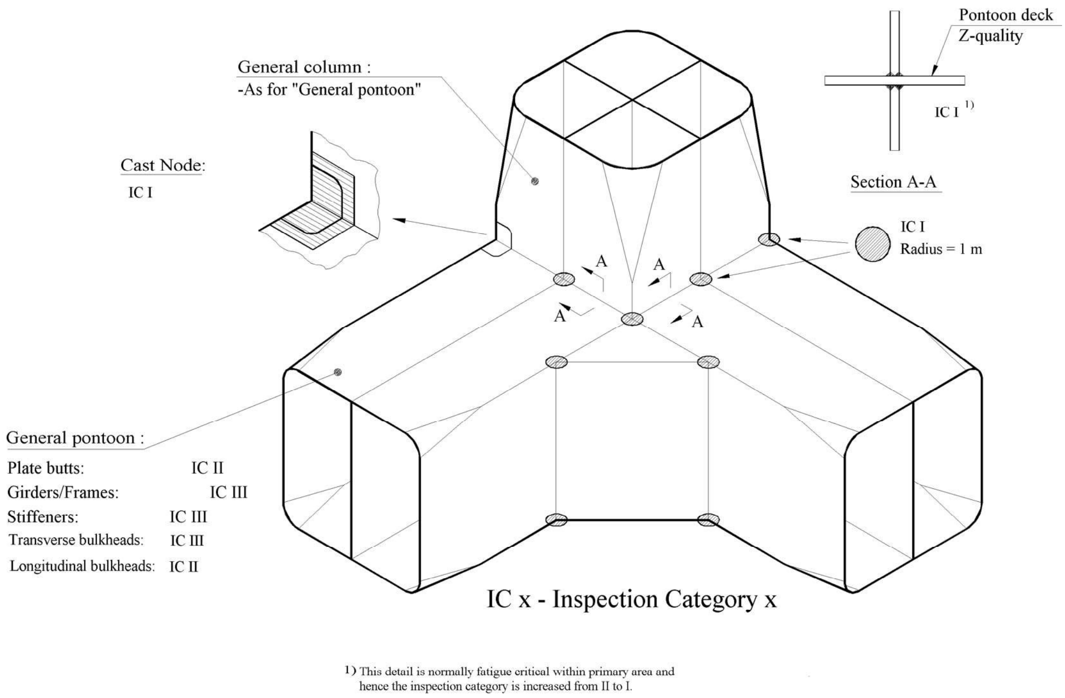


Figure 2
Column and ring pontoon connection, ring-pontoon design

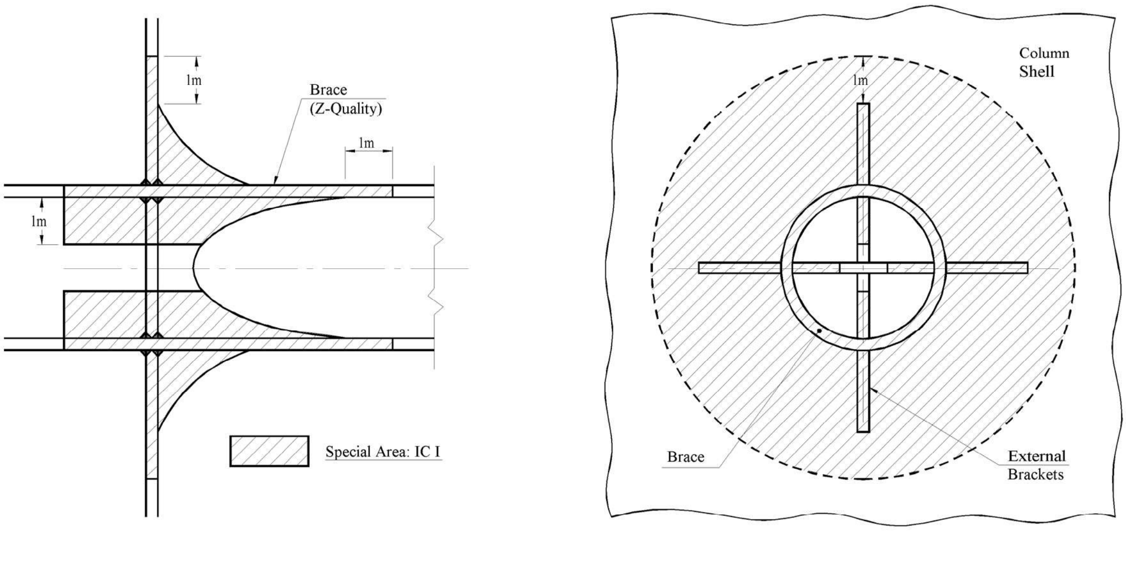
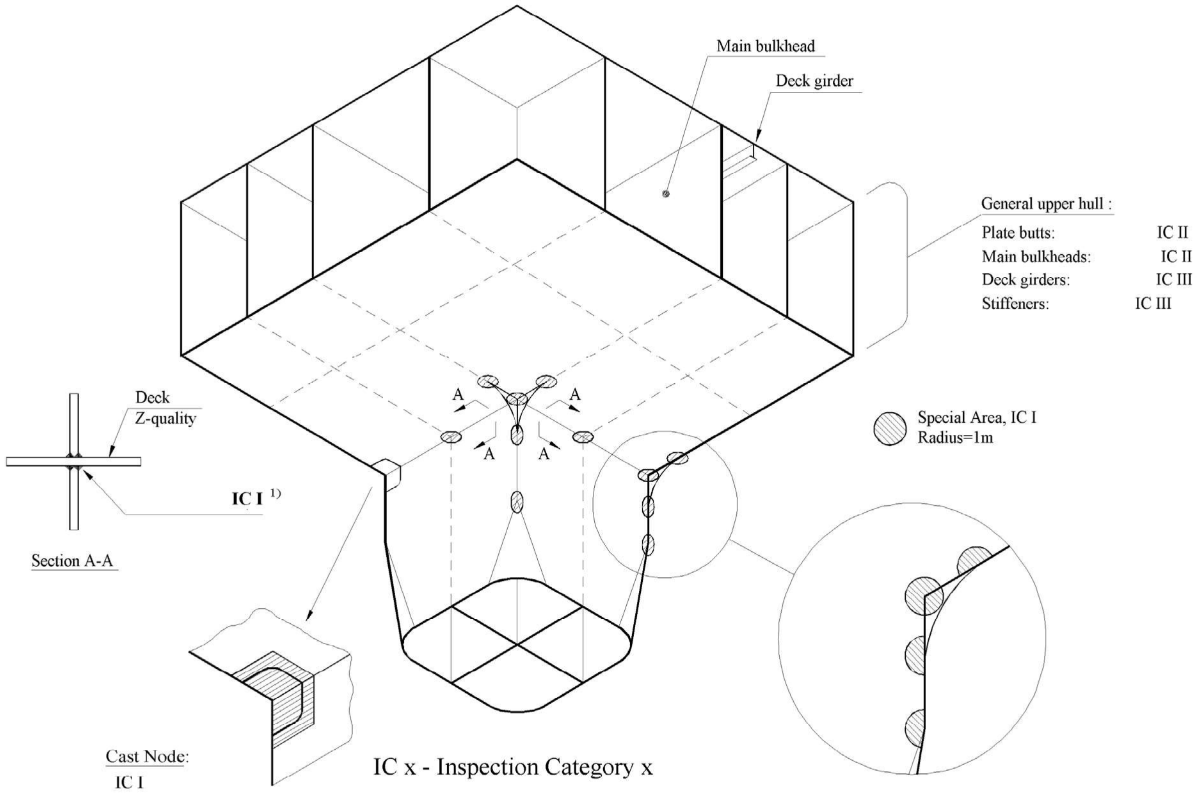


Figure 3
Brace connection



1) This detail is normally fatigue critical, and hence the inspection category is increased from II to I.

Figure 4
Connection column and upper hull

SECTION 3
DESIGN LOADS

A. Introduction

A 100 General

101 The requirements in this section define and specify load components and load combinations to be considered in the overall strength analysis as well as design pressures applicable for local design.

102 Characteristic loads shall be used as reference loads. Design loads are, in general, defined in DNV-OS-C101 and described in DNV-RP-C103 and Classification Note 30.5. Guidance concerning load categories relevant for column-stabilised unit designs are given in this section.

B. Definition

B 100 Load point

101 The load point for which the design pressure for a plate field shall be calculated, is defined as midpoint of a horizontally stiffened plate field, and half of the stiffener spacing above the lower support of vertically stiffened plate field, or at lower edge of plate when the thickness is changed within the plate field.

102 The load point for which the design pressure for a stiffener shall be calculated, is defined as midpoint of the span. When the pressure is not varied linearly over the span, the design pressure shall be taken as the greater of the pressure at the midpoint, and the average of the pressures calculated at each end of the stiffener.

103 The load point for which the design pressure for a girder shall be calculated, is defined as midpoint of the load area.

C. Permanent Loads (G)

C 100 General

101 Permanent loads are loads that will not vary in magnitude, position, or direction during the period considered, and include:

- lightweight of the unit, including mass of permanently installed modules and equipment, such as accommodation, helideck, drilling and production equipment
- hydrostatic pressures resulting from buoyancy
- pretension in respect to mooring, drilling and production systems, e.g. mooring lines, risers etc. See DNV-OS-E301.

D. Variable Functional Loads (Q)

D 100 General

101 Variable functional loads are loads that may vary in magnitude, position and direction during the period under consideration.

102 Except where analytical procedures or design specifications otherwise require, the value of the variable loads utilised in structural design shall be taken as either the lower or upper design value, whichever gives the more unfavourable effect. Variable loads on deck areas for local design are given in DNV-OS-C101, Sec.3 D200.

103 Variations in operational mass distributions, including variations in tank load conditions in pontoons, shall be adequately accounted for in the structural design.

104 Design criteria resulting from operational requirements shall be fully considered. Examples of such operations may be:

- drilling, production, workover, and combinations thereof
- consumable re-supply procedures
- maintenance procedures
- possible mass re-distributions in extreme conditions.

105 Dynamic loads resulting from flow through air pipes during filling operations shall be adequately considered in the design of tank structures.

D 200 Lifeboat platforms

201 Structural strength requirements related to lifeboat platforms and their supporting structure are given in DNV-OS-C101 Sec.3 D400.

D 300 Tank loads

301 A minimum design density (ρ) of 1.025 t/m^3 should be considered in the determination of the required scantlings of tank structures.

302 The extent to which it is possible to fill sounding, venting or loading pipe arrangements shall be fully accounted for in determination of the maximum design pressure to which a tank may be subjected to.

303 Dynamic pressure heads resulting from filling of such pipes shall be included in the design pressure head where such load components are applicable.

304 All tanks shall be designed for the following internal design pressure:

$$p_d = \rho \cdot g_0 h_{op}\left(\gamma_{f,G,Q} + \frac{a_v}{g_0}\gamma_{f,E}\right) \quad (\mathrm{kN/m^2})$$

a_v = maximum vertical acceleration, (m/s^2), being the coupled motion response applicable to the tank in question

h_{op} = vertical distance (m) from the load point to the position of maximum filling height. For tanks adjacent to the sea that are situated below the extreme operational draught (TE), hop should not be taken less than from the load point to the static sea level.
Descriptions and requirements related to different tank arrangements are given in DNV-OS-D101 Ch.2 Sec.3 C300.

$\gamma_{f,G,Q}$ = partial load factor, for permanent and functional loads see Sec.4 Table A1

$\gamma_{f,E}$ = partial load factor for environmental loads, see Sec.4 Table A1.

305 For tanks where the air pipe may be filled during filling operations, the following additional internal design pressure conditions shall be considered:

$$p_d = (\rho\, g_0\, h_{op} + p_{dyn})\, \gamma_{f,G,Q} \quad (\mathrm{kN/m^2})$$

p_{dyn} = Pressure (kN/m^2) due to flow through pipes, minimum 25 kN/m^2.

Guidance note:

This internal pressure need not to be combined with extreme environmental loads. Normally only static global response need to be considered.

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306 For external plate field boundaries, it is allowed to consider the external pressure up to the lowest waterline occurring in the environmental extreme condition, including relative motion of the unit.

Guidance note:

For preliminary design calculations, a_v may be taken as 0.3 g_0 and external pressure for external plate field boundaries may be taken up to half the pontoon height.

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307 In cases where the maximum filling height is less than the height to the top of the air pipe, it shall be ensured that the tank will not be over-pressured during operation and tank testing conditions.

308 Requirements for testing of tank tightness and structural strength are given in DNV-OS-C401, Ch.2 Sec.4.

E. Environmental Loads (E)

E 100 General

101 General considerations for environmental loads are given in DNV-OS-C101 Sec.3 E and Sec.3 F, and Classification Note 30.5.

102 Combinations of environmental loads are stated in DNV-OS-C101 Sec.3 Table F1.

103 Typical environmental loads to be considered in the structural design of a column-stabilised unit are:

- wave loads, including variable pressure, inertia, wave 'run-up', and slamming loads
- wind loads
- current loads
- snow and ice loads.

104 The following responses due to environmental loads shall be considered in the structural design of a column-stabilised unit:

- dynamic stresses for all limit states
- rigid body motion, e.g. in respect to air gap and maximum angles of inclination
- sloshing
- slamming induced vibrations
- vortex induced vibrations,e.g. resulting from wind loads on structural elements in a flare tower
- environmental loads from mooring and riser system.

105 For column-stabilised units with traditional catenary mooring systems, earthquake loads may normally be ignored.

E 200 Sea pressures

201 For load conditions where environmental load effects shall be considered the pressures resulting from sea loading are to include consideration of the relative motion of the unit.

202 The design sea pressure acting on pontoons and columns of column-stabilised platforms in operating conditions shall be taken as:

$$p_d = p_s \cdot \gamma_{f, G, Q} + p_e \cdot \gamma_{f, E}$$

where

$$p_s = \rho g_0 C_w (T_E - z_b) \quad (\text{kNm}^2) \quad \geq 0$$

and

$$p_e = \rho g_0 C_w (D_D - z_b) \quad (\text{kNm}^2) \text{ for } z_b \geq T_E$$

$$p_e = \rho g_0 C_w (D_D - T_E) \quad (\text{kNm}^2) \text{ for } z_b < T_E$$

T_E	=	extreme operational draught (m) measured vertically from the moulded baseline to the assigned load waterline
C_w	=	reduction factor due to wave particle motion (Smith effect) C_w = 0.9 unless otherwise documented
D_D	=	vertical distance in m from the moulded baseline to the underside of the deck structure (the largest relative distance from moulded baseline to the wave crest may replace D_D if this is proved smaller)
z_b	=	vertical distance in m from the moulded baseline to the load point
p_s	=	permanent sea pressure
p_e	=	environmental sea pressure.

203 When pressures are acting on both sides of bulkheads, the load factor shall be applied to the net pressure.

204 The Smith effect (C_w = 0.9) shall only be applied for loading conditions including extreme wave conditions.

E 300 Wind loads

301 The pressure acting on vertical external bulkheads exposed to wind shall in general not be taken less than 2.5 kN/m^2 for local design.

302 Further details regarding wind design loads are given in Classification Note 30.5.

E 400 Heavy components

401 The forces acting on supporting structures and lashing systems for rigid units of cargo, equipment or other structural components should be taken as:

$$P_{Vd} = (g_0 \gamma_{f, G, Q} + a_v \gamma_{f, E}) M \quad (\text{kN})$$

$$P_{Hd} = a_h \gamma_{f, E} M \quad (\text{kN})$$

For components exposed to wind, a horizontal force due to the design gust wind shall be added to P_{Hd}.

a_v	=	vertical acceleration (m/s^2)
a_h	=	horizontal acceleration (m/s^2)
M	=	mass of cargo, equipment or other components (t)
P_{Vd}	=	vertical design force
P_{Hd}	=	horizontal design force.

402 Further considerations with respect to environmental loads are given in Classification Note 30.5.

F. Deformation Loads (D)

F 100 General

101 Deformation loads are loads caused by inflicted deformations, such as:

- temperature loads
- built-in deformations.

Further details and description of deformation loads are given in DNV-OS-C101 Sec.3 H.

G. Accidental Loads (A)

G 100 General

101 The following ALS events shall be considered in respect to the structural design of a column-stabilised unit:

— collision
— dropped objects, e.g. from crane handling
— fire
— explosion
— unintended flooding.

102 Requirements and guidance on accidental loads are given in DNV-OS-C101 and generic loads are given in DNV-OS-A101.

H. Fatigue Loads

H 100 General

101 Repetitive loads, which may lead to significant fatigue damage, shall be evaluated. The following listed sources of fatigue loads shall, where relevant, be considered:

— waves (including those loads caused by slamming and variable (dynamic) pressures).
— wind (especially when vortex induced vibrations may occur)
— currents (especially when vortex induced vibrations may occur)
— mechanical loading and unloading, e.g. crane loads.

The effects of both local and global dynamic response shall be properly accounted for when determining response distributions related to fatigue loads.

102 Further considerations in respect to fatigue loads are given in DNV-RP-C203 and Classification Note 30.5.

I. Combination of Loads

I 100 General

101 Load factors and load combinations for the design limit states are in general, given in DNV-OS-C101.

102 Structural strength shall be evaluated considering all relevant, realistic load conditions and combinations. Scantlings shall be determined on the basis of criteria that combine, in a rational manner, the effects of relevant global and local responses for each individual structural element.

Further guidance on relevant load combinations is given in DNV-RP-C103.

103 A sufficient number of load conditions shall be evaluated to ensure that the characteristic largest (or smallest) response, for the appropriate return period, has been established.

SECTION 4
ULTIMATE LIMIT STATES (ULS)

A. General

A 100 General

101 General requirements in respect to methods of analysis and capacity checks are given in DNV-OS-C101.

Detailed considerations with respect to analysis methods and models are given in DNV-RP-C103.

102 Both global and local capacity shall be checked with respect to ULS. The global and local stresses shall be combined in an appropriate manner.

103 Analytical models shall adequately describe the relevant properties of loads, stiffness, displacement, response, and satisfactorily account for the local system, effects of time dependency, damping and inertia.

104 Two sets of design load combinations, a) and b) shall be checked. Partial load factors for ULS checks of column-stabilised units according to the present standard are given in Table A1.

Table A1 Load factors, Ultimate Limit States

Combination of design loads	*Load categories*		
	Permanent and variable functional loads, $\gamma_{f,G,Q}$	*Environmental loads,* $\gamma_{f,E}$	*Deformation loads,* $\gamma_{f,D}$
a	1.2 1)	0.7	1.0
b	1.0	1.2	1.0

1) If the load is not well defined, e.g. masses or functional loads with great uncertainty, possible overfilling of tanks etc., the coefficient should be increased to 1.3.

105 The loads shall be combined in the most unfavourable way, provided that the combination is physically feasible and permitted according to the load specifications. For permanent and variable functional loads, a load factor of 1.0 shall be used in load combination a) where this gives the most unfavourable response.

106 The material factor γ_M for ULS yield check should be 1.15 for steel structural elements. Material factors γ_M for ULS buckling checks and bolt connections are given in DNV-OS-C101 sec.5. Material factors γ_M for ULS weld connections are given in DNV-OS-C101 Sec.9.

A 200 Global capacity

201 Gross scantlings may be utilised in the calculation of hull structural strength, provided a corrosion protection system in accordance DNV-OS-C101, is maintained.

202 Ultimate strength capacity check shall be performed for all structural members contributing to the global and local strength of the column-stabilised unit. The structures to be checked includes, but are not limited to, the following:

— outer skin of pontoons
— longitudinal and transverse bulkheads, girders and decks in pontoons
— connections between pontoon, columns and bracings
— bracings
— outer skin of columns
— decks, stringers and bulkheads in columns
— main bearing bulkheads, frameworks and decks in the deck structure
— connection between bracings and the deck structure
— connection between columns and the deck structure
— girders in the deck structure.

A 300 Transit condition

301 The structure shall be analysed for zero forward speed. For units in transit with high speed, also maximum speed shall be considered in the load and strength calculations.

Guidance note:
Roll and pitch motion at resonance should be somewhat smaller than calculated by a linear wave theory due to flow of water on top of the pontoons. This effect may be accounted for provided rational analysis or tests prove its magnitude.

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302 Slamming on bracings shall be considered as a possible limiting criterion for operation in transit. The effect of forward speed shall be accounted for in the slamming calculations.

B. Method of Analysis

B 100 General

101 The analysis shall be performed to evaluate the structural capacity due to global and local effects. Consideration of relevant analysis methods and procedures are given in DNV-RP-C103, and in Appendix B.

102 Model testing shall be performed when significant non-linear effects cannot be adequately determined by direct calculations. In such cases, time domain analysis may also be considered as being necessary. Model tests shall also be performed for new types of column-stabilised units.

103 Where non-linear effects may be considered insignificant, or where such loads may be satisfactorily accounted for in a linear analysis, a frequency domain analysis may be adequately and satisfactorily undertaken. Transfer functions for structural response shall be established by analysis of an adequate number of wave directions, with an appropriate radial spacing. A sufficient number of periods shall be analysed to:

— adequately cover the site specific wave conditions
— satisfactorily describe transfer functions at, and around, the wave "cancellation" and "amplifying" periods
— satisfactorily describe transfer functions at, and around, the heave resonance period of the unit.

104 Global, wave-frequency, structural responses shall be established by an appropriate methodology, e.g.:

— a regular wave analysis
— a "design wave" analysis
— a stochastic analysis.

105 Design waves established based on the "design wave" method, see DNV-RP-C103, shall be based on the 90% fractile value of the extreme response distribution (100 years return period) developed from contour lines and short term extreme conditions.

106 A global structural model shall represent the global stiffness and should be represented by a large volume, thin-walled three dimensional finite element model. A thin-walled model should be modelled with shell or membrane elements sometimes in combination with beam elements. The structural connections in the model shall be modelled with adequately stiffness in order to represent the actual stiffness in such a way that the resulting responses are appropriate to the model being analysed. The global model usually comprises:

— pontoon shell, longitudinal and transverse bulkheads

— column shell, decks, bulkheads and trunk walls
— main bulkheads, frameworks and decks for the deck structure (“secondary” decks which are not taking part in the global structural capacity should not be modelled)
— bracing and transverse beams.

107 The global analyses should include consideration of the following load effects as found relevant:

— built-in stresses due to fabrication or mating
— environmental loads
— different ballast conditions including operating and survival
— transit.

108 Wave loads should be analysed by use of sink source model in combination with a Morison model when relevant. For certain designs a Morison model may be relevant. Details related to normal practice for selection of models and methods are given in Appendix B.

109 When utilising stochastic analysis for world wide operation the analyses shall be undertaken utilising North Atlantic scatter diagram given in Classification Note 30.5.

110 For restricted operation the analyses shall be undertaken utilising relevant site specific environmental data for the area(s) the unit will be operated. The restrictions shall be described in the operation manual for the unit.

C. Scantlings and Weld Connections

C 100 General

101 Minimum scantlings for plate, stiffeners and girders are given in DNV-OS-C101 Sec.5.

102 The requirements for weld connections are given in DNV-OS-C101 Sec.9.

D. Air Gap

D 100 General

101 In the ULS condition, positive air gap should in general be ensured for waves with a 10^{-2} annual probability of exeedance. However, local wave impact may be accepted if it is documented that such loads are adequately accounted for in the design and that safety to personnel is not significantly impaired.

102 Analysis undertaken to check air gap should be calibrated against relevant model test results when available. Such analysis should take into account:

— wave and structure interaction effects
— wave asymmetry effects
— global rigid body motions (including dynamic effects)
— effects of interacting systems, e.g. mooring and riser systems
— maximum and minimum draughts.

103 Column “run-up” load effects shall be accounted for in the design of the structural arrangement in the way of the column and bottom plate of the deck connection. These “run-up” loads shall be treated as environmental load component, however, they should not be considered as occurring simultaneously with other environmental loads.

104 Evaluation of sufficient air gap shall include consideration of all affected structural items including lifeboat platforms, riser balconies, overhanging deck modules etc.

SECTION 5
FATIGUE LIMIT STATES (FLS)

A. General

A 100 General

101 General requirements for the fatigue limit states are given in DNV-OS-C101 Sec.6. Guidance concerning fatigue calculations are given in DNV-RP-C203.

102 Units intended to follow normal inspection requirements according to class requirements, i.e. 5 yearly inspection in sheltered waters or drydock, may apply a Design Fatigue Factor (DFF) of 1.0.

103 Units intended to stay on location for prolonged survey period, i.e. without planned sheltered water inspection, shall comply with the requirements given in Appendix A.

104 The design fatigue life of the unit shall be minimum 20 years.

105 The fatigue capacity of converted units will be considered on a case-by-case basis, and is a function of the following parameters:

— results and findings form surveys and assessment of critical details
— service history of the unit and estimated remaining fatigue life.

Guidance note:
New structural steel on converted units older than 10 years, may normally be accepted with minimum 15 years documented fatigue life from the time of conversion.

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106 Local effects, e.g. due to:

— slamming
— sloshing
— vortex shedding
— dynamic pressures
— mooring and riser systems.

shall be included in the fatigue damage assessment when relevant.

107 In the assessment of fatigue resistance, relevant consideration shall be given to the effects of stress concentrations including those occurring as a result of:

— fabrication tolerances, including due regard to tolerances in way of connections involved in mating sequences or section joints
— cut-outs
— details at connections of structural sections, e.g. cut-outs to facilitate construction welding
— attachments.

108 Local detailed finite element analysis of critical connections, e.g. pontoon and pontoon, pontoon and column, column and deck and brace connections, should be undertaken in order to identify local stress distributions, appropriate SCF's, and/or extrapolated stresses to be utilised in the fatigue evaluation. Dynamic stress variations through the plate thickness shall be checked and considered in such evaluations, see DNV-RP-C203, for further details.

109 For well known details the local finite element analysis may be omitted, provided relevant information regarding SCF are available.

110 Principal stresses, see DNV-RP-C203 Sec.2.2, should be applied in the evaluation of fatigue responses.

B. Fatigue Analysis

B 100 General

101 The basis for determining the acceptability of fatigue resistance, with respect to wave loads, shall be in accordance with the requirements given in Appendix B. The required models and methods are dependent on type of operation, environment and design type of the unit.

B 200 World-wide operation

201 For world wide operation the analyses shall be undertaken utilising environmental data, e.g. scatter diagram, spectrum, given in Classification Note 30.5. The North Atlantic scatter diagram shall be utilised.

B 300 Restricted operation

301 The analyses shall be undertaken utilising relevant site specific environmental data for the area(s) the unit will be operated. The restrictions shall be described in the operation manual for the unit.

B 400 Simplified fatigue analysis

401 Simplified fatigue analysis may be undertaken in order to establish the general acceptability of fatigue resistance, or as a screening process to identify the most critical details to be considered in a stochastic fatigue analysis, see 500.

402 Simplified fatigue analyses should be undertaken utilising appropriate conservative design parameters. A two-parameter, Weibull distribution, see DNV-RP-C203, Sec.2.14, may be utilised to describe the long-term stress range distribution. In such cases the Weibull shape parameter 'h', see 403 for a two-pontoon semisubmersible unit should have a value of h = 1.1.

403 The following formula may be used for simplified fatigue evaluation:

$$\Delta\sigma_{n_0} = \frac{1}{\gamma_c} \cdot \frac{(\ln(n_0))^{\frac{1}{h}}}{(DFF)^{\frac{1}{m}}} \left[\frac{\bar{a}}{n_0 \Gamma\left(1 + \frac{m}{h}\right)} \right]^{\frac{1}{m}}$$

n_0	=	total number of stress variations during the lifetime of the structure
$\Delta\sigma_{n_0}$	=	extreme stress range (MPa) that is exceeded once out of n_0 stress variations. The extreme stress amplitude $\Delta\sigma_{ampl\_n_0}$ is thus given by $\left(\frac{\Delta\sigma_{n_0}}{2}\right)$
h	=	the shape parameter of the Weibull stress range distribution
$\bar{a}$	=	the intercept of the design S-N curve with the log N axis (see DNV-RP-C203 Sec.2.3)
$\Gamma\left(1 + \frac{m}{h}\right)$	=	is the complete gamma function (see DNV-RP-C203 Sec.2.14)
m	=	the inverse slope of the S-N curve (see DNV-RP-C203 Sec.2.14)
DFF	=	Design Fatigue Factor.

404 A simplified fatigue evaluation shall be based on dynamic stresses from design waves analysed in the global analysis as described in Sec.4 B. The stresses should be scaled to the return period of the minimum fatigue life of the unit. In such cases, scaling may be undertaken utilising the appropriate factor found from the following:

$$\Delta\sigma_{n_0} = \Delta\sigma_{n_i}\left[\frac{\log n_0}{\log n_i}\right]^{\frac{1}{h}}$$

n_i = the number of stress variations in i years appropriate to the global analysis

$\Delta\sigma_{n_i}$ = the extreme stress range (MPa) that is exceeded once out of n_i stress variations.

B 500 Stochastic fatigue analysis

501 Stochastic fatigue analyses shall be based upon recognised procedures and principles utilising relevant site specific data or North Atlantic environmental data.

502 Simplified fatigue analyses should be used as a "screening" process to identify locations for which a detailed, stochastic fatigue analysis should be undertaken.

503 Fatigue analyses shall include consideration of the directional probability of the environmental data. Providing that it can be satisfactorily checked, scatter diagram data may be considered as being directionally specific. Scatter diagram for world wide operations (North Atlantic scatter diagram) is given in Classification Note 30.5. Relevant wave spectra and energy spreading shall be utilised as relevant. A Pierson-Moskowitz spectrum and a $\cos^4$ spreading function should be utilised in the evaluation of column-stabilised units.

504 Structural response shall be determined based upon analyses of an adequate number of wave directions. Transfer functions should be established based upon consideration of a sufficient number of periods, such that the number, and values of the periods analysed:

— adequately cover the wave data
— satisfactorily describe transfer functions at, and around, the wave "cancellation" and "amplifying" periods (consideration should be given to take into account that such "cancellation" and "amplifying" periods may be different for different elements within the structure)
— satisfactorily describe transfer functions at, and around, the relevant excitation periods of the structure.

505 Stochastic fatigue analyses utilising simplified structural model representations of the unit, e.g. a space frame model, may form basis for identifying locations for which a stochastic fatigue analysis, utilising a detailed model of the structure, should be undertaken, e.g. at critical intersections. See also Appendix B for more details regarding models and methods.

SECTION 6
ACCIDENTAL LIMIT STATES (ALS)

A. General

A 100 General

101 Satisfactory protection against accidental damage shall be obtained by the following means:

— low damage probability
— acceptable damage consequences.

102 The structure's capability to redistribute loads should be considered when designing the structure. The structural integrity shall be intact and should be analysed for the following damage conditions:

— fracture of braces and major pillars important for the structural integrity, including their joints
— fracture of primary girder in the upper hull.

After damage requiring immediate repair, the unit shall resist functional and environmental loads corresponding to a return period of one year.

103 Analysis as stated shall satisfy relevant strength criteria given in this standard and in DNV-OS-C101. The damage consequences of other accidental events shall be specially considered in each case, applying an equivalent standard of safety.

Guidance note:
Energy absorption by impact types of accidental events requires the structure to behave in a ductile manner. Measures to obtain adequate ductility are:

- select materials with sufficient toughness for the actual service temperature and thickness of structural members
- make the strength of connections of primary members to exceed the strength of the member itself
- provide redundancy in the structure, so that alternate load redistribution paths may be developed
- avoid dependency on energy absorption in slender members with a non-ductile post buckling behaviour
- avoid pronounced weak sections and abrupt change in strength or stiffness.

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104 The loads and consequential damage due to accidental events or accidental flooding such as:

— collision
— dropped objects, e.g. from crane handling
— fire
— explosion
— unintended flooding
— abnormal wave events

shall not cause loss of floatability, capsizing, pollution or loss of human life. Requirements for watertight integrity and hydrostatic stability are given in DNV-OS-C301.

Guidance note:
10^{-4} waves need not to be considered as a ALS condition.

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

B. Collision

B 100 General

101 A collision between a supply vessel and a column of a column-stabilised unit shall be considered for all elements of the unit which may be exposed to sideway, bow or stern collision. The vertical extent of the collision zone shall be based on the depth and draught of the supply vessel and the relative motion between the supply vessel and the unit.

102 A collision will normally only cause local damage of the column. However, for a unit with slender columns, the global strength of the unit shall be checked.

103 A collision against a brace will normally cause complete failure of the brace and its connections, e.g. K-joints. These parts shall be assumed non-effective for check of the residual strength of the unit after collision.

C. Dropped Object

C 100 General

101 Critical areas for dropped objects shall be determined on the basis of the actual movement of potentially dropped objects relative to the structure of the unit itself. Where a dropped object is a relevant accidental event, the impact energy shall be established and the structural consequences of the impact assessed.

102 A dropped object on a brace will normally cause complete failure of the brace or its connections, e.g. K-joints. These parts are assumed to be non-effective for the check of the residual strength of the unit after dropped object impact.

103 Critical areas for dropped objects shall be determined on the basis of the actual movement of loads assuming a drop direction within an angle with the vertical direction:

— 10° in air, for floating units
— 5° in air, for bottom supported units
— 15° in water.

Dropped objects shall be considered for vital structural elements of the unit within the areas given above.

D. Fire

D 100 General

101 The main loadbearing structure that is subjected to a fire shall not lose the structural capacity. The following fire scenarios shall be considered:

— fire inside the unit
— fire on the sea surface.

102 Further requirements concerning accidental limit state events involving fire is given in DNV-OS-A101.

103 Assessment of fire may be omitted provided assumptions made in DNV-OS-D301 are met.

E. Explosion

E 100 General

101 In respect to design, considering loads resulting from explosions, one or a combination of the following design philosophies are relevant:

— hazardous areas are located in unconfined (open) locations and that sufficient shielding mechanisms,e.g. blast walls, are installed
— hazardous areas are located in partially confined locations and the resulting, relatively small overpressures are accounted for in the structural design
— hazardous areas are located in enclosed locations and pressure relief mechanisms are installed, e.g. blast panels designed to take the resulting overpressure.

102 As far as practicable, structural design accounting for large plate field rupture resulting from explosion loads should be avoided due to the uncertainties of the loads and the consequences of the rupture itself.

F. Heeled Condition

F 100 General

101 Heeling of the unit after damage flooding, as described in DNV-OS-C301 shall be accounted for in the assessment of structural strength. Maximum static allowable heel after accidental flooding is 17º including wind. Structures that are wet when the static equilibrium angle is achieved, shall be checked for external water pressure.

Guidance note:

The heeled condition corresponding to accidental flooding in transit conditions will normally not be governing for the design.

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102 The unit shall be designed for environmental condition corresponding to 1 year return period after damage, see DNV-OS-C101.

Guidance note:

The environmental loads may be disregarded if the material factor is taken as $\gamma_M = 1.33$.

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103 Local exceedance of the structural resistance is acceptable provided redistribution of forces due to yielding, buckling and fracture is accounted for.

104 Wave pressure, slamming forces and green sea shall be accounted for in all relevant areas. Local damage may be accepted provided progressive structural collapse and damage of vital equipment is avoided.

105 Position of air-intakes and openings to areas with vital equipment which need to be available during an emergency situation, e.g. emergency generators, shall be considered taking into account the wave elevation in a 1 year storm.

SECTION 7
SPECIAL CONSIDERATIONS

A. Redundancy

A 100 General

101 Structural robustness shall, when considered necessary, be demonstrated by appropriate analysis. Slender, main load bearing structural elements shall normally be demonstrated to be redundant in the accidental limit state condition.

A 200 Brace arrangements

201 For bracing systems the following listed considerations shall apply:

— brace structural arrangements shall be investigated for relevant combinations of global and local loads
— structural redundancy of slender bracing systems (see 100) shall normally include brace node redundancy, i.e. all braces entering the node, in addition to individual brace element redundancy
— brace end connection, e.g. brace and column connections, shall normally be designed such that the brace element itself will fail before the end connection
— underwater braces shall be watertight and have a leakage detection system
— the effect of slamming on braces shall be considered, e.g. in transit condition.

B. Support of Mooring Equipment, Towing Brackets etc.

B 100 Structural Strength

101 Structure supporting mooring equipment such as fairleads and winches, towing brackets etc. shall be designed for the loads and acceptance criteria specified in DNV-OS-E301, Ch.2 Sec.4. Details related to design of supporting structure for mooring equipment may be found in DNV-RP-C103.

C. Structural Details

C 100 General

101 In the design phase particular attention should be given to structural details, and requirements for reinforcement in areas that may be subjected to high local stresses, for example:

— critical connections
— locations that may be subjected to wave impact (including wave run-up effects along the columns)
— locations in way of mooring arrangements
— locations that may be subjected to damage.

102 In way of critical connections, structural continuity should be maintained through joints with the axial stiffening members and shear web plates being made continuous. Particular attention should be given to weld detailing and geometric form at the point of the intersections of the continuous plate fields with the intersecting structure.

APPENDIX A
PERMANENTLY INSTALLED UNITS

A. Introduction

A 100 Application

101 The requirements and guidance given in this Appendix are supplementary requirements for units that are intended to stay on location for prolonged periods, normally more than 5 years, see also DNV-OSS-101 and DNV-OSS-102 for requirements related to in-service inspections.

102 The requirements apply to all types of column-stabilised units.

103 Permanently located units shall be designed for site specific environmental criteria for the area(s) the unit will be located.

B. Inspection and Maintenance

B 100 Facilities for inspection on location

101 Inspections may be carried out on location based on procedures outlined in a maintenance system and inspection arrangement, without interrupting the function of the unit. The following matters should be taken into consideration to be able to carry out condition monitoring on location:

- arrangement for underwater inspection of hull, propellers, thrusters and openings affecting the unit's seaworthiness
- means of blanking of all openings
- marking of the underwater hull
- use of corrosion resistant materials for propeller
- accessibility of all tanks and spaces for inspection
- corrosion protection of hull
- maintenance and inspection of thrusters
- ability to gas free and ventilate tanks
- provisions to ensure that all tank inlets are secured during inspection
- testing facilities of all important machinery.

C. Fatigue

C 100 Design fatigue factors

101 Design Fatigue Factors (DFF) are introduced as fatigue safety factors. DFF shall be applied to structural elements according to the principles in DNV-OS-C101 Sec.6. See also Fig.1.

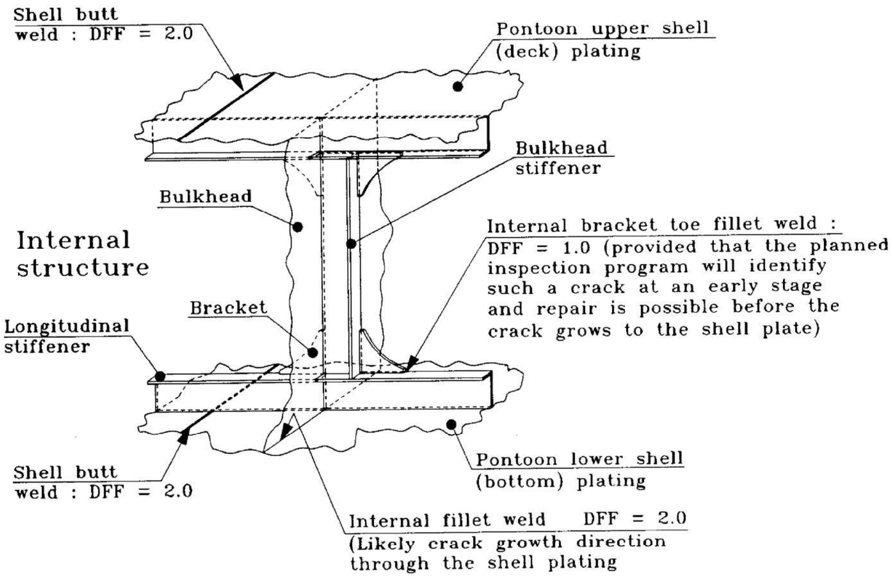

Figure 1
Example illustrating considerations relevant for selection of DFF in a typical pontoon section

102 Fatigue safety factors applied to column-stabilised units will be dependent on the accessibility for inspection and repair with special considerations in the splash zone, see 200.

103 When defining the appropriate DFF for a specific fatigue sensitive detail, consideration shall be given to the following:

- evaluation of likely crack propagation paths (including direction and growth rate related to the inspection interval), may indicate the use of a higher DFF, such that:
  - where the likely crack propagation indicates that a fatigue failure affect another detail with a higher design fatigue factor
  - where the likely crack propagation is from a location satisfying the requirement for a given 'Access for inspection and repair' category to a structural element having another access categorisation.

C 200 Splash zone

201 For fatigue evaluation of column-stabilised units, reference to the draught that is intended to be utilised during condition monitoring, shall be given as basis for the selection of DFF.

202 If significant adjustment in draught of the unit is possible to provide satisfactory access with respect to inspection, maintenance and repair, account may be taken of this possibility in the determination of the DFF. In such cases, a sufficient margin in respect to the minimum inspection draught should be considered when deciding upon the appropriate DFF in relation to the criteria for ‘Below splash zone’ as opposed to ‘Above splash zone’. Where draught adjustment possibilities exist, a reduced extent of splash zone may be applicable.

203 Requirements related to vertical extent of splash zone are given in DNV-OS-C101 Sec.10 B200.

APPENDIX B
METHODS AND MODELS FOR DESIGN OF COLUMN-STABILISED UNITS

A. Methods and Models

A 100 General

101 The guidance given in this appendix is normal practice for methods and models utilised in design of typical column-stabilised units i.e. ring-pontoon design and two-pontoon design.

For further details reference is made to DNV-RP-C103.

102 Table A1 gives guidance on methods and models normally applied in the design of typical column-stabilised units. For new designs deviating from well-known designs, e.g. by the slenderness of the structure and the arrangement of the load bearing elements, etc., the relevance of the methods and models should be considered.

A 200 World wide operation

201 Design for world wide operation shall be based on the environmental criteria given by the North Atlantic scatter diagram, see Classification Note 30.5.

202 The simplified fatigue method described in Sec.5 may be utilised with a Weibull parameter of 1.1. For units intended to operate for a longer period, see definition "Y" below, the simplified fatigue method should be verified by a stochastic fatigue analysis of the most critical details.

A 300 Benign waters or restricted areas

301 Design for restricted areas or benign waters shall be based on site specific environmental data for the area(s) the unit shall operate.

302 The simplified fatigue method described in Sec.5 shall be based on a Weibull parameter calculated based on site specific criteria.

Table A1 Methods and models which should be used for design of typical column-stabilised units

		Two-pontoon semisubmersible			*Ring-pontoon semisubmersible*		
		Hydrodynamic model, Morison	*Global structural strength model*	*Fatigue method*	*Hydrodynamic model, Morison*	*Global structural strength model*	*Fatigue method*
Harsh environment, restricted areas or World-Wide	X	1	4	6	1	5	7
	Y	1	4	7	1	5	7
Benign areas	X	2	3	6	1	5	7
	Y	1	4	6	1	5	7

Definitions

X-unit following normal class survey intervals (survey in sheltered waters or drydock every 4 to 5 years).

Y-unit located for a longer period on location – surveys carried out in-water at location.

Hydrodynamic models

1) Hybrid model - Sink-source and/or Morison (when relevant, for calculation of drag forces).

2) Morison model with contingency factor 1.1 for ULS and FLS. The contingency factors shall be applied in addition to the relevant load factors.

Global structural models

3) Beam model.

4) Combined beam and shell model. The extent of the beam and shell models may vary depending on the design. For typical beam structures a beam model alone may be acceptable.

5) Complete shell model.

Fatigue method

6) Simplified fatigue analysis. Contingency factor of 1.1 shall be applied, as given in Sec.5 B403.

7) Stochastic fatigue analysis, based on a screening process with simplified approach to identify critical details.

Harsh environment or World-Wide

— Units (X) designed for operation based on world wide requirements given in Classification Note 30.5.
— Units (Y) designed for operation based on site specific requirements.

Benign waters or restricted areas

— Units (X) designed for operation based on site specific criteria for benign waters or restricted areas.
— Units (Y) designed for operation based on site specific criteria for benign waters or restricted areas.

Guidance note:

Benign area:

Simplifications with respect to modelling procedures required for design documentation may be accepted for units intended for operations i benign areas, where the environmental design conditions dominate for the design of the unit, are less strict than for world-wide operation.

Units operating in benign areas are less dominated by environmental loads. Therefore, the ULS-b condition and fatigue capacity for standard performed detail are of minor importance for the design, and simplifications as described in the table above may be accepted.

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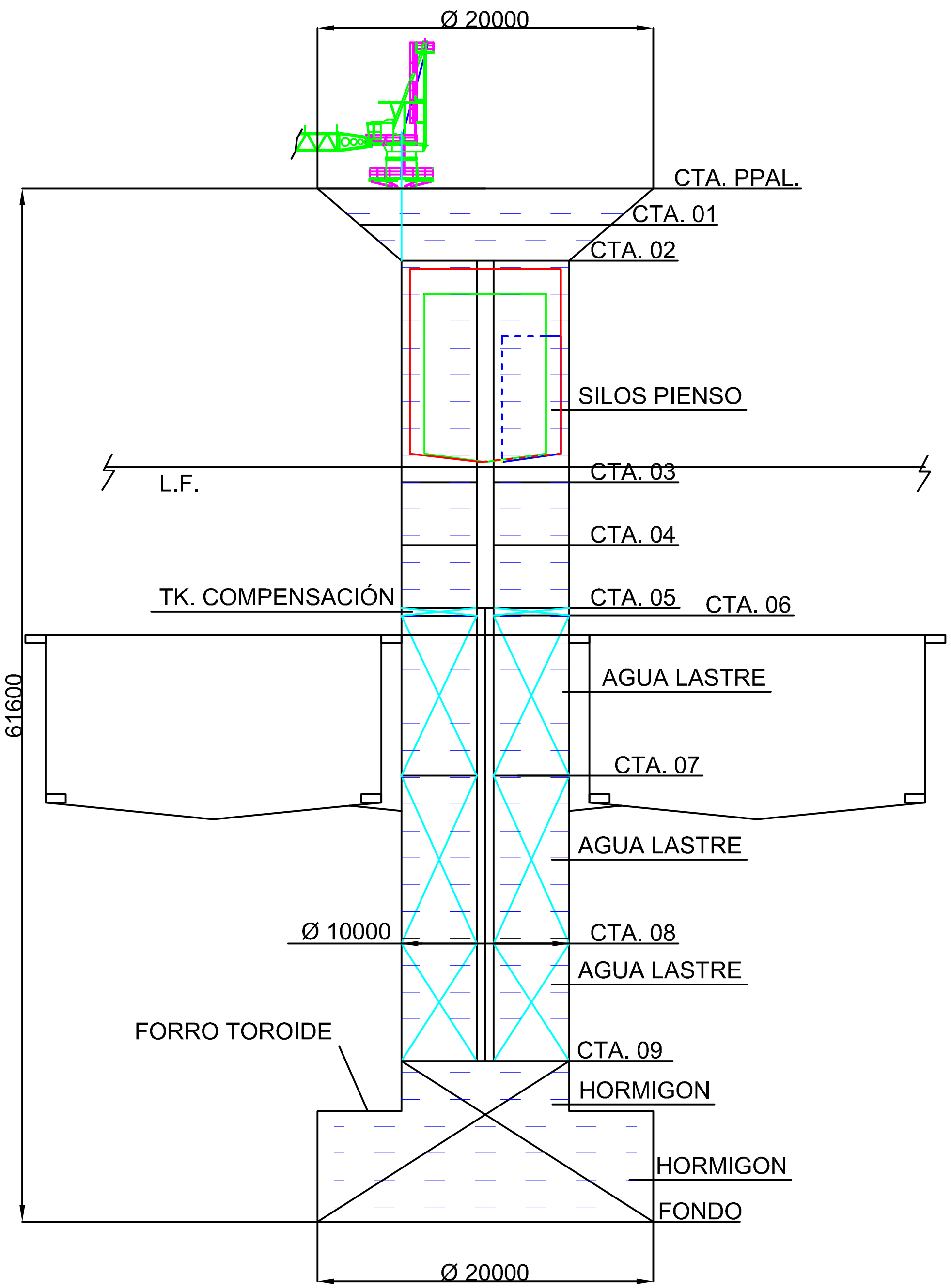
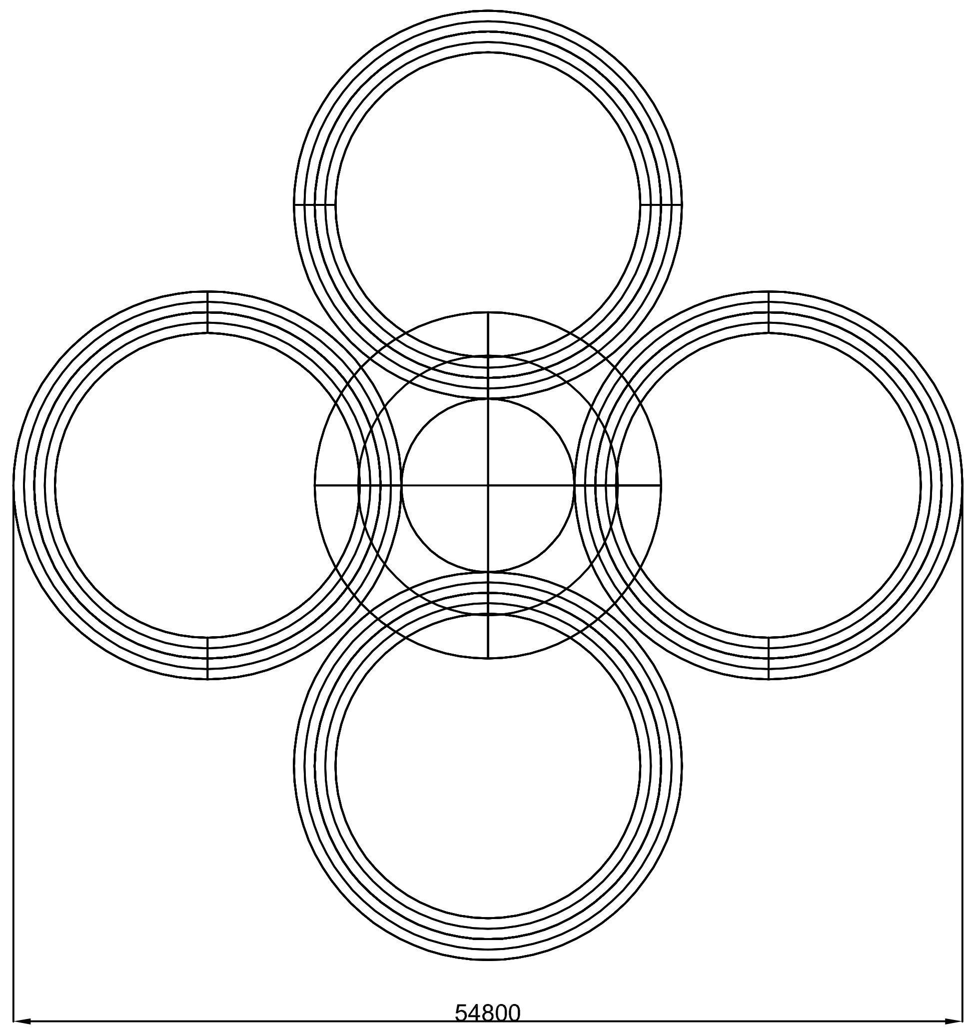
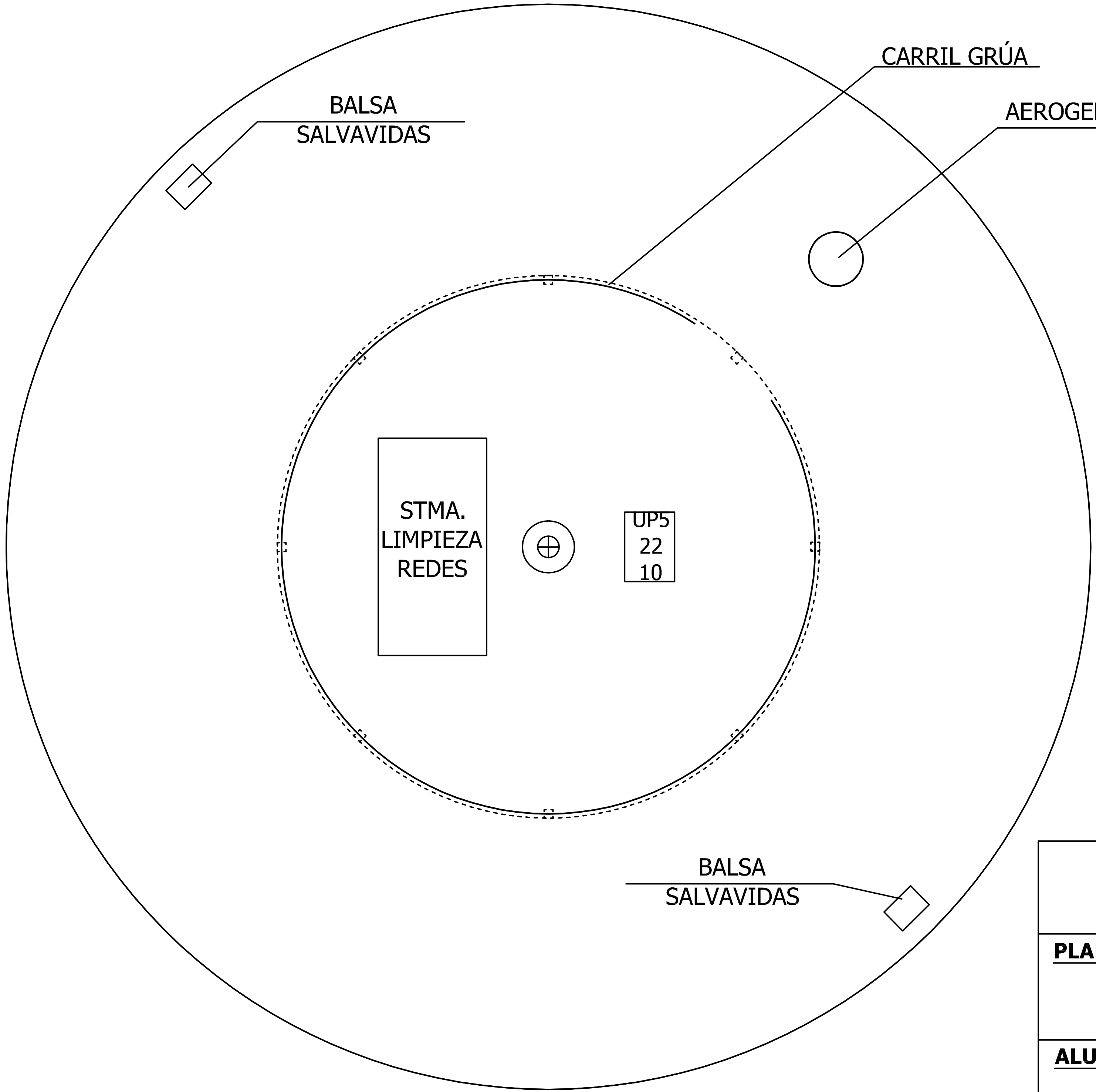




DISPOSICIÓN GENERAL

ESLORA 54,8m
MANGA 54,8m
PUNTAL 61,6m
CALADO PROYECTO 45m
CALADO ESCANTILLONADO 46,5m

PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: DISPOSICIÓN GENERAL PLANTA Y ALZADO	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	



CARACTERÍSTICAS CTA PPAL:

BALSA SALVAVIDAS
PESO 36.50kg, 690X490X230mm

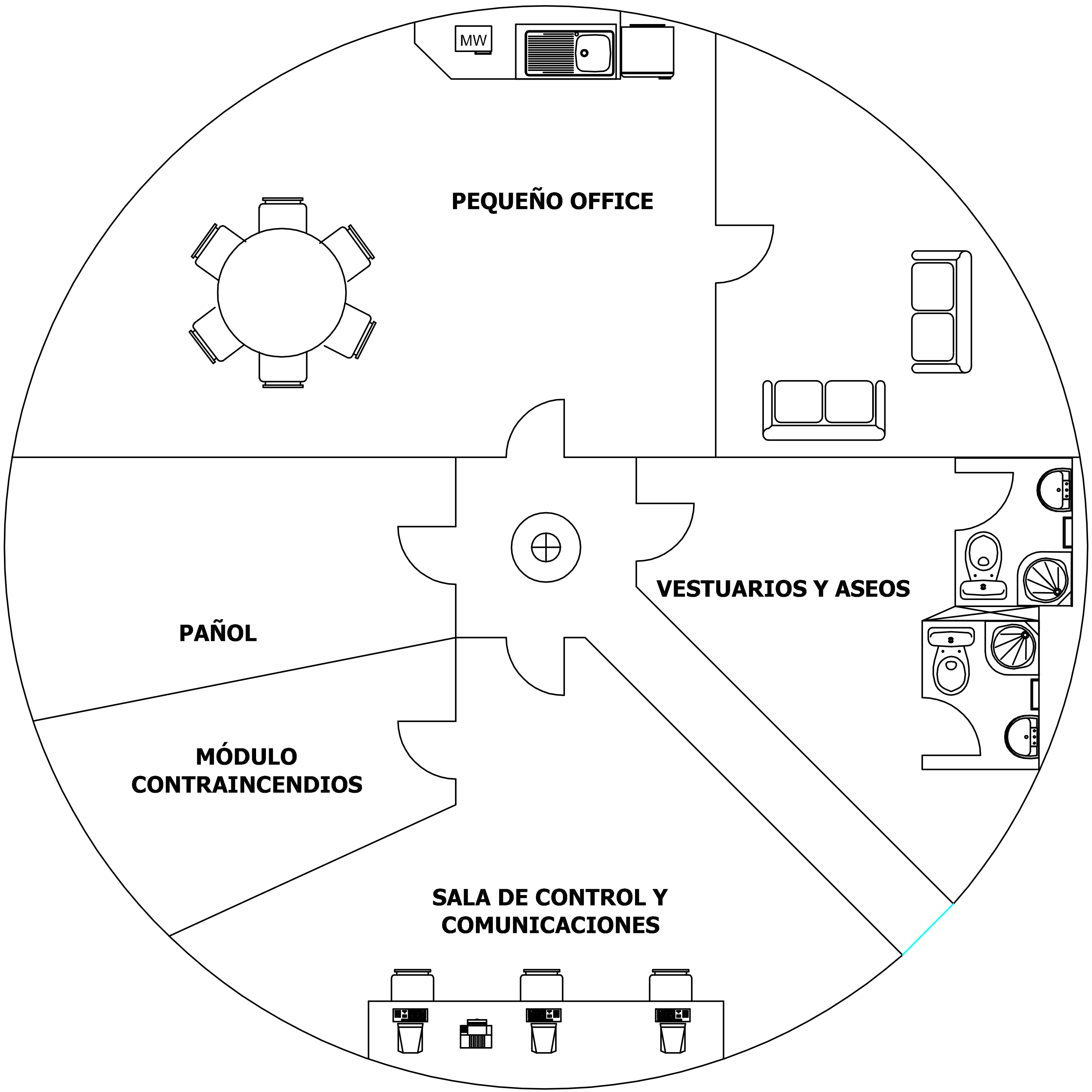
CARRIL GRÚA

AEROGENERADOR
PESO 150kg

SISTEMA DE LIMPIEZA DE REDES
(4000X2000X2000mm 2400KG)

UP5 22-10 SISTEMA EXTRACCIÓN
PECES MUERTOS
(1280X920X1050mm 540kg).

PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: DISPOSICIÓN GENERAL CUBIERTA PPAL.	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	



CARACTERÍSTICAS CTA PPAL:

OFFICE

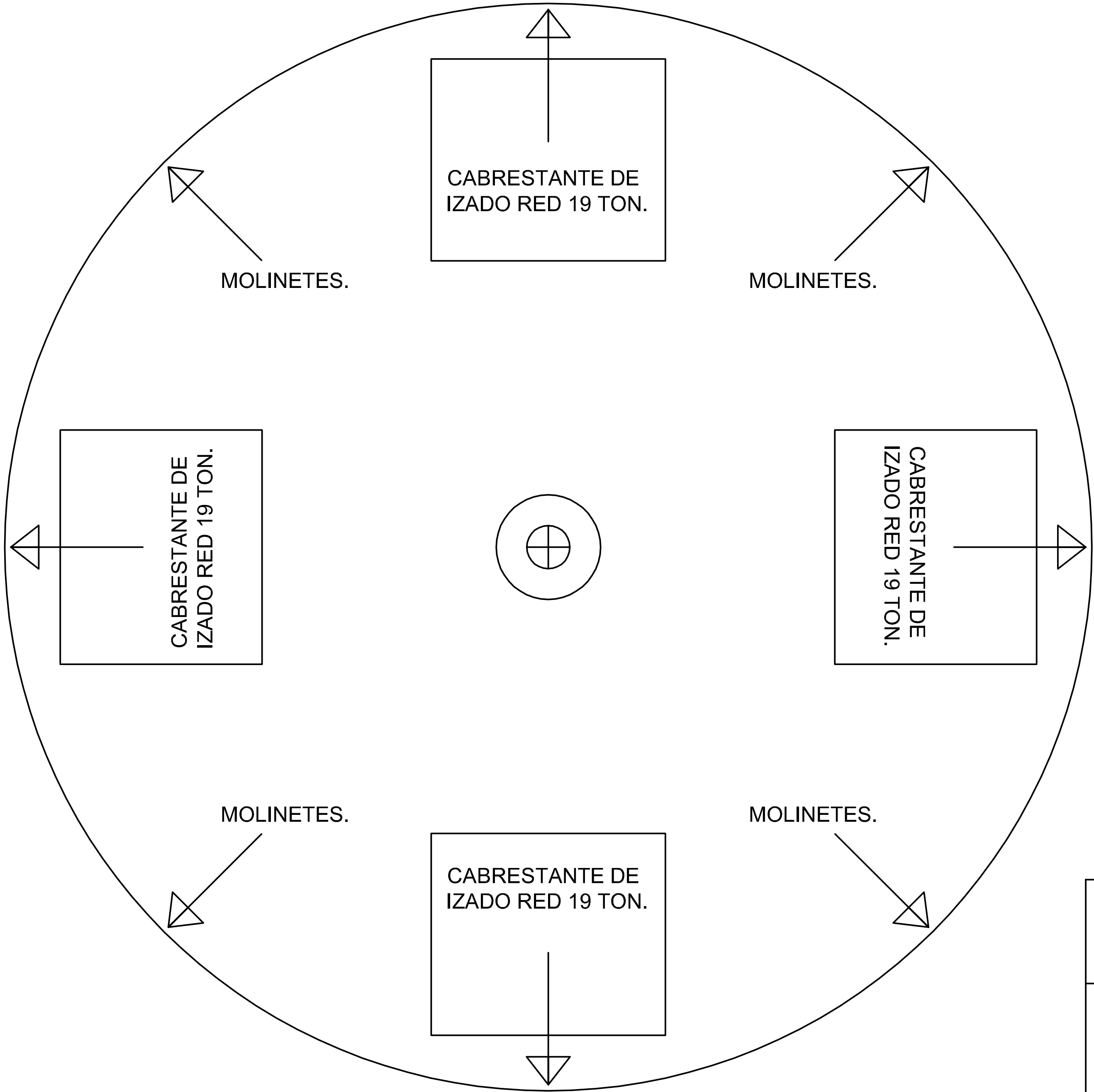
ASEOS

PAÑOL

MÓDULO CONTRAINCENDIOS

SALA DE CONTROL Y COMUNICACIONES

PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: DISPOSICIÓN GENERAL CUBIERTA 01	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	



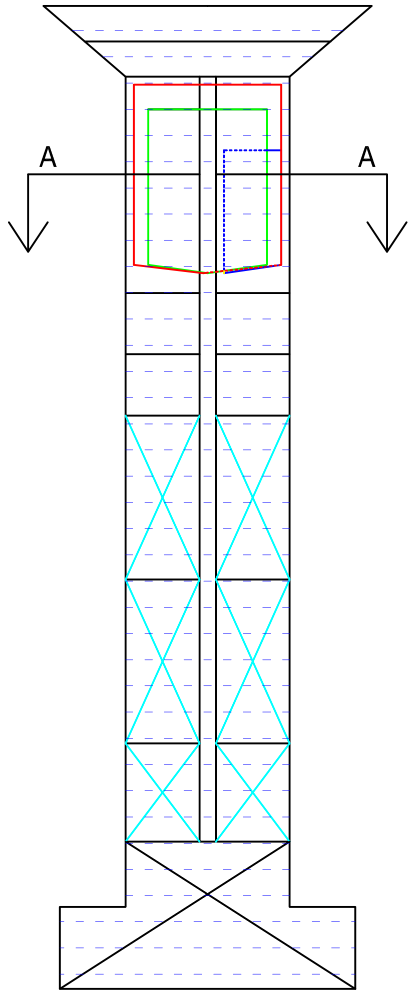
CARACTERÍSTICAS CTA 02:

CABRESTANTE: 2155X1856X1429 mm
2867 KG

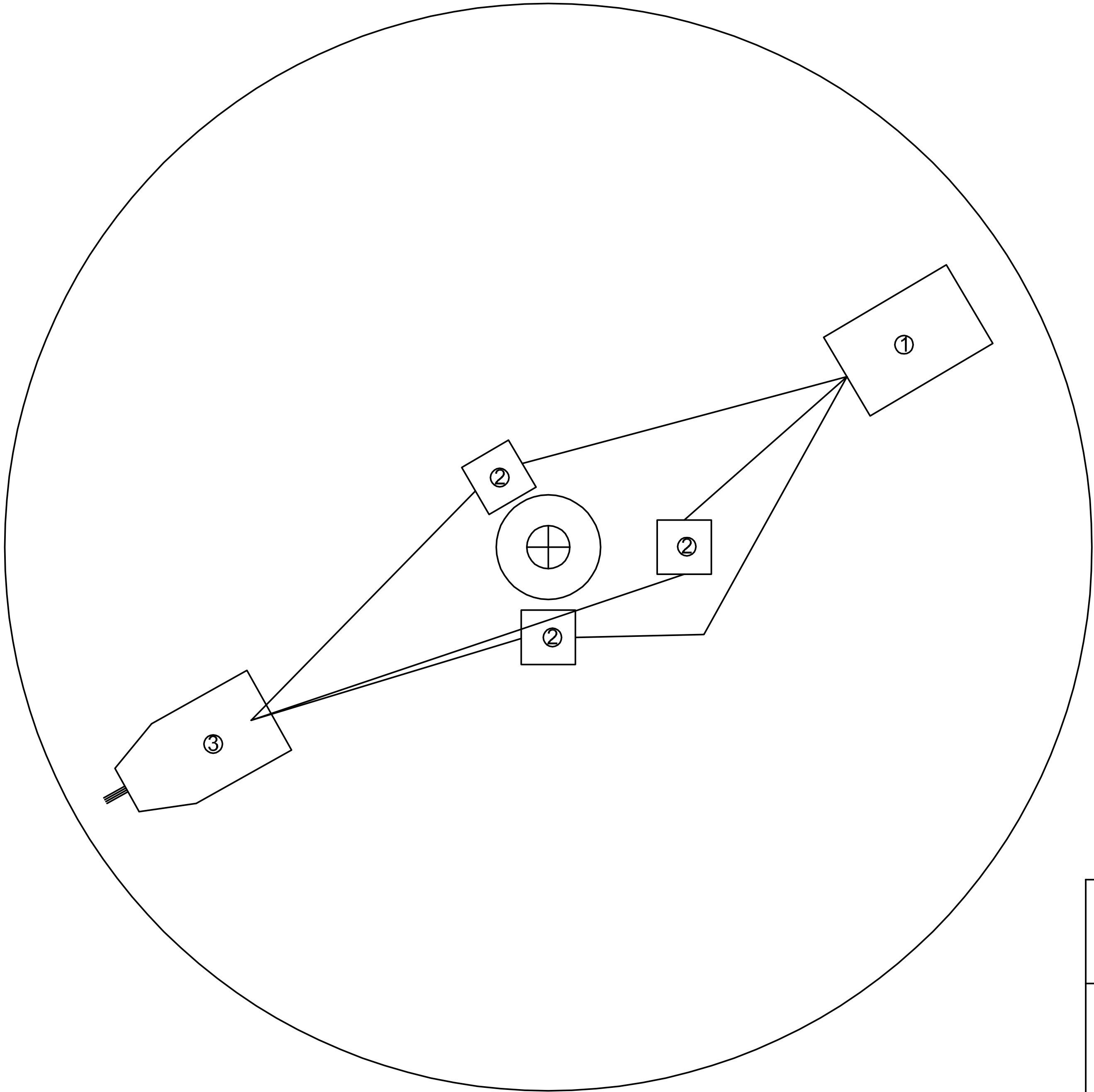
EQUIPO DE FONDEO

PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: DISPOSICIÓN GENERAL CUBIERTA 02	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	

SECCION A-A



PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: DISPOSICIÓN GENERAL SECCION A-A	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	



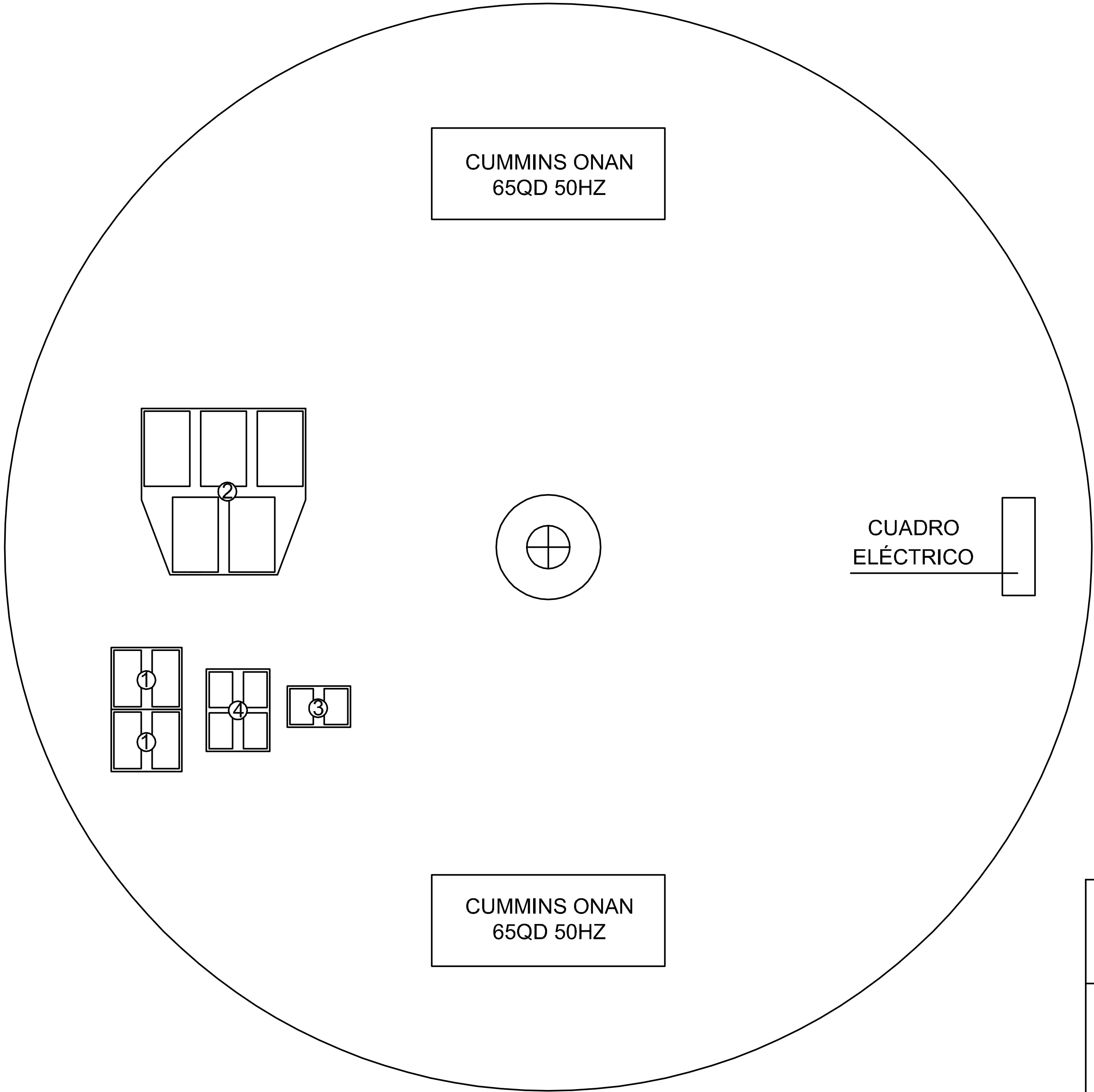
CARACTERÍSTICAS CTA 03:

MARCA 1 COMPRESOR
(1310X840X230mm 750 kg)

MARCA 2 VÁLVULA Y DOSIFICADOR
(500X500X500mm 50kg) por unidad.

MARCA 3 DISPERSOR DE PIENSO
(1500x840x400 mm 400 kg)

PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: DISPOSICIÓN GENERAL CUBIERTA 03	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	



CARACTERÍSTICAS CTA 04:

DIESEL GENERADOR: 2146X840X1039mm
1434KG

CUADRO ELÉCTRICO

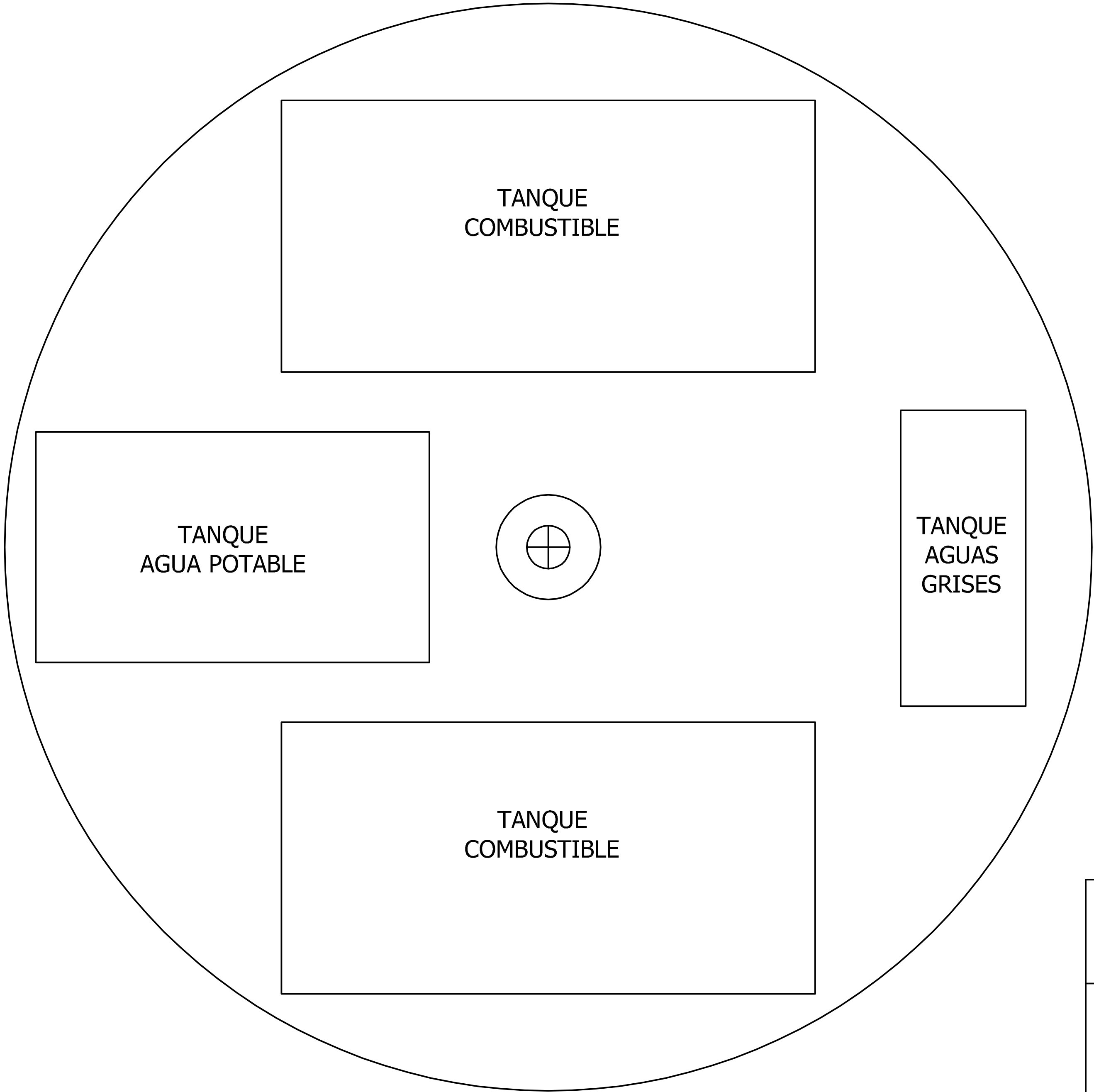
MARCA 1 BOMBAS COMPENSACIÓN
(520X250X310mm 37 kg) por unidad.

MARCA 2 BOMBAS AGUA DE LASTRE
(690x420x456mm 161 kg) por unidad.

MARCA 3 BOMBAS DE AGUA POTABLE
(328x216x230mm 14 kg) por unidad.

MARCA 4 BOMBAS SERVICIO DDGG
(328x216x230mm 14 kg) por unidad.

PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: DISPOSICIÓN GENERAL CUBIERTA 04	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	



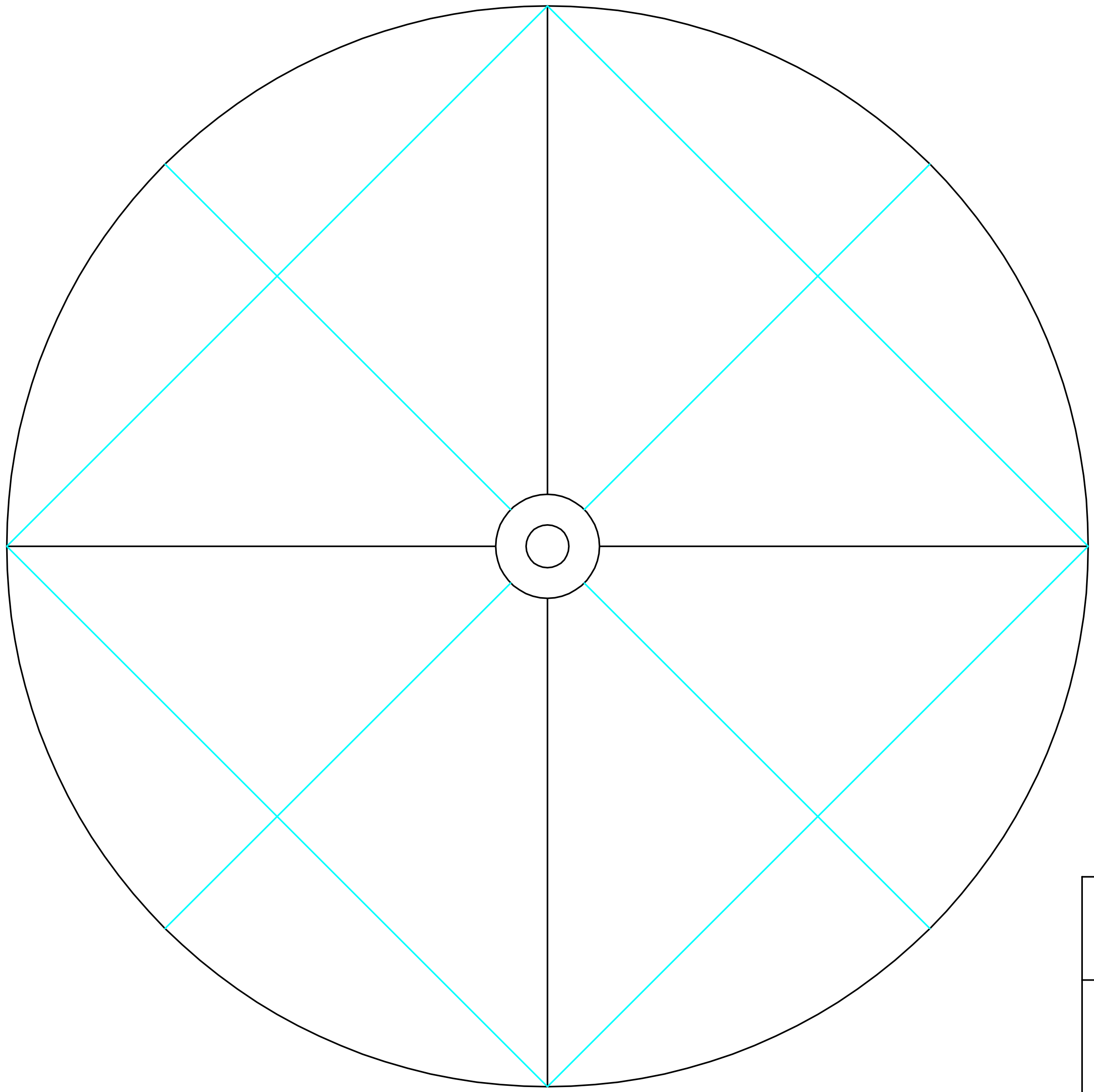
CARACTERÍSTICAS CTA 05:

TANQUE COMBUSTIBLE
PESO 1590kg, 4910XØ2500mm

TANQUE DE AGUA POTABLE
PESO 250kg, 3620XØ2120mm

TANQUE AGUAS GRISES
PESO 60kg, 2720XØ1150mm

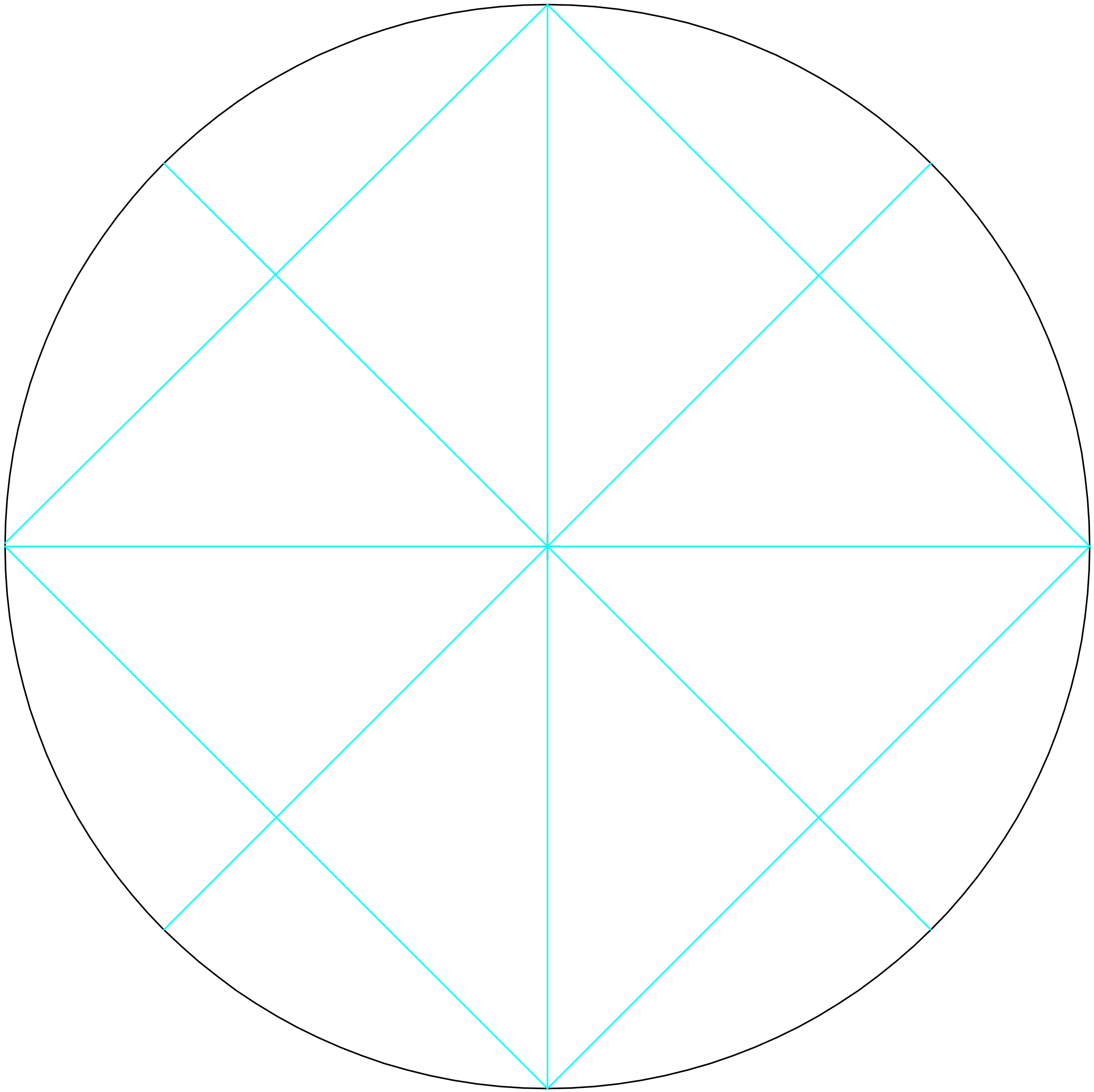
PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: DISPOSICIÓN GENERAL CUBIERTA 05	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	



CARACTERÍSTICAS CTA 06-07:

TANQUES DE LASTRE DE AGUA

PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: DISPOSICIÓN GENERAL CUBIERTA 06-07-08	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	

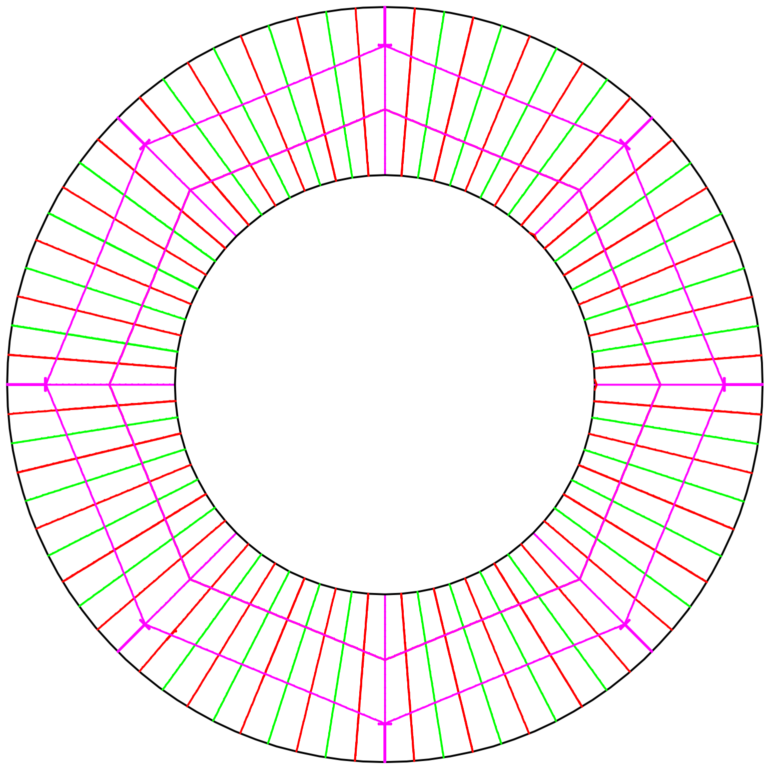


CARACTERÍSTICAS CTA 08:

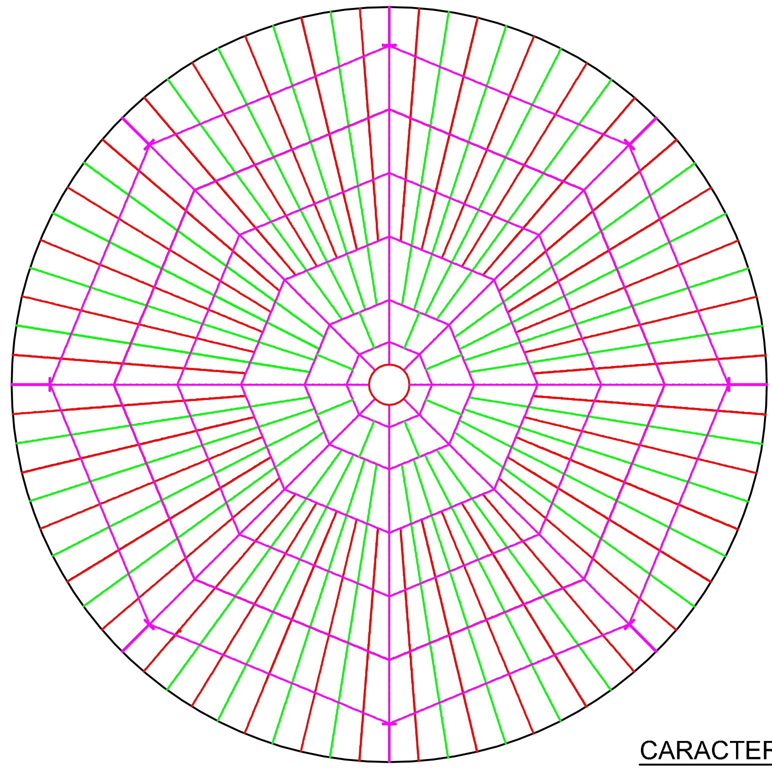
TANQUE DE LASTRE
SÓLIDO

PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: DISPOSICIÓN GENERAL FONDO	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	

CUBIERTA FORRO TOROIDE



SECCIÓN TÍPICAS CUBIERTAS SPAR

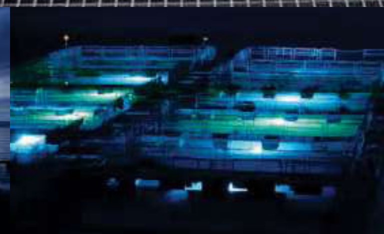


CARACTERÍSTICAS CTA 08:

- REFUERZOS PRIMARIOS
- REFUERZOS SECUNDARIOS

PROYECTO 2016: PLATAFORMA ACUÍCOLA EN MAR ABIERTO	
PLANO: SECCIONES TÍPICAS CUBIERTAS	**ESCALA:** N/A
ALUMNO: MÓNICA Mª RODRÍGUEZ LAPIDO	

CAGE FARMING AQUACULTURE 2014/2015-E



www.akvagroup.com

AKVA GROUP™

Your Aquaculture Technology and Service Partner

AKVA GROUP™

Your Aquaculture Technology and Service Partner

C O N T E N T S :

Certain products and services may not be available in all countries. Please contact a sales representative in your country or region for further details.

wavemaster™ polarcirkel™ fishtalk™ akvasmart™

Reliable and innovative aquaculture solutions combined with professional service and support

As a partner our mission is to improve your profitability and sustainability.

During more than 40 years as innovator and provider of technology and services to the global aquaculture industry, we in AKVA group have learned what really matters to our customers as well as to ourselves. Partnerships, good partnerships – enabling us to contribute solutions and services that make our customers successful in developing and operating sustainable and profitable aquaculture operations. Good Partnerships, where our contribution to solutions and services earn us the opportunity to develop AKVA group as a sustainable and profitable company.

We will continue to build AKVA group with this as our mission. We will be focused on our customers' needs, being attentive and responsive. We will develop and use our knowledge to contribute solutions and services that lifts our customers performance.

We will take pride in being reliable and honest in what we do and how we act, and we will use our enthusiasm to generate the energy and joy needed to take our customers as well as AKVA group forward.

In AKVA we strongly believe that we can make a difference. We are proud to be part of the global aquaculture industry which is playing a crucial role providing healthy seafood world wide.

We are partners – and in it for the long run.

AKVA group is a solid partner with offices and facilities in Norway, Chile, Denmark, Scotland, Iceland, Canada, Australia and Turkey. With 8 offices and several agents and distributors around the globe AKVA group is present in all markets worldwide. AKVA group is a unique partner with the capability to offer both cage farming and land based aquaculture operations with complete technical solutions and service.

The company holds strong, well-known brand names and the product line range from plastic and steel cages, mooring systems, nets, net cleaners, work boats, feed barges, feed systems, camera systems, environmental sensors, underwater lights, production and process control software, recirculation systems, PE piping systems, farm design, on-site services and training courses.

Partnering with AKVA group allows customers to keep their focus on fine tuning farm operations to increase profitability, while sharing the technical challenges with a reliable partner with the right people, the right technology and the right knowledge to achieve excellence.

CEO, AKVA group ASA.

AKVA group is a leading technology and service partner to the aquaculture industry worldwide

Project planning

Two heads think better than one, says an old proverb. In terms of planning an aquaculture operation it translates into allowing people with different know-how to work together in the planning process. Letting AKVA's technical experts team up with your own operational experts will ensure well founded and correctly dimensioned farming solutions.

Budgeting

Budgeting means planning years ahead to create an image of the size and shape of your operations.This is imperative to secure adequate financing and proper financial control. Allowing technical considerations into the budget will also help you identify constraints or bottle-necks in your operation.

Technical solutions

Are you happy with standard solutions or does your operation or managers require fine tuning of some of the hardware? In a carefully planned complete project, specific hardware requirements can be taken into account at an early stage so they won't add extra costs or delays along the way.

Installations

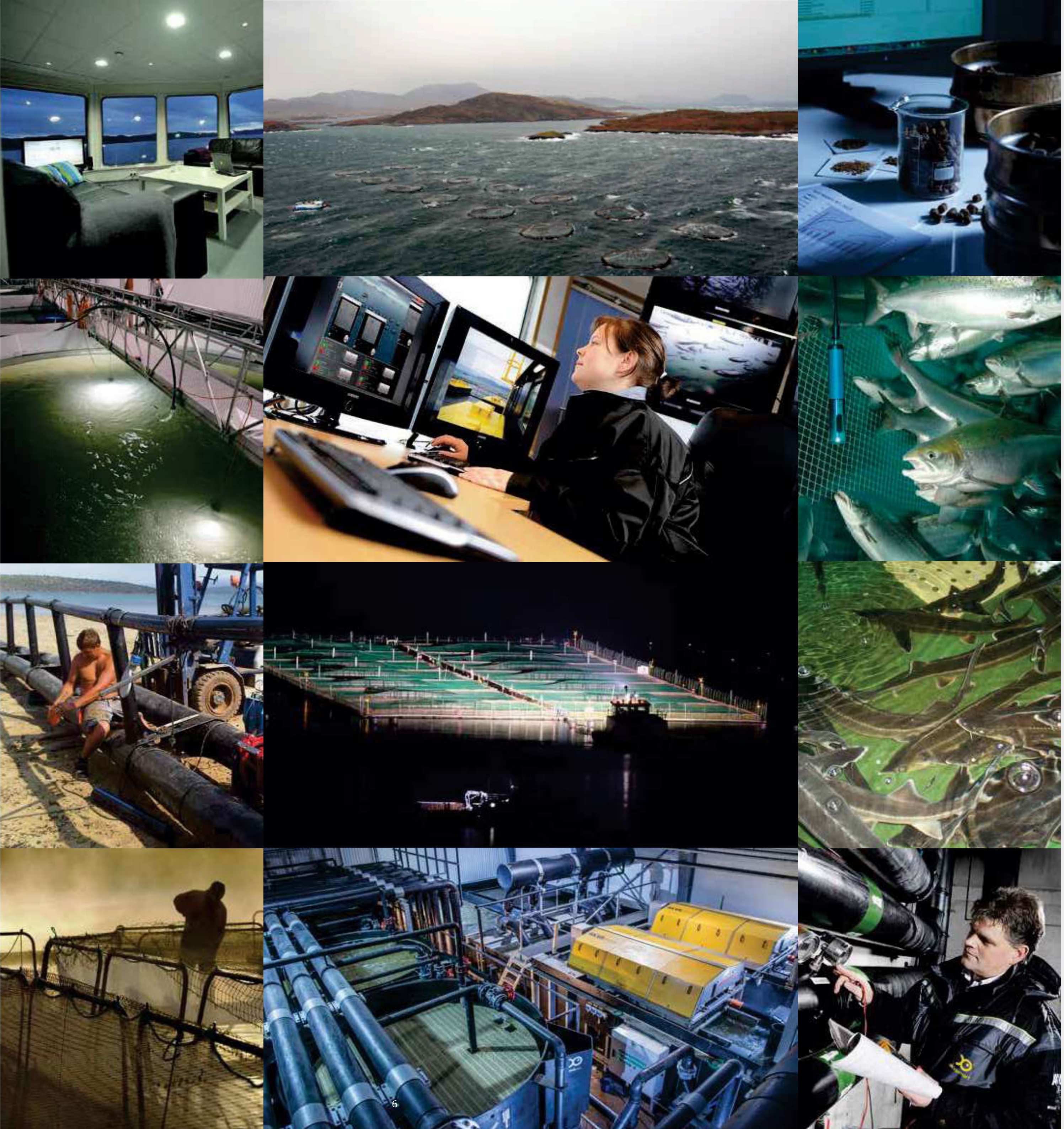
Plug and play may be the preferred mode for anyone wanting to connect two pieces of equipment together. In an aquaculture facility, putting the pieces together may not be quite as simple, although it might seem like it when our experts are at work. Professional commissioning and start-up will prevent future headaches and costly mistakes.

Service & support

Systems running year after year, sometimes in extreme weather, will always be subject to extensive wear and tear. In order to maintain reliable operations, preventive service agreements and regular maintenance are critical. AKVA group's Service department has decades of experience in supporting and performing maintenance under such conditions.

Product training

Knowledge is always an important part of successful farm operations. Sufficient training of your staff and managers will minimize the amount of frustration that builds up while browsing through a manual in search of a solution to a problem. Hands-on training of staff, face-to-face is always the most effective method and a wise investment.



Worldwide Aquaculture

Reliable and efficient solutions

AKVA group had designed and supplied professional and commercially sound projects worldwide. From complete cage farms for many fin fish species, to land based hatcheries with recirculation systems to break-through projects with new species.

AKVA group is the only supplier with the capability to offer both cage farming and land based aquaculture operations with complete technical solutions. Being a dedicated AKVA group partner means leaving responsibility for technical matters to external experts, while allowing your own personnel to focus on biology and production.

AKVA group's team of professionals knows what is important to succeed in the aquaculture industry. We are able and willing to take on the responsibility for delivering reliable technology with the quality, standards and service level needed to minimize the risk of technical problems which may lead to production down-time and associated financial losses.

We will ensure the integration and quality of our work by undertaking thorough and detailed planning and pre-project design of your farm.

From single components to complete aquaculture solutions with professional service and support.

Cage Farming Aquaculture - Complete Solutions Worldwide

Feed Barges

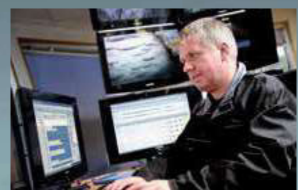
AKVA group is the world´s leading supplier of feed barges with decades of experience and nearly 300 barges delivered worldwide.

Feed Systems

The central feed system was invented by AKVA group in 1980 and Akvasmart CCS is today the world´s most popular and reliable feed system.

Cages

AKVA group is the leading supplier of both plastic and steel cages in aquaculture, and has since 1974 delivered more than 60,000 cages.



Software Solutions

Fishtalk is a unique IT concept and tool that provides integrated operations and biological production. AKVAconnect is the latest farm operations and technical control software platform.

Camera and Sensor Systems

Advanced video camera and sensor systems monitor both fish, the feeding process and the environment. This ensures optimum operations and a healthy fish.

Workboats

The robust Polarcirkel workboats offers great design, quality build, unique flexibility, safety and low maintenance.

Cages

The world´s leading cage supplier

AKVA group is the world's leading supplier of both plastic and steel cages. Polarcirkel, the most recognized brand in aquaculture, invented the plastic cage concept in Norway in 1974, and has since supplied more than 45,000 cages worldwide. The renowned Wavemaster steel cages originated in Ireland in 1985, and more than 15,000 cages have since been delivered globally.

In order to ensure the highest possible quality, competitive pricing and on-time deliveries, the cages and components are manufactured in many different regions. All cages are installed by professional installation teams, and serviced by professional AKVA group service technicians.

AKVA group invests heavily in innovative and professional R&D in order to remain the leading supplier of cages, not only to improve products in the short term, but also to look into the future of tomorrow's demands for cage technology.

Polarcirkel All-Plastic-Cages

A safe and stable platform designed for extreme weather conditions.

A well proven concept in flexible cage design

Polarcirkel Cage history

Experience is a crucial success factor in the fish farming business. AKVA group (Polarcirkel) invented the plastic cage in 1974, and has since then supplied more than 45.000 Polarcirkel Cages and 15.000 Polarcirkel Boats. The cages are made from PE raw materials especially suited for the dynamic loads of the sea, and are available in a wide range of models, shapes and sizes to suit individual needs.

Newspaper photo presenting the first Polarcirkel cage in 1974.

Many have tried to copy these products, but none have managed to match the genuine Polarcirkel designs and quality builds.
Plastic cages started out as small single pipe circles, but now our largest models approach 200m circumference, and with floating pipes of 500mm diameter. Both circular and square cage systems are available. Combined with AKVA group´s global sales and service network, the Polarcirkel Cage is well proven and recognized worldwide.

Photos showing today's large 500mm cages compared to the 225mm "Gigante" cage 20 years ago!

Forget corrosion! Polarcirkel bracket after 10 years in saltwater!

Long life - built to withstand extreme weather conditions

Extensive use of Polyethylene in our latest Pressure Injection Moulded (PIM) brackets eliminates corrosion, minimizes expensive and difficult maintenance, and substantially increases cage lifespan compared to steel brackets. This is especially important in areas with high salinity, warm water temperatures and choppy seas.

Cages designed for extreme weather conditions, such as here on Norway's stormy coastline at 70° North.

Only strong and high quality PE is used for Polarcirkel brackets, while many suppliers use weak and low quality rotationally moulded medium and low density Polyethylene. This makes the Polarcirkelbrackets superior in terms of structural strength, durability and UV resistance. This is especially important in high energy offshore farm sites and areas with high UV radiation from the sun.

All Polarcirkel Cages are NS9415 certified.

For areas prone to icing, such as Norway, Canada and Russia,, another critical advantage of the Polarcirkel PE brackets is that they will not ice up as steel brackets do. Icing is a dangerous safety issue for all floating structures, including cages.

Heavy ice overloads the cage, reduces stability and jeopardizes overall cage integrity. As the name indicates, the Polarcirkel cages are built for extreme arctic conditions!

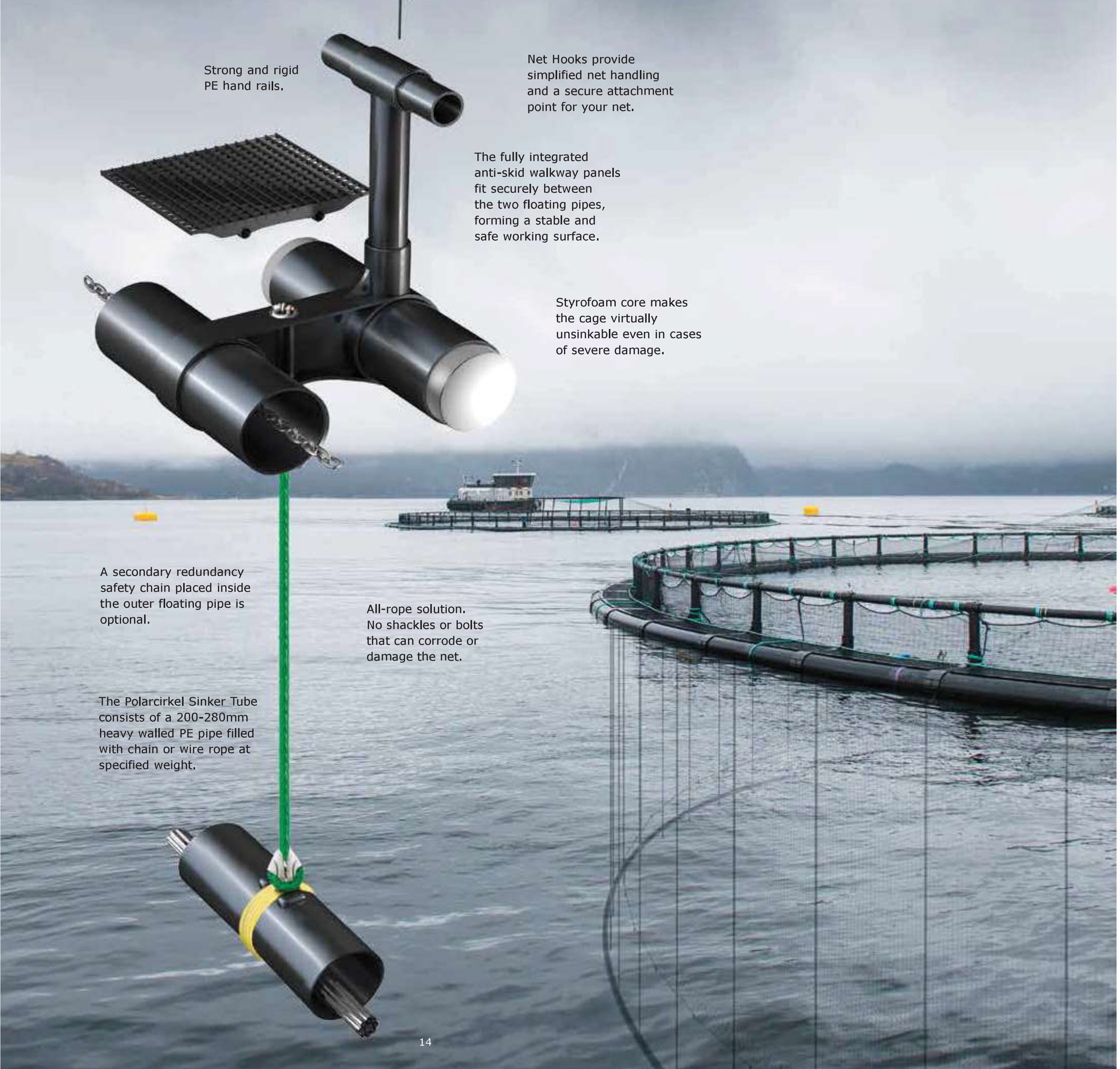
Polarcirkel PE brackets are tested in arctic areas to withstand extreme icing such as here in the Russian Sea.

All Polarcirkel Cage designs are carried out by our professional R&D department. Independent marine engineering consultants are also involved in advanced static and dynamic load calcu-lations to ensure all designs meet or exceed expected real life loads as well as applicable industry standards.

Polarcirkel Cages are used all over the world, such as here in Tunisia.

polarcirkel™

The safest and most escape proof cages on the market



Extra wide catamaran design

Polarcirkel's extra wide catamaran design ensures maximum cage stability and railing stiffness. Combined with strong stanchions and interlocked railing design, this makes the Polarcirkel Cages safe and easy to work on without sacrificing seaworthiness and strength.

Due to its low weight-to-strength ratio, the Polarcirkel Cages have very high reserve buoyancy compared to cages with other brackets. This easily results in our larger cages having up to 4-5 metric tons higher reserve buoyancy. This substantially increases cage safety margins in case of sudden operational problems that weigh down the cages (dirty nets, icing, storms, strong currents etc.).

Unique redundancy systems

In addition to obvious redundancy safety factors such as individu-ally secured brackets, individually secured anchoring connectors and Styrofoam inside the outer floating pipe pipes, Polarcirkel also offer an optional secondary continous safety chain inside the outer floating pipe. This will serve as an unbreakable barrier in case the cage integrity is severely compromised. Keeping the chain inside the pipe leaves it out of the water until needed and maintains a clean exterior cage layout. All of this makes the Polar-cirkel Cages the safest and most escape proof cages on the market!

The new Pressure Injection Moulded brackets design provides superior strength.

Safe Polarcirkel PE walkways

In order to increase crew safety on fish farms, another Polarcirkel innovation was launched in 1999, the integrated Polarcirkel PE walkways.The anti-skid walkway panels fit securely between the two floating pipes, forming a stable and safe working surface. The PE pressure moulded panels are held in place with strong and flexible continuous 50mm PE tubing inter locking the panels to the PIM brackets.

Proven Sinker Tube concept

As cages grew bigger and nets became harder and harder to control in strong currents, Polarcirkel invented the sinker tube concept in 1989. A concept that later has been adopted as an industry to keep nets stretched out and weighed down.

The Polarcirkel Sinker Tube consists of a 200-280mm heavy walled PE pipe filled with steel wires or chain (typically 20-70 kg/m). It is supported by strong ropes fastened through the stainless steel sleeve in the PIM brackets.

All the weight of the net and sinker tube system is supported by the floating pipe - NOT by the handrail.

polarcirkel™

To avoid fish escapes we need to ensure that all potential sources of chafe and net damage are eliminated.

Simplified net handling and maintenance

A wide range of accessories with smart features

AKVA group offers a wide range of optional accessories for the cages. This equipment will improve the safety and efficiency on the fish farms. Dedicated accessories will also make it easier for the farm staff to do their job. Here´s some of the accessories we can recommend, anti-skid walkway panels, center support stands, cart wheels, net hooks, harvest trawl float rope etc.

Various types of net hooks are available. The systems simplify net handling on the cages and provide secure attachment points for your nets.

Most plastic cages are moored in a grid system and include sinker tube, center support stand, feed system/barge, cameras and sensors.

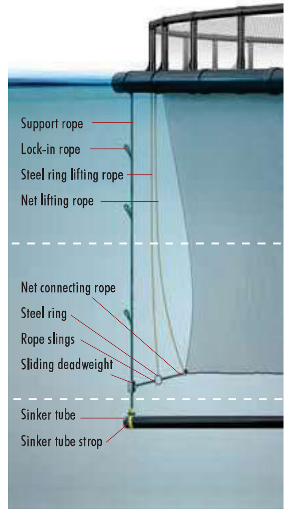
Both fiber nets and non fiber nets (EcoNet) can be installed in all Polarcirkel cages.

When harvesting, the net volume is reduced by lifting thr vertical ropes of the sinker tube system. This leaves no load on the handrails.

Rugged Polarcirkel Cages combined with a Wavemaster Feed Barge will always makes a perfect match.

Polarcirkel "Cart Wheels" Center Support Stands can be offered with circumference from 30 up to 72m.

Center Support Stands keeps the bird nets high off the water. Standard sizes from 4m to 5m high. Other hights can also be delivered on request.



Sliding deadweight principle - a new sinker tube solution

In terms of our sinker tube concept, this means going from chain to an all-rope solution, including the use of new type of sliding dead weights as an option. This means no potential chafe from metal parts, practical ways of handling the net and replacing parts, excellent stretching out of the net (maximum water exchange) and no shackles or bolts that can loosen or corrode.

When you need to lift or lower the net for harvesting, grading etc, the sinker tube is lifted 5m at a time using the lifting and lock-in loops in the support ropes. These rope runs through the PIM cage bracket and locking pins are used to secure it at the various levels. Number of loops and net hooks can be customized to suit individual needs.

Plastic Cage Specifications

Cage Models:	225/250	315	400	450	500	Comments
Cage sizes – Floating pipe diameter:	225/250mm (9"/10")	315mm (12")	400mm (16")	450mm (18")	500mm (20")	Imperial sizes to be confirmed.
Cage sizes – Standard circumferences:	40 - 90m (130 - 300')	60 - 100m (200 - 330')	90 - 160m (300 - 530')	120 - 160m (400 - 530')	130 - 200m (430 - 660')	At centre of inner floating pipe.
Cage sizes – Standard diameters:	13 – 29m (42 – 94')	19 – 32m (63 – 104')	29 – 51m (94 – 167')	38 – 51m (125 – 167')	41 – 64m (136 – 209')	At centre of inner floating pipe.
Center - center distance between floating pipes:	52cm (20")	66cm (26")	85cm (33")	100cm (39")	110cm (43")	
Bracket – PE Injection Moulded (new PIM Type):	–	Yes	Yes	Yes	Yes	PIM Bracket (Pressure Injection Moulded Bracket) with plastic uprights.
Bracket – PE Welded (original "Nova" type)	–	Yes	Yes	–	–	Original welded NOVA bracket.
Bracket – PE Injection Moulded (original type):	Yes	-	–	–	–	Original injection moulded bracket.
Standard distance between brackets:	2m (6' 7")	2m (6' 7")	2.5m (8' 2")	2.5m (8' 2")	2.6m (8' 6")	Can be customized to fit nets.
Dimension – PE Handrail Upright:	125mm (5")	125mm (5")	160mm (6,5")	160mm (6,5")	160mm (6,5")	Not applicable for steel brackets.
Dimension – Handrail Pipe:	110mm (4,5")	110mm (4,5")	140mm (5,5")	140mm (5,5")	140mm (5,5")	Applies for both PE and steel brackets.
Net hook on uprights:	PE (SS opt.)	PE (SS opt.)	Stainless Steel (12mm)	Stainless Steel (12mm)	Stainless Steel (12mm)	One single hook per upright included. Custom hooks available
Polystyrene Safety Floatation added:	Only inner pipe	Only inner pipe	Only inner pipe	Only inner pipe	Only inner pipe	Available in all floating pipes on request.
Available with – Secondary Safety Chain (redundancy):	Inside outer pipe	Inside outer pipe	Inside outer pipe	Inside outer pipe	Inside outer pipe	Continuous internal safety chain inside the outer floating pipe for an extra safety
Materials used – PE80 & PE100:	Yes	Yes	Yes	Yes	Yes	Applies to plastic components.
NS-EN ISO 9001:2000 Certification:	Yes	Yes	Yes	Yes	Yes	The Polarcirkel factory is ISO 9001 and ISO 14001 certified.
Norwegian Standard – NS9415 Certified:	–	Yes	Yes	Yes	Yes	Mandatory for Norway only.
Available as Two-Ring Cage:	Yes	Yes	Yes	Yes	Yes	Standard Cage
Available as Three-Ring Cage:	Yes	-	–	–	–	
Option:	Yes	Yes	Yes	Yes	Yes	
Option:	Yes	Yes	Yes	Yes	Yes	Mainly used for 315 model and up.
Avail. as Submergible Cage:	Yes	Yes	Not yet	Not yet	Not yet	Ask for specific details.
Polarcirkel Square Cages - Standard sizes available:	3x3m (10x10') / 5x5m (17x17') / 7x7m (23x23') / 9x9m (30x30') / 11x11m (37x37') 13x13m (43x43')					* Available outside Norway only – as individual cages or cage systems.

Polarcirkel quality and certification

All Polarcirkel Cages are manufactured and assembled in accordance with AKVA group's Quality Assurance System (ISO 9001 and ISO 14001) which is certified by DNV (Det Norske Veritas). All cages in Norway are designed in accordance with NS9415 (Norwegian Standard 9415 for cage farming equipment to prevent fish escape).

AKVA group delivers complete cage farming solutions worldwide.

polarcirkel™

Wavemaster Steel Cages

Safe and strong steel cage solutions

Wavemaster Cage history

Wavemaster began producing steel cages in Ireland in 1985, in Canada in 1988 and in Chile in 1990, and today supplies cages to all world markets. The large number of cages currently in use on a wide variety of sites, operating under diverse wave and wind conditions world wide, has demonstrated the reliability of the Wavemaster design.

The first Wavemaster cages was designed and delivered in Ireland in 1985.

Produced locally and designed to suit local markets, Wavemaster provides the most cost effective steel cages available to the industry. Steel cages are suitable for sites with moderate exposure and strong tidal currents.

Combined with a global sales and service network, the Wavemaster Steel Cages are a well proven concept.

Wavemaster has a proven track record of installations on a wide range of sites and in many different climates around the world, such as here in Chile.

The wide walkways provide superior support for predator nets, well spaced from the fish net. This is a crucial feature for some areas.

Superior design makes an ideal platform for fish farming

Wavemaster is the world's leading brand of steel cages with over to 15.000 cages delivered since 1985! The cages provide an ideal platform for fish farming. Wide non-slip walkways with high free-board around all sides of the cages allow the operator full flexibility of operation and easy access from cage to cage. This is becoming essential for good fish husbandry and maintenance.

The compactness and simplified mooring arrangements make Wavemaster Steel Cages a very attractive option for many sites.

Safe and stable cage construction make a safe workplace.

Wavemaster cages are available in a wide range of models, single- or double string systems and sizes up to 40x40m to suit individual needs.

The upper surface of each float incorporates sloping surfaces so that any feed or debris deposited can be washed away by wave action or water hose. High reserve buoyancy is crucial in case of sudden excessive or mooring loads.

Hot dip galvanizing

All components are hot dipped galvanized after manufacture. This has proven to be the most effective and durable coating for use on fish pen structures.

Wavemaster cages produced by AKVA group Chile.

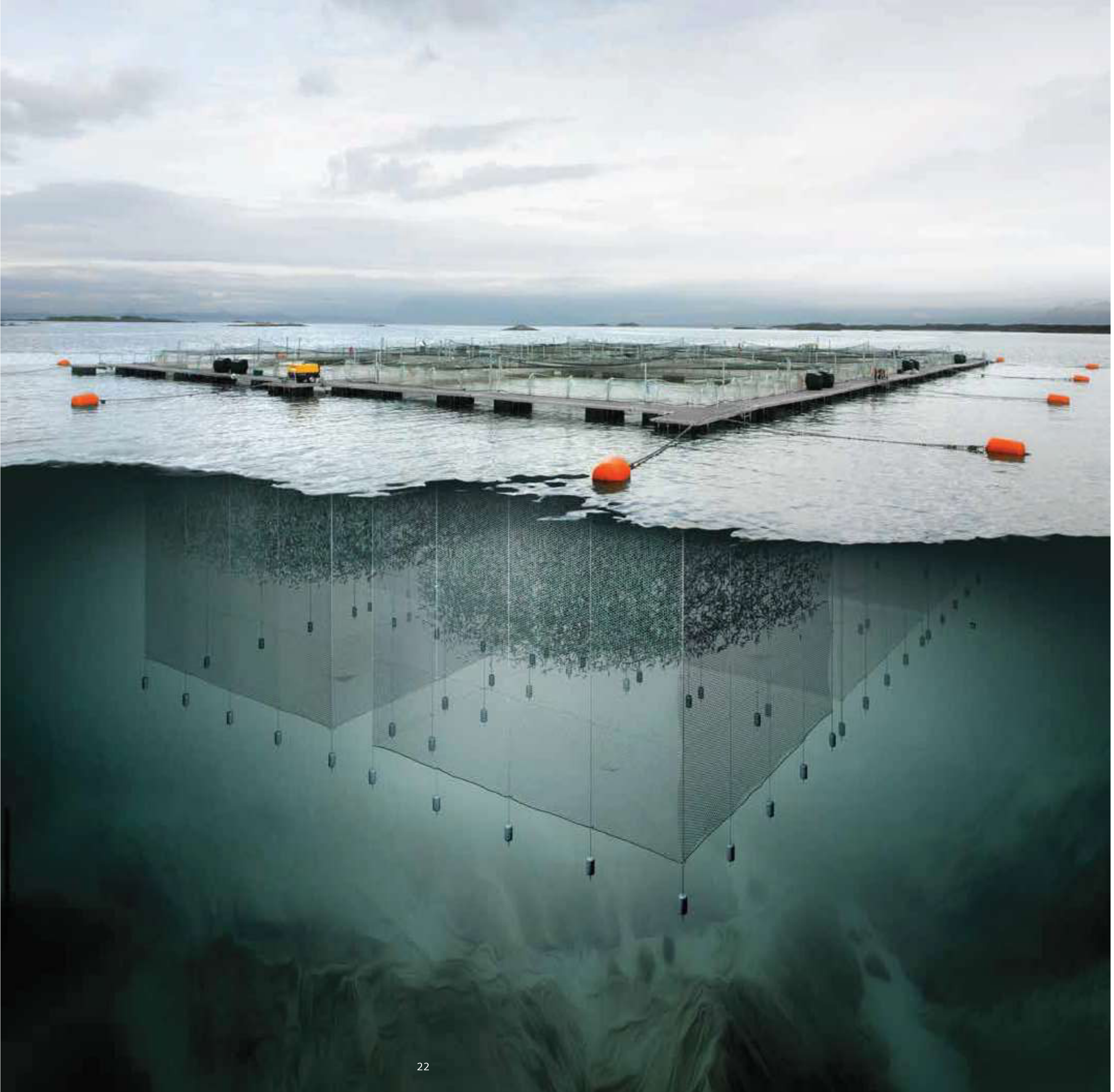
Ongoing R&D

All of the Wavemaster designs are continuously updated to reflect operating experience and the changing work practises of the fish farmers using the equipment. This continues to make Wavemaster the leading edge steel cage in the fish farming industry.

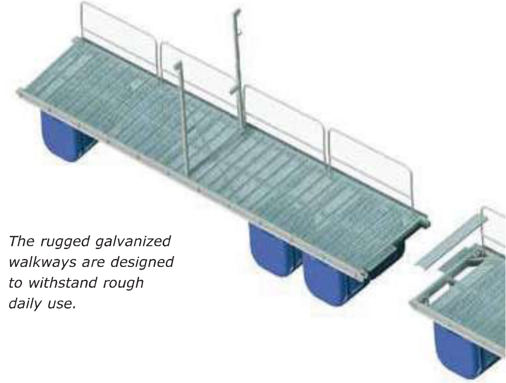
Wavemaster cages include smart solutions for fully integrated non-slip walkways, net supports and floats with self-draining top.

wavemaster™

A trusted and well proven steel cage concept



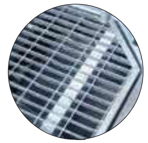
Patented moulded rubber hinge system reduces loads and increases life-span.



The rugged galvanized walkways are designed to withstand rough daily use.

All components are hot dip galvanized.

Bushing type hinge for less exposed sites.



Self-draining tops make it easier to maintain.

Secure floats filled with expanded polystyrene.

A wide range of strong, high quality mooring systems are also available in various dimensions.

The removable handrail system provides tie off points and posts to support the net.

Feed barges can be moored at the end of steel cages and provide easy access to the cages for farm staff.

Wavemaster steel cages are also available with driveable centre walkway, such as here in Canada.

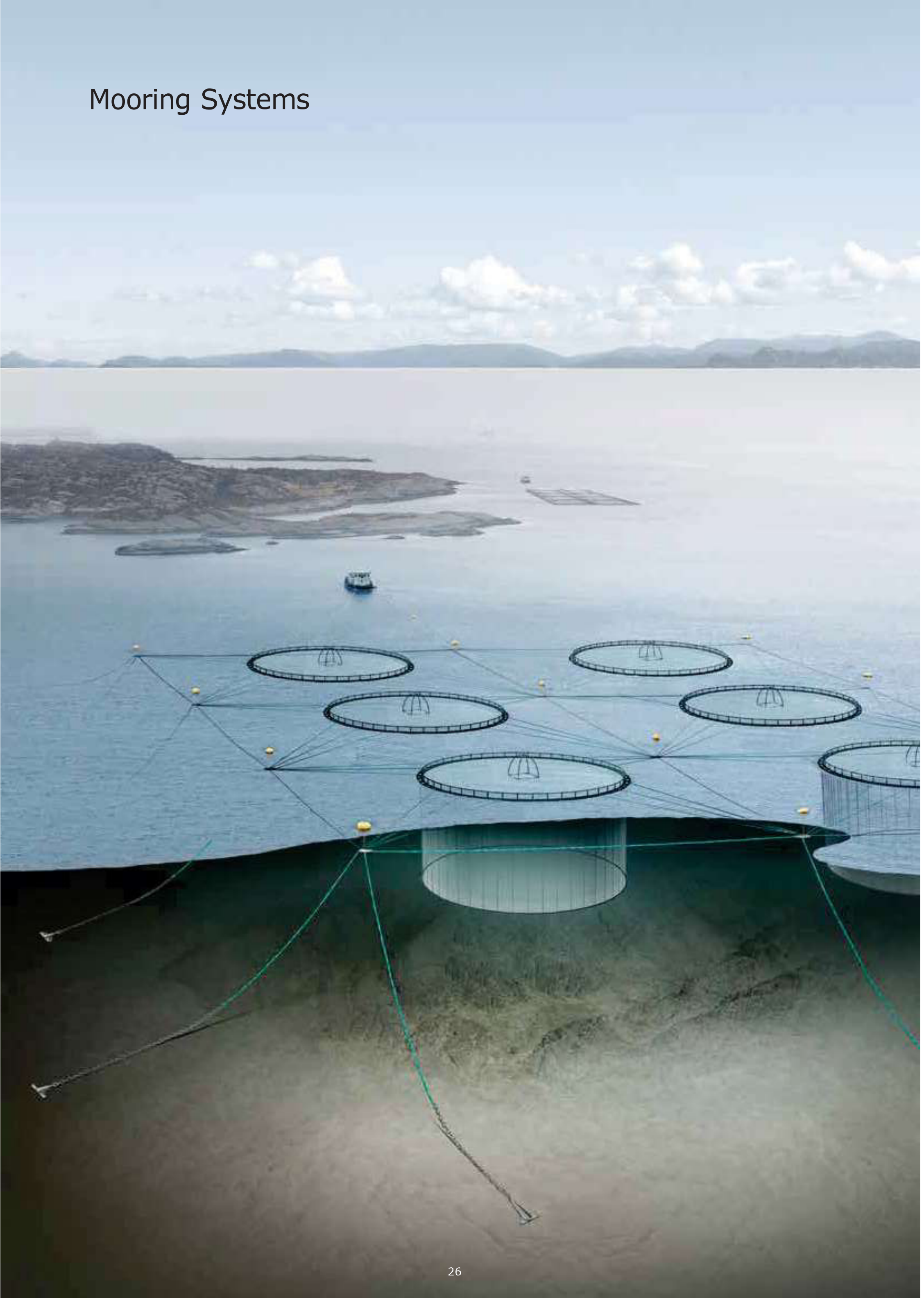
wavemaster™

Galvanized quality cages with wide walkways

Steel Cage Specifications

Wavemaster Cages:	EX-1	EX-2	Comments
Model description:	High Performance	High Exposure	Please consult your Wavemaster representative for expert advice on proper model selection.
Cages sizes available - inner measurements:	10x10m (30´x30´) 12x12m (40´x40´) 15x15m (50´x50´) 20x20m (60´x60´) 25x25m (82´x82´) 30x30m (100´x100´) 40x40m (130´x130´)	25x25m (82´x82´) 30x30m (100´x100´) 40x40m (130´x130´)	Others sizes available on request.
Main walkway width:	1.1 - 2.5 m (3´3" - 8´2")	1.1 - 3.0 m (3´3" - 10')	Others sizes available on request.
Perimeter walkway width:	1.1 - 2.5 m (3´3" - 8´2")	1.1 - 2.5 m (3´3" - 8'2")	Others sizes available on request.
Suitable for shipping into 40" containers:	Yes	Yes	On request.
Driveable (Forklift):	No	Yes	On request.
Deck type:	2 or 3mm stamped plate, 32x5 or 38x5 serrated vertical grating	2 or 3mm stamped plate, 32x5 or 38x5 serrated vertical grating	Others design on request.
Main beam sizes:	80x40x5mm up to 200x70x6mm	150x50x5mm up to 200x70x6mm	
Hinge bushing:	35mm (1 3/8") - 45mm (1 3/4")	35mm (1 3/8") - 45mm (1 3/4")	Available in both moulded rubber or nylon type.
Cage configuration layout:	Single or double string	Single or double string	
Floats available - standard:	Yes	Yes	Rotational moulded PE or blowing PE (Colors under request).
Floats available - increased volum:	Yes	Yes	Rotational moulded polyethylene (Colors under request).
Floats filled with expanded polystyrene and sealed for added safety:	Yes	Yes	
Ralling height:	1000mm (39,7")	1000mm (39,7")	Others sizes available on request.
Ralling net hooks included:	Yes (Pointed up, down or both)	Yes (Pointed up, down or both)	
Post options for:	Predator net, bird net, Lifting.	Predator net, bird net, Lifting.	On request.
Others accesories:	On request	On request	Please inquire.
Hot dipped galvanizing:	Yes	Yes	

Wavemaster Steel Cages in Scotland.



Mooring Systems

Safer mooring with low cage point loading

Extra safe and strong mooring solutions

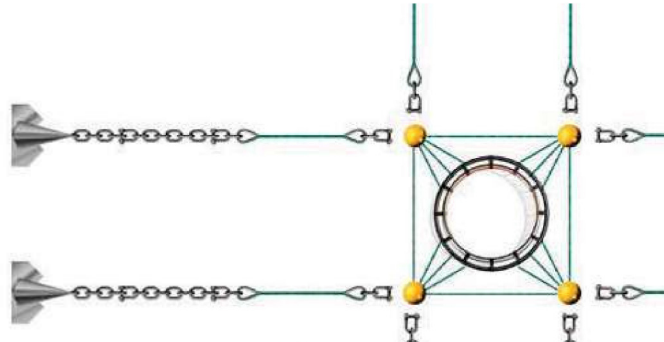
We are introducing a new and innovative mooring connector system that simplifies the mooring process and improves the structural strength of the cage when moored at the site. All anchoring connections and components are NS9415 certified. (Norwegian Standard 9415).

The new Polarcirkel anchoring connector eliminates most of the weak points typical of steel brackets: Corrosion, damage to work boats, sideways jamming of brackets, chafe on floating pipes, need for chafe sleeves, point loading floating pipes, bending connection lugs, icing loads etc.

Experienced crew and certified mooring solutions.

Anchoring of Polarcirkel cages outside Lofoten in the North of Norway.

Our mooring systems have been tested in rough weather conditions worldwide.



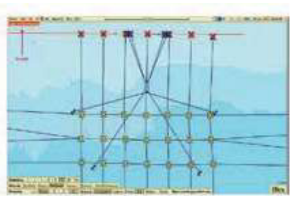
Quality buoys in various sizes.

Practical and safe shackle point connection.

All ropes are connected to the mooring plate well below propeller depth, gives safe transport aroiund the cage. mainly use of rope close to the cage prevents damage to the nets.

A wide range of anchors, depending on depth and bottom conditions. All steel components used near or under the surface are hot dip galvanized.

The bouys are made of rotation moulded polyethylen filled with polystyrene foam. This retain full floating capasity even if the shell has been damaged.



A typical mooring design showing grid, anchors, buoys and barge locations etc. This design allows for for custom positioning to the farm site.

Akvasmart Mort Collection concept

Eductor pump principle
The compressed air is injected through a number of small holes in a separate air chamber.
The benefits obtained by the stream of injected air entered through many holes, is to create a constant and rapid flow.

Automatic system for collecting morts

- A prerequisite for a healthy and vibrant fish environment

A basis for a continued healthy environment for the live fish in the system is that all morts are removed as soon as possible from the cage.

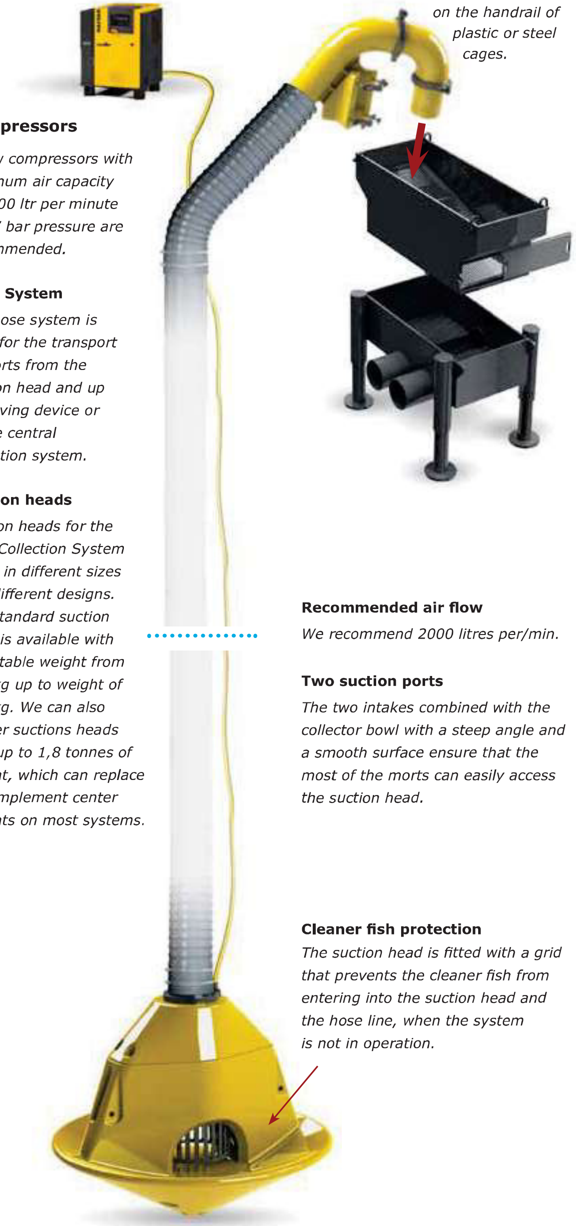
Most feed barges from AKVA group have integrated silage tanks in the hull below the feed selector valves.

AKVA group, HSE and several fish farming companies has developed an automated, robust and very practical system for removing morts. The system is adapted to today's Polarcirkel plastic cages, Wavemaster steel cages, nets and various other site infrastructure solutions.

The Akvasmart mort system is offered as semi-open or as a fully closed system. The system can be delivered with central collection where the fish goes right from the cages for further treatment.

A wide range of sieve designs can be mounted on a work boat or at the site, or integrated into a central collection unit, depending on the farmers demand for mort collection infrastructure.

The automatic Mort Collection System:



Compressors

Screw compressors with minimum air capacity of 2000 ltr per minute and 7 bar pressure are recommended.

Hose System

The hose system is used for the transport of morts from the suction head and up to sieving device or to the central collection system.

Suction heads

Suction heads for the Mort Collection System come in different sizes and different designs. Our standard suction head is available with adjustable weight from 200 kg up to weight of 700 kg. We can also deliver suctions heads with up to 1,8 tonnes of weight, which can replace or complement center weights on most systems.

Handrail protection

Tube and handrail protectors are available in several designs for mounting on the handrail of plastic or steel cages.

Recommended air flow

We recommend 2000 litres per/min.

Two suction ports

The two intakes combined with the collector bowl with a steep angle and a smooth surface ensure that the most of the morts can easily access the suction head.

Cleaner fish protection

The suction head is fitted with a grid that prevents the cleaner fish from entering into the suction head and the hose line, when the system is not in operation.

akvasmart™

Cage Nets

The highest quality nets safeguards your fish

AKVA group offer several types of nets for your cages. Both traditional and proven fiber nets (mainly nylon) made by Egersund Net in Norway, as well as the innovative and promising non-fiber EcoNets (solid PET wire), made by the Italian company Maccaferri.

As the net is the only barrier keeping your valuable farmed fish inside and predators outside, it is the most critical piece of equipment on a cage farm that prevents fish escapes and other fish losses. Consequently, only the highest quality and design must be used, combined with Norwegian Standard (NS9415) certification.
In order to ensure correct net specifications for your farm site, documented site environmental loads from currents, waves and wind must be used for dimensioning and design. This must be followed by professional and systematic inspection, maintenance and testing throughout the life span of the net.

The end result is a net you can trust, whether fiber or non-fiber materials.

Egersund Net - top of the line for more than 40 years

One of world´s leading net and net service suppliers

Egersund Net has developed into one of Europe's leading suppliers of fish farming nets and net services.

These quality nets are based on years of experience with the safety of our customers at heart.

Egersund fibre nets are designed for a wide range of round and square cage sizes.

Net testing and research

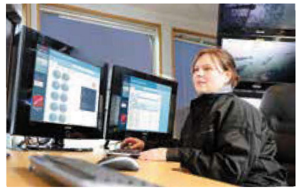
Egersund Net invests heavily into R&D to ensure leading edge net products and new concepts. Including material testing, net shape designs, net weight concepts and new anti-fouling treatment methods. Extensive scale testing is performed at SINTEF's large tank testing facility in Hirtshals, Denmark, in order to determine optimum performance in various current and wave conditions. The end result is a powerful combination of high-tech modern R&D with decades of personal craftsmanship and practical experience.

An efficient manufacturing line with a highly qualified and experienced staff.

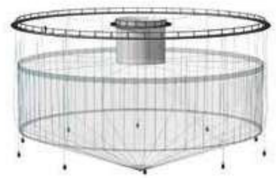
Construction and design

It is very important to ensure the nets are easy and safe to handle. A good user manual as well as clear marking of lifting points facilitate safe and secure handling. The risk of escape is thereby reduced.

The new ENCA (Egersund Net Circle Angled) net design is an example of a design which facilitates easier/ faster and safer net handling.



New dedicated database for documentation of net, floating and mooring components developed by Egersund Net.



New advanced 3D software is used to develop optimum net designs by simulating scenarios.

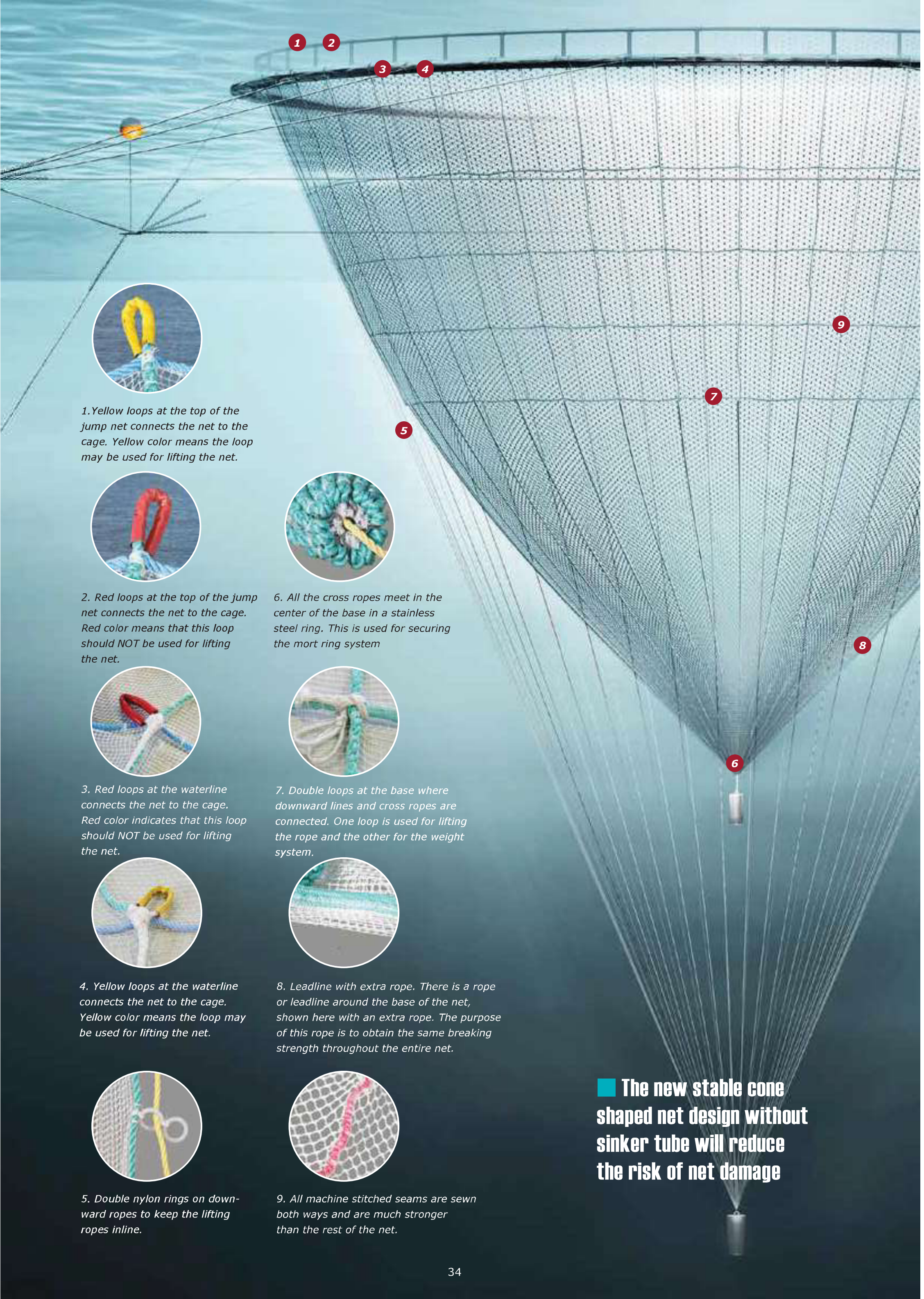
Quality control and ISO certification

Egersund Net supplies nets with both square and hexagonal mesh made of high quality materials at the modern plant in Egersund. A stringent quality assurance program ensures a high quality manufacturing process. They supply knotless net, super knotless net and Dyneema net materials. The entire net fabrication process is ISO 9001 certified by Det Norske Veritas (DNV) and NS9415.

The three main fibre net designs are: Standard knotless netting, Super netting and Hexagonal netting in nylon.

All new models are tested under different current conditions at SINTEF's research tank facility in Hirtshals, Denmark.

Testing of the new cone-shaped model without a sinker tube proved that it was structually stable even at current speeds in excess of 2 knots.



1.Yellow loops at the top of the jump net connects the net to the cage. Yellow color means the loop may be used for lifting the net.

2. Red loops at the top of the jump net connects the net to the cage. Red color means that this loop should NOT be used for lifting the net.

3. Red loops at the waterline connects the net to the cage. Red color indicates that this loop should NOT be used for lifting the net.

4. Yellow loops at the waterline connects the net to the cage. Yellow color means the loop may be used for lifting the net.

5. Double nylon rings on downward ropes to keep the lifting ropes inline.

6. All the cross ropes meet in the center of the base in a stainless steel ring. This is used for securing the mort ring system

7. Double loops at the base where downward lines and cross ropes are connected. One loop is used for lifting the rope and the other for the weight system.

8. Leadline with extra rope. There is a rope or leadline around the base of the net, shown here with an extra rope. The purpose of this rope is to obtain the same breaking strength throughout the entire net.

9. All machine stitched seams are sewn both ways and are much stronger than the rest of the net.

Advanced net load calculations

Loops for proper connection of nets and bottom ropes

All connection loops are color coded to ensure that it will be easy for operators to ensure they lift the net using the correct loops and ropes. The loops have been lab tested in Egersund Nets' lab to document the horizontal and vertical forces acting on them.

The loops are fitted in such a way that a failure will not result in net damage. It is also easy to replace worn out loops when the net is serviced.

The bird nets are offered in standard sizes or tailor made on request for each farm.

Net materials

Customized cage nets and bird nets are available for a wide range of fish farming installations.

Nylon

Special knotless netting made from nylon ensures high quality netting with a long lifespan. Such netting is available in various thread and mesh sizes. Color: Black or green.

Dyneema

Cage nets made of knotless Dyneema are lighter in weight and have better water flow properties than regular nylon nets.
Color: White.

The service package includes cleaning of nets, inspection, repair and anti-fouling/ abrasion protection. (Some areas only)

Service and documentation

Egersund Net provides services for the fish farming industry from their modern facilitiesin Norway and Turkey. Emphasis. on high quality and environmentally friendly products and services ensures high capacity installations adapted to the needs of our customers.

All nets are quality assured and fabricated to stringent quality requirements. All fabrication at Egersund Net is ISO 9001 and NS 9415 certified.

Anti-fouling

Advanced anti-fouling technology ensures optimum antifouling effectiveness, product safety, environmental friendliness and HSE. Coating without use of antifouling agents is also available. The coating helps protect the nets from UV radiation, makes cleaning of the nets easier and increases the life-span of the nets.

The nets are lifted safely during harvesting and cleaning. We also supply sweep nets for all types of cages.

All nets are shipped on a pallet or in a big bag. This makes it simple and safe to install them in the cage.

Proven and thoroughly tested knot solutions in different colors make it easier to locate the correct lifting point.

A wide range of special design nets are available, including saithe nets, bird nets, harvest nets for both round and square cages.

High durability and escape prevention

- **High durability**
- **Escape prevention**
- **No net changes**
- **Maximized water flow**
- **No anti-fouling paint**

The unique **Polarcirkel EcoNet** concept can totally change today's fish farming! This non fibre net technology has been used to make over 4000 fish farming nets, in addition to many other usages including shark nets, rock slide nets etc.

EcoNet is used as shark nets as protection outside popular beaches.

The real strength of the EcoNet is well tested when used as rock slide nets!

The EcoNet is made from very strong but light weight PET and has some superior characteristics, including: Being virtually escape proof, predator proof and has a long lifespan.
The non-fibre wire has very hard surface that resists marine fouling and makes it easy to clean in the water using Idema Net Cleaners.
No use of antifouling paints or ongoing net changes.

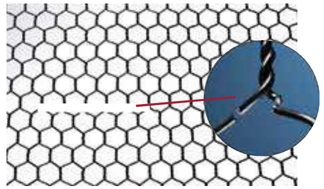
EcoNet is handled in very similar ways to a nylon net, including drying up the net for crowding fish during harvest.

Fish escaping through holes in the net accounts for most of reported cases.

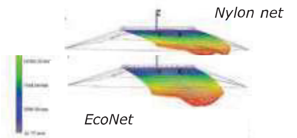
Fish farm net deformation and loads are affected by three main factors: CURRENTS + NET TYPE (rigidity, drag, strength) + NET WEIGHTS.

The semi-rigid structure keeps the net shape intact to maximize water flow and oxygen to the fish.

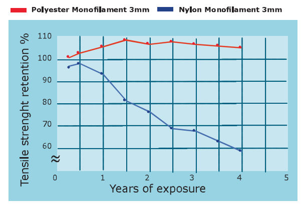
The unique semi-rigid and low-drag EcoNets maintain a superior net shape in strong currents compared to conventional nets, thus providing optimum water flow and oxygen levels for your fish. Less net weights are then required to keep EcoNets in place. The result is reduced deformation/drag, reduced risk of net chafe/damage and reduced overall displacement (weight) of the entire cage system. This means less load on the mooring systems and more reserve buoyancy for the cages.



A 20 cm cut in an EcoNet will tend to stay closed due to the double twisted thermo formed semi-rigid structure and non-tearing weaving.



Example of cages in 0.5 knots current (0.25 m/sec.). The EcoNet will still keep a very good and stable shape.



The PET netting wire retains high tensile strength for decades below and above water.

Less resistance and higher stiffness = reduced mooring loads, increased net volume and more oxygen!

Extreme weather

Predators

Mechanical damage

Biological deterioration

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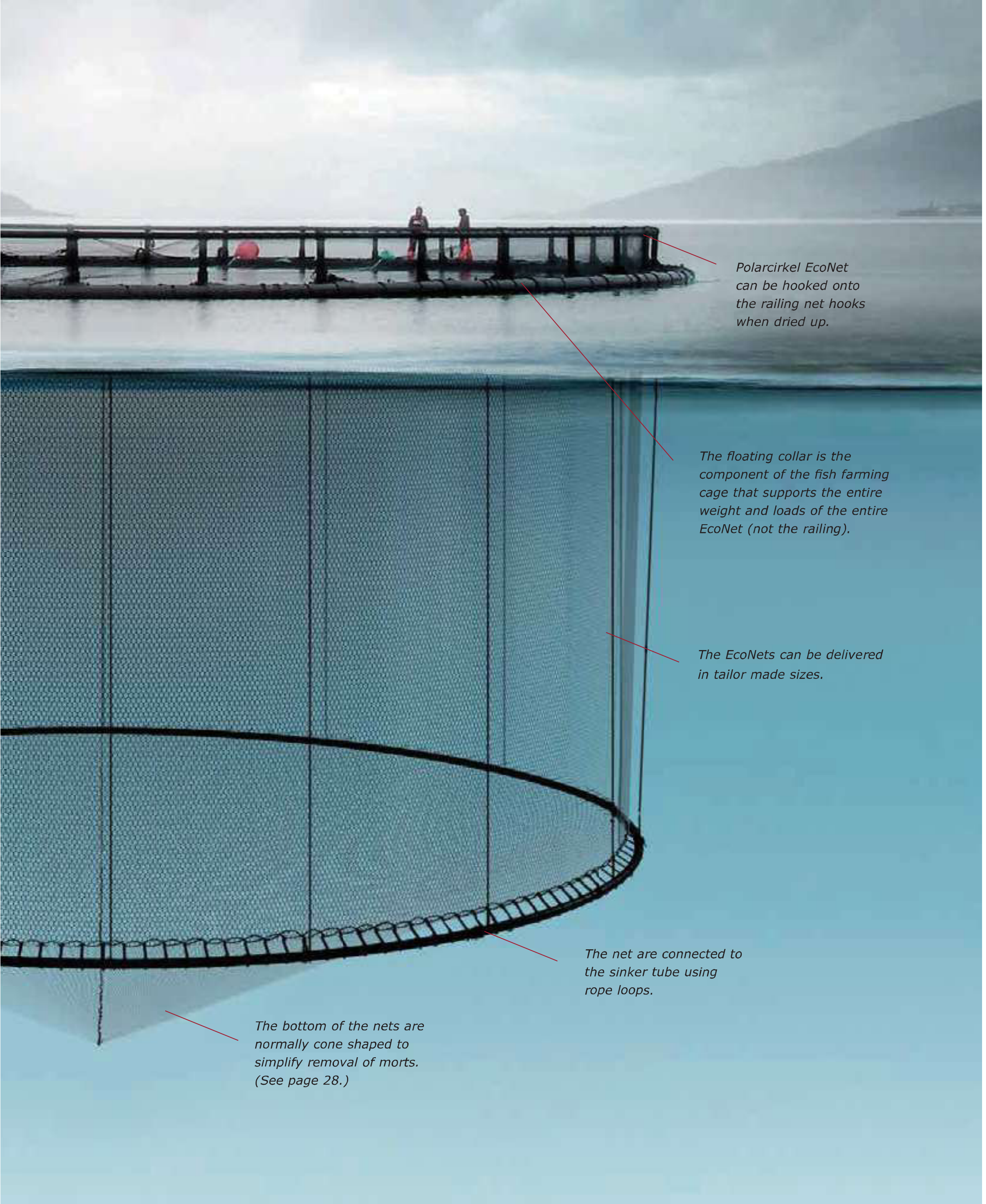
Extra strong long-life Polarcirkel EcoNets



Easy to install - easy to keep clean

The upper section of the EcoNets have slightly tapered vertical walls with a 1m jump-net up top and the bottom is normally cone shaped.

Polarcirkel EcoNet being installed by use of cranes and skilled farm technicians.

For shorter periods, Polarcirkel EcoNet can be hooked onto the railing net hooks when dried up.

The EcoNet tolerates icing and the ice is also easier to remove compared to other net materials.

Approved for fishfarming use according to Norwegian Standard 9415.

Once the Polarcirkel EcoNet is installed in the cage there is no need to disconnect it during normal operations. Exceptions will be in case of net damage. The EcoNets are cleaned in the water and are not taken out for cleaning or antifouling. This greatly reduces the risk of net damage as a result of net handling.

Net handling and fish husbandry

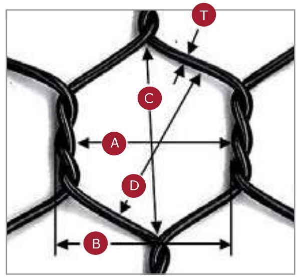
Although Polarcirkel EcoNet is a semi-rigid net, it can still be handled in very similar ways to a nylon net. This includes drying up the net for crowding fish during harvest, fastening the net to the cages and attaching sinker tubes etc. However, as the EcoNet is being tested and used in new markets and for new species, new and better techniques will continue to be developed to simplify net handling and ensure the best possible fish husbandry.

The Polarcirkel EcoNets are made for rough, daily use, from very strong but light weight PET.

Strong but light material

The shape of the EcoNet wire mesh is designed to remain intact if a single wire is cut. This means the mesh will remain relatively stable and the shape intact with minimum negative effect of the strength of the net cage structure.

The Polarcirkel EcoNet is made from very strong but light weight PET, (Polyethylene Terephthalate).



A = Mesh width
B = Mesh pitch
C = Mesh height
D = Mesh diagonal
T = Wire thickness

The hard non-fibre wire reduce settling of marine fouling and makes the net easy to clean with a net cleaner from AKVA group.

Polarcirkel EcoNet is available in two different mesh sizes:

Mesh size:	t (mm)	A (mm)	B (mm)	C (mm)	D (mm)	weight
Large:	3,0	45	50	71	59	590g/m²
Small:	2,5	35	40	43	37	570g/m²

Quick and easy cleaning of floating pipes and sinker tubes

Akvasmart Cage Cleaning system is easily operated by one person. The complete cleaning process is performed safely with people standing well away from the operation.

Effective high pressure cage cleaning

A standard version of Akvasmart Cage Cleaner is equipped with a high pressure washer for floating pipes with two rings.

All Akvasmart Cage Cleaners are designed with rugged, galvanised and coated steel profiles.

The washing unit can easily be mounted at the stern of a workboat or feeding boat.

A special designed hook for the crane will simplify the handling of the sinking tubes in the cages.

Regular cage cleaning ensures stable cage weight and reduces the risk of infection in the cages.

The Akvasmart Cage Cleaner is developed to simplify and streamline the cleaning and removal of marine fouling. The washing unit can easily be mounted at the stern of a workboat. The Cage Cleaning system consists of a lifting unit, a submersible part and a hydraulical driving wheel system that rotates the cage while it is being flushed and cleaned.

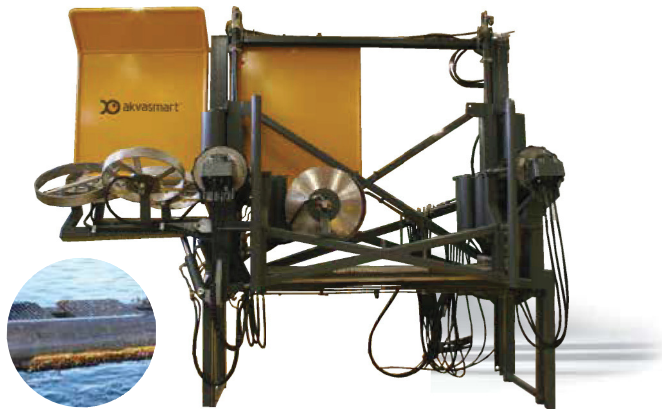
For cages without sinker tubes, the cleaner is submerged below the floating pipes. The unit is placed with the inner pipe connected to the drive rolls while the outer pipe is positioned against the sliding surface and steering rolls. The Cage Cleaner can also be delivered with a system for flushing sinker tubes where the sinker tube and floating pipes are cleaned simultaneously. It is generally enough to rotate the cage one turn to ensure proper cleaning.

An effective and well proven concept
The cleaning unit hydraulically lifts a part of the cage above the surface and the flushing occurs when the cage is rotated around it´s own axis, while a pressure washer mounted on rotating arms performs the cleaning using water under high pressure.

Installation and use
Connection points are included for the stern of the workboat. Dedicated work platforms can also be offered to simplify the access inspection and maintenance. The whole cleaning process occurs without any people close to the cage and can be operated by one single man in a workboat.

Specifications:
- Size: L:4946mm. H:3993mm. W:2450mm + 540mm in telescope
- Weight: Approx. 3000 kgs (without sinking tube cleaner)
- Surface treated steel profiles (galvanised and coated)
- Rotation speed while flushing: Approx. 4m/min
- The cleaners are hydraulical adjustable and it´s possible to clean pipes in various widths for example; Polarcirkel 160m 500 pipe 190cm or Polarcirkel 160m 450 pipe 150cm.

The Cage Cleaning Systems are developed in close cooperation with large aquaculture companies and are produced by SMV Hydraulic as.



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Net Cleaning Systems

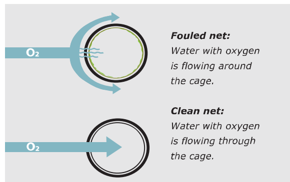
Effective Net Cleaning ensures optimum oxygen levels and faster growth

Idema Net Cleaners were launched in 1987, and are today renowned for quality, high performance and their ease of use. The first Net Cleaners had single 30cm diameter cleaning discs, operated from the cage edge using a shaft. Underwater pressure washing of cages containing fish has become even more common as the requirements to environmentally friendly aquaculture in larger cages provides the best scale of economics.

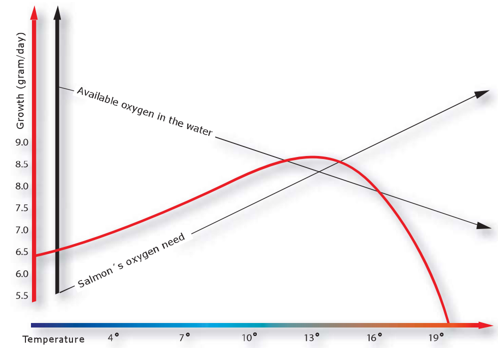
With this in mind we have developed and improved the Net Cleaners and can now present the best range of net cleaners and high pressure pumps ever. This combination offers you the most efficient cleaning system suited for all types and sizes of cages.

Reduced marine fouling improves the environmental conditions

Strong marine fouling on the net will reduce the oxygen supply. Algae growth can increase bacterial loads and cause diseases and stress in the biomass.



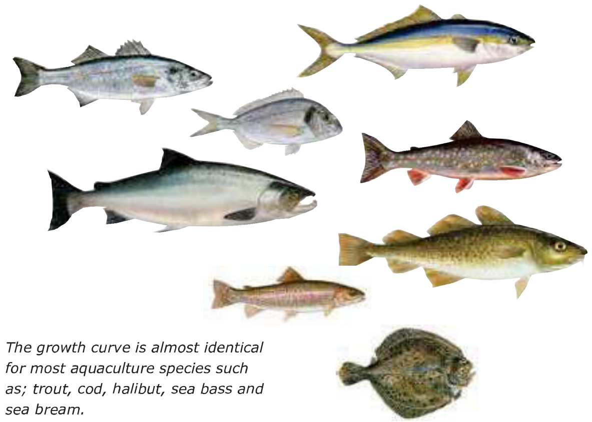
It is proven that increased marine fouling leads to reduced water flow. As a result, the oxygen rich water will mostly flow around the cage.



Growth curve for salmon

Good waterflow through the nets are crucial at high water temperatures.

Growth
Temperature



The growth curve is almost identical for most aquaculture species such as; trout, cod, halibut, sea bass and sea bream.

It is important to keep the weight of the cages light in cold periods. Icing and fouling can indirectly cause breakdowns and serious damage.

Idema Net Cleaners also keep nets clean in tropical waters, as here in Thailand.

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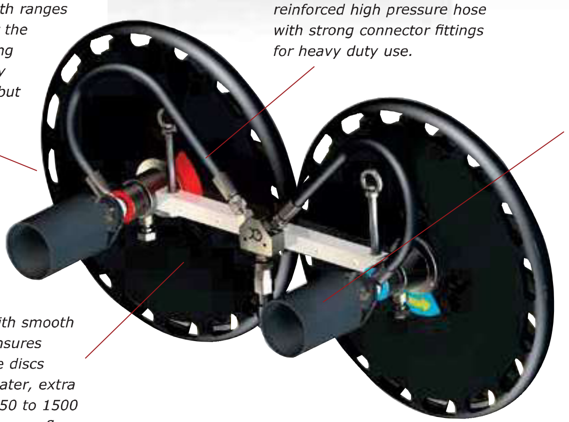
Environmentally friendly and flexible solutions

In Net Cleaning, filtered high pressure sea water is used to remove marine fouling on the nets. Idema Net Cleaners use rotating cleaning discs mounted on support frames in various shapes and combinations. We use rugged, tailor-made high-pressure pumps to drive the cleaning discs. The cleaning process starts with submerging the frame on the inside of the net, using only sea water under high pressure. Idema cleaning systems do not use chemicals or scrubbing action making them environmentally friendly while ensuring minimal wear on the nets.

The Heavy Duty center bearing with silicium-carbide pressure housing mean less service calls and minimal down time.



The width of the cleaning path ranges from 80cm, up to 290cm for the largest model using 7 washing discs. The discs are generally delivered in 40cm diameter but can also be ordered in 30cm or 50cm diameter.

Extra strong 2-layer steel reinforced high pressure hose with strong connector fittings for heavy duty use.

The new water jet thrusters creates a significantly better push against net. It is available as an option on all new systems, or as an upgrade-kit for already delivered net cleaners.

Heavy duty cleaning discs with smooth front rail in stainless steel ensures minimal wear of the net. The discs have low resistance in the water, extra high rotation speed - from 750 to 1500 rpm depending of water pressure, flow rate and cleaning disc diameter.

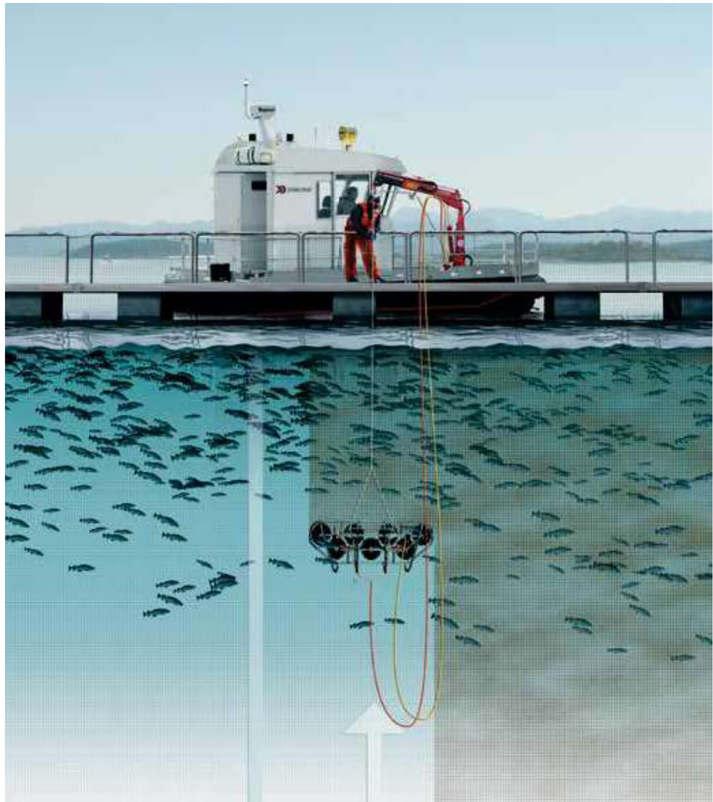
- a wide range of Net Cleaners

The large Net Cleaners can be operated in automatic mode by two persons using a crane, winch, cap stand or as a integrated option on ROV (Remotely Operated Vehicle). The smallest Net Cleaners can easily be operated from the cage by a single person.

One of the new models is the net cleaner, an effective 7 disc washing rig with a stainless steel protective net guard.

Video camera control

On the larger Idema frames we offer tailor-made camera and video systems that provide a full overview, and the possibility to inspect the nets.



A new series rugged washing rigs with improved features and long lifespan:

- New washing rig with pan/tilt camera and new water jet thrusters that create significantly better push against the net.
- Stainless shock absorbers reduce vibrations and water pressure hammering in connections and pipes.
- Large integrated particle filter included.

A camera installed directly on the net cleaner will send you clear video images that can be saved for later inspection and documentation.

All Net Cleaners are offered with smooth front discs in stainless steel that ensure minimal wear of the net.

The environmental conditions in the cages are the most vital parameters for top quality and faster biomass growth.

akvasmart™

Net Cleaning Specifications

High Pressure Washers:	F-Drive K-28-280-SB	D-Drive K-28-250-SD	D-Drive K-136-300-SD	D-Drive K-188-300-SD-JD	D-Drive K-240-280-SD-JD
Engine:	Vanguard V-Twin	HATZ 2G40	John Deere	John Deere	John Deere
Max hp:	22hp	22hp	150hp	150hp	150hp
Size:	120x60x75cm	120x80x80cm	400x200x200cm	400x200x200cm	400x200x200cm
Weight:	80kg	180kg	approx. 2300kg	approx. 2400kg	approx. 2400kg
Fuel:	Gasoline	Diesel	Diesel	Diesel	Diesel
Max cleaning discs:	2	2	8	10	10
Recommended cage circumference:	Up to 90 meter	Up to 90 meter	Up to 200 meter	Up to 200 meter	Up to 200 meter
Standard equipment:	40m high pressure hose, 3m suction hose, power nozzle with 40cm extension and swivel coupling.	Delivered on a stainless steel frame in Euro pallet size with lifting lugs.	Delivered with sound proof cabinet and integrated pump.	Delivered with stainless steel sound proof cabinet and integrated pump.	Delivered with stainless steel sound proof cabinet and integrated pump.
Water, liter/min:	28	28	136	188	240
Bar:	280	250	300	300	280

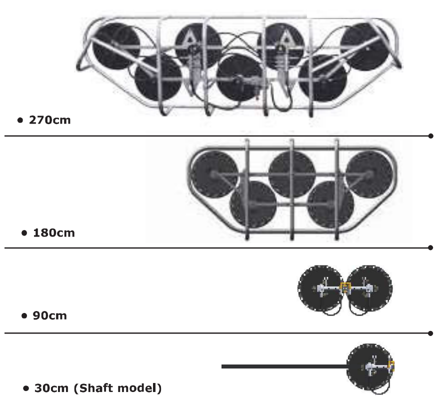
High Pressure Washers:	H-Drive K-28-280-SH	H-Drive K-30-200-SH	H-Drive K-41-210-SH	H-Drive K-136-300-H	H-Drive K-188-300-H
Engine:	Fitted to workboat	Fitted to workboat	Fitted to workboat	Fitted to workboat	Fitted to workboat
Max hp:					
Size:	60x35x25cm	60x35x25cm	60x45x25cm	113x73x52cm	113x73x52cm
Weight:	40kg	40kg	40kg	350kg	350kg
Fuel:	Hydraulic	Hydraulic	Hydraulic	Hydraulic	Hydraulic
Max cleaning discs:	2	2	2	8	8
Recommended cage circumference:	Up to 90 meter	Up to 200 meter	Up to 90 meter	Up to 200 meter	Up to 200 meter
Standard equipment:	Integrated pump	Integrated pump	Integrated pump	As stand alone unit or dedicated water supply.	As stand alone unit or dedicated water supply.
Water, liter/min:	28	30	41	136	188
Bar:	280	200	210	300	300

GASOLINE DRIVE
DIESEL DRIVE
HYDRAULIC DRIVE

The cleaning discs are generally delivered with 40cm diameter. They can also be offered in 30cm or 50cm diameter.

New improved and corrosion free MVN pumps from Prattisoli with extra long life-span.

WASHING AREA (WIDTH) FRAMES



Gasoline, diesel or hydraulic driven High Pressure Washers

We offer a rugged series of High Pressure Washers for seawater, suited to various system solutions and cage sizes. The gasoline driven washers (F-Drive), are light-weight and perfect as portable units. The diesel driven units (D-Drive), are almost maintenance free, use less fuel than the gasoline models and are well suited for large, powerful, permanent installations. The hydraulic driven high pressure models (H-Drive), are small, compact and almost maintenance free, perfect for below deck installations in workboats.

Net Cleaning system solutions

The table above presents a range of effective Net Cleaning frames for different cage constructions and sizes. The high pressure pumps can be driven by gasoline, diesel or hydraulics, depending on the best solution for your farm. Heavy Duty Cleaning discs with smooth frames in stainless steel ensure minimal wear on the net. Additional benefits include low drag in the water and extra high rotation speed, from 750 to 1500 rpm.

- **Stainless steel cabinet with hydraulic winch and remote control for raising and sinking the washing rig.**
- **New corrosion free pumps with extra long life-span.**
- **Dedicated pre-feeder pump boosts water flow.**
- **Hydraulic driven hose reel for 100m ¾ hose.**

Diesel (D-Drive) 2-10 cleaning discs
Idema K-188-300-SD-JD-150
Size 400x200x200cm. Cleaning discs: 5+5.

Hydraulical (H-Drive)
2-8 cleaning discs
Idema K-30-200-SH
Size: 60x35x25cm.
Cleaning discs: 2.

Gasoline (F-Drive)
2 cleaning discs
Idema K-28-280-SB-VA-22
Size: 120X60x75 cm.
Cleaning discs: 2.

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Workboats

Designed for extreme conditions

The robust workboats offers great design, quality build, unique flexibility, user-friendliness and low maintenance. More than 2000 boats are in use in fish farming, marine industry, gas/oil industry, emergency services, military, arctic tour operators and pleasure boaters who need an indestructible boat.

All AKVA group boats are tested in extreme weather conditions all over the world. All models are loaded with smart details and unique features for safe operation in tough conditions and we ensure our products have an emphasis on safety and the environment.

Polarcirkel Open Workboats

Virtually maintenance free and unsinkable

These robust Open Workboats offers great design, quality build, unique flexibility, user-friendliness and low maintenance. Polarcirkel RBBs (Rigid Buoyancy Boats) are self-bailing, in contrast to a conventional RIB, and have rigid pontoons filled with polystyrene. Combined with 21° V-shaped hull, this design makes a virtually unsinkable boat with unique stability and excellent seaworthiness.

We offer Polarcirkel Open workboats with outboards in sizes from 5,85 up to 8,45 meters. The inboard series ranges from 6,85 to 8,45 meters.

All Polarcirkel boats are tested in extreme conditions all over the world. They are loaded with smart details and unique features for safe operation in tough conditions, with emphasis on safety and the environment. The PE-100 plastic is LNG-based with great recycling properties.

The 685, 785 and 845 models are offered with new hull design, which gives better lift, and forces the spray out to the sides. These improvements provides better seaworthiness and and a more comfortable ride.

Polarcirkel has flexible model solutions, such as Polarcirkel Sport, with removable cockpit canvas for windy or rainy days.

Open Workboats, standard equipment:

- 4 pcs mooring cleats
- Extra protective hull strips
- Stowage space with hatch
- Manual bilge pump
- Self-bailing deck
- Red gunwales
- Fire extinguisher
- Non-skid rubber deck mat outside
- Red PE rub rail on pontoons
- Built-in steps in aft pontoons
- Hydraulic steering wheel
- CE approved, category C

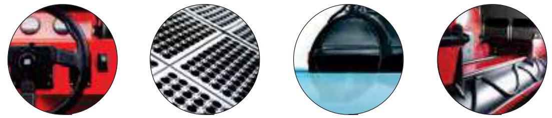
Inboard only:
- Dashboard mounted controls
- Electric bilge pump with sensor
- Battery, main switch & ignition lock
- Insulated engine hatch with pneumatic lifters
- Built-in diesel tanks 2 x 220 litres or 1 x 310 litres

- RPM gauge, temperature gauge, oil pressure gauge, voltmeter and tilt indicator
- Steering console with instrumentation and antenna arch with nav-lights

Outboard only:
- 4 x lifting eyes
- Step boards
- Fuel tank: 103L (560) or 210L (685, 785 and 845)
- Fuel gauge
- Battery compartment under bench
- Guard rails around bench
- Seat with stowage space

Optional equipment:
Search lights, work lights, antenna arch, bow platform with pulpits, marine electronics, etc.

Open Workboats	560	685	785	845
Lenght (LOA):	560cm (18'5")	685cm (21' 8")	785cm (25'8)	845cm (27'7")
Beam (BOA):	207cm (6' 9")	248cm (8' 2")	271cm (8' 10")	271cm (8' 10")
Displacement:	750kg/1650 lbs	950kg/2090 lbs	1250kg/2750 lbs	1375kg/3025 lbs
Max HP:	100HP	250HP	300HP	350HP
Recommended HP:	From 60HP	From 100HP	From 115HP	From 150HP
Max load:	1000kg/2200 lbs	1250kg/2760 lbs	2250kg/4960 lbs	2250kg/4960 lbs
Max persons:	10	10	12	12
Shaft:	Long	X-Long	X-Long	X-Long/Ultra long
V-bottom :	21°	21°	21°	21°
Inboard engine:	Not available	Available	Available	Available
Water Jet:	Not available	Not available	Available	Available



Hydraulic steering wheel, self-bailing deck, sloping pontoons with integrated steps and smart options like hinged gunwale.

We deliver tailor made workboats for professional users such as, fish farming coast guard, navy, police, fire department, tour operators etc.

The boats have performed exceptionally well in arctic and tropical regions and can handle temperatures from -40°C to +55°C.

polarcirkel™

Polarcirkel Cabin Workboats

New bow and hull design provides better seaworthiness and less sea spray.

Customized to suit your needs

AKVA group´s tough and reliable hand-crafted Polarcirkel Cabin Workboats benefit from great design values, high quality build, unique flexibility and extremely low maintenance. Polarcirkel RBBs (Rigid Buoyancy Boats) are self-bailing, in contrast to a conventional RIB (Rigid Inflatable Boat), have rigid pontoons filled with polystyrene for ultimate safety.

Polarcirkel Workboats are offered in three versions with inboard engines from 130hp to 435hp and lengths of 7.85, 8.45 and 9.10 meters.

New hull design

The Polarcirkel Cabin 785 and 845 models have a new and improved bow design. The bow is raised with 25cm. The bow has been raised 25cm to improve ride comfort and reduce spray.

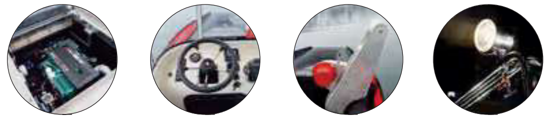
Polarcirkel Cabin Workboat can also be delivered in a popular outboard version. A smart solution with large deck space.

Cabin Workboats, standard equipment:

- 4 pcs mooring cleats
- Extra protective hull strips
- Stowage space with hatch in bow
- Manual bilge pump
- Self-bailing deck
- Red gunwales
- Fire extinguisher
- Hydraulic steering wheel
- Dashboard mounted controls
- Electric bilge pump with sensor
- Insulated engine hatch with pneumatic lifters
- Battery, main switch & ignition lock
- Insulated cabin
- 3-passenger bench seat
- RPM gauge, temperature gauge, oil pressure gauge, voltmeter and tilt indicator
- Built-in diesel tanks 2 x 220 litres
- Head available on the 910 model
- Non-skid rubber deck mat outside
- Red PE rub rail on pontoons
- Built-in steps in aft pontoons
- CE approved, category C

Optional equipment:
Search lights, work ligths, hydraulic installation, capstan, bow platform with pulpits, marine electronics, etc.

New bow and hull design.



Volvo Penta inboard turbo-diesels from 130hp to 435hp and hydraulic steering wheel. Useful options like hydraulic winch and search lights.

Cabin Workboats, inboard	785	845	910
Length (LOA):	785cm (25,8')	845cm (27,7')	910cm (30")
Beam (BOA):	270cm (9')	270cm (9')	300cm (10')
Displacement:	2400kg/5290 lbs	2600kg/5730 lbs	3600kg/7940 lbs
Max Hp:	260hp	310hp	435hp
Recommended HPS:	From 225hp	From 225hp	From 370hp
Max load:	1600kg/3530 lbs	1400kg/3090 lbs	1400kg/3090 lbs
Max persons:	5	5	5
Material, Polyethylene:	12mm	12mm	15mm
Shaft (Outboard versions):	X-long	X-long	–
V-bottom 21°:	•	•	•

The models have a comfortable cabin and can be equipped with cage control monitors and advanced software.

Polarcirkel RBB hulls are self-bailing and have rigid pontoons filled with polystyrene that makes them virtually unsinkable.

polarcirkel™

Polarcirkel 1050

New model with double sloping pontoons

New smart work boat concept

AKVA group has developed a new prototype for a larger cabin boat. This boat is based on an entirely new concept. The boat has double buoyancy pontoons manufactured from 500 mm PE tubing. The hull is approximately identical to our other boats, featuring a 21° V-bottom, however, this model has 3 pressure-tested chambers. This ensures very good buoyancy.

The new Polarcirkel 1050 model is a tailor made workplace with many practical solutions and smart details.

The new 1050 model can be offered with an inboard motor with drive propulsion, inboard motor with water jet, or ordinary outboard motors. The cabin boat can also be delivered with twin motors.

The prototype has been equipped with two 265 hp motors, and the boat has a maximum speed of around 40 knots. Window wipers are installed for all front windows. A number of useful details are included, such as stainless steels shackles, lots of cabin space, slanted stern tube with incorporated steps and comfortable padded seats.

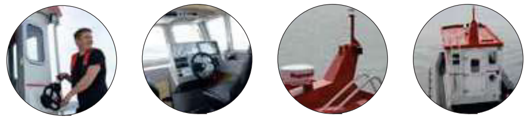
The prototype has also been equipped with an external control position for the helmsman, rescue net, map plotter, Raymarine radar and bow propeller.

Polarcirkel 1050 standard equipment:

- Bow propeller 6hp, continuously variable
- Manual bilge pump
- Electric bilge pump with sensor
- Self-bailing deck
- Hydraulic steering with servo assisted steering wheel
- Motor installation includes battery, cabling, main power switch
- Built-in fuel tanks, 630 litres
- Built-in steps in aft pontoons
- Pulpits
- Insulated motor hatch with pneumatic lifters
- Stowage space in bow
- Step mouldings
- Material: aluminium
- 14 windows, sliding windows for captain and helmsman
- Ladder to roof (mounted on rear side)
- 3 window wipers for front windows
- 4 adjustable chairs with padding
- Passenger bench on starboard side and stowage space under bench
- 6 Spotlighs (LED) in ceiling
- Exit on rear side. (Libra door)
- Mast with lanterns on roof
- Dashboard with motor control instruments, navigation equipment, etc.
- 2 cupholders
- Control handles mounted on top of dashboard
- Two 12V sockets in dashboard
- Fire extinguisher
- Large stowage space under forward pulpit (A toilet can be installed here)
- Rescue door in pulpit. Libra door.
- Defroster 10 KW
- Railing along roof and walls
- Stowage net on rear side of seat
- Compass

The Polarcirkel 1050 models have got new spacious cabins with entrance aft and emergency exit at the front. Both pilot and co-pilot have sliding windows.

Polarcirkel 1050	
Length (LOA):	1050cm (32´)
Beam (BOA)	350cm (11´)
Displacement:	5.700kg
Max hp:	40 knots
Max persons:	8
V-bottom :	21°
Material, hull:	PE 100
Cabin:	Aluminum 1,9x4,2m
Pontoons:	Double, 0,5m Ø filled with polystyrene
Construction:	Buttwelded hull with 3 water proof bulkheads



The new 1050-series has well arranged dashboard. All antennas, radars o.e. are mounted on the roof and are easy available with an aft ladder. Exterior steering position can also be installed.

Polarcirkel 1050 can also be offered with other engin alternatives, here´s a version with two inboard motors and drive.

The boat is equipped with a large cabin type walk-around. Inside the cabin, there are four padded seats and a large bench seating three persons.

polarcirkel™

AKVAcat 1350/750 Workboats

(Legge inn Polarcirkel merder!!!!)

(Nye gråfarger , ny merking)

Designed for excellent performance

AKVAcat is designet to create the optimal working conditions and is a perfect choice for demanding fish farmers. Excellent comfort, elegant design, lots of power and enough space provides the best fasilities you can disire. The workboats are seaworthy and manufactured in accordance with DNV – Nordic boat standard. AKVAcat is offered with seawater resistant aluminum type 6060/6083.

The new AKVAcat models are tailor-made for aquaculture.

Excellent quality in every detail

Fully insulated engine room provides better working conditions and fully upholstered inside gunwales makes cleaning and disinfection much easier. Welded construction provides extra strength and the wide hull ensures high stability and buoyancy. The workboats have excellent finish both exterior and inside.

Powerfull hydraulic cranes

AKVAcat is equipped with a Palfinger 32080G (M) crane with remote control and marine upgrading. The crane is CE certified and driven by a hydraulic aggregate connected to the engin.

AKVAcat Workboats, standard equipment:

Capstan:
2 capstans of 3 and 5 tons can be delivered as standard equipment. Emergency stop is also included.

Navigation and communication:
- Radar and chart plotter with integrated GPS: Furuno
- VHF radio: Furuno
- Sonar: Furuno FCV
- Autopilot: Furuno Navpilot

Generator:
230W/30 kW, 3 fase

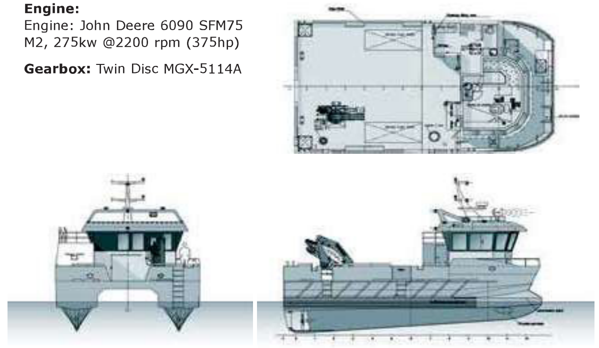
Engine:
Engine: John Deere 6090 SFM75 M2, 275kw @2200 rpm (375hp)

Gearbox: Twin Disc MGX-5114A

Bow thruster:
SP 550 HYD bow thruster will be mounted on port side

Other:
- Extra helm behind the wheelhouse
- Liferaft for 6 men
- Fire extinguisher

Hydraulics:
Driven by 2 PTO Parker pumps 105ccm supplying common hydraulic system for all hydraulic users.



All AKVAcat models are manufactured in accordance with DNV – Nordic standard.

AKVAcat	1350/750
Length (LOA):	13.50m
Beam (BOA):	7.50m
Beam hull:	2.10m
Depth:	2.50m
Displacement:	max. 30.000kgs
Oil tanks:	4 x 2000 litres
Water tanks:	1 x 2000 litres
Max hp without cargo:	13 - 15 knots
Plate thickness:	5-7mm

Stylish wheel house equipped with a selection of avanced maritim electronics. Soft, comfortable and adjustable seats.

A certified hydraulic Palfinger PK crane with a 3.5 ton winch with remote control.

AKVAcat workboats have large loading capacity and they are often used as service and supply boats offshore.

AKVAcat 1499/1000

King of the sea!

AKVAcat 1499/1000 is the largest and best best equipped workboat in our product line. Excellent comfort, elegant design, lots of power and enough space provides the best fasilities you can disire. The workboats are seaworthy and manufactured in accordance with DNV – Nordic boat standard. AKVAcat is offered with seawater resistant aluminum type 6060/6083.

AKVAcat workboats have large loading capacity and they are often used as service and supply boats offshore.

Excellent quality in every detail

Fully insulated engine room provides better working conditions and fully upholstered inside gunwales makes cleaning and disinfection much easier. Welded construction provides extra strength and the wide hull ensures high stability and buoyancy. The workboats have excellent finish both exterior and inside.

Powerfull hydraulic crane

The model is offered with a Palfinger PK 50002 G (M) crane, connected to a 3,5 ton winch with remote and marine upgrading. The crane is CE certified and driven by a hydraulic aggregate on the engine.

Stylish wheel house equipped with a selection of avanced maritim electronics. Soft, comfortable and adjustable seats.

AKVAcat Workboats, standard equipment:

Capstan:
4 capstans of 1, 1, 3 and 8 tons can be delivered as standard. Foot pedals and emergency stop are also included.

Navigation and communication:
- Radar and chart plotter with integrated GPS: Furuno
- VHF radio: Furuno
- Sonar: Furuno FCV
- Autopilot: Furuno Navpilot

Generator:
230V/30 kW, 3 fase

Engine:
Engine: John Deere 13,5 litres 575hp, 6135SFM75 M3 @2000 RPM (575hp)

Gearbox: Twin Disc MGX-5114A

Bow thruster:
Two bow thrusters of 50hp will be be mounted on port side

Other:
- Extra helm by the crane or behind the wheelhouse
- Liferaft for 6 men
- Fire extinguisher

Hydraulics:
Driven by 2 PTO Parker pumps 105ccm supplying common hydraulic system for all hydraulic users.

All AKVAcat models are manufactured in accordance with DNV – Nordic standard.

AKVAcat	1499/1000
Length (LOA):	14.99m
Beam (BOA):	10.00m
Beam hull:	2.90m
Depth:	2.50m
Displacement:	max. 40.000kgs
Oil tanks:	4 x 2000 litres
Water tanks:	1 x 2000 litres
Max hp without cargo:	13 - 15 knots
Plate thickness:	5-7mm

A certified hydraulic Palfinger PK crane with a 3.5 ton winch with remote control.

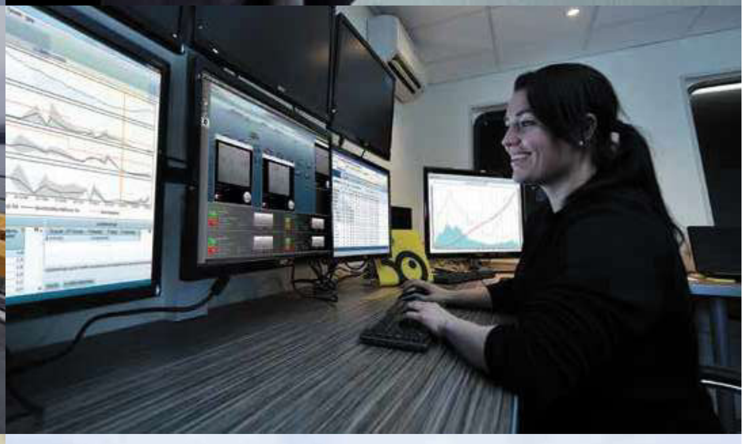
A fully insulated engine room with a stainless steel deck. The main engine is a John Deere 13,5 liter with 575 hp.

Feed Barges

AKVA group is the world's leading supplier with decades of experience and with close to 300 barges delivered world wide.

The latest models provide true scale of economics efficiencies to a wide range of cage farming operations with sizes ranging from 96 to 850 metric tons. They include the latest innovations in FEED CARE OPTIMIZED and efficient feed handling, storage, logistics and personnel comforts to ensure a functional and safe farm base for your crew.

AKVA group has feed barges suitable for a wide range of sites and climates, including inshore, offshore, arctic and tropical areas. All barges are delivered complete, fully self contained with Akvasmart CCS Feed Systems, generator(s), control room, living quarters, safety equipment and all other optional equipment installed, such as integrated mort silage systems, camera- and sensor systems.



Wavemaster Feed Barges

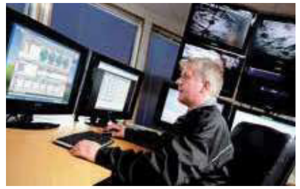
The main purpose for a feed barge is to provide the most efficient and reliable feed system for your farming operations. The second purpose is to provide a safe and seaworthy barge that can withstand the forces of nature at your farmbase site.

Each individual barge model has been optimized to ensure the lowest possible cost compared to size of barge. As a result, the AKVA group Feed Barges are the most cost efficient barges on the market with no material or space wasted.

Tailormade quality barges for a wide range of sites and climates.

Up to 24 feed silos

AKVA group is the world´s leading supplierof feed barges with decades of experience and a wide range of high quality models up to 850 mtons.



Full overview and control

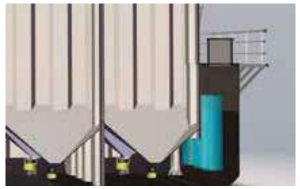
The control room is the heart of the feed barge. This is where the operator has all the information available and controls the entire feeding process.

Just like home

Modern feed barges today are becoming a main work place with proper facilities, living areas and entertainment centers.

Designed for rough conditions

The feed barges are constructed to withstand heavy weather. They are tested in demanding arctic conditions in the north of Norway.

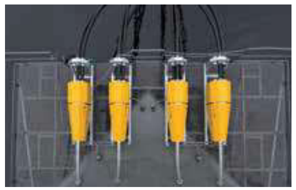


Integrated silage tanks

The mort silage tanks are integrated inthe hull below the feed selector valves. This is the most effective silage system in the marked today.

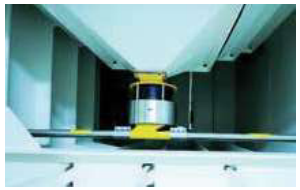
Flexible crane solutions

Cranes of high quality and different sizes can easily be installed on the barges.



Reliable feed system

The central feed system concept was invented by AKVA group in 1980 and CCS is today the most popular and reliable system world wide.



Gentle feed handling

Custom designed feed doser valves transfer the feed into the air flow. Air control ensures gentle feed handling.

Sound proof machine room

A big machine room with sound proofing makes the maintenance easier, and leaves room for more equipment.

wavemaster™

Up to 850 tons and 16 parallel feed lines

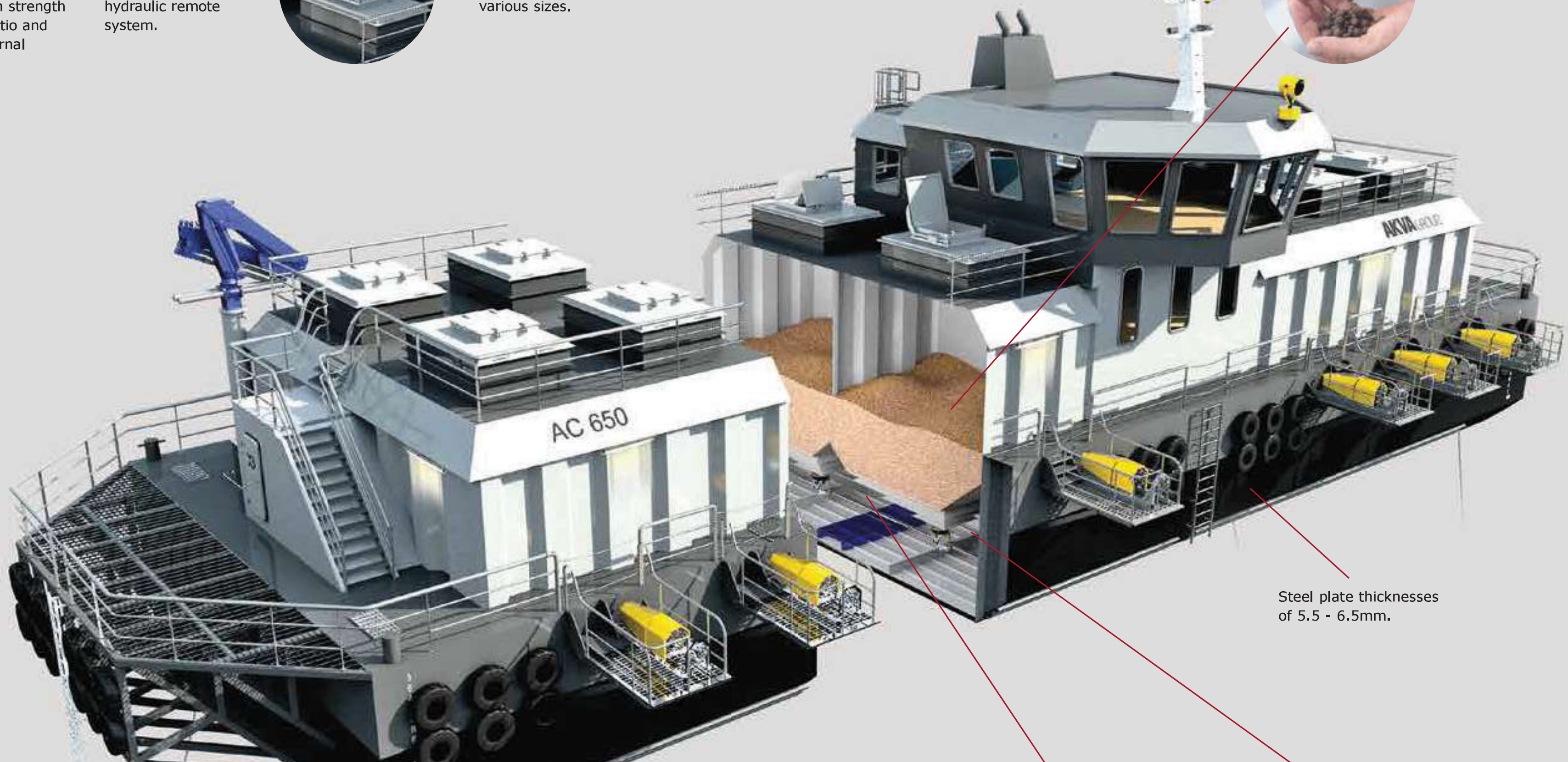
The silo sections are often made with corrugated steel plates in order to achieve high strength to weight ratio and smooth internal surfaces.

The new automatic silo hatches will open safely and easily with a new patented hydraulic remote system.

The feed is loaded into the silos using either bulk bags or bulk blower/conveyor systems. Hatches are available in various sizes.

The feed storage capacity in each silo range from 15-75 metric tons (based on a density of salmon feed at 650kg/m3).

In addition to the required safety gear onboard, most Wavemaster feed barges also include water intrusion and fire alarm systems.



Steel plate thicknesses of 5.5 - 6.5mm.

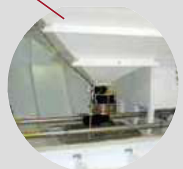
Metallization of outer surface above water line is an option to decrease maintenance and increase life-span.

Heavy duty internal mooring pipes with flared bottom openings. Oversized to allow for two anchor chains in each pipe.

Reinforced bottom "trumpet" mooring pipes distributes loads and prevents chain being snagged during tightening.

High quality and durable Polarcirkel feed pipes in coil lenghts up to 1000 metres.

Air control system allows for real time measurement of airflow, back-pressure and temperature ensuring optimum feed handling.

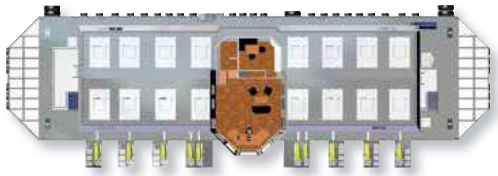


Subject to local safety regulations, most barges include 3-5 watertight bulkheads with two automatic bilgepumps in each.

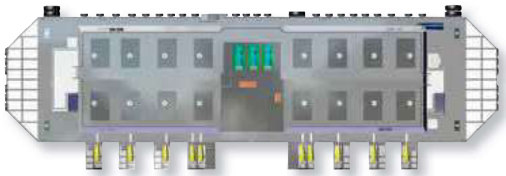
Most barges are supplied with large fuel tank(s), freshwater tank, hot water tank, sewer tank and optional integrated mort silage tank(s).

wavemaster™

AC 850 Panorama



Control room and silo deck level

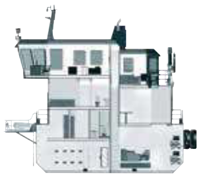


Main deck level

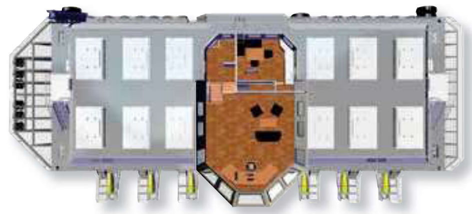
AC 850 Panorama features

- Feeding capacity up to 4 x Quattro System (16 x lines).
- Dimensioned to withstand up to 4,5m significant wave height (Hs).
- Design & comfort are key interior features.
- Panorama provides the view control of the silos and the cages.
- Suitable accomodation perfect for long stays onboard.
- Spaceous engine room prepared for the advanced power management system.
- Metallized above waterline to ensure high quality corrosion protection.
- 5 years paint warranty.
- Integrated mort grinding tank system.

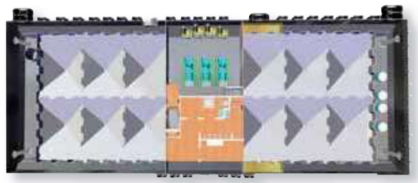
Capacity	
Feed storage capacity:	850 tons (16 silos)
Silage:	Up to 60 tons
Fuel Oil:	Up to 24 tons
Fresh water:	Up to $8m^3$
Sewage:	Up to $3m^3$
Main Dimentions	
Length (ex. platforms):	44,6m
Beam:	12m
Hull height:	4,0m
Minimum freeboard:	1,391m



AC 650 Panorama



Control room and silo deck level

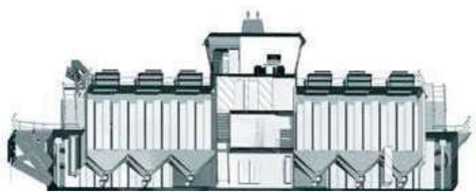


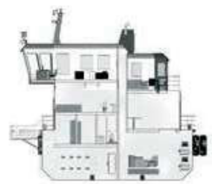
Main deck level

AC 650 Panorama features

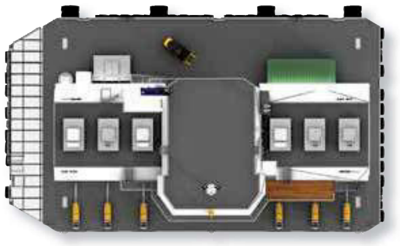
- Feeding capacity up to 3 x Quattro System (12 x lines).
- Dimensioned to withstand up to 4,5m significant wave height (Hs).
- Design & comfort are key interior features.
- Panorama provides the view control of the silos and the cages.
- Suitable accomodation perfect for long stays onboard.
- Spaceous engine room prepared for the advanced power management system.
- Metallized above waterline to ensure high quality corrosion protection.
- 5 years paint warranty.
- Integrated mort grinding tank system.

Capacity	
Feed storage capacity:	650 tons (12 silos)
Silage:	Up to 60 tons
Fuel Oil:	Up to 24 tons
Fresh water:	Up to $8m^3$
Sewage:	Up to $3m^3$
Main Dimentions	
Length (ex. platforms):	31,3m
Beam:	12m
Hull height:	4,0m
Minimum freeboard:	1,233m

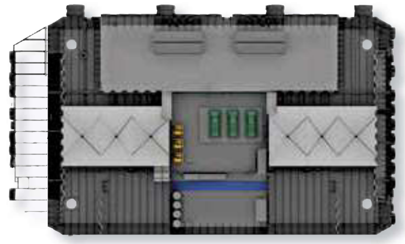




AB 450 Comfort



Silo deck level

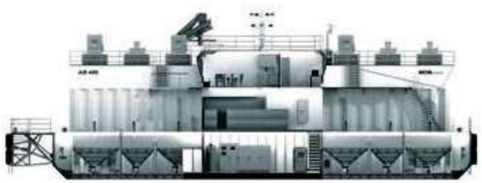


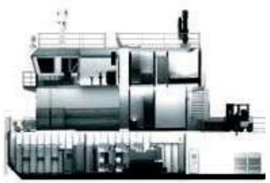
Main deck level

AB 450 Comfort features

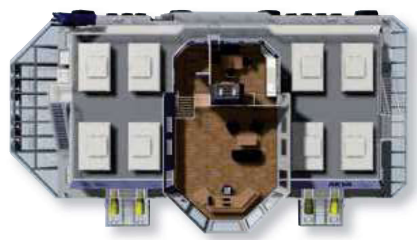
- Feeding capacity Hexa System - 6 silos, 75 ton each
- Big storage room under main deck up to 100 m²
- Working area on main deck up to 80m²
- Spaceous engine room prepared for the advanced power management system
- Dimensioned to withstand up to 4,5m significant wave height (Hs).
- Design & comfort are key interior features.
- Great stability features.
- Large crane capacity located on the mid barge.
- Metallized above waterline to ensure high quality corrosion protection.
- Five years paint warranty
- Integrated mort grinding tank system.

Capacitiy	
Feed storage capacity:	450 tons (6 silos)
Silage:	Up to 50 tons
Fuel Oil:	Up to 36 tons
Fresh water:	Up to 6m³
Sewage:	Up to 5m³
Main Dimentions	
Length (ex. platforms):	30m
Beam:	19m
Hull height:	3,3m
Minimum freeboard:	1,210m

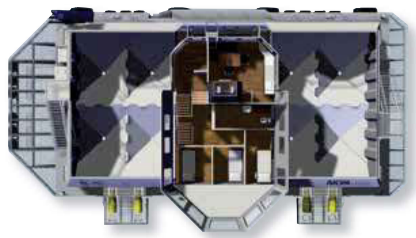




AC 450 Panorama



Control room and silo deck level

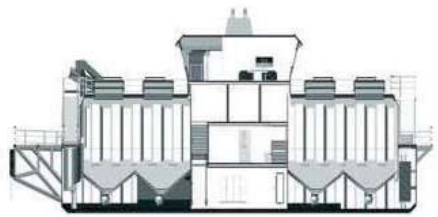


Living quarters, wardrobes, silos

AC 450 Panorama features

- Feeding capacity up to 2 x Quattro System (8 x lines).
- Dimensioned to withstand up to 4,5m significant wave height (Hs).
- Design & comfort are key interior features.
- Panorama provides the view of the silos and the cages.
- Suitable accomodation perfect for long stays onboard.
- Spaceous engine room prepared for the advanced power management system.
- Metallized above waterline to ensure high quality corrosion protection..
- 5 years paint warranty.
- Integrated mort grinding tank system.

Capacitiy	
Feed storage capacity:	450 tons (8 silos)
Silage:	Up to 50 tons
Fuel Oil:	Up to 30 tons
Fresh water:	Up to 6m³
Sewage:	Up to 5m³
Main Dimentions	
Length (ex. platforms):	22m
Beam:	12m
Hull height:	4,0m
Minimum freeboard:	1,074m



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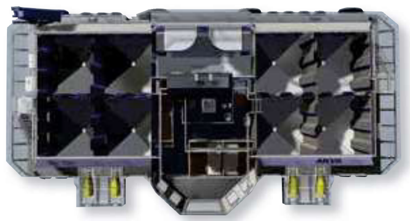
AC 350 Comfort

Control room and silo deck level

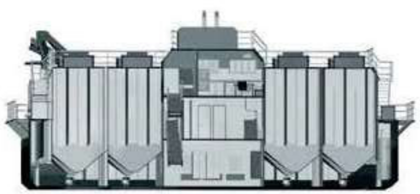


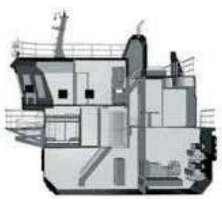
Living quarters, wardrobes, silos

AC 350 Comfort - features:

- Feed capacity dimensioned based on customer needs.
- Dimensioned to withstand up to 4,5m significant wave height (Hs).
- Design & comfort are key interior features.
- Spaceous engine room prepared for the advanced power management system.
- Metallized above waterline to ensure high quality corrosion protection..
- 5 years paint warranty.
- Integrated mort grinding tank system

Capacity	
Feed capacity:	350 tons (8 silos)
Ensilage:	Up to 50 tons
Diesel tank:	Up to 30 tons
Freshwater tank:	Up to $6m^3$
Sewage:	Up to $5m^3$
Main Dimentions	
Length (ex platforms):	22m
Breadth:	10m
Depth till main deck:	4,0m
Minimum freeboard:	1,074m





AM 320 Comfort

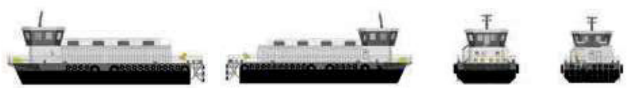
Control room and silo deck level

Machine room, silos, aft deck

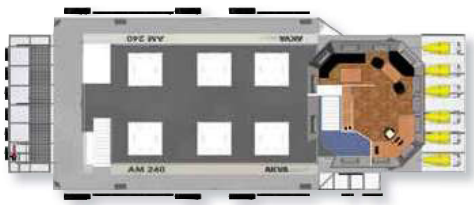
AM 320 Comfort - features:

- Feed capacity dimensioned based on customer needs.
- Dimensioned to withstand up to 4,5m significant wave height (Hs).
- Spaceous engine room prepared for the most demanding power management system.
- Comfort model's raised control room, provides full view control over the silos and the cages.
- Design & comfort are key interior features.
- Metallized above main deck to ensure high quality protection against sea conditions
- 5 years warranty on all painted surfaces.
- Hull integrated mill tank of high processing capacity.
- Large deck with high loading capacity pr. m^2.

Capacity	
Feed capacity:	320 tons (8 silos)
Silage:	Up to 40 tons
Diesel tank:	Up to 30 tons
Freshwater tank:	Up to $8m^3$
Sewage:	Up to $5m^3$
Main Dimentions	
Length (ex platforms):	28,4m
Bream:	10m
Hull height:	3,5m
Minimum freeboard:	1,182m



AM 240 Classic



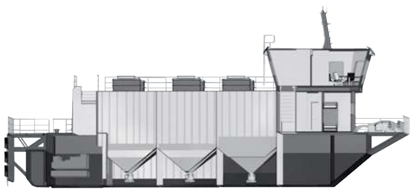
Control room and silo deck level

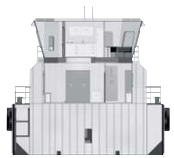
Machine room, silos aft deck

AM 240 Classic - features:

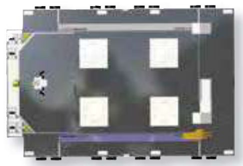
- Feed capacity dimensioned based on customer needs.
- Dimensioned to withstand up to 4,5m significant wave height (Hs).
- Spaceous engine room prepared for the advanced power management system.
- Metallized above waterline to ensure high quality corrosion protection.
- 5 years paint warranty.
- Hull integrated mill tank of high processing capacity.
- Large deck with high loading capacity pr. m².

Capacity	
Feed capacity:	240 tons (6 silos)
Silage:	Up to 30 tons
Diesel tank:	Up to 30 tons
Freshwater tank:	Up to $4m^3$
Sewage:	Up to $5m^3$
Main Dimentions	
Length (ex platforms):	21,5m
Breadth:	10m
Hull height:	3,5m
Minimum freeboard:	1,065m





AJ 130 Comfort Med



Silo deck

Control room, living quarters, silos

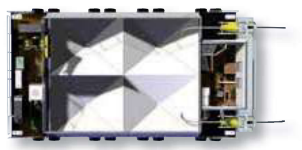
AJ 130 Comfort Med - features:

- Feeding capacity dimensioned based on customer needs.
- Dimensioned to withstand up to 4,5m significant wave height (Hs).
- Comfort model's raised control room, provides full view control over the silos and ther cages.
- 5 years paint warranty.

Capacity	
Feed capacity:	130 tons (4 silos)
Silage:	-
Diesel tank:	Up to 11 tons
Freshwater tank:	Up to $2m^3$
Sewage:	Up to $2m^3$
Main Dimentions	
Length (ex platforms):	14,5m
Beam:	10m
Hull height:	2,5m
Minimum freeboard:	0,947m

AJ 96 Classic

Silo deck

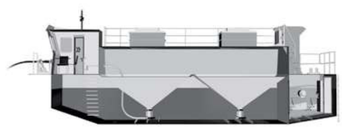


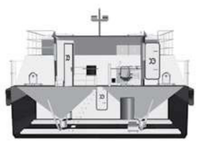
Control room, living quarters, silos

AJ 96 Classic - features:

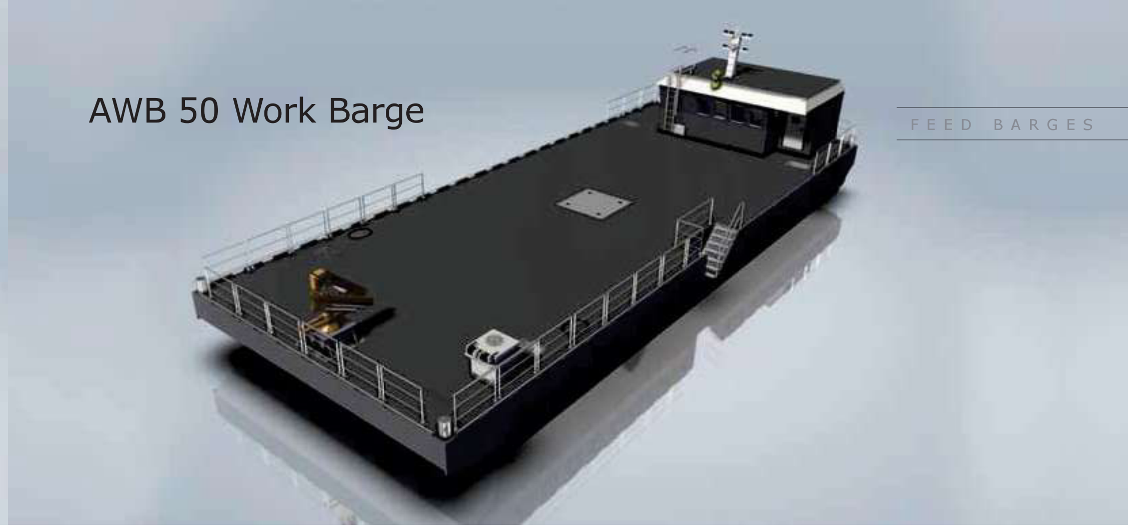
- Feed capacity dimensioned based on customer needs.
- Dimensioned to withstand up to 4,5m significant wave height (Hs).
- Spaceous engine room prepared for the most demanding power management system.
- 5 years paint warranty.

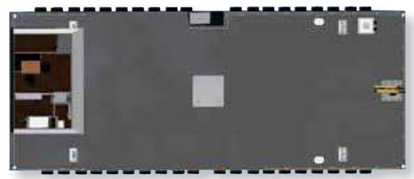
Capacity	
Feed capacity:	96 tons (4 silos)
Silage:	-
Diesel tank:	Up to 5,5 tons
Freshwater tank:	Up to 2m³
Sewage:	Up to 2m³
Main Dimentions	
Length (ex platforms):	14,5m
Beam:	8m
Hull height:	2,2m
Minimum freeboard:	0,947m



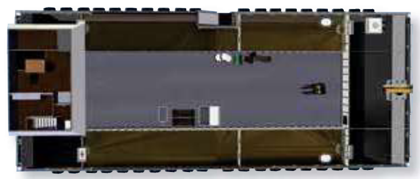


AWB 50 Work Barge





Control room, living quarters, deck area

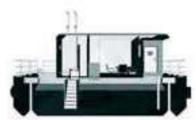


Machine room, storage

AWB 50 Work Barge - features:

- Deck area of 17x5m designed for optimal cargo handling and operations.
- Dimensioned to withstand up to 4,5m significant wave height (Hs).
- Accomodation of 6.5x4m, with living room, kitchen, toilet and garage available areas.
- Metallized above waterline to ensure high quality corrosion protection.
- 5 years paint warranty.
- Max cargo capacity up to 100 tons (including deck cargo, excluding ensilage)

Capacity	
Feed capacity:	50 tons
Silage:	Up to 125 tons
Diesel tank:	1 cubic meter
Freshwater tank:	Up to 125 tonn
Sewage:	1m³
Main Dimentions	
Length (ex platforms):	25m
Beam:	10m
Hull height:	2,2m
Minimum freeboard:	1,000m



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Wavemaster Feed Barges - Specifications

Model:	AC 850	AC 650	AB 450	AC 450	AC 350	AM 320	AM 240	AM 160	AJ 130 Med	AJ 96	AWB 50	Comments:
Feed capacity												
Loading capacity - feed (tons):	850	650	450	450	350	320	240	160	130	96	50 (on deck)	Based on density of 650kg/m³
Loading capacity - feed (m3):	1420	1050	715	715	579	495	405	260	210	155	No silos	***
Number of silos:	16	12	6-8	8	8	8	6	4	4	4		
Barge spesifications												
Length - total (LOA) excl. platform m:	44,6	31,3	30	22	22	28,35	21,5	17,5	14,5	14,5	25,0	***
Beam - total (BOA) m:	12	12	19	12	10	10	10	10	10	8	10	***
Hull height (m):	4	4	3,3	4	4	3,5	3,5	3,5	2,5	2,5	2,2	***
Water proof sections:	5	5	4	5	5	4	4	4	3	3	3	Subject to applicable regulations
Min. freeboard Hs >=3m, stand. mooring:	1,391	1,233	1,0210	1,074	1,074	1,182	1,065	0,998	0,947	0,947	1,125	Hs = Significant wave height
Min. freeboard Hs >=3m, cross mooring:	1,591	1,4	1,315	1,24	1,074	1,382	1,267	1,165	1,114	1,195		
Deck house - options available:	Panorama	Panorama	Comfort	Panorama/Comfort	Comfort/Panorama	Comfort/Classic	Comfort/Classic	Comfort/Classic	Comfort/Classic	Classic		
Veterinary/divers room possible:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	* Optional diver´s room
Biosecure zones:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	***
Max number of generators:	3+1 small	3+1 small	3+1 small	3+1 small	3	3+1 small	2+1 small	2+1 small	2	1	1	
Diesel tank, construction:	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	***
Diesel tank capacity (m3):	2x25	2x12	1x36	2x12.5	2x15	2x11.75	2x11.5	2x11.5	5,5-11	5,5	5,5	***
Freshwater tank, construction:	PE	PE	PE	PE	PE	PE	PE	PE	PE/GRP	PE/GRP	PE/GRP	***
Freshwater tank, capacity (m3):	2-8	2-8	2-6	2-6	2-6	2-8	2-4	2-4	1-2	1-2	1-2	***
Sewage, construction	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	***
Sewage tank, capacity (m3):	3-5	3	3-5	3-5	3-5	3-5	3-5	3-5	1-2	1-2	1-2	***
Silage tank, construction:	Painted steel	Painted steel	Painted steel	Painted steel	Painted steel	Painted steel	Painted steel	Painted steel	N/A	N/A	Painted steel	***
Silage tank, capacity (m3):	32-60	32-60	32-60	2x25	2x25	23-40	20-30	2x8	N/A	N/A	50-100	Strongly recommended
Mill tank, capacity, construction:	Integrated in the hull or inserted in aft plattform	Integrated in the hull or inserted in aft plattform	Integrated in the hull or inserted in aft plattform	Integrated in the hull or inserted in aft plattform	Integrated in the hull or inserted in aft plattform	2 m³ stainless steel tank inserted in aft plattform	2 m³ stainless steel tank inserted in aft plattform	2 m³ stainless steel tank inserted in aft plattform			2 m³ stainless steel tank inserted in aft plattform	
Control room + pantry (m²):	53/33,5	53/33,5	73	53/33,5	28	23/13	23/13	23/13	14	8	7	
Living quarters, wardrobe, wc (m²):	45	45	12	45	22	23/8	23/8	23/8	4			
Workshop (m²):	24	24	67	24	18							
Technical room (m²):	36	36	47	36	21	28	28	18	8	4		
Machine room (m²):	36	36	58	36	39	46	30	24	20	16,5	17	
Metallized above water line:	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	
Certified according to:	NS 9415/NYTEK	NS 9415/NYTEK	NS 9415/NYTEK	NS 9415/NYTEK	NS 9415/NYTEK	NS 9415/NYTEK	NS 9415/NYTEK	NS 9415/NYTEK			NS 9415/NYTEK	
Designed according to:	DNV 1A1 Barge R3	DNV 1A1 Barge R3	DNV 1A1 Barge R3	DNV 1A1 Barge R3	DNV 1A1 Barge R3	DNV 1A1 Barge R3	DNV 1A1 Barge R3	DNV 1A1 Barge R3	DNV 1A1 Barge R3	DNV 1A1 Barge R3	DNV 1A1 Barge R3	
Optional equipment:	Please inquire	Please inquire	Please inquire	Please inquire	Please inquire	Please inquire	Please inquire	Please inquire	Please inquire	Please inquire	Please inquire	
Feeding system												
Possible number of feed lines:	4-16	2-12	2-8		2-6	2-6	2-6	2-4	2-4	2-3		
Standard location of selectors:	Side	Side	Side		Side	Bow	Bow	Bow	Bow	Bow		
Air cooling system:	U-profile	U-profile	110mm steel cooling pipes/ U-profile		U-profile	U-profile	U-profile	U-profile	Air-to-air cooler or U-profile	Air-to-air cooler or U-profile		AJ 130 and AJ 150 have also U-profile

*Option to this can be; 2x11,5 silage tanks + 4x11,5 emergency silage tanks with out any facilities, ***Some variations may apply.

Certification guide, construction/anchoring:
The Wavemaster Feed Barges are designed in accordance with DNV 1A1 Barge R3 classification. Steel hull, superstructures and feed silos are manufactured using marine grade mild steel, type NVA or equivalent. All steel construction is performed in accordance with NS470, and all welding is tested by certified NDT (Non Destructive Testing) inspector. The silo modules are constructed with corrugated steel plates in order to get smooth internal surfaces and a high strength to weight ratio (not all models).

High quality on all windows, watertight doors and hatches. Extended bow and aft platforms is available as options. Well proven design and construction, combined with innovation makes Wavemaster Barges reliable, efficient and seaworthy barges. A wide range of models are available at a competitive price.

All barges are constructed according to NS9415:2009 Norwegian standard for floating fish farms. The barges are certified by Noomas.

NOOMAS SERTIFISERING

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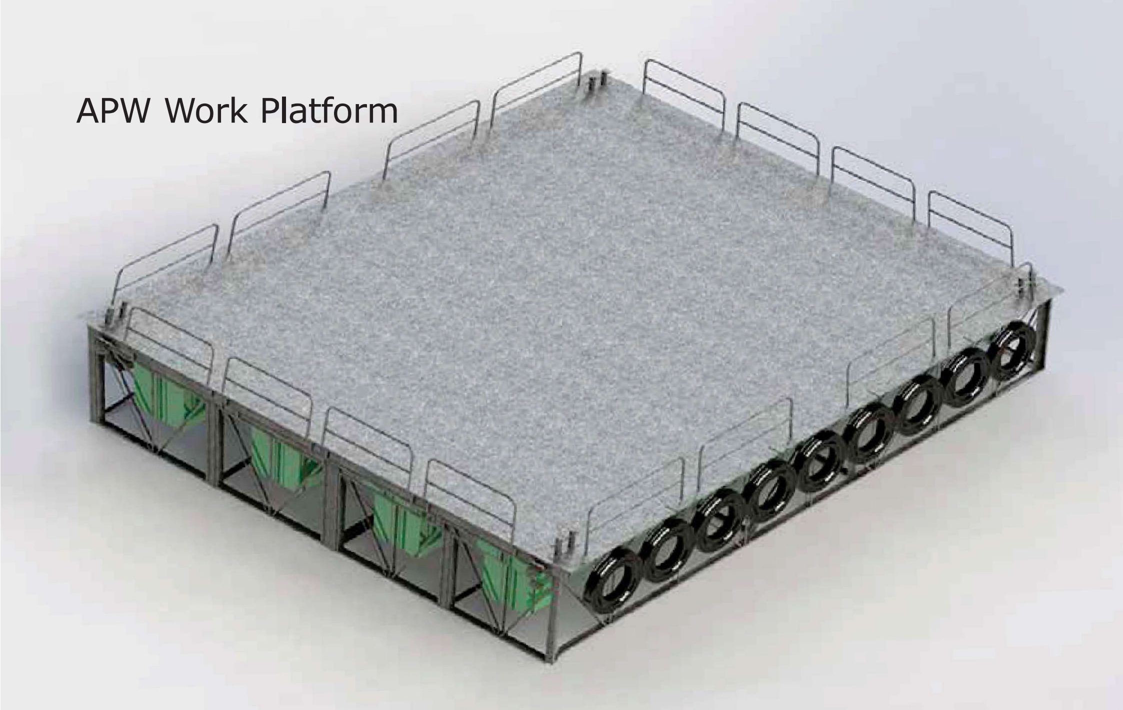
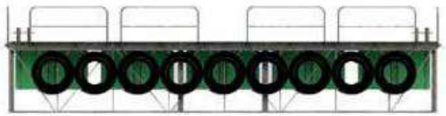
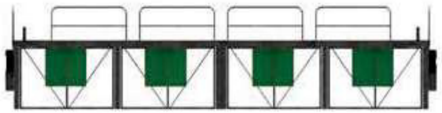
APW Work Platform





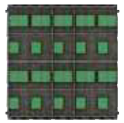
Side view with floats and fendering.



Side view with floats.

Wavemaster Work Platforms

- Load-capacity dimensions calculated according to customer needs.
- Structural strength calculated to withstand a significant wave height (Hs) of up to 2m.
- The modular construction/solution allows for easy containerisation and shipment anywhere in the world.



Float grid below the platform.

Local deck installation

The modules are transported to the locatation in parts and installed by experienced Wavemaster staff.

Flexible deck module sizes

The deck modules can be offered in five different sizes; 6x5m, 8x5m, 10x10m, 20x10m and 30x10m.

Withstands heavy loading

The modules are very stable and have a loading capacity from 6 tonns up to 40 tons on the largest deck model.

AP Platform Feed Barge

Transparent illustration showing silos and feed system. The house modules are flexible and can easily be tailor made for each location.

Wavemaster Platform Feed Barge

- Load-capacity dimensions calculated according to customer needs.
- Structural strength calculated to withstand a significant wave height (Hs) of up to 2m.
- The modular construction/solution allows for easy containerisation and shipment anywhere in the world.
- All Platform Barges include a control room for the feeding process using a CCS Feed System, sensors and cameras.
- Silos with 3 tons capacity are located in the bow.
- Equipped with a chain hoist trolley to lift up the feed to fill the silos. The number of silos per barge can be adjusted.

Tailor made platform barges

Tailor made solutions can be adapted for installation of any equipment that the customer need for the farm operation.

Hot dip galvanized construction

All structural steel components are hot dipped galvanized after manufacture. This has proven to be the most effective and durable coating for use on fish farming structures.

Designed for CCS Feeding System

All modular platforms are designed for integration with the Akvasmart CCS Feed System, from Twin (2) to Hexa (6) parallel feed-line systems.

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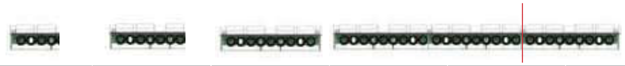
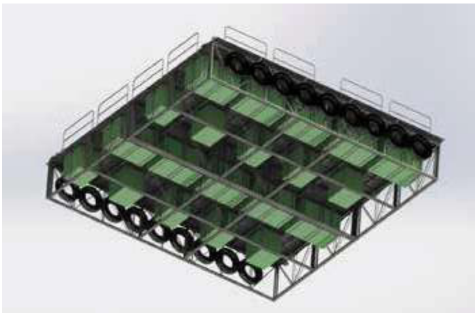
Wavemaster APW Work Platform - Specifications



Deck models:	APW 30	APW 40	APW 100	APW 200	APW 300	Comments
Length - Total (LOA) m:	6	8	10	20	30	
Beam - Total (BOA) m:	5	5	10	10	10	
Deck (m^2):	30	40	100	200	300	
Load capacity:	6 tons	9,7 tons	13 tons	27 tons	40 tons	
Depth to deck (mts):	1,5	1,5	1,5	1,5	1,5	
Freeboard full load, standard:	400mm	400mm	400mm	400mm	400mm	
Floats standard:	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Color on request (styrofoam filled)
Floats Increased Freeboard:	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Colour on request (styrofoam filled)
Handrails:	Optional	Optional	Optional	Optional	Optional	
Mooring points:	4	6	6	10	14	Mooring plate or pipes with flared bottom openings
Fendering:	Yes	Yes	Yes	Yes	Yes	Along sides on request
Deck:	2-3mm stamped plate, 32x5 grating, 4 mm checkered plate	2-3mm stamped plate, 32x5 grating, 4mm checkered plate	2-3mm stamped plate, 32x5 grating, 4mm checkered plate	2-3mm stamped plate, 32x5 grating, 4mm checkered plate	2-3mm stamped plate, 32x5 grating, 4mm checkered plate	
Hot Dipped Galvanizing:	Certified according to ASTM 123	Certified according to ASTM 123	Certified according to ASTM 123	Certified according to ASTM 123	Certified according to ASTM 123	
Duplex System (Galvanizing + Painting):	Available on request	Available on request	Available on request	Available on request	Available on request	
Cathodic protection:	Available on request	Available on request	Available on request	Available on request	Available on request	
Other equipment:	Please inquire	Please inquire	Please inquire	Please inquire	Please inquire	

Rugged and UV stabilized rotational moulded MDPE Floats, filled with expanded Polystyrene foam.



Safety details

All decks and platforms are supplied with all the safety gear required for the country of operation as a minimum. Typical standard / optional safety equipment may include: Safety handrails and non-skid surfaces, life rings with heaving line, boarding ladders, etc.

Design & Construction

All Wavemaster modular decks/platforms are designed/built supervised by professional naval/mechanical engineers. All welders are certified under AWS D1.1/D1.1M ed.2010

Wavemaster AP Platform Feed Barge

Platform models:	AP 50	AP 100	AP 150	AP 200	AP 300	AP 400	Comments
Feed capacity							
Loading capacity:	50 tons	100 tons	150 tons	200 tons	300 tons	400 tons	
Number of silos:	2-4	2-4	2-4	2-4	2-6	2-6	
Barge specifications							
Length - Total (LOA) m:	20	26	33	40	40	50	
Beam - Total (BOA) m:	12	12	12	12	17,5	17,5	
Depth to deck (mts):	1,5	1,5	1,5	1,5	1,5	1,5	
Freeboard full load (Standard Floats):	400mm	400mm	400mm	400mm	400mm	400mm	
Standard Floats:	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Colour on request
Floats increased freeboard:	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Rotational Moulded Polyethylene	Colour on request
Handrails	Optional	Optional	Optional	Optional	Optional	Optional	
Mooring points:	10	10	10	12	12	14	Mooring plate or pipes with flared bottom openings
Fendering:	Yes	Yes	Yes	Yes	Yes	Yes	Sides on request
Flooring:	4mm checkered plate	4mm checkered plate	4mm checkered plate	4mm checkered plate	4mm checkered plate	4mm checkered plate	Others on request
Discharge area (stern,m^2):	24	24	24	24	35	35	
Control Room (m^2)	14	14	14	14	14	14	
Room + Toilets (m^2):	14	14	14	14	14	14	Additional on request
Fuel Tank:	1000 to 4000 lts	1000 to 4000 lts	1000 to 4000 lts	1000 to 4000 lts	1000 to 4000 lts	1000 to 4000 lts	Optional
Hot dipped galvanizing:	Certified according to ASTM 123	Certified according to ASTM 123	Certified according to ASTM 123	Certified according to ASTM 123	Certified according to ASTM 123	Certified according to ASTM 123	
Duplex System (Galvanizing + Painting):	Available on request	Available on request	Available on request	Available on request	Available on request	Available on request	Extra protection for harsh environmments
Cathodic protection:	Available on request	Available on request	Available on request	Available on request	Available on request	Available on request	
Others Equipments:	Please inquire	Please inquire	Please inquire	Please inquire	Please inquire	Please inquire	
Feeding System							
Number of possible feedlines:	2-4	2-4	2-4	2-4	2-6	2-6	
Standard placement of selectors:	Bow	Bow	Bow	Bow	Bow	Bow	
Aircooling System:	Optional	Optional	Optional	Optional	Optional	Optional	

Certification and construction/anchoring:

Wavemaster Modular Decks and Platforms are designed and built supervised by professional naval and mechanical engineers to meet all required regulations. Steel hulls, superstructures and feed silos are manufacturing-certified steel.

All welders are certified under AWS D1.1/D1.1M, and all welding is tested by a certified NDT (Non Destructive Testing) inspector. As a standard all the deck/platform are hot dip galvanised in accordance with ASTM 123.

Feed Systems

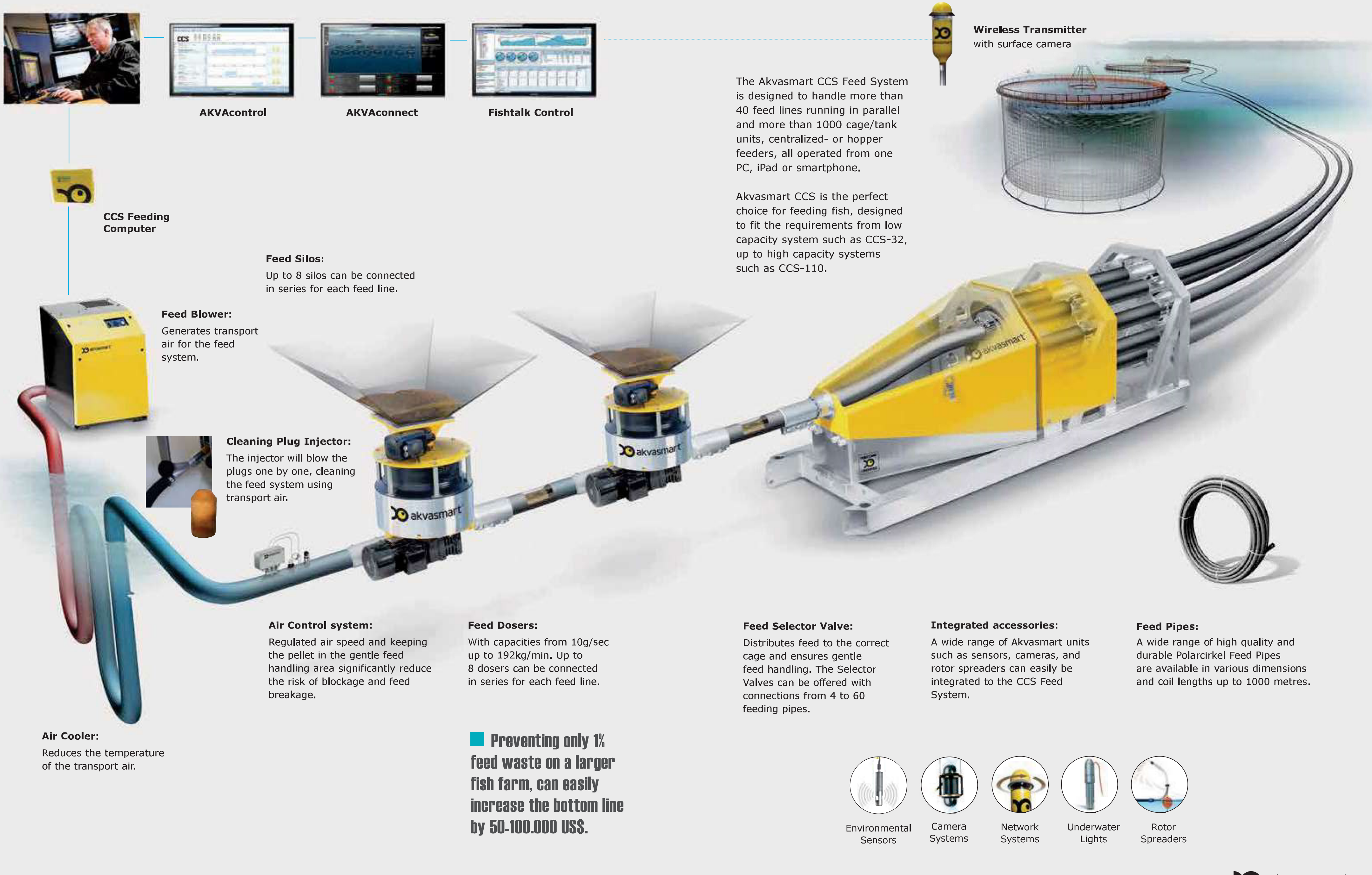
Matches fish appetite

The central feed system concept was invented by AKVA group in 1980 and Akvasmart CCS is today the most popular and reliable feed system world wide. The system is suitable for all species feeding on pellets. It is now also fully integrated with camera control, pellet- and environmental sensors, as well as Fishtalk production control software. All feeding and environmental data is stored in the Fishtalk database. This unique integration allows for full overview and control of all operational activities from farm site to top management level.

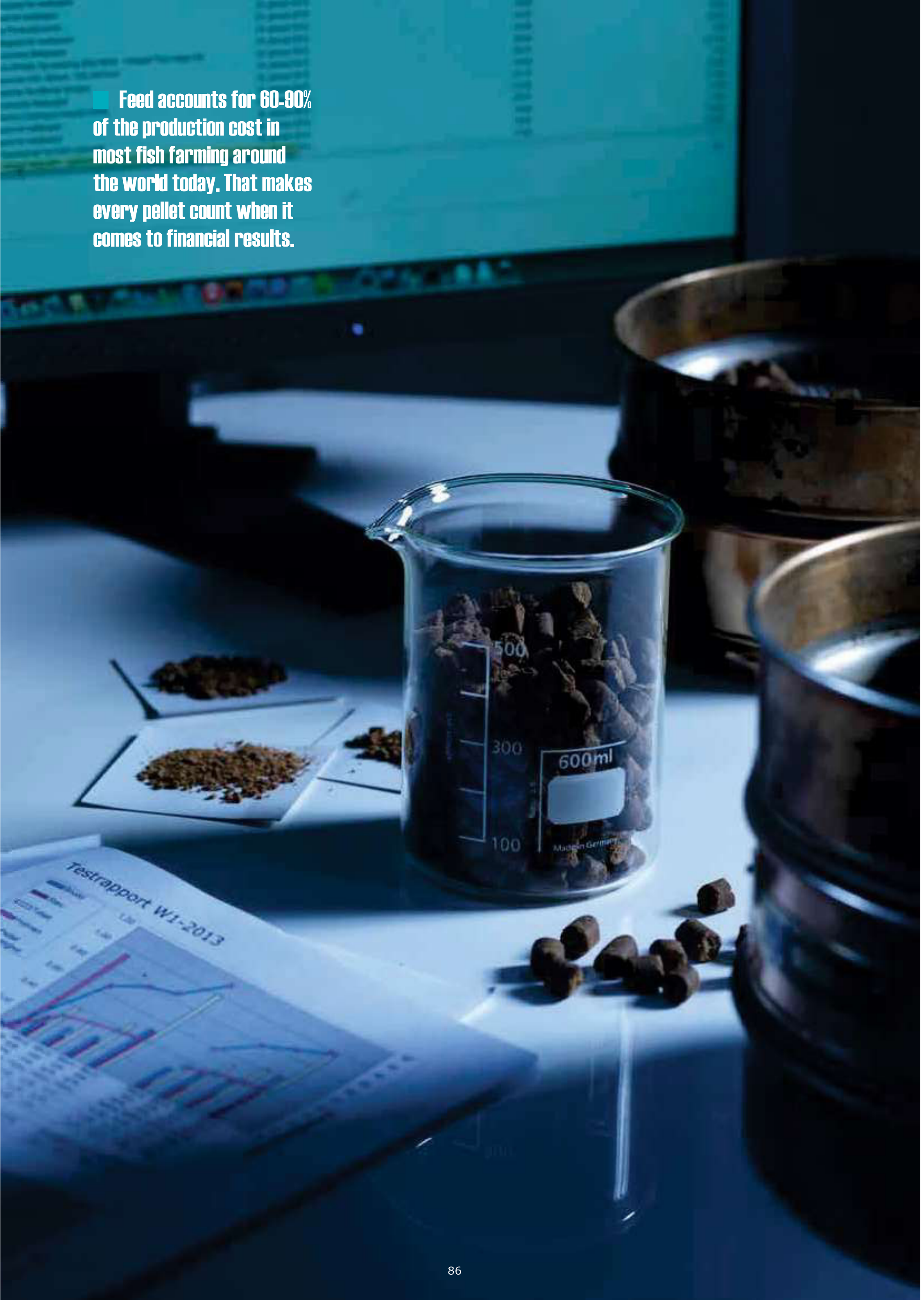
The Akvasmart CCS Feed System will feed the correct amount, at the optimal rate, on time and every time. This powerful system provides great opportunities to optimize the entire feeding process.

AKVAcontrol is the leading edge feed system software, now part of the Fishtalk software family. New functionality includes meal planner, group feeding and adaptive feeding. Combined with data from environmental sensors, this allows for efficient analysis and benchmarking between farm sites.

Akvasmart CCS Feed System



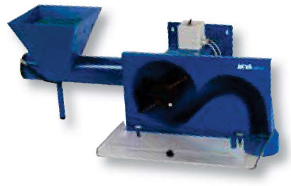
Preventing only 1% feed waste on a larger fish farm, can easily increase the bottom line by 50-100.000 US$.



AKVA group Feed Care

Commercial Scale testing

AKVA group has developed a special feed durability test machine (Doris) that makes it possible for farmers and feed manufacturers to test and document the physical quality of different feed types. We work closely with expereinced feed suppliers to optimize feed handling.

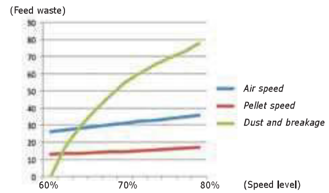


Our patented feed test unit "Doris", is also used by leading fish feed manufacturers and other aquaculture companies.

Video control of the pipes.

Monitoring and regulating the transport air speed is one of the most important factors. "Speed kills" also when it comes to feed systems, and only a 10-20% reduction of transport air speed make a significant reduction in feed dust and pellet breakage. This is where most of the feed dust has been created historically. Using the Air Control System combined with our highly effective (low friction start) Rotor Spreaders allow reduction in air speed while still getting excellent spreading.

Centre of Aquaculture Competence, CAC. The world´s largest full scale test site for salmonidae is owned by Marine Harvest, Skretting and AKVA group.



Graph showing how pellet speed influences dust and breakage.

Preventing up to 3% feed waste

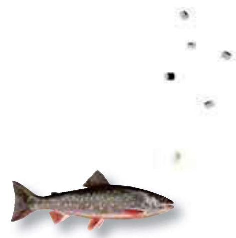
It is quite common for large scale fish farms today to spend 10-20.000 US$ average per day in fish feed. Preventing only 1% feed waste (dust and breakage) can add a total of 50 - 100.000 US$ to the bottom line each year! Consequently, it is critical that your feed system reliably deliver the feed to the fish 100% intact, at the correct rate, exactly the amount the fish wants to eat and with optimal spread.

All feed system equipment is tested by experienced AKVA group technicians to make sure all equipment meet our high standard.

Important elements in the feeding process

- **Feed storage, how to:**
  Fill silo
  Store feed
  Take feed out of silo
- **Pellet transport**
  Pipe work
  Connections
  Adjustment
  Cleaning
- **Air transport**
  Air temperature
  Cooling
  Air speed
  Back pressure
- **Adjustment in control system**
  Feeding speed
  Air speed
- **Feed spreading**
  Type of spreader
  Spreading area
- **General maintenance**
  All equipment

All issues above are down to how to transport the pellet undamaged to the fish!



akvasmart™

Cooled and controlled air flow

Air Blower, Air Cooler and Air Control

Feed Blowers

The blower generates the air pressure to transport the feed to each tank/cage. The combination of air control system and frequency regulated blowers makes it possible to optimize the pellet transportation. The air speed can be adjusted to optimize both feed spread and gentle feed handling. The blowers are delivered in high quality silencer cabinets which ensures a comfortable work environment.

AKVAconnect provides detailed feeding data from the silos to the cages/tanks.

The feed enters the air flow through the Doser Valves and is then blown through seamless stainless pipes and up to the Selector Valves.

Sound protected machine room with Feed Blowers and generators.

Inspection of a Feed Blower installation, noice cabinets with easy access.

Air Coolers

Depending on the transport distance and ambient temperature, many feed types and feed systems will benefit from installing air cooling systems.

Too high temperature may cause lipids to be released from the pellets and even proteins to be denaturated. This will lower the nutritional value of the feed.

If the lipids are released from the feed during transportation this will increase the risk of pipes being blocked hence increasing the need for pipe cleaning.

Feed blowers and air coolers come in a variety of models.

The cooling pipes are integrated in the hull construction on most of our Feed Barges.

AKVAconnect process control offers special alarm functions for air control (speed, temperature and back-pressure).

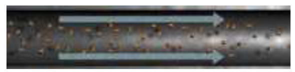
Air Control System

Akvasmart Air Control System with regulated air speed ensures optimal pellet flow, significantly reducing the risk of blockage and breakage. If the pellet/air speed is too low, the risk for pellet blockage is increased. If the pellet/air speed is too high, dust and breakage is increased. The system also monitors and logs air speed, back-pressure and temperature.

The Air Control unit is installed between the Air Cooler and Feed Doser Valve.

The Air Control system is visualized in AKVAconnect through a simple graph per feeding line. The graph displays real-time data for each unit being fed.

Too low pellet speed.



Optimal pellet speed.

Too high pellet speed.

From silo to fish - A critical part of the feed transport

Feed silos and Feed Doser Valves

Feed Doser Valves

A custom Feed Doser Valve is used to transfer the feed into the air flow. As this is a critical part of any feed system, it is important that only FEED CARE OPTIMIZED equipment is used. In order to meet all our customer's needs, we can offer both Feed Doser Valves and Feed Augers with Sluice Valves for this purpose. The CCS Feed Doser Valves are designed in two main models. Vari Doser 1500" and Feed Doser 4000".

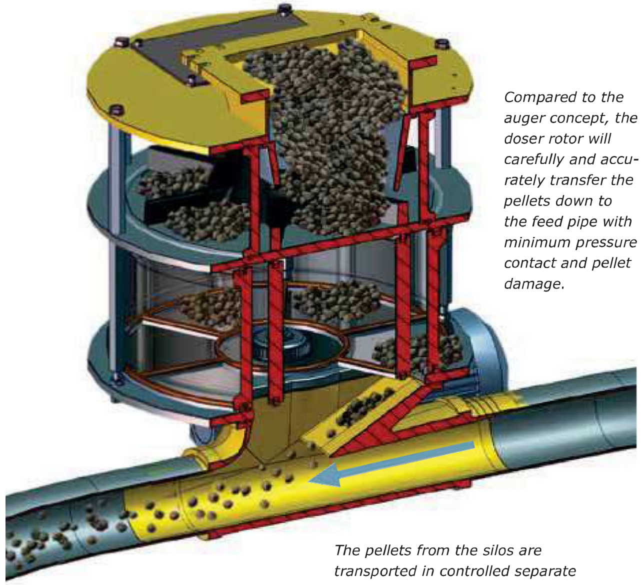
The Akvasmart Feed Doser Valves have capacities from 10g/sec. up to 192kg/min.

Silo Systems

A wide range of different feed tank solutions and sizes can be delivered to suit any requirements. We can deliver square or round silos in both aluminum and steel. Contact our sales department for more details and specifications.

Feed silos can be delivered in wide range of types, shapes and sizes.

A smart silo outlet gate, made from galvanized steel, can easily be installed at the doser top in between the silo flange and feed doser valve.



Compared to the auger concept, the doser rotor will carefully and accurately transfer the pellets down to the feed pipe with minimum pressure contact and pellet damage.

The pellets from the silos are transported in controlled separate doses to the feeding pipe below and then blown to each cage.

Service and cleaning of the feed doser can easily be done in 30 minutes. See more details in our CCS user manual.

Feed Doser:	VariDoser Start	VariDoser	Doser 4000
Min. feed rate (g/sec):	30	100	200
Min. feed rate (g/sec) - pulse:	15	75	150
Max feed rate (g/sec):	400	1250	2500
Material:	Polyethylene (PE) / Cast iron/ Stainless steel		
Weight:	75kgs	75kgs	95kgs

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The leading feed concept since 1980

Feed Selectors

Feed Selector Valve

The Feed Selector Valves disttributes the feed to the correct cage and is the connection point for the PE feeding pipes. The pipes are exposed to the full forces of the ocean, and consequently we have designed a very rugged strain relief bracket that can handle the expected loads. Our product line includes a wide variety of Selector Valve models with connections from 4 to 60 feeding pipes (depending on model).

The CCS system is designed to withstand the extreme forces of weather and salt corrosion.

Feed Selectors can easily be installed at the front or the side of the barge.

A new improved construction makes the Feed Selectors easier to open, clean and maintain.

Pipe length up to 1400m.

Pellet sizes from 1.2mm up to 25mm+.

Materials; aluminium, galvanized and stainless steel.

The new Wavemaster AC650 Feed Barge has 12 silos and 6 Feed Selector Valves.

Feed Selector	CCS32	CCS63	CCS90	CCS110
PE pipe dimension:	32mm (1")	63mm (2")	90mm (3")	110mm (4")
Max pellet size:	5-7mm	9-12mm	25mm (1")*	25mm+ (1")*
Outlets:	32-60	24-32	4, 10 or 24	4 or 8
Materials:	Stainless Steel/ Aluminum	Stainless Steel/ Aluminum	Stainless Steel/ Aluminum	Stainless Steel/ Aluminum
Weight:	45-55kg*	45-55kg*	50-65kg*	50-65kg*

* Depending on model/ex. pipe restrainer

akvasmart™

AKVA basic Feeding System

A complete, portable feed system in one small compact unit, provides better feed control and growth

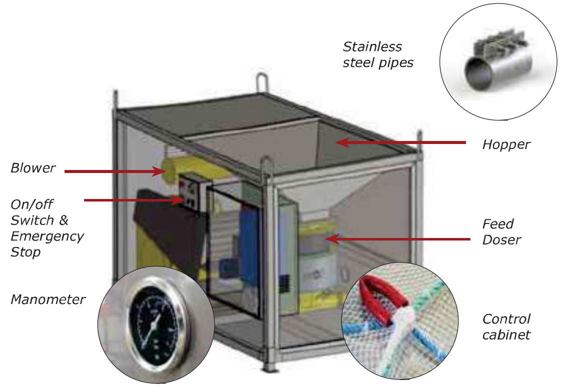
A compact solution for smaller locations

A user friendly and affordable feed system

Semi-automatic feeding system for fish farming. The centralized Feeding system AKVA basic has been specially designed for use in all types of farms due to its versatility in installation, easy operation and maintenance. During feeding, the feed pipe is manually operated by a single person, in communication with a AKVA basic operator in order to coordinate on and off times.

By opening/closing several guillotines strategically located on the system we are able to select the cage to be fed.

The AKVA basic is loaded manually with 20-25 kg feed bags, has a standard capacity of 125 kilos. Silos with extended capacity are available upon request.



The new feeding unit is made of a stainless steel case containing an Akvasmart blower, doser and control cabinet, which makes the AKVA basic a durable and reliable equipment.

Easy installation, operation and low maintenance makes AKVA basic an ideal and reliable equipment on smaller locations or isolated farms.

AKVA basic feed system							Comments
Equipment:	Silo capacity	Feeding pipe	Frequency inverter	Air Cooler	Selector Valve	CCS Control	
Standard *	125kg	90mm	-	-	-	-	Engine and Blower always works at 100% of capacity.
Upgrade 1	300kg	90mm	-	-	-	-	Increase silos feed capacities.
Upgrade 2	125kg	63-110mm	-	-	-	-	Based on client needs.
Upgrade 3	125kg	90mm	yes	-	-	-	Accurate control of air lines speed and feed calibration.
Upgrade 4	125kg	90mm	-	yes	--	--	Reduces temperature in the air line.
Upgrade 5	125kg	90mm	-	-	yes	-	Equiped with manual control for the Selector Valve. Rotor Spreader can be install in each cage.
Upgrade 6	125kg	90mm	yes	-	yes	yes	Centralizes all parts of the system in one computer.

** The **AKVA basic** standard model´s size is 2x1x1m, manual operation and is equippet with; 22kW Blower, 4000 Doser, On/off Switch, Timer, Manometer and Emergency Stop.*

***AKVA compact** system is larger with 20´- 40´containers, CCS Control and automatic operation.*

akvasmart™

Rotor Spreaders

Faster and even growth from excellent feed spread

Rugged and userfriendly

The unique Rotor Spreader is designed to provide excellent feed spread in cages. All our models have adjustable light weight aluminium rotor pipes that allow for lower air speed for start-up and rotation. This means less dust and breakage, power consumption, back pressure, air temperature, noise and wear and tear on the feed pipes.

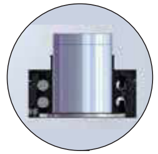
The Rotor Spreaders are designed for all types of cages. More than 7500 units are delivered world wide.

Our unique ventilated Zenon bearing requires no regular cleaning and does not corrode. Due to its light displacement and low point of gravity vs. centre of buoyancy, the Rotor Spreader is very stable in rough seas.

Strong feed pipe connection floating on the surface minimizes mechanical loads compared to submerged connectors.

The Rotor Spreaders are easy to install and simple to maintain.

The new twistable rotor tips are less curved and ensures more gentle feed care.



The new ventilated bearing has extra low friction and requires no regular cleaning and does not corrode!

Rotor Spreader designed for tanks, with 32mm or 63mm feed pipe.

A light weight but strong construction ensures reliable performance in rough water.

A heavy keel weight in galvanized steel is keeping the Rotor Spreader stable in rough seas.

Rotor Spreader	RS-63C	RS-90C	RS-110C
PE pipe dimension:	63mm (2")	90mm (3")	110mm (4")
Max pellet size:	12mm (1/2") *	25mm (1") *	25mm+ (1") *
Recommended RPM:	50-100 *	50-100*	50-100 *
Spread diameter (adjustable):	Approx. 4-12m Ø * Approx. 12-40' Ø *	Approx. 5-18m Ø * Approx. 16-60' *	Approx. 5-18m Ø * Approx. 16-60' *
Materials:	Stainless Steel/Alum. Rotor/POM (Delrin) Polyform buoy	Stainless Steel/Alum. Rotor/POM (Delrin) Polyform buoy	Stainless Steel/Alum. Rotor/POM (Delrin) Polyform buoy
Height above water:	1,2m (4')	1,2m (4')	1,4m (4'6")
Draft:	1,8m (6')	1,8m (6')	1,8m (6')
Total weight:	Approx. 30kg (66 lbs.)	33kg (73 lbs.)	38kg (84 lbs.)

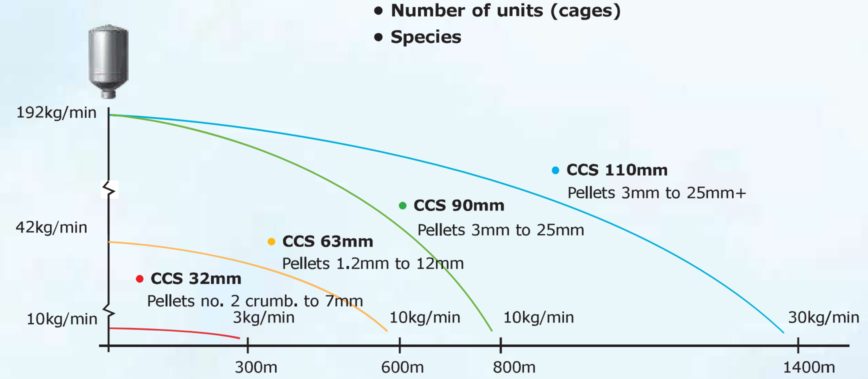
* Depending on feed system and feed type

Feed System capacities and transport lengths

The Akvasmart CCS Feed System is designed to fulfill all feeding requirements, regardless of species or how you want to feed your fish.

The configuration of the system is based on the following factors:

- **Transport lengths**
- **Biomass (feed amount)**
- **Number of units (cages)**
- **Species**



* The capacity of the feed system depends on the technical quality of the pellet, the feeding regime as well as the length of the feed pipe.

Feed System Specifications

System		CCS-32	CCS-63	CCS-90	CCS-110	Comments
Feeding pipe size:	OD (mm)	32 (1")	63 (2")	90 (3")	110 (4")	Imperial (North America)
Wall thickness:	(mm)	2,9 (0,11")	4 (0,16")	7 (0,28")	6,3 (0,25")	
Feeding data (for each feed line):						
Pellet sizes: */**	Max.(mm)	5 - 7	9 - 12	17 - 25	25+	
	Min.(mm)	No.2 crumb.	1,2	3	3	This must be evaluated in each specific case.
Max. feeding capacity: */**/***	kg/hour	648	2 520	5 220	5 220	with "VariDoser 1500"
		–	–	11 520	11 520	with "FeedDoser 4000"
Max. feeding rate: */**/***	kg/min.	10,8	42,0	87,0	87,0	with "VariDoser 1500"
		–	–	192	192	with "FeedDoser 4000"
Min. feeding rate: */**/***	kg/min.	1,2	2,4	3,0	3,0	
Min. feed dose (single dose) */**	grams	10	20	40	50	with "VariDoser 1500"
		–	–	200	200	with "FeedDoser 4000"
Transport lengths:						
Max. feed pipe length:	m	300	600	800	1400	*/**
Max. feeding rate at max. feeding pipe length:	kg/min.	3,6	12	36	30	***
Max. feeding rate at half of max. feeding pipe length:	kg/min.	5,4	21	108	150	***
Max. feeding rate at short feeding pipe length */**	kg/min.	10,8	42,0	87,0	87,0	with "VariDoser 1500"
		–	–	192	192	with "FeedDoser 4000"
Power consumption (max):						
Feed Blower:	kW	7,5	15 - 18,5	22 - 30	45	
FeedSelector Valve:	kW	0,18	0,18	0,18	0,18	
Feeder: FeedDoser/ VariDoser:	kW	0,37 0,37	0,75 0,75			Max. load/unit
Feeder: Auger & Sluice Valve:	kW	1,5	1,5	1,5	1,5	

* Depending on actual transport distance ** Depending on type of feed, technical feed quality, pellet size, feed rates and system settings
*** At continuous feeding **** Depending on actual feeding pipe length

Control Cabinet	Standard 400VAC 50Hz	Comments
Power consumption:	From 8kW to 185kW	Single CCS 32 to Quatro CCS 110
Size:	2100mm x 1200mm x 500mm	HxWxD - in mm
Weight:	From 120kg to 400kg	Single CCS 32 to Quatro CCS 110

PE Feeding pipes	Dimensions				
	OD	ID	Wall thickness	SDR**	Weight/m
32mm	32mm	26,2mm	2,9mm	11	280g/m
63mm	63mm	55mm	4mm	15,75	750g/m
*75mm**	*75mm*	*66,4mm*	*4,3mm*	*17,6*	*980g/m*
*90mm**	*90mm*	*79,8mm*	*5,1mm*	*17,6*	*1390g/m*
90mm	90mm	76mm	7mm	12,8	1900g/m
110mm	110mm	97,4mm	6,3mm	17,6	2090g/m

** Not standard dimensions for Akvasmart CCS Feed System. ** SDR = Outer diameter (OD) / Wall thickness.*

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CCS Feedsystem Software

Correct amount of feed, always served on time

AKVAcontrol is a powerful and advanced software for daily control of all your feeding processes. Combined with Akvasmart CCS Feed System, it is the most adaptable and user friendly system on the market. AKVAcontrol is developed over the last 30 years in close cooperation with fish farmers all over the world. This has resulted in full integration with camera systems, pellet- and environmental sensors.

AKVAcontrol software combined with the new AKVAconnect process platform provides full overview and control.

Biological approach

The only feed system software with biomass regulated feeding regimes based on accurate monitoring of fish appetite and environmental data.

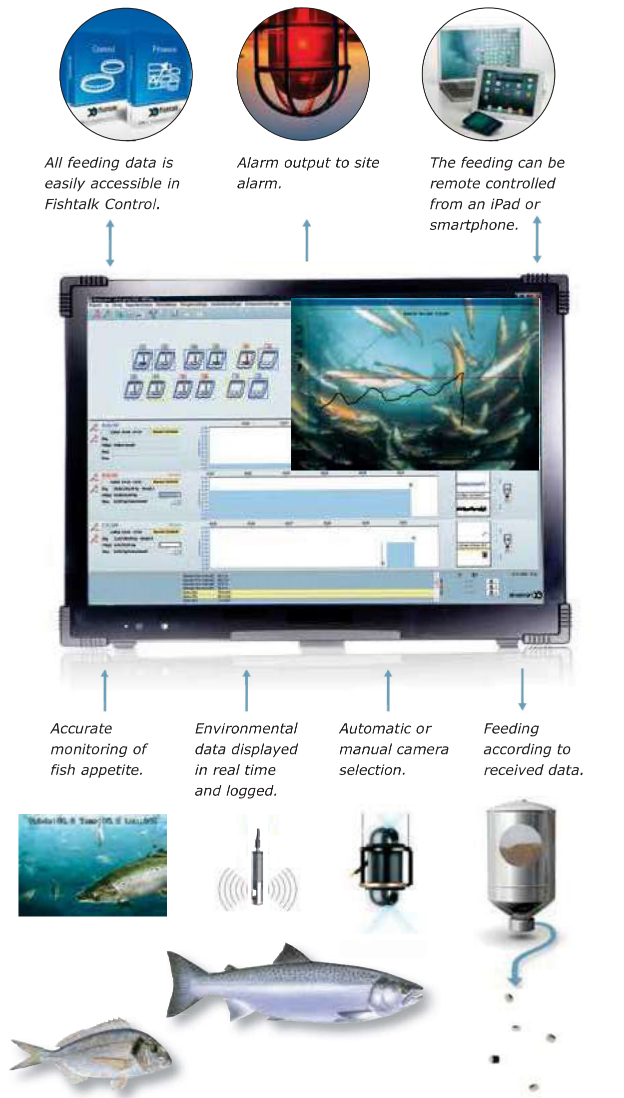
Environmental sensor data

Oxygen-, temperature- and current sensors are fully integrated in AKVAcontrol. All sensor data are displayed in real time and logged for further analysis. This allows for optimal feeding at all times.

Fishtalk software integration

All data generated in AKVAcontrol is accessible in Fishtalk Control, providing end-to-end production overview, control, analysis, benchmarking and reporting.

The most adaptable and user friendly feeding system on the market.



Key functionality:

- Full farm overview at a glance
- System capacity planning
- Advanced meal planning
- Multiple group feeding regimes
- Hopper control
- Integrated feeding camera control
- Accurate Air Control System
- Wizards
- Powerful reporting and analysis tools.

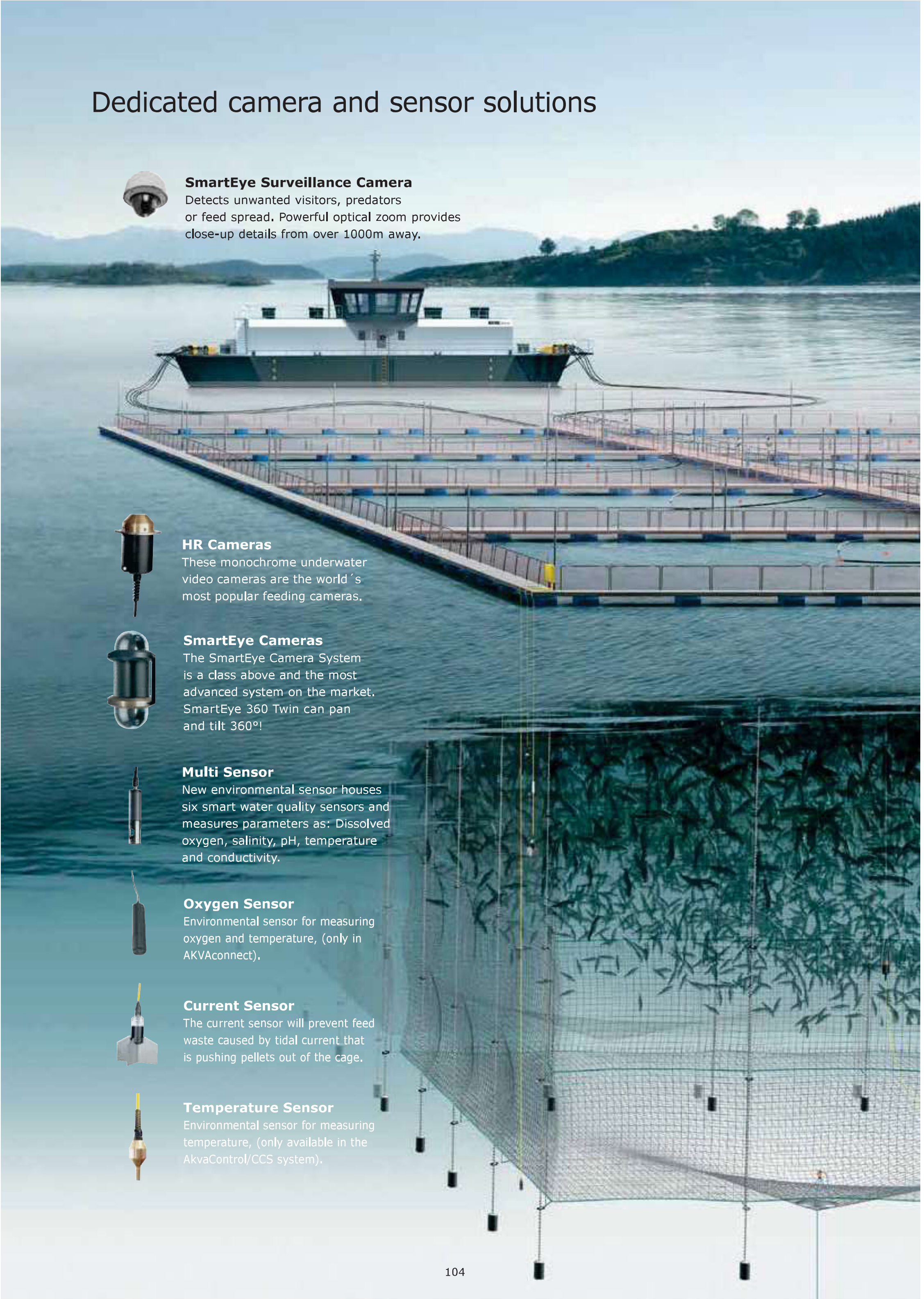
akvasmart™

Camera and Sensor Systems

Full overview, complete control

Akvasmart's advanced video camera and sensor systems monitor both the fish and the feeding process. This ensures optimum operations and a healthy environment for the fish.

Flexible camera solutions, like monochrome feeding cameras or winch controlled pan & tilt 360° Twin colour cameras, provides crystal clear pictures. Wireless transmission of surface and underwater video images, feeding- and environmental data to the farm base.



Dedicated camera and sensor solutions

SmartEye Surveillance Camera
Detects unwanted visitors, predators or feed spread. Powerful optical zoom provides close-up details from over 1000m away.

HR Cameras
These monochrome underwater video cameras are the world´s most popular feeding cameras.

SmartEye Cameras
The SmartEye Camera System is a class above and the most advanced system on the market. SmartEye 360 Twin can pan and tilt 360°!

Multi Sensor
New environmental sensor houses six smart water quality sensors and measures parameters as: Dissolved oxygen, salinity, pH, temperature and conductivity.

Oxygen Sensor
Environmental sensor for measuring oxygen and temperature, (only in AKVAconnect).

Current Sensor
The current sensor will prevent feed waste caused by tidal current that is pushing pellets out of the cage.

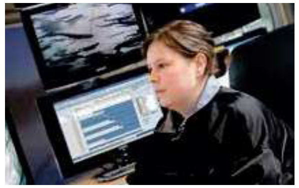
Temperature Sensor
Environmental sensor for measuring temperature, (only available in the AkvaControl/CCS system).

Underwater- and surface cameras

Akvasmart cameras have been produced for more than 20 years. Based on this experience AKVA group has a wide product range of cameras from basic fixed monochrome and dual pan/tilt colours to surveillance cameras tailored for aquaculture.

Akvasmart Cameras can be used to monitor:

- **Underwater feeding activity**
- **Surface feeding activity**
- **Fish maturation**
- **Fish behaviour**
- **Morts at the cage bottom**
- **Fish parasites (i.e. sea lice)**
- **General surveillance**



Akvasmart cameras provides perfect overview and ensures fast and accurate camera control.

The video camera looks straight up towards the surface during the feeding in order to see uneaten pellets.

An important part of the sensor and cameras is the infrastructure that transmits the signals/video from cage to office. In the Akva-smart system there are several possibilities either wireless or with cable.

Akvasmart cameras can monitor fish surface activity and feed spread, even in poor light conditions.

Environmental Sensors

Environmental sensor data is becoming an important factor in fish farming, to know the environment will always improve your production.

Every pellet counts

Feed accounts for 60-90% of the production cost in most fish farming today. That makes every pellet count when it comes to financial results.

The first parameter measured is temperature - to know the water temperature help to feed the fish correctly. The second parameter is oxygen, an important parameter helping to decide when to feed. The system will stop the feeding at low oxygen levels in the water. The third parameter is current. When the current speed exceeds the limit, the feeding temporarily stops in the cages and resumes at slack current later. All other cages will be fed as scheduled.

Using environmental sensors combined with AKVAconnect will monitor and control secure the stability in your system.

Full control of the environmental data will ensure correct farming decisions.

There are increasing numbers of parameters that help the fish farmer to understand the environmental con-ditions in the cage and how it effects the biomass. This knowledge is highly important in industrial fish farming.

The current sensor system will prevent feed waste caused by tidal current pushing pellets out of the cage.

Full overview ensures safer environment

akvasmart™

SmartEye Twin 360 Camera System


SmartEye 360 Twin with 2 cameras


SmartEye 360 Twin

Top of the line - feeding and inspection cameras

The SmartEye Twin 360 Camera System is a class above and without doubt the best system of it´s kind on the market. It is an advanced feeding and inspection colour camera with unique features that can be operated from the cage, a work boat, the feeding control room and via the internet. It provides sharp, colour and/or monochrome video underwater images.


Exceptionally sharp and clear video images in full colour provides useful information about your fish.

Standard configuration includes upper camera and lower camera in high resolution colour, but monochrome is used to get very high light sensitivity for looking down into deep and dark cages. Both cameras are syncronized for full 360° vertical movement using one joystick. No external moving parts will reduce the risk of leaks.

Combined with the dual Smart-Winch system, SmartEye 360 Twin provides a great insight into the feeding response and condition of your fish. It is a highly reliable camera that is connected to the base via our new CAP wireless video transmitter. SmartEye 360 Twin is also available with built-in depth- and temperature sensor.

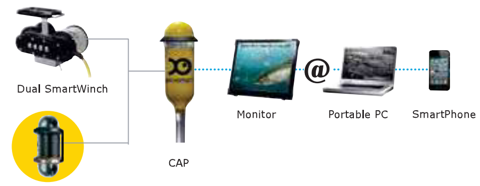
Unique camera features - a class above!

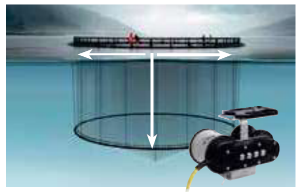

Robust and waterproof connection cable.

Advanced upper colour video camera and a high light sensitive monochrome underwater camera.


Synchronized endless 360° pan and tilt.


Fast and accurate camera and winch control using a PC, iPad or smartphone.




A flexible dual SmartWinch allows easy and accurate vertical and horizontal positioning inside the cages.


Cameras, cables and connection plugs are pressure tested down to 40m to ensure that the equipment is 100% pressure proof.

akvasmart™

Crystal clear first choice feeding cameras

Basic HR Feeding Camera

Super HR Feeding Camera

HR Feeding Cameras

The Akvasmart HR cameras are the world's most popular feeding camera series. These are stationary cameras hanging below the fish' eating area (typically 5-8m) aiming straight up to detect uneaten pellets sinking towards the camera.

All of our cameras can be used with Akvasmart hardwired or wireless camera systems and can be operated from the cage, a workboat, feeding control room or via the Internet. One camera is usually permanently installed in each cage.

Basic HR Camera

The Basic HR Feeding Camera is a simple, reliable and affordable monochrome camera and a smart choice if you need effective feeding control in cage.

Super HR provides exceptionally sharp and crystal clear video images, even during poor light and visibility conditions.

Super HR Camera

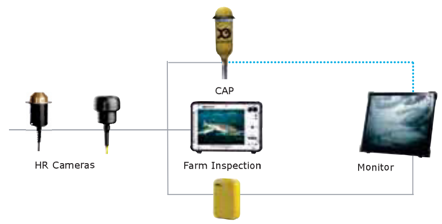
The Super HR Feeding Camera is a rugged and reliable high-resolution monochrome camera designed for use under all conditions.

A flexible, popular and affordable camera solution!

Robust and reliable suspension bridle.

The camera is built into the non-fouling bronze top of the Super HR housing.

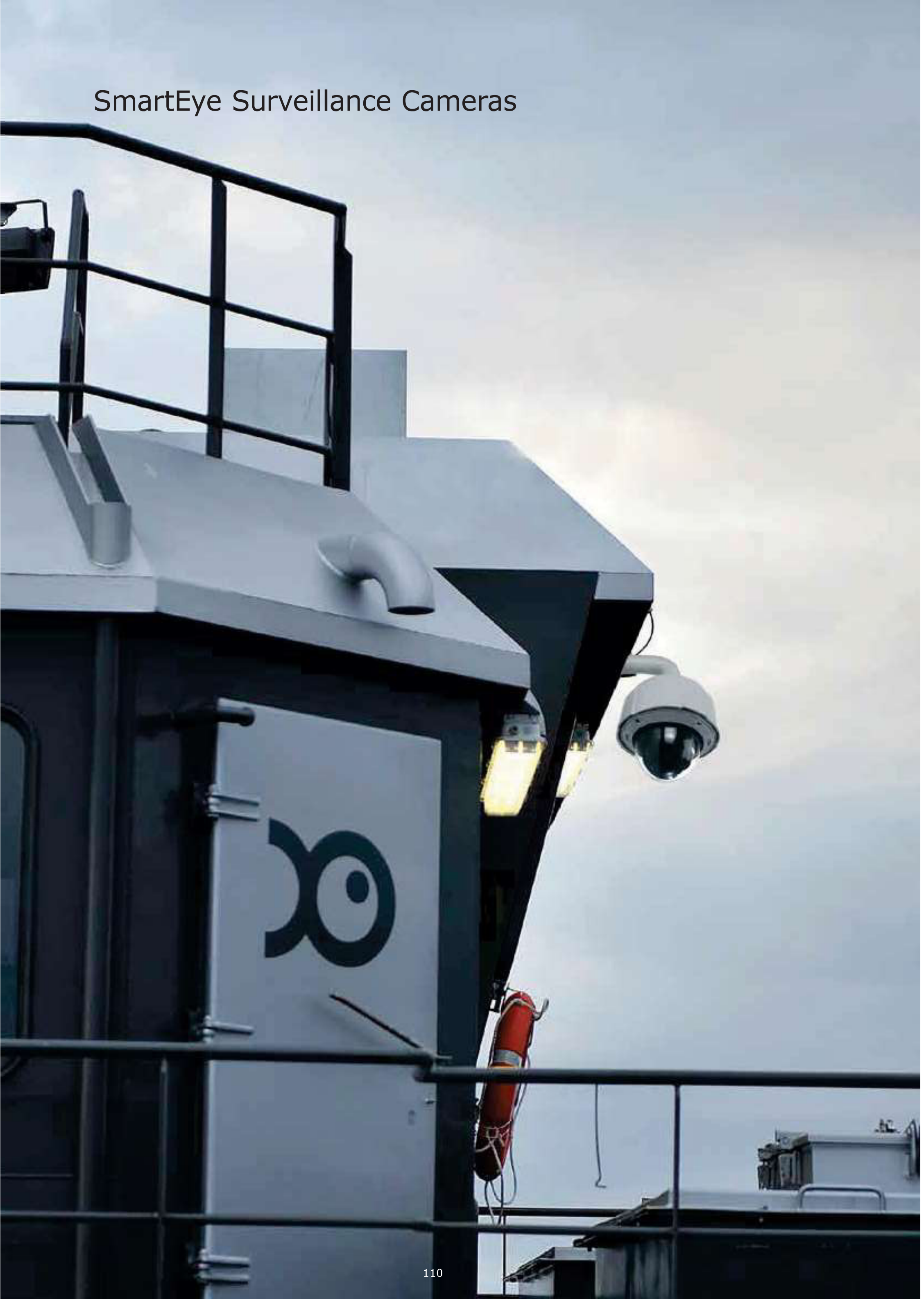
Robust urethane underwater cable includes a waterproof connection plug.



Looking straight up towards the bright surface makes it easy to spot uneaten pellets.

Up to three HR cameras works with the advanced wireless CAP transmitters. These also include built-in surface cameras.

SmartEye Surveillance Cameras



Complete overview of your barge and sites

A range of SmartEye Surveillance cameras provide better control over unwanted visitors, predators, feed spread or simply added safety when working alone at the farm.

These are advanced IP cameras with powerful 24x optical zoom, clear pictures and smart functionality, which can easily be operated from the cage, workboat, control room or via Internet.

Smarteye Surveillance cameras have full color but they will switch to monochrome under low light conditions.

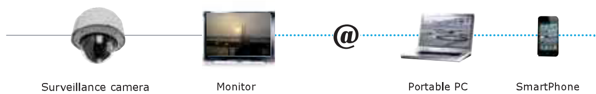
Surveillance cameras provides added safety when working alone on the feed barge.

Surveillance cameras can monitor the deck, machine room, feeding system or other vital areas on the barge.

The camera can pan 360°, and tilt 90°.

Surveillance camera with 90° to 10° zoom (24x optical).

Detects predators and unwanted visitors and increase safety when working alone on site.



Camera Specifications

Cameras	SmartEye 360 Twin		360 Twin with 2 cameras	Super HR	Basic HR	Surveillance		
Colour:	Upper: Colour	Lower: Mono.	Upper/Lower: Colour	Monochrome	Monochrome	Colour	Colour	Colour
Type:	Analog	Analog	Analog	Analog	Analog	IP	IP	IP
Resolution:	480 TVL	570 TVL	650 TVL	600 TVL	600 TVL	HD 720p	HD 720p	HD 720p
Angle of view:	Fix: 60	Fix: 70	Fix: 72	Fix: 72	Fix: 72	52°-4,4° optical	Fix: 84° dig. zoom	Fix: 84° dig. zoom
Cable:	75m (246')* PUR	75m (246')* PUR	30, 50, 75m (99, 165, 246') PUR	30m to 100m (99-328') PUR	30 to 100m (99-328') PUR	> 100m (>328')	> 100m (>328')	> 100m (>328')
Depth rating:	75m (246')*	75m (246')*	75m (246')*	100m (323')*	100m (323')*	Outdoor IP 54	Outdoor IP 54	Outdoor IP 52
Power:	12V DC	12V DC	12V DC	12V DC	12V DC	PoE	PoE	PoE

* Limited by cable

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Fish Farm Inspection System

- rugged, portable feeding control

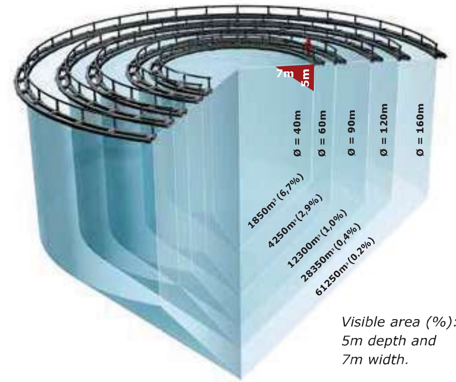
The Fish Farm Inspection System gives crystal clear video images from the submerged camera during feeding, and therefore provides a unique possibility to feed according to the fish appetite. The built-in battery gives the flexibility to use the system without any other infrastructure and the ruggedized system is built into a PELI-case.

Accurate fingertip control provides full overview of the cage in a few seconds, a smart and userfriendly solution.

The new inspection system can easily be connected to Akvasmart cameras such as; SmartEye 360 Twin, Basic- HR and SuperHR. There is also an integrated Pan/ Tilt controller for the SmartEye 360 Twin Camera.

LCD screen made for rough, daily use and provides excellent readability in all light conditions.

A rugged, portable unit with internal battery and waterproof connection plugs.

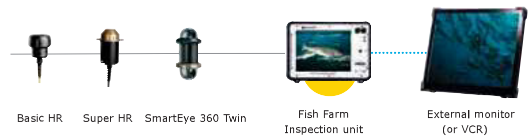


Visible area (%): 5m depth and 7m width.

Why use a camera to monitor feeding?

Cage sizes have rapidly increased over the last 20 years, and as a result, the visible area has decreased accordingly. In a cage of 160m circumference, only 0,2% is visible from the surface. Therefore a submersible camera is a requirement for monitoring and controlling feeding.

The Inspection System is tailor made for control of feeding and fish behavior, and can easily be connected to Akvasmart cameras like SmartEye, Super HR and Basic HR.



Fish Farm Inspection System	
Power supply:	230v AC
Power supply: (optional external battery)	12V DC
Power consumption:	30W * 230v AC - 400mA 12v DC - 2,75A
Internal battery capacity:	13Ah/12v DC 3 - 6 hours *
Sizes: (length/width/height - weight)	470mm x 350mm x 180mm - 10kg (18,3" x 14,3" x 7" - 22 lbs)
Ingress Protection. Lid closed:	IP68
Lid open:	IP65

* Depending on connected equipment

Environmental data - a critical feeding parameter

To know the environmental data such as temperature, oxygen, salinity, pH and current speed and direction is important when feeding fish. Akvasmart Feeding Software allows full control of the environmental status on the site, at all times. The data can be viewed real-time or logged for later analysis. The Akvasmart software can also be set to automatically control the feeding based on these parameters.

Temperature – the foundation for all feeding regimes and growth models.

There can be high temperature differences in different water layers. It is therefore important to know the exact temperature in the depth where the fish are eating.

Temperature measurements are done in our oxygen and multi-parameter sensors and in the Akvasmart Temperature Sensor. These sensors are reliable and robust and can be submerged at the desired depth.

The new compact Multi Sensor has 6 different functions and 12 parameters including temperature and oxygen control.

Accurate real time readings are displayed and logged in the control software and AkvaControl will calculate the expected daily feed amount based on feed tables with these temperature data.

Oxygen data – an important factor for growth and fish welfare.

Oxygen measurements are done with our different oxygen and multi parameter sensors and will also be logged and displayed in the control system.

Environmental current knowledge will help you to prevent feed waste.

Water flow or current is an important parameter when it comes to feed waste. To feed when it´s to high a current will lead to feed waste and uneaten pellets.

AKVA group offer two types of current sensors. The Tilt sensor measures only one current value while the Doppler measures current speed and direction at three different depths.

Environmental sensors are a smart investment that will ensure efficient feeding.

AOS OxyBox – stand alone system for oxygen and current measurements

It´s a flexible system that's self powered from battery and communicate via Internet. Communication is standard via Iridium (satellite). All information from the AOS Oxy Box are presented on a WEB page that makes it easy to access and evaluate.

AOS OxyBox - a complete stand alone system for measuring oxygen and current.

AOS oxygen data outside (blue) and inside (red) the cage. (mg/l)

AOS Sensor Buoy Current is a virtually maintenance free satellite based system for measuring real time current from 3 depths.

Correct feeding is always the key to achieving good farming results. The Doppler Pellet Sensor allows the fish to be fed to satiation automatically.

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AOS Sensors - online sensor data worldwide

AOS Sensor Buoy Current

You can simply receive oxygen-current,- temperature-, and salinity data from all your farms and locations from a WEB-site, using an AOS online system with internet connection. The main part of AOS is a receiver of sensor data that transmit the data further to a sentral server, using an international satellite network called Iridium. The network is available almost in every corner of the world without using any local network suppliers. You will get access to the server with your own username and password and can enter and check your status whenever and wherever you want.

AOS is logging and saving data for export to Excel and eventually local saving and later analyzis.

AOS Sensor Buoy Current are equipped with a yellow coloured top, a warning light and a reflex tape to ensure better visibility.

Current data is a very important factor for correct feeding and various operations like debugging, sorting, retrieval and delivering of fish etc.

The blue line is showing current speed (m/sec) and the red dots are showing current direction on a selected depth the last 5 days.

The system is driven by a built-in battery with approx. 3 - 4 months duration.

The AOS buoy is made of Polyehylene (PE), has no moveable parts and is therefore virtually maintenance free.

The Sensor Buoy messure current speed and current direction from three different depths, (5, 10 og 15 meters) below the buoy. We are usings the most avanced doppler technology to ensure accurate data supply.

AOS Doppler Current Sensor unit

The AOS Sensor Buoy Current is moored two diameter lenghts away from the location to avoid impact from the cages.

The AOS OxyBox can messure oxygen and temperature from up to 3 sensors. See more data on next page.

AOS Sensor Buoy Current	
Dimensions	
Height:	250cm
Diameter buoy:	36cm
Width incl. handles:	60cm
Above sea level:	approx. 100cm
Weight:	45kgs
Material, buoy:	Polythylene (PE)

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Environmental Sensor Specifications

Temperature - the foundation for all feeding regimes and growth models

There are two different temperature sensors: a separate sensor/ stand-alone sensor for connecting to AKVAcontrol or integrated in the optical oxygen sensor for using in AKVAconnect and OxyBox.

Oxygen – an important factor for growth and fish welfare

The oxygen sensors are with optical reading which reduces the need of calibration and maintains high accuracy and operates with no drift over long-term deployments. On the Oxygen RDO all this information is stored in the replaceable CAP tip. The optical sensors have a fast respons and maintains stability, even in dynamically changing conditions.

Environmental current knowledge prevent feed waste

An important parameter is the current or water flow when you feed but also to know your site. We can offer two types of current sensors, the Tilt sensor that gives current speed in one layer and the Doppler current profiler that gives you speed and direction at three different levels in the water column.

Full environmental overview - know your site

The new Multi Sensor is a compact instrument that houses six water quality sensors and measures 12 parameters: • Actual and specific conductivity, salinity, total dissolved solids, resistivity, and density • Dissolved oxygen • ORP • pH • Temperature • Water level and water pressure (absolute)

Intelligent Pellet Sensor with built-in camera

The Doppler Pellet Sensor will regulate the feeding based on the amount of pellets passing the Doppler´s sensing area.

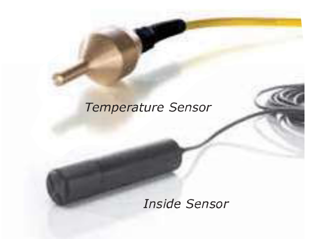
Temperature Sensors	Separate	Inside
Resolution:	+/- 0.1° C	+/- 0.1° C
Accuracy:	+/- 0.5° C typical	+/- 0.1° C typical
Operating temp.:	0-50° C / 32-122°F	0-50° C / 32-122°F
Depth rating:	30m ltd. by cable	210m ltd. by cable
Housing:	Bronze	Polyethylene
Cable:	30m urethane	30m urethane

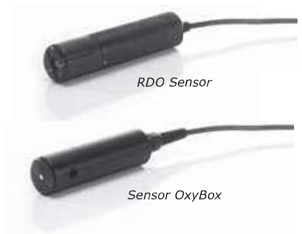
Oxygen Sensors	RDO sensor	Sensor OxyBox
Accuracy:	+/- 0.1mg/L 0-8mg/L +/- 0.2mg/L 8-20mg/L +/- 0.10% 20-50mg/L	+/- 0.1° C typical
Operating temp.:	0-50° C / 32-122°F	0-50° C / 32-122°F
Depth rating:	210m ltd. by cable	300m ltd. by cable
Housing:	Polyethylene	Polyethylene
Cable:	10 or 50m	10 or 50m

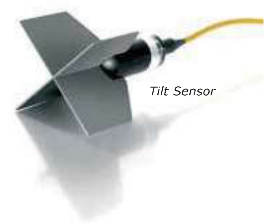
Current Sensors	0-50cm/sec	0-100cm/sec
Accuracy:	+/- 0.1cm/sec	+/- 0.2cm/sec
Measurement range:	0-50° C / 32-122°F	0-50° C / 32-122°F
Measuring principle:	Electronic tilt sensor	Electronic tilt sensor
Power consumption:	75mA	75mA
Depth rating:	Polyethylene	PE/alu. or SS wings
Housing:	Acrylic/Pom/Alu.	Acrylic/Pom/Alu.
Cable:	30m Polyethylene	30m Polyethylene

Multi Sensor	
Supported parameter:	Actual conductivity, specific conductivity, dissolved oxygen, pH, OPR, temperature, water level/depth/pressure (absolute)
Oxygen:	+/- 0.1mg/L 0-8mg/L +/- 0.2mg/L 8-20mg/L +/- 0.10% 20-50mg/L
Conductivity:	+/- 0.5% +1uS/cm typical +/- 1% max range
ORP:	+/- 0.5mV
pH:	+/- 0.1 pH unit
Temperature:	+/- 0.5° C
Housing:	PVC, acetal, titanium, 316 stainless steel

Doppler Pellet Sensor	
Sencing area:	2,5m x Ø 2,5m (8´x 8´diam.)
Sencing method:	Acoustics (Doppler effect)
Depth rating:	Limited by cable
Housing:	Polyethylene/aluminum/bronze
Camera:	Monochrome


Temperature Sensor
Inside Sensor


RDO Sensor
Sensor OxyBox


Tilt Sensor


Multi Sensor


Doppler Pellet Sensor

Infrastructure for cameras and sensors

AOS OxyBox - ideal for accurate environment logging and site surveyor

No need for additional infrastructure, the system has built in Iridium communication and battery. One standard unit and optional number of sensors

CAP and SmartBox - wireless infrastructure for cameras

A connection point for all our underwater cameras and winch. With transmission of up to 6 parallel video channels the system suits all types of farm sites.

CSU - Wireless infrastructure for both HR cameras and sensors

One connection point for camera and sensors as oxygen, current, temperature and Doppler Pellet Sensor. With transmission of up to 6 parallel video channels the system suits all type of farm sites.

Hard wired solutions - when simple stability counts

Infrastructure that fulfil your need for fixed solutions. Adapted and customized for each site – various sensors and cameras can be adapted to the system.

AOS OxyBox	
Iridium communication:	Standard
Doppler Current sensor/profiler	Optional - 1 sensor
Oxygen Sensor	1 - 3 sensors
Power supply:	Internal replaceable battery 3 - 6 moths lifetime

Model	SmartBox	CAP
Video:	Maximum 6 parallel channels	
Above water camera:	In front	In the top
Under the water:	All models of our underwater cameras	
Camera Winch:	Standard	HT Winch
Power supply:	Battery (12V) or mains 230V	
Housing:	Aluminum/ Delrin	Aluminum/ PC/Stainless steel

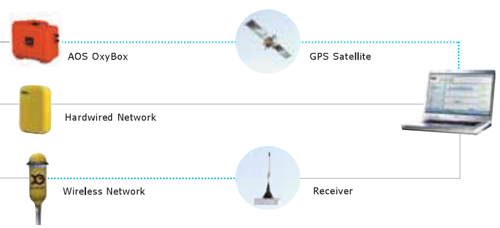
Model	CSU
Video:	Maximum 6 parallel channels
Above water camera:	In front
Under water:	All our models of underwater cameras
Winch:	Standard Winch
Power supply:	Battery (12V) or mains 230V
Sensor:	Aluminum/ Delrin

Hardwired transmitter	
Wired network:	Ethernet 100/1000Mbit - customized solutions, depend of site layouts and distances Ethernet, Coax or fiber cables.
Above water camera:	Surveillance camera with P/T/Z
Under water:	All our models underwater cameras
Winch:	Standard and Winch HT
Sensors:	Both Optical Oxygen sensor and temperature sensors and either current sensor – tilt or Doppler pellet feed sensor
Power supply:	Mains 230V


AOS OxyBox


CAP
SmartBox
CSU


Wired Network



Vicass HD Biomass Estimator

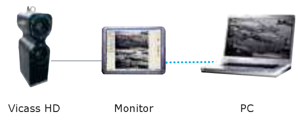
Measures length and height with high accuracy

The new **Vicass HD (High Definition)** will provide farmers with accurate and efficient biomass estimation, taking high quality digital stereo images of the live fish swimming in the cage.

The images are analyzed in order to determine average weight of each fish. Vicass HD has high accuracy, capacity and speed and the camera unit captures 300-500 images at three different depths before they are analyzed.

The red graph is here showing calcultated fish weight in different weight classes.

Accurate biomass estimation, taking high quality digital stereo images of the live fish while swimming in the cage or tank.



New Vicass features:

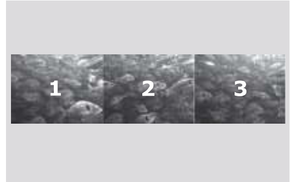
- Possible to zoom images for exact data input.
- The weight distribution curve is continuously updated while fish is being entered/recorded by clicking.
- Measures fish sizes at a distance from 60cm up to 2m from the camera.
- Better image overlap because lenses on the new camera are located as little as 15cm apart.

Vicass HD estimation

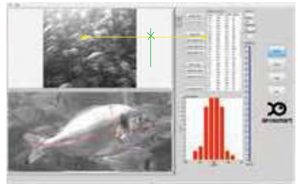
A stereoscopic video image measures the height and length of each fish. Advanced geometry algorithms accurately calculate the live weight of the fish.

Models are now available for species like:

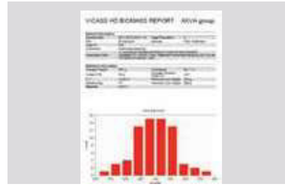
Atlantics, Chinook, Coho, Tasman Salmon, Rainbow Trout, Altantic Haddock, Red Sea Bream, Med. Sea Bass/Bream, Striped Jack, Yellowtail, Japanese Amberjack and Southern Blue Fin Tuna.



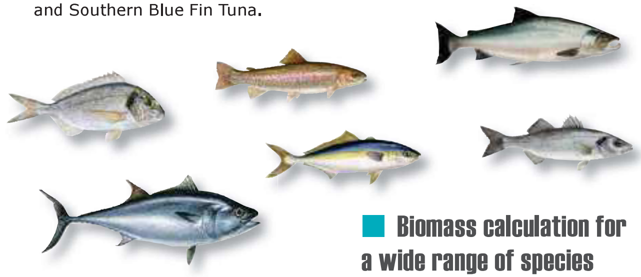
Grabbing of images



Analyzing



Reporting



Biomass calculation for a wide range of species

Vicass HD	
Power supply:	4A
Ingress protection:	Camera unit: IP68
	Field computer lid open + plugs inserted: IP64
	Field computer, lid closed: IP67
Camera size: length/ width/height - weight:	515mm x 130mm x 195mm - 16kg
Field computer size: length/ width/height - weight:	485mm x 392mm x 195mm - 12kg

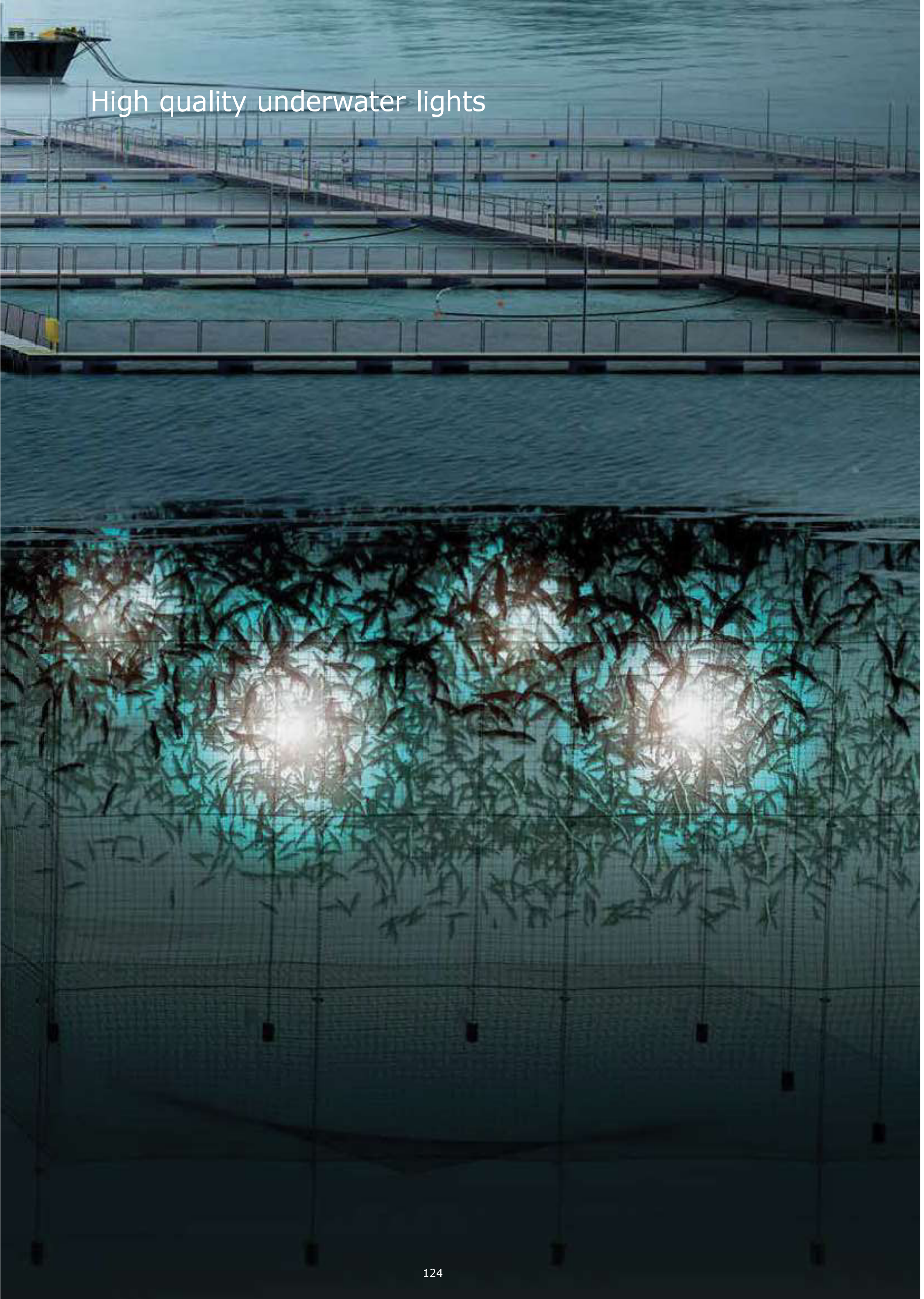
akvasmart™

Underwater Lights

Stable and accurate lighting increases profits

The correct use of underwater lights for many aquaculture species, ensures reduced fish maturation. In addition it results in faster growth and more effective feed utilization. The Idema Underwater Lights series are adapted for smolt and juveniles in small tanks, as well as for salmon, cod and other fast growing species that require light in larger cage farms. The high quality underwater lights have excellent light distribution, the design allows for for easy bulb replacement, functional design and a rugged construction.

- Qualty is always profitable.



High quality underwater lights

BlueLED or metal halogen lights?

For indoor locations we recommend 100W to 400W illumination. BlueLed or SubLite 250W/400W is the smart choice here.

Idema Underwater Lights are a smart solution in Artic areas where the light conditions are poor during winter time.

Accurate even light distribution throughout the biomass is vital in tanks with high density and turbid loaded water.

Idema Underwater Lights can easily be installed at various depths, ensuring stable and accurate light distribution.

Expected service life on the LED bulbs is in the region of 50.000 hours!

ISO approved Pyro Borosilicate glass to withstand rough use in cage farming operations.

Idema BlueLed 400W

Standard 35m or 55m rugged underwater cable (urethane cable), and a waterproof connection plug.

An extra strong construction that is almost maintenance free.

Idema SubLite 1000W

Idema BlueLED 400W is a perfect light solution for cage farms with medium or large cages.

Idema Underwater Lights are often used for salmon, trout, cod and other fast growing species.

Light treatment is also successfully used for smolt and juveniles in tanks and cages of different types and sizes.

More than 16.000 Idema Underwater Lights have been delivered world wide in the last 15 years.

Up to 8 times stronger light effect with the new BlueLed 400W!

akvasmart™

Bright solutions for a wide range of tanks and cages

BlueLED 100W with blue light rays, have the highest penetration in seawater, and therefore the greatest efficiency. LED (Light Emitting Diode) is often called ´eternity light´ and is the most cost effective light solution on the market – and a perfect match to a diesel generator. The light diodes have extremely long duration with a predicted service life of up to 50.000 hours! Which means, no bulb changing for many years ahead. Recommended use: Tanks and smaller cages.

NEW BlueLED 400W with blue light rays is our newly developed luminaire for the sea cages. This luminairie is utilizing the newest High Intensity LED-technology with almost four times more effective light source than the BlueLED 100W. The blue colour has proven to be the most efficient when it comes to effect on biology in the fish. LED luminaires can provide more effective output from each luminaire compared to other lamp technologies. It saves cost on power generators, less power use and uses less copper in the installations. All this in addition to a long service life of the luminaire. Recommended use: Medium and large cages.

SubLite Integra 250W/400W is the smallest member of the SubLite family. The light can be offered in two luminosities for smolt, juvenile and smaller locations. This model is often used in cod farming with lights placed at various depths for a smooth distribution of light all over the cage. The light bulb and the electronic control device is integrated in the housing compartment and has a service time in the region of 5.000 hours. Recommended use: Tanks, smaller and medium cages.

SubLite Integra 1000W is our bestseller for salmon farms and the most rugged light unit in the market. It is placed at various depths and the powerful light ensures an excellent spread. The light bulb and the electronic control device is integrated in the housing and is easy to install. This unit also has a service life in the region of 5.000 hours. Recommended use: Medium and large cages.

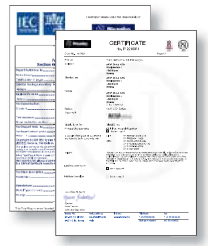
SubLite Standard 2000W - the most powerful solution we offer. It provides extra strong lighting in large cages where there is a need for strong light conditions without using a lot of separate units. It features solid construction with a separate connection box and a service life in the region of 5.000 hours. Recommended use: Large cages.

Underwater Lights Specifications

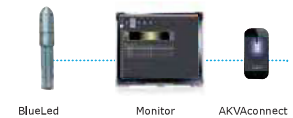
Specifications:	BlueLed 100W	BlueLed 400W	Integra 250/400W	Integra 1000W	Standard 2000W
Operating voltage:	230 VAC/50Hz (24DC)	230 VAC 50Hz (60DC)	230 VAC 50Hz	230 VAC 50Hz	230 VAC 50Hz
Starting current 0,5 second:	1,0A (230W)	1,8A (400W)	2,45A (563W) / 3,0A (690W)	8,0A (1840W)	13,0A (2990W)
Starting current 1 second:	2,5A (115W)	1,8A (400W)	1,9A (437W) / 2,0A (460W)	6,4A (1472W)	12,1A (2783W)
Operating current (2 minutes):	0,5A (106W)	2,15A (480W)	1,3A (299W) / 1,8A (414W)	5A (1150W)	9,35A (2150W)
Total efficiency:	115W	480W	275W / 460W	1065W	2070W
Service life with even colour:	appr. 50 000 hours	appr. 50 000 hours	appr. 5000 hours	appr. 5000 hours	appr. 5000 hours
Light source:	1080 LED	184 LED	HQI-T 250D / HQI-T 400D	HQI-T 1000D	HQI-T 2000D
Color temperature (Kelvin):	20000 K	20000 K (480 nm Blue)	5300K / 6100K	6000K	4400K
Luminosity:	-	-	20 000 lm / 35 000 lm	85 000 lm	190 000 lm
Weight, light housing:	8,5kg	11kg	7kg / 10kg	21,6kg	11kg
Weight, with cable:	14kg (appr. 2 l. oil)	19kg (appr. 2 l. oil)	11kg / 14kg	28kg	17kg
Weight, connection box:	-	-	-	-	19,2kg
Size, length + Ø:	641mm + 120mm	641mm + 120mm	648mm + 140mm	818mm + 180mm	642mm + 140mm
Material in the main housing, density:	POM 1,41g/cm³ DIN 53479 - L15	Aluminum 6082 T6 2,7g/cm³	POM 1,41g/cm³ DIN 53479 - L15	POM 1,41g/cm³ DIN 53479 - L15	POM 1,41g/cm³ DIN 53479 - L15
Material in connection box:	-	-	-	-	Fire coated aluminum
Pyro Borosilicate glass 3.3:	ISO 3585- 2,23 g/cm³	ISO 3585- 2,23 g/cm³	ISO 3585- 2,23 g/cm³	ISO 3585- 2,23 g/cm³	ISO 3585- 2,23 g/cm³
Cable, standard lenght:	PUR 3G1,5 35m or 55m	PUR 3G1,5 35m or 55m	PUR 3G1,5 35m or 55m	PUR 3G2,5 35m or 55m	PUR 3G2,5 35m or 55m
Cooling fluid:	Silikon fluid	Silikon fluid			
Recommended use:	Tanks /smaller cages	Medium & large cages	Tanks /medium & small cages	Medium & large cages	Large cages

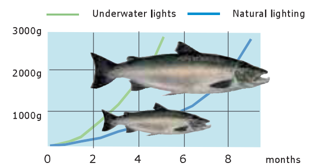
Blue light Daylight

Note: Specifications are subject to change without prior notice.



We base our CE- marking on tests run by Nemko according to the EMC and LVD directives.





By using extra light on i.e. salmon, you will achieve faster growth and get higher harvest weight as opposed to not using underwater lights.

You can easily install the underwater lights at fixed depths and positions by using buoys and ropes.

AKVA group offer a regular service visit with equipment control and maintenance, including a detailed status report.

akvasmart™

Production and process control software

Intelligent IT solutions

AKVAconnect, Fishtalk and Wisefish are unique tools that integrate fish farming operations processing. This ensures optimum efficiency, excellent fish quality and increased profitability. The software covers all needs for process control, production control and planning.

Fishtalk: This software covers most aspects of the biological production control and planning, as well as production costing and budgeting. Reports and analysis are the basis for decisions, both long term and short term, and provides historical overview, status and prognosis.

Wisefish: Gain complete control of costs with the ability to apply detailed costing at the site or even cage level. You can easily manage the complete cycle from smolt to harvest and delivery to the customer and capture a detailed fish history.

AKVAconnect: A software platform that is designed for optimal control of the processes and activities on fish farms. The system offers full control, surveillance and integration of machines, sensors and all processes on both sea and land based fish farms.

Complete software solutions from AKVA group

Complete Value Chain Control

A result of more than 35 years of aquaculture experience

Our software is in use by most Norwegian aquaculture companies, a strong testimony to the fact that AKVA group offers aquaculture software solutions that are second to none! Fishtalk software gives a fast and detailed summary of when the fish will be ready for the market, as well as trends in production costs over time. Easily viewed, through simulating changes in growth conditions, the environment, feeding regimes, feed prices, smolt costs, harvests, and numerous other planned or simulated factors, the biological and financial consequences of changes in underlying conditions.

Full control from broodstock to customer.

An interactive control platform

AKVAconnnect provides the ability to gather data and combine information from all levels of your aquaculture operations, including controlling and monitoring all technical processes. This improves management´s production overview and control. AKVAconnect also provides the maintenance team with dedicated logging of all parameters associated with the equipment on site.

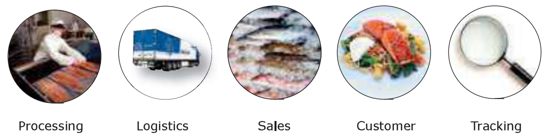
AKVAconnect allows full process control via internet on a PC, iPAD or Smartphone.

Fishtalk – From broodstock to harvest

Fishtalk captures data from broodstock to harvest and has powerful reporting and analysis capabilities. With the financial and planning modules Fishtalk becomes a primary tool, from day to day use on a single site to mapping out a 5-year plan for the whole company.

Wisefish - Fully integrated end-to-end ERP solution

Combine fish stock inventory details captured in AKVA group's premier Fishtalk software with the advanced accounting features of Wisefish. Capture the total Cost Of Goods Sold of live fish stock inventories, distributed down to the site or even cage level.



AKVAconnect - Process control platform

AKVAconnect software is designed for optimal industrial control of the processes and activities on fish farms. The system offers full control, surveillance and perfect integration of machines, sensors and all processes on a fish farm.

Production control and planning

From Broodstock to Harvest

The Fishtalk-family

We often say that the modules in Fishtalk are seamlessly integrated. But **Fishtalk Control**, **Plan and Finance** are in fact part of the same software. Shared by the modules is one single database containing all data, as well as common functionality and models. This resulting in a better user experience and more consistent software.

Biology and finance, past and future are dimensions that goes hand in hand in Fishtalk. The reporting and analysis tools greatly demonstrate the effect of including all 4 areas in the same software solution.

Effective and accurate control, budgeting and planning.

Additional modules like **Fishtalk Connect** will provide a version stable interface to third party applications like Business Intelligence or reporting tools. It also contains **OLAP** cubes using **Microsoft Analysis Services.** The cubes are already prepared to go with data from Fishtalk, giving you the option to integrate using standards like Excel and similar.

Other Fishtalk software solutions

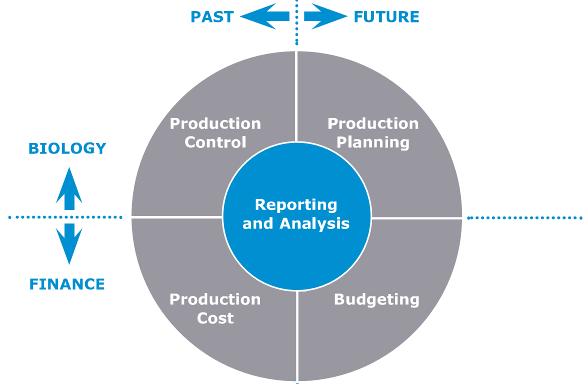
Fishtalk Lice and Fishtalk Wrasse will greatly improve your overview of the lice situation, and with **Fishtalk Tide** you can plan activities taking the tide level and current into consideration. You may use **Fishtalk Benchmarking** to benchmark your production, and finally **Fishtalk Broodstock** closes the loop, giving you full traceability across generations - down to individual level!

Fishtalk Control

Fishtalk Control software provides producers complete control of the production from broodstock to harvest. Used by single sites as well as large corporations, Fishtalk is the most complete production control software in the market.

Fishtalk Plan

Fishtalk Plan is a user friendly tool for production planning. Yet it includes advanced features such as rolling forecasts, scenarios and flexible plan structures, making it a more powerful tool. The flexible reporting system helps you take operational decisions by comparing different scenarios efficiently.



Fishtalk Finance

Production cost calculation is easy with Fishtalk Finance. A minimum of setup is required, and you will be up and running in no time. Simply import data from accounting once a month and you will easily obtain new insight into your cost of production.

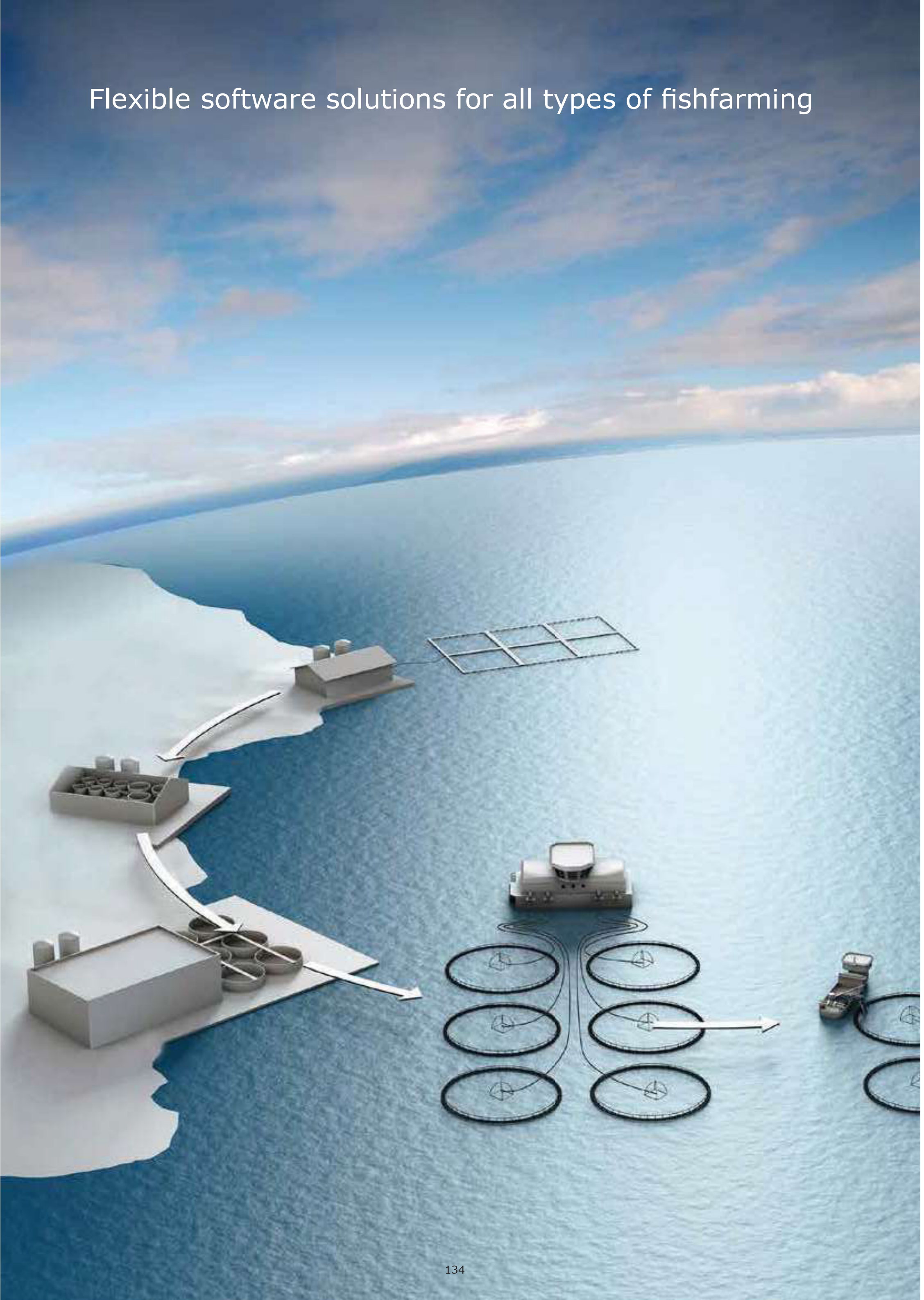
Fishtalk Finance

Budgeting using Fishtalk Finance is simpler than ever. Just define your cost models and any production plan can be used to generate the major cost factors like feed, transport and harvest. Comparing budgets generated from different scenarios quickly gives you the financial impact of your decisions.

The Fishtalk-family software ensures complete value chain control.

fishtalk™

Flexible software solutions for all types of fishfarming



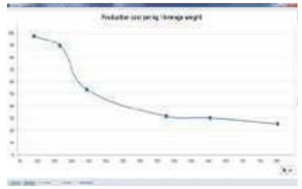
The Fishtalk-family

Fishtalk Control

Fishtalk Control provides a complete overview of the biological status of the production. The tool keeps track of all activities through the sophisticated log; from unit and farm level, to top executive management.

Fishtalk Plan

Fishtalk Plan provides optimal production plans according to your strategies. This gives you a unique basis for making qualified operational decisions based on various scenarios for each species.



Fishtalk Finance

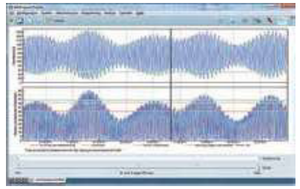
Fishtalk Finance enables simulation of the financial effects of the planned activities. The solution provides in-depth information according to the biological plans, budgets and forecasts, - all based on a set of different scenarios.

Fishtalk Lice

Fishtalk Lice shows lice developments and effect of treatments for each cage or region. Fishtalk Wrasse provides stocking numbers for each cage and percentage of Wrasse vs. salmon.

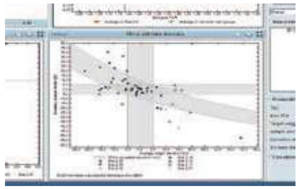
Fishtalk Wrasse

Fishtalk Wrasse ensures a full updated overview of the treatment. The module extends the lice module in Fishtalk and provides an unique tool for monitoring and analysing.



Fishtalk Tide

Fishtalk Tide provides predicted hourly tide levels and change in tide level. This makes it easy to plan operations that depends on slack tide and low currents, like net changes and lice treatments.

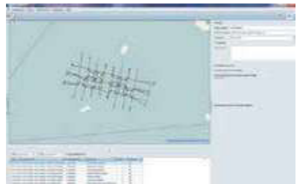


Fishtalk Benchmarking

Fishtalk Benchmarking provides fast and simple rankings compared to established production goals, such as growth rates, feed conversion rates, hit rates and other KPIs as VF3 and SGR.

Fishtalk Broodstock

Fishtalk Broodstock seamlessly integrates broodstock and production control, and provides full traceability to genetic origin and across generations of broodstock. It captures group level information as well as data for individual fish, like genetic markers and quality samples.



Fishtalk Equipment

The new Fishtalk Equipment software organizes all the farming equipment with documentation and maintenance, maintaining full traceability on component level. Comply with the Norwegian NS9415:2009 and NYTEK.

For more detailed software information, please visit:
www.fishtalk.com

From hatchery to customer

The world´s leading ERP solution for seafood

The Wisefish software family

WiseFish is developed as an industry-specific layer built on the backbone of Microsoft's business solution software – Dynamics NAV. Dynamics NAV brings together finance, manufacturing, customer relations management, analytics and e-commerce with a core, world class accounting system.

Wisefish - award winning ERP software.

The leading ERP solution for seafood producers, distributors, processors, brokers and traders

WiseFish, Certified for Microsoft Dynamics, is a comprehensive family of software products that combine the best of standard Microsoft Dynamics NAV with a wide range of seafood industry-focused packages and business intelligence analytics tools. Take advantage of role tailored, information-driven workflow which supports your business goals:

- **Innovative industry solutions for the entire seafood value chain.**
- **Built on Microsoft's Dynamics NAV**
- **Processing, Planning, and Demand Forecasting**
- **Lower inventory costs and improve food safety with integrated HACCP-compliant Quality Control**
- **Inventory managed by both catch weight and regular weight**
- **Primary processing and Value added production tools**
- **Industry-specific functionality straight out of the box**

For more detailed software information, please visit:
www.wisefish.com

Wisefish Aquaculture

Account for live fish stock inventories from smolt to harvest and beyond using advanced financial forecasting and cash flow management tools, complete vendor and customer management, HACCP-compliant quality control, and end-to-end traceability.

Wisefish Quality

Easily manage increasingly stringent legislated and customer mandated rigorous quality control through third party audits, SQF, or other recognized programs. WiseFish Quality is fully compliant with HACCP specifications. End to end traceability is a click away in case of a recall.

Wisefish Processing

Seamlessly integrate inventory control, quality inspections, lot tracking, catch weight management, Electronic Data Interchange (EDI), and expiration date management with complete and detailed costing for full financial and regulatory control of your seafood processing operation.

Wisefish Trade

Inventory Control, Broker Commissions and more for fast paced seafood sales operations. These tools are indispensable in meeting the rigorous buyer requirements of today's seafood market.

WiseFish Peripherals

WiseFish Peripherals are applications that run outside of WiseFish and integrate with:

- Scales (Marel, Digi, Scanvaegt, Mettler Toledo, Rice Lake, etc.) through serial or TCP / IP ports
- Scanners (Symbol and Intermec) through USB, keyboard wedge, or serial port.
- Barcode printers – (Zebra, Intermec, Toshiba, etc.) Uses BarTender labelling software - the world's leading design and print software for labels, barcodes, and RFID tags.
- Dynamics NAV/WiseFish database (Connected to SQL Server through ODBC).

Box or Pallet level detail with optional barcode enabled identification. Track material movement within a warehouse, between warehouses, and beyond.

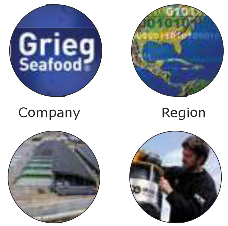
BI Tools

Affordable and user friendly BI and analytics reporting software and integrated data warehousing tools, including WiseAnalyzer are available as part of the WiseFish suite. Create customised reports, set targets, see results and easily understand the business implications of the data with easy to use SQL report builder tools.

AKVAconnect software

Role based control platform

AKVAconnect is a new process control platform used to connect to and keep control on everything from local farm sites to large international aquaculture corporations. The system is open ended and compatible with all types of equipment, sensors and technical installations. Smart 3D design with interactive control functions, makes it incredibly easy to operate.



Company Region

Group Device

A reliable software concept

AKVAconnect Site Control provides full overview and shows you the operating status of every component on your farm at all times. It also pin-points an alarm to the exact location of a problem should it occur.

The main overview provides fast access to the present state of the entire system.

The environmental software can easily supply individual data from each site.

AKVAconnect provides the ability to gather data and combine information from all levels of your aquaculture operations.

AKVAconnect is fully customizable, bringing forth exactly the information that the individual user needs.

The smart feeding control functions, well known in AKVA Control, are also avalible if needed.

Get the full picture in seconds...

The AKVAconnect-family

Site Control

Site suveillance provides detailed information and status reports from multiple sites in real-time and is a very useful tool when you centralize the operations.

AKVAconnect alarm system supports full traceability; "who, did what, and when" is not a question anymore.

Camera Control

Both analog and digital cameras are integrated in the system, and are fully controllable from any site or position.

Multible scalable camera windows can be shown and controlled directly on screen and monitored via internet using a Remote Video unit.

Remote Video

The advanced wireless sensor network provides the opportunity for live video images from the feed barge and each feed cage.

With our Remote Video system and SmartEye Surveillance camera, you can zoom in on details.

Environmental Control

Monitor and control all parameters in your production environment to secure maximum stability in your system. Temperature, oxygen, salinity, pH etc.

Process Control

All devices (are closely) can be monitored and controlled. Information about the present state, running hours and maintenance is conveniently monitored.

Control Menu

It is easy to navigate the different sites and systems through the intuitive menu.

Achieve full access to the process on the farm via internet using a PC, iPAD or a SmartPhone.

The new AKVAconnect-family provides optimal process control.

akvasmart™

Service, support and training

Advanced aquaculture needs professional maintenance

As aquaculture equipment becomes more advanced, the need for professional service and preventive maintenance increases. AKVA group offers global professional service on all products.

Through on-site visits, AKVA group technician will get a complete overview and understanding of specific solutions on the site, specific requirements, preferences and work routines of local staff.

Sufficient training of your staff and managers will minimize the amount of frustration that builds up while browsing through a manual in search of a solution to a problem. Training of staff, face-to-face is always a smart investment.

Professional aquaculture training

Preparing, Training, Follow-up

All training programs are tailor-made and planned in close cooperation with the customer. Further on, and to ensure the highest possible learning outcome, the following stages are followed:

1. **Individual self-paced preparation phase**
2. **Face-to-face training**
3. **Close post-training follow-up**

The courses can take place in one of AKVA group's dedicated training facilities or, if preferred, at the customers site. The classes are instructed by AKVA group's dedicated specialists, ensuring the highest possible quality of the courses. Some of the most popular training modules include:

- **Product Specific Training, spanning the full AKVA group product range**
- **Advanced Product Maintenance**
- **Software Training**
- **Quality Farming programs (Level 1 & 2).**

Training is a key component of employee development, and is guaranteed to have a positive effect on staff motivation and operation. The invaluable relations and shared knowledge of the product specialists, ensures optimal utilization of all your AKVA technology.

The extensive curriculum includes numerous practical and theoretical product training courses, as well as a comprehensive 2 year Quality Farming program.

Well trained emploiees is a smart investment. It will improve the results and reduce the failures.

A range of useful courses

AKVA group's software courses are among the most popular. The course can also easily be tailor made for each aquaculture farm.

The 2 year Quality Farming program ensures production optimization and improved results on the bottom line.

AKVA group offers a wide range of advanced aquaculture technology, and provides customized product training on demand.

Experienced and highly qualified AKVA group personel will teach the classes, both at the main courses and out on the customer´s locations.

Advanced aquaculture needs profesional maintenance

As aquaculture equipment becomes more advanced, the need for professional service and preventive maintenance increases. AKVA group offers global professional service on all products; on or off location including:

- **Fixed pricing on reconditioned critical spare parts with guaranteed local availability.**
- **Technical telephone support during local office hours.**
- **Professional consultancy services.**
- **System upgrades, including fixed pricing on specific rebuild kits.**
- **Fast service response times.**

SmartService - a safe solution

Regular service prevents downtime, and thus ensures predictable and uninterrupted production. AKVA group's comprehensive and flexible Smart Service agreement is a safe solution providing a wide range of benefits, such as:

- **Prioritized 24 hour telephone support.**
- **Discount on spare parts.**
- **Discount on service technician rates.**
- **Discount on software upgrades.**
- **Discount on AKVA training programs.**
- **Dedicated AKVA group service representative during office hours.**

It is recommended that the SmartService agreement is upgraded to include regular on-site visits by experienced technicians resulting in:

- **Status report of the site.**
- **Yearly maintenance documentation in accordance to local HSE standards.**
- **Development of regular preventive maintenance routines.**

Through on-site visits, AKVA group technician will get a complete overview and understanding of specific solutions on the site, specific requirements, preferences and work routines of local staff. Adding a face factor to this will ease communication between the site staff and the dedicated technician in the future.

Software Support - a necessary tool

Turning a software solution into the optimal work tool requires both understanding about local knowledge, work routines and preferences. Achieving optimal control on the farm often takes settings, tuning and adjustment of the software solution according to local requirements and priorities. For its turn-key customers, AKVA group's dedicated software team offers:

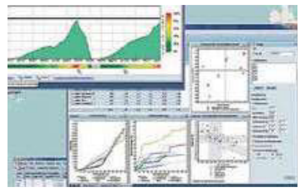
- **On-site support Telephone support Online support**
- **Implementation**
- **Training**
- **Upgrading of licenses**
- **Consulting**
- **Tailor-made solutions**
- **On-site training**
- **In depth training**
- **Securing long time investments**

Service is a smart insurance

With a SmartService agreement, the farm manager can focus completely on the fish, while our technical staff looks after the equipment.

More advanced aquaculture technology increases the need for more professional service, support and maintenance.

AKVA group offer a regular service visit with equipment control and maintenance, including detailed status reports.



Software support can include training, online support, consulting, implementation, server control & server security oe.

Financing - loan or leasing?

Financing through Export Credit Norway

In close cooperation with Export Credit Norway, AKVA group ASA can offer competitive financing arrangements for our customers in the export markets.

Export Credit Norway extends loans to large and small companies abroad for purchases from Norwegian exporters, offering favorable long-term financing. The company manages the whole lending process, including processing, documentation, disbursement and loan administration.

Export Credit Norway is a limited liability company wholly owned by the Norwegian government, and they finance export contracts ranging in value from a few million to several billion Norwegian kroner, across sectors and worldwide. The loans comply with the OECD framework on officially supported export credits.

AKVA group´s professional teams have decades of experience in planning and designing aquaculture projects.

Export Credit Norway offers competitively priced fixed and variable interest rates. Loan on Commercial Interest Reference Rate (CIRR) terms, may be given with a repayment period of between 2 and 18 years depending on the project type. Fish farming projects have so far qualified for a repayment period of 2-5 years, but a longer period might be achieved on a case-by-case basis.

CIRR is a free of charge interest rate option for the borrower in the period from acceptance of the loan until delivery of the equipment/service. Export Credit offers financing of up to 85% of the export contract.

The financing requires backing from the Norwegian Guarantee Institute for Export Credits and/or commercial bank(s) for 100% of the loan to cover political and commercial risks, related to the credit given in the whole repayment period.

Lending Process

All prospective borrowers that meet the requirements will receive a loan offer. For customers with low access to CAPEX this has proven to be a lucrative option to traditional financing.

Competitive financing from Export Credit Norway may benefit both AKVA group and customers as customers will be supported in their investments making transactions in the export markets possible at lower risk.

For more information, please visit;
www.eksportfinans.no

Competitive solutions

Flexible water treatment systems for salt- or fresh water, both outdoors and indoors installations, are often made possible through export finance.

Feed systems, monitoring equipment, net cleaners, and underwater lights can be leased.

New innovative projects, both land based and cage farming aquaculture have been financed world wide.

A wide range of cages, feed barges and work boats of different types and sizes have also been financed.

Land Based Aquaculture

Your partner in advanced water treatment technology

AKVA group has more than 30 years of aquaculture engineering experience. Our team of world leading experts is renowned for designing sustainable recirculation systems that are second to none. Having delivered systems globally for more than 20 different species, AKVA group provides optimal water quality conditions for both fresh- and seawater operations.

Supplier of land based solutions for a wide range of species

A few years ago it was hard to imagine a supplier of complete land based aquaculture solutions. Today AKVA group steps into that role, with all the commitment and dedication it takes to become the preferred supplier-, maintenance-, service- and training partner for such companies worldwide. AKVA group's team of professionals have decades of experience supplying functional aquaculture technology to land based fish farming companies worldwide.

Your business will never be easier than this.

From single components - to complete solutions

Tank solutions

AKVA group tanks can be customized to any desired diameter and height thus making it possible to obtain perfect utilization of the available site space.

Water treatment

AKVA group has 30 years experience providing optimal water quality conditions for both fresh- and seawater operations.

Piping and pipework

AKVA group has one of the most modern production lines for polyethylene pipes in Europe and thousands of kilometres have been delivered since 1971.

Feeding systems

The Akvasmart CCS Feed System will feed the correct amount, at the optimal rate, on time, every time.

Sensor systems

Environmental sensor data is of vital importance. A better environment will always improve your production.

Underwater Lights

Light treatment is successfully used for smolt and juveniles in tanks and cages of different types and sizes.

Polarcirkel Polyethylene (PE) Pipes

Maintenance free, flexible solutions

AKVA group has one of the most modern production lines for polyethylene pipes in Europe and thousands of kilometres have been delivered since 1971. The pipes are straight pressure pipes made from PE raw materials especially suited for continuous use in harsh environments, and are based on decades of experience in pipe technology. Polarcirkel pipes are available in a wide range of models, shapes and sizes to suit individual needs and offer many benefits over competing systems.

Extruder- and butt-welding PE is a proven and strong method of joining piping components.

No corrosion or decay is caused by the electrolytic process and no risk of material deterioration as algae, bacteria or multicellular organisms are unable to attach themselves to the pipes. Polarcirkel pipe production is certified under Det Norske Veritas (DNV), ISO-EN 9001 /ISO 14001 Standard and NS-EN 12201.

All installations are carried out by certified welders which ensure accurate and quality assured installations of PE 100 pipes.

Maintenance free pipes

AKVA group produces PE pipes with state-of-the-art machinery, and offers complete pipe systems for high and low pressure applications. High quality raw materials are used throughout, and full documentation of the pipe production process can be provided by an in-line scanning system. This provides cost savings as well as ensures long, maintenance free lifespan of the pipes.

PE piping and plumbing parts are suitable for a wide range of industrial use, chemicals, corrosive fluids, sewage, sludge, water, food and agriculture granulates.

Industry and processing

The excellent corrosion and chemical resistance properties and long-term durability of PE pipe has resulted in the mining and process industries choosing polyethylene as their preferred pipework material.

Water and sewer

AKVA group offers a wide range of Polarcirkel PE pipes for underground water supply and sewage, all with outstanding performance advantages such as joint tightness, flexibility, abrasion resistance and extremely long durability.

AKVA group provides Polarcirkel solutions for water supply, outlet pipes, internal pipes, parts and fittings for hatcheries and land based aquaculture.

AKVA group offers a wide range of pipes and fittings from 20mm up to 1000mm diameter.

Sophisticated machinery produces pipes in a wide range of models, shapes and sizes to fit individual needs.

Feeding Pipes in various dimensions, wall thicknesses and coil lengths up to 1000 metres.

From extensive to intensive water treatment

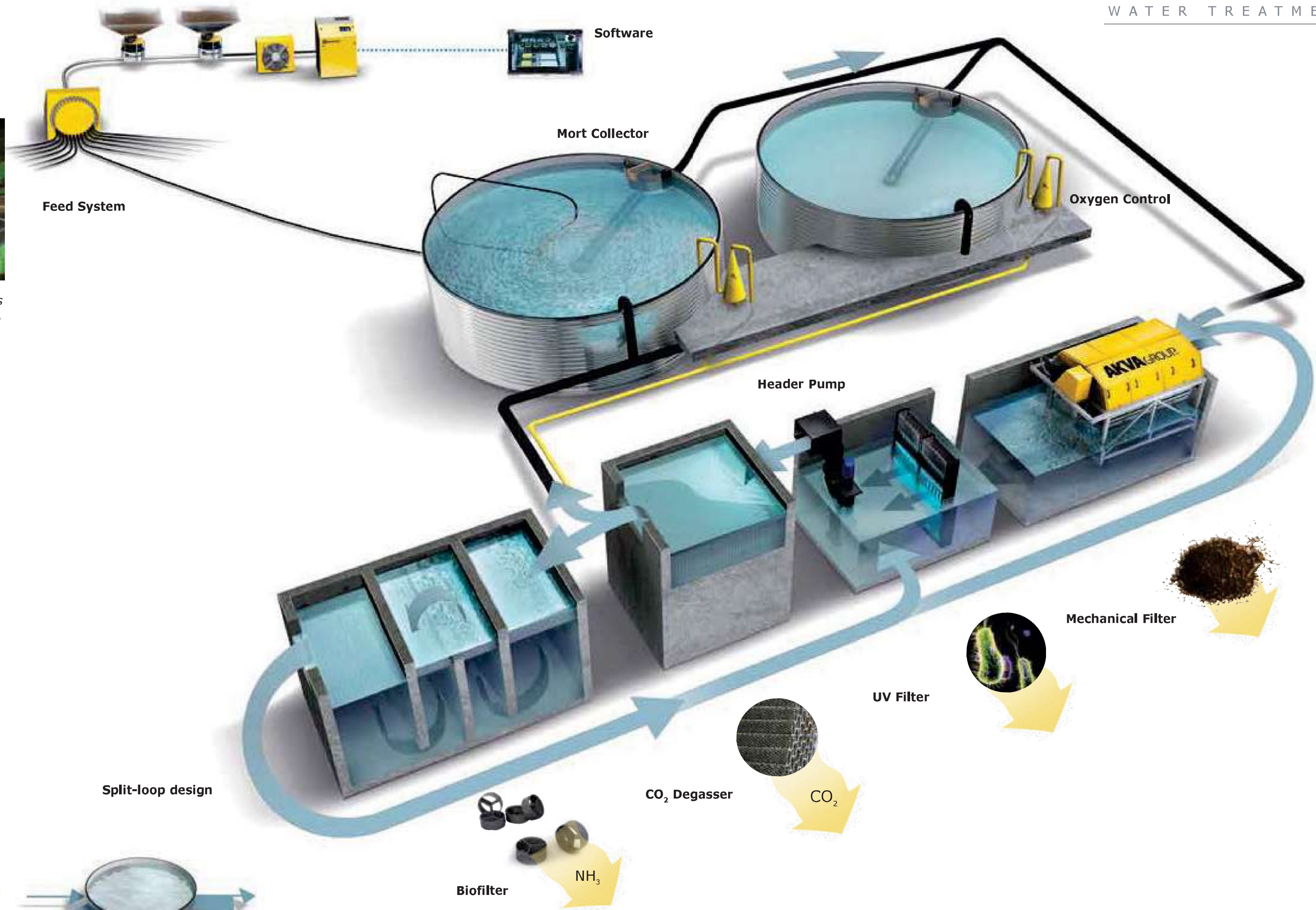
AKVA group offers a wide range of land based aquaculture technology, from single components to complete installations worldwide. The complete range of quality products and software provides maximum reliability and cost effectiveness.

Unlike the short history of cage farming aquaculture, land based aquaculture goes back thousands of years with most of the production being fresh water farms in China and Asia.

Land based aquaculture is today one of the fastest growing food industries in the world. Although most of the industry was developed as extensive fish farming in ponds with low technology solutions, the main reason for today's growth is the increased use of intensive solutions and the latest innovations in water treatment technology. This makes it possible to maintain excellent water quality combined with exceptional low water- and energy consumption.

Successfully spawned valuable species like sturgeon and tuna can reduce the pressure on wild stocks.

Over the last 20 years, energy consumption per kilo fish produced has been reduced by more than 80% while water recirculation has increased to more than 99%. In addition to freshwater, AKVA group also has unique knowledge in saltwater recirculation systems, making it feasible with profitable production of almost any species anywhere in the world. Our main success criteria include scientific competence, practical experience and close cooperation with both customers and research communities. This has enabled us to develop innovative and cost-effective solutions for most land based aquaculture projects.



Flow through system

The traditional form of landbased aquaculture with low level of water treatment technology. This form of aquaculture is commonly used on sites with vast amounts of water with a good temperature profile.

Re-use system

Re-use is often a result of a gradual increasing implementation of technology including for instance oxygenation and degassing. Depending on the level of technology, the Re-use relative to flow-through is often between 20 and 60%.

Recirculated system

Recirculation systems are currently being built all over the world and for many different species. A high level of technology allows a very high degree of water Re-use; normally in the range of 95-99% compared to the water consumption in a flow through system.

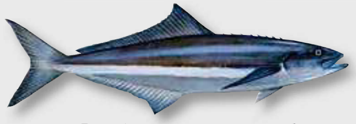
A wide range of land based aquaculture solutions prepared for various species.

For more information, order our Land Based Aquaculture Catalogue. www.akvagroup.com

Dedicated aquaculture solutions

AKVA group offers tailor made solutions for a wide range of species both land based and cage farming aquaculture. Here´s some examples;


Acipencer sp.
N: Stør - GB: Sturgeon - ES: Esturión


Rachycentron canadum
N: Cobia - GB: Cobia - ES: Cobia


Oncorhynchus mykiss
N: Regnbueørret - GB: Rainbow Trout - ES: Trucha Arco Iris


Salmo salar
N: Laks - GB: Atlantic Salmon - ES: Salmón del Atlántico


Dicentrarchus labrax
N: Europeisk Havabbor - GB: European Sea Bass - ES: Lubina


Salvelinus alpinus
N: Røye - GB: Artic Char - ES: Trucha Alpina


Coregonus lavaretus
N: Sik - GB: Common Whitefish - ES: Lavareto


Sparus aurata
N: Dorade - GB: Sea Bream - ES: Dorada


Gadus morhua
N: Torsk - GB: Atlantic Cod - ES: Bacalao del Atlantico


Ctenopharyngodon idella
N: Gresskarpe - GB: Grass Carp - ES: Carpa China


Cyprinus sp.
N: Karpe - GB: Common Carp - ES: Carpa


Sander lucioperca
N: Gjørs - GB: Zander - ES: Lucioperca

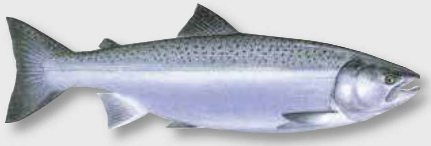

Hippoglossus hippoglossus
N: Kveite - GB: Halibut - ES: Halibut


Psetta maxima
N: Piggvar - GB: Turbot - ES: Rodaballo


Solea solea
N: Sjøtunge - GB: Sole - ES: Lenguado


Pangasius sp.
N: Asiatisk Malle - GB: Striped Catfish - ES: Basa


Thunnus thynnus
N: Blåfinnet Tunfisk - GB: Bluefin Tuna - ES: Atún Aleta Azul


Oncorhynchus kisutch
N: Sølvlaks - GB: Coho - ES: Salmón Coho


Seriola sp.
N: Kingfish - GB: Amberjack/Kingfish - ES: Seriola sp.


Oncorhynchus tshawytscha
N: Kongelaks - GB: Chinook Salmon - ES: Salmón Rey


Haliotis sp.
N: Sjøøre - GB: Abalone - ES: Abulón


Oreochromis niloticus
N: Nilmunnruger - GB: Nile Tilapia - ES: Tilapia del Nilo


Lates calcarifer
N: Asiatisk Havabbor - GB: Barramundi - ES: Perca Gigante


Litopenaeus vannamei
N: Hvitfotreke - GB: Whiteleg Shrimp - ES: Camarón blanco

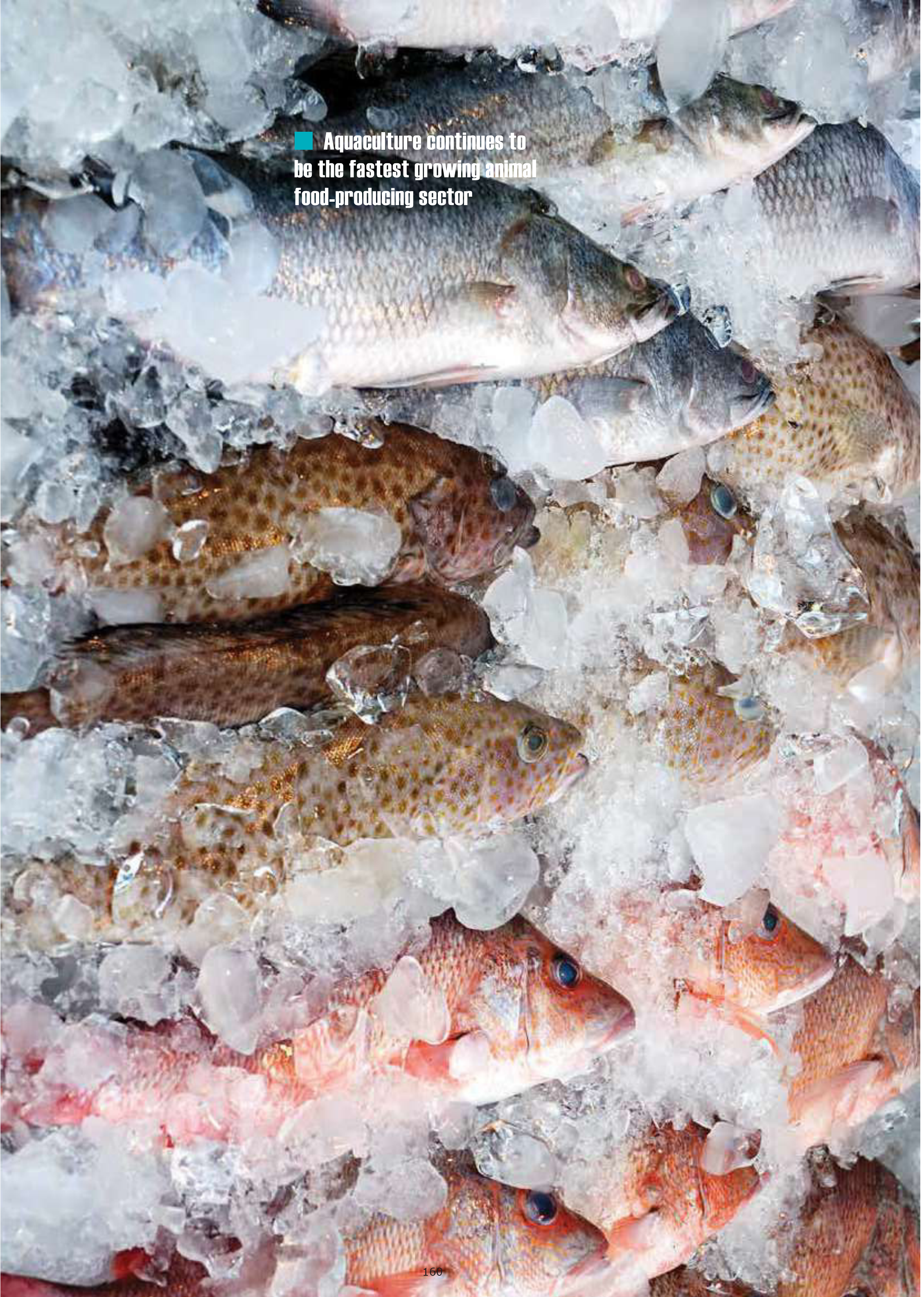

Ctenolabrus rupestris
N: Bergnebb - GB: Goldsinny Wrasse - ES: Tabernero


Labrus bergylta
N: Bergylte - GB: Ballan Wrasse - ES: Maragota


Penaeus monodon
N: Tigerreke - GB: Tiger Prawn - ES: Langostino Jumbo


Anarchicas minor
N: Flekksteinbit - GB: Catfish/Wolffish - ES: Perro del Norte


Holothuria sp.
N: Sjøpølse - GB: Sea Cucumber - ES: Pepino del Mar



State of the world aquaculture

Automated mort collection

The compressed air is injected through a number of small holes in a separate air chamber.

AKVA group in cooperation with leading fish farming companies has now developed an automated, robust and very practical system for removing morts. The system is adapted to today's Polarcirkel plastic cages, Wavemaster steel cages, nets and various other site infrastructure solutions.

The world´s largest feed barge

New giant panorama feed barge!

The new **AC 650** from AKVA group has a feed capacity of 650 tonns. "In the future there will be a need for larger and more exposed barge solutions then today," commented the region manager in Bremnes Seashore Norway.

Regional aquaculture growth

Production within each region is diverse. World aquaculture is heavily dominated by the Asia–Pacific region, which accounts for 89 percent of production in terms of quantity and 77 percent in terms of value. This dominance is mainly due to China's enormous production, which accounts for 67 percent of global production in terms of quantity and 49 percent of global value. China produces 77 percent of all carps (cyprinids) and 82 percent of the global supply of oysters (ostreidae). The Asia–Pacific region accounts for 98 percent of carp, 95 percent of oyster production, and 88 percent of shrimps and prawns (penaeidae). Norway and Chile are the world's two leading producers of cultured salmons (salmonids), accounting for 33 and 31 percent, respectively, of world production.

New Zealand kingfish.

80 million tons by 2050

According to FAO projections, it is estimated that in order to maintain the current level of per capita consumption, global aquaculture production will need to reach 80 million tons by 2050.

Aquaculture has the potential to make a significant contribution to this increasing demand for aquatic food in most regions of the world; however, in order to achieve this, the sector and the fish farmers will face great challenges.

(Source: FAO - 2011)

Aquaculture statistics

World aquaculture production of food fish* by continent (million tons).

	2010	2011	Share
Africa	1.3	1.4	2.2%
Americas	2.6	2.9	4.7%
Asia	52.4	55.5	88.5%
Europe	2.5	2.7	4.3%
Oceania	0.2	0.2	0.3%
Total	**59.0**	**62.7**	

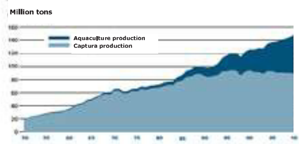
** Food fish = fishes, crustaceans, molluscs, amphibians (excluding crocodiles) and other aquatic animals (such as sea cucumber, sea urchin etc.) for human consumption.*

World top-20 aquaculture producers of food fish* (tons).

	2011
China	38 621 269
India	4 573 465
Vietnam	2 845 600
Indonesia	2 718 421
Bangladesh	1 523 759
Norway	1 138 797
Thailand	1 008 049
Egypt	986 820
Chile	954 845
Myanmar	816 820
Philippines	767 287
Brazil	629 309
Japan	556 761
Korea, RO	507 052
USA	396 841
Taiwan, POC	314 363
Ecuador	308 900
Malaysia	287 076
Spain	271 961
Iran	247 262
Total of top-20	**59 474 657**
Others	3 225 644
World Total	**62 700 300**

(Source: FAO - 2011)

World capture fisheries and aquaculture production



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General Disclaimer

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COMPRESORES DE TORNILLO TRANSMISION POR CORREAS

COMPRESORES DE TORNILLO 2.2 - 5.5 kW

Descripción

- Alimentación eléctrica estándar 400/3/50
- Arr. directo 2.2 kW, directo o Y/Δ 4 kW y Y/Δ 5.5 kW
- Todas las unidades sobre depósito de 200 litros
- BAJO NIVEL SONORO

TAS(*) **Unidades con secador, filtros y calderin integrados**

Ref	Mod	Potencia		Caudal m3/min	P max.	dB (A)
		Kw	Hp			
2350500053	R2.2IU-10-200	2.2	3.0	0.24	10	64
2350500054	R4IU-10-200	4.0	5.5	0.47	10	64
2350500055	R4IU-10-200SD	4.0	5.5	0.47	10	64
2350500055	R5.5IU-10-200SD	5.5	7.5	0.62	10	67

TAS (*)

2350500049	R2.2IU-10-200-D	2.2	3.0	0.24	10	64
2350500050	R4IU-10-200-D	4.0	5.5	0.47	10	64
0100300106	R5.5IU-10-200SD-D	5.5	7.5	0.62	10	67

COMPRESORES DE TORNILLO 5.5 - 11 kW

Descripción

- Suministro eléctrico estándar 400/3/50
- Aislamiento de bajo nivel sonoro
- Arranque directo a la red para el 4 kW, Estrella/triángulo para el 5.5 a 11 kW

Disponible:
Presiones hasta 14 bar.
Unidades con secador, filtros y calderin integrados.

Ref	Mod	Potencia		Caudal m3/min	P max.	dB (A)
		Kw	Hp			
2350500056	UP5-5-8	5.5	7.5	0.82	8	65
2350500057	UP5-5-10	5.5	7.5	0.74	10	65
2350500058	UP5-7-8	7.5	10	1.08	8	68
2350500059	UP5-7-10	7.5	10	0.96	10	68

COMPRESORES DE TORNILLO 11 - 22 kW

Características estándar

- Suministro eléctrico estándar 400/3/50
- Airend IR resistente y probado sobre rodamientos de rodillos cónicos dobles
- Motor IP55 de alta efifciencia con bajo aumento de temperaturas

Disponible:
Presiones hasta 14 bar.
Unidades con secador, filtros y calderin integrados.

Ref	Mod	Potencia		Caudal m3/min	P max.	dB (A)
		Kw	Hp			
2350500051	UP5-11-7	11	15	1.84	7.5	68
2350500052	UP5-11-10	11	15	1.54	10	68
0100300020	UP5-15-7	15	20	2.41	7.5	68
0100300021	UP5-15-10	15	20	2.07	10	68
0100300023	UP5-18-7	18	25	3.00	7.5	68
0100300024	UP5-18-10	18	25	2.61	10	68
0100300026	UP5-22-7	22	30	3.54	7.5	69
0100300027	UP5-22-10	22	30	3.11	10	69

COMPRESORES DE TORNILLO 22 - 30 kW

Características estándar

- Suministro eléctrico estándar 400/3/50
- Airend IR resistente y probado sobre rodamientos de rodillos cónicos dobles
- Eficiente sistema de separación del lubricante de tres etapas

Disponible:
Presiones hasta 14 bar.
Unidades con secador, filtros y calderin integrados.

Ref	Mod	Potencia		Caudal m3/min	P max.	dB (A)
		Kw	Hp			
0100300056	UP5-22E-7	22	30	3.95	7.5	69
0100300058	UP5-22E-10	22	30	3.35	10	69
0100300060	UP5-30-7	30	40	5.60	7.5	69
0100300062	UP5-30-10	30	40	4.70	10	69

COMPRESORES DE TORNILLO 37 kW

Características estándar:

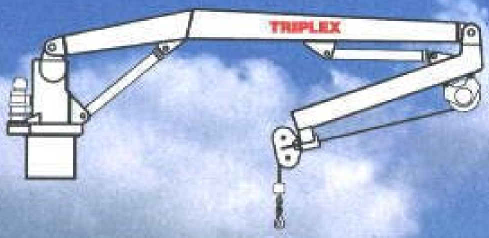
- Suministro eléctrico estándar 400/3/50
- Airend IR resistente y probado sobre rodamientos de rodillos cónicos dobles
- Motor IP55 de alta eficiencia (EFF1) y con bajo aumento de temperatura

Disponible:
Unidades con secador

Ref	Mod	Potencia		Caudal m3/min	P max.	dB (A)
		Kw	Hp			
0100300009	ML37-PE	37	50	6.2	7.5	69
0100300010	MM37-PE	37	50	6.0	8.5	69
0100300011	MH37-PE	37	50	5.7	10	69

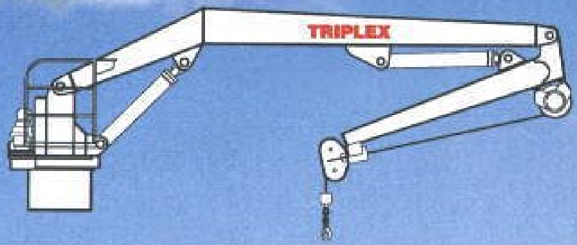
Disponible: Unidades con secador incorporado y unidades a 14 bar.

Designed for marine purposes



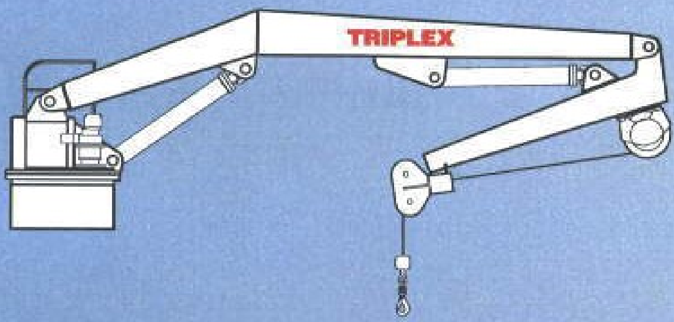
MODEL KN-10

Dimensioned lifting capacity SWL	10,5	T-m
Winch capacity	0,5–2,0	Tonnes
Max. swing radius (reach)	5,0–10,0	m
Weight, approx	2.400	kgs



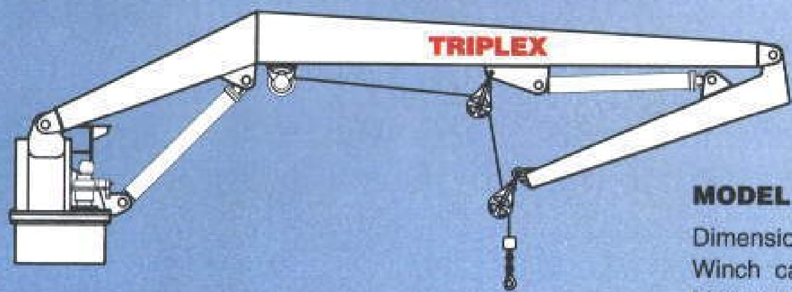
MODEL KN-16

Dimensioned lifting capacity SWL	16,0	T-m
Winch capacity	1,0–2,5	Tonnes
Max. swing radius (reach)	7,0–10,0	m
Weight, approx	2.900	kgs



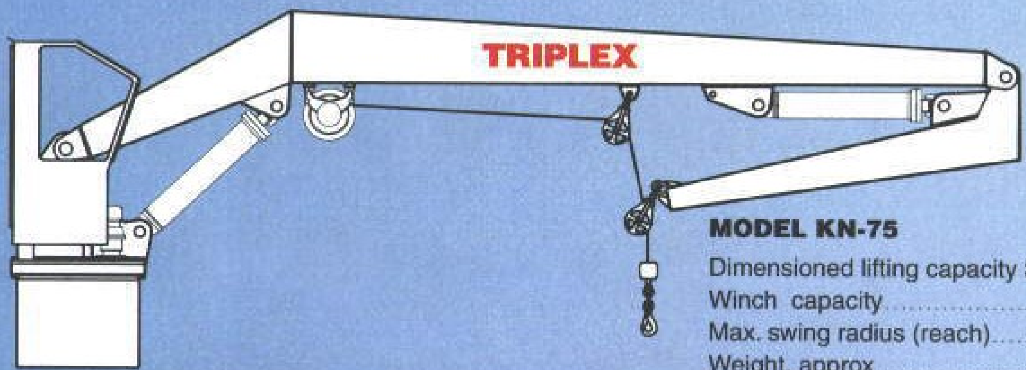
MODEL KN-30

Dimensioned lifting capacity SWL	30,0	T-m
Winch capacity	2,0–3,5	Tonnes
Max. swing radius (reach)	7,5–12,0	m
Weight, approx	4.500	kgs



MODEL KN-50

Dimensioned lifting capacity SWL	50,0	T-m
Winch capacity	2,5–5,0	Tonnes
Max. swing radius (reach)	10,0–16,0	m
Weight, approx	6.000	kgs

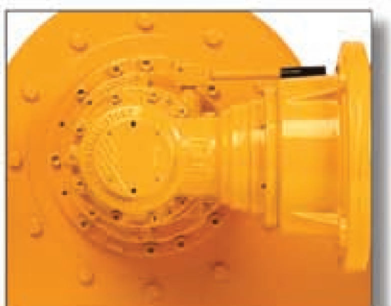


MODEL KN-75

Dimensioned lifting capacity SWL	75	T-m
Winch capacity	4,0–6,0	Tonnes
Max. swing radius (reach)	12,0–18,0	m
Weight, approx	9.000	kgs

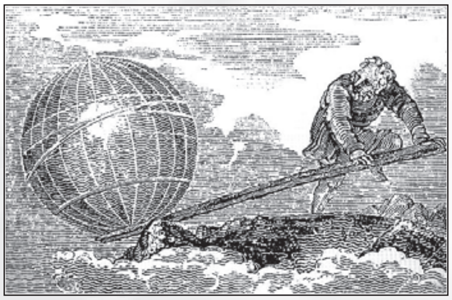
Winch and Hoist Solutions

Fulcrum Winches



www.WinchandHoistSolutions.com

Ingersoll Rand



Around 450 B.C. the Greek mathematician Archimedes declared, "Give me a fulcrum on which to rest, and I will move the earth." Archimedes had created the fulcrum as a tool, a way to gain leverage, and to make it easier for people to accomplish a task. The goal of the new FULCRUM Winch Series is to accomplish the same thing—provide the simplest, most cost-effective and efficient solution to your application.

We surveyed a variety of professionals actively operating, installing, and inspecting winches as to which features they'd like to see as part of a new winch line. This diverse group of riggers, end users, and regulatory officials responded back with their requirements: Safety, Versatility, Reliability, Simplicity, and Availability—all at a reasonable price!

Ingersoll-Rand has taken on the challenge with over 80 years of electric winch manufacturing experience, creating a tool (much like Archimedes) to make your work simpler and easier…The Fulcrum winch series.

The Fulcrum Leverage…

■ Safety

Instill security and confidence with winches that are built to meet or exceed American National Standard Institute/American Society of Mechanical Engineers (ANSI/ASME) specification B30.7 featuring two dedicated models:

- EL Series for lifting applications with an 18:1 *D/d* ratio
- EP Series for pulling applications with a 15:1 *D/d* ratio
- Plus a **5:1 Design Factor** on every Fulcrum model

■ Versatility

With a wide variety of options the Fulcrum allows you to "customize" a winch to meet your specific needs including:

- 5300 lbs. to 45600 lbs. capacity range
- 69 standard line pull / line speed configurations
- All world wide voltages
- Variable mounting configurations (inverted, side, etc.)
- Underwound or overwound cable take-offs
- 30+ standard options
- Air, Hydraulic and Man Rider™ models available on request
- Engineering support and design modifications available

■ Reliability

Reduce down time and maintenance costs with motors rated for continuous duty operation and gearboxes that are fully sealed to exclude harmful contaminants. The Fulcrum's planetary type gear reducer is 95% efficient, thereby decreasing the harmful friction and heat build-up so common in helical and worm style gearboxes. These same gear reducers have proven their durability with years of usage in the harsh environment of the offshore oil industry. We're so confident in the Fulcrum's design it comes with a ***full two-year warranty***, one of the longest available in the industry today!

■ Simplicity of design

- A completely enclosed gearbox and fan-cooled motor, with a self-adjusting brake coupled directly to the drum, provide a straightforward rugged assembly which is simple to operate and maintain.

■ Simplicity of product offering

- Our survey concluded that confusion between different ratings, different design factors, and radically different pricing is common when comparing various manufacturer's winches. Simply put, the Fulcrum utility winch is available in two versions.

Fulcrum Model	Line pull rated at layer	Winch design factor	*D/d* ratio	Built to meet or exceed
Pulling (EP)	1st	5:1	15:1	ANSI/ASME B30.7
Lifting (EL)	1st	5:1	18:1	ANSI/ASME B30.7

(1) based on the recommended wire rope for each winch

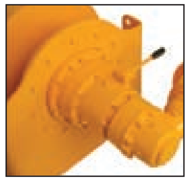
■ Availability

With locally stocked components, state of the art manufacturing systems, and a winch designed for easy assembly we've drastically reduced the long lead-time factors from our delivery equation. The Fulcrum winch series is ready to meet the customer's "need it now" expectations. Tell us where you want it, when it has to be there, and let us do the rest…

■ Pricing

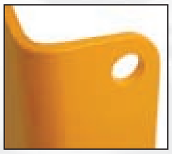
Dollar for dollar the Fulcrum series is priced to provide value not only at the time of purchase, but over the entire lifetime of the winch. It is built to the highest industry standards with quality components, and a 5:1 design factor, resulting in a winch that continues to provide savings through reduced operating and maintenance costs year after year.

The Fulcrum Leverage...

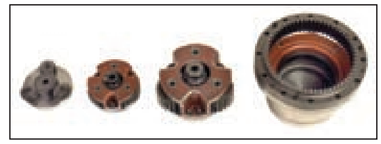


Optional Free-Spooling Drum Clutch
Totally enclosed to eliminate pinch points, the oil bath lubricated, clutch module allows the drum to free-spool. Unique design applies slight resistance on drum to prevent over-running and birdnesting of the cable.

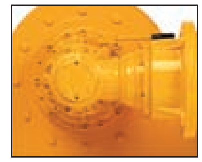
Integral Lifting Eyes
Preformed lifting points are provided on all units to facilitate transport and installation of the winch.

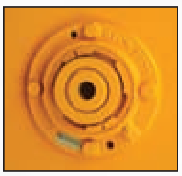


Planetary Gear Boxes
Fully sealed to exclude harmful contaminants. The Fulcrum's planetary type gear reducer is 95% efficient and features constant oil bath lubrication.



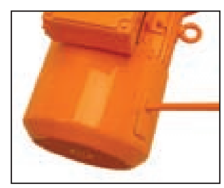
Right Angle Drive Gear Reducer
Provides a multitude of mounting configurations by "clocking" the reducer around its mounting flange. The winch can be deck, wall, or ceiling (inverted) mounted.



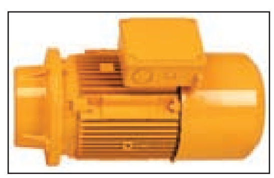


Regreasable Roller Bearings
All external bearings have readily accessible grease zerks for ease of maintenance.

Cable Anchor
Versatile design accepts multiple wire rope sizes and allows the cable to be spooled from the bottom (underwound) or top (overwound) of the drum.



Manual Brake Release Handle
for lowering of loads in the event of power loss



Standard High Torque Continuous Duty Motors
Totally enclosed, fan cooled (TEFC) motors are squirrel cage design, with heavy duty insulation for extended operations in high cycle applications. Available in all worldwide 3 phase voltages.

Drum Diameter Designed to Meet ANSI/ASME B30.7
Large drum diameter enhances spooling and reduces wear on wire rope. 15:1 D/d ratio (EP) pulling models, 18:1 D/d ratio on (EL) lifting models. (D/d = Diameter of the wire rope compared to diameter of drum expressed as a ratio. Lower the ratio the more a rope is forced to bend to wrap around the drum).

Fulcrum FAQs

Q: What is the basis of the Fulcrum design?
A: The Fulcrum is a modular design which allows it to be easily modified to provide the most efficient solution for a given application. A planetary gearbox with a wide range of ratios coupled with a universal motor adaptor allows us to mix and match components to provide line pulls and speeds to meet a client's requirements. From feet per minute to inches per hour, the Fulcrum is able to provide the solutions you require.

Q: What specification is the Fulcrum designed to?
A: Each Fulcrum is designed to meet or exceed ANSI/ASME B30.7 BASE MOUNTED DRUM HOISTS. Since B30.7 does not specifically address what a unit's design factor should be, and because these units could be used for lifting, Ingersoll-Rand has opted for a higher design factor of 5:1 on all models to maximize safety and reliability. This ratio is derived from ANSI/ASME B30.16 OVERHEAD HOISTS (UNDERHUNG) which requires a 5:1 (minimum) design factor for all load bearing components used in a hoisting application.

Q: Why is there one winch for lifting and one for pulling?
A: Two reasons: First, the Fulcrum is built to ANSI/ASME B30.7 which recommends a minimum winch *D*rum diameter to wire rope *d*iameter ratio (*D/d* ratio) of 18:1 for lifting and 15:1 for pulling. This requirement drives the need for two different winch models. Second, the drum diameter affects the amount of torque a winch can provide, so as the diameter increases the line pull decreases slightly (due to "torque arm effect") which results in different rating by model.

Q: What is this D/d ratio?
A: The relationship between the wire rope *d*iameter as it's bent around the *D*rum's diameter is expressed as a (*D/d*) ratio. The smaller the ratio the sharper the bend a wire rope must make as it spools onto a drum. Imagine how a garden hose (small "*d*") would bend and kink if you wrapped it around the small diameter of a pencil (big "*D*").

Q: Why is the D/d ratio so important?
A: Using a smaller than recommended *D/d* ratio aggravates the bending motion thereby causing fatigue, irregular wear and accelerated deterioration of wire rope. Increased wear usually results in more frequent inspections and/or wire rope replacement so as to avoid unexpected failures. For this reason Ingersoll-Rand (and most wire rope manufacturers) conform to ANSI/ASME B30.7 which recommends a minimum of 15:1 (*D/d*) ratio for pulling and hauling applications and a minimum of 18:1 (*D/d*) ratio for lifting and lowering applications.

To calculate the *D/d* ratio: Add the drum barrel diameter to the diameter of the wire rope you want to use. Then divide the result by the diameter of the wire rope.

Example: When using .5" wire rope on a 10.75" drum barrel.
10.75" + .5" = 11.25". 11.25 divided by .5 = 22.5:1 *D/d* ratio. This meets both the 15:1 minimum for pulling and the 18:1 for lifting applications.

Q: Why would anyone build a winch that doesn't have the correct D/d ratio or meets ANSI/ASME recommendations?
A: With all inputs being equal, the smaller the drum diameter the greater the load a winch can lift or pull. This is due to the "torque arm" effect. By using a smaller diameter drum, a winch is capable of pulling much greater loads using a lower horsepower motor and less costly gearbox. While this design philosophy provides a cheaper winch, hidden costs such as reduced safety factor, increased maintenance, greater liability, and reduced winch life span can begin to add up. Consequently, some manufacturers will modify their winch to meet B30.7 only upon request and at an additional charge. The illustrations to the right demonstrate the effects of high loads being pulled around a small diameter drum. Such damage shortens the life span of a wire rope and may lead to more frequent replacement of this critical component. *Photos courtesy of Wire Rope Users Manual, Third Edition, Second Printing.*

Q: Will the Fulcrum be available in Air and Hydraulic versions?
A: Air ("A" series) and hydraulic ("H" series) are available upon request. Please contact Client Services with your requirements so they may provide a quotation.

Q: What about design modifications to meet special applications?
A: "All you have to do is ask." 30-40% of our business is providing customized solutions for specific applications. We recognize that not all jobs are created equal and that the most cost-effective solutions may not be in an off-the-shelf item. We've designed and manufactured winches for applications as simple as moving bags of lettuce, to as intricate as installing critical payloads on space vehicles.

Line Speed Specifications (US)

Frame	Pulling model 15:1 *D/d* ratio	Lifting model 18:1 *D/d* ratio	Std drum length in.	hp	Line pull, layer (lbs) 1st	mid	full	Std line speed, layer (fpm) 1st	mid	full	Wire rope size in.	Drum capacity, layer (ft) 1st	mid	<2 layers(1)	full(2)
3	EP5300-17-18	EL5300-17-18	18	3	5300	4000	3200	17	23	28	1/2	84	387	768	1066
3	EP6700-20-17		18	5	6700	4900	4200	20	28	32	9/16	75	351	578	840
3		EL6000-23-18	18	5	6000	4900	4200	23	28	32	9/16	84	277	506	768
4	EP8200-23-24	EP8200-23-24	24	7.5	8200	6200	5000	23	30	37	5/8	111	515	1024	1421
4	EP11700-13-27		24	5	11700	8500	7200	13	17	21	3/4	93	443	733	1070
4		EL9200-23-24	24	7.5	9200	7700	7100	23	28	30	3/4	120	394	548	892
5	EP15900-19-24		24	10	15900	11900	10200	19	26	30	7/8	103	481	790	1145
5		EL14100-22-24	24	10	14100	11700	10100	22	26	30	7/8	117	385	699	1059
5	EP20600-19-24		24	15	20600	16400	13600	19	24	29	1	90	305	566	872
5		EL16400-20-24	24	15	16400	14900	13600	20	22	24	1	114	240	378	686
6	EP26000-17-24		24	20	26000	18900	16000	17	23	28	1-1/8	91	433	718	1048
6		EL21300-21-24	24	20	21300	17700	16300	21	25	27	1-1/8	112	371	518	1026
7	EP31900-20-24		24	20	31900	26000	22000	20	24	28	1-1/4	101	338	619	1127
7		EL27000-22-24	24	20	27000	22700	21000	22	28	30	1-1/4	120	395	549	892
7	EP38400-20-24		24	25	38400	30800	25700	20	25	30	1-3/8	92	310	573	881
7		EL32600-19-24	24	20	32600	29500	27000	19	21	22	1-3/8	109	230	362	659
8	EP45600-18-30		30	30	45600	37200	31500	18	22	26	1-1/2	127	423	776	1186
8		EL42400-20-30	30	30	42400	35100	29900	20	24	28	1-1/2	137	453	826	1255

Line Speed Specifications (Metric)

Frame	Pulling model 15:1 *D/d* ratio	Lifting model 18:1 *D/d* ratio	Std drum length mm	hp	Line pull, layer (kg) 1st	mid	full	Std line speed, layer (mpm) 1st	mid	full	Wire rope size (mm)	Drum capacity, layer (m) 1st	mid	<2 layers(1)	full(2)
3	EP5300-17-18	EL5300-17-18	457	3	2409	1818	1455	5	7	9	13	26	118	234	325
3	EP6700-20-17		457	5	3045	2227	1909	6	9	10	14	23	107	176	256
3		EL6000-23-18	457	5	2727	2227	1909	7	9	10	14	26	84	154	234
4	EP8200-23-24	EP8200-23-24	610	7.5	3727	2818	2273	7	9	11	16	34	157	312	433
4	EP11700-13-27		610	5	5318	3864	3273	4	5	6	20	28	135	223	326
4		EL9200-23-24	610	7.5	4182	3500	3227	7	9	9	20	37	120	167	272
5	EP15900-19-24		610	10	7227	5409	4636	6	8	9	22	31	147	241	349
5		EL14100-22-24	610	10	6409	5318	4591	7	8	9	22	36	117	213	323
5	EP20600-19-24		610	15	9364	7455	6182	6	7	9	26	27	93	173	266
5		EL16400-20-24	610	15	7455	6773	6182	6	7	7	26	35	73	115	209
6	EP26000-17-24		610	20	11818	8591	7273	5	7	9	28	28	132	219	320
6		EL21300-21-24	610	20	9682	8045	7409	6	8	8	28	34	113	158	313
7	EP31900-20-24		610	20	14500	11818	10000	6	7	9	32	31	103	189	344
7		EL27000-22-24	610	20	12273	10318	9545	7	9	9	32	37	120	167	272
7	EP38400-20-24		610	25	17455	14000	11682	6	8	9	36	28	95	175	269
7		EL32600-19-24	610	20	14818	13409	12273	6	6	7	36	33	70	110	201
8	EP45600-18-30		762	30	20727	16909	14318	5	7	8	40	39	129	237	362
8		EL42400-20-30	762	30	19273	15955	13591	6	7	9	40	42	138	252	383

(1) <2 layers = full drum less 2 layers for working
(2) full = full drum for storage

Drum Lengths

Frame	Pulling	Lifting	Available Drum Length in. (mm) 18 (457)	24 (610)	30 (762)	36 (914)	42 (1067)	48 (1219)	54 (1372)
3	EP5300-18	EL5300-18	Std	–	Opt	–	Opt	–	–
3	EP6700-23	EL6700-25	Std	–	Opt	–	Opt	–	–
4	EP8200-19	EL8200-19	–	Std	–	Opt	–	Opt	–
4	EP11700-14	EL9200-18	–	Std	–	Opt	–	Opt	–
5	EP15900-21	EL14100-23	–	Std	–	Opt	–	Opt	–
5	EP20600-21	EL16400-26	–	Std	–	Opt	–	Opt	–
6	EP26000-18	EL21300-23	–	Std	–	Opt	–	Opt	
7	EP31900-21	EL27000-24	–	Std	–	Opt	–	Opt	–
7	EP38400-25	EL32600-25	–	Std	–	Opt	–	Opt	–
8	EP45600-21	EL42400-23	–	–	Std	–	Opt	–	Opt

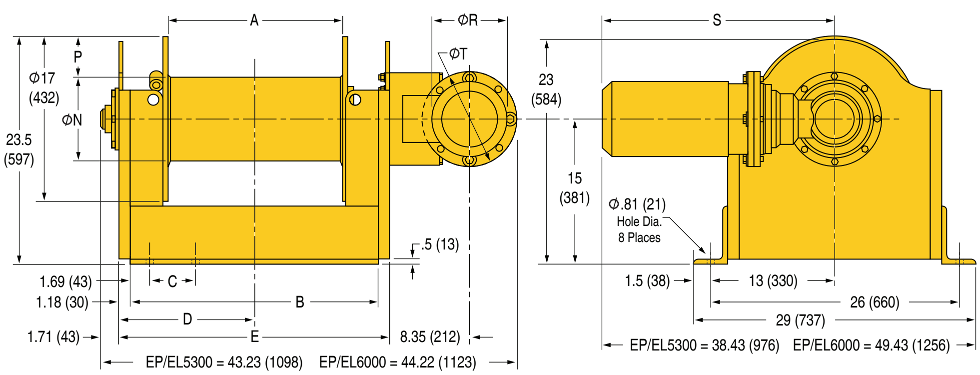
Note: Dimensions are for standard base models only and subject to change. For optional drum lengths and gearbox combinations please contact the factory for dimensional drawings.

Dimensions (Standard Winch Model)

Pulling

Frame	Model	"A" Std Drum in.	"A" Std Drum mm	B in.	B mm	C in.	C mm	in.	mm	E in.	E mm	N in.	N mm	P in.	P mm	R in.	R mm	S in.	S mm	T in.	T mm
3	EP5300-17-	18	457	25.89	658	7.50	190	14.12	359	28.25	718	8.62	219	4.19	106	7.76	197	23.93	608	9.84	250
3	EP6700-20-	18	457	25.89	658	7.50	190	14.12	359	28.25	718	8.62	219	4.19	106	10.83	275	34.93	887	11.81	300
4	EP8200-23-	24	610	32.35	822	9.75	248	17.88	454	35.75	908	10.75	273	5.86	149	7.76	197	23.93	608	9.84	250
4	EP11700-13-	24	610	32.35	822	9.75	248	17.88	454	35.75	908	10.75	273	5.86	149	7.76	197	23.93	608	9.84	250
5	EP15900-19-	24	610	34.64	879	7.63	193	19.25	488	38.50	977	14.00	356	7.00	178	10.83	275	33.80	858	11.81	300
5	EP20600-19-	24	610	34.64	879	7.63	193	19.25	488	38.50	977	14.00	356	7.00	178	10.83	275	34.93	887	13.78	350
6	EP26000-17-	24	610	36.51	927	6.62	168	20.25	514	40.50	1028	16.00	406	9.00	229	13.03	331	40.72	1034	13.78	350
7	EP31900-20-	24	610	36.65	931	8.12	206	20.82	529	41.65	1058	20.00	508	9.00	229	13.03	331	40.72	1034	13.78	350
7	EP38400-20-	24	610	36.65	931	8.12	206	20.82	529	41.65	1058	20.00	508	9.00	229	13.03	331	43.56	1106	13.78	350
8	EP45600-18-	30	762	42.50	1080	9.50	241	24.75	629	49.50	1257	24.00	610	10.50	267	13.03	331	43.56	1106	13.78	350
Lifting																					
3	EL5300-17-	18	457	25.89	658	7.50	190	14.12	359	28.25	718	8.62	219	4.19	106	7.76	197	23.93	608	9.84	250
3	EL6000-23-	18	457	25.89	658	7.50	190	14.12	359	28.25	718	9.75	248	3.63	92	10.83	275	34.93	887	11.81	300
4	EP8200-23-	24	610	32.35	822	9.75	248	17.88	454	35.75	908	10.75	273	5.86	149	7.76	197	23.93	608	9.84	250
4	EL9200-23-	24	610	32.35	822	9.75	248	17.88	454	35.75	908	14.00	356	4.00	102	7.76	197	23.93	608	9.84	250
5	EL14100-22-	24	610	34.64	879	7.63	193	19.25	488	38.50	977	16.00	406	6.00	152	10.83	275	33.80	858	11.81	300
5	EL16400-20-	24	610	34.64	879	7.63	193	19.25	488	38.50	977	18.00	457	5.00	127	10.83	275	34.93	887	13.78	350
6	EL21300-21-	24	610	36.51	927	6.62	168	20.25	514	40.50	1028	20.00	508	7.00	178	13.03	331	40.72	1034	13.78	350
7	EL27000-22-	24	610	36.65	931	8.12	206	20.82	529	41.65	1058	24.00	610	7.00	178	13.03	331	40.72	1034	13.78	350
7	EL32600-19-	24	610	36.65	931	8.12	206	20.82	529	41.65	1058	24.00	610	7.00	178	13.03	331	43.56	1106	13.78	350
8	EL42400-20-	30	762	42.50	1080	9.50	241	24.75	629	49.50	1257	26.00	660	9.50	241	13.03	331	43.56	1106	13.78	350

Frame 3



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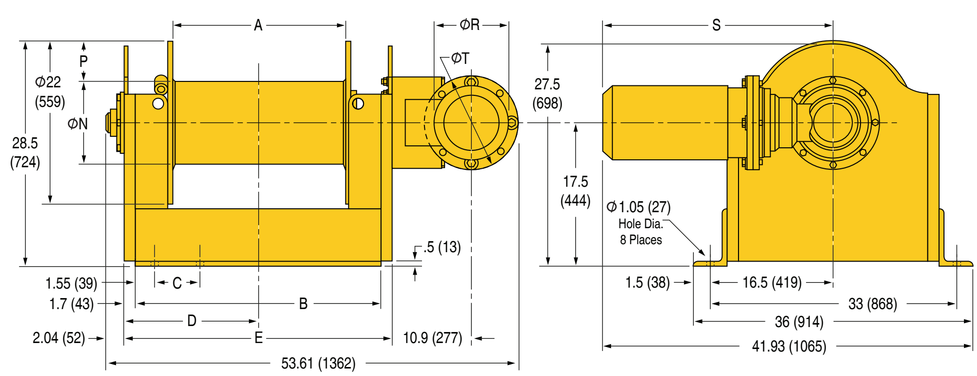
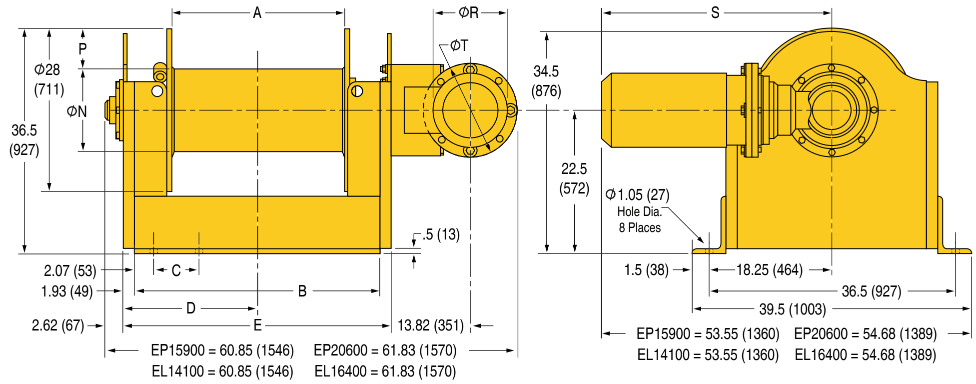


Note: Dimensions are for standard base models only and subject to change. For optional drum lengths and gearbox combinations please contact the factory for dimensional drawings.

Dimensions

Frame 5



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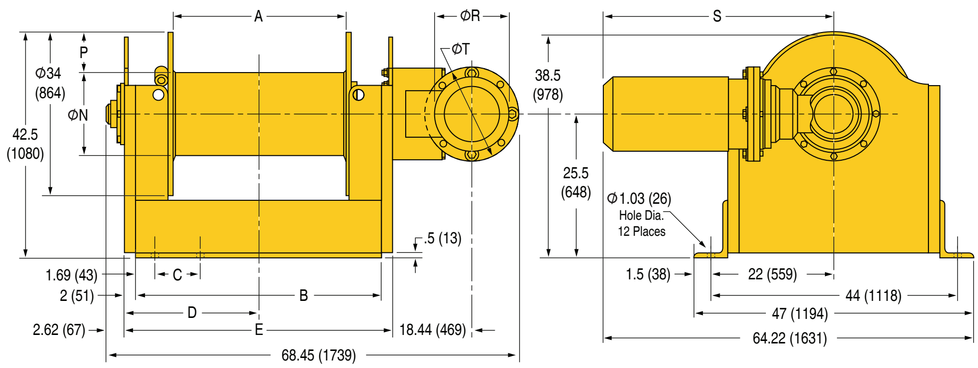

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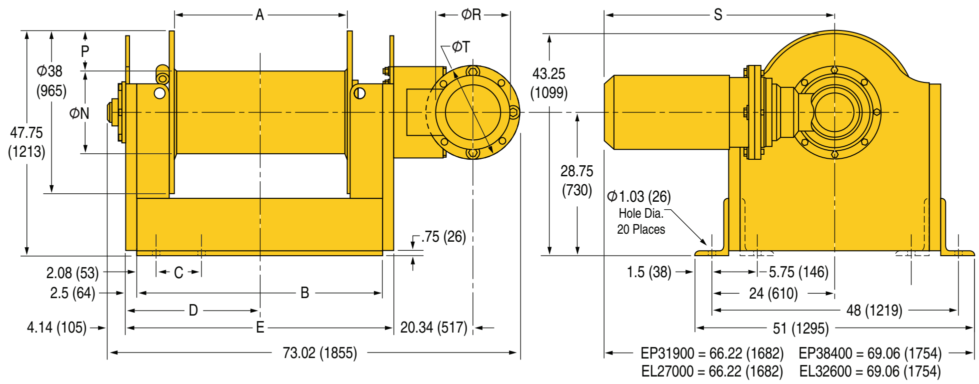
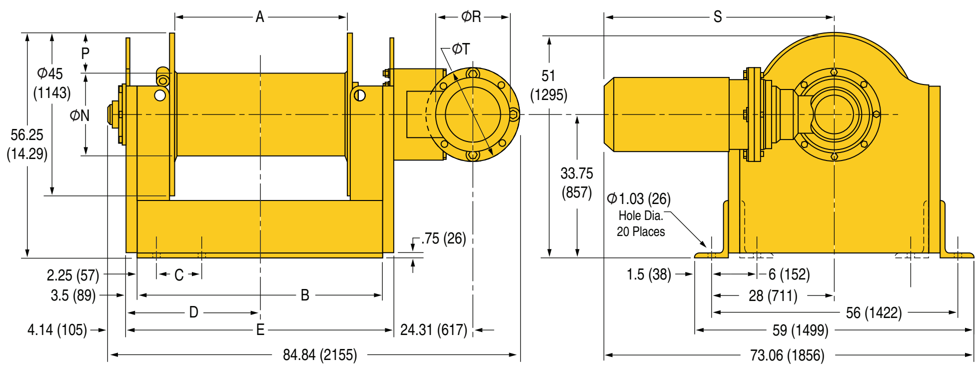


Frame 8



Note: Dimensions are for standard base models only and subject to change. For optional drum lengths and gearbox combinations please contact the factory for dimensional drawings.

Fulcrum versatility provides...

Winch Standard Options

- Drum divider flanges
- Mainline disconnect with "on-off" on pendent
- Free-spooling clutch
- Grooved drums
- Space heater in motor and control boxes
- Hand crank for manual operation in the event of power failure
- Drum locking pin
- Marine duty, IEEE45 motor
- Mirror image versions
- Marine 812-X paint specification
- Press roller on drum
- NEMA 4 upper and lower, rotary limit switches
- Drum guards
- Manual level wind and drum guard combinations
- Dual speed motors
- Electronic overload limiter
- Sandblast/Carbozinc surface preparations

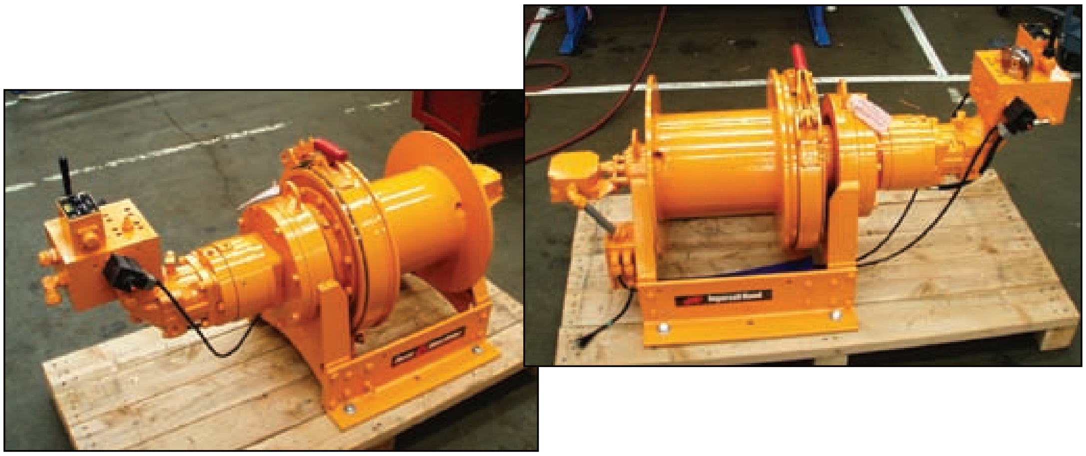
50,000 pound hose positioning winch

38,400 pound railway car moving winch

Other engineered options available upon request

- Horizontal load reversing drums
- Multiple brakes
- Explosion proof motors and control systems
- Programmable logic controls (PLC)
- Variable frequency (speed) drives (VFD) and vector duty motors
- Wireless infrared and radio controls
- Man Riding winches
- European Machinery Directive compliant models
- Hydraulic and air versions
- Custom paint coating systems and colors

21,300 pound maintenance winch with dual brakes and vector duty motor



16,400 pound hydraulic pipe handling winch

Custom launch vehicle payload handling winch

Man Rider™ winches

Explosion proof motors and controls

Extended drums

IR Winch Check List

Fax: 206-624-6265; Toll Free: 866-273-3278; email: WinchandHoistSolutions@irco.com

Ingersoll Rand

This form should accompany all winch inquiries. Use of this check list will help minimize changes after the order has been entered.

Distributor ____________________ End user ____________________

Contact name ____________________ Contact name ____________________

Fax/phone no. ____________________ Fax/phone no. ____________________

Reference no. (order/inquiry/bid) Reference no. (order/inquiry/bid)

General description/model or application requirements (please describe in detail the application and provide a sketch or drawing if possible).

____

____ Quantity ____________________

Power source:

- ❑ Manual ____________________
- ❑ Air (pressure, flow) ____________________
- ❑ Electric (cycles, phase, voltage) ____________________
- ❑ Hydraulic (pressure, flow) ____________________

Lifting or pulling application ____________________ How far/how high ____________________

Selected winch capacity ____________________ Winch speed? ____________________ fpm

Speed at mid-drum, top or first wrap layer? ____________________ fpm

Drum storage ____________________ Rope diameter ____________________ in./min

Duty cycle (if known) ____________________ Environment ____________________

Time required to complete lift or pull (speed) ____________________ fpm

Control type (local, remote, electrical voltage. Include maximum distance.) ____________________

____

Special standards or documents required? ____________________ Name/no. ____________________

Special paint/color/coating? ____________________ Details ____________________

Special manufacturing requirements? ____________________ QA/QC ____________________

____

Options:

Brakes Manual ____________ Auto ____________ Band ____________

Disc ____________ Special ____________

Drum Standard ____________ Other length ____________ Flange ____________

Grooving ____________ Divider flange ____________

Drum guard ____________ (fixed/movable)

Air line equipment (FRL's, muffler, tension manifold) ____________________

Other options ____________________

____

Attach additional sheets if required and sketches if possible.

Winch and Hoist Solutions Limited Warranty

Ingersoll-Rand (IR) warrants to the original user its Winch and Hoist Solutions Products to be free of defects in material and workmanship for a period of one year ***(two years for all Fulcrum™ electric winches)*** from the date of purchase. IR will repair without cost any Product found to be defective, including parts and labor charges; or at its option, will replace such Products or refund the purchase price less a reasonable allowance for depreciation in exchange for the Product. Repairs or replacements are warranted for the remainder of the original warranty period. If any Product proves defective within its original one year warranty period, it should be returned to any Authorized Hoist and Winch Service Distributor, transportation prepaid, with proof of purchase or warranty card.

This warranty does not apply to Products which IR has determined to have been misused or abused, improperly maintained by the user, or where the malfunction or defect can be attributed to the use of non-genuine IR parts. IR makes no other warranty, and all implied warranties including any warranty of merchantability or fitness for a particular purpose are limited to the duration of the expressed warranty period as set forth above. IR's maximum liability is limited to the purchase price of the Product and in no event shall IR be liable for any consequential, indirect, incidental, or special damages of any nature arising from the sale or use of the Product, whether based on contract, tort, or otherwise.

Note: Some states do not allow limitations on incidental or consequential damages or how long an implied warranty lasts so that the above limitations may not apply to you. This warranty gives you specific legal rights and you may also have other rights which may vary from state to state.

Fulcrum Two Year Limited Warranty

The IR Winch and Hoist Solutions line of powered winches and hoists proudly incorporates over 80 years of combined engineering and manufacturing expertise to build rugged and quality equipment for the most demanding applications in the world. Backed by decades of experience and offices world-wide, IR's warranty is as solid as its heritage; Ingersoll-Rand guarantees its Winch and Hoist Solutions Products to be free of defects in material and workmanship for a period of ***two years*** on all Fulcrum electric winches or we'll repair (or replace it) for free.


Warranty Registration

Complete this form and drop it in the mail or FAX it to: Ingersoll-Rand, Inc., 1-206-624-6265

Model Number | Serial Number | Purchase Date

Your Name | Title | Phone Number

Company Name | E-mail | Fax Number

Address | State | Zip Code

City | Distributor Address | State | Zip Code

Distributor Name Where Purchased

Type of Business: ☐ Construction ☐ Petro-Chemical ☐ Oil Drilling ☐ Manufacturing ☐ Mining ☐ Shipbuilding ☐ Other:

What influenced your decision to buy: ☐ Price ☐ Quality ☐ Features ☐ Reliability ☐ Availability ☐ Support ☐ Other:

Product used for: ☐ Lifting ☐ Pulling

Please describe application:

Ingersoll Rand

MHD55319/010103

Ingersoll Rand

Office and distributors in principal cities throughout the world. Contact the nearest Ingersoll-Rand office for the name and address of the distributor in your country or write to: Ingersoll-Rand, 2724 Sixth Avenue South, Seattle, WA 98134 USA

United States Regional Sales Offices

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Phone: (615) 672-0321 Fax: (615) 672-0801

For Technical Support:
Ingersoll-Rand Winch and Hoist Solutions
2724 Sixth Avenue South, Seattle, WA 98134
Phone: (206) 624-0466 Fax: (206) 624-6265
Toll Free: (866) 273-3278
Email: WinchandHoistSolutions@irco.com
Website: www.WinchandHoistSolutions.com
www.fulcrumwinch.com

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Australia Ingersoll-Rand Ltd.
Landmark Corporate Centre
Level 2, 454-472 Nepean Highway, Frankston, Vic. Australia 3199
Phone: (61) 3-8781-1600 Fax: (61) 3-8781-1611

WARNING: This equipment is not designed for transporting people or lifting loads over people. It is the user's responsibility to determine the suitability of this product for any particular use and to check compliance with applicable regulations. Before installation, see maintenance and operations manual for additional warnings and precautions.

Call 1-800-IR HOIST (474-6478) for the distributor nearest you.
Visit our website at: www.WinchandHoistSolutions.com

Form No. MHD55327/082305 Printed in U.S.A./2K

Fulcrum Winches

ANSI-RAB QMS ACCREDITED BSI REGISTERED
FM 53539

HPe™ High Performance Ergonomics

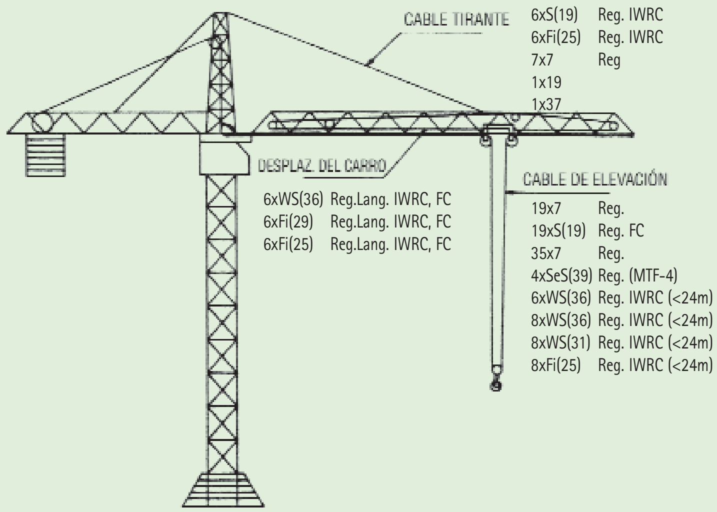
CABLES DE ACERO

GALVANIZADOS Y NO GALVANIZADOS

DE ASCENSOR

ESPECIALES

CABLES PARA GRÚAS



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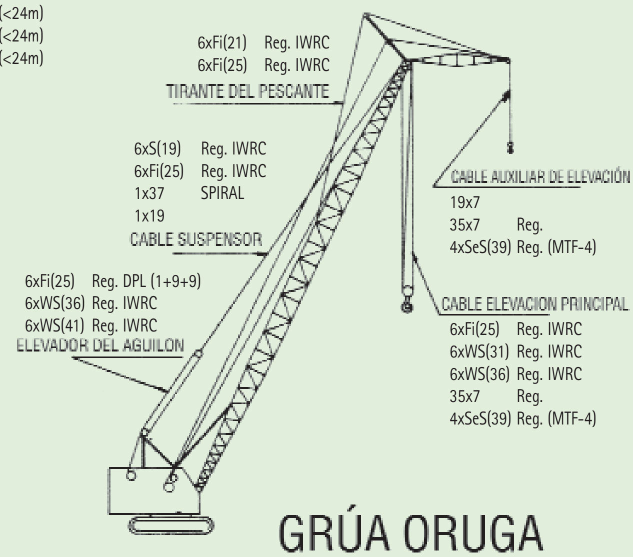

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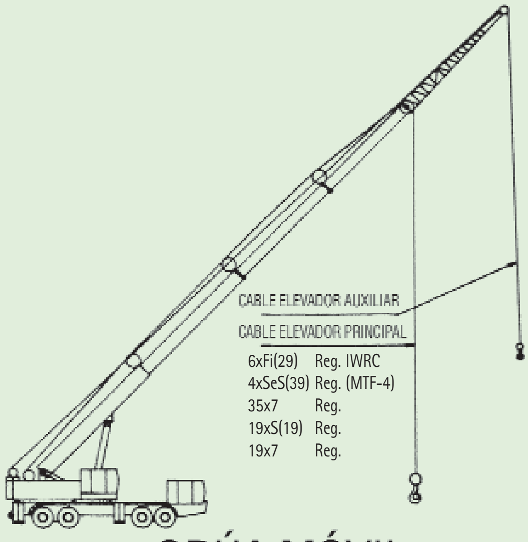
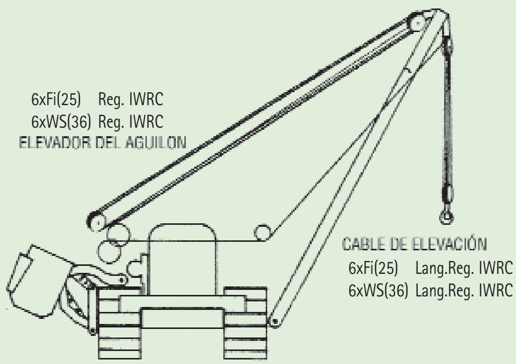


GRÚA MÓVIL



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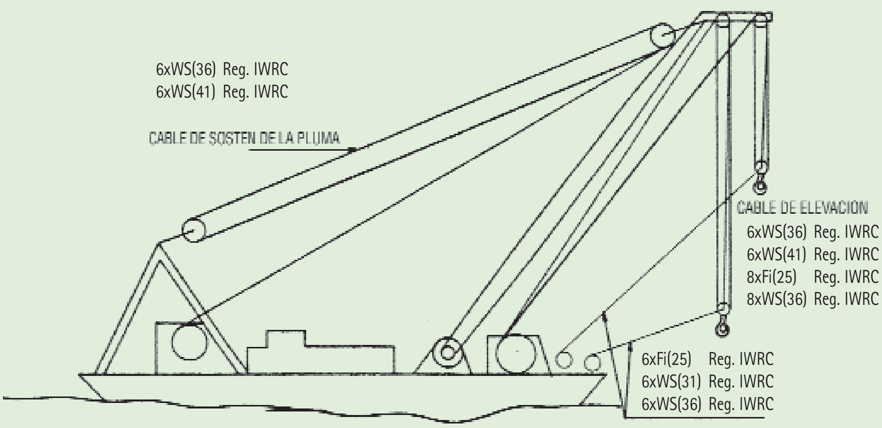

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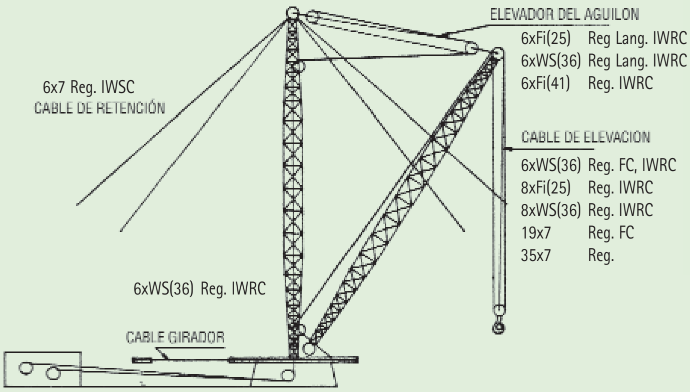
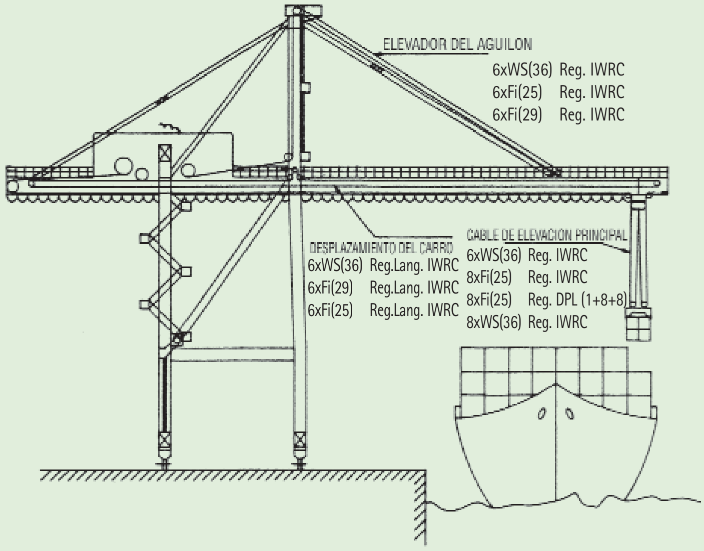
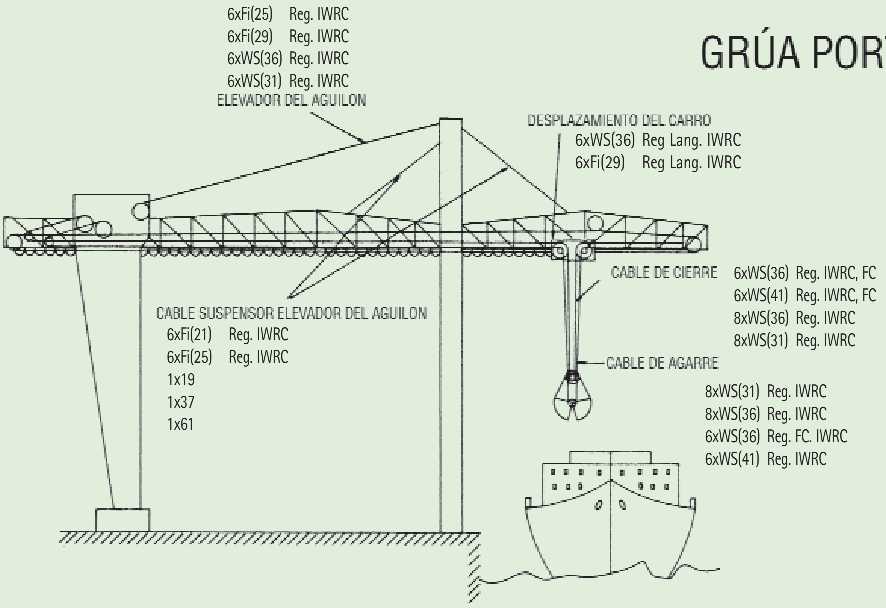


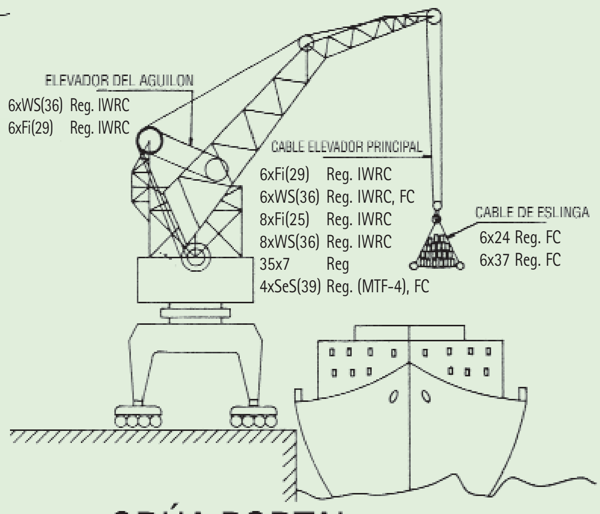
GRÚA FIJA



GRÚA PORTA-CONTENEDORES

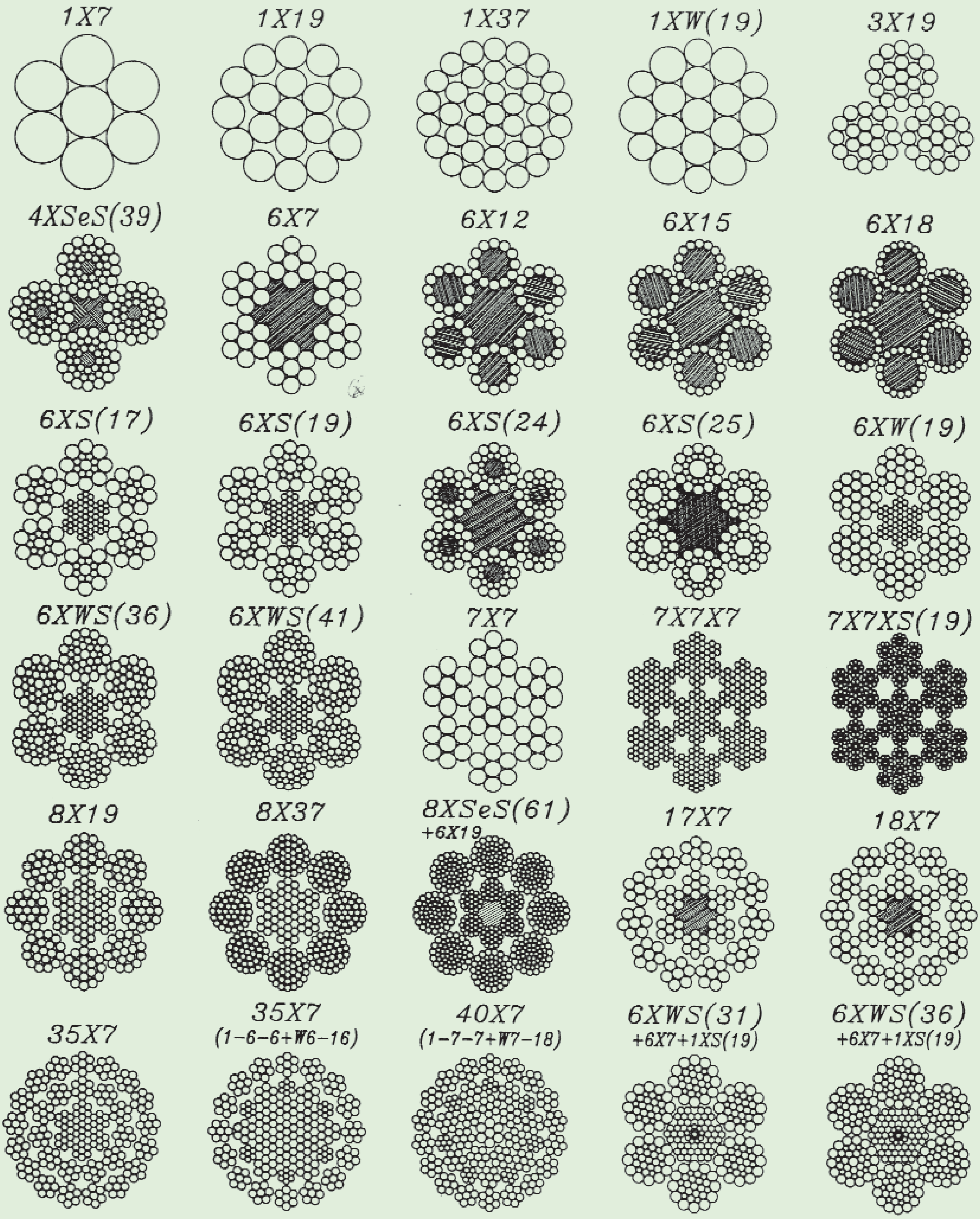


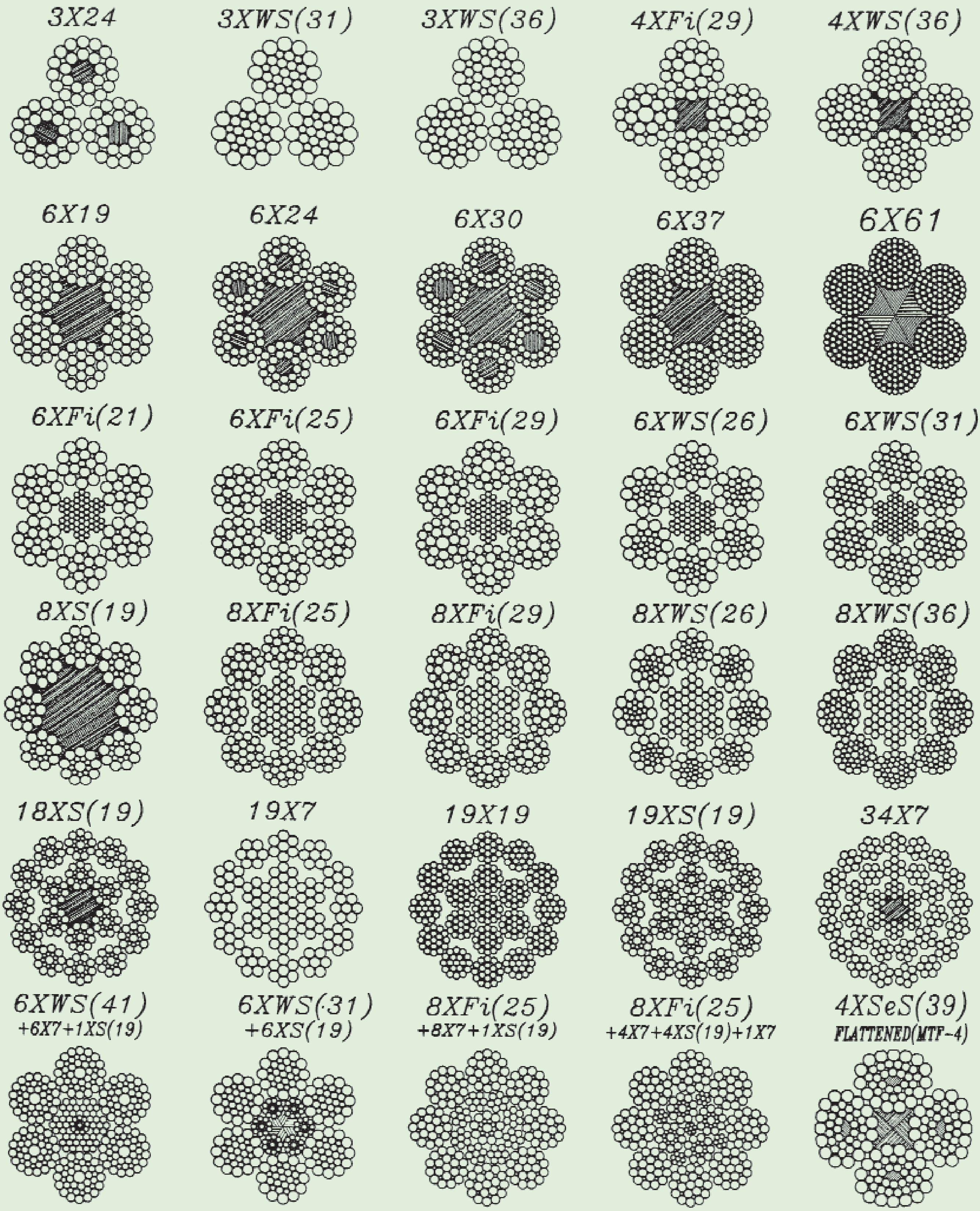
GRÚA DE DESCARGA



GRÚA PORTAL

CONSTRUCIÓN DE CABLES



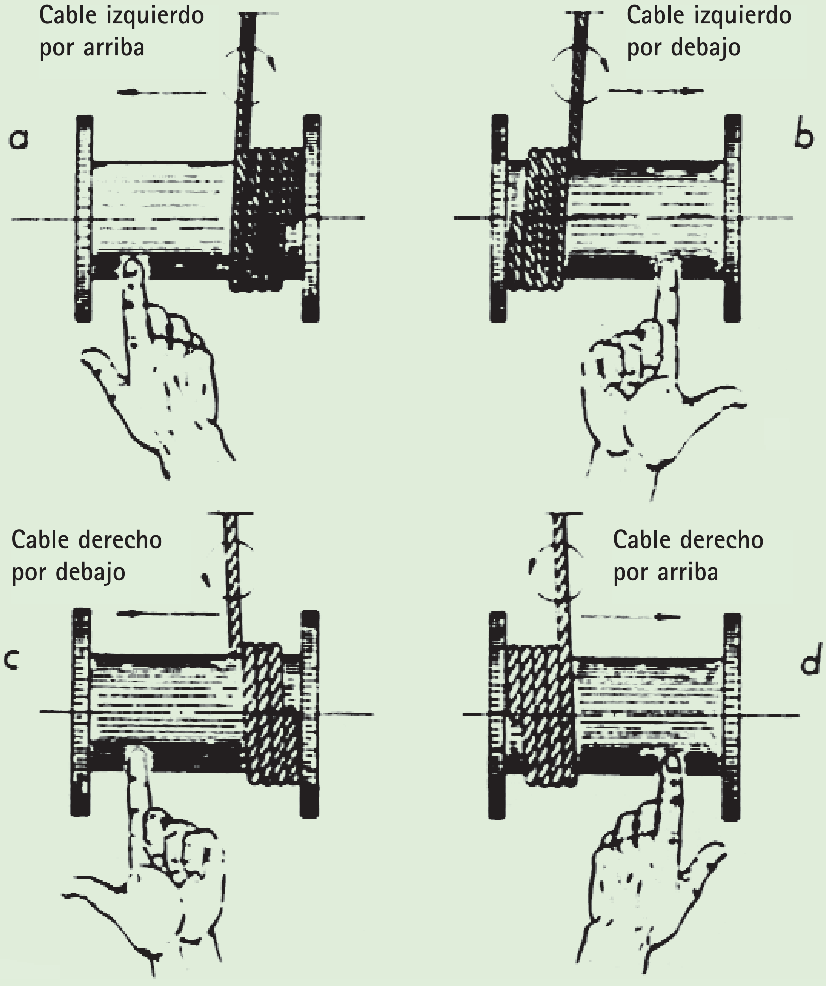

3X24
3XWS(31)
3XWS(36)
4XFi(29)
4XWS(36)
6X19
6X24
6X30
6X37
6X61
6XFi(21)
6XFi(25)
6XFi(29)
6XWS(26)
6XWS(31)
8XS(19)
8XFi(25)
8XFi(29)
8XWS(26)
8XWS(36)
18XS(19)
19X7
19X19
19XS(19)
34X7
6XWS(41) +6X7+1XS(19)
6XWS(31) +6XS(19)
8XFi(25) +8X7+1XS(19)
8XFi(25) +4X7+4XS(19)+1X7
4XSeS(39) FLATTENED(MTF-4)

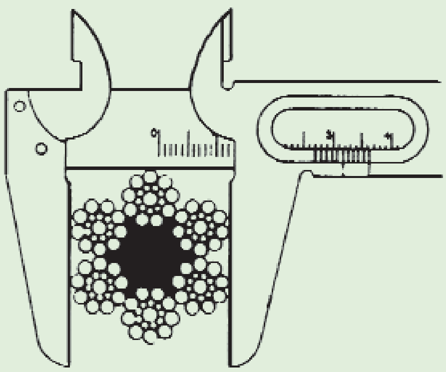
NORMA CONVENIENTE DE ARROLLAMIENTO DE LOS CABLES EN LOS TAMBORES

Es muy importante que estas reglas sean respetadas. Su incumplimiento implica que las adujas del cable se solapen y entrecrucen, ocasionando el aplastamiento y deformación de los cordones.

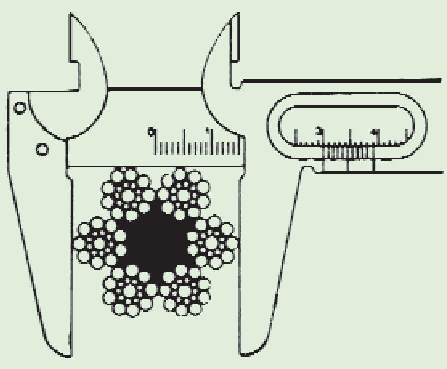
En la figura inferior reflejamos la norma a seguir: Para los cables de cableado a la derecha se emplea la mano izquierda, y para los cableados a izquierda la mano derecha. Ambas manos se colocan con la palma hacia abajo, si el cable se enrolla o desenrolla por arriba del tambor, y con la palma hacia arriba es si se enrolla o desenrrolla por debajo.

El sentido de enrollamiento del cable queda señalado por el dedo pulgar de la mano que se emplee, en dirección, SIEMPRE, de dedo meñique a dedo pulgar.



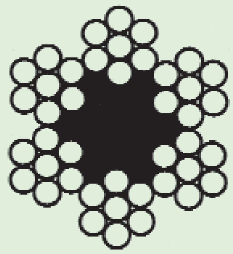


MAL CALIBRADO



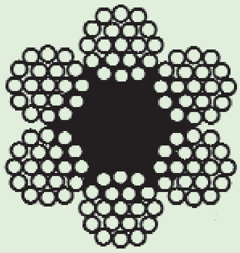
BIEN CALIBRADO

Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
1006071NGD02A	2	0,0143	239
1006071NGD03A	3	0,0322	538
1006071NGD04A	4	0,0572	957
1006071NGD05A	5	0,0894	1.500
1006071NGD06A	6	0,1290	2.150
1006071NGD07A	7	0,1750	2.930



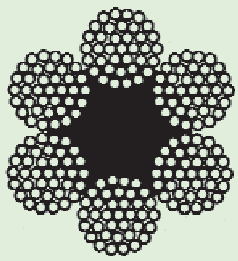
COMPOSICIÓN
6 x 7 + 1
Galvanizado
(180 kg/mm²)

Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
1006191NGD03A	3	0,0311	498
1006191NGD04A	4	0,0554	885
1006191NGD05A	5	0,0865	1.380
1006191NGD06A	6	0,1250	1.990
1006191NGD07A	7	0,1700	2.710
1006191NGD08A	8	0,2210	3.540
1006191NGD09A	9	0,2800	4.480
1006191NGD10A	10	0,3460	5.530
1006191NGD11A	11	0,4190	6.690
1006191NGD12A	12	0,4980	7.970
1006191NGD13A	13	0,5850	9.350
1006191NGD14A	14	0,6780	10.800
1006191NGD16A	16	0,8860	14.200
1006191NGD18A	18	1,1200	17.900
1006191NGD20A	20	1,3800	22.100
1006191NGD22A	22	1,6700	26.800
1006191NGD24A	24	1,9900	31.900



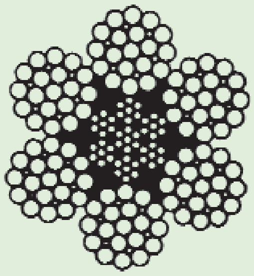
COMPOSICIÓN
6 x 19 + 1
Galvanizado
(180 kg/mm²)

Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
1006371NGD06A	6	0,125	1.910
1006371NGD07A	7	0,170	2.600
1006371NGD08A	8	0,221	3.400
1006371NGD09A	9	0,280	4.300
1006371NGD10A	10	0,346	5.310
1006371NGD11A	11	0,419	6.420
1006371NGD12A	12	0,498	7.640
1006371NGD13A	13	0,585	8.970
1006371NGD14A	14	0,678	10.400
1006371NGD16A	16	0,886	13.600
1006371NGD18A	18	1,120	17.200
1006371NGD20A	20	1,380	21.200
1006371NGD22A	22	1,670	25.700
1006371NGD24A	24	1,990	30.600
1006371NGD26A	26	2,340	35.900
1006371NGD28A	28	2,710	41.600
1006371NGD30A	30	3,125	47.724
1006371NGD32A	32	3,540	54.300
1006371NGD34A	34	4,010	61.367
1006371NGD36A	36	4,480	68.800
1006371NGD40A	40	5,540	84.900
1006371NGD44A	44	6,700	103.000
1006371NGD48A	48	7,970	122.000
1006371NGD50A	50	8,650	133.100
1006371NGD55A	55	10,500	161.100
1006371NGD60A	60	12,500	191.700



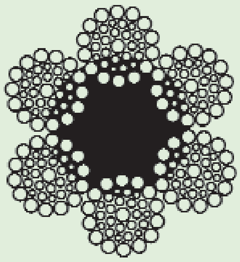
COMPOSICIÓN
6 x 37 + 1
Galvanizado
(180 kg/mm²)

COMPOSICIÓN
6 x 25 (7 x 7 + 0)
Negro
(180 kg/mm²)



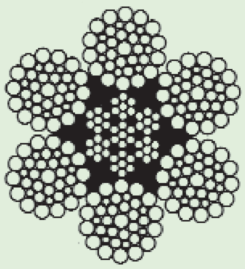
Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100625MNND08A	8	0,267	4.200
100625MNND09A	9	0,339	5.310
100625MNND10A	10	0,418	6.570
100625MNND11A	11	0,506	7.950
100625MNND12A	12	0,602	9.450
100625MNND13A	13	0,707	11.100
100625MNND14A	14	0,820	12.900
100625MNND15A	15	0,941	14.800
100625MNND16A	16	1,070	16.800

COMPOSICIÓN
6 x 36 + 1 WS
Negro
(180 kg/mm²)



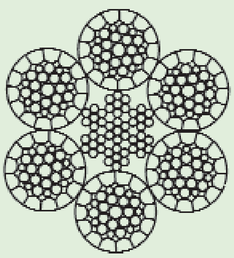
Código T. D.	Código T. I.	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
1006361NND20A	1006361NNI20A	20	1,520	23.800
1006361NND22A	1006361NNI22A	22	1,840	28.700
1006361NND24A	1006361NNI24A	24	2,19	34.200
1006361NND26A	1006361NNI26A	26	2,570	40.100
1006361NND28A	1006361NNI28A	28	2,980	46.600
1006361NND30A	1006361NNI30A	30	3,435	53.437
1006361NND32A	1006361NNI32A	32	3,890	60.800
1006361NND34A	1006361NNI34A	34	4,410	68.682
1006361NND36A	1006361NNI36A	36	4,930	77.000
1006361NND38A	1006361NNI38A	38	5,500	85.737
1006361NND40A	1006361NNI40A	40	6,080	95.000

COMPOSICIÓN
6 x 36 + (7 x 7 + 0) WS
Negro
(180 kg/mm²)



Código T. D.	Código T. I.	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100636MNND14A	100636MNNI14A	14	0,820	12.600
100636MNND16A	100636MNNI16A	16	1,070	16.400
100636MNND18A	100636MNNI18A	18	1,350	20.800
100636MNND20A	100636MNNI20A	20	1,670	25.600
100636MNND22A	100636MNNI22A	22	2,020	31.000
100636MNND24A	100636MNNI24A	24	2,410	36.900
100636MNND25A	100636MNNI25A	25	2,620	40.039
100636MNND26A	100636MNNI26A	26	2,830	43.300
100636MNND28A	100636MNNI28A	28	3,280	50.300
100636MNND30A	100636MNNI30A	30	3,780	57.744
100636MNND32A	100636MNNI32A	32	4,280	65.700
100636MNND34A	100636MNNI34A	34	4,850	74.169
100636MNND36A	100636MNNI36A	36	5,420	83.100
100636MNND38A	100636MNNI38A	38	6,050	92.957
100636MNND40A	100636MNNI40A	40	6,690	103.000
100636MNND45A	100636MNNI45A	45	8,470	130.300
100636MNND50A	100636MNNI50A	50	10,500	160.800
100636MNND55A	100636MNNI55A	55	12,700	194.600
100636MNND60A	100636MNNI60A	60	15,100	231.600

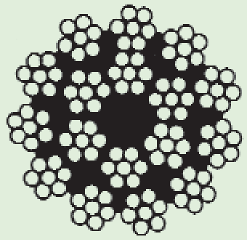
COMPOSICIÓN
6 x 36 + (7x7+0) COMPACTO
Negro
(180 kg/mm²)



Código T. D.	Código T. I.	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100636MCND14A	100636MCNI14A	14	0,89	15.489
100636MCND16A	100636MCNI16A	16	1,16	19.006
100636MCND18A	100636MCNI18A	18	1,47	24.055
100636MCND20A	100636MCNI20A	20	1,82	29.695
100636MCND22A	100636MCNI22A	22	2,20	36.009
100636MCND24A	100636MCNI24A	24	2,62	42.766
100636MCND26A	100636MCNI26A	26	3,07	50.188
100636MCND28A	100636MCNI28A	28	3,56	57.378
100636MCND30A	100636MCNI30A	30	4,09	66.822
100636MCND32A	100636MCNI32A	32	4,65	76.025
100636MCND34A	100636MCNI34A	34	5,25	85.828
100636MCND36A	100636MCNI36A	36	5,89	93.895

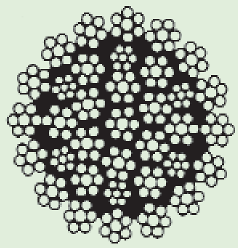
CABLES DE ACERO

Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
1001771NNL04B	4	0,06	1.053
1001771NNL05B	5	0,10	1.645
1001771NNL06B	6	0,14	2.369
1001771NNL07B	7	0,19	3.410
1001771NNL08B	8	0,25	4.470
1001771NNL09B	9	0,32	5.640
1001771NNL10B	10	0,40	6.970
1001771NNL11B	11	0,48	7.951
1001771NNL12B	12	0,56	10.040
1001771NNL13B	13	0,66	11.111
1001771NNL14B	14	0,77	13.700
1001771NNL16B	16	1,01	17.900
1001771NNL18B	18	1,30	22.600
1001771NNL20B	20	1,59	27.900



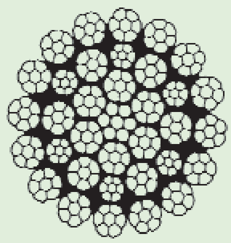
CABLES ANTIGIRATORIOS COMPOSICIÓN 17 x 7 + 1 Lang Negro ($200\ kg/mm^2$)

Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100357MWNL10B	10	0,45	7.990
100357MWNL12B	12	0,64	11.500
100357MWNL13B	13	0,75	12.538
100357MWNL14B	14	0,87	16.330
100357MWNL15B	15	1,00	17.329
100357MWNL16B	16	1,13	20.650
100357MWNL17B	17	1,28	22.833
100357MWNL18B	18	1,43	26.830
100357MWNL19B	19	1,59	28.236
100357MWNL20B	20	1,75	32.550
100357MWNL21B	21	1,93	34.352
100357MWNL22B	22	2,11	39.550
100357MWNL24B	24	2,51	46.670
100357MWNL26B	26	3,01	55.650
100357MWNL28B	28	3,39	63.000
100357MWNL30B	30	3,92	73.850
100357MWNL32B	32	4,41	82.720
100357MWNL34B	34	5,01	93.680
100357MWNL36B	36	5,63	105.000



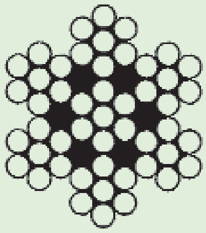
CABLES ANTIGIRATORIO COMPOSICIÓN 35 x 7 Warrington Negro ($200\ kg/mm^2$)

Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100357MCNL10C	10	0,515	10.000
100357MCNL12C	12	0,742	14.300
100357MCNL13C	13	0,870	16.800
100357MCNL14C	14	1,01	19.400
100357MCNL15C	15	1,16	21.300
100357MCNL16C	16	1,27	25.400
100357MCNL17C	17	1,44	28.600
100357MCNL18C	18	1,61	32.200
100357MCNL19C	19	1,79	35.800
100357MCNL20C	20	1,97	39.700
100357MCNL21C	21	2,17	43.700
100357MCNL22C	22	2,38	48.100
100357MCNL24C	24	2,82	57.200
100357MCNL25C	25	3,10	62.100
100357MCNL26C	26	3,39	67.100
100357MCNL28C	28	3,81	77.900
100357MCNL30C	30	4,41	89.400
100357MCNL32C	32	5,00	101.800
100357MCNL34C	34	5,64	114.400
100357MCNL36C	36	6,33	128.700



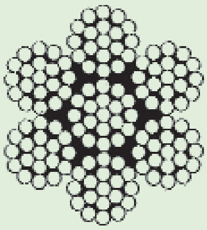
CABLES ANTIGIRATORIOS COMPOSICIÓN 35 x 7 Warrington Compacto Negro ($220\ kg/mm^2$)

CABLES DE ACERO INOXIDABLE AISI 316 COMPOSICIÓN 7 x 7 (160 Kg/mm²)



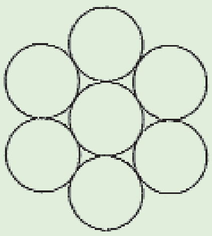
Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100077MNID02E	2	1,57	229
10077MNID025E	2,5	2,70	358
100077MNID03E	3	3,54	516
100077MNID04E	4	6,29	915
100077MNID05E	5	9,83	1.440
100077MNID06E	6	14,20	2.060
100077MNID07E	7	19,30	2.800
100077MNID08E	8	25,20	3.670

CABLES DE ACERO INOXIDABLE AISI 316 COMPOSICIÓN 7 x 19 (160 Kg/mm²)



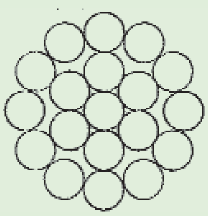
Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100719MNID03E	3	3,42	480
100719MNID04E	4	6,09	850
100719MNID05E	5	9,52	1.320
100719MNID06E	6	13,80	1.900
100719MNID08E	8	24,3	3.390
100719MNID09E	9	30,8	4.300
100719MNID10E	10	38,1	5.300
100719MNID12E	12	54,8	7.650
100719MNID13E	13	64,3	8.970
100719MNID14E	14	74,6	10.400
100719MNID16E	16	97,4	12.800
100719MNID18E	18	123	16.080

CORDÓN DE ACERO INOXIDABLE AISI 316 COMPOSICIÓN 1 x 7 (160 Kg/mm²)



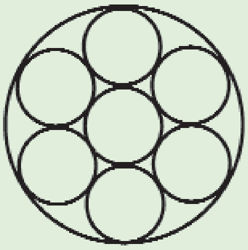
Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100017MNII02E	2	2,01	370
100017MNII03E	3	4,52	785
100017MNII04E	4	8,03	1.390
100017MNII05E	5	12,6	2.180
100017MNII06E	6	18,1	3.140
100017MNII07E	7	24,6	4.270
100017MNII08E	8	32,1	5.570
100017MNII09E	9	40,7	7.050
100017MNII10E	10	50,2	8.100

CORDÓN DE ACERO INOXIDABLE AISI 316 COMPOSICIÓN 1 x 19 (160 Kg/mm²)



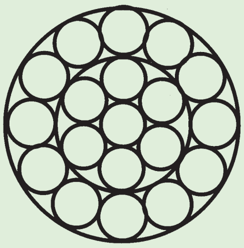
Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100119MNII02E	2	1,98	336
100119MNII03E	3	4,46	756
100119MNII04E	4	7,93	1.340
100119MNII05E	5	12,4	2.100
100119MNII06E	6	17,8	3.030
100119MNII07E	7	24,3	4.120
100119MNII08E	8	31,7	5.380
100119MNII09E	9	40,1	6.810
100119MNII10E	10	49,5	8.400
100119MNII11E	11	59,9	10.200
100119MNII12E	12	71,3	12.100
100119MNII13E	13	83,7	14.000
100119MNII14E	14	97,1	16.200
100119MNII16E	16	127,0	20.400

CORDÓN 1 x 7 + 0 Galvanizado (160 kg/mm²)



Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100017MNGD04E	4	0,0813	1.390
100017MNGD05E	5	0,1260	2.180
100017MNGD06E	6	0,1810	3.140
100017MNGD07E	7	0,2460	4.270
100017MNGD08E	8	0,3210	5.570
100017MNGD09E	9	0,4070	7.050
100017MNGD10E	10	0,5020	8.710

CORDÓN 1 x 19 + 0 Galvanizado (160 kg/mm²)



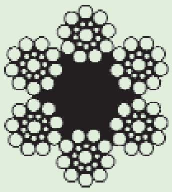
Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100119MNGI04E	4	0,0793	1.340
100119MNGI05E	5	0,1240	2.100
100119MNGI06E	6	0,1780	3.030
100119MNGI07E	7	0,2430	4.120
100119MNGI08E	8	0,3170	5.380
100119MNGI09E	9	0,4010	6.810
100119MNGI10E	10	0,4950	8.400
100119MNGI11E	11	0,5990	10.200
100119MNGI12E	12	0,7130	12.100
100119MNGI13E	13	0,8370	14.200
100119MNGI14E	14	0,9710	16.500
100119MNGI15E	15	1,1100	18.900
100119MNGI16E	16	1,2700	21.500

- Los diámetros más habituales son los reflejados en estas tablas. Para otras medidas rogamos consultar.
- Disponemos de otras construcciones según la aplicación o maquinaria.
- Galvanización normal, reforzada, y doble galvanizada.

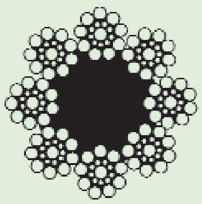
CABLES
DE ASCENSOR

INTRODUCCIÓN

Todos los cables ofrecidos por BEZABALA se suministran de acuerdo a las normas UNE 36-715-89 y UNE-EN 12385-5 (estas normas especifican las características de los cables de acero utilizados como elementos de suspensión de ascensores y de montacargas que se desplazan en guías verticales o guías inclinadas con un ángulo que no sea superior a 15º respecto a la vertical).



Codigo T.D.	Codigo T.I.	Diámetro nominal mm	6 x 19 Alma textil Resistencia 1370/1770
1006191SND08D	1006191SNI08D	8	31,7
1006191SND09D	1006191SNI09D	9	40,1
1006191SND10D	1006191SNI10D	10	49,5
1006191SND11D	1006191SNI11D	11	59,9
1006191SND12D	1006191SNI12D	12	71,3
1006191SND13D	1006191SNI13D	13	83,7
1006191SND14D	1006191SNI14D	14	97,1
1006191SND16D	1006191SNI16D	16	127,0



Codigo T.D.	Codigo T.I.	Diámetro nominal mm	8 x 19 Alma textil Resistencia 1370/1770
1008191SND08D	1008191SNI08D	8	28,1
1008191SND09D	1008191SNI09D	9	35,6
1008191SND10D	1008191SNI10D	10	44
1008191SND11D	1008191SNI11D	11	53,2
1008191SND12D	1008191SNI12D	12	63,3
1008191SND13D	1008191SNI13D	13	74,3
1008191SND14D	1008191SNI14D	14	86,1
1008191SND16D	1008191SNI16D	16	113,0

CÓMO REALIZAR UN PEDIDO

Cuando se consulta o se pide un cable, éste deberá estar definido con exactitud, detallando la siguiente información:

- Construcción del cable
- Diámetro
- Sentido y tipo de torsión
- Lubricación
- Carga de rotura específica
- Embalaje
- Uso del cable (tracción, regulador, compensación)
- Normas de fabricación

CUERDA POLYESTIL PARA COMPENSACIÓN

Características:

- Cuerda 20 mm de diámetro. Peso: 1 kg/metro
- Cuerda 30 mm de diámetro. Peso: 2 kg/metro
- Cuerda 34 mm de diámetro. Peso: 3 kg/metro

RECOMENDACIONES

- Los cables de ascensor se suministran preformados y en acabado gris brillante o galvanizado.

- Según cada aplicación se recomiendan cables de 6 u 8 cordones tipos SL (19), WA (19) ó FI (25) y alma textil.

- Para cables con el mismo diámetro y el mismo tipo de cordón, los alambres en los cables de 6 cordones tienen mayor diámetro que los alambres en cable de 8 cordones, por este motivo los cables de 6 cordones tienen mayor resistencia contra acuñaduras.

  Sin embargo son menos flexibles y por esto requieren poleas y tambores de mayor diámetro y no son adecuados para utilizar en ascensores de alta velocidad o donde se requieran plegados invertidos.

- Si el acuñamiento es menor, pueden usarse cables de 8 cordones que son más resistentes a la fatiga por flexión.

- Los cables de 8 cordones tienen mayor superficie de contacto con las poleas que los cables de 6 cordones.

- Al cambiar un cable de ascensor debe cambiarse el juego completo al mismo tiempo. Si se instalan cables nuevos no deben mezclarse con usados ya que el alargamiento sería diferente con lo que tendríamos una diferente distribución de cargas en los cables.

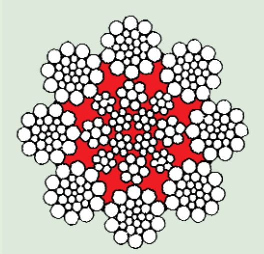
CABLES ESPECIALES

NO ANTIGIRATORIOS

ANTIGIRATORIOS

CABLE ESPECIAL Q810 V

8 Cordones
Alma plastificada
Cruzado normal
Galvanizado



Resistencia Construcción Diámetro (mm)	Peso (kg/m)	Código	200 Kg/ mm² Carga de rot. mín.(kg)	220 Kg/ mm² Carga de rot. mín. (kg)	Código
12	0,62	100Q810VGD12B	11.315	12.470	100Q810VGD12C
13	0,73	100Q810VGD13B	13.150	14.492	100Q810VGD13C
14	0,82	100Q810VGD14B	14.883	16.401	100Q810VGD14C
15	0,94	100Q810VGD15B	17.125	18.873	100Q810VGD15C
16	1,1	100Q810VGD16B	19.878	21.906	100Q810VGD16C
17	1,22	100Q810VGD17B	22.120	24.377	100Q810VGD17C
18	1,37	100Q810VGD18B	24.771	27.298	100Q810VGD18C
19	1,55	100Q810VGD19B	28.236	31.118	100Q810VGD19C
20	1,7	100Q810VGD20B	30.887	34.039	100Q810VGD20C
21	1,87	100Q810VGD21B	33.945	37.409	100Q810VGD21C
22	2,04	100Q810VGD22B	37.003	40.779	100Q810VGD22C
24	2,45	100Q810VGD24B	44.343	48.867	100Q810VGD24C
26	2,86	100Q810VGD26B	51.886	57.180	100Q810VGD26C
28	3,32	100Q810VGD28B	60.347	66.504	100Q810VGD28C
30	3,82	100Q810VGD30B	69.215	76.278	100Q810VGD30C
32	4,4	100Q810VGD32B	79.715	87.849	100Q810VGD32C
34	4,91	100Q810VGD34B	88.991	98.072	100Q810VGD34C
36	5,51	100Q810VGD36B	100.000		
38	6,07	100Q810VGD38B	110.092		
40	6,8	100Q810VGD40B	123.445		
42	7,69	100Q810VGD42B	135.882		
44	8,5	100Q810VGD44B	149.032		
46	9,28	100Q810VGD46B	162.793		
48	10,1	100Q810VGD48B	178.695		
50	10,92	100Q810VGD50B	192.762		
52	11,7	100Q810VGD52B	207.747		

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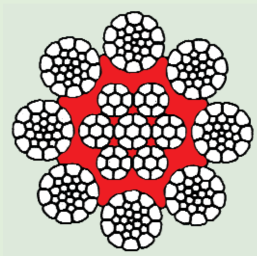
CABLE ESPECIAL QS816 V

8 Cordones
Alma plastificada
Cruzado normal
Compactado
Galvanizado



Resistencia Construcción Diámetro (mm)	Peso (kg/m)	Código	180 Kg/ mm² Carga de rot. mín.(kg)	200 Kg/ mm² Carga de rot. mín. (kg)	Código
10	0,46	10QS816VGD10A	8.257	9.143	10QS816VGD10B
11	0,55	10QS816VGD11A	9.888	10.949	10QS816VGD11B
12	0,69	10QS816VGD12A	11.927	13.207	10QS816VGD12B
13	0,81	10QS816VGD13A	14.373	15.916	10QS816VGD13B
14	0,93	10QS816VGD14A	16.514	18.286	10QS816VGD14B
15	1,06	10QS816VGD15A	18.858	20.883	10QS816VGD15B
16	1,20	10QS816VGD16A	21.407	23.705	10QS816VGD16B
17	1,35	10QS816VGD17A	23.955	26.527	10QS816VGD17B
18	1,55	10QS816VGD18A	26.809	29.687	10QS816VGD18B
19	1,71	10QS816VGD19A	30.785	34.090	10QS816VGD19B
20	1,89	10QS816VGD20A	33.639	37.250	10QS816VGD20B
21	2,15	10QS816VGD21A	38.124	42.217	10QS816VGD21B
22	2,34	10QS816VGD22A	41.590	46.055	10QS816VGD22B
23	2,54	10QS816VGD23A	45.362	50.231	10QS816VGD23B
24	2,75	10QS816VGD24A	47.604	52.715	10QS816VGD24B
25	2,97	10QS816VGD25A	52.803	58.471	10QS816VGD25B
26	3,19	10QS816VGD26A	56.575	62.648	10QS816VGD26B
27	3,51	10QS816VGD27A	60.652	67.163	10QS816VGD27B
28	3,77	10QS816VGD28A	66.871	74.049	10QS816VGD28B
29	3,98	10QS816VGD29A	70.744	78.338	10QS816VGD29B
30	4,37	10QS816VGD30A	77.880	86.240	10QS816VGD30B
31	4,62	10QS816VGD31A	79.307	87.820	10QS816VGD31B
32	4,96	10QS816VGD32A	88.073	97.528	10QS816VGD32B
33	5,15	10QS816VGD33A	91.030	100.801	10QS816VGD33B
34	5,59	10QS816VGD34A	96.330	106.671	10QS816VGD34B
36	6,36	10QS816VGD36A	109.174	120.894	10QS816VGD36B
38	7,03	10QS816VGD38A	124.567	137.938	10QS816VGD38B
40	7,81	10QS816VGD40A	136.799	151.484	10QS816VGD40B
42	8,60	10QS816VGD42A	151.070	167.287	10QS816VGD42B
44	9,24	10QS816VGD44A	162.691	180.155	10QS816VGD44B
46	10,21	10QS816VGD46A	179.409	198.667	10QS816VGD46B
48	10,78	10QS816VGD48A	188.379	208.601	10QS816VGD48B

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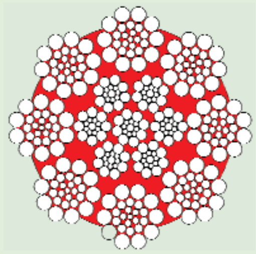
CABLE ESPECIAL HYFIL R8

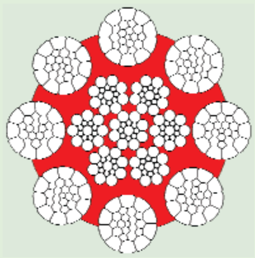
8 Cordones
Alma plastificada
Negro



Resistencia Construcción			200 Kg/ mm²
Diámetro (mm)	Peso (kg/m)	Código	Carga de rot. mín.(kg)
12	59	100826MNPD12B	11.000
14	80	100826MNPD14B	15.000
16	104	100826MNPD16B	19.500
18	132	100826MNPD18B	24.700
19	147	100826MNPD19B	27.500
20	167	100826MNPD20B	30.500
22	202	100826MNPD22B	36.900
24	240	100826MNPD24B	44.000
25	261	100826MNPD25B	47.700
26	282	100826MNPD26B	51.600
28	327	100826MNPD28B	59.800
30	375	100826MNPD30B	68.700
32	427	100826MNPD32B	78.200
34	482	100826MNPD34B	85.500
35	511	100826MNPD35B	90.700
36	540	100826MNPD36B	95.900
38	602	100826MNPD38B	106.900
42	735	100826MNPD42B	130.600
48	960	100826MNPD48B	170.600

CABLE ESPECIAL HYFIL C8

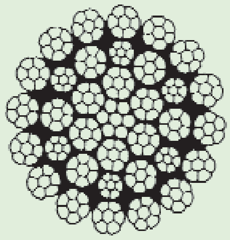
8 Cordones
Alma plastificada
Compactado
Negro



Resistencia Construcción			200 Kg/ mm²	220 Kg/ mm²	
Diámetro (mm)	Peso (kg/m)	Código	Carga de rot. mín.(kg)	Carga de rot. mín. (kg)	Código
12	64	100826MCPD12B	12.200	13.500	100826MCPD12C
14	87	100826MCPD14B	16.600	18.400	100826MCPD14C
16	114	100826MCPD16B	21.700	24.100	100826MCPD16C
18	144	100826MCPD18B	27.400	30.500	100826MCPD18C
19	161	100826MCPD19B	30.900	33.900	100826MCPD19C
20	178	100826MCPD20B	34.200	37.600	100826MCPD20C
22	216	100826MCPD22B	41.000	45.500	100826MCPD22C
24	257	100826MCPD24B	48.800	54.200	100826MCPD24C
25	279	100826MCPD25B	52.900	58.800	100826MCPD25C
26	301	100826MCPD26B	57.300	63.600	100826MCPD26C
28	349	100826MCPD28B	66.400	73.800	100826MCPD28C
30	401	100826MCPD30B	76.200	84.700	100826MCPD30C
32	456	100826MCPD32B	86.700	96.400	100826MCPD32C
34	515	100826MCPD34B	97.900	109.000	100826MCPD34C
35	546	100826MCPD35B	104.000	115.000	100826MCPD35C
36	577	100826MCPD36B	110.000	122.000	100826MCPD36C
38	640	100826MCPD38B	122.000	136.000	100826MCPD38C
40	705	100826MCPD40B	136.000	151.000	100826MCPD40C
42	777	100826MCPD42B	142.000	166.000	100826MCPD42C
48	1.020	100826MCPD48B	195.000	217.000	100826MCPD48C

CABLES ESPECIALES ANTIGIRATORIOS

Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100357MCNL10C	10	0,515	10.000
100357MCNL12C	12	0,742	14.300
100357MCNL13C	13	0,870	16.800
100357MCNL14C	14	1,01	19.400
100357MCNL15C	15	1,16	21.300
100357MCNL16C	16	1,27	25.400
100357MCNL17C	17	1,44	28.600
100357MCNL18C	18	1,61	32.200
100357MCNL19C	19	1,79	35.800
100357MCNL20C	20	1,97	39.700
100357MCNL21C	21	2,17	43.700
100357MCNL22C	22	2,38	48.100
100357MCNL24C	24	2,82	57.200
100357MCNL25C	25	3,10	62.100
100357MCNL26C	26	3,39	67.100
100357MCNL28C	28	3,81	77.900
100357MCNL30C	30	4,41	89.400
100357MCNL32C	32	5,00	101.800
100357MCNL34C	34	5,64	114.400
100357MCNL36C	36	6,33	128.700

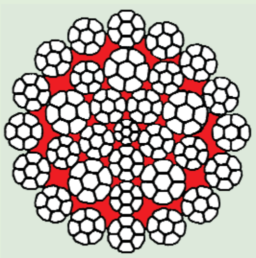


CABLES ANTIGIRATORIOS

35 x 7 Warrington
Compacto
(220 kg/mm²)

CABLE ESPECIAL TK 16

Antigiratorio
Alma plastificada
Cruzado normal
Compactado
Galvanizado

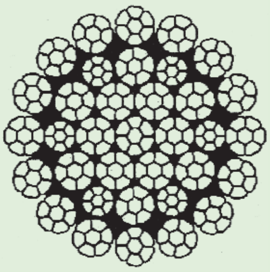


Resistencia Construcción			200 Kg/ mm²	220 Kg/ mm²	
Diámetro (mm)	Peso (kg/m)	Código	Carga de rot. mín.(kg)	Carga de rot. mín. (kg)	Código
8	0,34	100TK16CGD08B	5.770	6.218	100TK16CGD08C
9	0,42	100TK16CGD09B	7.329	7.951	100TK16CGD09C
10	0,53	100TK16CGD10B	9.225	9.684	100TK16CGD10C
11	0,63	100TK16CGD11B	10.907	12.029	100TK16CGD11C
12	0,76	100TK16CGD12B	12.946	14.067	100TK16CGD12C
13	0,89	100TK16CGD13B	15.596	16.412	100TK16CGD13C
14	1,02	100TK16CGD14B	17.431	18.960	100TK16CGD14C
15	1,25	100TK16CGD15B	20.489	22.120	100TK16CGD15C
16	1,41	100TK16CGD16B	23.140	25.178	100TK16CGD16C
17	1,59	100TK16CGD17B	26.198	28.440	100TK16CGD17C
18	1,75	100TK16CGD18B	30.173	32.212	100TK16CGD18C
19	1,97	100TK16CGD19B	33.231	35.882	100TK16CGD19C
20	2,18	100TK16CGD20B	36.493	39.959	100TK16CGD20C
21	2,36	100TK16CGD21B	40.367	43.833	100TK16CGD21C
22	2,69	100TK16CGD22B	44.241	47.910	100TK16CGD22C
23	2,92	100TK16CGD23B	48.318	51.784	100TK16CGD23C
24	3,05	100TK16CGD24B	52.192	57.187	100TK16CGD24C
25	3,37	100TK16CGD25B	56.881	61.978	100TK16CGD25C
26	3,54	100TK16CGD26B	61.570	66.871	100TK16CGD26C
27	3,81	100TK16CGD27B	66.565	72.171	100TK16CGD27C
28	4,21	100TK16CGD28B	71.560	78.084	100TK16CGD28C
29	4,49	100TK16CGD29B	76.860	83.486	100TK16CGD29C
30	4,76	100TK16CGD30B	82.569	89.093	100TK16CGD30C
32	5,40	100TK16CGD32B	93.374	101.427	100TK16CGD32C
34	6,08	100TK16CGD34B	105.097	114.985	100TK16CGD34C
36	6,77	100TK16CGD36B	118.145	128.338	100TK16CGD36C
38	7,67	100TK16CGD38B	132.314	143.731	100TK16CGD38C
40	8,43	100TK16CGD40B	139.144	152.396	100TK16CGD40C
42	9,28	100TK16CGD42B	153.415	167.890	100TK16CGD42C
44	10,17	100TK16CGD44B	167.992	183.894	100TK16CGD44C
46	11,03	100TK16CGD46B	182.263	199.490	100TK16CGD46C
48	12,02	100TK16CGD48B	198.471	217.227	100TK16CGD48C

Teufelberger

CABLE ESPECIAL TK 17

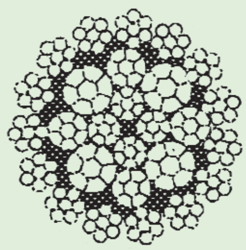
Antigiratorio
Compactado
Torsión Lang
Galvanizado



Resistencia Construcción			200 Kg/ mm²	220 Kg/ mm²	
Diámetro (mm)	Peso (kg/m)	Código	Carga de rot. min.(kg)	Carga de rot. min. (kg)	Código
9	0,42	100TK17CGD09B	7.034	7.747	100TK17CGD09C
10	0,54	100TK17CGD10B	8.665	9.888	100TK17CGD10C
11	0,65	100TK17CGD11B	10.907	11.927	100TK17CGD11C
12	0,75	100TK17CGD12B	12.844	13.761	100TK17CGD12C
13	0,91	100TK17CGD13B	14.985	16.718	100TK17CGD13C
14	1,04	100TK17CGD14B	17.125	19.164	100TK17CGD14C
15	1,21	100TK17CGD15B	20.285	22.324	100TK17CGD15C
16	1,36	100TK17CGD16B	23.344	24.975	100TK17CGD16C
17	1,53	100TK17CGD17B	25.994	28.236	100TK17CGD17C
18	1,71	100TK17CGD18B	29.358	31.498	100TK17CGD18C
19	1,90	100TK17CGD19B	32.416	35.066	100TK17CGD19C
20	2,06	100TK17CGD20B	35.576	38.124	100TK17CGD20C
21	2,26	100TK17CGD21B	38.838	41.590	100TK17CGD21C
22	2,53	100TK17CGD22B	43.017	46.687	100TK17CGD22C
23	2,75	100TK17CGD23B	47.197	50.765	100TK17CGD23C
24	3,06	100TK17CGD24B	52.701	56.473	100TK17CGD24C
25	3,32	100TK17CGD25B	56.575	61.264	100TK17CGD25C
26	3,56	100TK17CGD26B	60.958	65.647	100TK17CGD26C
27	3,84	100TK17CGD27B	65.341	70.846	100TK17CGD27C
28	4,14	100TK17CGD28B	69.623	76.351	100TK17CGD28C
29	4,39	100TK17CGD29B	74.924	81.040	100TK17CGD29C
30	4,69	100TK17CGD30B	80.632	86.544	100TK17CGD30C
32	5,31	100TK17CGD32B	91.233	97.961	100TK17CGD32C

CABLE ESPECIAL TK 12 (200 kg/mm²)

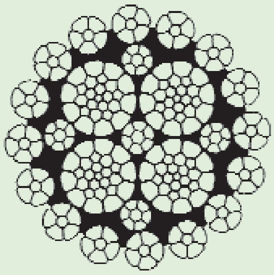
Antigiratorio
Cruzado normal o Lang
Cordones interior compactado
Galvanizado



Código	Ø (mm)	Peso (kg/m)	Carga de rotura mín. (kg)
100TK123CY07B	7	0,37	3.812
100TK123CY08B	8	0,40	4.985
100TK123CY09B	9	0,45	6.228
100TK123CY10B	10	0,50	7.717
100TK123CY11B	11	0,55	9.297
100TK123CY12B	12	0,60	11.213
100TK123CY13B	13	0,65	13.354
100TK123CY14B	14	0,70	15.392
100TK123CY15B	15	0,80	17.941
100TK123CY16B	16	0,85	20.082
100TK123CY17B	17	0,90	23.038
100TK123CY18B	18	0,95	25.688
100TK123CY19B	19	1,00	28.644
100TK123CY20B	20	1,05	31.702
100TK123CY21B	21	1,10	34.659
100TK123CY22B	22	1,15	38.124
100TK123CY23B	23	1,20	41.386
100TK123CY24B	24	1,25	45.260
100TK123CY25B	25	1,30	49.337
100TK123CY26B	26	1,35	52.803
100TK123CY27B	27	1,40	57.390
100TK123CY28B	28	1,45	61.774
100TK123CY29B	29	1,50	65.647
100TK123CY30B	30	1,55	70.438
100TK123CY32B	32	1,65	79.409
100TK123CY34B	34	1,75	89.908
100TK123CY35B	35	1,80	93.986
100TK123CY36B	36	1,85	101.223
100TK123CY38B	38	1,95	112.946
100TK123CY40B	40	2,05	124.057
100TK123CY42B	42	2,15	137.411
100TK123CY44B	44	2,25	150.561
100TK123CY46B	46	2,40	165.036
100TK123CY48B	48	2,30	180.224

CABLE ESPECIAL TK 16 EVOLUTION

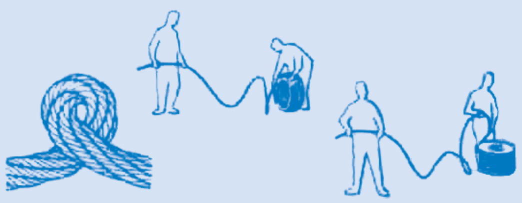
Antigiratorio



Resistencia Construcción Diámetro (mm)	Peso (kg/m)	Código	200 Kg/ mm² Carga de rot. mín.(kg)	220 Kg/ mm² Carga de rot. mín. (kg)	Código
12	0,74	100TK16EV012B	13.570	14.690	100TK16EV012C
13	0,87	100TK16EV013B	15.900	17.340	100TK16EV013C
14	1,02	100TK16EV014B	18.460	20.100	100TK16EV014C
15	1,17	100TK16EV015B	21.930	23.570	100TK16EV015C
16	1,34	100TK16EV016B	24.890	26.830	100TK16EV016C
17	1,50	100TK16EV017B	27.240	29.590	100TK16EV017C
18	1,68	100TK16EV018B	31.520	33.970	100TK16EV018C
19	1,86	100TK16EV019B	34.080	36.930	100TK16EV019C
20	2,07	100TK16EV020B	38.160	40.910	100TK16EV020C
21	2,25	100TK16EV021B	42.140	45.300	100TK16EV021C
22	2,50	100TK16EV022B	46.120	49.690	100TK16EV022C
23	2,75	100TK16EV023B	50.300	54.380	100TK16EV023C
24	2,97	100TK16EV024B	54.590	59.180	100TK16EV024C
25	3,25	100TK16EV025B	60.710	65.200	100TK16EV025C
25,4	3,30	100TK16EV254B	61.120	65.710	100TK16EV254C
26	3,50	100TK16EV026B	63.970	68.870	100TK16EV026C
27	3,78	100TK16EV027B	68.770	73.970	100TK16EV047C
28	4,07	100TK16EV028B	73.970	79.590	100TK16EV028C
28,57	4,09	100TK16EV285B	74.480	80.100	100TK16EV285C
29	4,27	100TK16EV029B	79.280	85.200	100TK16EV029C
30	4,57	100TK16EV030B	84.690	91.120	100TK16EV030C
32	5,20	100TK16EV032B	96.325	103.670	100TK16EV032C
34	5,88	100TK16EV034B	108.260	116.420	100TK16EV034C
36	6,59	100TK16EV036B	121.120	130.300	100TK16EV036C
38	7,34	100TK16EV038B	139.690	150.200	100TK16EV038C
40	8,13	100TK16EV040B	148.770	160.000	100TK16EV040C
42	8,97	100TK16EV042B	164.080	176.420	100TK16EV042C

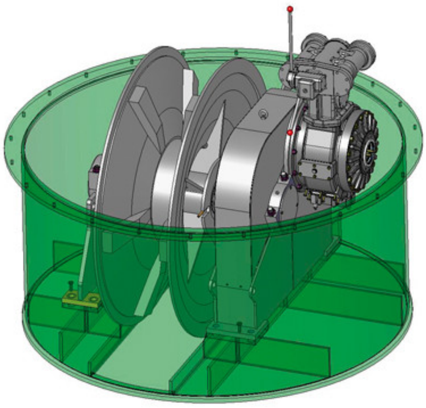
ATENCIÓN:

Cable con vicio (coca) debido a una mala acción de desenrrollar.



MACGREGOR | MENU

Chain pulling winches



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Contacts

Send us a contact request

Electric chain handling winches have variable frequency drives and allow for the safe use of various chain sizes by limiting the load on the chain to a preset value. They can be supplied as portable units with taylormade foundation for installation in chain locker hatches. Chain guide rollers and adjustable guide rollers for various chain sizes are also available.

Pull / speed:	40 kN at 0 - 100 m / min (for 127 mm chain) 70 kN at 0 - 60 m / min (for 70 mm chain)
Design:	Reduction gear with wheel protection, grease lubricated
Drive:	1 Hatlapa low pressure motor with built-on change-over valve and throttle valve with remote control for hauling-in/ paying-out
Weight:	approx. 4,200 kg without motor approx. 5,400 kg with motor

CNX 50

ELETTROPOMPE CENTRIFUGHE MONOBLOCCO INOX

APPLICAZIONI
Elettropompe centrifughe, monoblocco e monogirante adatte per il pompaggio di acqua pulita e di altri liquidi chimicamente e meccanicamente non aggressivi; la possibilità di installazione in qualunque posizione, fatta eccezione di quella che comporta la bocca aspirante rivolta verso l’alto. Unitamente alla forma costruttiva, che consente l’estrazione (back pull out) del motore con le parti rotanti della pompa, ed il successivo rimontaggio, senza rimozione del corpo pompa e delle tubazioni ad esso connesse, ne rende agevole e conveniente l’utilizzo per le più svariate esigenze in campo civile, agricolo, industriale o impiantistico in generale. Approvvigionamenti d’acqua, irrigazioni a pioggia o a scorrimento, alimentazioni autoclavi e sopraelevazioni di pressione, riscaldamento e condizionamento, qualsiasi altro impiego che comporta il travaso di liquidi puliti in genere.

APPLICATION
Centrifugal, monoblock and single-impeller electrical pumps are ideal for pumping clean water and other chemically and mechanically non-aggressive liquids. These system can be installed in any position, provided the inlet opening faces upwards, and, thanks to their special design - which allows back pull out of the motor and the rotary parts of the pump and subsequent re-assembly without having to remove the pump body and the pipes connected to it - can be easily and conveniently used for a wide variety of applications in civil, agricultural, industrial or general plant uses. Water supply, spray or flowing irrigation, autoclave feed, high pressure system, heating, conditioning and any other general service requiring transfer of clean liquids.

LIMITI D’IMPIEGO
- Temperatura liquido fino a 90°C
- Temperatura ambiente fino a 40°C
- Altezza d’aspirazione manometrica fino a 7 mt.
- Servizio continuo

MOTORE
- Motore elettrico ad induzione a 2 poli (n = 2850 min^{-1})
- Isolamento Classe F
- Protezione IP 55

MATERIALI

- Corpo pompa	Acciaio Inox AISI 304
- Flangia portatenuta	Acciaio Inox AISI 304
- Girante	Acciaio Inox AISI 304
- Albero motore	Acciaio Inox AISI 304
- Tenute meccaniche	Silicio/Silicio/NBR

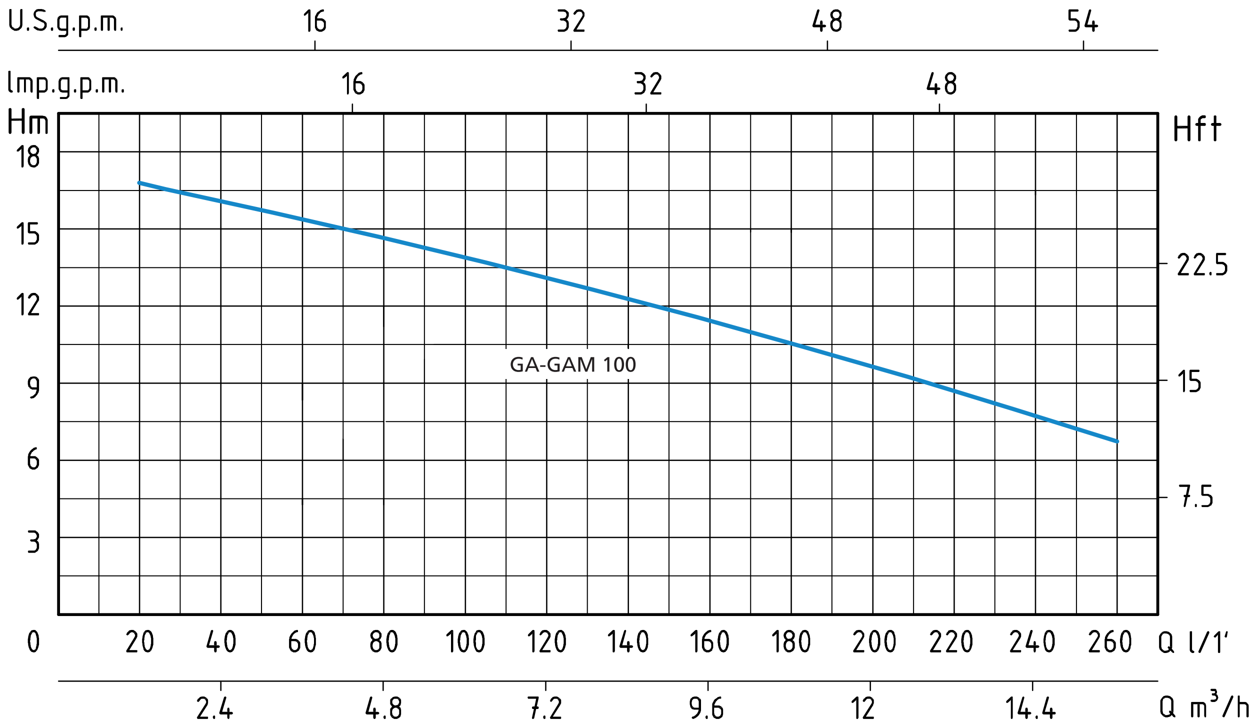
OPERATING CONDITIONS
- *Liquid temperature up to 90°C*
- *Ambient temperature up to 40°C*
- *Total suction lift up to 7 mt.*
- *Continuous duty*

MOTOR
- *Two-Pole induction motor (n = 2850 min^{-1})*
- *Insulation Class F*
- *Protection IP 55*

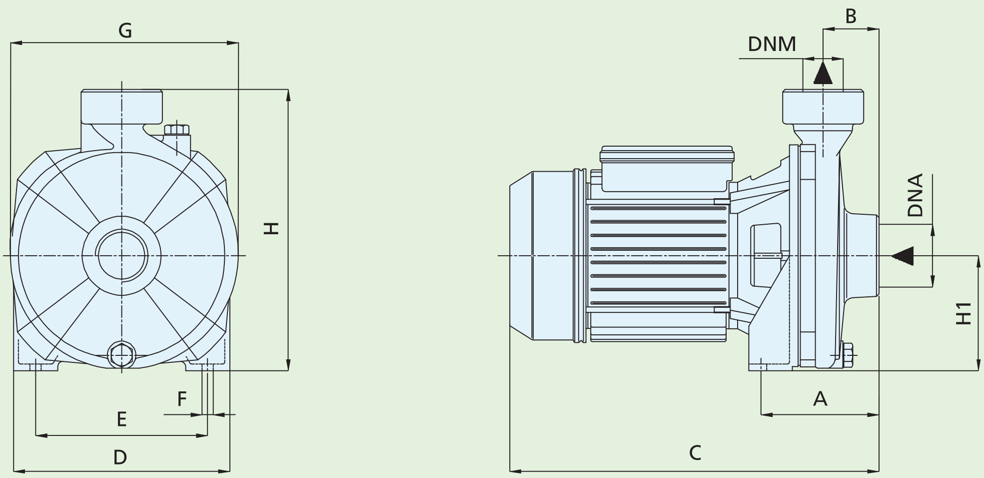
MATERIALS

- Pump body	*Stainless Steel AISI 304*
- Pump flange	*Stainless Steel AISI 304*
- Impeller	*Stainless Steel AISI 304*
- Shaft with rotor	*Stainless Steel AISI 304*
- Mechanical seal	*Silicon/Silicon/NBR*

TIPO *TYPE*	POTENZA NOMINALE *NOMINAL POWER*		POTENZA ASSORBITA *INPUT POWER*	Q = PORTATA - *CAPACITY*									
Trifase *Three-phase*	P2		P1	m^3/h	6	9	15	21	30	42	54	60	72
	HP	kW	kW	lt/1’	100	150	250	350	500	700	900	1000	1200
230/400V-50Hz				Prevalenza manometrica totale in m.C.A. - *Total head in meters w.c.*									
CNX 50-125/4	5,5	4	5,2	H (m)	24,2	24,2	23,9	23,6	22,6	20,7	18	14,8	
CNX 50-200/7,5	10	7,5	9,9		36,6	36,6	36,5	36,4	35,6	34,1	32	29,6	
CNX 50-200/11	15	11	14,4		51,5	51,5	51,3	51	50	49,3	48	45,6	
CNX 50-200/15	20	15	18,1		59,7	59,7	59,6	59,5	59,4	59	58	56,2	53
CNX 50-200/18,5	25	18,5	23		70,2	70,2	70,1	70	70	69,1	68	66,4	64



TIPO *TYPE*		POTENZA NOMINALE *NOMINAL POWER*		POTENZA ASSORBITA *INPUT POWER*	AMPERE		Q = PORTATA - *CAPACITY*										
Monofase *Single-phase*	Trifase *Three-phase*	P2		P1	Monofase *Single-phase*	Trifase *Three-phase*	m³/h	1,2	2,4	3,6	4,8	6	7,2	8,4	10,2	13,2	15,6
		HP	kW	kW			lt/1'	20	40	60	80	100	120	140	180	220	260
230V-50Hz	230/400V-50Hz				1 x 230V	3 x 400V	Prevalenza manometrica totale in m.C.A. - *Total head in meters w.c.*										
GAM 100	GA 100	1	0,75	1	4,5	1,7	H (m)	16,6	16	15,2	14,8	13,7	13	12,2	10,5	8,8	7



TIPO *TYPE*		DIMENSIONI mm - *DIMENSIONS mm*											DIMENSIONI *DIMENSIONS* mm			PESO *WEIGHT*
Monofase *Single-phase*	Trifase *Three-phase*	A	B	C	D	E	F	G	H	H1	DNA	DNM	P	L	H	Kg
GAM 100	GA 100	128	44	311	182	144	10	182	232	94	1" ½	1" ½	200	330	250	15

CXM

ELETTROPOMPE CENTRIFUGHE MONOGIRANTI INOX

APPLICAZIONI

Elettropompe centrifughe monogiranti adatte a coprire richieste di piccole, medie e grandi portate.
Utilizzo in impianti domestici, agricoli e industriali, distribuzione automatica dell'acqua per mezzo di piccoli serbatoi (autoclave), per irrigazione a pioggia e a scorrimento in giardino e agricoltura, per aumentare, in derivazione la pressione di rete degli acquedotti.

APPLICATION

Single impeller centrifugal pumps suitable to cover any small, medium or large capacity request; for domestic, agricultural and industrial purposes; with automatic water distribution through small and medium sized tanks; for sprinkler and flood irrigation systems in gardening and agriculture; to increase in derivation system pressure in aqueducts.

LIMITI D'IMPIEGO
- Temperatura liquido fino a 90°C
- Temperatura ambiente fino a 40°C
- Altezza d'aspirazione manometrica fino a 7 mt.
- Servizio continuo

MOTORE
- Motore elettrico ad induzione a 2 poli (n = 2850 min^{-1})
- Isolamento Classe F
- Protezione IP 55

MATERIALI

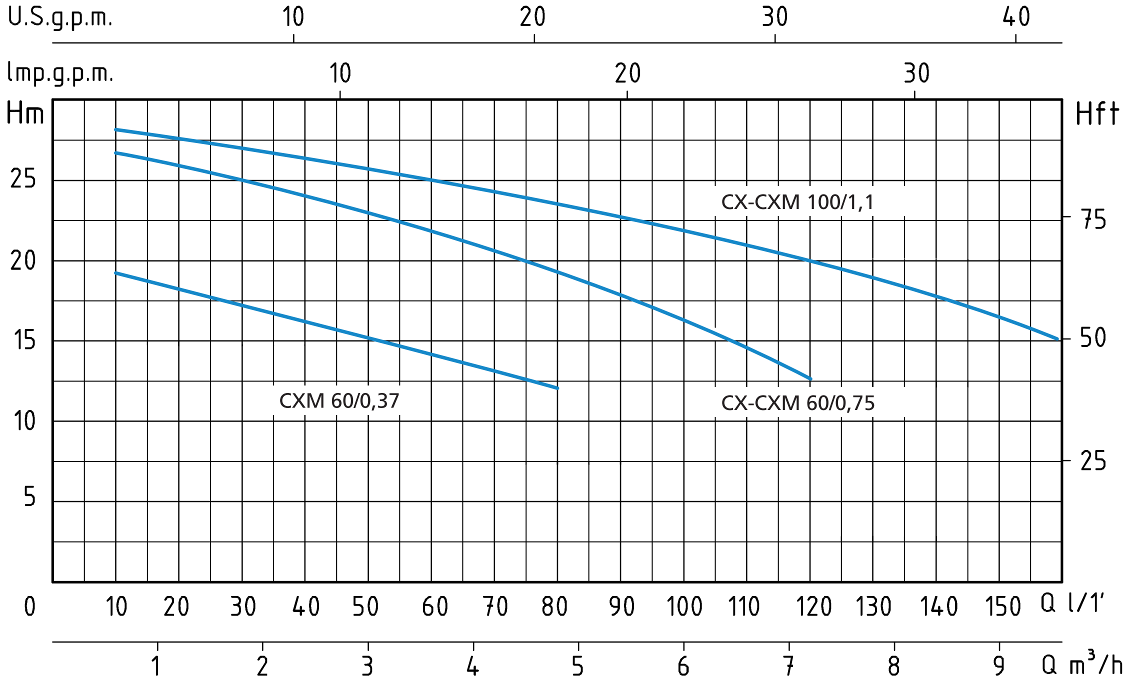
- Corpo pompa	Acciaio Inox AISI 304
- Supporto motore	Alluminio
- Girante	Acciaio Inox AISI 304
- Albero motore	Acciaio Inox AISI 304
- Tenute meccaniche	Silicio/Silicio/Viton

OPERATING CONDITIONS
- *Liquid temperature up to 90°C*
- *Ambient temperature up to 40°C*
- *Total suction lift up to 7 mt.*
- *Continuous duty*

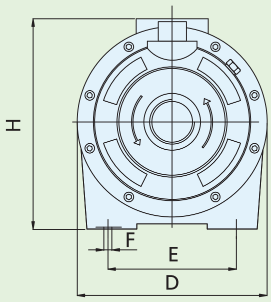
MOTOR
- *Two-Pole induction motor (n = 2850 min^{-1})*
- *Insulation Class F*
- *Protection IP 55*

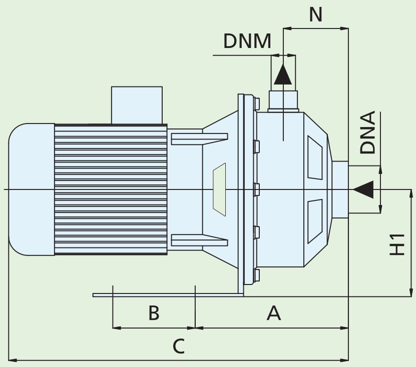
MATERIALS

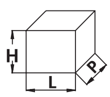
- Pump body	*Stainless Steel AISI 304*
- Motor Support	*Aluminium*
- Impeller	*Stainless Steel AISI 304*
- Shaft with rotor	*Stainless Steel AISI 304*
- Mechanical seal	*Silicon/Silicon/Viton*



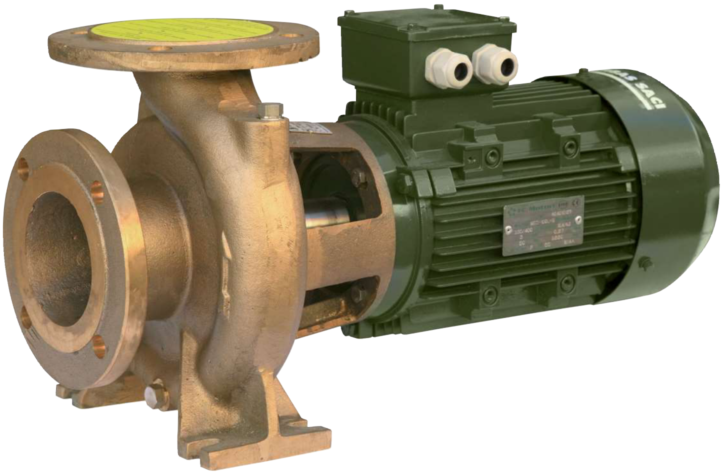
TIPO *TYPE*		POTENZA NOMINALE *NOMINAL POWER*		POTENZA ASSORBITA *INPUT POWER*	AMPERE		Q = PORTATA - *CAPACITY*									
Monofase *Single-phase*	Trifase *Three-phase*	P2		P1	Monofase *Single-phase*	Trifase *Three-phase*	m³/h	0,6	1,2	2,4	3,6	4,8	6	7,2	8,4	9,6
		HP	kW	kW			lt/1'	10	20	40	60	80	100	120	140	160
230V-50Hz	230/400V-50Hz				1 x 230V	3 x 400V	Prevalenza manometrica totale in m.C.A. - *Total head in meters w.c.*									
CXM 60/0,37		0,5	0,37	0,5	2,3		H (m)	18	17	16	13,5	12,4				
CXM 60/0,75	CX 60/0,75	1	0,75	1	4,6	1,7		27	26	23	22	18,5	16	12,5		
CXM 100/1,1	CX 100/1,1	1,5	1,1	1,3	5,8	2,3		28	27,5	26	25	23,5	22,5	20,5	17,6	15





TIPO *TYPE*		DIMENSIONI mm - *DIMENSIONS mm*											DIMENSIONI *DIMENSIONS* mm 			PESO *WEIGHT*
Monofase *Single-phase*	Trifase *Three-phase*	A	B	C	D	E	F	H	H1	N	DNA	DNM	P	L	H	Kg
CXM 60/0,37		113	115	328	216	150	11	230	111	51	1" ¼	1"	225	380	250	10
CXM 60/0,75	CX 60/0,75	113	115	361	216	150	11	245	111	51	1" ¼	1"	225	380	250	14
CXM 100/1,1	CX 100/1,1	113	115	361	216	150	11	245	111	51	1" ¼	1"	225	380	250	16

Serie "CRB"



■ Aplicaciones:

Electrobombas centrífugas construidas integramente en bronce marino especialmente adecuados para grandes trasvases de líquidos especialemente agresivos o bien agua de mar a presiones relativamente bajas.

■ Características Constructivas:

Cuerpo bomba, soporte y turbina en bronce. Eje, tornilleria y sello mecánico en acero inoxidable AISi 316. Partes de rozamiento del sello mecánico en carbón-cerámica.

■ Motor:

Asíncrono standard, cerrado de ventilación externa. Grado de protección IP-54. 50 Hz. Todos los motores de esta serie son a 2.850 r.p.m.

■ *Applications:*

Centrifugal electropumps built entirely in marine bronze, particularly suitable for large transfers of very aggressive liquids or sea water at relatively low pressures.

■ *Construction:*

Pump body, support and impeller in bronze. Shaft, bolts and mechanical seal in AISI 316 stainless steel. Contact parts of mechanical seal in carbon ceramic.

■ *Motor:*

Standard sealed asynchronous motor with external ventilation. IP-55 protection. 50 Hz All motors are standard at 2,850 rpm.

Tipo *Type*	HP	KW	r.p.m.	"A"		Caudal m³/h / *Flow m³/h*										Ø ASP.	Ø IMP.
				230 V	400 V	20	45	60	85	100	120	150	175	200	220		
						Altura m.c.a. / *Height w.c.m.*											
CRB 300	3	2,2	2.850	9	5,2	17,2	12,5	6,8								DN 80	DN 80
CRB 400	4	3	2.850	12	6,9	20	15	10								DN 80	DN 80
CRB 550	5,5	4	2.850	16,5	9,5	19	17	15	10	6						DN 125	DN 100
CRB 551	5,5	4	2.850	16,5	9,5	17,2	15,5	14,7	12,5	11	8					DN 125	DN 100
CRB 750*	7,5	5,5	2.850	21,7	12,5	19	18,7	18	16,5	15	12,8	8				DN 125	DN 100
CRB 1000*	10	7,5	2.850	-	15,5	23,8	22,5	21,5	19,5	18	16	12	8			DN 125	DN 100
CRB 1250*	12,5	9,2	2.850	-	19	24,2	23,2	22,5	20,8	19,5	17,8	14,5	11	7		DN 125	DN 100
CRB 1500*	15	11	2.850	-	23	27	25,7	24,8	23	21,5	19,7	16,5	13,5	10	7	DN 125	DN 100

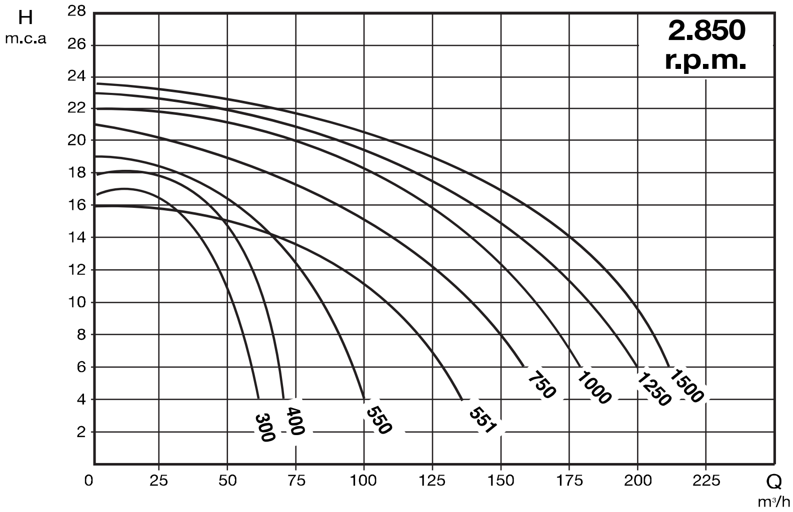
En los modelos de 3 y 4 CV recomendamos la instalación con tubo de 90 mm. *(For 3-4 HP we recomend minimum 90 mm. pipe)*

* Voltaje de Serie 400/690 V (bajo demanda 230/400 V) / * *Standard voltage 400/690 V (under demand 230/400 V)*

CURVA GRÁFICA
GRAPHIC CURVE

50 Hz

Modelos / Types : CR - CRB



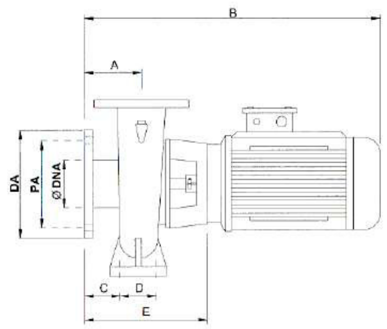
DATOS TECNICOS
TECHNICAL DATA

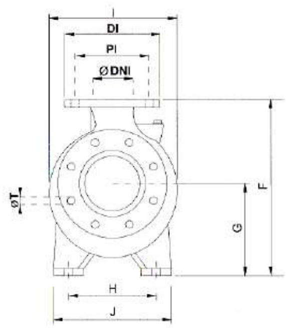
Tipo / Type		HP	KW	R.P.M	"A"		Altura manométrica m.c.a. - Manometric height w.c.m.									DNA	DNI
Hierro Cast Iron	Bronce Bronze				230 V	400 V	6	8	10	12	14	16	18	20	22		
							Caudal m³/h - Flow m³/h										
CR 300	**CRB 300**	3	2,2	2.850	9	5,2	61	54	51	46	35	29				DN80*	DN80*
CR 400	**CRB 400**	4	3	2.850	12	6,9	70	64	59	55	49	42	30			DN80*	DN80*
CR 550	**CRB 550**	5,5	4	2.850	16,5	9,5	95	90	84	77	65	54	32			DN125	DN100
CR 551	**CRB 551**	5,5	4	2.850	16,5	9,5	128	121	107	90	69	30				DN125	DN100
CR 750	**CRB 750**	7,5	5,5	2.850	21,7	12,5	159	152	135	125	109	88	60			DN125	DN100
CR 1000	**CRB 1000**	10	7,5	2.850	-	15,5	180	175	162	149	135	119	101	78		DN125	DN100
CR 1250	**CRB 1250**	12,5	9,2	2.850	-	19	200	196	182	165	150	136	110	95		DN125	DN100
CR 1500	**CRB 1500**	15	11	2.850	-	23	216	210	200	185	171	155	137	118	95	DN125	DN100

* Para modelos de 3 y 4 CV recomendamos instalación con tuberías de Ø 90 mm. mínimo.

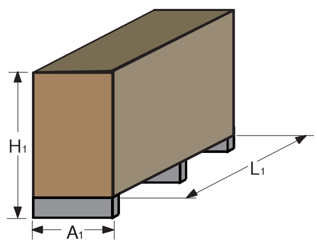
* For 3 and 4 HP types is recomended to install at least Ø 90 mm. pipes.

DIMENSIONES
DIMENSIONS





EMBALAJE
PACKING

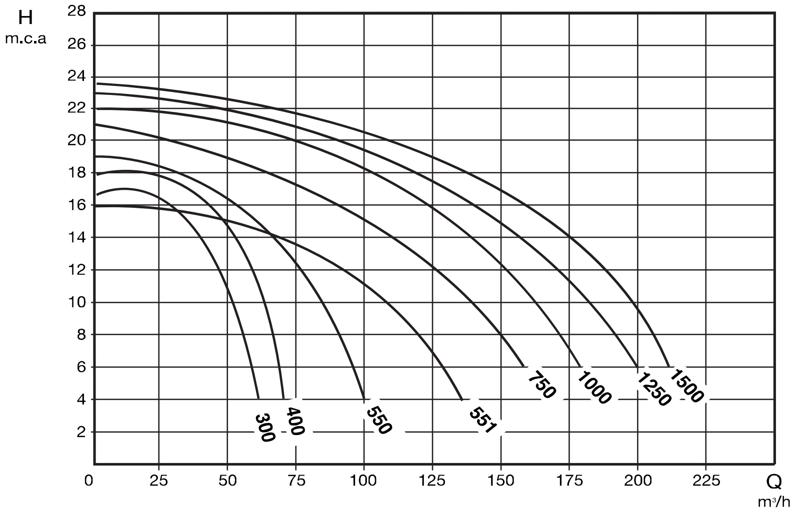


HIERRO	BRONCE	A	B	C	D	E	F	G	H	I	J	Aspiración/Intake					Impulsión/Output					Embalaje			PESO Kg.	
CAST IRON	BRONZE	Modelos/Types a 2.900 r.p.m.										ØDNA	DA	PA	Nº T	Ø T	ØDNI	DI	PI	Nº T	Ø T	L_1	A_1	H_1	Hi	Br
CR 300	**CRB 300**	110	520	70	80	245	310	145	200	260	250	80	200	160	4	18	80	200	160	4	18	1.050	400	660	37	46
CR 400	**CRB 400**	110	550	70	80	245	310	145	200	260	250	80	200	160	4	18	80	200	160	4	18	1.050	400	660	41	58
CR 550	**CRB 550**	125	595	73	105	290	365	165	215	290	280	125	250	210	8	18	100	220	180	8	18	1.150	400	660	60	85
CR 551	**CRB 551**	125	595	73	105	290	365	165	215	290	280	125	250	210	8	18	100	220	180	8	18	1.150	400	660	62	88
CR 750	**CRB 750**	125	660	73	105	275	365	165	215	330	280	125	250	210	8	18	100	220	180	8	18	1.150	400	660	75	101
CR 1000	**CRB 1000**	145	705	85	120	340	440	205	260	335	330	125	250	210	8	18	100	220	180	8	18	1.150	400	660	94	123
CR 1250	**CRB 1250**	145	740	85	120	340	440	205	260	335	330	125	250	210	8	18	100	220	180	8	18	1.150	400	660	103	139
CR 1500	**CRB 1500**	145	740	85	120	340	440	205	260	335	330	125	250	210	8	18	100	220	180	8	18	1.150	400	660	103	139

60 Hz

CURVA GRÁFICA
GRAPHIC CURVE

Modelos / Types : CR - CRB



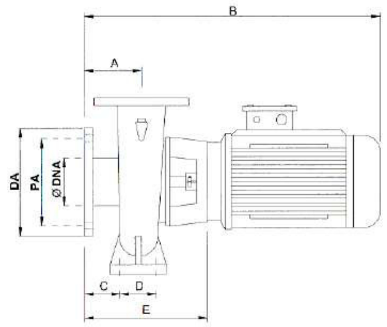
DATOS TECNICOS
TECHNICAL DATA

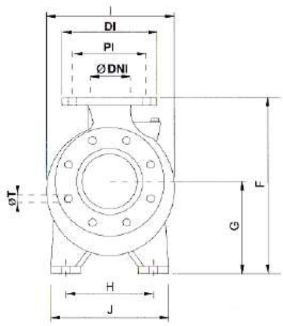
Tipo / Type		HP	KW	R.P.M	"A"		Altura manométrica m.c.a. - Manometric height w.c.m.									DNA	DNI
Hierro Cast Iron	Bronce Bronze				230 V	400 V	6	8	10	12	14	16	18	20	22		
							Caudal m³/h - Flow m³/h										
CR 300	**CRB 300**	3	2,2	3.450	9	5,2	61	54	51	46	35	29				DN80*	DN80*
CR 400	**CRB 400**	4	3	3.450	12	6,9	70	64	59	55	49	42	30			DN80*	DN80*
CR 550	**CRB 550**	5,5	4	3.450	16,5	9,5	95	90	84	77	65	54	32			DN125	DN100
CR 551	**CRB 551**	5,5	4	3.450	16,5	9,5	128	121	107	90	69	30				DN125	DN100
CR 750	**CRB 750**	7,5	5,5	3.450	21,7	12,5	159	152	135	125	109	88	60			DN125	DN100
CR 1000	**CRB 1000**	10	7,5	3.450	-	15,5	180	175	162	149	135	119	101	78		DN125	DN100
CR 1250	**CRB 1250**	12,5	9,2	3.450	-	19	200	196	182	165	150	136	110	95		DN125	DN100
CR 1500	**CRB 1500**	15	11	3.450	-	23	216	210	200	185	171	155	137	118	95	DN125	DN100

* Para modelos de 3 y 4 CV recomendamos instalación con tuberías de Ø 90 mm. mínimo.

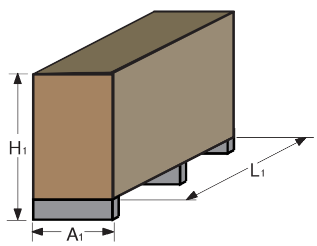
* For 3 and 4 HP types is recomended to install at least Ø 90 mm. pipes.

DIMENSIONES
DIMENSIONS





EMBALAJE
PACKING



HIERRO	BRONCE	A	B	C	D	E	F	G	H	I	J	Aspiración/Intake					Impulsión/Output					Embalaje			PESO Kg.	
CAST IRON	BRONZE	Modelos/Types a 2.900 r.p.m.										ØDNA	DA	PA	Nº T	Ø T	ØDNI	DI	PI	Nº T	Ø T	L_1	A_1	H_1	Hi	Br
CR 300	**CRB 300**	110	520	70	80	245	310	145	200	260	250	80	200	160	4	18	80	200	160	4	18	1.050	400	660	37	46
CR 400	**CRB 400**	110	550	70	80	245	310	145	200	260	250	80	200	160	4	18	80	200	160	4	18	1.050	400	660	41	58
CR 550	**CRB 550**	125	595	73	105	290	365	165	215	290	280	125	250	210	8	18	100	220	180	8	18	1.150	400	660	60	85
CR 551	**CRB 551**	125	595	73	105	290	365	165	215	290	280	125	250	210	8	18	100	220	180	8	18	1.150	400	660	62	88
CR 750	**CRB 750**	125	660	73	105	275	365	165	215	330	280	125	250	210	8	18	100	220	180	8	18	1.150	400	660	75	101
CR 1000	**CRB 1000**	145	705	85	120	340	440	205	260	335	330	125	250	210	8	18	100	220	180	8	18	1.150	400	660	94	123
CR 1250	**CRB 1250**	145	740	85	120	340	440	205	260	335	330	125	250	210	8	18	100	220	180	8	18	1.150	400	660	103	139
CR 1500	**CRB 1500**	145	740	85	120	340	440	205	260	335	330	125	250	210	8	18	100	220	180	8	18	1.150	400	660	103	139

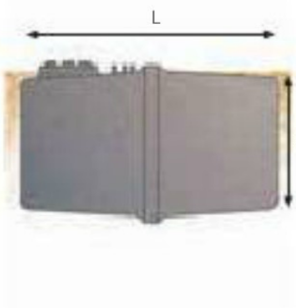
DEPÓSITOS - CUBA
PARA AGUA POTABLE HORIZONTALES

Estos depósitos cumplen el certificado sanitario para poder estar en contacto con alimentos según la **Directiva 92/39/CEE.**
Estos equipos se fabrican según laminación "hand-lay-up".

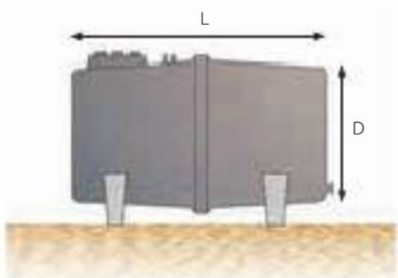
ACCESORIOS INCLUIDOS

- Boca acceso en polipropileno D.410 mm / D.567 mm (para cuba de 8.000 y 10.000 litros).
- **Depósitos enterrar:** Entrada / Salida / Aireación: rosca 2" superior.
- **Depósitos superficie:** Entrada / Aireación: rosca 2" superior; Salida: tubuladura DN 50 inferior.

ENTERRAR



SUPERFICIE



ENTERRAR

REFERENCIA	VOLUMEN l	D mm	L mm	Ø BOCA DE ACCESO mm	PESO APROX. Kg
DCHE 2200	2.200	1.150	2.720	410	60
DCHE 3500	3.500	1.600	2.140	410	75
DCHE 4500	4.500	1.600	2.660	410	110
DCHE 6000	6.000	1.750	2.930	410	150
DCHE 8000	8.000	2.120	2.900	567	180
DCHE 10000	10.000	2.120	3.620	567	225

SUPERFICIE

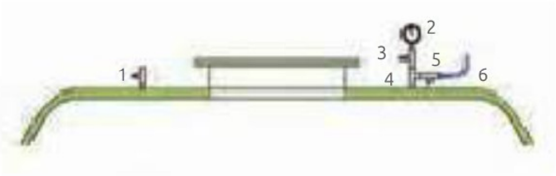
REFERENCIA	VOLUMEN l	D mm	L mm	Ø BOCA DE ACCESO mm	PESO APROX. Kg
DCHS 2200	2.200	1.150	2.720	410	70
DCHS 3500	3.500	1.600	2.140	410	90
DCHS 4500	4.500	1.600	2.660	410	125
DCHS 6000	6.000	1.750	2.930	410	170
DCHS 8000	8.000	2.120	2.900	567	205
DCHS 10000	10.000	2.120	3.620	567	250

TANQUE DE COMBUSTIBLE DOBLE PARED

EVITA LA CONSTRUCCIÓN DE CUBETO

Este equipo está especialmente diseñado para la contención de combustible según la instrucción técnica complementaria **MI-IP03:** instalaciones de almacenamiento para su consumo en la propia instalación del **Real Decreto 1523/1999**. El tanque está dotado de una barrera química interior adecuada para el almacenamiento de carburantes petrolíferos líquidos.
El equipo incorpora una segunda pared al tanque formando, entre la pared interior y la exterior, una cámara de aire estanca. Esta doble pared facilita su instalación evitando la construcción de cubeto estanco para la recogida de posibles derrames.

DETALLE SISTEMA DE DETECCIÓN DE FUGAS



1. Llave de paso cerrada
2. Manómetro de 0 a 1 bar
3. Llave de paso
4. Derivación en forma de T
5. Llave de paso
6. Tubería de conexión al detector

ENTERRAR

REFERENCIA	VOLUMEN l	D mm	L mm	Ø BOCA DE ACCESO mm	PESO APROX. Kg
STD 1	1.000	1.000	1.600	600	180
STD 1.5	1.500	1.000	2.200	600	200
STD 2	2.000	1.300	1.950	600	210
STD 3	3.000	1.300	2.700	600	250
STD 5	5.000	1.600	2.950	600	360
STD 10	10.000	2.000	3.700	600	760
STD 15	15.000	2.000	5.290	600	940
STD 20	20.000	2.500	4.910	600	1.460
STD 25	25.000	2.500	5.600	600	1.580
STD 30	30.000	2.500	6.650	600	1.900
STD 40	40.000	2.500	8.700	600	2.330

SUPERFICIE

REFERENCIA	VOLUMEN l	D mm	L mm	Ø BOCA DE ACCESO mm	PESO APROX. Kg
STDS 1	1.000	1.000	1.600	600	195
STDS 1.5	1.500	1.000	2.200	600	220
STDS 2	2.000	1.300	1.950	600	230
STDS 3	3.000	1.300	2.700	600	275
STDS 5	5.000	1.600	2.950	600	475
STDS 10	10.000	2.000	3.700	600	860
STDS 15	15.000	2.000	5.290	600	1.080
STDS 20	20.000	2.500	4.910	600	1.590
STDS 25	25.000	2.500	5.600	600	1.750
STDS 30	30.000	2.500	6.650	600	2.150
STDS 40	40.000	2.500	8.700	600	2.650

Boca de incendio equipada 25mm. y 45mm.

Las bocas de incendio equipadas pueden ser de los tipos B.I.E. 25mm. y B.I.E. 45mm.
Se deberán montar sobre un soporte rígido y la altura de su centro quedará como máximo a 1,50 m. del nivel del suelo y a una distancia máxima de 5 m. de las salidas de cada sector de incendios, quedando una zona libre de obstáculos para permitir el acceso y su maniobra sin dificultad. Además deberán cubrir una zona de 25 m. en recorridos reales en espacios con obstáculos.

BIE 25mm CERRADA Y ABIERTA de 620mm x 620mm x fondo 220mm.

BIE 25mm con extintor, pulsador, sirena y emergencia.

BIE 45mm de 450mm x 600mm x fondo 130mm

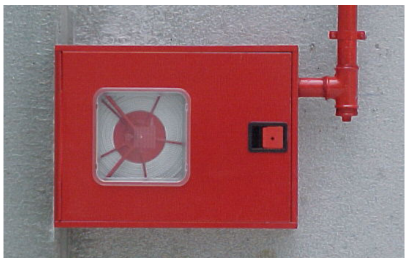
Cumplirán las siguientes condiciones hidráulicas:

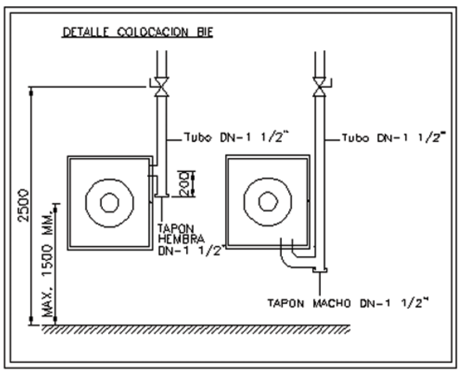
NIVEL DE RIESGO INTRÍNSECO DEL ESTABLECIMIENTO	TIPO DE BIE	SIMULTANEIDAD	TIEMPO DE AUTONOMIA
BAJO	DN 25mm.	2	60 minutos
MEDIO	DN 45mm.	2	60 minutos
ALTO	DN 45mm.	3	90 minutos

ESTABLECIMIENTOS INDUSTRIALES				
TIPO ESTABLECIMIENTO	SUPERFICIE	RIESGO INTRÍNSECO		
		BAJO	MEDIO	ALTO
A	≥300	SÍ	SÍ	SÍ
B	≥200	NO	NO	SÍ
	≥500	NO	SI	SÍ
C	≥500	NO	NO	SÍ
	≥1000	NO	SÍ	SÍ
D o E	≥5000	NO	NO	SI

Según reglamento la presión en boquilla será de 2 a 5 Bares.
Condición de descarga en boquilla a 3,5 Bares descargarán:
- 200l/min. la BIE 45
- 100l/min. la BIE 25

El sistema se someterá a una prueba de estanqueidad y resistencia mecánica, sometiendo a la red a una presión estática igual a la máxima de servicio y como mínimo a 980kPA, manteniendo esta presión durante 2 horas.





Esquema de instalación

BIE con arcada y extintor

Un extintor es un aparato que contiene un agente o sustancia extintora que puede ser proyectada y dirigida sobre un fuego por la acción de una presión interna.

Se instalarán extintores de incendio portátiles en todos los sectores de incendio de los establecimientos industriales y en todo tipo de edificios.

Se dispondrán extintores en número suficiente para que el recorrido real en cada planta desde cualquier origen de evacuación hasta un extintor no supere los 15 m.
El emplazamiento será visible y accesible, situados en lugares con mayor probabilidad de iniciarse el incendio y cercanos a las salidas de incendio.

Se deberán colocar sobre soportes fijados verticalmente, quedando la parte superior del extintor como máximo a 1,70 metros sobre el suelo.

Se considerarán adecuados para las clases de fuego los agentes extintores de la siguiente tabla I-1 del RIPCI:

Extintores de polvo certificados

AGENTES EXTINTORES Y SU ADECUACIÓN A LAS DISTINTAS CLASES DE FUEGO				
AGENTE EXTINTOR	CLASES DE FUEGO			
	A (Sólidos)	B (Líquidos)	C (Gases)	D (Metales)
Agua pulverizada	(2) xxx	x		
Agua a chorro	(2) xx			
Polvo BC (convencional)		xxx	xx	
Polvo ABC (polivalente)	xx	xx	xx	
Polvo específico metales				xx
Espuma física	(2) xx	xx		
Anhídrido carbónico	(1) x	x		
Hidrocarburos halogenados	(1) x	xx		

xxx, muy adecuado. xx adecuado. x aceptable.
(1) En fuegos pocos profundos (profundidad < 5 mm) puede asignarse xx.
(2) En presencia de tensión eléctrica no son aceptables como agentes extintores el agua a chorro ni la espuma; el resto de los agentes extintores podrán utilizarse en aquellos extintores que superen el ensayo dieléctrico normalizado en UNE 23.110.

Extintor CO2 2 kg. Eficacia 34 B
Extintor CO2 5 kg. Eficacia 89 B

En aparatos, cuadros, conductores y elementos bajo tensión eléctrica superior a 24 V se deberá realizar con extintores de dióxido de carbono, o polvo seco BC o ABC, cuya carga se determinará según el tamaño del objeto protegido con una valor mínimo de 5 Kg. de CO_2 y 6 Kg. de polvo seco BC o ABC.

MOD.	EFICACIA	AGENTE EXTINTOR	AGENTE IMPULSOR	PESO CARGADO	PESO VACIO	ALTURA EN mm.	DÍAMETRO EN mm.	PRESIÓN DE PRUEBA	Tª UTILIZACIÓN
P-6P	21A-144B-C	POLVO A-B-C	N_2	9,30 Kgs.	3,80 Kgs.	518	150	23 Kgs/cm²	-20°C/+60°C
P-6PF	27A-183B-C	POLVO A-B-C	N_2	9,30 Kgs.	3,30 Kgs.	520	150	23 Kgs/cm²	-20°C/+60°C
P-6 2000	34A-233B-C	POLVO A-B-C	N_2	9,30 Kgs.	3,30 Kgs.	520	150	23 Kgs/cm²	-20°C/+60°C
P-9P	34A-183B-C	POLVO A-B-C	N_2	14,00 Kgs.	5,50 Kgs.	588	150	23 Kgs/cm²	-20°C/+60°C
E-6H	21A-1838-C	5,4l+0,6 AFFF	N_2	9,35 Kgs.	3,40 Kgs.	550	150	23 Kgs/cm²	-20°C/+60°C
E-9H	27A-233B-C	5,4l+0,6 AFFF	N_2	14,4 Kgs.	5,60 Kgs.	590	150	23 Kgs/cm²	-20°C/+60°C

PP. 9 kg

PP. 6 kg

Carros de PP. de 25 y 50 Kg

Cuando en el sector de incendio coexistan combustibles de la clase A y B, se tomará A o B cuando uno de los dos supere el 90%, en otro caso se considerará A-B.

La dotación de extintores se determinará con las tablas siguientes:

DETERMINACIÓN DE DOTACIÓN DE EXTINTORES EN SECTORES DE INCENDIO CON CARGA DE FUEGO DE COMBUSTUBLES DE CLASE A SEGÚN TABLA 3.1 DEL REGLAMENTO DE SEGURIDAD CONTRA INCENDIOS EN ESTABLECIMIENTOS INDUSTRIALES		
GRADO DE RIESGO INTRÍNSECO DEL SECTOR DEL INCENDIO	**EFICACIA MÍNIMA DEL EXTINTOR**	**ÁREA MÁXIMA PROTEGIDA DEL SECTOR DE INCENDIO**
BAJO	21A	Hasta 600 m²(un extintor más por cada 200 m², o fracción en exceso)
MEDIO	21A	Hasta 400 m²(un extintor más por cada 200 m², o fracción en exceso)
ALTO	34A	Hasta 300 m²(un extintor más por cada 200 m², o fracción en exceso)

DETERMINACIÓN DE DOTACIÓN DE EXTINTORES EN SECTORES DE INCENDIO CON CARGA DE FUEGO DE COMBUSTIBLES DE CLASE B				
	VOLUMEN MÁXIMO DE COMBUSTIBLES LÍQUIDOS EN SECTOR DE INCENDIO (1 Y 2)			
	V ≤ 20	**20 < V ≤ 50**	**50 < V ≤ 100**	**50 < V ≤ 100**
EFICACIA MÍNIMA DEL EXTINTOR	113B	113B	144B	233B

(1) Si más del 50 % del volumen de combustibles líquidos está contenido en recipientes metálicos, la eficacia mínima del extintor puede reducirse a la inmediatamente anterior de la clase B.
(2) Si el volumen de combustibles líquidos supera los 200 l, se incrementa la dotación de extintores con extintores sobre ruedas de 50 kg. a razón de 1 extintor si 200 l<V<750 l; 2 extintores si 750 l <V<2000 l.

Extintores de agua 6 y 9 Kg. certificados

Carros de CO2 de 10 kg. y 20 kg.

El Grupo de Presión es un sistema de impulsión por bombeo.
Está formado por un equipo de bombeo, un grupo de bombeo auxiliar y material diverso (grupo hidroneumático, valvulería, instrumentación, controles, etc.)

El equipo de bombeo principal responderá a las exigencias de caudal y presión de agua requerida. El equipo de bombeo auxiliar servirá fundamentalmente para mantener, de forma automática, la instalación a una presión constante, reponiendo las fugas que se permitan en la red general contra incendios.

Estos grupos están diseñados cumpliendo normas UNE o CEPREVEN. Están diseñados según especifica la Regla Técnica RT2-ABA, incluyendo además las especificaciones puntuales de la norma UNE 23.500. En casos especiales y bajo normativas americanas se fabrican con la Norma NFPA 20 y certificados UL / FM.

El equipo de bombeo principal puede ser:

Único, que pueda suministrar por sí solo la demanda total de agua. (eléctrico o diesel)

Doble, cada uno es capaz de suministrar por sí solo la demanda total de agua (eléctrico + diesel, eléctrico + eléctrico si hay dos fuentes de energía independientes)

La línea de alimentación al grupo será independiente y con interruptor exclusivo y además el arranque será automático y parada manual para la bomba principal según norma.

Para la aspiración en instalación de rociadores, siempre que sea posible, deben usarse bombas centrífugas horizontales instaladas en carga, es decir, al menos 2/3 de la capacidad efectiva del depósito de aspiración a no más de 2 m por encima del nivel más bajo del eje de la bomba y el eje de la bomba debe estar situado a no más de 2 m por encima del nivel más bajo del depósito de aspiración.

Para bombas en carga, el Ø de tubo de aspiración debe ser ≥ 65 mm, y ser suficiente para no superar una velocidad de 1,8 m/s. Para bombas no en carga, el Ø de tubo de aspiración debe ser ≥ 80 mm, y ser suficiente para no superar una velocidad de 1,5 m/s.

Para las bombas no en carga, cada una debe disponer de un sistema independiente de cebado automático. Dispondrá un depósito situado a un nivel más alto que la bomba con un tubo de conexión con pendiente desde el depósito hasta la impulsión de la bomba, también deberá disponer de válvula de retención esta conexión. Tal y como se indica en la figura adjunta.

Grupo de presión

Equipo de Presión bajo normas americanas NFPA 20 y certificados

Condiciones para la instalación de un grupo de presión:

Para bombas en carga, instalar una válvula de cierre en la línea de aspiración.

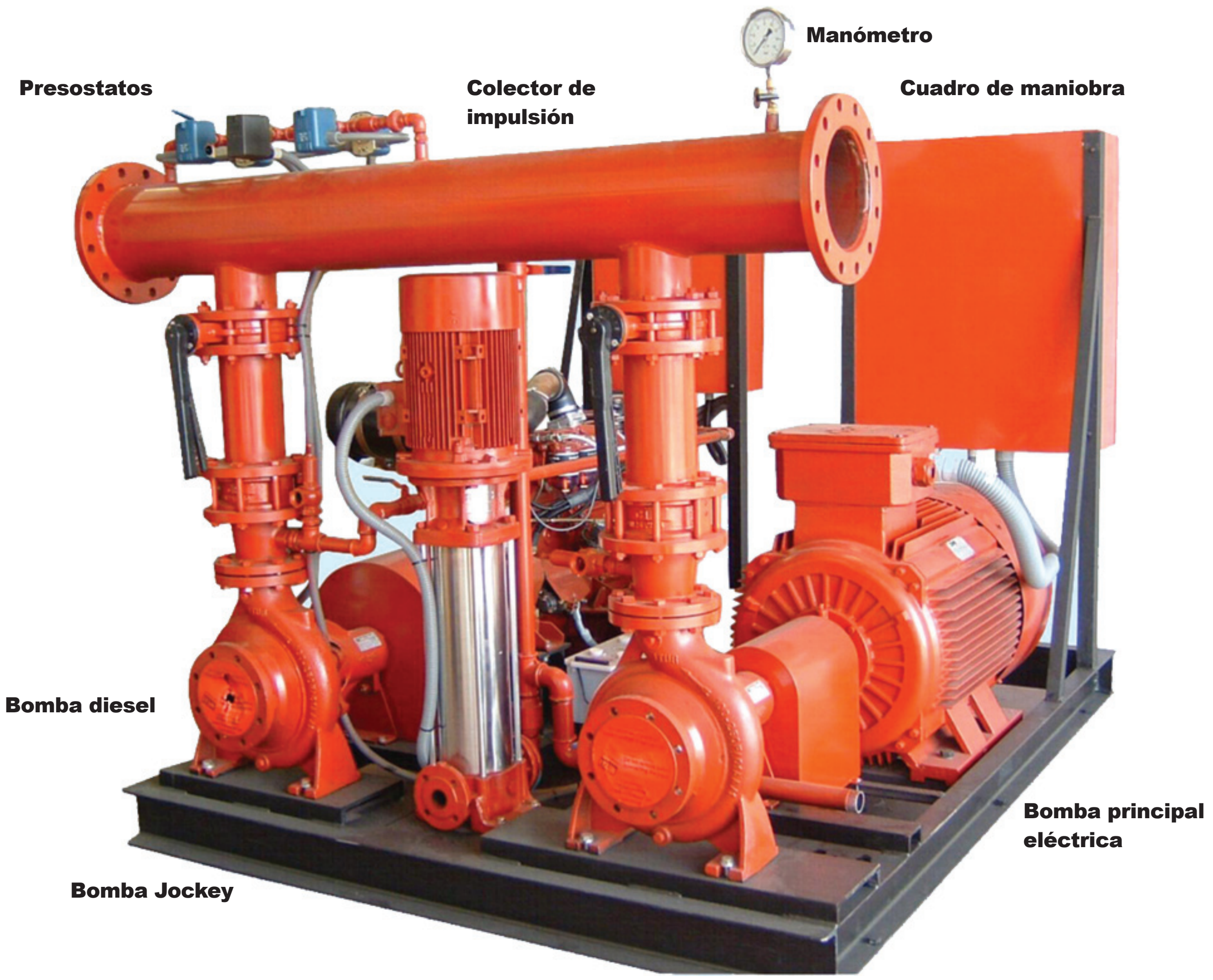
En la línea de impulsión de cada bomba, se instalará:

- Reducción concéntrica.
- Válvula de seguridad de escape conducido, de 25mm de diámetro nominal mínimo, para alivio a caudal cero.
- Válvula de retención.
- Válvula de cierre (normalmente abierta).

Cualquier reducción en la línea de aspiración será del tipo excéntrica, con la generatriz paralela al eje hacia arriba.

Purgador automático de aire en la parte alta de la carcasa de la bomba.

Se instalará un sistema de medida de caudal que permita comprobar la curva característica de cada bomba principal hasta el punto de 150% del caudal nominal.

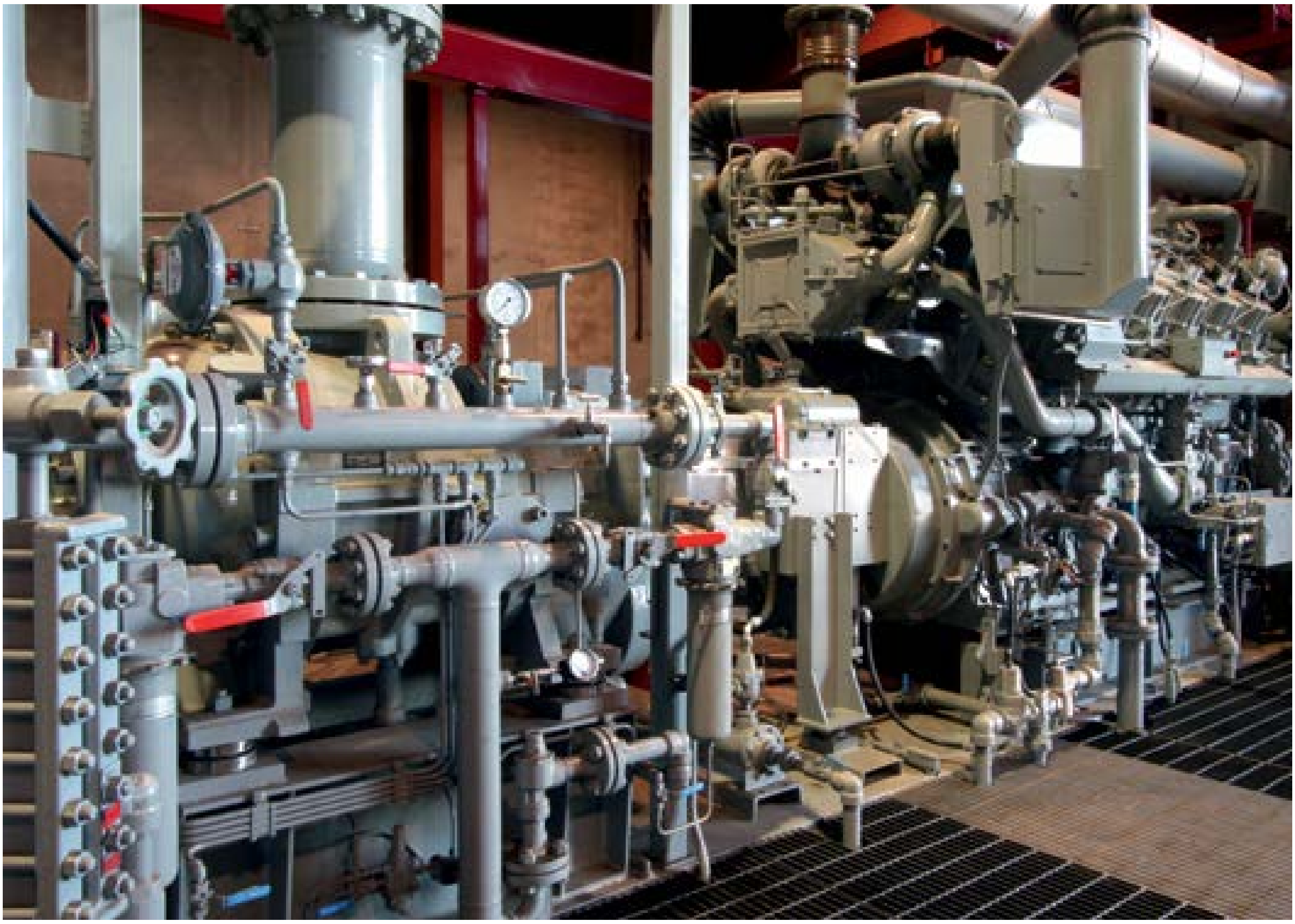


Bomba Diesel + Eléctrica + Jockey para instalación de rociadores

HI-FOG®
water mist fire protection

Protecting machinery spaces from fire

HI-FOG® total flooding systems



Marioff
United Technologies

Top performance a

Machinery spaces, such as turbine and generator enclosures, require special fire protection. These spaces are very susceptible to fires due to the presence of heat generated by the equipment and highly flammable liquids. A minor malfunction or leak in machinery spaces can quickly turn into a serious fire.

These spaces are also becoming larger in order to accommodate the size and output of bigger machines. The larger machinery spaces are particularly difficult to protect because they may be hard to seal off, take more time to evacuate, and can result in more intense fires - but HI-FOG® rises to this challenge!

HI-FOG® total flooding systems protect many types of hazards:

- Gas turbines
- Diesel generators
- Steam turbines
- Transformers
- Switch gear
- Compressors

How HI-FOG® fights fire?
High pressure water mist technology delivers some of the best fire fighting performance available today, making it ideal for challenging applications such as machinery spaces.

HI-FOG® water mist fights fire using three main mechanisms: cooling the fire itself and the air surrounding it, blocking the radiant heat, and starving the fire of oxygen.

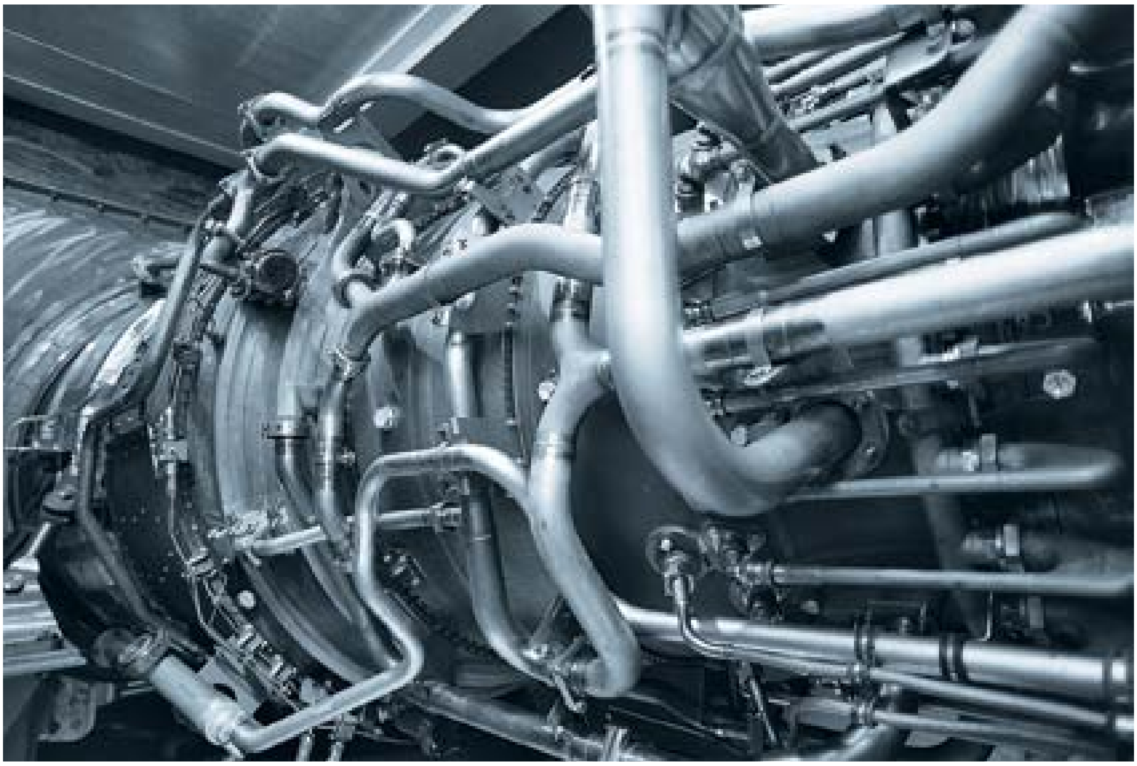
Don't wait, activate!
One of the major benefits of HI-FOG® system is that it can be activated immediately the moment a fire is detected, when fire is still in its infancy. This reduces the potential damage fire can cause.

The pure water mist of HI-FOG® is equally valuable in terms of personnel safety. It poses no danger to people; a false alarm and discharge is merely a nuisance, not a health hazard.

The third significant benefit of HI-FOG® in machinery spaces is its cooling effect. HI-FOG® discharges a very fine water mist as a high-pressure fog, which as such blocks radiant heat and absorbs heat efficiently through evaporation.

HI-FOG®
water mist fire protection

gainst tough fires



Standards and regulations compliant
HI-FOG® is compliant with the relevant land based requirements and the latest International Maritime Organization (IMO) regulations.

The Factory Mutual (FM) standards give special consideration to gas turbines, machinery spaces and special hazard machinery spaces. In Europe, a recognized approval body is VdS Schadenverhütung GmbH (VdS).

Machinery space total flooding systems for marine applications are regulated by IMO and approved by various classification societies.

	FM (Land)	VdS (Land)	IMO (Marine)
MAU	$\leq 260\ m^3$	$\leq 260\ m^3$	
GPU	$\leq 1500\ m^3$	$\leq 1375\ m^3$	$\leq 1500\ m^3$
MT4	$\leq 1375\ m^3$	$\leq 1375\ m^3$	$\leq 6600\ m^3$

Different HI-FOG® systems are certified for different space sizes.

The HI-FOG® machinery space accumulator unit (MAU) and gas-driven pump unit (GPU) are approved by FM and VdS.

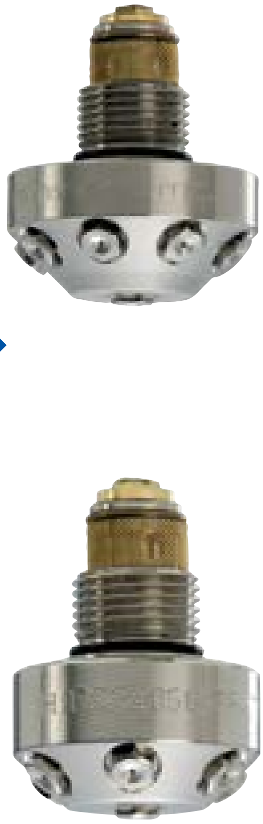
HI-FOG® MT4 system is approved by a number of marine classification societies in accordance with IMO regulations.

HI-FOG® key benefits:

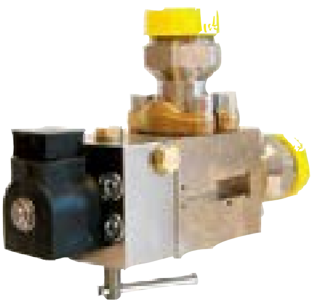
- **Fast:** immediate activation
- **Safe:** harmless to people and environment
- **Cooling:** prevents fire from reigniting
- **Proven:** success in countless type approval tests and real fires

VdS

FM APPROVED

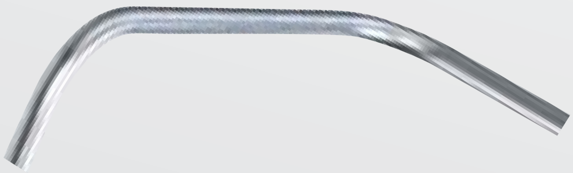


HI-FOG® sprayheads



Machinery space section valve

12 mm and 30 mm stainless steel tubes in actual sizes



The small diameter, high quality stainless steel tubing bends easily around corners and obstructions.

Machinery space accumulator unit (MAU)

Gas-driven pump unit (GPU)

Electrically-driven pump unit (SPU)

Head Office
Marioff Corporation Oy
Plaza Business Park Halo
P.O.Box 1002, 01511 Vantaa, Finland
Tel. +358 (0)10 6880 000
Fax +358 (0)10 6880 010
Email: info@marioff.fi

Information on Marioff group companies, agents/distributors and references can be found at **www.marioff.com**.

Marine generator set
Quiet Diesel™ Series
65 QD 50 Hz
Model MDDCH


Cummins Onan Digital Display

Cummins **Onan**

Performance you rely on.™

Features and benefits

- Rugged dependability, high quality and innovation make Cummins Onan Marine Generators the leader in marine generator design and development, providing performance you rely on.™
- The digital QD (Quiet Diesel) Series models are the first marine generator sets with self-monitoring capability and network communication.
- The standard Cummins Onan Digital Display provides user-friendly diagnostics including extensive engine and alternator information, self-diagnostic features and text display.
- The Cummins Onan Marine Generators with advanced design and development processes use technology to lower sound and vibration. Our sound shields minimize noise and deliver better sound quality. The optimized mounting system greatly reduces vibration.
- Certified to U.S. Environmental Protection Agency (EPA) emission standards.
- Cummins Onan Marine Generators have the largest worldwide certified distributor/dealer support network in the industry with more than 70 years of experience.

Models and ratings

Model	kW*/kVA	Voltage	Amps	Phase	Hz	Engine RPM
65MDDCH	65.0/65.0	110/220	590.9/295.5	1	50	1500
		115/230	565.2/282.6			
		120/240	541.7/270.8			
65MDDCH	65.0/81.25	110/190	246.9	3	50	1500
		115/200	234.5			
		120/208	225.5			
		110/220	213.2			
		115/230	204.0			
		120/240	195.5			
		220/380	123.4			
		230/400	117.3			
		240/416	112.8			
		255/440	106.6			

Three phase output at 0.8 power factor. Rating conditions are 100 kPa (29.6 in Hg) barometric pressure, 30% relative humidity and 25° C (77° F) (ref. ISO 3046). *Unlimited running time at rated power, additional 10% reserve power available.

Sound level, weight, and size

	Sound level	Dimensions			
	50 Hz configuration	**Weight (dry)**	**Length**	**Width**	**Height**
With sound shield	70 dB(A)*	1434 kg (3161 lb)	2146 mm (84.5 in)	840 mm (33.1 in)	1039 mm (40.9 in)
Without sound shield		1320 kg (2910 lb)	2142 mm (84.3 in)	822 mm (32.4 in)	994 mm (39.1 in)

* Full load at 1 m, with optional Cummins Onan sound shield

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Standard features

- Advanced digital electronic control providing extensive diagnostic capability
- SAE J-1939 CAN data link for monitoring generator set status and diagnostics for engine and alternator
- Cummins Onan Digital Display - graphical LCD display for generator set operating parameters, diagnostics, and pre-alarm indication in text format
- Shutdown with diagnostic indicator light for: high engine coolant temperature, low oil pressure, over speed/voltage, starter overcrank, additional customer input and many more
- Electronic governor allows the generator set to maintain isochronous frequency control and close voltage regulation to provide quality power for digital appliances and computers
- Three phase alternator, 90° C rise at 50° C ambient, brushless, 12 lead reconnectable
- Digital voltage regulator integral with control
- 12 V DC electric system with battery charging, negative ground
- Mechanical fuel transfer pump with manual priming lever
- Engine starter with automatic start disconnect
- Water cooled exhaust manifold and turbocharger
- Freshwater cooling system with keel cooling connections
- Coolant overflow bottle to easily maintain coolant level
- Dry exhaust elbow with flange connection
- Common fault relay for external alarm
- Combustion air filter with washable element
- Full flow lube oil filter
- Oil drain valve
- Fuel filter/water separator, primary and secondary
- Drip pan
- Bulk head type fuel line connections for ease of installation
- Captive focalized mounting systems with vibration isolators
- Single point lifting bracket for ease of installation
- Plug-in watertight connector for optional remote panel
- Closed crankcase ventilation system with filter to eliminate engine room contamination
- Factory load tested
- Five year limited warranty

Engine details

Design: 4-cycle, turbocharged, water-cooled diesel
Cylinders: 6 turbocharged
Bore: 106.5 mm (4.2 in)
Stroke: 127 mm (5.0 in)
Displacement: 6.8 L (415 in^3)
Compression ratio: 17.0:1
Max fuel lift: 3 m (10 ft)
Lube oil capacity: 19.4 L (20.5 qt)
Coolant flow rate: 116 L/min (31 Gal/min)
Raw water flow rate: 70 L/min (18 Gal/min)
Starting system: Remote 3-wire, 12 V starting battery required, 800 CCA; 24 V optional
Power (max): SAEJ1349
50 Hz at 1500 RPM 98 kW (131 hp)
Fuel injection pump: Stanadyne DE-10
Combustion chamber: Direct injection
Max raw water lift: 3 m (10 ft)

Typical fuel consumption

No. 2 diesel fuel, L/hr (Gal/hr)	1/4 load	1/2 load	3/4 load	Full load
65.0 MDDCH	5.7 (1.5)	9.9 (2.6)	14.1 (3.7)	18.4 (4.9)

Alternator details

Design: Cummins Onan brushless, revolving field, 4-pole alternator; rigidly coupled to engine and permanently aligned
Voltage regulator: Solid state, circuit board encapsulated for corrosion protection
Exciter system: Brushless with 8-pole stator mounted in endbell; rotating rectifier assemblies are encapsulated for protection from adverse environments
Stator: Skewed stator and 2/3 pitch windings minimize field heating and voltage harmonics; resin-coated for corrosion protection
Rotor: Dynamically balanced assembly; direct-coupled to engine by flexible drive discs; supported by pre-lubricated, maintenance-free ball bearing
Cooling: Direct drive centrifugal blower
Insulation system: Class H per NEMA MG1-1.65 and BS 5000

Generator set performance

Operating environment: Generator sets are durability tested at maximum ambient air temperature: 50° C (122° F); raw water temperature 37.8° C (100° F)
Frequency regulation: Isochronous
Steady-state frequency band: Less than 0.5% per ISO 8528-5
Steady-state voltage deviation: Less than +/-1% per ISO 8528-5

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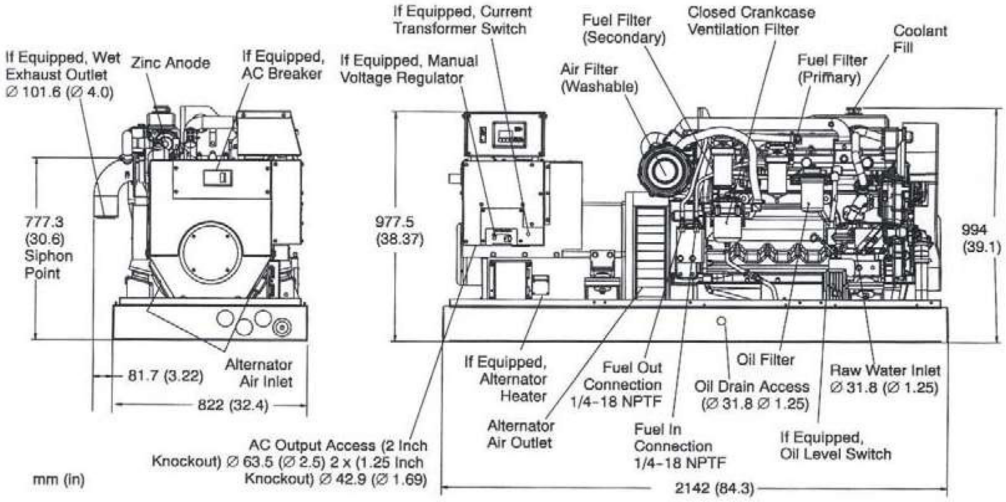
Basic dimensions



Note: This outline drawing is provided for general reference only and is not intended for design or installation. For more information see Operation and Installation manuals or obtain drawing 500-3800 and wiring diagram from your distributor/dealer.

Options

- Low and high oil level indicator and shutdown
- Heat exchanger cooling with gear-driven raw water pump with loss of raw water flow protection
- 12 V DC electric system with battery charging, isolated DC
- 24 V DC electric system with battery charging, negative ground
- 24 V DC electric system with battery charging, isolated DC
- Single phase alternator, 90° C rise at 50° C ambient, 4 lead
- Set-mounted mainline circuit breaker; shunt trip and auxiliary contacts available
- Water cooled exhaust mixing elbow with high temperature shutdown
- Dry exhaust elbow with 8 bolt flange per ASME B16.5
- Electric fuel transfer pump for increased fuel lift capability
- Front power take off - 12 V or 24 V - 70 or 100 hp clutch with torsional coupling and configured for a "C" splined 1-1/4 in pump shaft (SAE J744)
- Coolant heater, 120 V or 240 V, 1000 W
- Anti-condensation resistance heater, 120 V or 240 V, 100 W
- Permanent magnet generator (PMG) exciter and analog voltage regulator for paralleling operation
- Manual voltage regulator
- Droop compensator for parallel operation
- Commercial limited warranty packages
- Export box packing
- Sound shield housing with fire extinguisher access port

Standard model without sound shield

Accessories

- Cummins Onan Digital Display - graphical LCD remote display for generator set operating parameters, diagnostics, and pre-alarm indication in text format
- Basic remote panel with start/stop switch with run (green) and control status (amber) lamps
- Remote start/stop switch with dual lamps and mating harness for panel installation
- Panel with start/stop switch with run (green) and control status (amber) lamps; replaces Cummins Onan Digital Display if mounted remotely
- Pigtail harness for generator set remote connectors and remote panels
- Remote panel wire harness - 15 ft, 25 ft, 45 ft, 75 ft, 100 ft or 150 ft
- Y adapter harness for dual remote stations
- Set-mounted mainline circuit breaker; shunt trip and auxiliary contacts available
- Siphon break kit
- Wet exhaust hose
- Marine muffler and water separator
- Battery
- Coolant heater, 120 V or 240 V, 1000 W
- Anti-condensation resistance heater, 120 V or 240 V, 100 W
- Low and high oil level indicator and shutdown
- Manual voltage regulator
- Keel cooling expansion tank, set-mountable
- Secondary vibration isolator system
- Front power take off - 12 V or 24 V - 70 or 100 hp clutch with torsional coupling and configured for a "C" splined 1-1/4 in pump shaft (SAE J744)
- Sound shield housing with fire extinguisher access port
- Electric fuel transfer pump for increased fuel lift capability

Cummins Onan Digital Display

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Standards and testing

National Marine Manufacturers Association (NMMA) members produce every conceivable product used by recreational boaters. NMMA provides a wide variety of programs and services including technical expertise, standards monitoring, government relations advocation and industry statistics.

The American Boat and Yacht Council (ABYC) develops standards and recommended practices for designing, constructing, equipping and maintaining small pleasure and commercial craft.

This generator set was designed and manufactured in facilities certified to ISO 9001.

Lloyd's Register states that Cummins Onan Marine Generators have been successfully tested in accordance with the relevant requirements of the Lloyd's Register Type Approval System for Marine, offshore and industrial applications.

Cummins Onan Marine Generators have Type Approval for the engine and 3 phase alternator issued by Det Norske Vertas (DNV), an autonomous, independent risk management foundation and leading maritime classification society.

Warranty policy

The Cummins Onan express, written limited warranty covers virtually everything except routine maintenance for the first two years you own your marine generator set, and covers parts and labor on major power train and generator set parts during the third through fifth years.

WARNING:

Back feed to a utility system can cause electrocution and/or property damage. Do not connect to any building electrical except through an approved device or after building main breaker is open.

After sale support

Largest distributor/dealer support network
Cummins Onan generator sets are supported by the largest and best trained worldwide certified distributor/dealer network in the industry. This network of knowledgeable Cummins Onan distributor/dealers will help you select and install the right generator set and accessories to meet the requirements of your specific application. This same network offers a complete selection of commonly used generator set maintenance parts, accessories and products plus manuals and specification sheets. Plus, they can answer your questions regarding proper operation, maintenance schedules and more.

Manuals: Operation and installation manuals ship with the generator set. To obtain additional copies or other manuals for this model, see your Cummins Onan distributor/dealer and request the following manual numbers: Operation (981-0179), Installation (981-0639), Parts (981-0276), Service (981-0539).

To easily locate the nearest Cummins Onan distributor/dealer in your area, or for more information, contact us at 1-800-888-6626 (or 763-574-5000), or visit www.cumminsonan.com.

Contact your distributor/dealer for more information

Cummins **Onan**

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A-1471c (03/07)

Overview

The Polar Wind-12 is a Polarimetric Vertical Axis Wind Turbine (VAWT) that converts wind energy to electrical power. The Polar Wind-12 is an omni-directional, multi-axis, low wind-speed generator that may be easily installed practically anywhere with good wind exposure. This silent turbine may be painted to aesthetically blend into its surrounding environment. The VAWT is seen as a solid object as the rotational speed increases, making it visible to birds. Polar Wind-12 runs quietly and is vibration free and wildlife friendly. The Polar Wind-12 has a 3-phase A.C. electrical power connection and is supplied with a 3-phase rectifier and 240V, 60 Hz A.C. grid-tie inverter.

Features:

- Low Wind Speed Operation
- Direct Drive Generator
- Silent Operation
- Operation and Maintenance Free

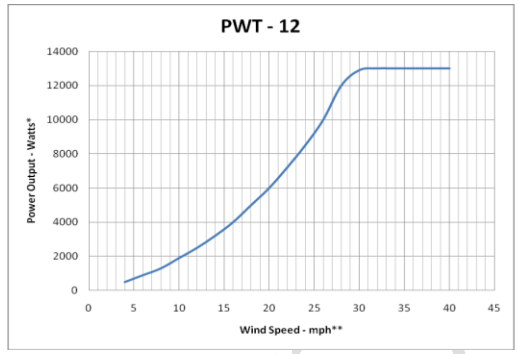
Polar Wind-12

Power Generator Description

The Polar Wind-12 proprietary Axial Flux Permanent Magnet Generator converts wind energy to electrical energy. The wind pressure (associated with wind speed) on the cage blades cause the cage structure to rotate. The magnetic field movement across wire-coils produces current flow and an associated voltage.

The typical wind-speed to power conversion is shown in the subsequent graph. Note: wind pressure varies with atmospheric pressure, altitude, and air particulate composition. All

VAWT Systems' products are covered by U.S. Patents or Patents Pending.



*Instantaneous Power ** At Sea Level

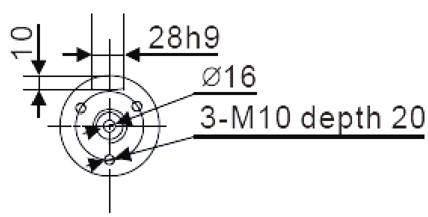
Electrical Specifications

Power Interface:

D.C. Voltage output – H.V.	0-650 V Peak
D.C. Current output – H.V.	0-25 A Peak
Wire Type	6 AWG
Electromagnetic Containment	FCC Class B

Physical Specifications

Cage Height	144 inches
Cage Diameter	96 inches
Cage Weight	180 pounds
Cage Rotation Speed	0 to 160 RPM
Sound (Noise) Pressure Level	6 dB (at 5ft) Above Ambient
Vibration	Vibration Free
Generator Height	20.35 inches
Generator Diameter	25.62 inches
Generator Weight	772 pounds
Hazardous Materials	RoHS Compliant



Polar Wind - 12 Mounting Pattern

Environment:

• Operating Temperature	-40 to 120° F
• Storage Temperature	-50 to 140° F
• Relative Humidity	0 to 95% NC

Note: Specifications subject to change without notice

VAWT Systems, LLC, 1424 S. Allec Street, Anaheim, CA 92805
info@vawtsystems.com, Phone: +1.714.224.0886; FAX: +1.714.956.7413

SECTION 1 INTRODUCTION

A. General

A 100 Introduction

101 This document provides requirements for the structural design of Deep Draught Floater (DDF) units, fabricated in steel, in accordance with the provisions of DNV-OS-C101 utilizing the LRFD design Method. For WSD methodology, reference is made to DNV-OS-C201.

102 A DDF platform is categorised as having a relatively large draught when compared to ship shaped, semi-submersible or TLP type units. This large draught is mainly introduced to obtain sufficiently high "Eigen period" in heave and reduced wave excitation in heave such that resonant responses in heave can be omitted or minimised.

103 A DDF can include a Spar, deep draught semi (DDS) or other deep draught floating units. Spar can consist of multi-vertical columns, single column with or without moonpool (e.g. classic, truss and cell spar). A DDS can consist of multi-vertical columns with ring pontoon with or without a heave damping structure.

104 The unit is usually kept in position by a passive mooring system. The mooring system may also be activated in case of horizontal movements above wells (drilling riser placed vertically above well), or other needed operational adjustments (e.g. reduction in VIM responses).

105 The deck or topside solution may be modular, or integrated type.

106 The standard has been written for general world-wide application. Governmental regulations may include requirements in excess of the provisions of this standard depending on size, type, location and intended service of the offshore unit/installation.

A 200 Objectives

The objectives of the standard are to:

— provide an internationally acceptable standard for structural design of DDF's
— serve as a contractual reference document for suppliers, yards and owners
— serve as guidance for designers, suppliers, owners and regulators
— specify procedures and requirements for units and installations subject to DNV verification and classification services.

A 300 Scope and application

301 The DDF unit may be applied for drilling, production, export and storage.

302 A DDF unit may be designed to function in different modes, typically operational (inclusive horizontal movement above wells) and survival. Limiting design criteria when going from one mode of operation to another shall be established.

303 The DDF unit should also be designed for transit relocation, if relevant.

304 For novel designs, or unproven applications of designs where limited, or no direct experience exists, relevant analyses and model testing shall be performed which clearly demonstrate that an acceptable level of safety can be obtained, i.e. safety level is not inferior to that obtained when applying this standard to traditional designs.

305 Requirements concerning mooring are given in DNV-OS-E301 and riser systems are given in DNV-OS-F201.

306 Requirements related to floating stability are given in DNV-OS-C301.

A 400 Classification

401 For use of this standard as technical basis for offshore classification as well as descriptions of principles, procedures and applicable class notations related to classification services see, DNV Offshore Service Specification given in Table B1.

402 Documentation for classification shall be in accordance with the NPS DocReq (i.e. DNV's Nauticus Production System for documentation requirements) and DNV-RP-A201.

Guidance note 2:
For units storing oil, the stability requirements of MARPOL should be considered, see IMO Res. MEPC 139 & 142.

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

4.3 Column stabilised units

4.3.1 The area under the righting moment curve to the angle of downflooding shall be not less than 30% in excess of the area under the wind heeling moment curve to the same limiting angle.

(See MODU Code 3.3.1.2)

4.3.2 The righting moment curve shall be positive over the entire range of angles from upright to the second intercept.

(See MODU Code 3.3.1.3)

4.3.3 During temporary conditions the metacentric height (GM) shall be at least 0.3 m.

4.4 Self elevating units or installations

4.4.1 The area under the righting moment curve to the second intercept or downflooding angle, whichever is less, shall be not less than 40% in excess of the area under the wind heeling moment curve to the same limiting angle.

(See MODU Code 3.3.1.1)

4.4.2 The righting moment curve shall be positive over the entire range of angles from upright to the second intercept.

(See MODU Code 3.3.1.3)

4.5 Deep draught floating installations

4.5.1 The area under the righting moment curve to the second intercept or downflooding angle, whichever is less, shall be not less than 30% in excess of the area under the wind heeling moment curve to the same limiting angle.

(See MODU Code 3.3.1.2)

4.5.2 The righting moment curve shall be positive over the entire range of angles from upright to the second intercept.

(See MODU Code 3.3.1.3)

4.5.3 Current is to be included in calculation of overturning moment. Guidance on calculation of current can be found in DNV-RP-C205.

4.5.4 Intact inclination angle is limited to 6° and 12° for normal operating conditions and survival conditions, respectively.

4.6 Cylindrical surface units

4.6.1 The area under the righting moment curve to the angle of downflooding shall be not less than 30% in excess of the area under the wind heeling moment curve to the same limiting angle.

(See MODU Code 3.3.1.2)

4.6.2 The righting moment curve shall be positive over the entire range of angles from upright to the second intercept.

(See MODU Code 3.3.1.3)

Guidance note:
For units storing oil, the stability requirements of MARPOL may be applicable, see IMO Res. MEPC 139 & 142.

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

Height above sea level (metres)	C_H
198.0 – 213.5	1.72
213.5 – 228.5	1.75
228.5 – 244.0	1.77
244.0 – 259.0	1.79
above 259	1.80

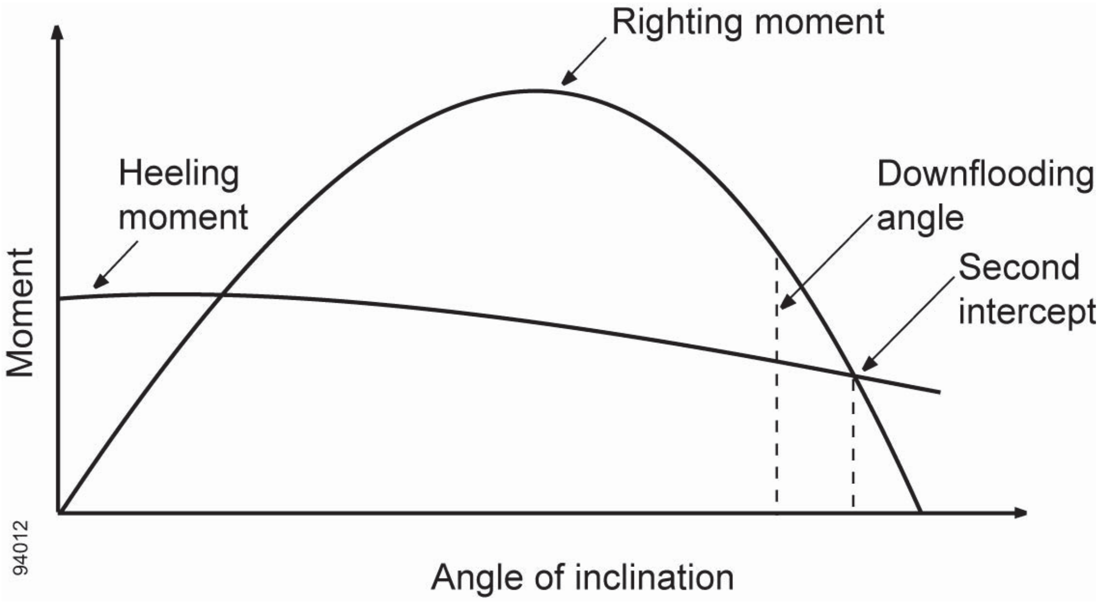


Figure 3-1 – Righting moment and heeling moment curves

3.3 Intact stability criteria

3.3.1 The stability of a unit in each mode of operation should meet the following criteria (see also figure 3-1):

.1 For surface and self-elevating units the area under the righting moment curve to the second intercept or downflooding angle, whichever is less, should be not less than 40% in excess of the area under the wind heeling moment curve to the same limiting angle.

.2 For column-stabilized units[8] the area under the righting moment curve to the angle of downflooding should be not less than 30% in excess of the area under the wind heeling moment curve to the same limiting angle.

.3 The righting moment curve should be positive over the entire range of angles from upright to the second intercept.

[8] Refer to An example of alternative intact stability criteria for twin-pontoon column-stabilized semisubmersible units, adopted by the Organization by resolution A.650(16).

HIDROSTÁTICAS CON LAS JAULAS EN LA POSICIÓN INFERIOR.

Draft Amidships	**0**	**0,514**	**1,028**	**1,542**	**2,056**	**2,57**	**3,084**	**3,598**	**4,112**	**4,626**	**5,14**	**5,654**	**6,168**	**6,682**
m														
Displacement t	0	158,6	321,1	484,7	649,3	814,5	980,1	1146	1312	1478	1643	1808	1976	2128
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	0	0,514	1,028	1,542	2,056	2,57	3,084	3,598	4,112	4,626	5,14	5,654	6,168	6,682
Draft at AP m	0	0,514	1,028	1,542	2,056	2,57	3,084	3,598	4,112	4,626	5,14	5,654	6,168	6,682
Draft at LCF m	0	0,514	1,028	1,542	2,056	2,57	3,084	3,598	4,112	4,626	5,14	5,654	6,168	6,682
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	0	20	20	20	20	20	20	20	20	20	20	20	20	10
Beam max extents on WL m	0	20	20	20	20	20	20	20	20	20	20	20	20	10
Wetted Area m^2	0	331,271	357,423	382,808	407,386	431,114	453,949	475,851	496,777	516,685	535,533	553,374	577,87	836,782
Waterpl. Area m^2	0	306,147	307,348	308,432	309,393	310,228	310,933	311,504	311,936	312,226	312,37	312,373	313,058	76,032
Prismatic coeff. (Cp)	0	0,279	0,28	0,281	0,282	0,283	0,284	0,284	0,285	0,285	0,285	0,285	0,286	0,285
Block coeff. (Cb)	0	0,279	0,28	0,281	0,282	0,283	0,284	0,284	0,285	0,285	0,285	0,285	0,286	0,568
Max Sect. area coeff. (Cm)		1	1	1	1	1	1	1	1	1	1	1	1	1,989
Waterpl. area coeff. (Cwp)	0	0,279	0,28	0,281	0,282	0,283	0,284	0,284	0,285	0,285	0,285	0,285	0,286	0,139
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	0	0,261	0,518	0,775	1,032	1,289	1,546	1,803	2,06	2,317	2,574	2,831	3,088	3,318
KG m	26,87	26,87	26,87	26,87	26,87	26,87	26,87	26,87	26,87	26,87	26,87	26,87	26,87	26,87
BMt m	0	49,736	24,565	16,276	12,156	9,693	8,057	6,892	6,022	5,349	4,812	4,375	4,002	0,231
BML m	0	47,245	23,685	15,907	12,024	9,689	8,126	7,003	6,153	5,485	4,943	4,494	4,147	0,221
GMt m	-26,87	23,127	-1,787	-9,818	-13,682	-15,888	-17,267	-18,174	-18,787	-19,204	-19,484	-19,664	-19,779	-23,321
GML m	-26,87	20,636	-2,666	-10,187	-13,814	-15,891	-17,197	-18,064	-18,657	-19,068	-19,352	-19,545	-19,634	-23,332
KMt m	0	49,997	25,083	17,052	13,188	10,982	9,603	8,696	8,083	7,666	7,386	7,206	7,091	3,549
KML m	0	47,506	24,204	16,683	13,056	10,979	9,673	8,806	8,213	7,802	7,518	7,325	7,236	3,538
Immersion (TPc) tonne/cm	0	3,138	3,15	3,161	3,171	3,18	3,187	3,193	3,197	3,2	3,202	3,202	3,209	0,779
MTc tonne.m	0	0,597	-0,156	-0,901	-1,637	-2,362	-3,076	-3,778	-4,467	-5,142	-5,802	-6,447	-7,081	-9,061
RM at 1deg = GMt.Disp.sin(1) tonne.m	0	64,004	-10,015	-83,062	-155,033	-225,833	-295,36	-363,505	-430,173	-495,26	-558,66	-620,305	-682,258	-866,188
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Draft Amidships	**7,252**	**7,77**	**8,288**	**8,806**	**9,324**	**9,842**	**10,36**	**10,878**	**11,396**	**11,914**	**12,432**	**12,95**	**13,468**	**13,986**
m														
Displacement t	2178	2305	2602	2885	3169	3452	3736	4020	4304	4588	4873	5157	5441	5726
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	7,252	7,77	8,288	8,806	9,324	9,842	10,36	10,878	11,396	11,914	12,432	12,95	13,468	13,986
Draft at AP m	7,252	7,77	8,288	8,806	9,324	9,842	10,36	10,878	11,396	11,914	12,432	12,95	13,468	13,986
Draft at LCF m	7,252	7,77	8,288	8,806	9,324	9,842	10,36	10,878	11,396	11,914	12,432	12,95	13,468	13,986
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4
Beam max extents on WL m	10	52,4	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613
Wetted Area m^2	850,316	1383,536	1756,977	1803,598	1849,949	1895,871	1941,434	1986,63	2031,45	2075,884	2119,923	2163,558	2206,78	2249,58
Waterpl. Area m^2	76,032	571,814	533,381	533,569	533,746	533,91	534,062	534,201	534,328	534,441	534,541	534,628	534,7	534,759
Prismatic coeff. (Cp)	1,535	0,297	0,32	0,344	0,365	0,386	0,405	0,423	0,44	0,456	0,471	0,485	0,499	0,512
Block coeff. (Cb)	2,933	0,106	0,152	0,158	0,164	0,169	0,174	0,178	0,182	0,186	0,189	0,192	0,195	0,198
Max Sect. area coeff. (Cm)	0,355	1,826	1,778	1,734	1,696	1,661	1,629	1,601	1,575	1,551	1,529	1,508	1,489	1,472
Waterpl. area coeff. (Cwp)	0,76	0,208	0,264	0,264	0,264	0,264	0,264	0,264	0,264	0,264	0,264	0,264	0,264	0,264
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	3,392	3,621	4,123	4,557	4,96	5,34	5,702	6,049	6,385	6,711	7,029	7,341	7,648	7,949
KG m	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41
BMt m	0,226	19,027	8,879	8,007	7,29	6,691	6,183	5,746	5,367	5,035	4,741	4,48	4,246	4,035
BML m	0,216	48,977	51,266	46,277	42,175	38,742	35,827	33,321	31,142	29,231	27,541	26,034	24,684	23,465
GMt m	-22,792	-3,762	-13,409	-13,846	-14,159	-14,379	-14,525	-14,615	-14,658	-14,664	-14,64	-14,589	-14,517	-14,426
GML m	-22,802	26,188	28,978	24,424	20,725	17,672	15,119	12,96	11,117	9,532	8,16	6,966	5,921	5,004
KMt m	3,618	22,648	13,001	12,564	12,251	12,031	11,885	11,795	11,752	11,746	11,77	11,821	11,893	11,984
KML m	3,608	52,598	55,388	50,834	47,135	44,082	41,529	39,37	37,527	35,942	34,57	33,376	32,331	31,414
Immersion (TPc) tonne/cm	0,779	5,861	5,467	5,469	5,471	5,473	5,474	5,476	5,477	5,478	5,479	5,48	5,481	5,481
MTc tonne.m	-9,062	11,018	13,759	12,859	11,984	11,134	10,308	9,508	8,732	7,981	7,256	6,555	5,879	5,229
RM at 1deg = GMt.Disp.sin(1) tonne.m	-866,247	-151,352	-608,877	-697,206	-783,034	-866,348	-947,142	-1025,409	-1101,139	-1174,327	-1244,964	-1313,043	-1378,558	-1441,503
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Draft Amidships	**14,504**	**15,022**	**15,54**	**16,058**	**16,576**	**17,094**	**17,612**	**18,13**	**18,648**	**19,166**	**19,684**	**20,202**	**20,72**
m													
Displacement t	6010	6294	6578	6862	7146	7431	7870	7911	7951	7992	8032	8072	8113
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	14,504	15,022	15,54	16,058	16,576	17,094	17,612	18,13	18,648	19,166	19,684	20,202	20,72
Draft at AP m	14,504	15,022	15,54	16,058	16,576	17,094	17,612	18,13	18,648	19,166	19,684	20,202	20,72
Draft at LCF m	14,504	15,022	15,54	16,058	16,576	17,094	17,612	18,13	18,648	19,166	19,684	20,202	20,72
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	52,4	52,4	52,4	52,4	52,4	52,4	10	10	10	10	10	10	10
Beam max extents on WL m	38,613	38,613	38,613	38,613	38,613	38,613	10	10	10	10	10	10	10
Wetted Area m^2	2291,949	2333,877	2375,355	2416,374	2457,919	2502,671	3722,509	3732,869	3743,229	3753,589	3763,949	3774,309	3784,669
Waterpl. Area m^2	534,803	534,833	534,849	534,849	534,927	535,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	0,524	0,536	0,547	0,558	0,568	0,578	3,111	3,062	3,016	2,972	2,929	2,888	2,848
Block coeff. (Cb)	0,2	0,202	0,204	0,206	0,208	0,21	4,362	4,259	4,162	4,07	3,983	3,9	3,821
Max Sect. area coeff. (Cm)	1,456	1,44	1,426	1,413	1,4	1,402	1,391	1,38	1,37	1,36	1,351	1,342	1,334
Waterpl. area coeff. (Cwp)	0,264	0,264	0,264	0,264	0,264	0,264	0,76	0,76	0,76	0,76	0,76	0,76	0,76
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	8,247	8,541	8,832	9,121	9,407	9,691	10,118	10,158	10,2	10,244	10,29	10,338	10,388
KG m	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41
BMt m	3,844	3,67	3,512	3,367	3,233	3,109	0,063	0,062	0,062	0,062	0,061	0,061	0,061
BML m	22,36	21,354	20,433	19,588	18,817	18,105	0,06	0,059	0,059	0,059	0,058	0,058	0,058
GMt m	-14,319	-14,198	-14,066	-13,923	-13,771	-13,61	-16,229	-16,19	-16,149	-16,105	-16,059	-16,011	-15,961
GML m	4,197	3,485	2,856	2,298	1,813	1,386	-16,232	-16,193	-16,151	-16,108	-16,062	-16,014	-15,964
KMt m	12,091	12,212	12,344	12,487	12,639	12,8	10,181	10,22	10,261	10,305	10,351	10,399	10,449
KML m	30,607	29,895	29,266	28,708	28,223	27,796	10,178	10,217	10,259	10,302	10,348	10,396	10,446
Immersion (TPc) tonne/cm	5,482	5,482	5,482	5,482	5,483	5,484	0,779	0,779	0,779	0,779	0,779	0,779	0,779
MTc tonne.m	4,603	4,003	3,428	2,878	2,365	1,879	-23,313	-23,376	-23,435	-23,49	-23,542	-23,589	-23,633
RM at 1deg = GMt.Disp.sin(1) tonne.m	-1501,871	-1559,656	-1614,852	-1667,455	-1717,518	-1765,21	-2229,223	-2235,239	-2240,89	-2246,176	-2251,098	-2255,654	-2259,845
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0

Draft Amidships	**21,238**	**21,756**	**22,274**	**22,792**	**23,31**	**23,828**	**24,346**	**24,864**	**25,382**	**25,9**	**26,418**	**26,936**
m												
Displacement t	8153	8193	8234	8274	8315	8355	8395	8436	8476	8516	8557	8597
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	21,238	21,756	22,274	22,792	23,31	23,828	24,346	24,864	25,382	25,9	26,418	26,936
Draft at AP m	21,238	21,756	22,274	22,792	23,31	23,828	24,346	24,864	25,382	25,9	26,418	26,936
Draft at LCF m	21,238	21,756	22,274	22,792	23,31	23,828	24,346	24,864	25,382	25,9	26,418	26,936
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	3795,029	3805,389	3815,749	3826,109	3836,469	3846,829	3857,189	3867,549	3877,909	3888,269	3898,629	3908,989
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	2,81	2,773	2,737	2,703	2,67	2,638	2,607	2,577	2,548	2,52	2,493	2,466
Block coeff. (Cb)	3,747	3,676	3,608	3,543	3,481	3,422	3,365	3,311	3,259	3,209	3,161	3,115
Max Sect. area coeff. (Cm)	1,326	1,318	1,311	1,304	1,297	1,291	1,285	1,279	1,273	1,268	1,263	1,258
Waterpl. area coeff. (Cwp)	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
KB m	10,441	10,495	10,552	10,61	10,671	10,733	10,797	10,863	10,931	11,001	11,072	11,146
KG m	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41
BMt m	0,06	0,06	0,06	0,059	0,059	0,059	0,059	0,058	0,058	0,058	0,058	0,057
BML m	0,058	0,057	0,057	0,057	0,056	0,056	0,056	0,056	0,055	0,055	0,055	0,055
GMt m	-15,909	-15,855	-15,799	-15,74	-15,68	-15,618	-15,554	-15,488	-15,421	-15,351	-15,28	-15,207
GML m	-15,912	-15,857	-15,801	-15,743	-15,683	-15,621	-15,557	-15,491	-15,424	-15,354	-15,283	-15,21
KMt m	10,501	10,555	10,611	10,67	10,73	10,792	10,856	10,922	10,989	11,059	11,13	11,203
KML m	10,498	10,553	10,609	10,667	10,727	10,789	10,853	10,919	10,986	11,056	11,127	11,2
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779
MTc tonne.m	-23,673	-23,709	-23,742	-23,77	-23,795	-23,816	-23,833	-23,846	-23,856	-23,861	-23,863	-23,861
RM at 1deg = GMt.Disp.sin(1) tonne.m	-2263,672	-2267,133	-2270,23	-2272,961	-2275,328	-2277,329	-2278,966	-2280,238	-2281,144	-2281,686	-2281,863	-2281,675
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0

Draft Amidships	**27,454**	**27,972**	**28,49**	**29,008**	**29,526**	**30,044**	**30,562**	**31,08**	**31,598**	**32,116**	**32,634**	**33,152**
m												
Displacement t	8637	8678	8718	8759	8799	8839	8880	8920	8960	9001	9041	9082
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	27,454	27,972	28,49	29,008	29,526	30,044	30,562	31,08	31,598	32,116	32,634	33,152
Draft at AP m	27,454	27,972	28,49	29,008	29,526	30,044	30,562	31,08	31,598	32,116	32,634	33,152
Draft at LCF m	27,454	27,972	28,49	29,008	29,526	30,044	30,562	31,08	31,598	32,116	32,634	33,152
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	3919,349	3929,709	3940,069	3950,429	3960,789	3971,149	3981,509	3991,869	4002,229	4012,589	4022,949	4033,309
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	2,441	2,416	2,392	2,368	2,346	2,323	2,302	2,281	2,261	2,241	2,222	2,203
Block coeff. (Cb)	3,07	3,028	2,986	2,947	2,908	2,871	2,835	2,801	2,767	2,735	2,704	2,673
Max Sect. area coeff. (Cm)	1,253	1,249	1,244	1,24	1,236	1,232	1,228	1,224	1,221	1,217	1,214	1,21
Waterpl. area coeff. (Cwp)	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
KB m	11,221	11,297	11,376	11,456	11,538	11,621	11,706	11,792	11,88	11,97	12,061	12,154
KG m	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41
BMt m	0,057	0,057	0,056	0,056	0,056	0,056	0,055	0,055	0,055	0,055	0,054	0,054
BML m	0,054	0,054	0,054	0,054	0,053	0,053	0,053	0,053	0,052	0,052	0,052	0,052
GMt m	-15,132	-15,056	-14,978	-14,898	-14,816	-14,733	-14,649	-14,562	-14,475	-14,385	-14,294	-14,202
GML m	-15,135	-15,059	-14,98	-14,901	-14,819	-14,736	-14,651	-14,565	-14,477	-14,388	-14,297	-14,205
KMt m	11,278	11,354	11,432	11,512	11,594	11,677	11,761	11,848	11,935	12,025	12,116	12,208
KML m	11,275	11,351	11,43	11,509	11,591	11,674	11,759	11,845	11,933	12,022	12,113	12,205
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779
MTc tonne.m	-23,856	-23,846	-23,832	-23,815	-23,794	-23,769	-23,741	-23,708	-23,672	-23,632	-23,588	-23,54
RM at 1deg = GMt.Disp.sin(1) tonne.m	-2281,122	-2280,204	-2278,921	-2277,273	-2275,26	-2272,882	-2270,139	-2267,032	-2263,559	-2259,721	-2255,519	-2250,951
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0

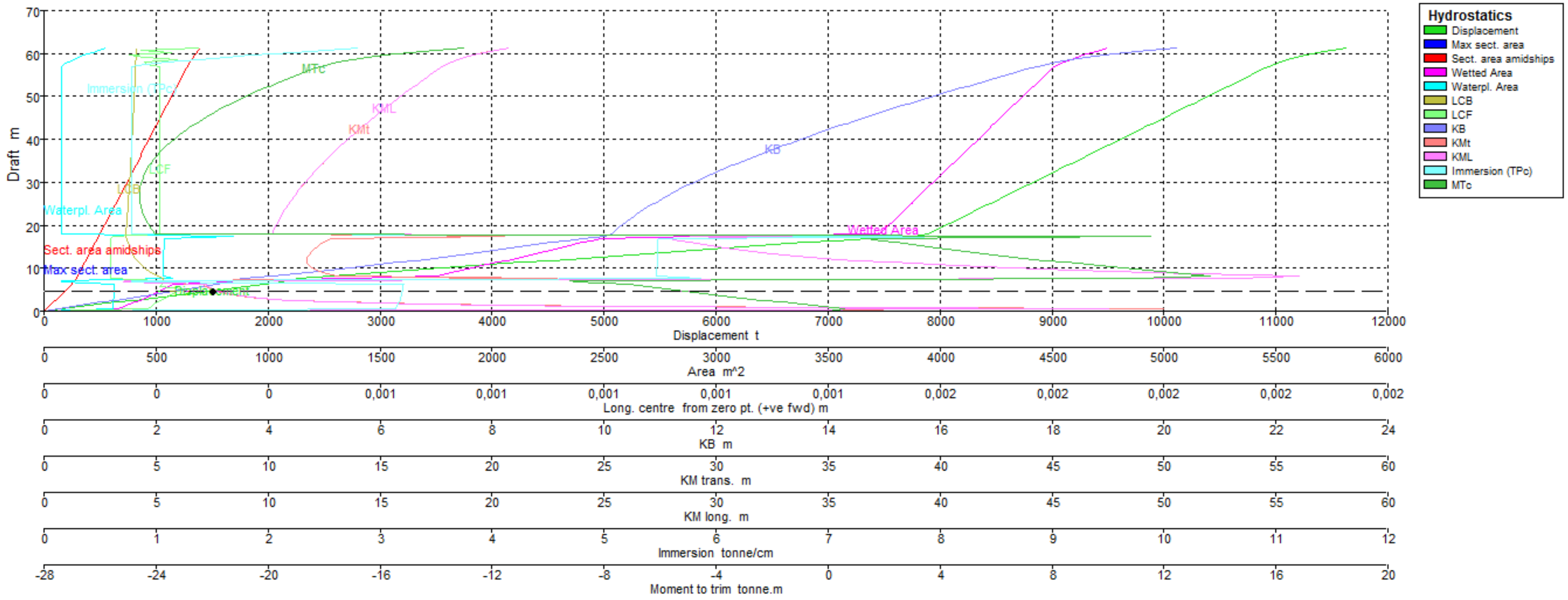
Draft Amidships	33,67	34,188	34,706	35,224	35,742	36,26	36,778	37,296	37,814	38,332	38,85	39,368
m												
Displacement t	9122	9162	9203	9243	9283	9324	9364	9404	9445	9485	9526	9566
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	33,67	34,188	34,706	35,224	35,742	36,26	36,778	37,296	37,814	38,332	38,85	39,368
Draft at AP m	33,67	34,188	34,706	35,224	35,742	36,26	36,778	37,296	37,814	38,332	38,85	39,368
Draft at LCF m	33,67	34,188	34,706	35,224	35,742	36,26	36,778	37,296	37,814	38,332	38,85	39,368
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	4043,669	4054,029	4064,389	4074,749	4085,109	4095,469	4105,829	4116,189	4126,549	4136,909	4147,269	4157,629
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	2,184	2,166	2,149	2,132	2,115	2,099	2,083	2,068	2,053	2,038	2,024	2,01
Block coeff. (Cb)	2,644	2,615	2,588	2,561	2,535	2,509	2,485	2,461	2,437	2,415	2,393	2,371
Max Sect. area coeff. (Cm)	1,207	1,204	1,201	1,198	1,195	1,193	1,19	1,187	1,185	1,182	1,18	1,178
Waterpl. area coeff. (Cwp)	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
KB m	12,248	12,343	12,44	12,539	12,638	12,74	12,842	12,946	13,051	13,158	13,265	13,374
KG m	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41
BMt m	0,054	0,054	0,053	0,053	0,053	0,053	0,053	0,052	0,052	0,052	0,052	0,051
BML m	0,051	0,051	0,051	0,051	0,051	0,05	0,05	0,05	0,05	0,049	0,049	0,049
GMt m	-14,108	-14,013	-13,916	-13,818	-13,719	-13,618	-13,515	-13,412	-13,307	-13,2	-13,093	-12,984
GML m	-14,111	-14,015	-13,919	-13,821	-13,721	-13,62	-13,518	-13,414	-13,309	-13,203	-13,095	-12,986
KMt m	12,302	12,397	12,494	12,592	12,691	12,792	12,895	12,998	13,103	13,21	13,317	13,426
KML m	12,299	12,395	12,491	12,589	12,689	12,79	12,892	12,996	13,101	13,207	13,315	13,424
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779
MTc tonne.m	-23,488	-23,433	-23,374	-23,311	-23,244	-23,173	-23,099	-23,021	-22,938	-22,853	-22,763	-22,669
RM at 1deg = GMt.Disp.sin(1) tonne.m	-2246,019	-2240,721	-2235,059	-2229,031	-2222,639	-2215,882	-2208,759	-2201,272	-2193,42	-2185,203	-2176,621	-2167,674
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0

Draft Amidships	39,886	40,404	40,922	41,44	41,958	42,476	42,994	43,512	44,03	44,548	45,066	45,584
m												
Displacement t	9606	9647	9687	9727	9768	9808	9849	9889	9929	9970	10010	10050
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	39,886	40,404	40,922	41,44	41,958	42,476	42,994	43,512	44,03	44,548	45,066	45,584
Draft at AP m	39,886	40,404	40,922	41,44	41,958	42,476	42,994	43,512	44,03	44,548	45,066	45,584
Draft at LCF m	39,886	40,404	40,922	41,44	41,958	42,476	42,994	43,512	44,03	44,548	45,066	45,584
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	4167,989	4178,349	4188,709	4199,069	4209,429	4219,789	4230,149	4240,509	4250,869	4261,229	4271,589	4281,949
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	1,996	1,982	1,969	1,956	1,944	1,931	1,919	1,907	1,896	1,884	1,873	1,862
Block coeff. (Cb)	2,35	2,33	2,31	2,291	2,272	2,253	2,235	2,218	2,201	2,184	2,167	2,151
Max Sect. area coeff. (Cm)	1,175	1,173	1,171	1,169	1,167	1,165	1,163	1,161	1,159	1,157	1,155	1,154
Waterpl. area coeff. (Cwp)	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
KB m	13,485	13,596	13,709	13,823	13,938	14,055	14,172	14,291	14,411	14,532	14,654	14,777
KG m	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41
BMt m	0,051	0,051	0,051	0,051	0,05	0,05	0,05	0,05	0,05	0,049	0,049	0,049
BML m	0,049	0,049	0,048	0,048	0,048	0,048	0,048	0,047	0,047	0,047	0,047	0,047
GMt m	-12,874	-12,763	-12,65	-12,536	-12,421	-12,305	-12,188	-12,069	-11,95	-11,829	-11,707	-11,584
GML m	-12,876	-12,765	-12,652	-12,539	-12,424	-12,307	-12,19	-12,071	-11,952	-11,831	-11,709	-11,586
KMt m	13,536	13,647	13,76	13,874	13,989	14,105	14,222	14,341	14,46	14,581	14,703	14,826
KML m	13,534	13,645	13,758	13,871	13,986	14,103	14,22	14,339	14,458	14,579	14,701	14,824
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779
MTc tonne.m	-22,572	-22,471	-22,366	-22,257	-22,144	-22,028	-21,908	-21,784	-21,656	-21,524	-21,388	-21,249
RM at 1deg = GMt.Disp.sin(1) tonne.m	-2158,362	-2148,685	-2138,643	-2128,236	-2117,465	-2106,328	-2094,826	-2082,96	-2070,728	-2058,132	-2045,17	-2031,844
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0

Draft Amidships	**46,102**	**46,62**	**47,138**	**47,656**	**48,174**	**48,692**	**49,21**	**49,728**	**50,246**	**50,764**	**51,282**	**51,8**
m												
Displacement t	10091	10131	10171	10212	10252	10293	10333	10373	10414	10454	10494	10535
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	46,102	46,62	47,138	47,656	48,174	48,692	49,21	49,728	50,246	50,764	51,282	51,8
Draft at AP m	46,102	46,62	47,138	47,656	48,174	48,692	49,21	49,728	50,246	50,764	51,282	51,8
Draft at LCF m	46,102	46,62	47,138	47,656	48,174	48,692	49,21	49,728	50,246	50,764	51,282	51,8
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	4292,309	4302,669	4313,029	4323,389	4333,749	4344,109	4354,469	4364,829	4375,189	4385,549	4395,909	4406,269
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	1,851	1,841	1,831	1,82	1,811	1,801	1,791	1,782	1,773	1,763	1,755	1,746
Block coeff. (Cb)	2,136	2,121	2,106	2,091	2,077	2,063	2,049	2,036	2,022	2,009	1,997	1,984
Max Sect. area coeff. (Cm)	1,152	1,15	1,149	1,147	1,145	1,144	1,142	1,141	1,139	1,138	1,137	1,135
Waterpl. area coeff. (Cwp)	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
KB m	14,901	15,027	15,153	15,281	15,409	15,539	15,669	15,801	15,933	16,067	16,201	16,337
KG m	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41
BMt m	0,049	0,049	0,048	0,048	0,048	0,048	0,048	0,047	0,047	0,047	0,047	0,047
BML m	0,047	0,046	0,046	0,046	0,046	0,046	0,045	0,045	0,045	0,045	0,045	0,045
GMt m	-11,46	-11,335	-11,208	-11,081	-10,953	-10,823	-10,693	-10,562	-10,429	-10,296	-10,162	-10,027
GML m	-11,462	-11,337	-11,211	-11,083	-10,955	-10,826	-10,695	-10,564	-10,432	-10,298	-10,164	-10,029
KMt m	14,95	15,075	15,202	15,329	15,457	15,587	15,717	15,848	15,981	16,114	16,248	16,383
KML m	14,948	15,073	15,199	15,327	15,455	15,584	15,715	15,846	15,978	16,112	16,246	16,381
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779
MTc tonne.m	-21,106	-20,959	-20,808	-20,654	-20,495	-20,333	-20,167	-19,997	-19,823	-19,646	-19,464	-19,279
RM at 1deg = GMt.Disp.sin(1) tonne.m	-2018,152	-2004,096	-1989,675	-1974,888	-1959,737	-1944,221	-1928,34	-1912,094	-1895,483	-1878,507	-1861,166	-1843,46
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0

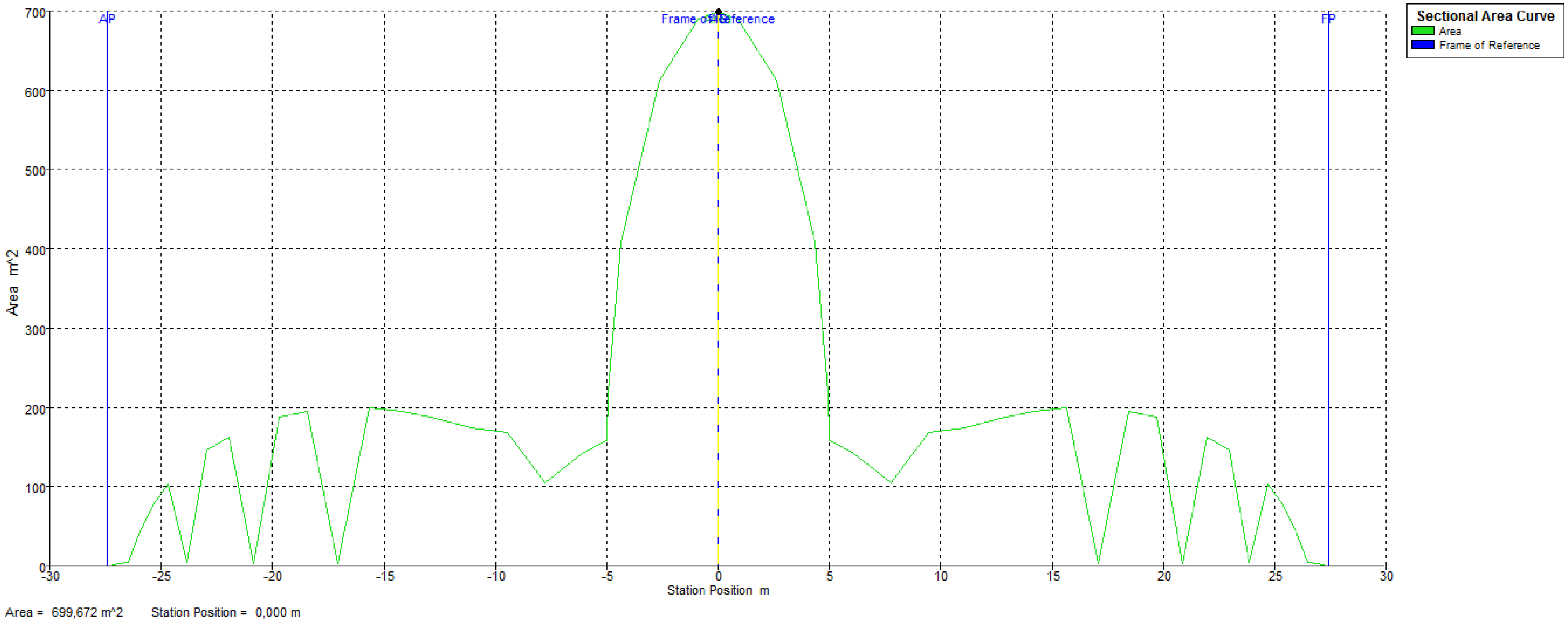
Draft Amidships	**52,318**	**52,836**	**53,354**	**53,872**	**54,39**	**54,908**	**55,426**	**55,944**	**56,462**	**56,98**	**57,498**	**58,016**
m												
Displacement t	10575	10616	10656	10696	10737	10777	10817	10858	10898	10939	10980	11031
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	52,318	52,836	53,354	53,872	54,39	54,908	55,426	55,944	56,462	56,98	57,498	58,016
Draft at AP m	52,318	52,836	53,354	53,872	54,39	54,908	55,426	55,944	56,462	56,98	57,498	58,016
Draft at LCF m	52,318	52,836	53,354	53,872	54,39	54,908	55,426	55,944	56,462	56,98	57,498	58,016
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10,44	11,645
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10,44	11,645
Wetted Area m^2	4416,629	4426,989	4437,349	4447,709	4458,069	4468,429	4478,789	4489,149	4499,509	4509,869	4527,33	4549,884
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	85,757	104,8
Prismatic coeff. (Cp)	1,737	1,729	1,72	1,712	1,704	1,696	1,689	1,681	1,674	1,666	1,589	1,419
Block coeff. (Cb)	1,972	1,96	1,949	1,937	1,926	1,915	1,904	1,894	1,883	1,873	1,709	1,368
Max Sect. area coeff. (Cm)	1,134	1,133	1,131	1,13	1,129	1,128	1,127	1,125	1,124	1,076	0,964	0,875
Waterpl. area coeff. (Cwp)	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,76	0,787	0,773
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0
KB m	16,473	16,61	16,749	16,888	17,028	17,169	17,311	17,453	17,597	17,741	17,89	18,073
KG m	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41	26,41
BMt m	0,047	0,046	0,046	0,046	0,046	0,046	0,046	0,045	0,045	0,045	0,053	0,082
BML m	0,044	0,044	0,044	0,044	0,044	0,044	0,043	0,043	0,043	0,043	0,058	0,082
GMt m	-9,89	-9,753	-9,615	-9,476	-9,336	-9,196	-9,054	-8,911	-8,768	-8,624	-8,467	-8,255
GML m	-9,893	-9,755	-9,617	-9,478	-9,339	-9,198	-9,056	-8,914	-8,77	-8,626	-8,462	-8,254
KMt m	16,52	16,657	16,795	16,934	17,074	17,214	17,356	17,499	17,642	17,786	17,943	18,155
KML m	16,517	16,655	16,793	16,932	17,071	17,212	17,354	17,496	17,64	17,784	17,948	18,156
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,879	1,074
MTc tonne.m	-19,09	-18,898	-18,701	-18,501	-18,296	-18,088	-17,877	-17,661	-17,441	-17,218	-16,955	-16,615
RM at 1deg = GMt.Disp.sin(1) tonne.m	-1825,389	-1806,953	-1788,152	-1768,987	-1749,456	-1729,56	-1709,3	-1688,674	-1667,684	-1646,329	-1622,471	-1589,108
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0

Draft Amidships	**58,534**	**59,052**	**59,57**	**60,088**	**60,606**	**61,6**
m						
Displacement t	11093	11170	11258	11362	11485	11622
Heel deg	0	0	0	0	0	0
Draft at FP m	58,534	59,052	59,57	60,088	60,606	61,124
Draft at AP m	58,534	59,052	59,57	60,088	60,606	61,124
Draft at LCF m	58,534	59,052	59,57	60,088	60,606	61,124
Trim (+ve by stern) m	0	0	0	0	0	0
WL Length m	12,85	14,054	15,259	16,464	17,668	18,873
Beam max extents on WL m	12,85	14,054	15,259	16,464	17,668	18,873
Wetted Area m^2	4581,187	4609,656	4635,419	4677,466	4712,549	4745,106
Waterpl. Area m^2	132,272	156,45	177,63	214,719	244,378	271,279
Prismatic coeff. (Cp)	1,28	1,166	1,071	0,989	0,92	0,86
Block coeff. (Cb)	1,12	0,934	0,792	0,681	0,592	0,521
Max Sect. area coeff. (Cm)	0,801	0,74	0,688	0,644	0,606	
Waterpl. area coeff. (Cwp)	0,801	0,792	0,763	0,792	0,783	0,762
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0
KB m	18,299	18,577	18,899	19,273	19,71	20,195
KG m	26,41	26,41	26,41	26,41	26,41	26,41
BMt m	0,121	0,175	0,24	0,321	0,422	0,541
BML m	0,141	0,187	0,224	0,35	0,434	0,503
GMt m	-7,99	-7,658	-7,271	-6,816	-6,278	-5,673
GML m	-7,971	-7,645	-7,287	-6,787	-6,266	-5,712
KMt m	18,42	18,752	19,139	19,594	20,132	20,737
KML m	18,439	18,765	19,123	19,623	20,144	20,698
Immersion (TPc) tonne/cm	1,356	1,604	1,821	2,201	2,505	2,781
MTc tonne.m	-16,134	-15,583	-14,971	-14,073	-13,131	-12,113
RM at 1deg = GMt.Disp.sin(1) tonne.m	-1546,81	-1492,823	-1428,73	-1351,628	-1258,242	-1150,663
Max deck inclination deg	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0

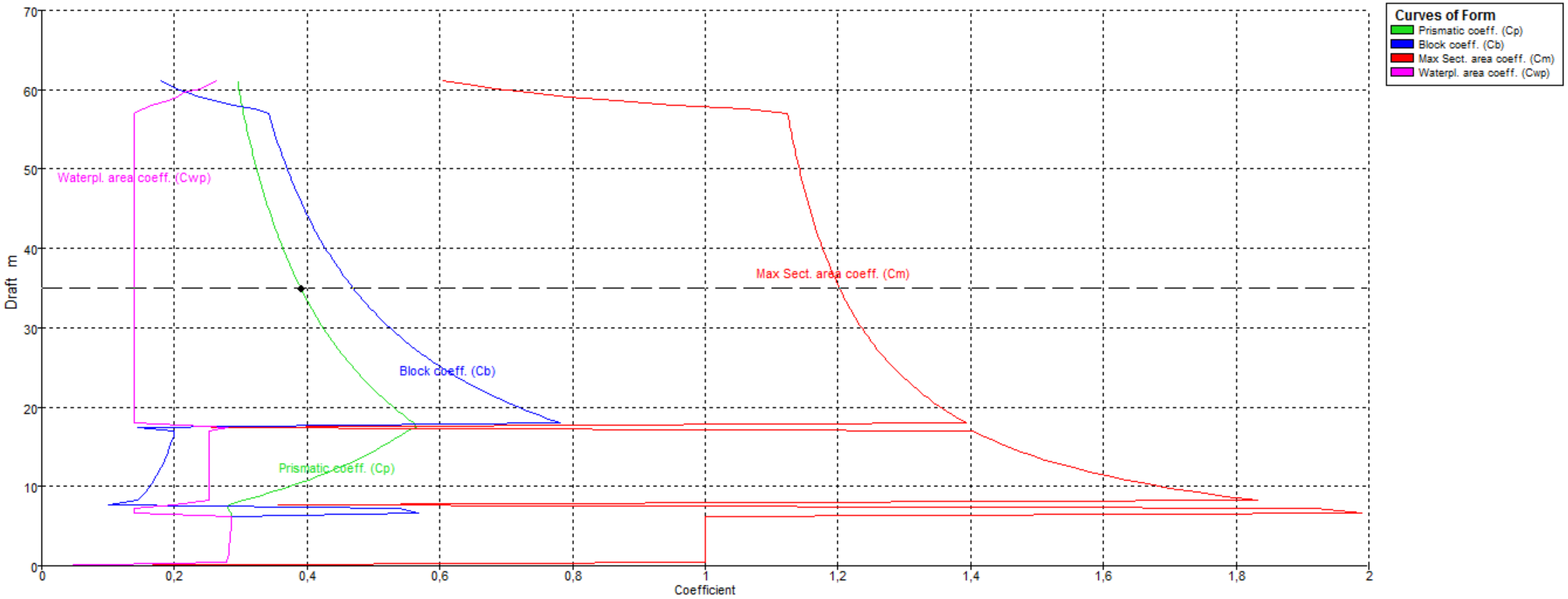


Draft = 4,715 m Displacement = 1506,200 t

CURVA DE ÁREAS



COEFICIENTES DE FORMA



Draft = 35,000 m   Prismatic coeff. (Cp) = 0,390

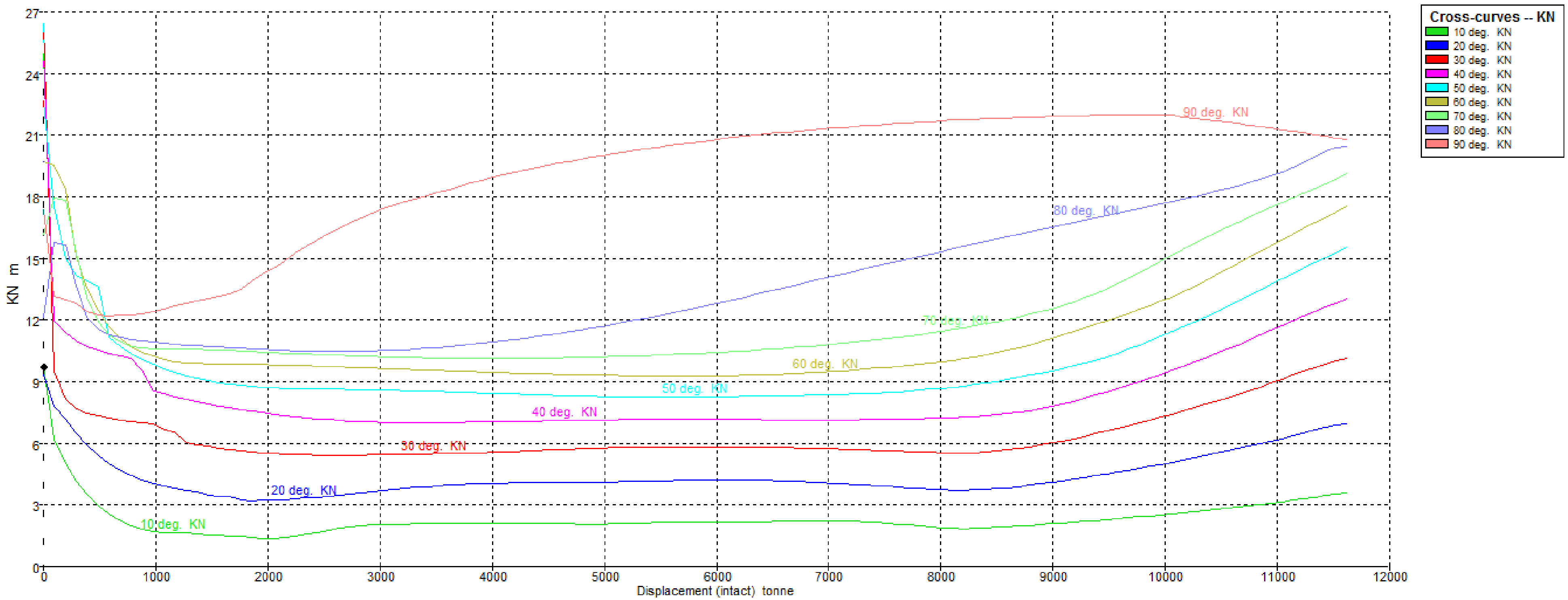
CURVAS KN

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
0,01	0,009	0	0	0	26,87	9,742	9,325	26,443	24,933	22,666	19,714	16,169	12,155	17,354
97,67	0,32	0	0	0	26,87	6,182	7,804	9,511	11,975	17,55	19,559	17,947	15,765	13,178
195,3	0,631	0	0	0	26,87	5,018	7,182	8,16	11,374	15,009	18,36	17,817	15,667	12,982
293	0,939	0	0	0	26,87	4,179	6,495	7,705	10,975	14,198	15,076	15,285	13,676	12,794
390,7	1,247	0	0	0	26,87	3,515	5,908	7,472	10,729	13,878	13,574	13,084	12,135	12,417
488,3	1,553	0	0	0	26,87	2,972	5,389	7,332	10,533	13,605	12,459	11,908	11,544	12,243
586	1,859	0	0	0	26,87	2,538	4,995	7,229	10,378	11,171	11,658	11,263	11,295	12,189
683,7	2,163	0	0	0	26,87	2,225	4,687	7,136	10,257	10,729	11,102	10,912	11,167	12,224
781,3	2,467	0	0	0	26,87	1,997	4,437	7,044	10,151	10,377	10,714	10,729	11,066	12,248
879	2,77	0	0	0	26,87	1,826	4,233	6,982	9,553	10,091	10,438	10,638	10,989	12,322
976,6	3,073	0	0	0	26,87	1,695	4,066	6,941	8,564	9,85	10,239	10,603	10,926	12,426
1074	3,376	0	0	0	26,87	1,646	3,929	6,647	8,41	9,639	10,093	10,592	10,871	12,548
1172	3,678	0	0	0	26,87	1,655	3,815	6,575	8,267	9,458	9,989	10,589	10,826	12,684
1270	3,981	0	0	0	26,87	1,637	3,716	6,026	8,134	9,302	9,928	10,581	10,789	12,815
1367	4,284	0	0	0	26,87	1,61	3,628	5,928	8,017	9,169	9,891	10,572	10,759	12,919
1465	4,586	0	0	0	26,87	1,566	3,489	5,84	7,913	9,059	9,869	10,559	10,73	13,032
1563	4,89	0	0	0	26,87	1,521	3,424	5,76	7,819	8,967	9,858	10,542	10,699	13,155
1660	5,194	0	0	0	26,87	1,491	3,394	5,687	7,732	8,889	9,851	10,519	10,669	13,277
1758	5,499	0	0	0	26,87	1,458	3,221	5,627	7,651	8,825	9,844	10,495	10,64	13,5
1856	5,801	0	0	0	26,87	1,423	3,217	5,576	7,575	8,769	9,835	10,47	10,606	13,882
1953	6,098	0	0	0	26,87	1,393	3,224	5,534	7,501	8,726	9,826	10,446	10,573	14,229
2051	6,394	0	0	0	26,87	1,389	3,243	5,5	7,43	8,696	9,817	10,42	10,542	14,548
2149	6,919	0	0	0	26,87	1,437	3,269	5,476	7,366	8,677	9,805	10,395	10,513	14,858
2246	7,669	0	0	0	26,87	1,505	3,301	5,458	7,307	8,664	9,791	10,372	10,488	15,239
2344	7,836	0	0	0	26,87	1,583	3,338	5,445	7,253	8,655	9,775	10,349	10,471	15,591
2442	8,002	0	0	0	26,87	1,668	3,378	5,436	7,204	8,648	9,758	10,328	10,461	15,913
2539	8,174	0	0	0	26,87	1,761	3,428	5,431	7,161	8,642	9,74	10,307	10,457	16,208
2637	8,352	0	0	0	26,87	1,853	3,491	5,43	7,123	8,635	9,721	10,287	10,458	16,481
2735	8,531	0	0	0	26,87	1,934	3,556	5,433	7,089	8,626	9,702	10,267	10,464	16,735
2832	8,709	0	0	0	26,87	1,993	3,613	5,439	7,06	8,617	9,682	10,248	10,476	16,973
2930	8,888	0	0	0	26,87	2,033	3,664	5,447	7,036	8,607	9,662	10,23	10,491	17,196

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
3028	9,066	0	0	0	26,87	2,054	3,712	5,455	7,017	8,595	9,643	10,213	10,511	17,404
3125	9,244	0	0	0	26,87	2,064	3,76	5,465	7,004	8,582	9,625	10,199	10,535	17,584
3223	9,423	0	0	0	26,87	2,072	3,804	5,474	6,999	8,568	9,606	10,186	10,563	17,753
3321	9,601	0	0	0	26,87	2,081	3,847	5,482	6,999	8,553	9,588	10,174	10,595	17,914
3418	9,779	0	0	0	26,87	2,087	3,887	5,49	7,004	8,538	9,569	10,164	10,631	18,065
3516	9,958	0	0	0	26,87	2,09	3,925	5,498	7,011	8,523	9,55	10,155	10,67	18,209
3614	10,136	0	0	0	26,87	2,095	3,961	5,508	7,02	8,507	9,531	10,147	10,712	18,347
3711	10,314	0	0	0	26,87	2,104	3,993	5,519	7,029	8,49	9,512	10,14	10,759	18,505
3809	10,492	0	0	0	26,87	2,113	4,019	5,533	7,038	8,473	9,493	10,136	10,809	18,657
3907	10,67	0	0	0	26,87	2,12	4,038	5,548	7,048	8,456	9,475	10,133	10,863	18,802
4004	10,848	0	0	0	26,87	2,125	4,052	5,564	7,058	8,439	9,458	10,133	10,922	18,94
4102	11,026	0	0	0	26,87	2,128	4,064	5,581	7,067	8,422	9,441	10,134	10,985	19,07
4200	11,205	0	0	0	26,87	2,129	4,075	5,601	7,075	8,405	9,425	10,137	11,051	19,192
4297	11,383	0	0	0	26,87	2,126	4,086	5,623	7,083	8,388	9,409	10,142	11,121	19,31
4395	11,561	0	0	0	26,87	2,118	4,096	5,649	7,092	8,371	9,395	10,148	11,195	19,422
4493	11,739	0	0	0	26,87	2,108	4,103	5,675	7,1	8,353	9,382	10,156	11,272	19,53
4590	11,917	0	0	0	26,87	2,098	4,107	5,7	7,108	8,336	9,369	10,165	11,353	19,633
4688	12,095	0	0	0	26,87	2,087	4,111	5,723	7,116	8,321	9,357	10,175	11,436	19,732
4786	12,273	0	0	0	26,87	2,073	4,114	5,743	7,124	8,308	9,346	10,187	11,523	19,827
4883	12,451	0	0	0	26,87	2,065	4,117	5,762	7,132	8,297	9,335	10,2	11,612	19,918
4981	12,629	0	0	0	26,87	2,071	4,123	5,778	7,139	8,287	9,325	10,215	11,704	20,006
5079	12,807	0	0	0	26,87	2,088	4,129	5,791	7,145	8,279	9,315	10,23	11,797	20,091
5176	12,985	0	0	0	26,87	2,105	4,137	5,802	7,15	8,273	9,307	10,246	11,894	20,173
5274	13,163	0	0	0	26,87	2,118	4,144	5,812	7,153	8,268	9,3	10,263	11,993	20,251
5372	13,34	0	0	0	26,87	2,129	4,154	5,819	7,156	8,265	9,294	10,281	12,095	20,33
5469	13,518	0	0	0	26,87	2,139	4,166	5,824	7,158	8,264	9,289	10,3	12,2	20,408
5567	13,696	0	0	0	26,87	2,149	4,18	5,827	7,16	8,264	9,285	10,321	12,309	20,483
5665	13,874	0	0	0	26,87	2,158	4,193	5,829	7,16	8,265	9,284	10,342	12,42	20,555
5762	14,052	0	0	0	26,87	2,166	4,204	5,829	7,161	8,267	9,284	10,365	12,533	20,625
5860	14,23	0	0	0	26,87	2,172	4,213	5,827	7,161	8,27	9,286	10,39	12,649	20,692
5958	14,408	0	0	0	26,87	2,179	4,219	5,823	7,16	8,274	9,291	10,416	12,767	20,758
6055	14,586	0	0	0	26,87	2,185	4,221	5,819	7,159	8,279	9,298	10,443	12,887	20,821
6153	14,764	0	0	0	26,87	2,189	4,221	5,815	7,157	8,285	9,307	10,472	13,008	20,882

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
6250	14,942	0	0	0	26,87	2,19	4,219	5,811	7,154	8,292	9,319	10,503	13,13	20,941
6348	15,12	0	0	0	26,87	2,191	4,212	5,806	7,15	8,299	9,334	10,535	13,253	20,998
6446	15,298	0	0	0	26,87	2,192	4,201	5,8	7,146	8,308	9,351	10,569	13,377	21,054
6543	15,477	0	0	0	26,87	2,197	4,185	5,793	7,143	8,318	9,37	10,606	13,502	21,105
6641	15,655	0	0	0	26,87	2,206	4,167	5,784	7,14	8,329	9,392	10,644	13,628	21,154
6739	15,833	0	0	0	26,87	2,215	4,147	5,774	7,138	8,341	9,416	10,685	13,754	21,201
6836	16,011	0	0	0	26,87	2,222	4,125	5,762	7,137	8,354	9,443	10,727	13,88	21,247
6934	16,189	0	0	0	26,87	2,224	4,1	5,749	7,137	8,367	9,472	10,772	14,005	21,291
7032	16,367	0	0	0	26,87	2,222	4,07	5,735	7,139	8,38	9,503	10,818	14,13	21,334
7129	16,544	0	0	0	26,87	2,214	4,037	5,719	7,142	8,395	9,538	10,867	14,255	21,376
7227	16,722	0	0	0	26,87	2,198	4,004	5,701	7,147	8,413	9,574	10,918	14,379	21,417
7325	16,9	0	0	0	26,87	2,176	3,973	5,683	7,152	8,433	9,614	10,972	14,503	21,456
7422	17,078	0	0	0	26,87	2,149	3,942	5,662	7,158	8,456	9,657	11,028	14,625	21,495
7520	17,2	0	0	0	26,87	2,115	3,91	5,641	7,165	8,482	9,703	11,088	14,746	21,532
7618	17,313	0	0	0	26,87	2,076	3,876	5,618	7,174	8,512	9,75	11,152	14,866	21,568
7715	17,425	0	0	0	26,87	2,03	3,841	5,596	7,184	8,547	9,8	11,22	14,986	21,603
7813	17,539	0	0	0	26,87	1,978	3,806	5,575	7,195	8,587	9,853	11,292	15,106	21,639
7911	18,13	0	0	0	26,87	1,924	3,773	5,558	7,209	8,632	9,912	11,368	15,225	21,673
8008	19,383	0	0	0	26,87	1,882	3,746	5,542	7,225	8,681	9,976	11,45	15,345	21,707
8106	20,636	0	0	0	26,87	1,863	3,727	5,53	7,245	8,734	10,046	11,536	15,466	21,74
8204	21,889	0	0	0	26,87	1,85	3,724	5,531	7,27	8,794	10,122	11,626	15,587	21,764
8301	23,142	0	0	0	26,87	1,86	3,733	5,551	7,303	8,863	10,205	11,722	15,708	21,782
8399	24,395	0	0	0	26,87	1,886	3,765	5,581	7,343	8,94	10,298	11,823	15,828	21,799
8497	25,649	0	0	0	26,87	1,915	3,807	5,622	7,394	9,027	10,402	11,929	15,949	21,815
8594	26,902	0	0	0	26,87	1,945	3,842	5,673	7,451	9,12	10,519	12,038	16,07	21,831
8692	28,155	0	0	0	26,87	1,977	3,894	5,748	7,511	9,215	10,649	12,153	16,19	21,846
8790	29,408	0	0	0	26,87	2,01	3,96	5,837	7,585	9,315	10,792	12,277	16,308	21,863
8887	30,661	0	0	0	26,87	2,045	4,029	5,929	7,678	9,418	10,949	12,411	16,426	21,883
8985	31,914	0	0	0	26,87	2,082	4,102	6,023	7,786	9,526	11,114	12,556	16,542	21,902
9083	33,168	0	0	0	26,87	2,121	4,178	6,11	7,916	9,642	11,28	12,715	16,658	21,921
9180	34,421	0	0	0	26,87	2,16	4,256	6,225	8,058	9,771	11,451	12,89	16,772	21,938
9278	35,674	0	0	0	26,87	2,202	4,337	6,344	8,204	9,906	11,624	13,082	16,886	21,956
9376	36,927	0	0	0	26,87	2,244	4,422	6,467	8,356	10,05	11,798	13,291	16,999	21,973

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
9473	38,18	0	0	0	26,87	2,289	4,508	6,593	8,511	10,204	11,969	13,518	17,11	21,99
9571	39,433	0	0	0	26,87	2,334	4,598	6,724	8,663	10,385	12,143	13,765	17,222	22,007
9669	40,687	0	0	0	26,87	2,381	4,69	6,859	8,822	10,587	12,321	14,03	17,334	22,014
9766	41,94	0	0	0	26,87	2,429	4,784	6,997	9,001	10,792	12,508	14,312	17,445	22,004
9864	43,193	0	0	0	26,87	2,478	4,881	7,138	9,182	11,004	12,699	14,595	17,558	21,992
9962	44,446	0	0	0	26,87	2,528	4,98	7,283	9,369	11,222	12,904	14,88	17,671	21,981
10059	45,699	0	0	0	26,87	2,579	5,081	7,431	9,559	11,444	13,125	15,157	17,784	21,959
10157	46,953	0	0	0	26,87	2,632	5,185	7,582	9,753	11,668	13,367	15,436	17,899	21,898
10255	48,206	0	0	0	26,87	2,686	5,29	7,737	9,952	11,893	13,628	15,711	18,017	21,833
10352	49,459	0	0	0	26,87	2,74	5,398	7,894	10,154	12,118	13,9	15,98	18,138	21,766
10450	50,712	0	0	0	26,87	2,796	5,508	8,054	10,36	12,366	14,181	16,245	18,267	21,698
10548	51,965	0	0	0	26,87	2,853	5,619	8,217	10,569	12,634	14,466	16,502	18,399	21,629
10645	53,218	0	0	0	26,87	2,91	5,733	8,383	10,785	12,909	14,75	16,752	18,538	21,563
10743	54,472	0	0	0	26,87	2,969	5,848	8,553	11,02	13,186	15,031	16,999	18,684	21,494
10841	55,725	0	0	0	26,87	3,028	5,965	8,731	11,262	13,459	15,32	17,242	18,839	21,422
10938	56,978	0	0	0	26,87	3,089	6,091	8,926	11,505	13,731	15,608	17,482	19,005	21,349
11036	58,068	0	0	0	26,87	3,157	6,227	9,124	11,739	14	15,894	17,714	19,192	21,271
11134	58,824	0	0	0	26,87	3,23	6,37	9,315	11,972	14,265	16,177	17,941	19,411	21,194
11231	59,42	0	0	0	26,87	3,304	6,51	9,502	12,199	14,526	16,457	18,161	19,67	21,116
11329	59,934	0	0	0	26,87	3,378	6,642	9,681	12,421	14,783	16,733	18,382	19,951	21,034
11427	60,37	0	0	0	26,87	3,452	6,765	9,852	12,637	15,036	17,002	18,606	20,231	20,953
11524	60,763	0	0	0	26,87	3,514	6,874	10,015	12,845	15,284	17,262	18,847	20,384	20,871
11622	61,122	0	0	0	26,87	3,563	6,972	10,163	13,042	15,525	17,536	19,118	20,468	20,805



Cross-curves -- KN
10 deg. KN
20 deg. KN
30 deg. KN
40 deg. KN
50 deg. KN
60 deg. KN
70 deg. KN
80 deg. KN
90 deg. KN
KN m
Displacement (intact) tonne

ESTUDIO DE LAS CONDICIONES DE CARGA

EQUILIBRIO CONDICIÓN DE CARGA Nº1

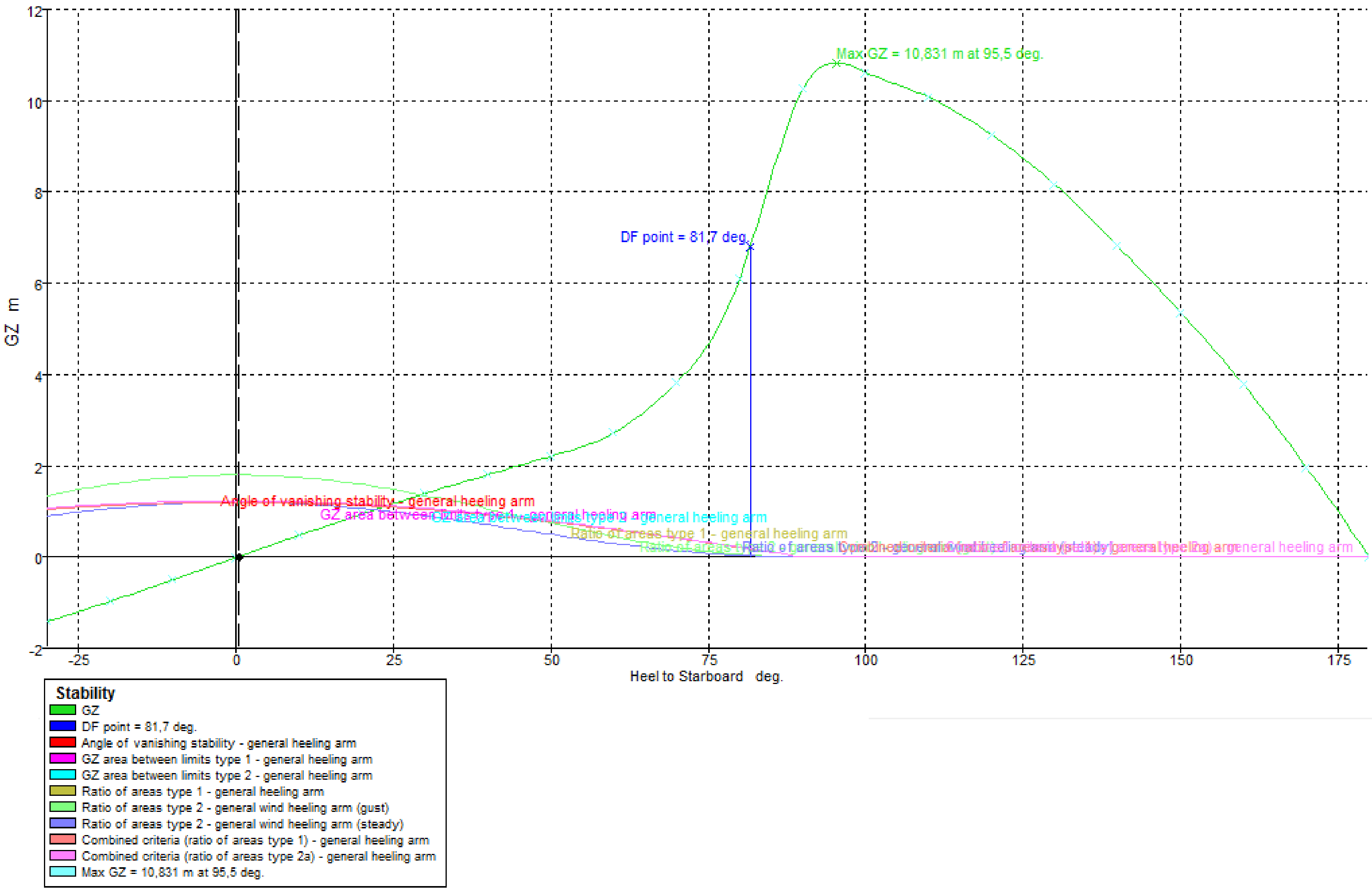
Draft Amidships m	44,356
Displacement t	9955
Heel deg	0,4
Draft at FP m	44,964
Draft at AP m	43,748
Draft at LCF m	44,356
Trim (+ve by stern) m	-1,216
WL Length m	10,002
Beam max extents on WL m	10
Wetted Area m^2	4401,406
Waterpl. Area m^2	76,053
Prismatic coeff. (Cp)	0,345
Block coeff. (Cb)	0,398
Max Sect. area coeff. (Cm)	1,158
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0,001

LCF from zero pt. (+ve fwd) m	0
KB m	14,487
KG fluid m	11,739
BMt m	0,049
BML m	0,047
GMt corrected m	2,799
GML m	2,796
KMt m	14,536
KML m	14,534
Immersion (TPc) tonne/cm	0,78
MTc tonne.m	5,08
RM at 1deg = GMt.Disp.sin(1) tonne.m	486,195
Max deck inclination deg	1,3207
Trim angle (+ve by stern) deg	-1,2717

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº1

Loadcase - Condición de Carga N.1
Damage Case - Intact
Fixed Trim = 0 m (+ve by stern)
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

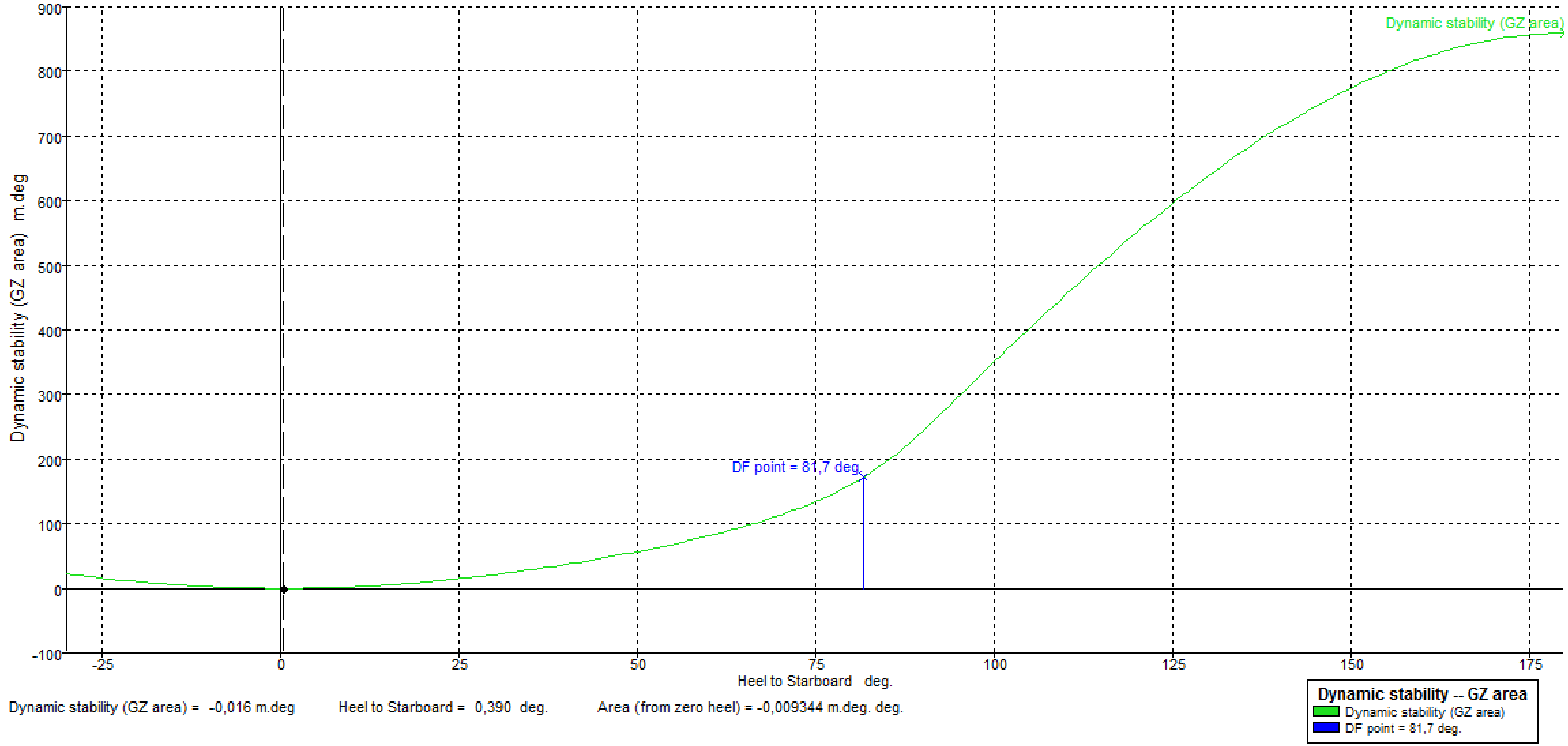
Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	1210,080	1210,080			0,030	0,040	26,870	0,000	User Specified
Peso Pienso Ø6mm	1	253,630	253,630			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	1	134,360	134,360			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	1	36,690	36,690			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5891,055	5891,055	2031,398	2031,398	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	662,085	662,085	228,305	228,305	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	0%	184,681	0,000	180,176	0,000	-2,130	2,134	26,600	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	0%	184,681	0,000	180,176	0,000	-2,130	-2,134	26,600	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	98%	17,493	17,143	20,580	20,168	0,000	2,050	37,825	0,000	IMO A.749(18)
MGO Nº2	98%	17,493	17,143	20,580	20,168	0,000	-2,050	37,825	0,000	IMO A.749(18)
Agua Potable	98%	10,161	9,957	10,161	9,957	-2,900	0,000	37,384	0,000	IMO A.749(18)
Aguas Grises	0%	2,260	0,000	2,205	0,000	3,600	0,150	36,600	0,000	IMO A.749(18)
Total Loadcase			9954,713	4353,069	3980,796	0,062	0,017	11,739	0,000	
FS correction								0,000		
VCG fluid								11,739		



Max GZ = 10,831 m at 95,5 deg.
DF point = 81,7 deg.
Angle of vanishing stability - general heeling arm
GZ m
Heel to Starboard deg.
Stability
GZ
DF point = 81,7 deg.
Angle of vanishing stability - general heeling arm
GZ area between limits type 1 - general heeling arm
GZ area between limits type 2 - general heeling arm
Ratio of areas type 1 - general heeling arm
Ratio of areas type 2 - general wind heeling arm (gust)
Ratio of areas type 2 - general wind heeling arm (steady)
Combined criteria (ratio of areas type 1) - general heeling arm
Combined criteria (ratio of areas type 2a) - general heeling arm
Max GZ = 10,831 m at 95,5 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	70,0	80,0	90,0
GZ m	-1,418	-0,974	-0,503	-0,017	0,469	0,942	1,388	1,796	2,203	2,714	3,824	6,099	10,243
Area under GZ curve from zero heel m.deg	21,9955	10,0163	2,6082	-0,0317	2,2625	9,3300	21,0108	36,9451	56,9527	81,2284	113,4039	161,0135	243,7400
Displacement t	9955	9955	9955	9955	9955	9955	9955	9955	9955	9955	9955	9955	9954
Draft at FP m	44,358	44,356	44,356	44,366	44,356	44,356	44,356	44,356	44,509	45,173	46,188	53,770	n/a
Draft at AP m	44,358	44,356	44,356	44,366	44,356	44,356	44,356	44,356	44,509	45,173	46,188	53,770	n/a
WL Length m	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	18,348	22,400	40,685	50,746	52,541
Beam max extents on WL m	11,547	10,642	10,154	10,000	10,154	10,642	11,547	13,054	36,150	43,231	39,411	62,550	61,600
Wetted Area m^2	4398,520	4401,038	4401,153	4257,591	4401,068	4401,202	4394,898	4401,255	4334,856	4233,630	4235,965	3781,822	3533,665
Waterpl. Area m^2	87,795	80,912	77,205	76,032	77,205	80,912	87,795	99,253	120,482	181,316	281,147	591,090	570,736
Prismatic coeff. (Cp)	0,345	0,345	0,345	0,345	0,345	0,345	0,345	0,345	0,344	0,340	0,327	0,309	0,273
Block coeff. (Cb)	0,342	0,369	0,384	0,400	0,384	0,369	0,342	0,302	0,112	0,099	0,119	0,084	0,089
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,001
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,015	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	10,617	10,071	9,252	8,171	6,819	5,367	3,789	1,968	0,017
Area under GZ curve from zero heel m.deg	350,6911	454,1382	551,0276	638,3665	713,4751	774,4597	820,4083	849,3677	859,3408
Displacement t	9955	9955	9954	9955	9954	9955	9954	9954	9955
Draft at FP m	15,579	2,802	-1,544	-3,629	-4,618	-5,188	-5,522	-5,610	-5,626
Draft at AP m	15,579	2,802	-1,544	-3,629	-4,618	-5,188	-5,522	-5,610	-5,626
WL Length m	51,528	50,885	51,101	51,194	51,066	50,472	48,734	20,000	20,000
Beam max extents on WL m	43,831	41,928	39,407	36,418	33,128	30,264	24,144	22,760	20,000
Wetted Area m^2	3893,820	3925,748	3966,747	4048,689	4085,804	4147,795	4315,638	4563,381	4563,676
Waterpl. Area m^2	383,389	406,253	421,519	399,032	392,951	404,245	350,419	302,760	312,367
Prismatic coeff. (Cp)	0,269	0,272	0,275	0,279	0,282	0,287	0,293	0,297	0,297
Block coeff. (Cb)	0,123	0,129	0,116	0,108	0,107	0,109	0,131	0,137	0,158
LCB from zero pt. (+ve fwd) m	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,002	0,000	0,000	0,001	0,000	0,004	0,020	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Dynamic stability (GZ area) = -0,016 m.deg   Heel to Starboard = 0,390 deg.   Area (from zero heel) = -0,009344 m.deg. deg.

Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = 0,055 m)		32,2	n/a
Deck Edge (immersion pos = 0,055 m)		32,3	n/a
DF point	Downflooding point	82,2	0
DF point	Downflooding point	81,7	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	81,7	Pass	+16,73
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	131,9358	Pass	+8125,42
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	52,6107	m.deg	118,5056	Pass	+125,25
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	36,80	Pass	+22,67
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	182,48	Pass	+40,37
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	68,88	Pass	+72,20
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	16,17	Pass	+73,05
	Area 1 shall not be less than (>=)	5,1600	m.deg	118,5056	Pass	+2196,62
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

EQUILIBRIO CONDICIÓN DE CARGA Nº2

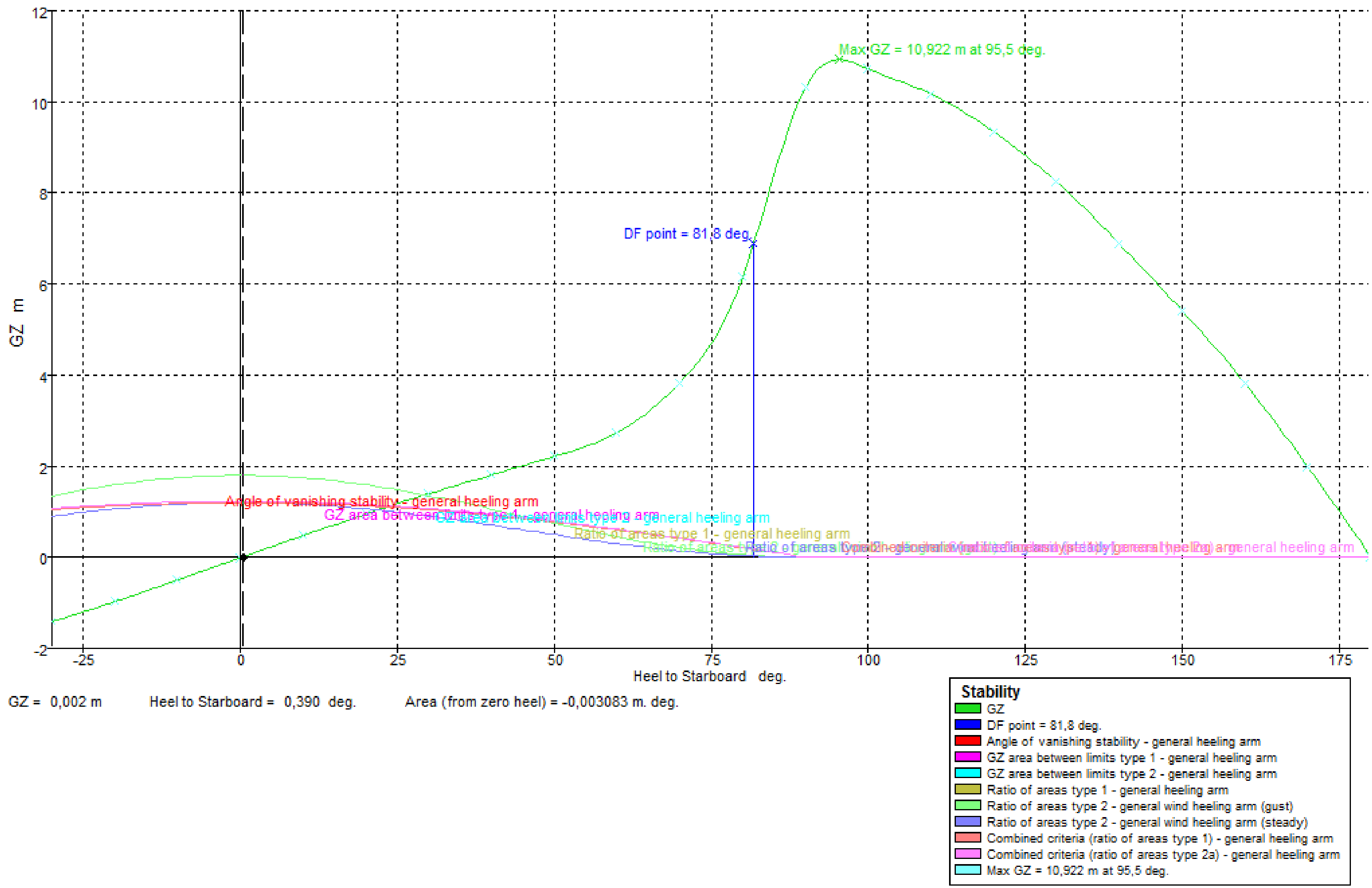
Draft Amidships m	44,077
Displacement t	9933
Heel deg	0,4
Draft at FP m	44,631
Draft at AP m	43,524
Draft at LCF m	44,077
Trim (+ve by stern) m	-1,107
WL Length m	10,002
Beam max extents on WL m	10
Wetted Area m^2	4392,612
Waterpl. Area m^2	76,049
Prismatic coeff. (Cp)	0,346
Block coeff. (Cb)	0,399
Max Sect. area coeff. (Cm)	1,159
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0,001

LCF from zero pt. (+ve fwd) m	0
KB m	14,422
KG fluid m	11,664
BMt m	0,05
BML m	0,047
GMt corrected m	2,808
GML m	2,806
KMt m	14,471
KML m	14,469
Immersion (TPc) tonne/cm	0,78
MTc tonne.m	5,086
RM at 1deg = GMt.Disp.sin(1) tonne.m	486,807
Max deck inclination deg	1,2104
Trim angle (+ve by stern) deg	-1,1568

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº2

Loadcase - Condición de Carga N.2
Damage Case - Intact
Fixed Trim = 0 m (+ve by stern)
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

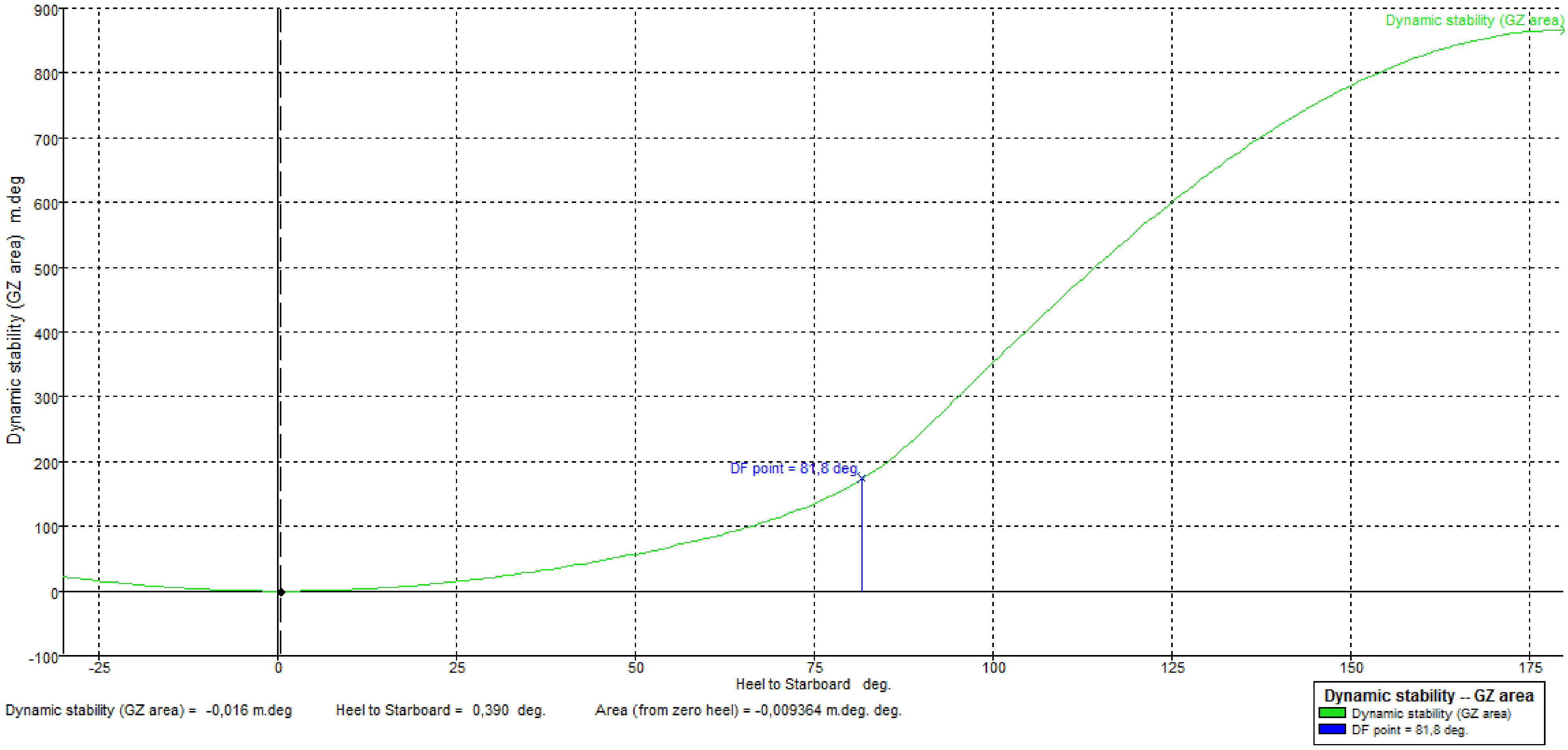
Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	1210,080	1210,080			0,030	0,040	26,870	0,000	User Specified
Peso Pienso Ø6mm	1	253,630	253,630			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	1	134,360	134,360			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	0,5	36,690	18,345			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5891,055	5891,055	2031,398	2031,398	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	662,085	662,085	228,305	228,305	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	0%	184,681	0,000	180,176	0,000	-2,130	2,134	26,600	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	0%	184,681	0,000	180,176	0,000	-2,130	-2,134	26,600	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	90%	17,493	15,744	20,580	18,522	0,000	2,050	37,725	2,546	IMO A.749(18)
MGO Nº2	90%	17,493	15,744	20,580	18,522	0,000	-2,050	37,725	2,546	IMO A.749(18)
Agua Potable	90%	10,161	9,145	10,161	9,145	-2,900	0,000	37,320	1,697	IMO A.749(18)
Aguas Grises	10%	2,260	0,226	2,205	0,221	3,600	0,150	36,645	1,295	IMO A.749(18)
Correccion Corrimiento Pienso(-	-1	0,423	-0,423			1,313	0,000	47,780	0,000	User Specified
Correccion Corrimiento Pienso(+	1	0,423	0,423			4,080	0,000	47,780	0,000	User Specified
Total Loadcase			9932,982	4353,069	3976,911	0,057	0,017	11,663	8,083	
FS correction								0,001		
VCG fluid								11,664		



GZ = 0,002 m Heel to Starboard = 0,390 deg. Area (from zero heel) = -0,003083 m. 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	70,0	80,0	90,0
GZ m	-1,423	-0,978	-0,505	-0,017	0,470	0,945	1,393	1,802	2,212	2,731	3,831	6,147	10,320
Area under GZ curve from zero heel m.deg	22,0716	10,0508	2,6171	-0,0317	2,2706	9,3630	21,0840	37,0746	57,1477	81,5642	113,8384	161,6975	245,0610
Displacement t	9933	9933	9933	9933	9933	9933	9933	9933	9933	9933	9933	9933	9932
Draft at FP m	44,080	44,077	44,077	44,077	44,077	44,077	44,077	44,077	44,236	44,935	45,965	53,563	n/a
Draft at AP m	44,080	44,077	44,077	44,077	44,077	44,077	44,077	44,077	44,236	44,935	45,965	53,563	n/a
WL Length m	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	18,720	22,376	40,997	50,805	52,580
Beam max extents on WL m	11,547	10,642	10,154	10,000	10,154	10,642	11,547	13,054	36,003	43,162	39,384	62,550	61,600
Wetted Area m^2	4392,957	4395,461	4395,561	4251,819	4395,491	4395,625	4389,321	4395,678	4328,433	4222,657	4226,679	3772,540	3529,032
Waterpl. Area m^2	87,795	80,912	77,205	76,032	77,205	80,912	87,795	99,253	120,314	180,576	281,606	594,792	571,055
Prismatic coeff. (Cp)	0,346	0,346	0,346	0,346	0,346	0,346	0,346	0,346	0,345	0,341	0,328	0,309	0,273
Block coeff. (Cb)	0,343	0,371	0,386	0,401	0,386	0,371	0,343	0,303	0,113	0,099	0,119	0,084	0,089
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,001
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,015	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	10,717	10,165	9,338	8,248	6,884	5,418	3,824	1,988	0,017
Area under GZ curve from zero heel m.deg	352,9093	457,3424	555,1269	643,2825	719,1069	780,6767	827,0586	856,2956	866,3713
Displacement t	9933	9933	9932	9933	9932	9933	9932	9932	9933
Draft at FP m	15,262	2,649	-1,645	-3,711	-4,688	-5,248	-5,586	-5,685	-5,693
Draft at AP m	15,262	2,649	-1,645	-3,711	-4,688	-5,248	-5,586	-5,685	-5,693
WL Length m	51,586	50,943	51,134	51,234	51,114	50,581	49,021	20,000	20,000
Beam max extents on WL m	43,840	41,947	39,436	36,462	33,192	30,355	24,122	22,760	20,000
Wetted Area m^2	3883,873	3916,139	3959,024	4041,942	4075,379	4138,262	4301,891	4550,858	4560,909
Waterpl. Area m^2	387,207	409,083	423,432	402,317	395,542	406,054	351,344	299,702	312,425
Prismatic coeff. (Cp)	0,269	0,272	0,275	0,279	0,282	0,287	0,293	0,297	0,297
Block coeff. (Cb)	0,123	0,129	0,116	0,108	0,106	0,108	0,131	0,137	0,158
LCB from zero pt. (+ve fwd) m	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,001	0,000	0,000	0,001	0,000	0,006	0,022	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Dynamic stability (GZ area) = -0,016 m.deg Heel to Starboard = 0,390 deg. Area (from zero heel) = -0,009364 m.deg. deg.

Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = 0,055 m)		32,6	n/a
Deck Edge (immersion pos = 0,055 m)		32,7	n/a
DF point	Downflooding point	82,3	0
DF point	Downflooding point	81,8	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	81,8	Pass	+16,82
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	133,0953	Pass	+8197,71
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	52,9709	m.deg	119,6504	Pass	+125,88
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	36,77	Pass	+22,57
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	183,29	Pass	+40,99
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	69,07	Pass	+72,67
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	15,98	Pass	+73,37
	Area 1 shall not be less than (>=)	5,1600	m.deg	119,6504	Pass	+2218,81
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

EQUILIBRIO CONDICIÓN DE CARGA Nº3

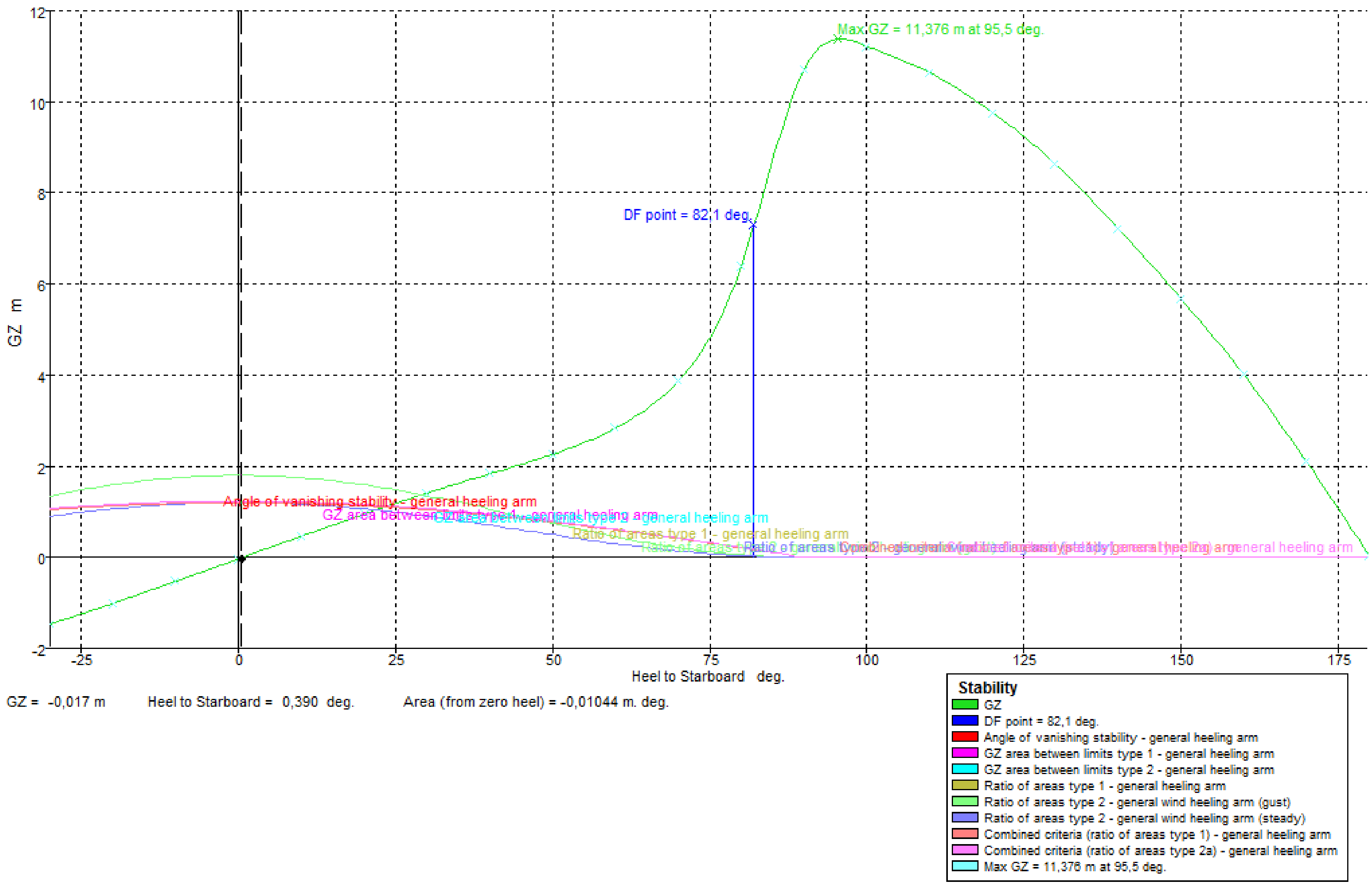
Draft Amidships m	42,756
Displacement t	9830
Heel deg	0,7
Draft at FP m	43,265
Draft at AP m	42,248
Draft at LCF m	42,756
Trim (+ve by stern) m	-1,017
WL Length m	10,002
Beam max extents on WL m	10,001
Wetted Area m^2	4369,404
Waterpl. Area m^2	76,052
Prismatic coeff. (Cp)	0,351
Block coeff. (Cb)	0,407
Max Sect. area coeff. (Cm)	1,162
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0,001

LCF from zero pt. (+ve fwd) m	0
KB m	14,118
KG fluid m	11,296
BMt m	0,05
BML m	0,048
GMt corrected m	2,874
GML m	2,871
KMt m	14,168
KML m	14,166
Immersion (TPc) tonne/cm	0,78
MTc tonne.m	5,15
RM at 1deg = GMt.Disp.sin(1) tonne.m	492,984
Max deck inclination deg	1,2886
Trim angle (+ve by stern) deg	-1,0632

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº3

Loadcase - Condición de Carga N.3
Damage Case - Intact
Fixed Trim = 0 m (+ve by stern)
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

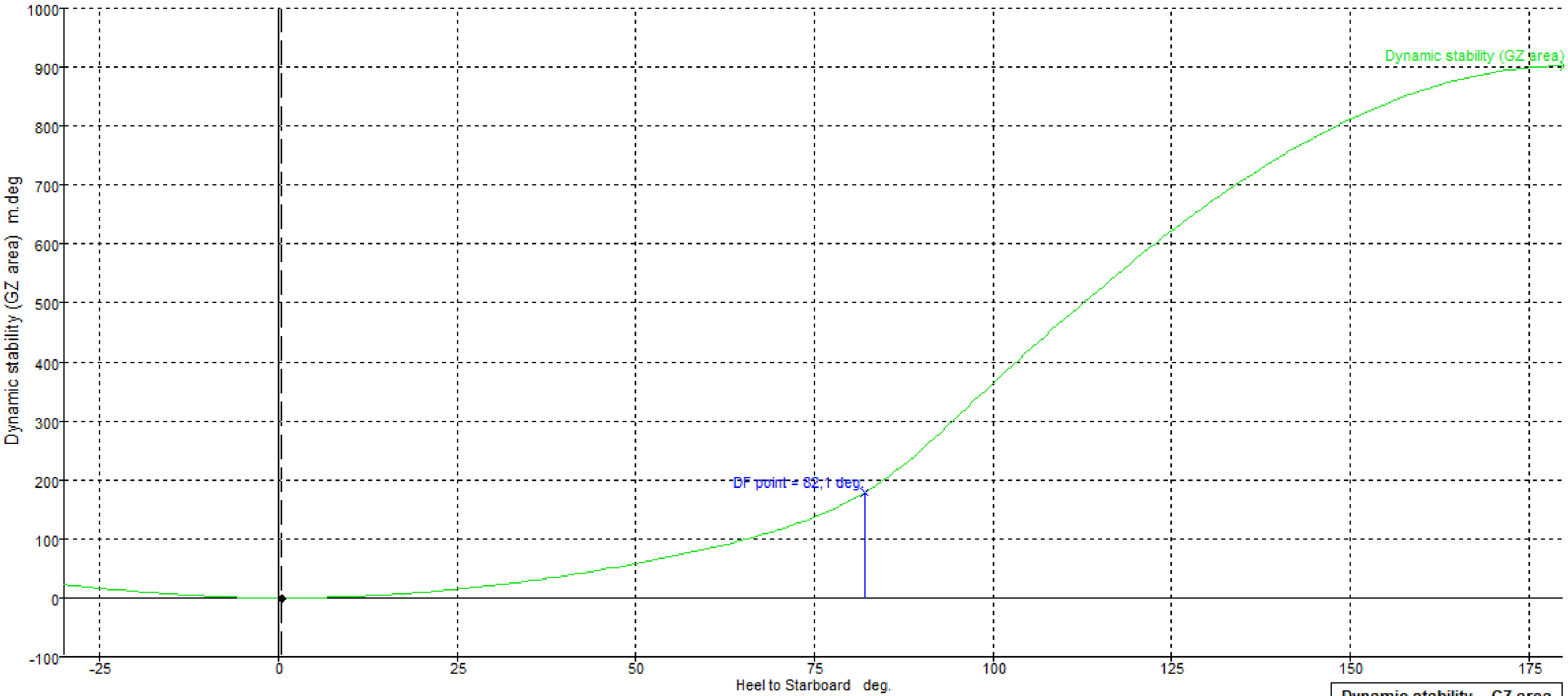
Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	1210,080	1210,080			0,030	0,040	26,870	0,000	User Specified
Peso Pienso Ø6mm	1	253,630	253,630			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	0,5	134,360	67,180			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	0	36,690	0,000			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5891,055	5891,055	2031,398	2031,398	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	662,085	662,085	228,305	228,305	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	0%	184,681	0,000	180,176	0,000	-2,130	2,134	26,600	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	0%	184,681	0,000	180,176	0,000	-2,130	-2,134	26,600	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	50%	17,493	8,747	20,580	10,290	0,000	2,050	37,225	2,546	IMO A.749(18)
MGO Nº2	50%	17,493	8,746	20,580	10,290	0,000	-2,050	37,225	2,546	IMO A.749(18)
Agua Potable	50%	10,161	5,080	10,161	5,080	-2,900	0,000	37,000	1,697	IMO A.749(18)
Aguas Grises	40%	2,260	0,904	2,205	0,882	3,600	0,150	36,780	1,295	IMO A.749(18)
Correccion Corrimiento Pienso(-	-1	2,027	-2,027			-1,820	2,250	49,150	0,000	User Specified
Correccion Corrimiento Pienso(+	1	2,027	2,027			1,820	2,250	49,150	0,000	User Specified
Total Loadcase			9830,076	4353,069	3957,045	0,053	0,037	11,295	8,083	
FS correction								0,001		
VCG fluid								11,296		



Max GZ = 11,376 m at 95,5 deg.
DF point = 82,1 deg.
Angle of vanishing stability - general heeling arm
GZ area between limits type 1 - general heeling arm
GZ area between limits type 2 - general heeling arm
Ratio of areas type 1 - general heeling arm
GZ m
Heel to Starboard deg.
GZ = -0,017 m
Heel to Starboard = 0,390 deg.
Area (from zero heel) = -0,01044 m. deg.
Stability
GZ
DF point = 82,1 deg.
Angle of vanishing stability - general heeling arm
GZ area between limits type 1 - general heeling arm
GZ area between limits type 2 - general heeling arm
Ratio of areas type 1 - general heeling arm
Ratio of areas type 2 - general wind heeling arm (gust)
Ratio of areas type 2 - general wind heeling arm (steady)
Combined criteria (ratio of areas type 1) - general heeling arm
Combined criteria (ratio of areas type 2a) - general heeling arm
Max GZ = 11,376 m at 95,5 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	70,0	80,0	90,0
GZ m	-1,473	-1,018	-0,535	-0,037	0,463	0,949	1,409	1,830	2,253	2,829	3,870	6,388	10,700
Area under GZ curve from zero heel m.deg	23,1208	10,6501	2,8636	-0,0664	2,1377	9,2162	21,0378	37,2594	57,6271	82,8235	115,7103	164,8500	251,3879
Displacement t	9831	9830	9830	9830	9830	9830	9830	9830	9830	9829	9830	9830	9830
Draft at FP m	42,763	42,757	42,757	42,757	42,757	42,757	42,757	42,757	42,930	43,825	44,912	52,606	n/a
Draft at AP m	42,763	42,757	42,757	42,757	42,757	42,757	42,757	42,757	42,930	43,825	44,912	52,606	n/a
WL Length m	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	19,866	22,258	42,477	51,079	52,760
Beam max extents on WL m	11,547	10,642	10,154	10,000	10,154	10,642	11,547	13,054	35,299	42,841	47,069	62,550	61,600
Wetted Area m^2	4366,614	4369,118	4369,343	4225,410	4369,397	4369,191	4362,913	4369,269	4293,206	4182,289	4172,814	3728,093	3505,089
Waterpl. Area m^2	87,795	80,912	77,205	76,032	77,205	80,912	87,795	99,253	121,136	182,720	278,760	611,832	573,921
Prismatic coeff. (Cp)	0,351	0,351	0,351	0,351	0,351	0,351	0,351	0,351	0,350	0,345	0,332	0,310	0,275
Block coeff. (Cb)	0,348	0,377	0,393	0,409	0,393	0,377	0,348	0,306	0,116	0,100	0,099	0,083	0,089
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,001
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,015	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	11,212	10,634	9,769	8,641	7,222	5,688	4,015	2,104	0,037
Area under GZ curve from zero heel m.deg	363,6802	473,0183	575,2869	667,5692	747,0576	811,6764	860,3587	891,1378	901,9062
Displacement t	9829	9830	9829	9829	9830	9829	9829	9829	9829
Draft at FP m	13,793	1,938	-2,112	-4,094	-5,015	-5,533	-5,887	-6,055	-6,014
Draft at AP m	13,793	1,938	-2,112	-4,094	-5,015	-5,533	-5,887	-6,055	-6,014
WL Length m	51,854	51,115	51,289	51,419	51,338	51,049	49,922	41,734	20,000
Beam max extents on WL m	43,885	42,036	39,571	36,669	33,490	30,782	24,019	22,760	20,000
Wetted Area m^2	3837,596	3875,971	3919,749	4000,083	4034,498	4092,980	4238,576	4480,205	4547,717
Waterpl. Area m^2	405,025	417,466	434,062	419,523	406,252	416,104	358,295	288,799	312,853
Prismatic coeff. (Cp)	0,267	0,270	0,273	0,277	0,281	0,286	0,292	0,296	0,298
Block coeff. (Cb)	0,123	0,128	0,115	0,107	0,105	0,106	0,131	0,136	0,157
LCB from zero pt. (+ve fwd) m	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,001	0,000	-0,014	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Dynamic stability (GZ area) = -0,043 m.deg   Heel to Starboard = 0,390 deg.   Area (from zero heel) = -0,0214 m.deg. deg.

Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = 0,055 m)		34,5	n/a
Deck Edge (immersion pos = 0,055 m)		34,6	n/a
DF point	Downflooding point	82,5	0
DF point	Downflooding point	82,1	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	82,1	Pass	+17,23
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	138,9393	Pass	+8562,05
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	54,6882	m.deg	125,4415	Pass	+129,38
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	36,71	Pass	+22,37
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	187,12	Pass	+43,94
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	70,09	Pass	+75,22
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	15,10	Pass	+74,83
	Area 1 shall not be less than (>=)	5,1600	m.deg	125,4415	Pass	+2331,04
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

EQUILIBRIO CONDICIÓN DE CARGA Nº4

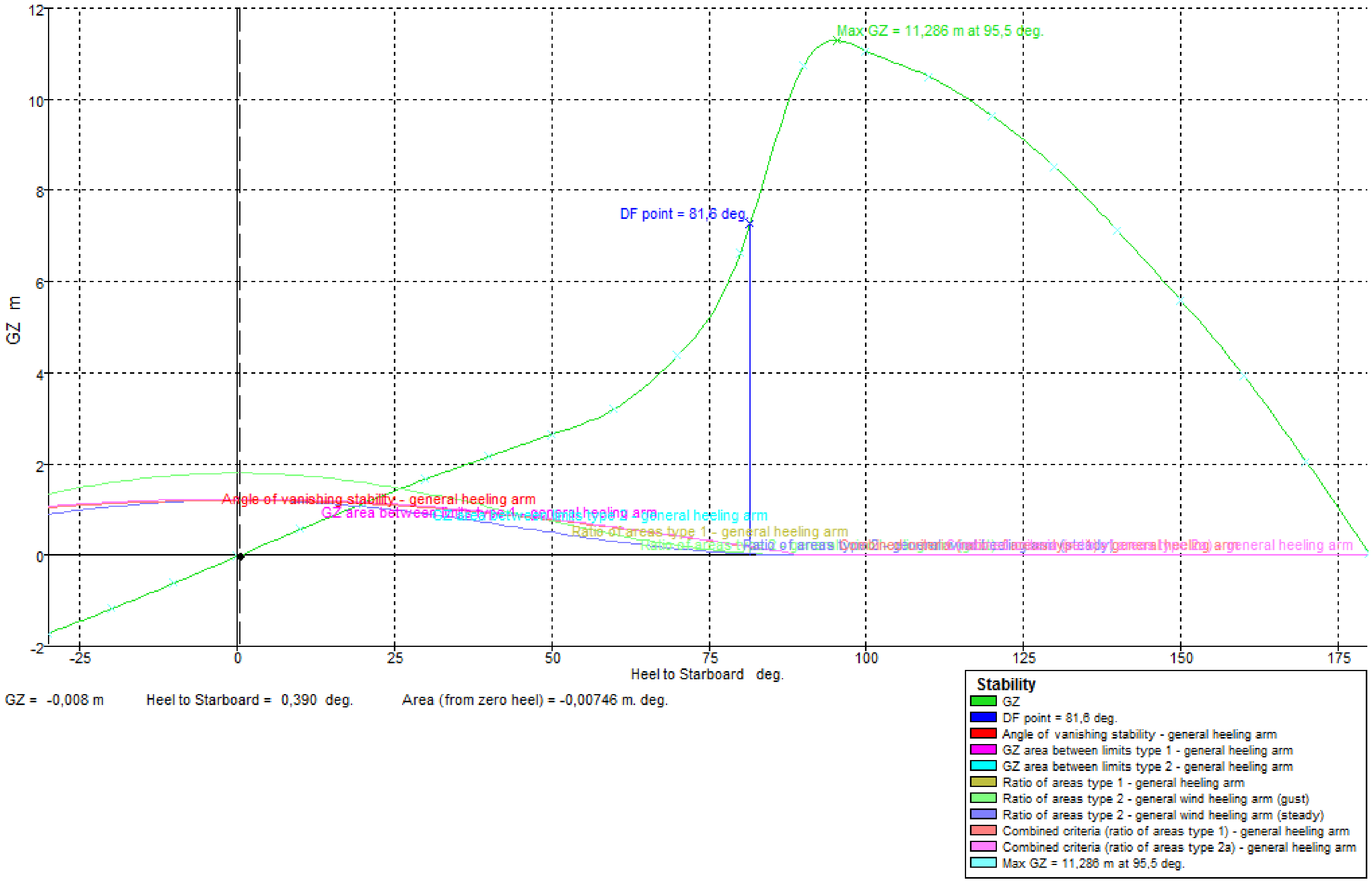
Draft Amidships m	44,79
Displacement t	9989
Heel deg	0,5
Draft at FP m	44,715
Draft at AP m	44,865
Draft at LCF m	44,79
Trim (+ve by stern) m	0,15
WL Length m	10
Beam max extents on WL m	10
Wetted Area m^2	4409,999
Waterpl. Area m^2	76,036
Prismatic coeff. (Cp)	0,343
Block coeff. (Cb)	0,396
Max Sect. area coeff. (Cm)	1,156
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0

LCF from zero pt. (+ve fwd) m	0
KB m	14,589
KG fluid m	11,255
BMt m	0,049
BML m	0,047
GMt corrected m	3,384
GML m	3,381
KMt m	14,638
KML m	14,636
Immersion (TPc) tonne/cm	0,779
MTc tonne.m	6,163
RM at 1deg = GMt.Disp.sin(1) tonne.m	589,864
Max deck inclination deg	0,5421
Trim angle (+ve by stern) deg	0,1568

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº4

Loadcase - Condición de Carga N.4
Damage Case - Intact
Fixed Trim = 0 m (+ve by stern)
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

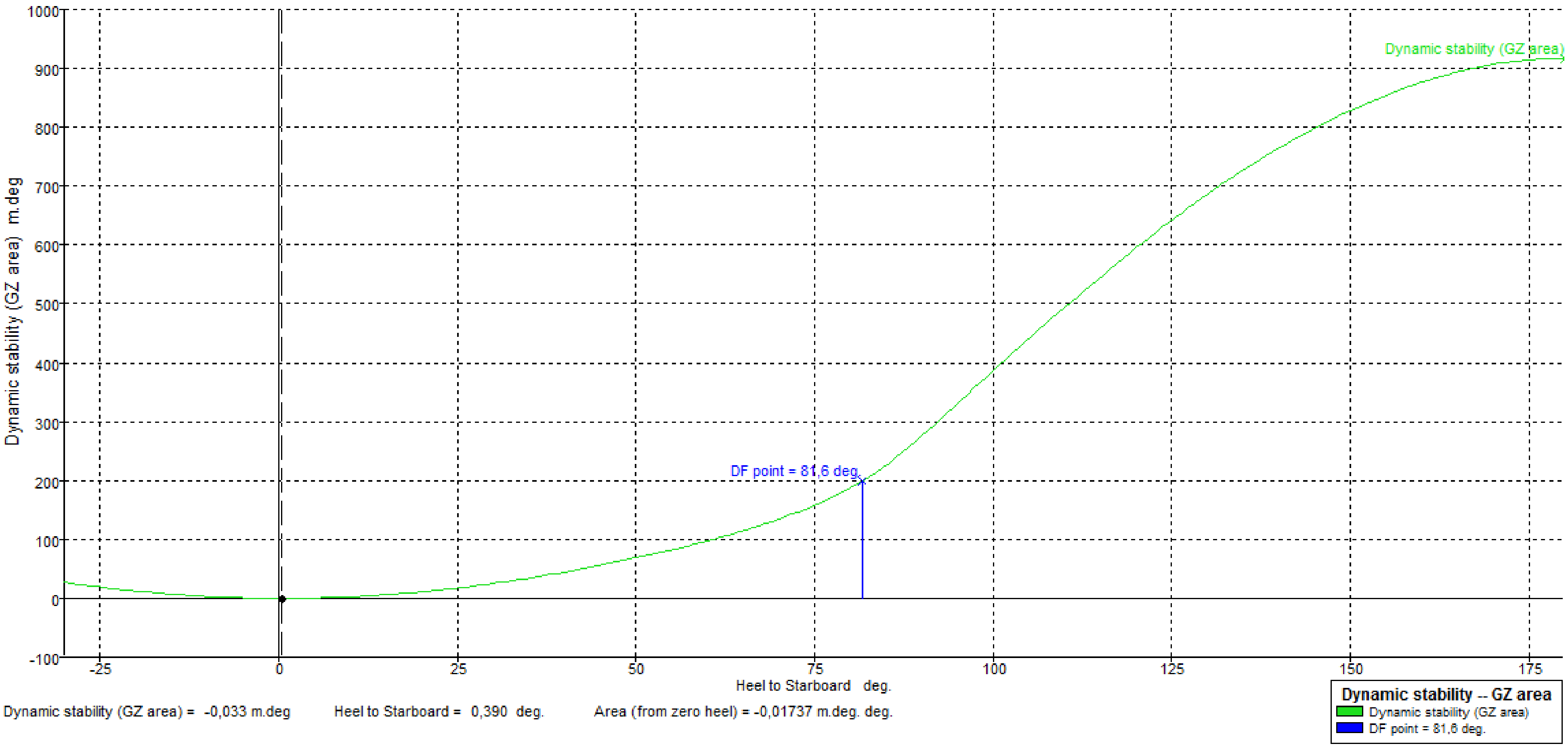
Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	1210,080	1210,080			0,030	0,040	26,870	0,000	User Specified
Peso Pienso Ø6mm	0,5	253,630	126,815			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	0	134,360	0,000			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	0	36,690	0,000			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5891,055	5891,055	2031,398	2031,398	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	662,085	662,085	228,305	228,305	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	100%	184,681	184,681	180,176	180,176	-2,130	2,134	31,370	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	100%	184,681	184,681	180,176	180,176	-2,130	-2,134	31,370	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	10%	17,493	1,749	20,580	2,058	0,000	2,050	36,725	2,546	IMO A.749(18)
MGO Nº2	10%	17,493	1,749	20,580	2,058	0,000	-2,050	36,725	2,546	IMO A.749(18)
Agua Potable	10%	10,161	1,016	10,161	1,016	-2,900	0,000	36,680	1,697	IMO A.749(18)
Aguas Grises	90%	2,260	2,034	2,205	1,985	3,600	0,150	37,005	1,295	IMO A.749(18)
Correccion Corrimiento Pienso(-	-1	4,628	-4,628			-2,580	1,960	49,970	0,000	User Specified
Correccion Corrimiento Pienso(+	1	4,628	4,628			2,580	1,960	49,970	0,000	User Specified
Total Loadcase			9988,514	4353,069	4297,971	-0,009	0,031	11,254	8,083	
FS correction								0,001		
VCG fluid								11,255		



GZ = -0,008 m Heel to Starboard = 0,390 deg. Area (from zero heel) = -0,00746 m. 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	70,0	80,0	90,0
GZ m	-1,722	-1,187	-0,618	-0,031	0,558	1,130	1,669	2,162	2,641	3,201	4,368	6,612	10,722
Area under GZ curve from zero heel m.deg	26,8720	12,3048	3,2520	-0,0557	2,6433	11,0993	25,1325	44,3114	68,3612	97,2548	134,6240	187,5659	275,2529
Displacement t	9989	9989	9989	9990	9989	9989	9989	9989	9989	9989	9988	9988	9988
Draft at FP m	44,791	44,790	44,800	44,803	44,800	44,790	44,790	44,790	44,934	45,537	46,521	54,092	n/a
Draft at AP m	44,791	44,790	44,800	44,803	44,800	44,790	44,790	44,790	44,934	45,537	46,521	54,092	n/a
WL Length m	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	17,768	22,400	39,871	50,653	52,481
Beam max extents on WL m	11,547	10,642	10,154	10,000	10,154	10,642	11,547	13,054	36,380	43,336	39,453	62,550	61,600
Wetted Area m^2	4407,145	4409,712	4410,028	4266,323	4409,935	4409,876	4403,507	4409,929	4345,768	4250,792	4251,702	3795,579	3540,876
Waterpl. Area m^2	87,795	80,912	77,205	76,032	77,205	80,912	87,795	99,253	120,482	182,710	278,784	585,886	570,240
Prismatic coeff. (Cp)	0,343	0,343	0,343	0,343	0,343	0,343	0,343	0,343	0,342	0,339	0,326	0,309	0,273
Block coeff. (Cb)	0,340	0,367	0,382	0,397	0,382	0,367	0,340	0,301	0,111	0,099	0,119	0,084	0,090
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,001
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,016	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	11,055	10,492	9,645	8,518	7,112	5,598	3,951	2,054	0,031
Area under GZ curve from zero heel m.deg	386,7808	494,5123	595,4914	686,5383	764,8562	828,4676	876,3861	906,5870	917,0541
Displacement t	9988	9988	9988	9988	9988	9988	9988	9988	9989
Draft at FP m	16,078	3,042	-1,387	-3,499	-4,508	-5,093	-5,421	-5,495	-5,521
Draft at AP m	16,078	3,042	-1,387	-3,499	-4,508	-5,093	-5,421	-5,495	-5,521
WL Length m	51,437	50,795	51,048	51,132	50,986	50,303	48,286	20,000	20,000
Beam max extents on WL m	43,815	41,898	39,362	36,348	33,027	30,122	24,178	22,760	20,000
Wetted Area m^2	3910,347	3939,334	3977,954	4061,767	4099,534	4162,842	4337,627	4582,068	4567,980
Waterpl. Area m^2	378,119	402,689	420,475	393,875	389,466	400,952	349,050	307,563	312,379
Prismatic coeff. (Cp)	0,269	0,272	0,276	0,280	0,283	0,288	0,293	0,297	0,297
Block coeff. (Cb)	0,124	0,129	0,117	0,109	0,107	0,109	0,131	0,137	0,159
LCB from zero pt. (+ve fwd) m	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,003	0,000	0,000	0,002	0,000	-0,037	0,017	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Dynamic stability (GZ area) = -0,033 m.deg   Heel to Starboard = 0,390 deg.   Area (from zero heel) = -0,01737 m.deg. deg.

Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = 0,055 m)		31,5	n/a
Deck Edge (immersion pos = 0,055 m)		31,6	n/a
DF point	Downflooding point	82,1	0
DF point	Downflooding point	81,6	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	81,6	Pass	+16,59
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	156,8000	Pass	+9675,56
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	60,6257	m.deg	143,1424	Pass	+136,11
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	41,48	Pass	+38,27
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	216,70	Pass	+66,69
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Angle of steady heel / Marginline immersion angle shall not be greater than (<=)	80,00	%	63,33	Pass	+20,84
	Area1 / Area2 shall be greater than (>)	40,00	%	72,02	Pass	+80,05
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	15,51	Pass	+74,15
	Area 1 shall not be less than (>=)	5,1600	m.deg	143,1424	Pass	+2674,08
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

HIDROSTÁTICAS CON LAS JAULAS EN LA POSICIÓN MEDIA.

DRAFT AMIDSHIPS (m)	**0**	**0,518**	**1,035**	**1,553**	**2,071**	**2,588**	**3,106**	**3,624**	**4,141**	**4,659**	**5,176**	**5,694**	**6,212**	**6,729**	**7,247**
Displacement t	0	159,3	321,6	484,5	647,7	811,2	975,2	1139	1304	1469	1634	1800	1965	2102	2145
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	0	0,518	1,035	1,553	2,071	2,588	3,106	3,624	4,141	4,659	5,176	5,694	6,212	6,729	7,247
Draft at AP m	0	0,518	1,035	1,553	2,071	2,588	3,106	3,624	4,141	4,659	5,176	5,694	6,212	6,729	7,247
Draft at LCF m	0	0,518	1,035	1,553	2,071	2,588	3,106	3,624	4,141	4,659	5,176	5,694	6,212	6,729	7,247
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	0	20	20	20	20	20	20	20	20	20	20	20	20	10	10
Beam max extents on WL m	0	20	20	20	20	20	20	20	20	20	20	20	20	10	10
Wetted Area m^2	0	330,766	356,931	382,901	408,673	434,243	459,609	484,765	509,709	534,436	558,943	583,227	607,283	861,095	870,656
Waterpl. Area m^2	0	305,262	305,665	306,058	306,441	306,812	307,173	307,523	307,862	308,189	308,505	308,81	309,103	76,032	76,032
Prismatic coeff. (Cp)	0	0,279	0,279	0,279	0,28	0,28	0,28	0,281	0,281	0,281	0,281	0,282	0,282	0,281	0,276
Block coeff. (Cb)	0	0,279	0,279	0,279	0,28	0,28	0,28	0,281	0,281	0,281	0,281	0,282	0,282	0,557	0,527
Max Sect. area coeff. (Cm)		1	1	1	1	1	1	1	1	1	1	1	1	1,982	1,912
Waterpl. area coeff. (Cwp)	0	0,279	0,279	0,279	0,28	0,28	0,28	0,281	0,281	0,281	0,281	0,282	0,282	0,139	0,139
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	0	0,263	0,522	0,781	1,04	1,298	1,557	1,816	2,075	2,334	2,593	2,851	3,11	3,324	3,393
KG m	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89
BMt m	0	49,509	24,516	16,279	12,178	9,723	8,089	6,923	6,049	5,371	4,828	4,385	4,015	0,234	0,23
BML m	0	46,525	23,152	15,447	11,61	9,313	7,782	6,69	5,87	5,233	4,723	4,306	3,957	0,223	0,219
GMt m	-27,89	21,882	-2,852	-10,83	-14,672	-16,868	-18,244	-19,151	-19,766	-20,185	-20,469	-20,654	-20,764	-24,332	-24,268
GML m	-27,89	18,898	-4,216	-11,662	-15,24	-17,279	-18,55	-19,384	-19,945	-20,323	-20,574	-20,733	-20,822	-24,343	-24,279
KMt m	0	49,772	25,038	17,06	13,218	11,022	9,646	8,739	8,124	7,705	7,421	7,236	7,126	3,558	3,622
KML m	0	46,788	23,674	16,228	12,65	10,611	9,34	8,506	7,945	7,567	7,316	7,157	7,068	3,547	3,611
Immersion (TPc) tonne/cm	0	3,129	3,133	3,137	3,141	3,145	3,149	3,152	3,156	3,159	3,162	3,165	3,168	0,779	0,779
MTc tonne.m	0	0,549	-0,247	-1,031	-1,801	-2,558	-3,301	-4,03	-4,746	-5,448	-6,135	-6,809	-7,468	-9,339	-9,501
RM at 1deg = GMt.Disp.sin(1) tonne.m	0	60,819	-16,007	-91,565	-165,84	-238,819	-310,489	-380,837	-449,84	-517,489	-583,776	-648,688	-712,212	-892,791	-908,29
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	7,765	8,282	8,800	9,318	9,835	10,353	10,871	11,388	11,906	12,424	12,941	13,459	13,976	14,494	15,012
Displacement t	2187	2229	2271	2312	2354	2396	2437	2479	2520	2562	2603	2644	2685	2726	2767
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	7,765	8,282	8,8	9,318	9,835	10,353	10,871	11,388	11,906	12,424	12,941	13,459	13,976	14,494	15,012
Draft at AP m	7,765	8,282	8,8	9,318	9,835	10,353	10,871	11,388	11,906	12,424	12,941	13,459	13,976	14,494	15,012
Draft at LCF m	7,765	8,282	8,8	9,318	9,835	10,353	10,871	11,388	11,906	12,424	12,941	13,459	13,976	14,494	15,012
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	880,179	889,662	899,106	908,51	917,874	927,197	936,481	945,723	954,925	964,086	973,205	982,283	991,318	1000,312	1009,264
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	0,271	0,267	0,263	0,259	0,255	0,252	0,249	0,245	0,243	0,24	0,237	0,235	0,232	0,23	0,228
Block coeff. (Cb)	0,502	0,48	0,46	0,442	0,427	0,412	0,4	0,388	0,377	0,367	0,358	0,35	0,342	0,335	0,328
Max Sect. area coeff. (Cm)	1,851	1,798	1,751	1,709	1,672	1,638	1,608	1,58	1,555	1,532	1,51	1,491	1,473	1,456	1,44
Waterpl. area coeff. (Cwp)	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	3,468	3,551	3,639	3,734	3,833	3,939	4,049	4,164	4,283	4,407	4,535	4,667	4,802	4,941	5,084
KG m	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89
BMt m	0,225	0,221	0,217	0,213	0,209	0,205	0,202	0,199	0,195	0,192	0,189	0,186	0,183	0,181	0,178
BML m	0,215	0,211	0,207	0,203	0,199	0,196	0,193	0,189	0,186	0,183	0,18	0,178	0,175	0,172	0,17
GMt m	-24,196	-24,118	-24,034	-23,944	-23,847	-23,746	-23,639	-23,528	-23,412	-23,291	-23,166	-23,037	-22,905	-22,768	-22,628
GML m	-24,207	-24,129	-24,044	-23,953	-23,857	-23,755	-23,649	-23,537	-23,421	-23,3	-23,175	-23,046	-22,913	-22,776	-22,636
KMt m	3,694	3,772	3,856	3,946	4,043	4,144	4,251	4,362	4,478	4,599	4,724	4,853	4,985	5,122	5,262
KML m	3,683	3,761	3,846	3,937	4,033	4,135	4,241	4,353	4,469	4,59	4,715	4,844	4,977	5,114	5,254
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779
MTc tonne.m	-9,659	-9,813	-9,962	-10,108	-10,249	-10,386	-10,519	-10,647	-10,771	-10,892	-11,008	-11,119	-11,227	-11,33	-11,429
RM at 1deg = GMt.Disp.sin(1) tonne.m	-923,389	-938,089	-952,389	-966,29	-979,789	-992,888	-1005,586	-1017,883	-1029,777	-1041,27	-1052,36	-1063,047	-1073,332	-1083,212	-1092,689
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	**15,529**	**16,047**	**16,565**	**17,082**	**17,600**	**18,118**	**18,635**	**19,153**	**19,671**	**20,188**	**20,706**	**21,224**	**21,741**	**22,259**
Displacement t	2808	2848	2889	2929	2970	3010	3051	3092	3134	3176	3218	3259	3301	3343
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	15,529	16,047	16,565	17,082	17,6	18,118	18,635	19,153	19,671	20,188	20,706	21,224	21,741	22,259
Draft at AP m	15,529	16,047	16,565	17,082	17,6	18,118	18,635	19,153	19,671	20,188	20,706	21,224	21,741	22,259
Draft at LCF m	15,529	16,047	16,565	17,082	17,6	18,118	18,635	19,153	19,671	20,188	20,706	21,224	21,741	22,259
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	1018,172	1027,039	1035,862	1044,642	1053,378	1062,071	1071,073	1082,248	1093,393	1104,509	1115,596	1126,652	1137,678	1148,674
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	0,226	0,224	0,222	0,22	0,219	0,217	0,215	0,214	0,212	0,211	0,21	0,209	0,207	0,206
Block coeff. (Cb)	0,322	0,316	0,311	0,305	0,301	0,296	0,292	0,288	0,284	0,28	0,277	0,274	0,27	0,267
Max Sect. area coeff. (Cm)	1,425	1,412	1,399	1,387	1,375	1,364	1,354	1,345	1,336	1,327	1,319	1,311	1,304	1,297
Waterpl. area coeff. (Cwp)	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	5,23	5,38	5,532	5,687	5,846	6,007	6,17	6,335	6,502	6,671	6,842	7,015	7,191	7,368
KG m	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89
BMt m	0,175	0,173	0,17	0,168	0,166	0,164	0,161	0,159	0,157	0,155	0,153	0,151	0,149	0,147
BML m	0,167	0,165	0,162	0,16	0,158	0,156	0,154	0,152	0,15	0,148	0,146	0,144	0,142	0,14
GMt m	-22,484	-22,338	-22,188	-22,035	-21,879	-21,72	-21,559	-21,396	-21,231	-21,064	-20,895	-20,724	-20,55	-20,375
GML m	-22,493	-22,346	-22,196	-22,042	-21,886	-21,727	-21,566	-21,403	-21,238	-21,071	-20,902	-20,731	-20,557	-20,382
KMt m	5,406	5,552	5,702	5,855	6,011	6,17	6,331	6,494	6,659	6,826	6,995	7,166	7,34	7,515
KML m	5,397	5,544	5,694	5,848	6,004	6,163	6,324	6,487	6,652	6,819	6,988	7,159	7,333	7,508
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779
MTc tonne.m	-11,524	-11,615	-11,701	-11,783	-11,861	-11,935	-12,005	-12,078	-12,147	-12,212	-12,273	-12,33	-12,384	-12,433
RM at 1deg = GMt.Disp.sin(1) tonne.m	-1101,762	-1110,431	-1118,694	-1126,553	-1134,006	-1141,053	-1147,788	-1154,73	-1161,307	-1167,52	-1173,368	-1178,852	-1183,971	-1188,726
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	**22,776**	**23,294**	**23,812**	**24,329**	**24,847**	**25,365**	**25,882**	**26,400**	**26,918**	**27,435**	**27,953**	**28,471**	**28,988**	**29,506**
Displacement t	3385	3426	3468	3510	3552	3788	4099	4406	4714	5022	5330	5637	5945	6253
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	22,776	23,294	23,812	24,329	24,847	25,365	25,882	26,4	26,918	27,435	27,953	28,471	28,988	29,506
Draft at AP m	22,776	23,294	23,812	24,329	24,847	25,365	25,882	26,4	26,918	27,435	27,953	28,471	28,988	29,506
Draft at LCF m	22,776	23,294	23,812	24,329	24,847	25,365	25,882	26,4	26,918	27,435	27,953	28,471	28,988	29,506
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4
Beam max extents on WL m	10	10	10	10	10	52,4	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613
Wetted Area m^2	1159,64	1170,574	1181,478	1192,35	1203,19	1818,223	2159,533	2207,841	2255,298	2301,838	2347,398	2391,91	2435,308	2478,733
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	606,138	579,265	579,423	579,555	579,661	579,737	579,783	579,797	579,851
Prismatic coeff. (Cp)	0,205	0,204	0,203	0,202	0,201	0,21	0,223	0,236	0,249	0,261	0,273	0,284	0,295	0,306
Block coeff. (Cb)	0,265	0,262	0,259	0,257	0,255	0,051	0,073	0,077	0,081	0,084	0,088	0,091	0,095	0,098
Max Sect. area coeff. (Cm)	1,29	1,283	1,277	1,271	1,266	0,242	1,264	1,259	1,254	1,249	1,245	1,24	1,236	1,232
Waterpl. area coeff. (Cwp)	0,139	0,139	0,139	0,139	0,139	0,211	0,274	0,274	0,274	0,274	0,274	0,274	0,274	0,274
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	7,547	7,727	7,909	8,093	8,279	9,331	10,566	11,653	12,632	13,523	14,341	15,099	15,804	16,466
KG m	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89
BMt m	0,145	0,144	0,142	0,14	0,139	11,573	5,929	5,516	5,156	4,84	4,56	4,311	4,088	3,887
BML m	0,139	0,137	0,135	0,134	0,132	34,678	37,567	34,97	32,707	30,718	28,954	27,379	25,963	24,692
GMt m	-20,198	-20,019	-19,839	-19,656	-19,473	-6,986	-11,395	-10,722	-10,102	-9,527	-8,988	-8,48	-7,998	-7,537
GML m	-20,205	-20,026	-19,845	-19,663	-19,479	16,119	20,242	18,733	17,449	16,351	15,405	14,588	13,878	13,268
KMt m	7,692	7,871	8,051	8,234	8,417	20,904	16,495	17,168	17,788	18,363	18,902	19,41	19,892	20,353
KML m	7,685	7,864	8,045	8,227	8,411	44,009	48,132	46,623	45,339	44,241	43,295	42,478	41,768	41,158
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	6,213	5,937	5,939	5,94	5,942	5,942	5,943	5,943	5,943
MTc tonne.m	-12,479	-12,521	-12,56	-12,594	-12,625	11,143	15,141	15,063	15,01	14,984	14,982	15,006	15,055	15,138
RM at 1deg = GMt.Disp.sin(1) tonne.m	-1193,117	-1197,143	-1200,804	-1204,101	-1207,034	-461,897	-815,141	-824,525	-831,134	-834,967	-836,02	-834,293	-829,784	-822,496
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0

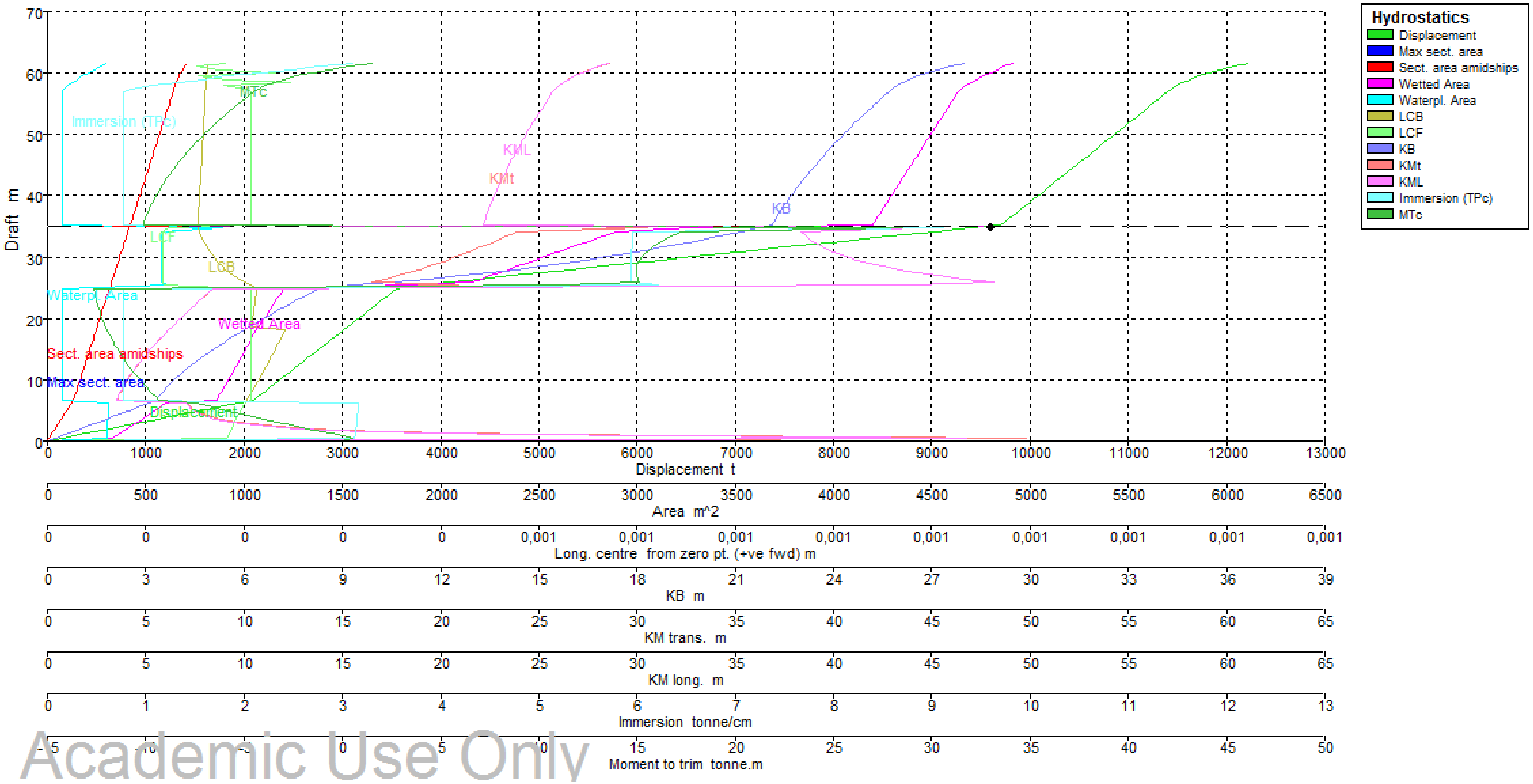
DRAFT AMIDSHIPS (m)	30,024	30,541	31,059	31,576	32,094	32,612	33,129	33,647	34,165	34,682	35,200	35,718	36,235	36,753
Displacement t	6561	6869	7178	7486	7795	8103	8412	8721	9030	9395	9704	9745	9785	9825
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	30,024	30,541	31,059	31,576	32,094	32,612	33,129	33,647	34,165	34,682	35,2	35,718	36,235	36,753
Draft at AP m	30,024	30,541	31,059	31,576	32,094	32,612	33,129	33,647	34,165	34,682	35,2	35,718	36,235	36,753
Draft at LCF m	30,024	30,541	31,059	31,576	32,094	32,612	33,129	33,647	34,165	34,682	35,2	35,718	36,235	36,753
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	54,8	10	10	10	10
Beam max extents on WL m	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613	54,8	10	10	10	10
Wetted Area m^2	2525,004	2571,33	2617,704	2664,117	2710,559	2757,022	2803,494	2849,966	2896,425	3284,253	4197,47	4207,823	4218,176	4228,529
Waterpl. Area m^2	579,956	580,06	580,165	580,27	580,374	580,479	580,583	580,688	580,793	890,173	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	0,317	0,327	0,337	0,347	0,356	0,366	0,375	0,384	0,392	0,402	0,409	0,405	0,402	0,399
Block coeff. (Cb)	0,101	0,104	0,107	0,109	0,112	0,115	0,117	0,12	0,122	0,088	0,491	0,486	0,481	0,476
Max Sect. area coeff. (Cm)	1,228	1,224	1,22	1,217	1,213	1,21	1,207	1,203	1,2	0,219	1,201	1,198	1,195	1,193
Waterpl. area coeff. (Cwp)	0,274	0,274	0,274	0,274	0,274	0,274	0,274	0,274	0,274	0,296	0,139	0,139	0,139	0,139
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	17,09	17,682	18,245	18,784	19,3	19,797	20,277	20,741	21,191	21,706	22,125	22,18	22,237	22,296
KG m	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89
BMt m	3,705	3,538	3,386	3,247	3,118	3	2,889	2,787	2,692	8,85	0,051	0,051	0,05	0,05
BML m	23,543	22,497	21,541	20,663	19,855	19,107	18,415	17,771	17,171	22,827	0,048	0,048	0,048	0,048
GMt m	-7,095	-6,67	-6,258	-5,859	-5,471	-5,093	-4,724	-4,362	-4,007	2,666	-5,714	-5,659	-5,603	-5,544
GML m	12,743	12,289	11,897	11,557	11,265	11,015	10,802	10,622	10,472	16,643	-5,717	-5,662	-5,605	-5,547
KMt m	20,795	21,22	21,632	22,031	22,419	22,797	23,166	23,528	23,883	30,556	22,176	22,231	22,287	22,346
KML m	40,633	40,179	39,787	39,447	39,155	38,905	38,692	38,512	38,362	44,533	22,173	22,228	22,285	22,343
Immersion (TPc) tonne/cm	5,945	5,946	5,947	5,948	5,949	5,95	5,951	5,952	5,953	9,124	0,779	0,779	0,779	0,779
MTc tonne.m	15,257	15,405	15,582	15,788	16,023	16,288	16,581	16,904	17,256	28,535	-10,124	-10,068	-10,008	-9,945
RM at 1deg = GMt.Disp.sin(1) tonne.m	-812,429	-799,577	-783,94	-765,516	-744,303	-720,3	-693,506	-663,918	-631,535	437,215	-967,813	-962,484	-956,79	-950,733
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	**37,271**	**37,788**	**38,306**	**38,824**	**39,341**	**39,859**	**40,376**	**40,894**	**41,412**	**41,929**	**42,447**	**42,965**	**43,482**	**44,000**
Displacement t	9866	9906	9946	9987	10027	10067	10108	10148	10188	10229	10269	10309	10350	10390
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	37,271	37,788	38,306	38,824	39,341	39,859	40,376	40,894	41,412	41,929	42,447	42,965	43,482	44
Draft at AP m	37,271	37,788	38,306	38,824	39,341	39,859	40,376	40,894	41,412	41,929	42,447	42,965	43,482	44
Draft at LCF m	37,271	37,788	38,306	38,824	39,341	39,859	40,376	40,894	41,412	41,929	42,447	42,965	43,482	44
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	4238,882	4249,235	4259,588	4269,941	4280,294	4290,647	4301	4311,353	4321,706	4332,059	4342,411	4352,764	4363,117	4373,47
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	0,396	0,393	0,39	0,387	0,385	0,382	0,379	0,377	0,374	0,372	0,369	0,367	0,364	0,362
Block coeff. (Cb)	0,471	0,467	0,462	0,458	0,454	0,45	0,446	0,442	0,438	0,434	0,431	0,427	0,424	0,42
Max Sect. area coeff. (Cm)	1,19	1,187	1,185	1,182	1,18	1,178	1,175	1,173	1,171	1,169	1,167	1,165	1,163	1,161
Waterpl. area coeff. (Cwp)	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	22,356	22,417	22,481	22,546	22,612	22,68	22,75	22,821	22,894	22,968	23,043	23,12	23,199	23,278
KG m	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89
BMt m	0,05	0,05	0,049	0,049	0,049	0,049	0,049	0,049	0,048	0,048	0,048	0,048	0,048	0,047
BML m	0,048	0,047	0,047	0,047	0,047	0,047	0,046	0,046	0,046	0,046	0,046	0,046	0,045	0,045
GMt m	-5,484	-5,423	-5,36	-5,295	-5,229	-5,161	-5,091	-5,02	-4,948	-4,874	-4,799	-4,722	-4,644	-4,564
GML m	-5,487	-5,425	-5,362	-5,297	-5,231	-5,163	-5,094	-5,023	-4,95	-4,876	-4,801	-4,724	-4,646	-4,566
KMt m	22,406	22,467	22,53	22,595	22,661	22,729	22,799	22,87	22,942	23,016	23,091	23,168	23,246	23,326
KML m	22,403	22,465	22,528	22,593	22,659	22,727	22,796	22,867	22,94	23,014	23,089	23,166	23,244	23,324
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779
MTc tonne.m	-9,878	-9,807	-9,732	-9,654	-9,571	-9,485	-9,395	-9,301	-9,203	-9,102	-8,997	-8,888	-8,775	-8,658
RM at 1deg = GMt.Disp.sin(1) tonne.m	-944,31	-937,523	-930,372	-922,857	-914,976	-906,732	-898,123	-889,149	-879,811	-870,109	-860,042	-849,611	-838,815	-827,655
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	**44,518**	**45,035**	**45,553**	**46,071**	**46,588**	**47,106**	**47,624**	**48,141**	**48,659**	**49,176**	**49,694**	**50,212**	**50,729**	**51,247**
Displacement t	10431	10471	10511	10552	10592	10632	10673	10713	10753	10794	10834	10874	10915	10955
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	44,518	45,035	45,553	46,071	46,588	47,106	47,624	48,141	48,659	49,176	49,694	50,212	50,729	51,247
Draft at AP m	44,518	45,035	45,553	46,071	46,588	47,106	47,624	48,141	48,659	49,176	49,694	50,212	50,729	51,247
Draft at LCF m	44,518	45,035	45,553	46,071	46,588	47,106	47,624	48,141	48,659	49,176	49,694	50,212	50,729	51,247
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	4383,823	4394,176	4404,529	4414,882	4425,235	4435,588	4445,941	4456,294	4466,647	4477	4487,353	4497,706	4508,059	4518,411
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032
Prismatic coeff. (Cp)	0,36	0,358	0,356	0,353	0,351	0,349	0,347	0,345	0,344	0,342	0,34	0,338	0,336	0,334
Block coeff. (Cb)	0,417	0,414	0,411	0,408	0,405	0,402	0,399	0,396	0,394	0,391	0,388	0,386	0,383	0,381
Max Sect. area coeff. (Cm)	1,159	1,157	1,155	1,154	1,152	1,15	1,149	1,147	1,146	1,144	1,142	1,141	1,14	1,138
Waterpl. area coeff. (Cwp)	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	23,36	23,442	23,526	23,611	23,698	23,785	23,875	23,965	24,057	24,15	24,244	24,339	24,436	24,533
KG m	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89
BMt m	0,047	0,047	0,047	0,047	0,046	0,046	0,046	0,046	0,046	0,046	0,045	0,045	0,045	0,045
BML m	0,045	0,045	0,045	0,044	0,044	0,044	0,044	0,044	0,044	0,043	0,043	0,043	0,043	0,043
GMt m	-4,483	-4,401	-4,317	-4,232	-4,146	-4,058	-3,969	-3,879	-3,788	-3,695	-3,601	-3,506	-3,409	-3,312
GML m	-4,485	-4,403	-4,319	-4,234	-4,148	-4,06	-3,971	-3,881	-3,79	-3,697	-3,603	-3,508	-3,411	-3,314
KMt m	23,407	23,489	23,573	23,658	23,744	23,832	23,921	24,011	24,102	24,195	24,289	24,384	24,481	24,578
KML m	23,405	23,487	23,571	23,656	23,742	23,83	23,919	24,009	24,1	24,193	24,287	24,382	24,479	24,576
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779
MTc tonne.m	-8,538	-8,413	-8,285	-8,153	-8,017	-7,878	-7,735	-7,587	-7,436	-7,282	-7,123	-6,961	-6,794	-6,624
RM at 1deg = GMt.Disp.sin(1) tonne.m	-816,13	-804,241	-791,987	-779,369	-766,387	-753,04	-739,328	-725,252	-710,812	-696,007	-680,838	-665,304	-649,406	-633,143
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0

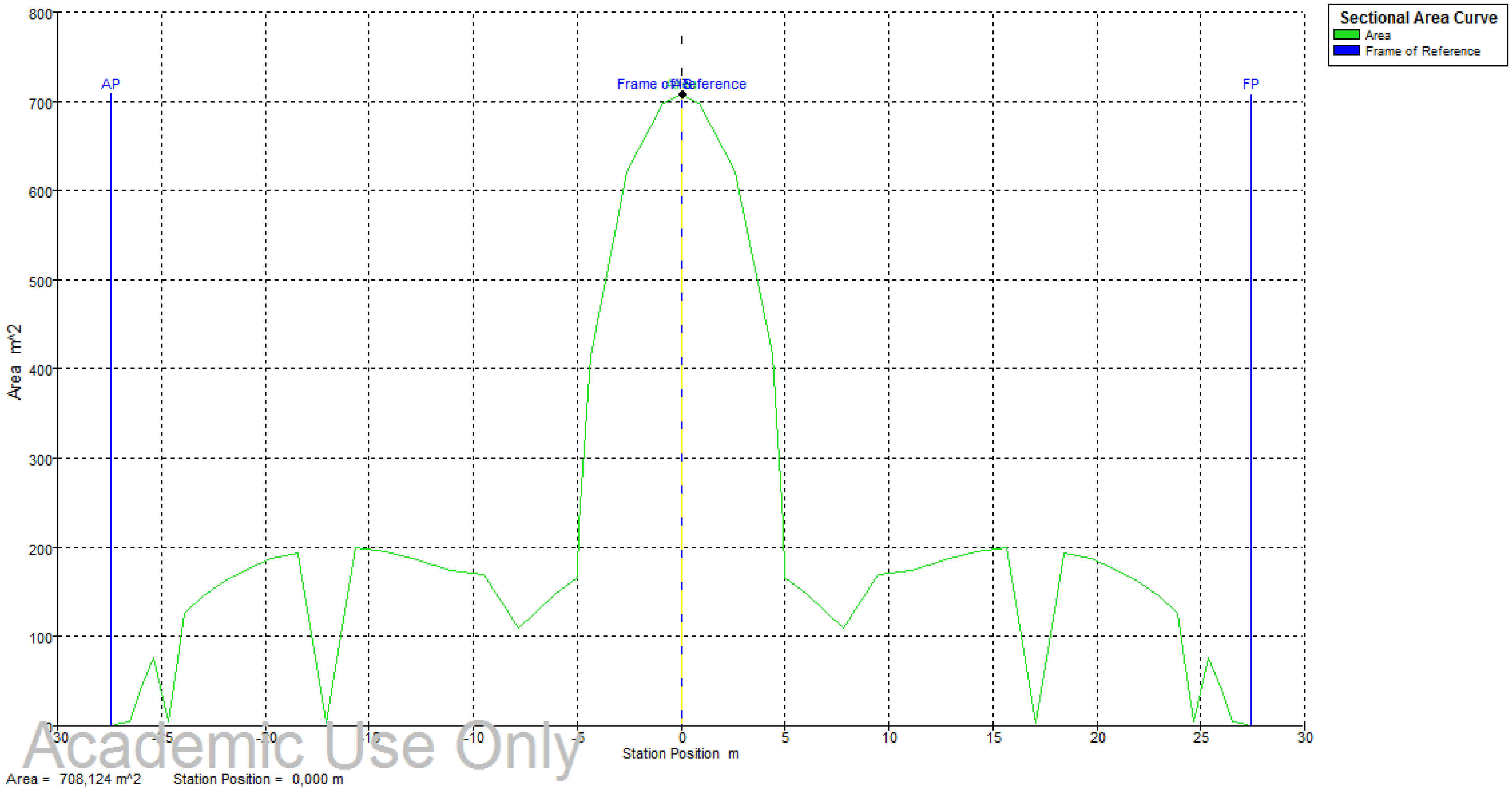
DRAFT AMIDSHIPS (m)	**51,765**	**52,282**	**52,800**	**53,318**	**53,835**	**54,353**	**54,871**	**55,388**	**55,906**	**56,424**	**56,941**	**57,459**	**57,976**	**58,494**
Displacement t	10995	11036	11076	11116	11157	11197	11237	11278	11318	11358	11399	11440	11490	11551
Heel deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	51,765	52,282	52,8	53,318	53,835	54,353	54,871	55,388	55,906	56,424	56,941	57,459	57,976	58,494
Draft at AP m	51,765	52,282	52,8	53,318	53,835	54,353	54,871	55,388	55,906	56,424	56,941	57,459	57,976	58,494
Draft at LCF m	51,765	52,282	52,8	53,318	53,835	54,353	54,871	55,388	55,906	56,424	56,941	57,459	57,976	58,494
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10	10,349	11,553	12,757
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10	10,349	11,553	12,757
Wetted Area m^2	4528,764	4539,117	4549,47	4559,823	4570,176	4580,529	4590,882	4601,235	4611,588	4621,941	4632,294	4648,551	4671,432	4701,922
Waterpl. Area m^2	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	76,032	84,023	103,417	130,124
Prismatic coeff. (Cp)	0,333	0,331	0,329	0,328	0,326	0,325	0,323	0,321	0,32	0,318	0,317	0,316	0,314	0,313
Block coeff. (Cb)	0,378	0,376	0,374	0,371	0,369	0,367	0,365	0,363	0,36	0,358	0,356	0,343	0,305	0,276
Max Sect. area coeff. (Cm)	1,137	1,135	1,134	1,133	1,132	1,13	1,129	1,128	1,127	1,125	1,124	1,085	0,972	0,881
Waterpl. area coeff. (Cwp)	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,139	0,148	0,163	0,186
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KB m	24,632	24,733	24,834	24,936	25,04	25,145	25,25	25,357	25,465	25,574	25,684	25,797	25,936	26,107
KG m	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89	27,89
BMt m	0,045	0,045	0,044	0,044	0,044	0,044	0,044	0,044	0,043	0,043	0,043	0,049	0,076	0,113
BML m	0,043	0,043	0,042	0,042	0,042	0,042	0,042	0,042	0,041	0,041	0,041	0,053	0,077	0,131
GMt m	-3,213	-3,113	-3,012	-2,909	-2,806	-2,702	-2,596	-2,489	-2,381	-2,272	-2,163	-2,044	-1,878	-1,67
GML m	-3,215	-3,115	-3,014	-2,911	-2,808	-2,704	-2,598	-2,491	-2,383	-2,274	-2,165	-2,039	-1,877	-1,653
KMt m	24,677	24,777	24,878	24,981	25,084	25,188	25,294	25,401	25,509	25,618	25,727	25,846	26,012	26,22
KML m	24,675	24,775	24,876	24,979	25,082	25,186	25,292	25,399	25,507	25,616	25,725	25,851	26,013	26,237
Immersion (TPc) tonne/cm	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,779	0,861	1,06	1,334
MTc tonne.m	-6,45	-6,273	-6,091	-5,906	-5,717	-5,524	-5,327	-5,127	-4,922	-4,714	-4,502	-4,257	-3,935	-3,484
RM at 1deg = GMt.Disp.sin(1) tonne.m	-616,516	-599,525	-582,169	-564,448	-546,363	-527,914	-509,1	-489,922	-470,379	-450,472	-430,2	-407,996	-376,538	-336,688
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	**59,012**	**59,529**	**60,047**	**60,565**	**61,082**	**61,600**
Displacement t	11626	11714	11817	11937	12073	12229
Heel deg	0	0	0	0	0	0
Draft at FP m	59,012	59,529	60,047	60,565	61,082	61,6
Draft at AP m	59,012	59,529	60,047	60,565	61,082	61,6
Draft at LCF m	59,012	59,529	60,047	60,565	61,082	61,6
Trim (+ve by stern) m	0	0	0	0	0	0
WL Length m	13,961	15,165	16,368	17,572	18,776	19,98
Beam max extents on WL m	13,961	15,164	16,368	17,572	18,776	19,98
Wetted Area m^2	4730,734	4756,67	4797,542	4833,11	4865,84	4917,016
Waterpl. Area m^2	154,665	176,047	212,003	242,183	269,284	304,325
Prismatic coeff. (Cp)	0,312	0,31	0,309	0,309	0,308	0,307
Block coeff. (Cb)	0,251	0,231	0,214	0,2	0,187	0,177
Max Sect. area coeff. (Cm)	0,806	0,744	0,692	0,647	0,609	0,575
Waterpl. area coeff. (Cwp)	0,202	0,212	0,236	0,252	0,262	0,278
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0
KB m	26,32	26,567	26,854	27,193	27,571	28,001
KG m	27,89	27,89	27,89	27,89	27,89	27,89
BMt m	0,163	0,225	0,301	0,398	0,511	0,642
BML m	0,177	0,213	0,328	0,412	0,479	0,601
GMt m	-1,407	-1,098	-0,734	-0,299	0,192	0,753
GML m	-1,394	-1,111	-0,708	-0,285	0,16	0,712
KMt m	26,483	26,792	27,156	27,591	28,082	28,643
KML m	26,496	26,779	27,182	27,605	28,05	28,602
Immersion (TPc) tonne/cm	1,585	1,804	2,173	2,482	2,76	3,119
MTc tonne.m	-2,957	-2,374	-1,527	-0,621	0,353	1,588
RM at 1deg = GMt.Disp.sin(1) tonne.m	-285,544	-224,511	-151,427	-62,366	40,537	160,646
Max deck inclination deg	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0

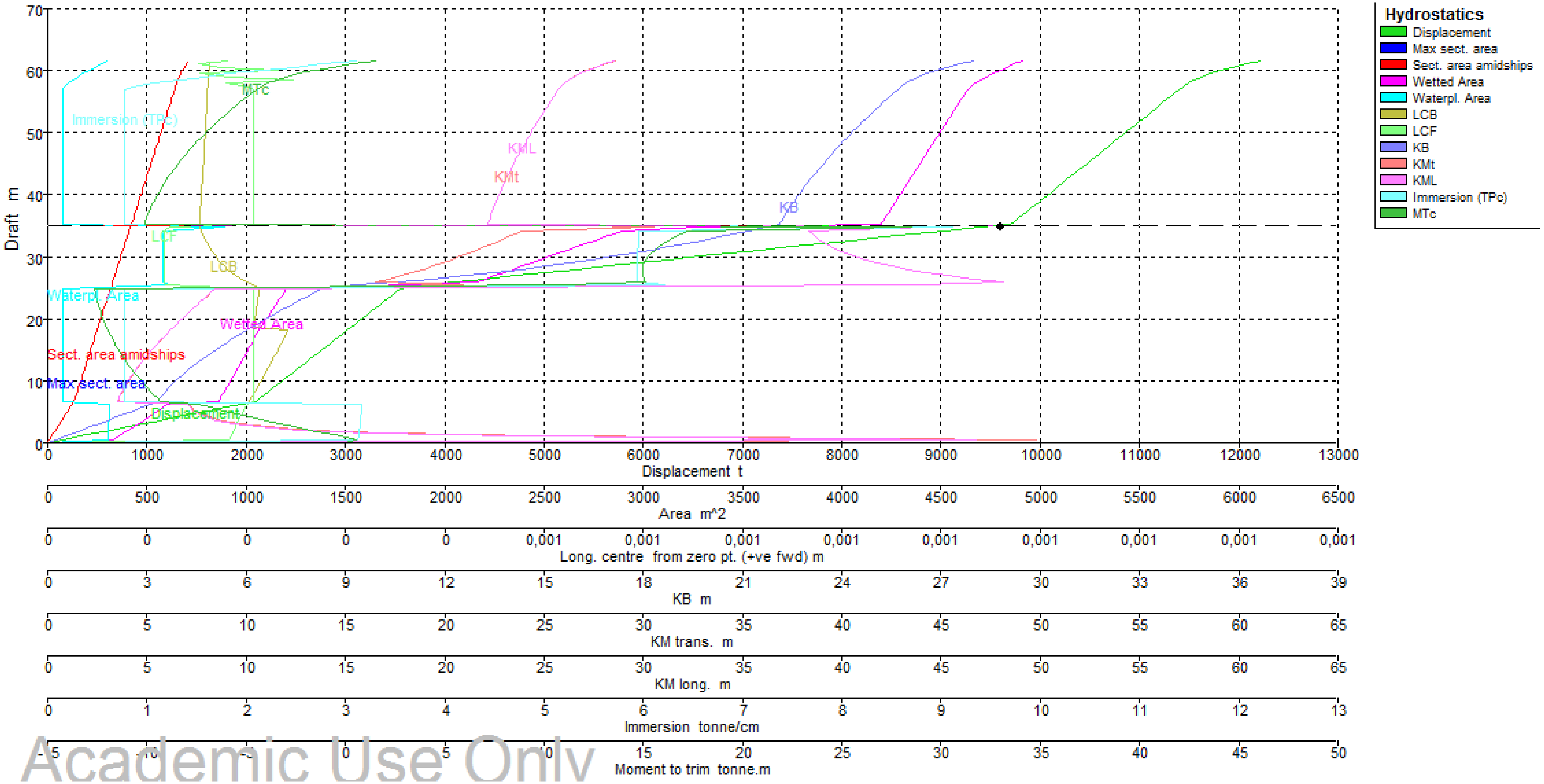


Hydrostatics
Displacement
Max sect. area
Sect. area amidships
Wetted Area
Waterpl. Area
LCB
LCF
KB
KMt
KML
Immersion (TPc)
MTc
Draft m
0 10 20 30 40 50 60 70
Immersion (TPc)
MTc
KML
KMt
KB
LCF
LCB
Waterpl. Area
Wetted Area
Sect. area amidships
Max sect. area
Displacement
0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000
Displacement t
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500
Area m^2
0 0 0 0 0 0,001 0,001 0,001 0,001 0,001 0,001 0,001 0,001 0,001
Long. centre from zero pt. (+ve fwd) m
0 3 6 9 12 15 18 21 24 27 30 33 36 39
KB m
0 5 10 15 20 25 30 35 40 45 50 55 60 65
KM trans. m
0 5 10 15 20 25 30 35 40 45 50 55 60 65
KM long. m
0 1 2 3 4 5 6 7 8 9 10 11 12 13
Immersion tonne/cm
-15 -10 -5 0 5 10 15 20 25 30 35 40 45 50
Moment to trim tonne.m

CURVA DE ÁREAS



COEFICIENTES DE FORMA



CURVAS KN

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
0,01	0,009	0,000 (fixed)	0	0	27,89	9,742	9,325	8,615	7,641	6,435	34,782	32,519	29,291	34,754
102,8	0,337	0,000 (fixed)	0	0	27,89	6,108	6,907	7,038	6,827	6,382	9,583	20,111	32,895	30,383
205,5	0,665	0,000 (fixed)	0	0	27,89	4,927	6,134	6,541	6,576	6,625	8,929	17,694	30,976	30,377
308,3	0,993	0,000 (fixed)	0	0	27,89	4,076	5,571	6,183	6,408	6,846	8,217	17,203	25,239	29,092
411,1	1,32	0,000 (fixed)	0	0	27,89	3,398	5,114	5,894	6,25	6,762	7,863	17,428	20,706	27,832
513,8	1,646	0,000 (fixed)	0	0	27,89	2,847	4,723	5,646	6,056	6,551	7,75	14,206	17,641	27,034
616,6	1,972	0,000 (fixed)	0	0	27,89	2,428	4,384	5,42	5,834	6,317	7,782	13,717	15,841	26,59
719,4	2,298	0,000 (fixed)	0	0	27,89	2,134	4,082	5,183	5,592	6,088	7,97	13,248	15,435	26,327
822,1	2,623	0,000 (fixed)	0	0	27,89	1,921	3,811	4,936	5,342	5,852	8,255	12,736	15,619	26,065
924,9	2,947	0,000 (fixed)	0	0	27,89	1,761	3,568	4,68	5,082	5,593	8,598	12,155	16,002	25,916
1028	3,271	0,000 (fixed)	0	0	27,89	1,639	3,346	4,417	4,827	5,43	8,942	11,576	16,395	25,845
1130	3,595	0,000 (fixed)	0	0	27,89	1,544	3,134	4,147	4,631	5,351	9,248	11,051	16,727	25,812
1233	3,918	0,000 (fixed)	0	0	27,89	1,469	2,932	3,877	4,48	5,287	9,525	10,728	16,999	25,809
1336	4,241	0,000 (fixed)	0	0	27,89	1,41	2,74	3,617	4,315	5,253	9,774	10,603	17,219	25,809
1439	4,564	0,000 (fixed)	0	0	27,89	1,364	2,554	3,371	4,152	5,229	8,418	10,621	17,398	25,766
1541	4,886	0,000 (fixed)	0	0	27,89	1,327	2,367	3,14	3,985	5,237	8,394	10,733	17,541	25,744
1644	5,208	0,000 (fixed)	0	0	27,89	1,285	2,19	2,931	3,825	5,264	8,359	10,914	17,663	25,739
1747	5,53	0,000 (fixed)	0	0	27,89	1,213	2,022	2,749	3,683	5,31	8,318	11,143	17,775	25,744
1850	5,851	0,000 (fixed)	0	0	27,89	1,102	1,865	2,593	3,556	5,375	8,271	11,393	17,88	25,78
1953	6,172	0,000 (fixed)	0	0	27,89	0,97	1,721	2,46	3,443	5,463	8,225	11,652	17,973	25,89
2055	6,492	0,000 (fixed)	0	0	27,89	0,828	1,591	2,349	3,338	5,579	8,187	11,912	18,057	25,994
2158	7,413	0,000 (fixed)	0	0	27,89	0,696	1,479	2,26	3,261	5,714	8,18	12,169	18,133	26,091
2261	8,679	0,000 (fixed)	0	0	27,89	0,666	1,398	2,197	3,226	5,861	8,21	12,415	18,204	26,184
2364	9,952	0,000 (fixed)	0	0	27,89	0,705	1,394	2,178	3,236	6,019	8,276	12,653	18,272	26,307
2466	11,231	0,000 (fixed)	0	0	27,89	0,751	1,481	2,271	3,298	6,191	8,379	12,88	18,337	26,421
2569	12,517	0,000 (fixed)	0	0	27,89	0,802	1,581	2,422	3,445	6,374	8,511	13,099	18,397	26,527
2672	13,81	0,000 (fixed)	0	0	27,89	0,858	1,692	2,613	3,682	6,564	8,666	13,311	18,454	26,626
2775	15,11	0,000 (fixed)	0	0	27,89	0,918	1,811	2,784	3,979	6,765	8,836	13,513	18,509	26,719

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
2877	16,417	0,000 (fixed)	0	0	27,89	0,983	1,987	3,004	4,337	6,969	9,017	13,704	18,563	26,805
2980	17,734	0,000 (fixed)	0	0	27,89	1,051	2,164	3,255	4,738	6,407	9,209	13,887	18,613	26,887
3083	19,036	0,000 (fixed)	0	0	27,89	1,119	2,308	3,545	5,145	6,668	9,41	14,06	18,663	26,964
3186	20,309	0,000 (fixed)	0	0	27,89	1,189	2,495	3,87	5,569	6,981	9,624	14,225	18,713	27,033
3288	21,583	0,000 (fixed)	0	0	27,89	1,342	2,719	4,233	5,806	7,324	9,853	14,383	18,766	27,081
3391	22,856	0,000 (fixed)	0	0	27,89	1,444	2,971	4,61	6,226	7,684	10,09	14,536	18,822	27,126
3494	24,13	0,000 (fixed)	0	0	27,89	1,619	3,272	4,975	6,606	8,05	10,336	14,683	18,881	27,169
3597	25,056	0,000 (fixed)	0	0	27,89	1,839	3,563	5,325	6,976	8,413	10,587	14,824	18,942	27,21
3700	25,222	0,000 (fixed)	0	0	27,89	2,046	3,841	5,662	7,331	8,768	10,845	14,959	19,006	27,249
3802	25,387	0,000 (fixed)	0	0	27,89	2,231	4,102	5,983	7,67	9,116	11,105	15,088	19,073	27,288
3905	25,556	0,000 (fixed)	0	0	27,89	2,394	4,345	6,289	7,994	9,456	11,366	15,211	19,142	27,336
4008	25,729	0,000 (fixed)	0	0	27,89	2,533	4,574	6,576	8,302	9,787	11,626	15,332	19,213	27,381
4111	25,902	0,000 (fixed)	0	0	27,89	2,651	4,798	6,847	8,595	10,109	11,886	15,449	19,287	27,424
4213	26,075	0,000 (fixed)	0	0	27,89	2,75	5,01	7,101	8,876	10,424	12,145	15,564	19,362	27,465
4316	26,248	0,000 (fixed)	0	0	27,89	2,834	5,203	7,341	9,145	10,732	12,402	15,676	19,44	27,505
4419	26,421	0,000 (fixed)	0	0	27,89	2,904	5,379	7,568	9,404	11,031	12,656	15,786	19,519	27,543
4522	26,594	0,000 (fixed)	0	0	27,89	2,964	5,54	7,782	9,653	11,32	12,906	15,894	19,6	27,579
4624	26,767	0,000 (fixed)	0	0	27,89	3,019	5,687	7,983	9,893	11,598	13,154	15,994	19,684	27,614
4727	26,94	0,000 (fixed)	0	0	27,89	3,071	5,823	8,173	10,124	11,866	13,398	16,097	19,771	27,648
4830	27,113	0,000 (fixed)	0	0	27,89	3,119	5,949	8,351	10,346	12,123	13,638	16,199	19,861	27,68
4933	27,285	0,000 (fixed)	0	0	27,89	3,162	6,066	8,518	10,563	12,369	13,873	16,302	19,954	27,712
5035	27,458	0,000 (fixed)	0	0	27,89	3,205	6,175	8,675	10,774	12,604	14,104	16,405	20,051	27,742
5138	27,631	0,000 (fixed)	0	0	27,89	3,247	6,278	8,823	10,976	12,83	14,329	16,51	20,15	27,771
5241	27,804	0,000 (fixed)	0	0	27,89	3,29	6,371	8,963	11,171	13,046	14,548	16,616	20,251	27,798
5344	27,977	0,000 (fixed)	0	0	27,89	3,331	6,456	9,097	11,358	13,253	14,759	16,723	20,355	27,825
5447	28,15	0,000 (fixed)	0	0	27,89	3,369	6,535	9,225	11,536	13,451	14,963	16,829	20,462	27,851
5549	28,323	0,000 (fixed)	0	0	27,89	3,404	6,61	9,347	11,706	13,642	15,16	16,937	20,569	27,877
5652	28,495	0,000 (fixed)	0	0	27,89	3,437	6,682	9,464	11,868	13,824	15,35	17,045	20,676	27,902

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
5755	28,668	0,000 (fixed)	0	0	27,89	3,467	6,75	9,577	12,022	13,999	15,532	17,155	20,785	27,927
5858	28,841	0,000 (fixed)	0	0	27,89	3,493	6,815	9,687	12,168	14,167	15,711	17,266	20,894	27,951
5960	29,014	0,000 (fixed)	0	0	27,89	3,515	6,877	9,794	12,307	14,328	15,883	17,379	21,003	27,975
6063	29,187	0,000 (fixed)	0	0	27,89	3,536	6,935	9,896	12,44	14,482	16,05	17,494	21,113	27,997
6166	29,36	0,000 (fixed)	0	0	27,89	3,555	6,99	9,992	12,566	14,629	16,213	17,612	21,223	28,019
6269	29,532	0,000 (fixed)	0	0	27,89	3,571	7,043	10,084	12,686	14,77	16,371	17,735	21,334	28,04
6371	29,705	0,000 (fixed)	0	0	27,89	3,586	7,093	10,171	12,8	14,905	16,525	17,861	21,443	28,06
6474	29,878	0,000 (fixed)	0	0	27,89	3,606	7,144	10,254	12,909	15,035	16,674	17,99	21,552	28,08
6577	30,05	0,000 (fixed)	0	0	27,89	3,635	7,194	10,334	13,013	15,16	16,819	18,123	21,66	28,099
6680	30,223	0,000 (fixed)	0	0	27,89	3,67	7,243	10,409	13,112	15,281	16,96	18,258	21,768	28,117
6782	30,396	0,000 (fixed)	0	0	27,89	3,705	7,292	10,48	13,204	15,397	17,098	18,396	21,876	28,134
6885	30,568	0,000 (fixed)	0	0	27,89	3,736	7,34	10,548	13,291	15,509	17,232	18,536	21,983	28,15
6988	30,741	0,000 (fixed)	0	0	27,89	3,765	7,388	10,612	13,373	15,616	17,363	18,678	22,088	28,165
7091	30,913	0,000 (fixed)	0	0	27,89	3,793	7,437	10,672	13,45	15,72	17,491	18,822	22,192	28,18
7194	31,086	0,000 (fixed)	0	0	27,89	3,82	7,486	10,73	13,524	15,82	17,616	18,966	22,297	28,195
7296	31,258	0,000 (fixed)	0	0	27,89	3,846	7,534	10,784	13,594	15,917	17,737	19,112	22,403	28,208
7399	31,431	0,000 (fixed)	0	0	27,89	3,871	7,579	10,836	13,662	16,01	17,857	19,257	22,509	28,222
7502	31,603	0,000 (fixed)	0	0	27,89	3,894	7,622	10,885	13,726	16,1	17,974	19,401	22,615	28,235
7605	31,776	0,000 (fixed)	0	0	27,89	3,917	7,662	10,932	13,788	16,186	18,087	19,545	22,723	28,247
7707	31,948	0,000 (fixed)	0	0	27,89	3,939	7,698	10,976	13,847	16,269	18,199	19,689	22,831	28,26
7810	32,12	0,000 (fixed)	0	0	27,89	3,96	7,732	11,018	13,904	16,349	18,308	19,833	22,939	28,271
7913	32,293	0,000 (fixed)	0	0	27,89	3,978	7,762	11,06	13,958	16,426	18,416	19,976	23,047	28,283
8016	32,465	0,000 (fixed)	0	0	27,89	3,994	7,789	11,099	14,01	16,502	18,521	20,122	23,157	28,294
8118	32,637	0,000 (fixed)	0	0	27,89	4,011	7,812	11,137	14,06	16,576	18,624	20,267	23,266	28,304
8221	32,809	0,000 (fixed)	0	0	27,89	4,029	7,83	11,173	14,109	16,647	18,725	20,414	23,374	28,314
8324	32,982	0,000 (fixed)	0	0	27,89	4,05	7,845	11,206	14,158	16,717	18,824	20,56	23,482	28,324
8427	33,154	0,000 (fixed)	0	0	27,89	4,072	7,857	11,237	14,206	16,786	18,921	20,708	23,59	28,333
8529	33,326	0,000 (fixed)	0	0	27,89	4,092	7,867	11,266	14,253	16,853	19,016	20,856	23,696	28,337

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
8632	33,498	0,000 (fixed)	0	0	27,89	4,11	7,874	11,293	14,299	16,919	19,111	21,005	23,802	28,341
8735	33,671	0,000 (fixed)	0	0	27,89	4,125	7,877	11,318	14,346	16,984	19,205	21,154	23,908	28,344
8838	33,843	0,000 (fixed)	0	0	27,89	4,134	7,876	11,341	14,393	17,049	19,298	21,304	24,013	28,347
8941	34,015	0,000 (fixed)	0	0	27,89	4,137	7,872	11,362	14,439	17,115	19,391	21,453	24,118	28,349
9043	34,187	0,000 (fixed)	0	0	27,89	4,134	7,869	11,38	14,486	17,181	19,483	21,603	24,223	28,352
9146	34,359	0,000 (fixed)	0	0	27,89	4,126	7,866	11,397	14,533	17,249	19,575	21,752	24,329	28,36
9249	34,522	0,000 (fixed)	0	0	27,89	4,112	7,862	11,412	14,579	17,318	19,667	21,902	24,435	28,369
9352	34,634	0,000 (fixed)	0	0	27,89	4,093	7,855	11,425	14,625	17,388	19,759	22,05	24,543	28,378
9454	34,747	0,000 (fixed)	0	0	27,89	4,068	7,847	11,436	14,671	17,462	19,852	22,198	24,651	28,386
9557	34,86	0,000 (fixed)	0	0	27,89	4,038	7,838	11,448	14,718	17,538	19,948	22,345	24,76	28,394
9660	34,973	0,000 (fixed)	0	0	27,89	4,003	7,828	11,46	14,766	17,618	20,045	22,491	24,868	28,402
9763	35,948	0,000 (fixed)	0	0	27,89	3,967	7,821	11,475	14,815	17,701	20,147	22,635	24,978	28,409
9865	37,267	0,000 (fixed)	0	0	27,89	3,948	7,819	11,491	14,866	17,787	20,252	22,779	25,09	28,416
9968	38,585	0,000 (fixed)	0	0	27,89	3,949	7,828	11,511	14,921	17,878	20,364	22,921	25,205	28,422
10071	39,904	0,000 (fixed)	0	0	27,89	3,948	7,849	11,548	14,981	17,974	20,483	23,062	25,322	28,419
10174	41,222	0,000 (fixed)	0	0	27,89	3,979	7,884	11,598	15,048	18,078	20,614	23,203	25,442	28,415
10276	42,541	0,000 (fixed)	0	0	27,89	4,012	7,937	11,656	15,121	18,19	20,757	23,343	25,564	28,411
10379	43,86	0,000 (fixed)	0	0	27,89	4,047	7,99	11,723	15,205	18,311	20,917	23,483	25,688	28,405
10482	45,178	0,000 (fixed)	0	0	27,89	4,083	8,043	11,806	15,288	18,434	21,09	23,623	25,813	28,386
10585	46,497	0,000 (fixed)	0	0	27,89	4,121	8,117	11,907	15,381	18,559	21,277	23,762	25,937	28,361
10688	47,816	0,000 (fixed)	0	0	27,89	4,16	8,194	12,012	15,492	18,688	21,474	23,903	26,059	28,335
10790	49,134	0,000 (fixed)	0	0	27,89	4,2	8,274	12,119	15,617	18,824	21,676	24,047	26,178	28,308
10893	50,453	0,000 (fixed)	0	0	27,89	4,242	8,356	12,219	15,76	18,985	21,885	24,196	26,294	28,279
10996	51,771	0,000 (fixed)	0	0	27,89	4,285	8,442	12,343	15,915	19,161	22,09	24,348	26,408	28,256
11099	53,09	0,000 (fixed)	0	0	27,89	4,33	8,529	12,471	16,075	19,346	22,291	24,508	26,518	28,233
11201	54,409	0,000 (fixed)	0	0	27,89	4,376	8,62	12,604	16,262	19,532	22,491	24,675	26,626	28,207
11304	55,727	0,000 (fixed)	0	0	27,89	4,423	8,713	12,747	16,452	19,718	22,685	24,853	26,732	28,18
11407	57,046	0,000 (fixed)	0	0	27,89	4,472	8,815	12,908	16,642	19,905	22,871	25,046	26,835	28,149

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
11510	58,161	0,000 (fixed)	0	0	27,89	4,529	8,929	13,072	16,825	20,102	23,05	25,258	26,936	28,114
11612	58,926	0,000 (fixed)	0	0	27,89	4,591	9,051	13,23	17,003	20,309	23,221	25,479	27,036	28,084
11715	59,535	0,000 (fixed)	0	0	27,89	4,654	9,167	13,383	17,188	20,515	23,392	25,689	27,134	28,052
11818	60,054	0,000 (fixed)	0	0	27,89	4,718	9,276	13,529	17,367	20,718	23,559	25,881	27,247	28,016
11921	60,498	0,000 (fixed)	0	0	27,89	4,778	9,373	13,667	17,541	20,917	23,728	26,037	27,419	27,982
12023	60,899	0,000 (fixed)	0	0	27,89	4,826	9,458	13,794	17,707	21,108	23,904	26,17	27,58	27,967
12126	61,265	0,000 (fixed)	0	0	27,89	4,858	9,529	13,907	17,862	21,282	24,086	26,269	27,588	27,988
12229	61,604	0,000 (fixed)	0	0	27,89	4,864	9,579	14,002	17,999	21,453	24,257	26,32	27,582	28,007

ESTUDIO DE LAS CONDICIONES DE CARGA

EQUILIBRIO CONDICIÓN DE CARGA Nº1

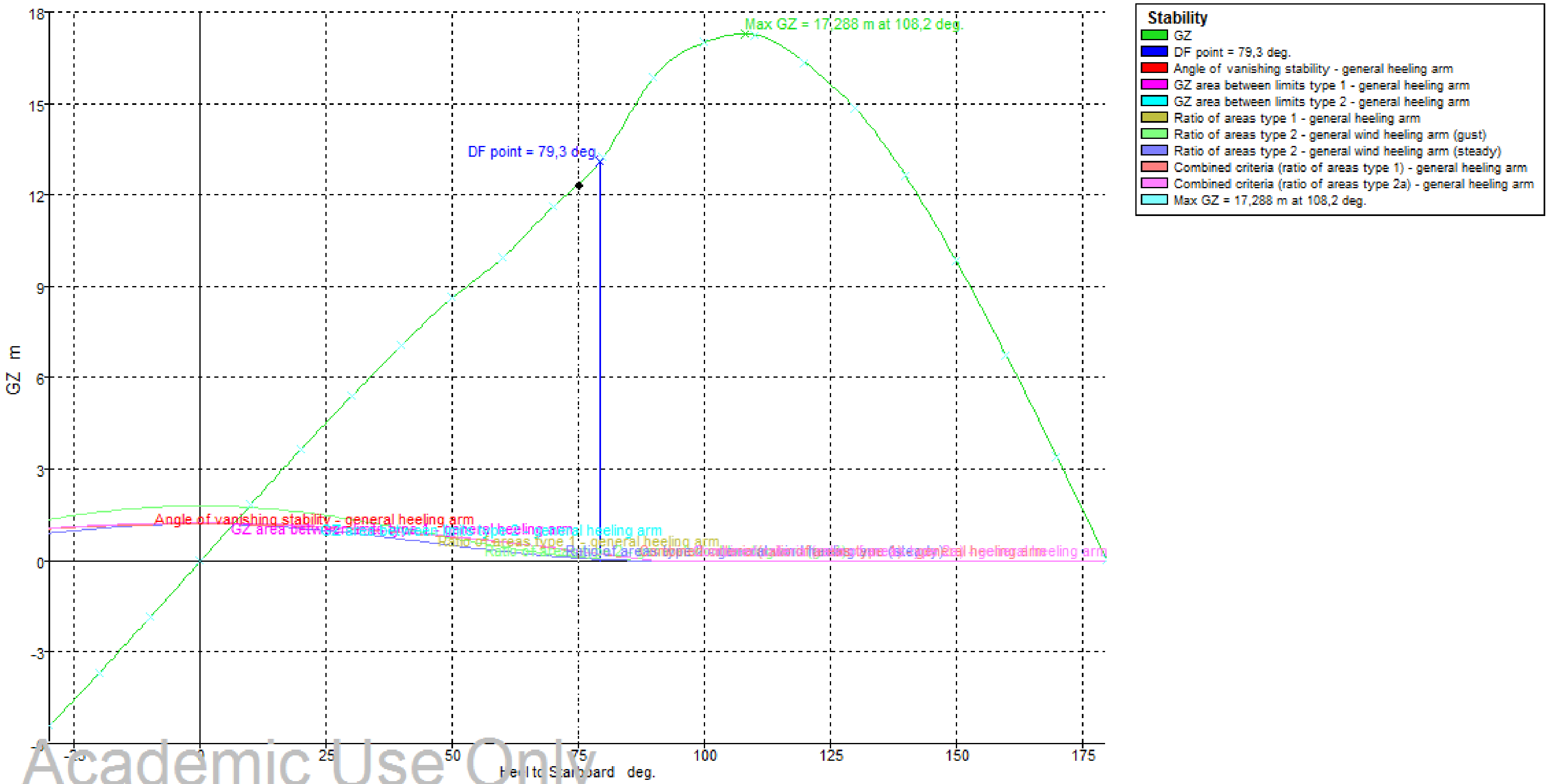
Draft Amidships m	43,152
Displacement t	10324
Heel deg	0,1
Draft at FP m	43,11
Draft at AP m	43,194
Draft at LCF m	43,152
Trim (+ve by stern) m	0,084
WL Length m	10
Beam max extents on WL m	10
Wetted Area m^2	4473,614
Waterpl. Area m^2	76,033
Prismatic coeff. (Cp)	0,366
Block coeff. (Cb)	0,426
Max Sect. area coeff. (Cm)	1,164
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0
LCF from zero pt. (+ve fwd) m	0

KB m	23,148
KG fluid m	12,561
BMt m	0,048
BML m	0,045
GMt corrected m	10,636
GML m	10,633
KMt m	23,196
KML m	23,194
Immersion (TPc) tonne/cm	0,779
MTc tonne.m	20,033
RM at 1deg = GMt.Disp.sin(1) tonne.m	1916,313
Max deck inclination deg	0,1263
Trim angle (+ve by stern) deg	0,0882

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº1.

Loadcase - Condición de Carga N.1
Damage Case - Intact
Fixed Trim = 0 m (+ve by stern)
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

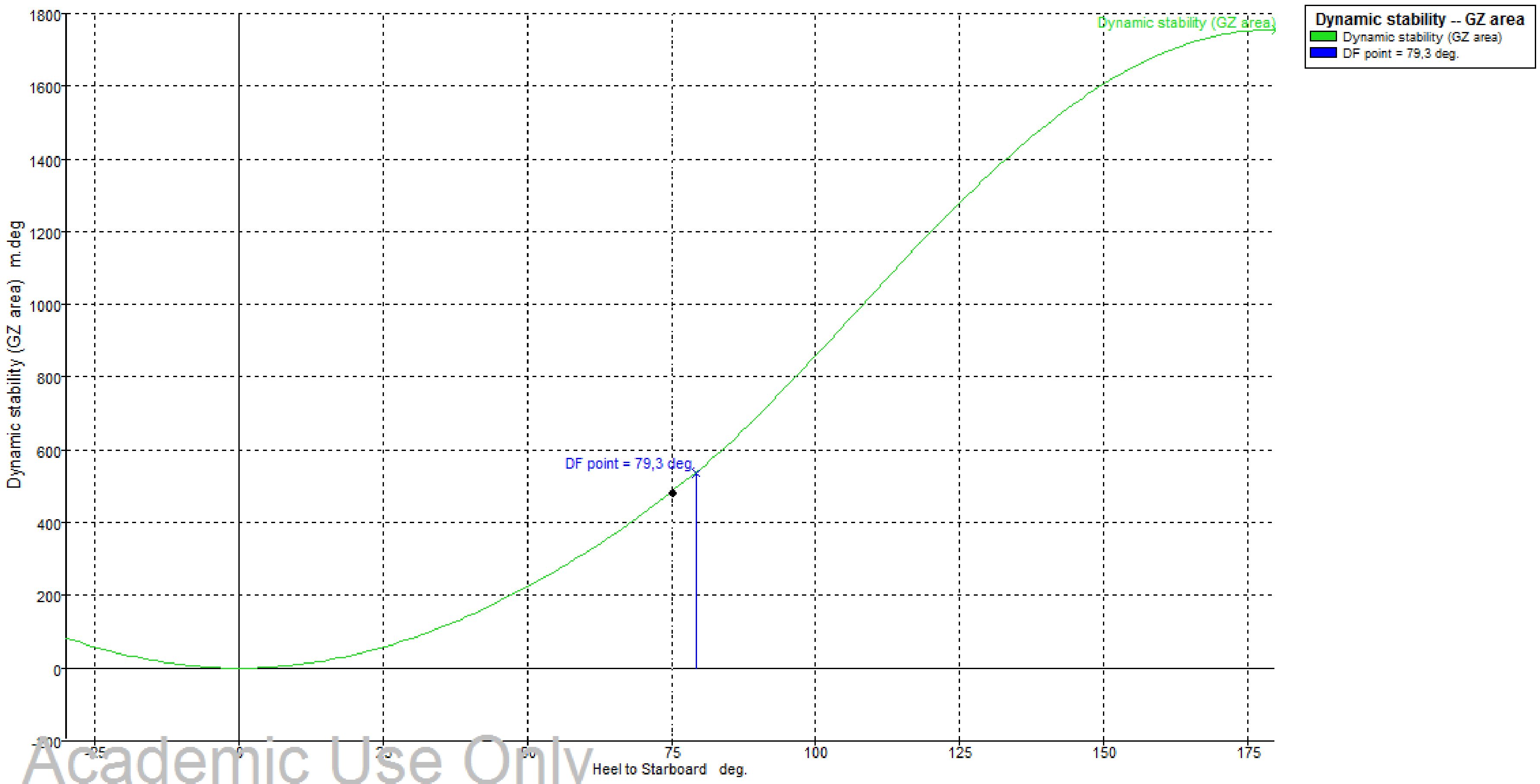
Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	1210,080	1210,080			0,030	0,040	27,890	0,000	User Specified
Peso Pienso Ø6mm	1	253,630	253,630			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	1	134,360	134,360			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	1	36,690	36,690			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5891,055	5891,055	2031,398	2031,398	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	662,085	662,085	228,305	228,305	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	100%	184,681	184,681	180,176	180,176	-2,130	2,134	31,370	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	100%	184,681	184,681	180,176	180,176	-2,130	-2,134	31,370	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	98%	17,493	17,143	20,580	20,168	0,000	2,050	37,825	0,000	IMO A.749(18)
MGO Nº2	98%	17,493	17,143	20,580	20,168	0,000	-2,050	37,825	0,000	IMO A.749(18)
Agua Potable	98%	10,161	9,957	10,161	9,957	-2,900	0,000	37,384	0,000	IMO A.749(18)
Aguas Grises	0%	2,260	0,000	2,205	0,000	3,600	0,150	36,600	0,000	IMO A.749(18)
Total Loadcase			10324,074	4353,069	4341,149	-0,016	0,017	12,561	0,000	
FS correction								0,000		
VCG fluid								12,561		



GZ = 12,330 m   Heel to Starboard = 75,000 deg.   Area (from zero heel) = 483 m. 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	70,0	80,0	90,0
GZ m	-5,420	-3,683	-1,864	-0,017	1,830	3,651	5,391	7,073	8,612	9,943	11,599	13,248	15,848
Area under GZ curve from zero heel m.deg	82,7540	37,1917	9,4066	0,0000	9,0731	36,5301	81,7993	144,1688	222,8319	315,4782	423,1806	546,7962	692,4370
Displacement t	10324	10325	10324	10324	10324	10324	10324	10324	10323	10324	10324	10324	10324
Draft at FP m	43,649	43,295	43,152	43,152	43,152	43,291	43,650	44,630	45,971	47,450	50,334	60,861	n/a
Draft at AP m	43,649	43,295	43,152	43,152	43,152	43,291	43,650	44,630	45,971	47,450	50,334	60,861	n/a
WL Length m	22,334	18,017	10,000	10,000	10,000	18,036	22,334	20,817	45,081	49,431	51,718	52,775	52,518
Beam max extents on WL m	22,969	26,286	10,154	10,000	10,154	26,275	22,968	30,770	25,974	31,297	38,954	58,347	61,600
Wetted Area m^2	4360,014	4419,403	4473,718	4356,508	4473,572	4419,443	4359,447	4299,756	4190,301	4069,484	3943,261	3808,278	3627,907
Waterpl. Area m^2	106,372	86,097	77,205	76,032	77,205	86,064	106,370	130,700	157,928	273,299	472,336	517,270	595,096
Prismatic coeff. (Cp)	0,363	0,365	0,366	0,366	0,366	0,365	0,363	0,356	0,347	0,336	0,316	0,296	0,283
Block coeff. (Cb)	0,187	0,159	0,409	0,426	0,409	0,159	0,187	0,147	0,190	0,173	0,142	0,098	0,093
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	16,999	17,254	16,345	14,826	12,622	9,857	14,826	12,622	9,857	6,733	3,401	0,017
Area under GZ curve from zero heel m.deg	857,8895	1029,9265	1198,7082	1355,0276	1492,8336	1605,6010	1355,0276	1492,8336	1605,6010	1688,7847	1739,5521	1756,6483
Displacement t	10324	10323	10324	10324	10324	10324	10324	10324	10324	10325	10324	10323
Draft at FP m	5,723	-6,580	-8,378	-8,538	-7,976	-7,222	-8,538	-7,976	-7,222	-6,568	-6,064	-5,919
Draft at AP m	5,723	-6,580	-8,378	-8,538	-7,976	-7,222	-8,538	-7,976	-7,222	-6,568	-6,064	-5,919
WL Length m	49,582	47,135	37,664	20,000	19,701	19,805	20,000	19,701	19,805	20,000	20,000	20,000
Beam max extents on WL m	44,132	43,096	41,380	39,305	36,194	30,436	39,305	36,194	30,436	23,786	16,915	20,000
Wetted Area m^2	3944,824	4128,331	4442,961	4521,040	4619,292	4680,298	4521,040	4619,292	4680,298	4690,022	4717,368	4676,298
Waterpl. Area m^2	491,562	431,590	261,357	269,289	230,368	210,457	269,289	230,368	210,457	206,672	229,975	308,939
Prismatic coeff. (Cp)	0,293	0,307	0,311	0,314	0,313	0,312	0,314	0,313	0,312	0,311	0,311	0,311
Block coeff. (Cb)	0,122	0,120	0,120	0,112	0,107	0,116	0,112	0,107	0,116	0,140	0,193	0,165
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	-0,003	0,003	0,000	-0,001	0,000	0,000	-0,001	0,000	-0,001	-0,001	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Dynamic stability (GZ area) = 483,020 m.deg Heel to Starboard = 75,000 deg. Area (from zero heel) = 1,238E+004 m.deg. deg.

Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = -27,4 m)		0	n/a
Deck Edge (immersion pos = -27,4 m)		0	n/a
DF point	Downflooding point	80,3	0
DF point	Downflooding point	79,3	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	79,3	Pass	+13,24
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	86,0583	Pass	+5265,23
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	162,1602	m.deg	362,5606	Pass	+123,58
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	67,49	Pass	+124,97
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	484,03	Pass	+272,33
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	88,17	Pass	+120,43
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	13,84	Pass	+76,93
	Area 1 shall not be less than (>=)	5,1600	m.deg	473,6353	Pass	+9078,98
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

EQUILIBRIO CONDICIÓN DE CARGA Nº2

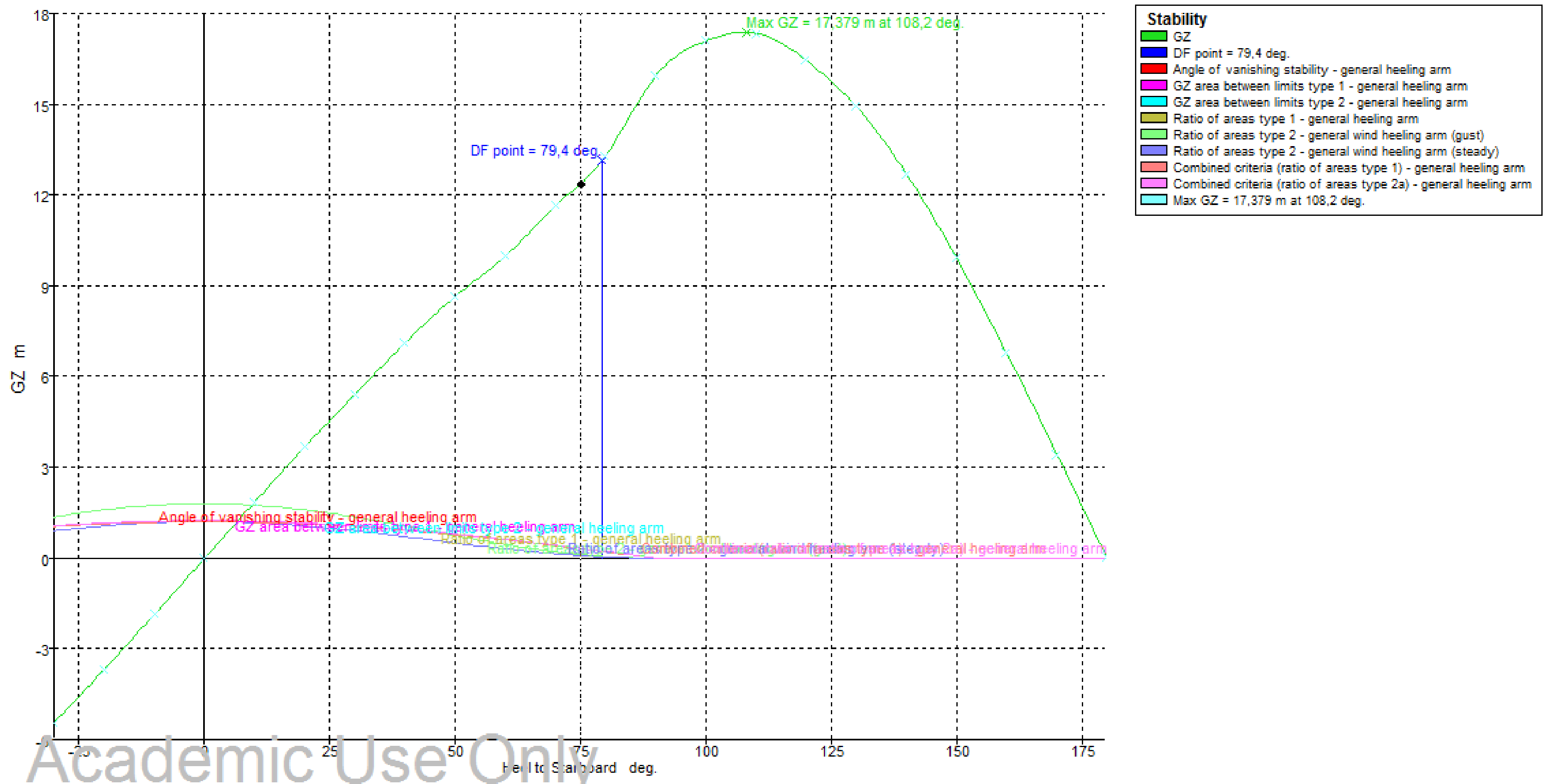
Draft Amidships m	42,873
Displacement t	10302
Heel deg	0,1
Draft at FP m	42,817
Draft at AP m	42,929
Draft at LCF m	42,873
Trim (+ve by stern) m	0,112
WL Length m	10
Beam max extents on WL m	10
Wetted Area m^2	4468,071
Waterpl. Area m^2	76,033
Prismatic coeff. (Cp)	0,367
Block coeff. (Cb)	0,428
Max Sect. area coeff. (Cm)	1,165
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0
LCF from zero pt. (+ve fwd) m	0

KB m	23,107
KG fluid m	12,49
BMt m	0,048
BML m	0,046
GMt corrected m	10,664
GML m	10,662
KMt m	23,154
KML m	23,152
Immersion (TPc) tonne/cm	0,779
MTc tonne.m	20,044
RM at 1deg = GMt.Disp.sin(1) tonne.m	1917,406
Max deck inclination deg	0,1478
Trim angle (+ve by stern) deg	0,1169

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº2.

Loadcase - Condición de Carga N.2
Damage Case - Intact
Fixed Trim = 0 m (+ve by stern)
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

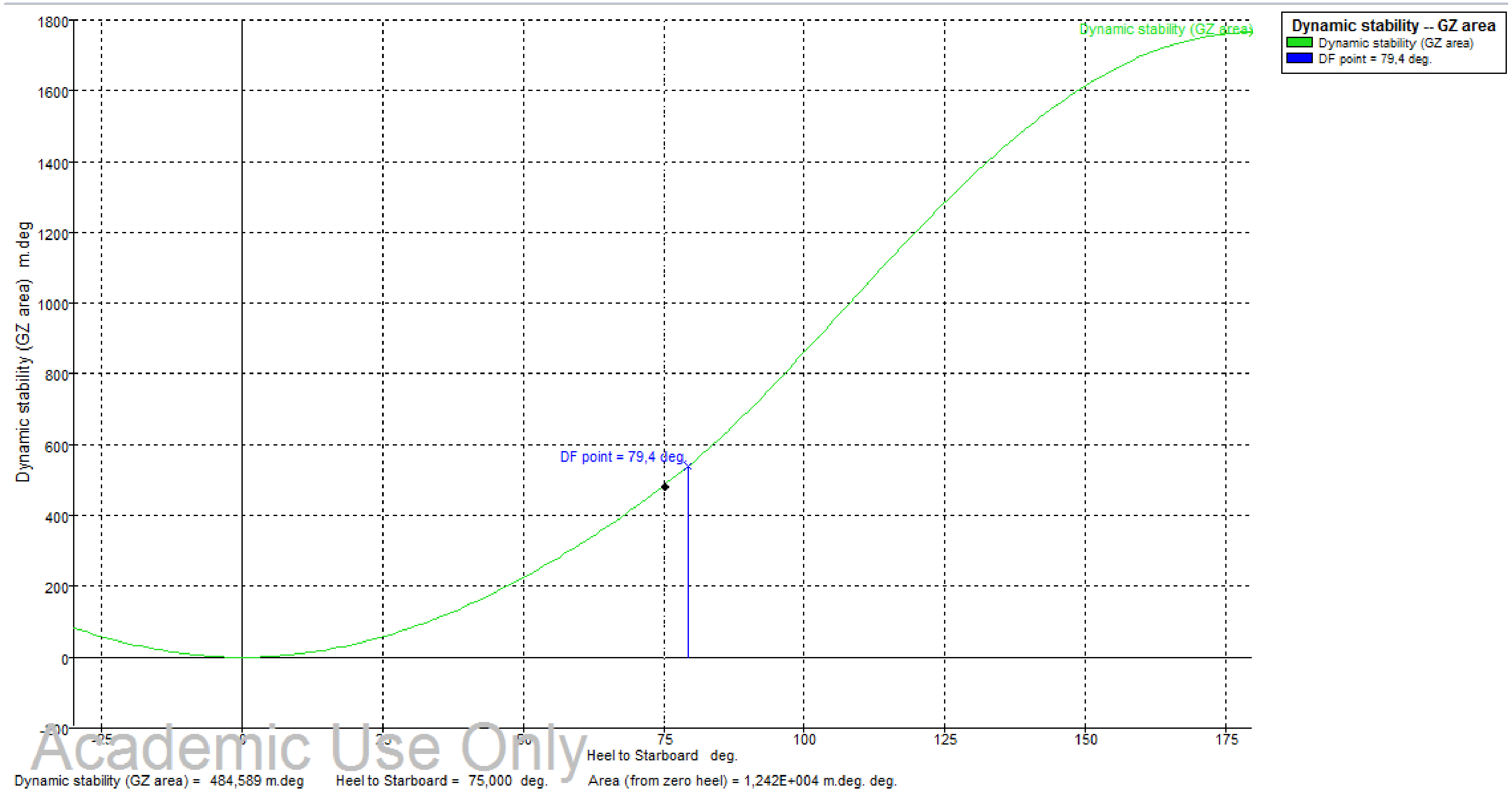
Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	1210,080	1210,080			0,030	0,040	27,890	0,000	User Specified
Peso Pienso Ø6mm	1	253,630	253,630			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	1	134,360	134,360			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	0,5	36,690	18,345			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5891,055	5891,055	2031,398	2031,398	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	662,085	662,085	228,305	228,305	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	100%	184,681	184,681	180,176	180,176	-2,130	2,134	31,370	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	100%	184,681	184,681	180,176	180,176	-2,130	-2,134	31,370	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	90%	17,493	15,744	20,580	18,522	0,000	2,050	37,725	2,546	IMO A.749(18)
MGO Nº2	90%	17,493	15,744	20,580	18,522	0,000	-2,050	37,725	2,546	IMO A.749(18)
Agua Potable	90%	10,161	9,145	10,161	9,145	-2,900	0,000	37,320	1,697	IMO A.749(18)
Aguas Grises	10%	2,260	0,226	2,205	0,221	3,600	0,150	36,645	1,295	IMO A.749(18)
Correccion Corrimiento Pienso(-	-1	0,423	-0,423			1,313	0,000	47,780	0,000	User Specified
Correccion Corrimiento Pienso(+	1	0,423	0,423			4,080	0,000	47,780	0,000	User Specified
Total Loadcase			10302,343	4353,069	4337,264	-0,022	0,017	12,489	8,083	
FS correction								0,001		
VCG fluid								12,490		



GZ = 12,368 m Heel to Starboard = 75,000 deg. Area (from zero heel) = 484,6 m. 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	70,0	80,0	90,0
GZ m	-5,441	-3,695	-1,868	-0,017	1,835	3,663	5,412	7,101	8,640	9,970	11,635	13,291	15,919
Area under GZ curve from zero heel m.deg	83,0301	37,3002	9,4304	0,0000	9,0962	36,6370	82,0719	144,6865	223,6318	316,5473	424,5644	548,5627	694,7603
Displacement t	10302	10302	10302	10302	10302	10302	10302	10302	10301	10302	10302	10302	10302
Draft at FP m	43,421	43,026	42,873	42,873	42,873	43,022	43,415	44,418	45,762	47,295	50,203	60,626	n/a
Draft at AP m	43,421	43,026	42,873	42,873	42,873	43,022	43,415	44,418	45,762	47,295	50,203	60,626	n/a
WL Length m	22,261	19,047	10,000	10,000	10,000	19,059	22,259	20,555	45,514	49,577	51,767	52,818	52,554
Beam max extents on WL m	23,083	25,592	10,154	10,000	10,154	25,581	23,086	30,577	25,861	31,297	38,954	58,586	61,600
Wetted Area m^2	4351,200	4408,913	4468,141	4350,931	4467,995	4408,967	4350,573	4291,049	4175,965	4053,291	3934,368	3799,041	3623,297
Waterpl. Area m^2	106,922	85,016	77,205	76,032	77,205	85,014	106,936	130,675	159,893	275,999	474,791	520,561	595,402
Prismatic coeff. (Cp)	0,364	0,367	0,367	0,367	0,367	0,367	0,364	0,357	0,348	0,337	0,316	0,296	0,283
Block coeff. (Cb)	0,187	0,163	0,411	0,428	0,411	0,164	0,187	0,148	0,191	0,173	0,142	0,098	0,093
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	17,089	17,346	16,447	14,918	12,707	9,926	6,782	3,428	0,017
Area under GZ curve from zero heel m.deg	861,0372	1033,9861	1203,7469	1361,0462	1499,7375	1613,2833	1697,0550	1748,2070	1765,4431
Displacement t	10301	10301	10302	10302	10302	10302	10303	10301	10302
Draft at FP m	5,465	-6,722	-8,539	-8,663	-8,096	-7,338	-6,677	-6,161	-5,984
Draft at AP m	5,465	-6,722	-8,539	-8,663	-8,096	-7,338	-6,677	-6,161	-5,984
WL Length m	49,656	47,219	38,314	20,000	19,675	19,768	19,965	20,000	20,000
Beam max extents on WL m	44,140	43,114	41,426	39,219	36,303	30,378	23,749	16,899	20,000
Wetted Area m^2	3936,232	4116,888	4440,624	4514,367	4610,101	4674,421	4683,523	4707,192	4673,641
Waterpl. Area m^2	495,134	436,323	262,563	270,831	229,426	207,925	203,497	222,844	308,975
Prismatic coeff. (Cp)	0,292	0,307	0,312	0,314	0,314	0,312	0,311	0,311	0,312
Block coeff. (Cb)	0,122	0,120	0,120	0,112	0,107	0,116	0,140	0,193	0,165
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	-0,002	0,015	0,000	-0,001	0,000	-0,001	-0,001	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Dynamic stability (GZ area) = 484,589 m.deg Heel to Starboard = 75,000 deg. Area (from zero heel) = 1,242E+004 m.deg. deg.

Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = -27,4 m)		0	n/a
Deck Edge (immersion pos = -27,4 m)		0	n/a
DF point	Downflooding point	80,3	0
DF point	Downflooding point	79,4	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	79,4	Pass	+13,42
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	86,3835	Pass	+5285,51
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	163,1630	m.deg	363,9350	Pass	+123,05
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	67,33	Pass	+124,43
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	484,91	Pass	+273,01
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	88,23	Pass	+120,57
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	13,80	Pass	+77,00
	Area 1 shall not be less than (>=)	5,1600	m.deg	476,9415	Pass	+9143,05
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

EQUILIBRIO CONDICIÓN DE CARGA Nº3

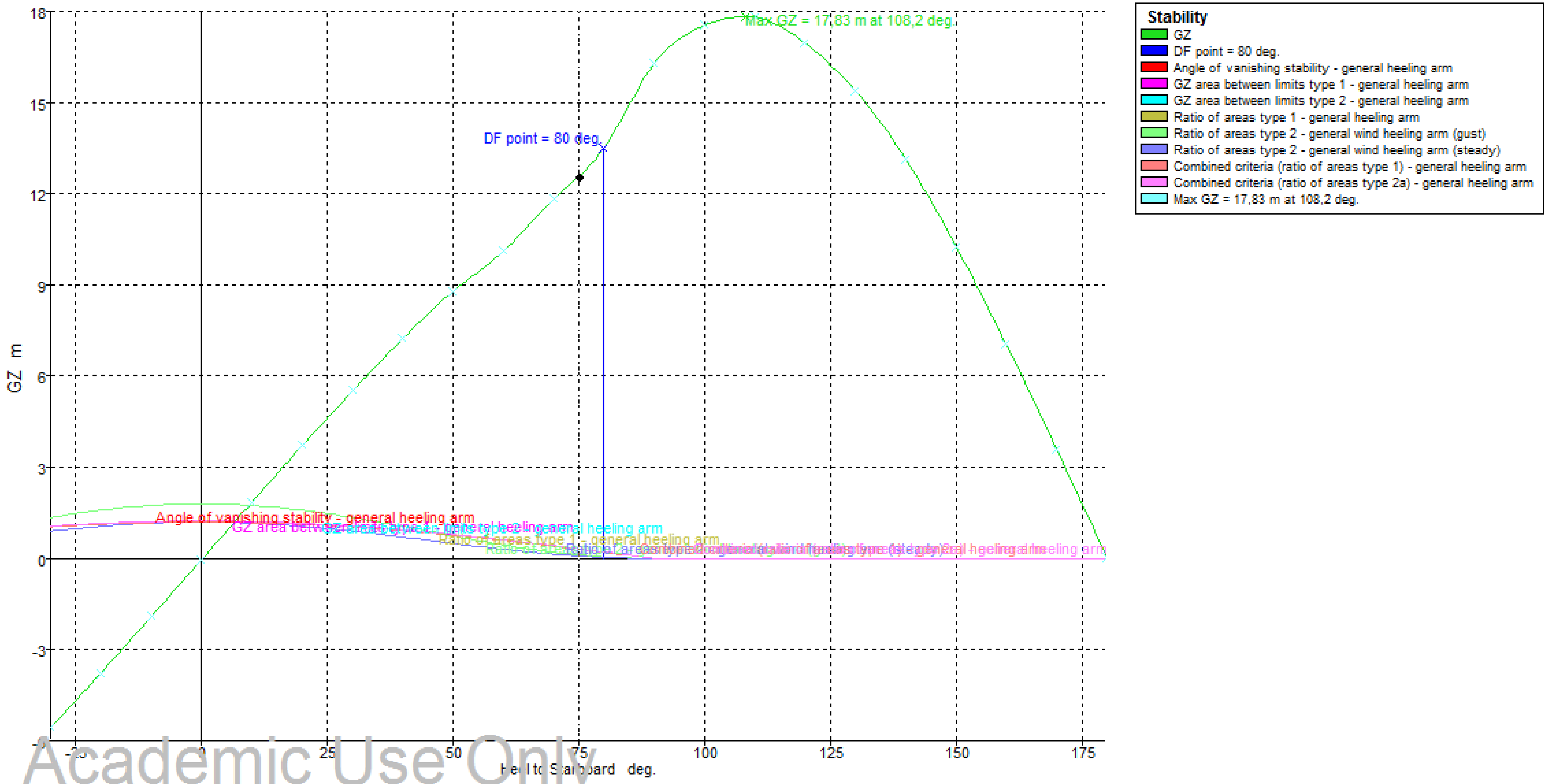
Draft Amidships m	41,553
Displacement t	10199
Heel deg	0,2
Draft at FP m	41,488
Draft at AP m	41,618
Draft at LCF m	41,553
Trim (+ve by stern) m	0,13
WL Length m	10
Beam max extents on WL m	10
Wetted Area m^2	4441,72
Waterpl. Area m^2	76,033
Prismatic coeff. (Cp)	0,373
Block coeff. (Cb)	0,437
Max Sect. area coeff. (Cm)	1,17
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0
LCF from zero pt. (+ve fwd) m	0

KB m	22,914
KG fluid m	12,144
BMt m	0,048
BML m	0,046
GMt corrected m	10,819
GML m	10,816
KMt m	22,962
KML m	22,96
Immersion (TPc) tonne/cm	0,779
MTc tonne.m	20,131
RM at 1deg = GMt.Disp.sin(1) tonne.m	1925,752
Max deck inclination deg	0,23
Trim angle (+ve by stern) deg	0,1359

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº3

Loadcase - Condición de Carga N.3
Damage Case - Intact
Fixed Trim = 0 m (+ve by stern)
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

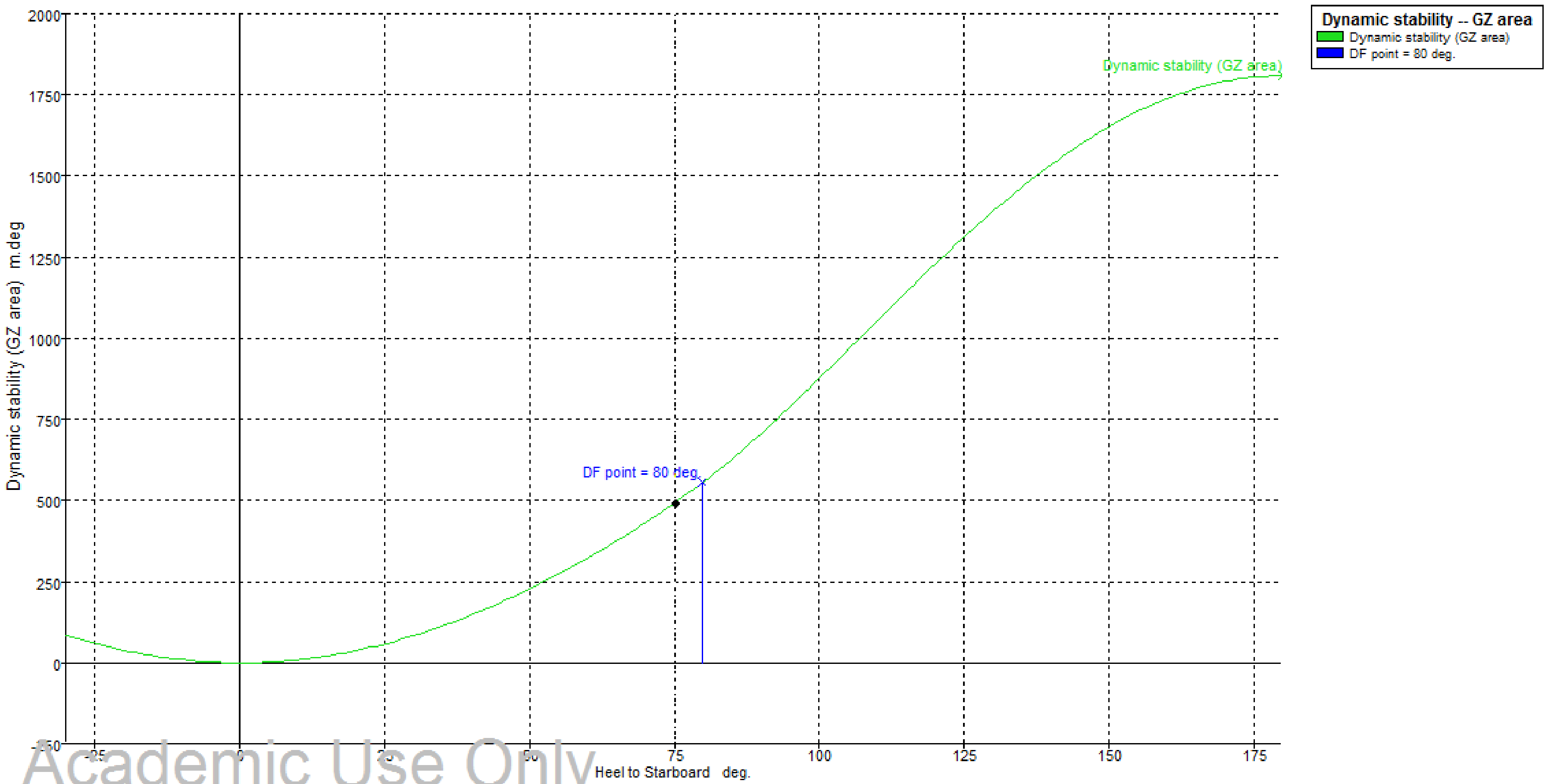
Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	1210,080	1210,080			0,030	0,040	27,890	0,000	User Specified
Peso Pienso Ø6mm	1	253,630	253,630			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	0,5	134,360	67,180			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	0	36,690	0,000			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5891,055	5891,055	2031,398	2031,398	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	662,085	662,085	228,305	228,305	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	100%	184,681	184,681	180,176	180,176	-2,130	2,134	31,370	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	100%	184,681	184,681	180,176	180,176	-2,130	-2,134	31,370	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	50%	17,493	8,747	20,580	10,290	0,000	2,050	37,225	2,546	IMO A.749(18)
MGO Nº2	50%	17,493	8,747	20,580	10,290	0,000	-2,050	37,225	2,546	IMO A.749(18)
Agua Potable	50%	10,161	5,080	10,161	5,080	-2,900	0,000	37,000	1,697	IMO A.749(18)
Aguas Grises	40%	2,260	0,904	2,205	0,882	3,600	0,150	36,780	1,295	IMO A.749(18)
Correccion Corrimiento Pienso(-	-1	2,027	-2,027			-1,820	2,250	49,150	0,000	User Specified
Correccion Corrimiento Pienso(+	1	2,027	2,027			1,820	2,250	49,150	0,000	User Specified
Total Loadcase			10199,438	4353,069	4317,397	-0,026	0,035	12,143	8,083	
FS correction								0,001		
VCG fluid								12,144		



GZ = 12,558 m   Heel to Starboard = 75,000 deg.   Area (from zero heel) = 492 m. 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	70,0	80,0	90,0
GZ m	-5,570	-3,777	-1,913	-0,035	1,844	3,711	5,509	7,232	8,780	10,114	11,814	13,506	16,270
Area under GZ curve from zero heel m.deg	85,0109	38,2348	9,7418	0,0000	9,0425	36,8513	83,0093	146,7881	227,1092	321,4220	431,0535	556,9746	705,9628
Displacement t	10199	10199	10199	10199	10199	10199	10199	10199	10199	10199	10199	10199	10199
Draft at FP m	42,359	41,776	41,553	41,553	41,553	41,775	42,361	43,455	44,834	46,587	49,591	59,534	n/a
Draft at AP m	42,359	41,776	41,553	41,553	41,553	41,775	42,361	43,455	44,834	46,587	49,591	59,534	n/a
WL Length m	21,706	21,814	10,000	10,000	10,000	21,816	21,708	41,966	47,430	50,242	51,998	53,017	52,729
Beam max extents on WL m	23,614	22,365	10,154	10,000	10,154	22,362	23,613	29,698	25,360	31,297	38,954	59,694	61,600
Wetted Area m^2	4318,400	4359,160	4441,732	4324,523	4441,587	4359,305	4317,832	4221,819	4103,205	3985,085	3890,443	3759,000	3599,513
Waterpl. Area m^2	112,785	88,010	77,205	76,032	77,205	88,011	112,768	143,027	176,297	288,097	484,894	538,938	598,216
Prismatic coeff. (Cp)	0,368	0,372	0,373	0,373	0,373	0,372	0,368	0,360	0,351	0,338	0,316	0,297	0,285
Block coeff. (Cb)	0,184	0,190	0,419	0,437	0,419	0,190	0,185	0,154	0,196	0,173	0,141	0,096	0,092
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	17,532	17,802	16,957	15,378	13,138	10,277	7,038	3,579	0,035
Area under GZ curve from zero heel m.deg	876,2983	1053,7350	1228,3560	1390,5496	1533,6918	1651,1863	1737,9966	1791,2068	1809,3056
Displacement t	10199	10199	10199	10198	10200	10199	10200	10199	10199
Draft at FP m	4,317	-7,374	-9,295	-9,254	-8,672	-7,907	-7,220	-6,641	-6,305
Draft at AP m	4,317	-7,374	-9,295	-9,254	-8,672	-7,907	-7,220	-6,641	-6,305
WL Length m	49,985	47,605	40,642	20,000	19,299	19,419	19,692	19,966	20,000
Beam max extents on WL m	44,175	43,195	41,644	39,452	36,405	30,093	23,563	16,815	20,000
Wetted Area m^2	3898,432	4062,127	4388,762	4483,677	4583,142	4645,538	4650,166	4662,356	4660,443
Waterpl. Area m^2	509,635	460,205	270,418	276,615	218,748	196,092	186,794	194,018	309,154
Prismatic coeff. (Cp)	0,292	0,306	0,312	0,315	0,315	0,314	0,313	0,312	0,312
Block coeff. (Cb)	0,122	0,119	0,119	0,111	0,106	0,117	0,141	0,193	0,164
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	-0,009	0,031	0,000	0,000	0,000	0,000	0,000	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Dynamic stability (GZ area) = 492,000 m.deg Heel to Starboard = 75,000 deg. Area (from zero heel) = 1,261E+004 m.deg. deg.

Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = -27,4 m)		0	n/a
Deck Edge (immersion pos = -27,4 m)		0	n/a
DF point	Downflooding point	80,7	0
DF point	Downflooding point	80	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	80,0	Pass	+14,22
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	88,1527	Pass	+5395,80
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	167,9188	m.deg	370,4900	Pass	+120,64
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	66,59	Pass	+121,97
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	488,31	Pass	+275,62
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	88,56	Pass	+121,40
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	13,58	Pass	+77,37
	Area 1 shall not be less than (>=)	5,1600	m.deg	492,7362	Pass	+9449,15
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

EQUILIBRIO CONDICIÓN DE CARGA Nº4

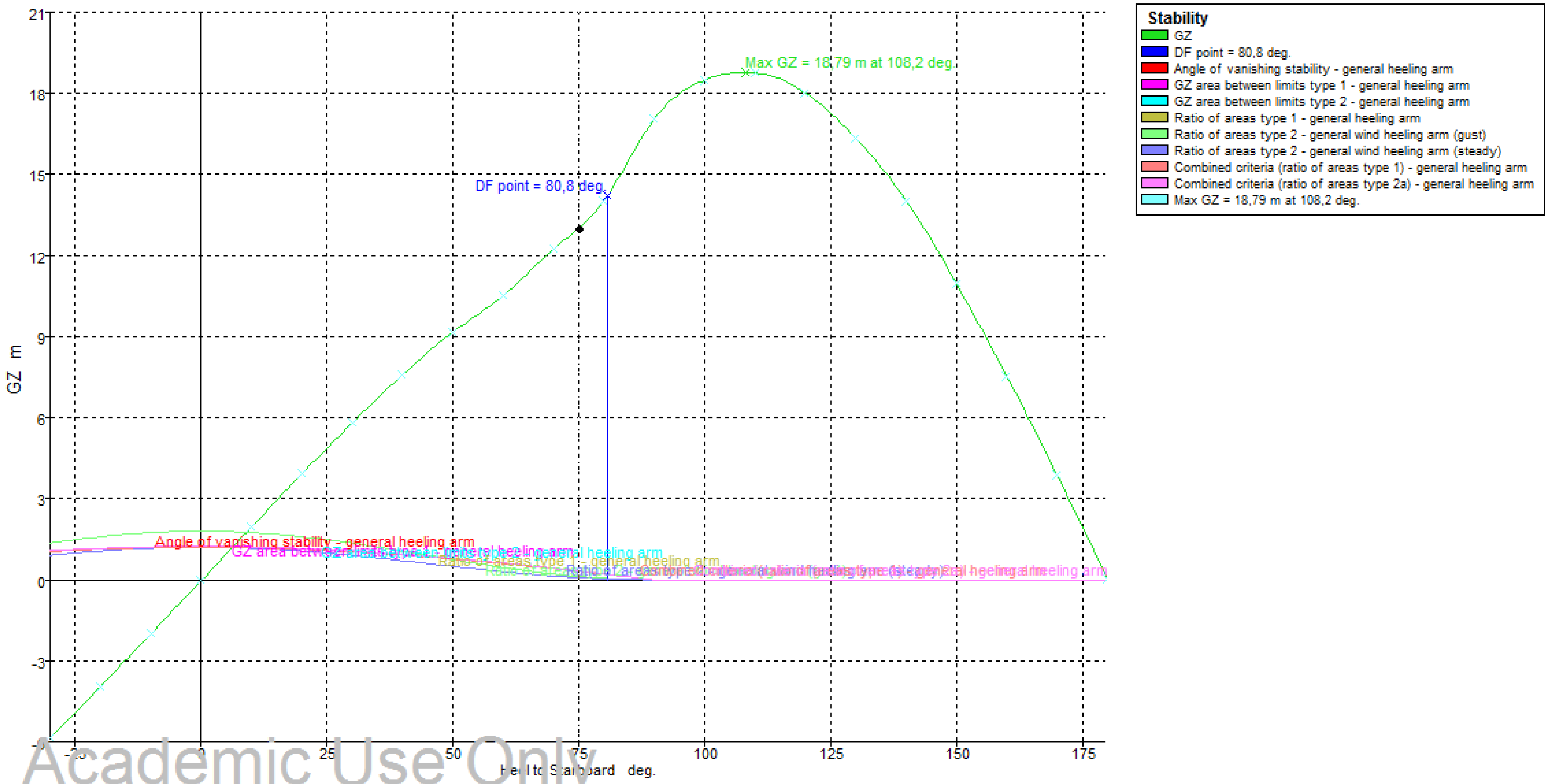
Draft Amidships m	38,846
Displacement t	9989
Heel deg	0,2
Draft at FP m	38,824
Draft at AP m	38,868
Draft at LCF m	38,846
Trim (+ve by stern) m	0,044
WL Length m	10
Beam max extents on WL m	10
Wetted Area m^2	4387,516
Waterpl. Area m^2	76,033
Prismatic coeff. (Cp)	0,387
Block coeff. (Cb)	0,458
Max Sect. area coeff. (Cm)	1,181
Waterpl. area coeff. (Cwp)	0,139
LCB from zero pt. (+ve fwd) m	0
LCF from zero pt. (+ve fwd) m	0

KB m	22,549
KG fluid m	11,378
BMt m	0,049
BML m	0,047
GMt corrected m	11,22
GML m	11,218
KMt m	22,598
KML m	22,596
Immersion (TPc) tonne/cm	0,779
MTc tonne.m	20,447
RM at 1deg = GMt.Disp.sin(1) tonne.m	1955,903
Max deck inclination deg	0,1576
Trim angle (+ve by stern) deg	0,0455

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA N4

Loadcase - Condición de Carga N.4
Damage Case - Intact
Fixed Trim = 0 m (+ve by stern)
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

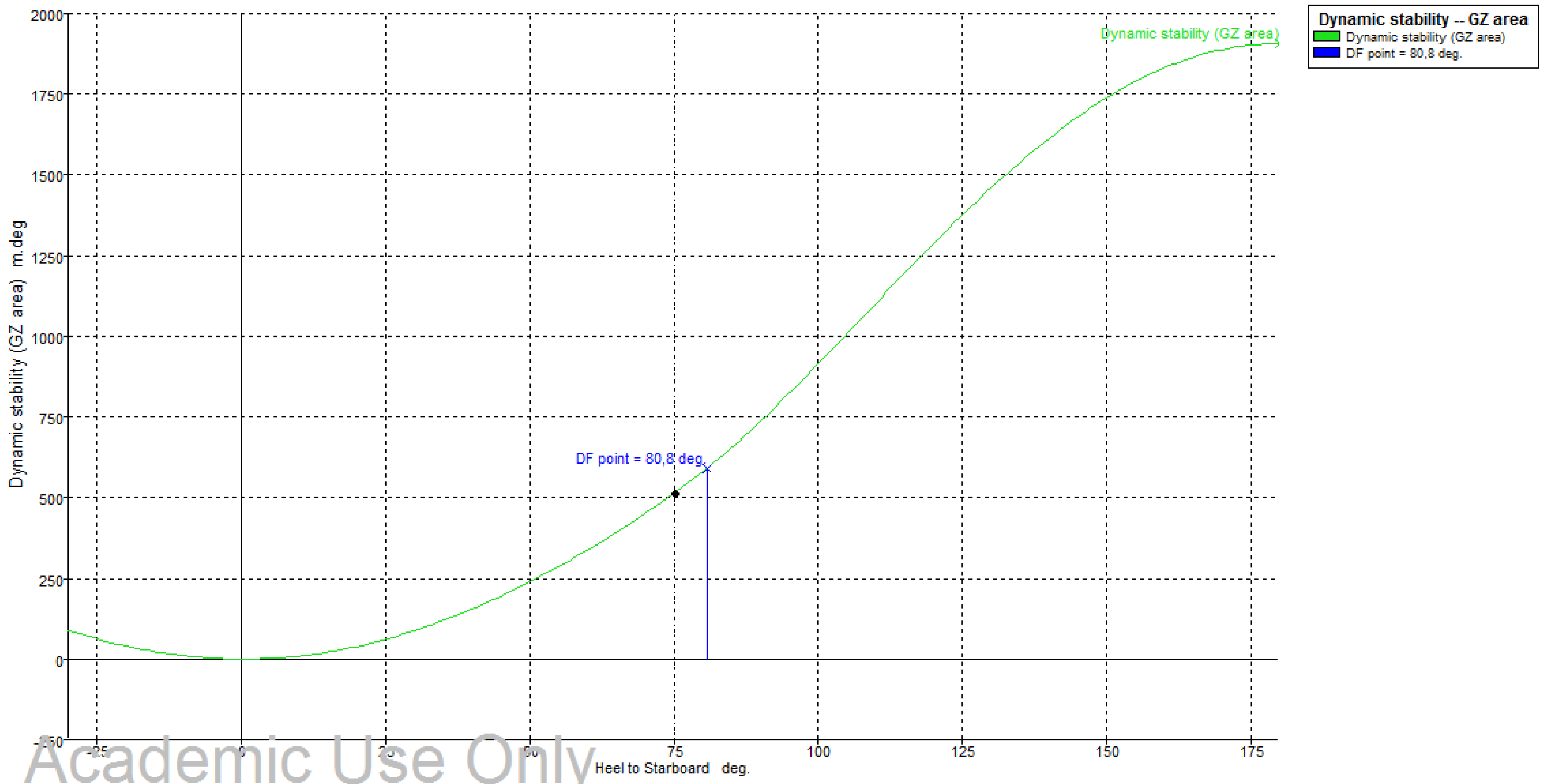
Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	1210,080	1210,080			0,030	0,040	27,890	0,000	User Specified
Peso Pienso Ø6mm	0,5	253,630	126,815			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	0	134,360	0,000			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	0	36,690	0,000			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5891,055	5891,055	2031,398	2031,398	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	662,085	662,085	228,305	228,305	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	100%	184,681	184,681	180,176	180,176	-2,130	2,134	31,370	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	100%	184,681	184,681	180,176	180,176	-2,130	-2,134	31,370	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	10%	17,493	1,749	20,580	2,058	0,000	2,050	36,725	2,546	IMO A.749(18)
MGO Nº2	10%	17,493	1,749	20,580	2,058	0,000	-2,050	36,725	2,546	IMO A.749(18)
Agua Potable	10%	10,161	1,016	10,161	1,016	-2,900	0,000	36,680	1,697	IMO A.749(18)
Aguas Grises	90%	2,260	2,034	2,205	1,985	3,600	0,150	37,005	1,295	IMO A.749(18)
Correccion Corrimiento Pienso(-	-1	4,628	-4,628			-2,580	1,960	49,970	0,000	User Specified
Correccion Corrimiento Pienso(+	1	4,628	4,628			2,580	1,960	49,970	0,000	User Specified
Total Loadcase			9988,514	4353,069	4297,971	-0,009	0,031	11,377	8,083	
FS correction								0,001		
VCG fluid								11,378		



GZ = 13,010 m Heel to Starboard = 75,000 deg. Area (from zero heel) = 513,8 m. 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	70,0	80,0	90,0
GZ m	-5,854	-3,968	-2,004	-0,031	1,944	3,911	5,801	7,595	9,160	10,517	12,246	14,017	17,043
Area under GZ curve from zero heel m.deg	89,2394	40,0754	10,1688	0,0000	9,5602	38,8691	87,4987	154,5926	238,6542	336,8714	450,6746	581,1812	736,5058
Displacement t	9988	9989	9989	9989	9989	9988	9988	9988	9988	9988	9988	9988	9988
Draft at FP m	40,388	39,504	38,978	38,846	38,974	39,495	40,387	41,697	43,190	45,228	48,367	57,409	n/a
Draft at AP m	40,388	39,504	38,978	38,846	38,974	39,495	40,387	41,697	43,190	45,228	48,367	57,409	n/a
WL Length m	44,780	21,781	18,415	10,000	18,453	21,767	44,783	48,101	49,947	51,383	52,460	53,326	53,085
Beam max extents on WL m	36,027	22,426	28,171	10,000	28,147	22,429	36,027	27,314	24,473	31,297	38,954	61,852	61,600
Wetted Area m^2	4188,993	4265,753	4339,057	4270,393	4338,688	4265,686	4190,414	4048,013	3954,161	3851,169	3802,383	3680,974	3552,531
Waterpl. Area m^2	135,252	105,265	88,195	76,032	88,111	105,346	135,274	170,129	216,819	318,322	500,246	575,717	601,123
Prismatic coeff. (Cp)	0,375	0,382	0,387	0,387	0,387	0,382	0,375	0,366	0,355	0,341	0,316	0,297	0,288
Block coeff. (Cb)	0,123	0,196	0,157	0,458	0,158	0,196	0,123	0,170	0,205	0,173	0,140	0,091	0,091
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	18,492	18,769	18,022	16,335	14,030	10,987	7,548	3,863	0,031
Area under GZ curve from zero heel m.deg	915,6868	1102,7576	1287,5895	1459,9823	1612,3713	1737,9655	1830,8701	1888,0929	1907,6268
Displacement t	9988	9988	9988	9988	9989	9989	9989	9988	9989
Draft at FP m	2,049	-8,628	-10,734	-10,442	-9,968	-9,212	-8,547	-8,069	-8,048
Draft at AP m	2,049	-8,628	-10,734	-10,442	-9,968	-9,212	-8,547	-8,069	-8,048
WL Length m	50,634	48,346	43,667	20,903	19,684	17,737	16,893	11,160	10,000
Beam max extents on WL m	44,245	43,351	42,060	40,093	35,572	29,441	23,110	16,567	10,000
Wetted Area m^2	3823,567	3971,848	4262,052	4419,847	4516,588	4577,623	4561,407	4510,288	4380,234
Waterpl. Area m^2	535,839	495,725	303,685	278,680	198,653	166,212	139,819	89,934	76,032
Prismatic coeff. (Cp)	0,290	0,305	0,314	0,317	0,319	0,318	0,317	0,316	0,316
Block coeff. (Cb)	0,120	0,118	0,118	0,109	0,109	0,120	0,144	0,197	0,332
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	-0,001	-0,007	0,000	0,000	0,000	0,000	0,000	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Dynamic stability (GZ area) = 513,824 m.deg Heel to Starboard = 75,000 deg. Area (from zero heel) = 1,322E+004 m.deg. deg.

Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = -27,4 m)		0	n/a
Deck Edge (immersion pos = -27,4 m)		0	n/a
DF point	Downflooding point	81,5	0
DF point	Downflooding point	80,8	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	80,8	Pass	+15,38
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	92,4905	Pass	+5666,24
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	178,6089	m.deg	389,8919	Pass	+118,29
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	65,86	Pass	+119,53
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	495,17	Pass	+280,90
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	89,18	Pass	+122,95
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	13,02	Pass	+78,30
	Area 1 shall not be less than (>=)	5,1600	m.deg	527,9887	Pass	+10132,34
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

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DRAFT AMIDSHIPS (m)	**0**	**0,518**	**1,035**	**1,553**	**2,071**	**2,588**	**3,106**	**3,624**	**4,141**	**4,659**	**5,176**
Displacement t	0	159,1	321,1	483,5	646,1	809,1	972,2	1136	1299	1463	1628
Heel deg	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	0	0,518	1,035	1,553	2,071	2,588	3,106	3,624	4,141	4,659	5,176
Draft at AP m	0	0,518	1,035	1,553	2,071	2,588	3,106	3,624	4,141	4,659	5,176
Draft at LCF m	0	0,518	1,035	1,553	2,071	2,588	3,106	3,624	4,141	4,659	5,176
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0
WL Length m	0	20	20	20	20	20	20	20	20	20	20
Beam max extents on WL m	0	20	20	20	20	20	20	20	20	20	20
Wetted Area m^2	0	330,419	356,545	382,54	408,403	434,13	459,722	485,175	510,489	535,66	560,689
Waterpl. Area m^2	0	304,888	305,171	305,45	305,723	305,991	306,255	306,512	306,765	307,013	307,255
Prismatic coeff. (Cp)	0	0,309	0,309	0,309	0,309	0,31	0,31	0,31	0,31	0,311	0,311
Block coeff. (Cb)	0	0,309	0,309	0,309	0,309	0,31	0,31	0,31	0,31	0,311	0,311
Max Sect. area coeff. (Cm)	0	1	1	1	1	1	1	1	1	1	1
Waterpl. area coeff. (Cwp)	0	0,309	0,309	0,309	0,309	0,31	0,31	0,31	0,31	0,311	0,311
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
KB m	0	0,263	0,522	0,781	1,04	1,298	1,557	1,816	2,075	2,334	2,593
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	0	49,503	24,522	16,289	12,19	9,736	8,102	6,936	6,063	5,383	4,84
BML m	0	46,467	23,097	15,394	11,559	9,262	7,733	6,642	5,824	5,187	4,678
GMt m	-28,52	21,246	-3,476	-11,45	-15,291	-17,486	-18,861	-19,768	-20,383	-20,803	-21,087
GML m	-28,52	18,21	-4,901	-12,345	-15,921	-17,959	-19,23	-20,062	-20,622	-20,999	-21,249
KMt m	0	49,766	25,044	17,07	13,229	11,034	9,659	8,752	8,137	7,717	7,433
KML m	0	46,73	23,619	16,175	12,599	10,561	9,29	8,458	7,898	7,521	7,271
Immersion (TPc) tonne/cm	0	3,125	3,128	3,131	3,134	3,136	3,139	3,142	3,144	3,147	3,149
MTc tonne.m	0	0,586	-0,319	-1,208	-2,082	-2,941	-3,785	-4,612	-5,424	-6,22	-7,001
RM at 1deg = GMt.Disp.sin(1) tonne.m	0	58,978	-19,481	-96,619	-172,429	-246,902	-320,032	-391,809	-462,228	-531,281	-598,96
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	**5,694**	**6,212**	**6,729**	**7,247**	**7,765**	**8,282**	**8,800**	**9,318**	**9,835**	**10,353**	**10,871**
Displacement t	1792	1957	2093	2138	2182	2226	2270	2315	2359	2403	2447
Heel deg	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	5,694	6,212	6,729	7,247	7,765	8,282	8,8	9,318	9,835	10,353	10,871
Draft at AP m	5,694	6,212	6,729	7,247	7,765	8,282	8,8	9,318	9,835	10,353	10,871
Draft at LCF m	5,694	6,212	6,729	7,247	7,765	8,282	8,8	9,318	9,835	10,353	10,871
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0
WL Length m	20	20	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	20	20	10	10	10	10	10	10	10	10	10
Wetted Area m^2	585,572	610,308	858,749	869,149	879,53	889,894	900,239	910,565	920,872	931,161	941,431
Waterpl. Area m^2	307,491	307,723	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75
Prismatic coeff. (Cp)	0,311	0,311	0,31	0,305	0,3	0,296	0,291	0,287	0,284	0,28	0,277
Block coeff. (Cb)	0,311	0,311	0,615	0,583	0,556	0,531	0,51	0,491	0,474	0,459	0,445
Max Sect. area coeff. (Cm)	1	1	1,982	1,912	1,851	1,798	1,751	1,709	1,672	1,638	1,608
Waterpl. area coeff. (Cwp)	0,311	0,311	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
KB m	2,851	3,11	3,325	3,398	3,479	3,566	3,66	3,76	3,865	3,976	4,092
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	4,397	4,027	0,24	0,235	0,23	0,226	0,221	0,217	0,213	0,209	0,205
BML m	4,262	3,915	0,287	0,281	0,275	0,27	0,265	0,259	0,255	0,25	0,245
GMt m	-21,272	-21,383	-24,955	-24,887	-24,811	-24,728	-24,639	-24,543	-24,442	-24,335	-24,223
GML m	-21,407	-21,495	-24,908	-24,841	-24,766	-24,684	-24,596	-24,501	-24,4	-24,294	-24,183
KMt m	7,248	7,137	3,565	3,633	3,709	3,792	3,881	3,977	4,078	4,185	4,297
KML m	7,113	7,025	3,612	3,679	3,754	3,836	3,924	4,019	4,12	4,226	4,337
Immersion (TPc) tonne/cm	3,152	3,154	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828
MTc tonne.m	-7,765	-8,513	-10,555	-10,749	-10,939	-11,124	-11,304	-11,48	-11,651	-11,817	-11,978
RM at 1deg = GMt.Disp.sin(1) tonne.m	-665,253	-730,154	-911,675	-928,432	-944,785	-960,734	-976,28	-991,422	-1006,16	-1020,494	-1034,424
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	**11,388**	**11,906**	**12,424**	**12,941**	**13,459**	**13,976**	**14,494**	**15,012**	**15,529**	**16,047**	**16,565**
Displacement t	2491	2535	2579	2623	2667	2710	2754	2798	2842	2885	2929
Heel deg	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	11,388	11,906	12,424	12,941	13,459	13,976	14,494	15,012	15,529	16,047	16,565
Draft at AP m	11,388	11,906	12,424	12,941	13,459	13,976	14,494	15,012	15,529	16,047	16,565
Draft at LCF m	11,388	11,906	12,424	12,941	13,459	13,976	14,494	15,012	15,529	16,047	16,565
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	951,682	961,914	972,127	982,321	992,496	1002,652	1012,788	1022,904	1033,002	1043,079	1053,137
Waterpl. Area m^2	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75
Prismatic coeff. (Cp)	0,274	0,271	0,268	0,265	0,263	0,26	0,258	0,256	0,254	0,252	0,25
Block coeff. (Cb)	0,432	0,421	0,41	0,401	0,392	0,383	0,376	0,368	0,362	0,355	0,349
Max Sect. area coeff. (Cm)	1,58	1,555	1,532	1,51	1,491	1,473	1,456	1,44	1,425	1,412	1,399
Waterpl. area coeff. (Cwp)	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
KB m	4,212	4,338	4,467	4,601	4,739	4,88	5,025	5,173	5,325	5,48	5,638
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	0,202	0,198	0,195	0,192	0,188	0,185	0,183	0,18	0,177	0,174	0,172
BML m	0,241	0,237	0,233	0,229	0,225	0,222	0,218	0,215	0,211	0,208	0,205
GMt m	-24,106	-23,984	-23,858	-23,727	-23,593	-23,455	-23,313	-23,167	-23,018	-22,866	-22,711
GML m	-24,067	-23,946	-23,82	-23,69	-23,556	-23,418	-23,277	-23,132	-22,984	-22,832	-22,677
KMt m	4,414	4,536	4,662	4,793	4,927	5,065	5,207	5,353	5,502	5,654	5,809
KML m	4,453	4,574	4,7	4,83	4,964	5,102	5,243	5,388	5,536	5,688	5,843
Immersion (TPc) tonne/cm	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828
MTc tonne.m	-12,135	-12,287	-12,435	-12,578	-12,716	-12,849	-12,978	-13,102	-13,221	-13,336	-13,446
RM at 1deg = GMt.Disp.sin(1) tonne.m	-1047,95	-1061,071	-1073,787	-1086,099	-1098,007	-1109,509	-1120,606	-1131,299	-1141,586	-1151,467	-1160,944
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	17,082	17,600	18,118	18,635	19,153	19,671	20,188	20,706	21,224	21,741	22,259
Displacement t	2973	3016	3060	3103	3147	3190	3233	3276	3320	3363	3406
Heel deg	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	17,082	17,6	18,118	18,635	19,153	19,671	20,188	20,706	21,224	21,741	22,259
Draft at AP m	17,082	17,6	18,118	18,635	19,153	19,671	20,188	20,706	21,224	21,741	22,259
Draft at LCF m	17,082	17,6	18,118	18,635	19,153	19,671	20,188	20,706	21,224	21,741	22,259
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	1063,175	1073,194	1083,192	1093,17	1103,129	1113,067	1122,985	1132,883	1142,76	1152,617	1162,453
Waterpl. Area m^2	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75
Prismatic coeff. (Cp)	0,248	0,246	0,245	0,243	0,241	0,24	0,238	0,237	0,236	0,234	0,233
Block coeff. (Cb)	0,344	0,339	0,334	0,329	0,325	0,32	0,316	0,313	0,309	0,306	0,302
Max Sect. area coeff. (Cm)	1,387	1,375	1,364	1,354	1,345	1,336	1,327	1,319	1,311	1,304	1,297
Waterpl. area coeff. (Cwp)	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
KB m	5,798	5,962	6,128	6,296	6,467	6,641	6,816	6,994	7,174	7,356	7,54
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	0,169	0,167	0,164	0,162	0,16	0,158	0,155	0,153	0,151	0,149	0,148
BML m	0,202	0,199	0,196	0,194	0,191	0,188	0,186	0,183	0,181	0,179	0,176
GMt m	-22,553	-22,392	-22,228	-22,062	-21,893	-21,722	-21,548	-21,373	-21,195	-21,015	-20,833
GML m	-22,52	-22,359	-22,196	-22,03	-21,862	-21,691	-21,518	-21,343	-21,165	-20,986	-20,804
KMt m	5,967	6,128	6,292	6,458	6,627	6,798	6,972	7,147	7,325	7,505	7,687
KML m	6	6,161	6,324	6,49	6,658	6,829	7,002	7,177	7,355	7,534	7,716
Immersion (TPc) tonne/cm	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828
MTc tonne.m	-13,551	-13,652	-13,747	-13,838	-13,925	-14,007	-14,084	-14,156	-14,223	-14,286	-14,344
RM at 1deg = GMt.Disp.sin(1) tonne.m	-1170,015	-1178,68	-1186,939	-1194,792	-1202,24	-1209,281	-1215,916	-1222,144	-1227,966	-1233,382	-1238,391
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	22,776	23,294	23,812	24,329	24,847	25,365	25,882	26,400	26,918	27,435	27,953
Displacement t	3449	3492	3535	3578	3621	3664	3707	3750	3793	3837	3880
Heel deg	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	22,776	23,294	23,812	24,329	24,847	25,365	25,882	26,4	26,918	27,435	27,953
Draft at AP m	22,776	23,294	23,812	24,329	24,847	25,365	25,882	26,4	26,918	27,435	27,953
Draft at LCF m	22,776	23,294	23,812	24,329	24,847	25,365	25,882	26,4	26,918	27,435	27,953
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	1172,269	1182,064	1191,839	1201,592	1211,325	1221,036	1230,727	1240,396	1250,691	1262,102	1273,499
Waterpl. Area m^2	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75
Prismatic coeff. (Cp)	0,232	0,231	0,23	0,229	0,227	0,226	0,225	0,224	0,224	0,223	0,222
Block coeff. (Cb)	0,299	0,296	0,293	0,291	0,288	0,285	0,283	0,281	0,278	0,276	0,274
Max Sect. area coeff. (Cm)	1,29	1,283	1,277	1,271	1,266	1,26	1,255	1,25	1,245	1,241	1,236
Waterpl. area coeff. (Cwp)	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
KB m	7,725	7,913	8,102	8,293	8,486	8,68	8,876	9,074	9,272	9,47	9,67
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	0,146	0,144	0,142	0,14	0,139	0,137	0,136	0,134	0,133	0,131	0,13
BML m	0,174	0,172	0,17	0,168	0,166	0,164	0,162	0,16	0,158	0,157	0,155
GMt m	-20,649	-20,463	-20,276	-20,086	-19,895	-19,703	-19,508	-19,312	-19,116	-18,919	-18,721
GML m	-20,621	-20,435	-20,248	-20,059	-19,868	-19,676	-19,482	-19,286	-19,09	-18,893	-18,695
KMt m	7,871	8,057	8,244	8,434	8,625	8,817	9,012	9,208	9,404	9,601	9,799
KML m	7,899	8,085	8,272	8,461	8,652	8,844	9,038	9,234	9,43	9,627	9,825
Immersion (TPc) tonne/cm	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828
MTc tonne.m	-14,398	-14,446	-14,49	-14,529	-14,564	-14,594	-14,619	-14,639	-14,657	-14,673	-14,685
RM at 1deg = GMt.Disp.sin(1) tonne.m	-1242,992	-1247,187	-1250,975	-1254,356	-1257,329	-1259,895	-1262,054	-1263,804	-1265,325	-1266,763	-1267,813
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	**28,471**	**28,988**	**29,506**	**30,024**	**30,541**	**31,059**	**31,576**	**32,094**	**32,612**	**33,129**	**33,647**
Displacement t	3924	3968	4012	4056	4100	4143	4187	4231	4275	4319	4363
Heel deg	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	28,471	28,988	29,506	30,024	30,541	31,059	31,576	32,094	32,612	33,129	33,647
Draft at AP m	28,471	28,988	29,506	30,024	30,541	31,059	31,576	32,094	32,612	33,129	33,647
Draft at LCF m	28,471	28,988	29,506	30,024	30,541	31,059	31,576	32,094	32,612	33,129	33,647
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	1284,881	1296,25	1307,604	1318,944	1330,27	1341,581	1352,877	1364,159	1375,426	1386,678	1397,915
Waterpl. Area m^2	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75
Prismatic coeff. (Cp)	0,221	0,22	0,219	0,219	0,218	0,217	0,217	0,216	0,215	0,215	0,214
Block coeff. (Cb)	0,272	0,27	0,269	0,267	0,265	0,264	0,262	0,26	0,259	0,258	0,256
Max Sect. area coeff. (Cm)	1,232	1,228	1,224	1,22	1,216	1,213	1,209	1,206	1,202	1,199	1,196
Waterpl. area coeff. (Cwp)	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
KB m	9,871	10,073	10,276	10,48	10,685	10,891	11,099	11,307	11,516	11,726	11,937
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	0,128	0,127	0,125	0,124	0,123	0,121	0,12	0,119	0,118	0,116	0,115
BML m	0,153	0,151	0,15	0,148	0,146	0,145	0,143	0,142	0,14	0,139	0,138
GMt m	-18,521	-18,321	-18,119	-17,916	-17,712	-17,507	-17,301	-17,094	-16,886	-16,678	-16,468
GML m	-18,496	-18,296	-18,095	-17,892	-17,688	-17,484	-17,278	-17,071	-16,864	-16,655	-16,446
KMt m	9,999	10,199	10,401	10,604	10,808	11,013	11,219	11,426	11,634	11,842	12,052
KML m	10,024	10,224	10,425	10,628	10,832	11,036	11,242	11,449	11,656	11,865	12,074
Immersion (TPc) tonne/cm	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828
MTc tonne.m	-14,693	-14,696	-14,695	-14,689	-14,679	-14,664	-14,645	-14,621	-14,593	-14,56	-14,523
RM at 1deg = GMt.Disp.sin(1) tonne.m	-1268,477	-1268,753	-1268,642	-1268,145	-1267,26	-1265,988	-1264,329	-1262,283	-1259,85	-1257,03	-1253,823
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0

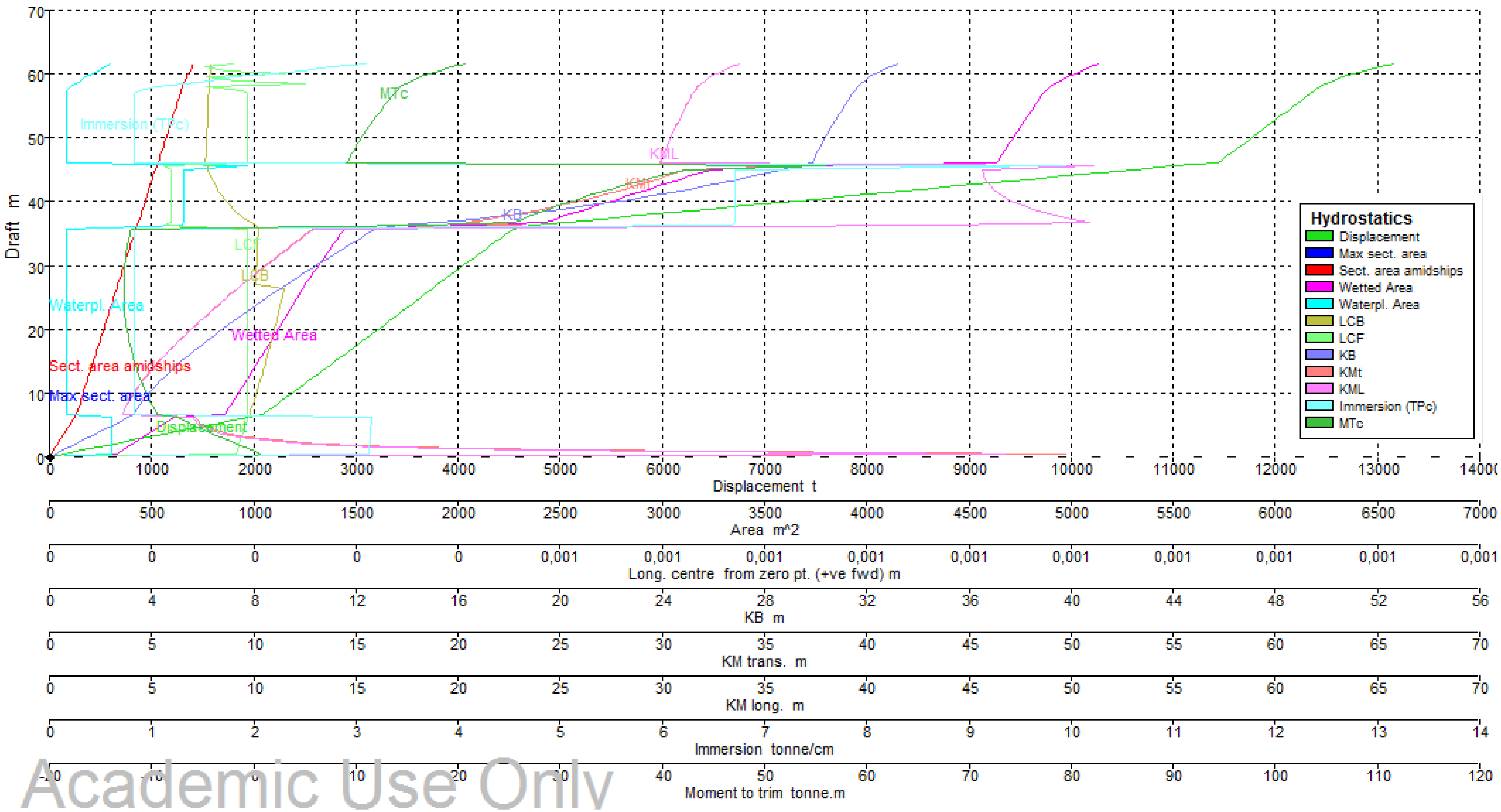
DRAFT AMIDSHIPS (m)	34,165	34,682	35,200	35,718	36,235	36,753	37,271	37,788	38,306	38,824	39,341
Displacement t	4406	4450	4494	4538	4717	5064	5411	5759	6106	6454	6801
Heel deg	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	34,165	34,682	35,2	35,718	36,235	36,753	37,271	37,788	38,306	38,824	39,341
Draft at AP m	34,165	34,682	35,2	35,718	36,235	36,753	37,271	37,788	38,306	38,824	39,341
Draft at LCF m	34,165	34,682	35,2	35,718	36,235	36,753	37,271	37,788	38,306	38,824	39,341
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	52,4	52,4	52,4	52,4	52,4	52,4	52,4
Beam max extents on WL m	10	10	10	10	52,4	38,613	38,613	38,613	38,613	38,613	38,613
Wetted Area m^2	1409,137	1420,344	1431,536	1442,713	2063,695	2426,366	2476,998	2527,63	2578,262	2628,895	2679,527
Waterpl. Area m^2	80,75	80,75	80,75	80,75	652,171	654,918	654,918	654,918	654,918	654,918	654,918
Prismatic coeff. (Cp)	0,214	0,213	0,212	0,212	0,217	0,229	0,242	0,255	0,267	0,279	0,291
Block coeff. (Cb)	0,255	0,253	0,252	0,251	0,049	0,07	0,074	0,078	0,082	0,085	0,088
Max Sect. area coeff. (Cm)	1,193	1,19	1,188	1,185	0,226	1,186	1,184	1,181	1,179	1,176	1,174
Waterpl. area coeff. (Cwp)	0,163	0,163	0,163	0,163	0,252	0,343	0,343	0,343	0,343	0,343	0,343
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
KB m	12,148	12,361	12,574	12,788	13,667	15,232	16,631	17,892	19,039	20,09	21,06
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	0,114	0,113	0,112	0,111	9,468	5,193	4,86	4,566	4,306	4,075	3,866
BML m	0,136	0,135	0,134	0,132	29,995	35,681	33,39	31,375	29,589	27,996	26,566
GMt m	-16,257	-16,046	-15,834	-15,621	-5,385	-8,095	-7,03	-6,062	-5,175	-4,355	-3,593
GML m	-16,235	-16,024	-15,812	-15,599	15,142	22,393	21,5	20,747	20,108	19,566	19,106
KMt m	12,263	12,474	12,686	12,899	23,135	20,425	21,49	22,458	23,345	24,165	24,927
KML m	12,285	12,496	12,708	12,921	43,662	50,913	50,02	49,267	48,628	48,086	47,626
Immersion (TPc) tonne/cm	0,828	0,828	0,828	0,828	6,685	6,713	6,713	6,713	6,713	6,713	6,713
MTc tonne.m	-14,481	-14,435	-14,385	-14,329	14,457	22,954	23,551	24,185	24,855	25,562	26,304
RM at 1deg = GMt.Disp.sin(1) tonne.m	-1250,228	-1246,247	-1241,879	-1237,123	-443,301	-715,385	-663,886	-609,248	-551,47	-490,553	-426,497
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	39,859	40,376	40,894	41,412	41,929	42,447	42,965	43,482	44,000	44,518	45,035
Displacement t	7149	7496	7844	8191	8539	8886	9234	9581	9929	10276	10624
Heel deg	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	39,859	40,376	40,894	41,412	41,929	42,447	42,965	43,482	44	44,518	45,035
Draft at AP m	39,859	40,376	40,894	41,412	41,929	42,447	42,965	43,482	44	44,518	45,035
Draft at LCF m	39,859	40,376	40,894	41,412	41,929	42,447	42,965	43,482	44	44,518	45,035
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0
WL Length m	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4	52,4
Beam max extents on WL m	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613	38,613
Wetted Area m^2	2730,159	2780,791	2831,423	2882,056	2932,688	2983,32	3033,952	3084,584	3135,217	3185,849	3236,481
Waterpl. Area m^2	654,918	654,918	654,918	654,918	654,918	654,918	654,918	654,918	654,918	654,918	654,918
Prismatic coeff. (Cp)	0,302	0,314	0,325	0,335	0,346	0,356	0,366	0,376	0,386	0,395	0,405
Block coeff. (Cb)	0,092	0,095	0,098	0,101	0,104	0,107	0,11	0,113	0,115	0,118	0,121
Max Sect. area coeff. (Cm)	1,172	1,169	1,167	1,165	1,163	1,161	1,159	1,157	1,155	1,154	1,152
Waterpl. area coeff. (Cwp)	0,343	0,343	0,343	0,343	0,343	0,343	0,343	0,343	0,343	0,343	0,343
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
KB m	21,962	22,803	23,593	24,338	25,044	25,714	26,354	26,965	27,553	28,117	28,662
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	3,678	3,508	3,352	3,21	3,08	2,959	2,848	2,745	2,648	2,559	2,475
BML m	25,274	24,103	23,035	22,058	21,16	20,333	19,567	18,858	18,198	17,582	17,007
GMt m	-2,88	-2,209	-1,574	-0,971	-0,397	0,153	0,681	1,19	1,681	2,156	2,618
GML m	18,716	18,386	18,108	17,876	17,684	17,527	17,401	17,303	17,23	17,18	17,15
KMt m	25,64	26,311	26,946	27,549	28,123	28,673	29,201	29,71	30,201	30,676	31,138
KML m	47,236	46,906	46,628	46,396	46,204	46,047	45,921	45,823	45,75	45,7	45,67
Immersion (TPc) tonne/cm	6,713	6,713	6,713	6,713	6,713	6,713	6,713	6,713	6,713	6,713	6,713
MTc tonne.m	27,084	27,9	28,752	29,641	30,566	31,527	32,525	33,559	34,63	35,737	36,881
RM at 1deg = GMt.Disp.sin(1) tonne.m	-359,302	-288,967	-215,493	-138,879	-59,127	23,765	109,796	198,967	291,277	386,726	485,315
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	45,553	46,071	46,588	47,106	47,624	48,141	48,659	49,176	49,694	50,212	50,729
Displacement t	10987	11442	11484	11527	11570	11613	11656	11699	11741	11784	11827
Heel deg	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	45,553	46,071	46,588	47,106	47,624	48,141	48,659	49,176	49,694	50,212	50,729
Draft at AP m	45,553	46,071	46,588	47,106	47,624	48,141	48,659	49,176	49,694	50,212	50,729
Draft at LCF m	45,553	46,071	46,588	47,106	47,624	48,141	48,659	49,176	49,694	50,212	50,729
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0
WL Length m	54,8	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	54,8	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	3612,447	4635,025	4645,864	4656,704	4667,544	4678,383	4689,223	4700,062	4710,902	4721,742	4732,581
Waterpl. Area m^2	970,971	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75
Prismatic coeff. (Cp)	0,414	0,425	0,423	0,42	0,418	0,415	0,413	0,411	0,408	0,406	0,404
Block coeff. (Cb)	0,087	0,491	0,487	0,483	0,48	0,476	0,473	0,47	0,467	0,464	0,461
Max Sect. area coeff. (Cm)	0,21	1,154	1,152	1,15	1,149	1,147	1,146	1,144	1,142	1,141	1,14
Waterpl. area coeff. (Cwp)	0,359	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
KB m	29,213	29,871	29,932	29,995	30,06	30,125	30,193	30,261	30,331	30,402	30,475
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	7,769	0,044	0,044	0,044	0,043	0,043	0,043	0,043	0,043	0,043	0,043
BML m	21,934	0,052	0,052	0,052	0,052	0,052	0,052	0,051	0,051	0,051	0,051
GMt m	8,462	1,395	1,456	1,519	1,583	1,649	1,716	1,784	1,854	1,925	1,998
GML m	22,626	1,404	1,465	1,527	1,592	1,657	1,724	1,793	1,862	1,933	2,006
KMt m	36,982	29,915	29,976	30,039	30,103	30,169	30,236	30,304	30,374	30,445	30,518
KML m	51,146	29,924	29,985	30,047	30,112	30,177	30,244	30,313	30,382	30,453	30,526
Immersion (TPc) tonne/cm	9,952	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828
MTc tonne.m	50,322	3,251	3,405	3,564	3,728	3,896	4,068	4,245	4,426	4,612	4,803
RM at 1deg = GMt.Disp.sin(1) tonne.m	1622,511	278,56	291,877	305,581	319,672	334,151	349,016	364,268	379,908	395,934	412,348
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0

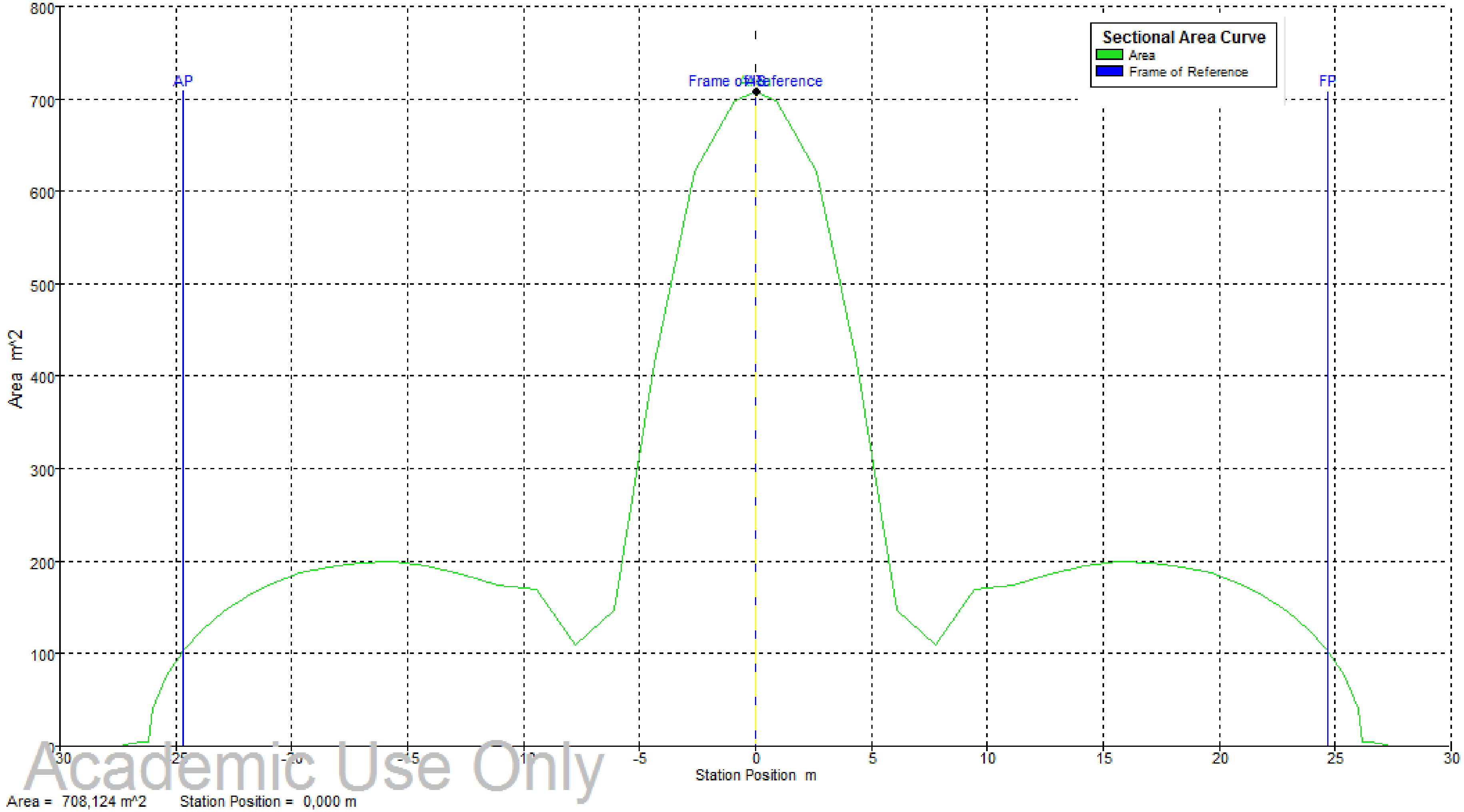
DRAFT AMIDSHIPS (m)	51,247	51,765	52,282	52,800	53,318	53,835	54,353	54,871	55,388	55,906	56,424
Displacement t	11870	11913	11956	11998	12041	12084	12127	12170	12213	12256	12298
Heel deg	0	0	0	0	0	0	0	0	0	0	0
Draft at FP m	51,247	51,765	52,282	52,8	53,318	53,835	54,353	54,871	55,388	55,906	56,424
Draft at AP m	51,247	51,765	52,282	52,8	53,318	53,835	54,353	54,871	55,388	55,906	56,424
Draft at LCF m	51,247	51,765	52,282	52,8	53,318	53,835	54,353	54,871	55,388	55,906	56,424
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10	10	10	10	10	10	10	10	10	10
Beam max extents on WL m	10	10	10	10	10	10	10	10	10	10	10
Wetted Area m^2	4743,421	4754,261	4765,1	4775,94	4786,78	4797,619	4808,459	4819,298	4830,138	4840,978	4851,817
Waterpl. Area m^2	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75	80,75
Prismatic coeff. (Cp)	0,402	0,4	0,398	0,396	0,394	0,392	0,39	0,388	0,386	0,384	0,383
Block coeff. (Cb)	0,458	0,455	0,452	0,449	0,446	0,443	0,441	0,438	0,436	0,433	0,431
Max Sect. area coeff. (Cm)	1,138	1,137	1,135	1,134	1,133	1,132	1,13	1,129	1,128	1,127	1,125
Waterpl. area coeff. (Cwp)	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163	0,163
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0	0
KB m	30,549	30,625	30,701	30,779	30,859	30,939	31,021	31,104	31,188	31,274	31,36
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	0,042	0,042	0,042	0,042	0,042	0,042	0,041	0,041	0,041	0,041	0,041
BML m	0,051	0,05	0,05	0,05	0,05	0,05	0,05	0,049	0,049	0,049	0,049
GMt m	2,072	2,147	2,223	2,301	2,38	2,461	2,542	2,625	2,709	2,795	2,881
GML m	2,08	2,155	2,232	2,309	2,388	2,469	2,55	2,633	2,717	2,803	2,889
KMt m	30,592	30,667	30,743	30,821	30,9	30,981	31,062	31,145	31,229	31,315	31,401
KML m	30,6	30,675	30,752	30,829	30,908	30,989	31,07	31,153	31,237	31,323	31,409
Immersion (TPc) tonne/cm	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828	0,828
MTc tonne.m	4,997	5,197	5,401	5,609	5,822	6,039	6,261	6,487	6,718	6,953	7,193
RM at 1deg = GMt.Disp.sin(1) tonne.m	429,148	446,336	463,911	481,873	500,222	518,958	538,081	557,591	577,488	597,773	618,444
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0	0

DRAFT AMIDSHIPS (m)	56,941	57,459	57,976	58,494	59,012	59,529	60,047	60,565	61,082	61,600
Displacement t	12341	12385	12434	12494	12570	12657	12759	12880	13016	13171
Heel deg	0	0	0	0	0	0	0	0	0	0
Draft at FP m	56,941	57,459	57,976	58,494	59,012	59,529	60,047	60,565	61,082	61,6
Draft at AP m	56,941	57,459	57,976	58,494	59,012	59,529	60,047	60,565	61,082	61,6
Draft at LCF m	56,941	57,459	57,976	58,494	59,012	59,529	60,047	60,565	61,082	61,6
Trim (+ve by stern) m	0	0	0	0	0	0	0	0	0	0
WL Length m	10	10,349	11,553	12,757	13,961	15,165	16,368	17,572	18,776	19,98
Beam max extents on WL m	10	10,349	11,553	12,757	13,961	15,164	16,368	17,572	18,776	19,98
Wetted Area m^2	4862,657	4876,509	4895,705	4926,632	4955,864	4982,125	5023,148	5058,685	5091,342	5142,625
Waterpl. Area m^2	80,75	85,961	101,685	128,917	153,88	175,627	211,755	241,888	268,899	304,076
Prismatic coeff. (Cp)	0,381	0,379	0,377	0,375	0,374	0,372	0,371	0,369	0,368	0,367
Block coeff. (Cb)	0,428	0,411	0,367	0,331	0,301	0,277	0,256	0,239	0,224	0,211
Max Sect. area coeff. (Cm)	1,124	1,085	0,972	0,881	0,806	0,744	0,692	0,647	0,609	0,575
Waterpl. area coeff. (Cwp)	0,163	0,168	0,178	0,205	0,223	0,234	0,262	0,279	0,29	0,308
LCB from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0
LCF from zero pt. (+ve fwd) m	0	0	0	0	0	0	0	0	0	0
KB m	31,448	31,538	31,643	31,771	31,933	32,122	32,343	32,605	32,899	33,235
KG m	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52	28,52
BMt m	0,041	0,047	0,072	0,105	0,151	0,208	0,279	0,368	0,473	0,595
BML m	0,049	0,054	0,068	0,118	0,162	0,196	0,303	0,381	0,444	0,558
GMt m	2,969	3,065	3,195	3,356	3,564	3,81	4,103	4,453	4,852	5,31
GML m	2,977	3,072	3,191	3,369	3,574	3,798	4,126	4,466	4,823	5,272
KMt m	31,489	31,585	31,715	31,876	32,084	32,33	32,623	32,973	33,372	33,83
KML m	31,497	31,592	31,711	31,889	32,094	32,318	32,646	32,986	33,343	33,792
Immersion (TPc) tonne/cm	0,828	0,881	1,042	1,321	1,577	1,8	2,17	2,479	2,756	3,117
MTc tonne.m	7,437	7,702	8,032	8,521	9,095	9,73	10,657	11,645	12,707	14,057
RM at 1deg = GMt.Disp.sin(1) tonne.m	639,502	662,472	693,297	731,801	781,728	841,659	913,557	1001,087	1102,217	1220,602
Max deck inclination deg	0	0	0	0	0	0	0	0	0	0
Trim angle (+ve by stern) deg	0	0	0	0	0	0	0	0	0	0

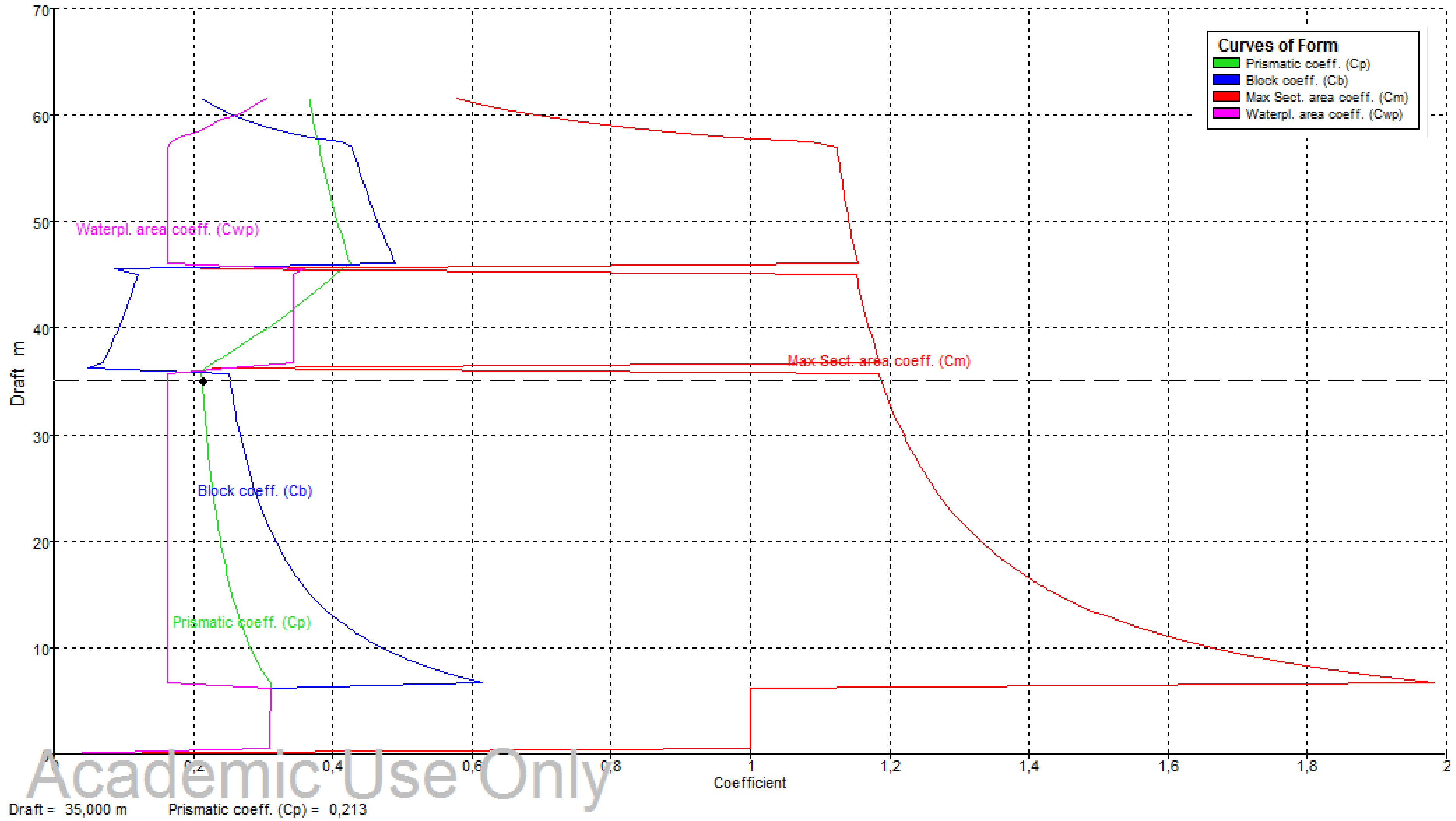


Draft m
Displacement t
Area m^2
Long. centre from zero pt. (+ve fwd) m
KB m
KM trans. m
KM long. m
Immersion tonne/cm
Moment to trim tonne.m
Hydrostatics
Displacement
Max sect. area
Sect. area amidships
Wetted Area
Waterpl. Area
LCB
LCF
KB
KMt
KML
Immersion (TPc)
MTc

CURVA DE ÁREAS



COEFICIENTES DE FORMA



TABLAS KN.

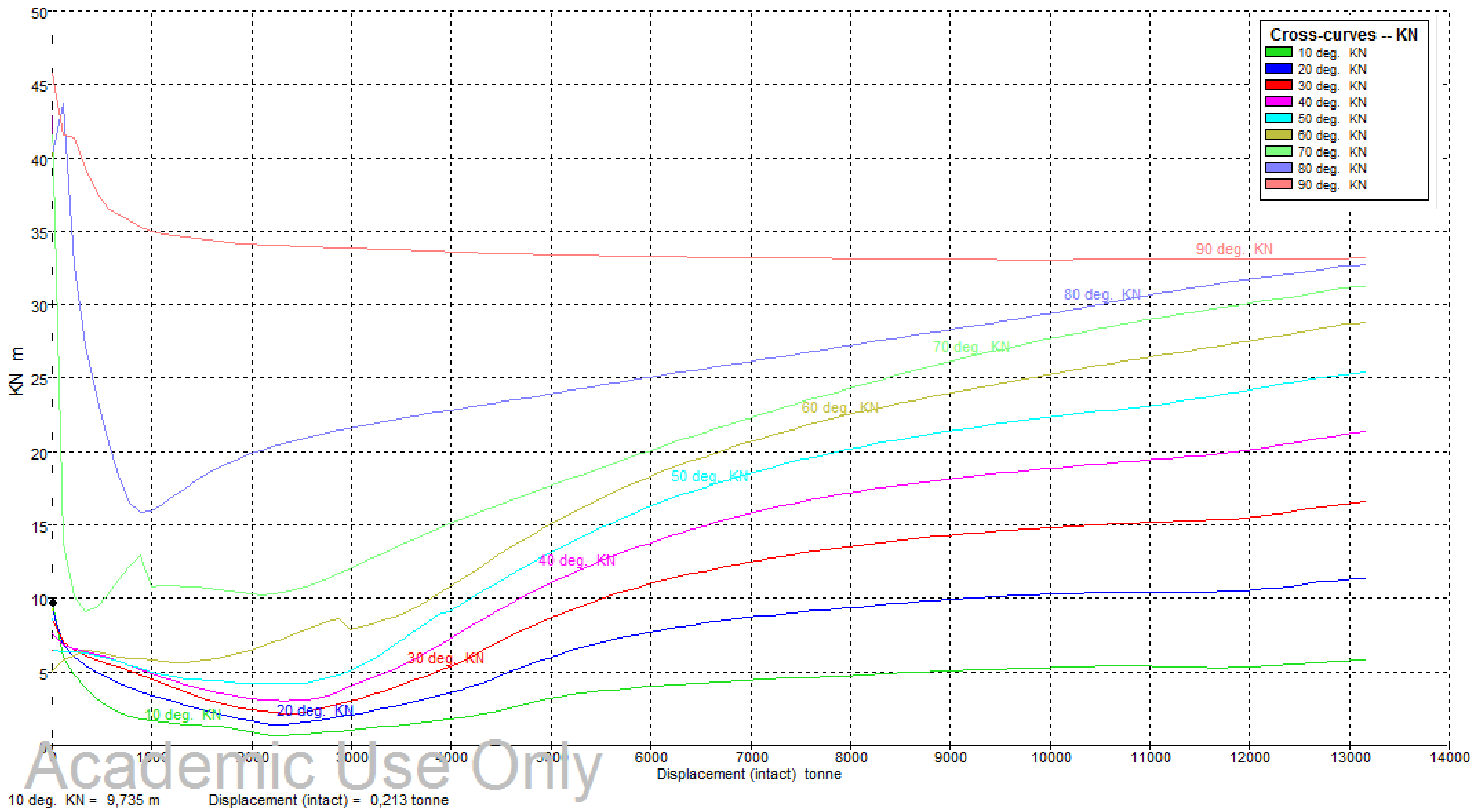
Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
0,01	0,009	0	0	0	28,52	9,742	9,325	8,615	7,641	6,435	5,035	42,856	40,123	45,754
110,7	0,363	0	0	0	28,52	5,995	6,836	6,993	6,808	6,391	5,828	13,758	43,721	41,571
221,4	0,717	0	0	0	28,52	4,777	6,037	6,48	6,547	6,392	6,083	10,113	32,676	41,372
332,1	1,07	0	0	0	28,52	3,904	5,457	6,111	6,375	6,301	6,429	9,146	27,213	39,283
442,7	1,423	0	0	0	28,52	3,212	4,986	5,814	6,194	6,137	6,368	9,386	23,892	37,738
553,4	1,776	0	0	0	28,52	2,665	4,587	5,56	5,972	5,928	6,202	10,186	20,964	36,624
664,1	2,128	0	0	0	28,52	2,277	4,241	5,314	5,723	5,701	5,99	11,282	18,377	36,08
774,8	2,479	0	0	0	28,52	2,009	3,931	5,051	5,459	5,46	5,916	12,19	16,502	35,716
885,5	2,831	0	0	0	28,52	1,815	3,657	4,778	5,182	5,224	5,92	12,924	15,816	35,293
996,1	3,182	0	0	0	28,52	1,672	3,411	4,497	4,902	5,013	5,833	10,821	15,959	35,014
1107	3,532	0	0	0	28,52	1,563	3,178	4,205	4,639	4,826	5,718	10,855	16,393	34,84
1217	3,882	0	0	0	28,52	1,479	2,957	3,91	4,396	4,661	5,666	10,868	16,939	34,715
1328	4,232	0	0	0	28,52	1,414	2,749	3,626	4,168	4,532	5,667	10,834	17,48	34,629
1439	4,582	0	0	0	28,52	1,364	2,546	3,359	3,959	4,469	5,718	10,781	17,987	34,554
1550	4,931	0	0	0	28,52	1,325	2,344	3,11	3,77	4,428	5,813	10,702	18,444	34,427
1660	5,279	0	0	0	28,52	1,274	2,152	2,89	3,598	4,366	5,937	10,604	18,854	34,326
1771	5,628	0	0	0	28,52	1,184	1,973	2,704	3,444	4,316	6,104	10,5	19,224	34,248
1882	5,976	0	0	0	28,52	1,053	1,81	2,548	3,31	4,267	6,297	10,394	19,554	34,19
1992	6,324	0	0	0	28,52	0,904	1,663	2,418	3,198	4,225	6,511	10,292	19,852	34,148
2103	6,843	0	0	0	28,52	0,756	1,536	2,315	3,116	4,198	6,743	10,247	20,115	34,096
2214	8,135	0	0	0	28,52	0,658	1,436	2,238	3,063	4,185	6,995	10,284	20,351	34,054
2324	9,431	0	0	0	28,52	0,694	1,393	2,195	3,04	4,188	7,268	10,397	20,568	34,018
2435	10,73	0	0	0	28,52	0,74	1,46	2,203	3,05	4,209	7,553	10,58	20,769	33,987
2546	12,032	0	0	0	28,52	0,792	1,562	2,292	3,104	4,251	7,836	10,812	20,956	33,948
2656	13,337	0	0	0	28,52	0,849	1,674	2,453	3,215	4,362	8,118	11,081	21,132	33,914
2767	14,644	0	0	0	28,52	0,911	1,795	2,63	3,406	4,55	8,399	11,384	21,299	33,884
2878	15,955	0	0	0	28,52	0,977	1,924	2,819	3,705	4,783	8,674	11,711	21,456	33,86
2988	17,27	0	0	0	28,52	1,046	2,061	3,018	3,989	5,073	7,926	12,048	21,608	33,838

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
3099	18,587	0	0	0	28,52	1,118	2,204	3,227	4,277	5,438	8,101	12,391	21,757	33,819
3210	19,908	0	0	0	28,52	1,194	2,353	3,446	4,572	5,862	8,292	12,737	21,901	33,802
3320	21,232	0	0	0	28,52	1,272	2,508	3,675	4,857	6,317	8,502	13,086	22,042	33,786
3431	22,559	0	0	0	28,52	1,353	2,668	3,964	5,178	6,809	8,739	13,433	22,179	33,764
3542	23,895	0	0	0	28,52	1,437	2,832	4,225	5,533	7,33	9,027	13,774	22,312	33,728
3652	25,227	0	0	0	28,52	1,522	2,998	4,475	5,936	7,862	9,391	14,107	22,442	33,694
3763	26,562	0	0	0	28,52	1,608	3,164	4,726	6,349	8,395	9,816	14,432	22,57	33,664
3874	27,875	0	0	0	28,52	1,694	3,387	5,021	6,785	8,912	10,283	14,75	22,695	33,635
3985	29,182	0	0	0	28,52	1,782	3,588	5,318	7,237	9,062	10,772	15,063	22,816	33,609
4095	30,489	0	0	0	28,52	1,871	3,772	5,644	7,696	9,529	11,263	15,372	22,936	33,582
4206	31,796	0	0	0	28,52	1,974	4,006	6,003	8,166	9,998	11,751	15,674	23,053	33,556
4317	33,103	0	0	0	28,52	2,125	4,249	6,472	8,557	10,461	12,237	15,973	23,17	33,531
4427	34,41	0	0	0	28,52	2,255	4,543	6,833	8,996	10,914	12,716	16,264	23,289	33,508
4538	35,718	0	0	0	28,52	2,451	4,851	7,219	9,422	11,357	13,19	16,549	23,409	33,486
4649	36,134	0	0	0	28,52	2,666	5,148	7,591	9,836	11,79	13,654	16,827	23,53	33,466
4759	36,299	0	0	0	28,52	2,86	5,432	7,95	10,236	12,214	14,108	17,102	23,652	33,447
4870	36,464	0	0	0	28,52	3,035	5,7	8,294	10,619	12,626	14,55	17,373	23,777	33,43
4981	36,629	0	0	0	28,52	3,19	5,952	8,623	10,987	13,029	14,977	17,641	23,903	33,413
5091	36,794	0	0	0	28,52	3,328	6,194	8,934	11,339	13,421	15,389	17,906	24,031	33,397
5202	36,959	0	0	0	28,52	3,448	6,429	9,23	11,678	13,803	15,789	18,168	24,159	33,382
5313	37,124	0	0	0	28,52	3,554	6,65	9,512	12,004	14,176	16,176	18,43	24,287	33,368
5423	37,289	0	0	0	28,52	3,647	6,854	9,781	12,316	14,539	16,549	18,695	24,415	33,354
5534	37,454	0	0	0	28,52	3,727	7,045	10,036	12,619	14,892	16,909	18,959	24,542	33,341
5645	37,619	0	0	0	28,52	3,798	7,223	10,279	12,912	15,233	17,256	19,224	24,669	33,328
5755	37,783	0	0	0	28,52	3,865	7,389	10,51	13,195	15,563	17,591	19,487	24,795	33,316
5866	37,948	0	0	0	28,52	3,93	7,545	10,731	13,467	15,88	17,915	19,75	24,921	33,305
5977	38,113	0	0	0	28,52	3,992	7,692	10,94	13,731	16,187	18,228	20,013	25,046	33,293
6087	38,278	0	0	0	28,52	4,048	7,83	11,139	13,989	16,482	18,532	20,275	25,17	33,283

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
6198	38,443	0	0	0	28,52	4,102	7,961	11,329	14,238	16,766	18,825	20,535	25,292	33,273
6309	38,608	0	0	0	28,52	4,156	8,084	11,51	14,48	17,041	19,109	20,792	25,413	33,263
6419	38,773	0	0	0	28,52	4,209	8,199	11,683	14,713	17,304	19,384	21,049	25,534	33,254
6530	38,938	0	0	0	28,52	4,261	8,307	11,849	14,939	17,558	19,651	21,303	25,654	33,245
6641	39,102	0	0	0	28,52	4,31	8,408	12,009	15,155	17,802	19,91	21,553	25,774	33,237
6752	39,267	0	0	0	28,52	4,357	8,504	12,162	15,364	18,038	20,161	21,798	25,892	33,228
6862	39,432	0	0	0	28,52	4,402	8,597	12,31	15,563	18,266	20,404	22,04	26,009	33,22
6973	39,597	0	0	0	28,52	4,444	8,687	12,453	15,754	18,486	20,637	22,276	26,124	33,212
7084	39,762	0	0	0	28,52	4,483	8,774	12,592	15,938	18,697	20,866	22,51	26,241	33,205
7194	39,927	0	0	0	28,52	4,518	8,858	12,727	16,114	18,901	21,088	22,74	26,358	33,197
7305	40,092	0	0	0	28,52	4,551	8,937	12,857	16,283	19,099	21,304	22,967	26,476	33,19
7416	40,257	0	0	0	28,52	4,582	9,012	12,983	16,446	19,289	21,514	23,191	26,594	33,183
7526	40,421	0	0	0	28,52	4,612	9,085	13,103	16,602	19,472	21,718	23,413	26,713	33,175
7637	40,586	0	0	0	28,52	4,639	9,155	13,217	16,751	19,648	21,918	23,632	26,833	33,169
7748	40,751	0	0	0	28,52	4,666	9,224	13,328	16,895	19,82	22,111	23,848	26,953	33,162
7858	40,916	0	0	0	28,52	4,698	9,292	13,434	17,032	19,985	22,299	24,061	27,074	33,155
7969	41,081	0	0	0	28,52	4,736	9,359	13,536	17,165	20,146	22,483	24,272	27,196	33,149
8080	41,246	0	0	0	28,52	4,778	9,424	13,634	17,291	20,3	22,663	24,481	27,318	33,142
8190	41,411	0	0	0	28,52	4,818	9,489	13,728	17,413	20,449	22,837	24,688	27,44	33,136
8301	41,576	0	0	0	28,52	4,856	9,553	13,819	17,528	20,593	23,007	24,892	27,561	33,13
8412	41,74	0	0	0	28,52	4,892	9,617	13,905	17,638	20,733	23,174	25,094	27,681	33,124
8522	41,905	0	0	0	28,52	4,926	9,68	13,988	17,745	20,869	23,336	25,294	27,799	33,118
8633	42,07	0	0	0	28,52	4,96	9,743	14,067	17,847	21,001	23,494	25,491	27,918	33,112
8744	42,235	0	0	0	28,52	4,994	9,805	14,144	17,945	21,129	23,649	25,687	28,037	33,106
8854	42,4	0	0	0	28,52	5,025	9,864	14,217	18,039	21,252	23,802	25,877	28,156	33,099
8965	42,565	0	0	0	28,52	5,055	9,921	14,287	18,13	21,372	23,95	26,066	28,275	33,093
9076	42,73	0	0	0	28,52	5,085	9,975	14,354	18,218	21,487	24,096	26,252	28,394	33,087
9186	42,895	0	0	0	28,52	5,114	10,026	14,419	18,304	21,6	24,241	26,433	28,513	33,081

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
9297	43,059	0	0	0	28,52	5,142	10,074	14,482	18,387	21,708	24,384	26,613	28,632	33,077
9408	43,224	0	0	0	28,52	5,167	10,119	14,543	18,466	21,815	24,525	26,789	28,751	33,072
9519	43,389	0	0	0	28,52	5,191	10,161	14,603	18,543	21,918	24,666	26,962	28,871	33,067
9629	43,554	0	0	0	28,52	5,215	10,2	14,66	18,618	22,018	24,806	27,133	28,992	33,062
9740	43,719	0	0	0	28,52	5,239	10,235	14,715	18,69	22,117	24,944	27,3	29,112	33,057
9851	43,884	0	0	0	28,52	5,264	10,265	14,767	18,761	22,213	25,081	27,465	29,232	33,057
9961	44,049	0	0	0	28,52	5,292	10,293	14,817	18,831	22,307	25,217	27,627	29,355	33,06
10072	44,214	0	0	0	28,52	5,318	10,319	14,865	18,9	22,399	25,353	27,786	29,481	33,063
10183	44,378	0	0	0	28,52	5,343	10,342	14,911	18,967	22,49	25,487	27,942	29,611	33,065
10293	44,543	0	0	0	28,52	5,366	10,361	14,955	19,034	22,579	25,619	28,095	29,743	33,068
10404	44,708	0	0	0	28,52	5,385	10,378	14,996	19,1	22,667	25,751	28,245	29,879	33,07
10515	44,873	0	0	0	28,52	5,399	10,391	15,035	19,166	22,754	25,882	28,393	30,018	33,071
10625	45,038	0	0	0	28,52	5,407	10,401	15,072	19,232	22,84	26,01	28,537	30,161	33,071
10736	45,203	0	0	0	28,52	5,411	10,411	15,107	19,296	22,927	26,135	28,677	30,304	33,072
10847	45,368	0	0	0	28,52	5,41	10,422	15,141	19,36	23,015	26,261	28,815	30,447	33,074
10957	45,524	0	0	0	28,52	5,404	10,43	15,172	19,424	23,105	26,384	28,95	30,587	33,077
11068	45,635	0	0	0	28,52	5,393	10,436	15,201	19,487	23,199	26,508	29,083	30,725	33,078
11179	45,746	0	0	0	28,52	5,377	10,44	15,229	19,55	23,3	26,629	29,212	30,86	33,079
11289	45,858	0	0	0	28,52	5,355	10,443	15,256	19,613	23,408	26,749	29,339	30,993	33,082
11400	45,969	0	0	0	28,52	5,329	10,446	15,284	19,677	23,522	26,868	29,464	31,122	33,084
11511	46,908	0	0	0	28,52	5,302	10,449	15,313	19,741	23,64	26,988	29,586	31,248	33,084
11621	48,245	0	0	0	28,52	5,291	10,458	15,344	19,808	23,759	27,108	29,706	31,371	33,083
11732	49,582	0	0	0	28,52	5,298	10,478	15,378	19,877	23,882	27,228	29,824	31,491	33,08
11843	50,919	0	0	0	28,52	5,304	10,51	15,427	19,953	24,007	27,35	29,939	31,607	33,085
11954	52,257	0	0	0	28,52	5,338	10,553	15,49	20,058	24,135	27,472	30,053	31,72	33,09
12064	53,594	0	0	0	28,52	5,373	10,613	15,559	20,174	24,265	27,595	30,166	31,828	33,094
12175	54,931	0	0	0	28,52	5,41	10,672	15,641	20,298	24,398	27,722	30,276	31,932	33,096
12286	56,268	0	0	0	28,52	5,448	10,733	15,753	20,423	24,536	27,854	30,386	32,032	33,093

Displacement (intact) tonne	Draft Amidships m	Trim (+ve by stern) m	LCG m	TCG m	Assumed VCG m	KN 10,0 deg. Starb.	KN 20,0 deg. Starb.	KN 30,0 deg. Starb.	KN 40,0 deg. Starb.	KN 50,0 deg. Starb.	KN 60,0 deg. Starb.	KN 70,0 deg. Starb.	KN 80,0 deg. Starb.	KN 90,0 deg. Starb.
12396	57,588	0	0	0	28,52	5,491	10,822	15,882	20,544	24,672	27,99	30,497	32,128	33,086
12507	58,594	0	0	0	28,52	5,542	10,923	16,013	20,661	24,802	28,133	30,612	32,222	33,09
12618	59,307	0	0	0	28,52	5,596	11,025	16,137	20,784	24,928	28,282	30,732	32,315	33,092
12728	59,902	0	0	0	28,52	5,65	11,12	16,256	20,906	25,045	28,427	30,865	32,409	33,085
12839	60,397	0	0	0	28,52	5,705	11,204	16,362	21,031	25,157	28,555	31,028	32,511	33,085
12950	60,838	0	0	0	28,52	5,747	11,276	16,454	21,161	25,266	28,66	31,158	32,646	33,1
13060	61,241	0	0	0	28,52	5,773	11,333	16,546	21,278	25,364	28,744	31,22	32,692	33,17
13171	61,599	0	0	0	28,52	5,773	11,369	16,619	21,365	25,466	28,788	31,235	32,735	33,238



Cross-curves -- KN
10 deg. KN
20 deg. KN
30 deg. KN
40 deg. KN
50 deg. KN
60 deg. KN
70 deg. KN
80 deg. KN
90 deg. KN
KN m
Displacement (intact) tonne
Academic Use Only
10 deg. KN = 9,735 m
Displacement (intact) = 0,213 tonne

ESTUDIO DE LAS CONDICIONES DE CARGA

EQUILIBRIO CONDICIÓN DE CARGA Nº1

Draft Amidships m	44,047
Displacement t	9960
Heel deg	0,1
Draft at FP m	44,092
Draft at AP m	44,002
Draft at LCF m	44,047
Trim (+ve by stern) m	-0,091
WL Length m	52,4
Beam max extents on WL m	38,613
Wetted Area m^2	3232,769
Waterpl. Area m^2	654,92
Prismatic coeff. (Cp)	0,387
Block coeff. (Cb)	0,116
Max Sect. area coeff. (Cm)	1,155
Waterpl. area coeff. (Cwp)	0,343
LCB from zero pt. (+ve fwd) m	0,033
LCF from zero pt. (+ve fwd) m	0

KB m	27,605
KG fluid m	11,939
BMt m	2,64
BML m	18,14
GMt corrected m	18,305
GML m	33,805
KMt m	30,245
KML m	45,745
Immersion (TPc) tonne/cm	6,713
MTc tonne.m	68,159
RM at 1deg = GMt.Disp.sin(1) tonne.m	3181,954
Max deck inclination deg	0,1184
Trim angle (+ve by stern) deg	-0,1051

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº1

Loadcase - Condición de Carga N.1

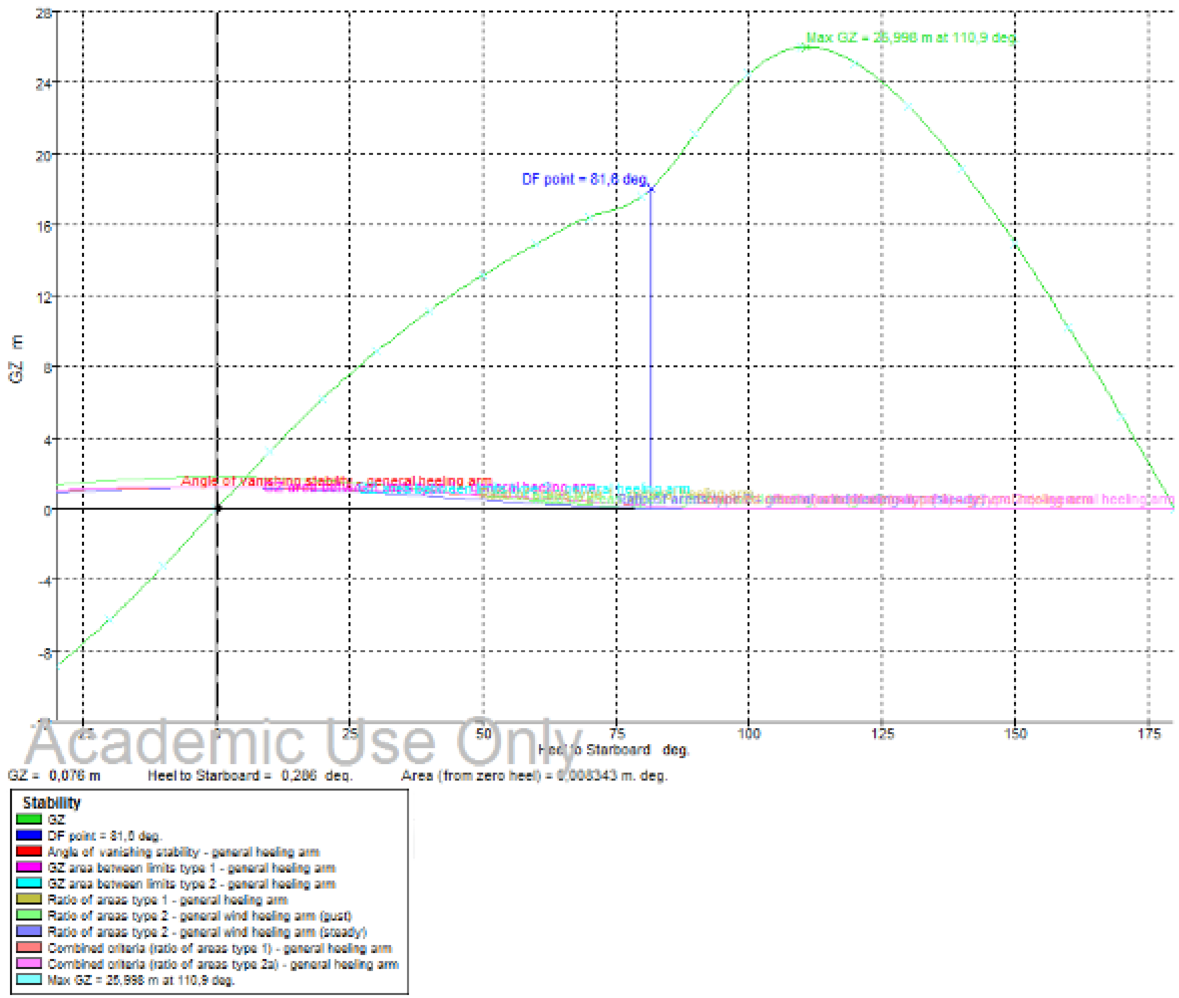
Damage Case - Intact

Fixed Trim = 0 m (+ve by stern)

Specific gravity = 1,025; (Density = 1,025 tonne/m^3)

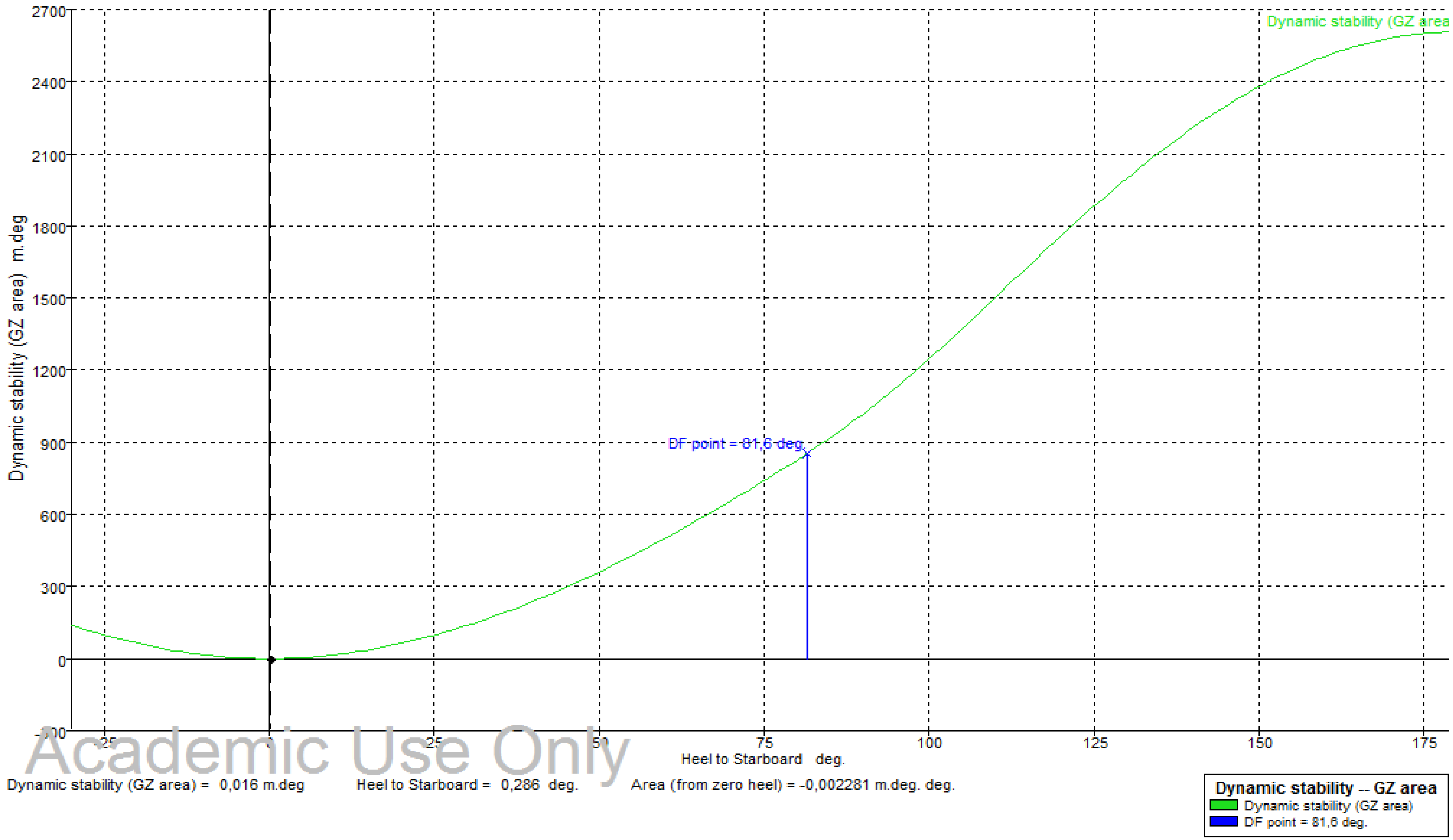
Fluid analysis method: Use corrected VCG

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
Lightship	1	1210,080	1210,080			0,030	0,040	28,520	0,000	User Specified
Peso Pienso Ø6mm	1	253,630	253,630			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	1	134,360	134,360			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	1	36,690	36,690			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5886,262	5886,262	2029,745	2029,745	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	672,225	672,225	231,802	231,802	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	0%	184,681	0,000	180,176	0,000	-2,130	2,134	26,600	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	0%	184,681	0,000	180,176	0,000	-2,130	-2,134	26,600	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	98%	17,493	17,143	20,580	20,168	0,000	2,050	37,825	0,000	IMO A.749(18)
MGO Nº2	98%	17,493	17,143	20,580	20,168	0,000	-2,050	37,825	0,000	IMO A.749(18)
Agua Potable	98%	10,161	9,957	10,161	9,957	-2,900	0,000	37,384	0,000	IMO A.749(18)
Aguas Grises	0%	2,260	0,000	2,205	0,000	3,600	0,150	36,600	0,000	IMO A.749(18)
Total Loadcase			9960,059	4354,913	3982,640	0,062	0,017	11,939	0,000	
FS correction								0,000		
VCG fluid								11,939		


Max GZ = 25,998 m at 110,9 deg.
DF point = 81,6 deg.
Angle of vanishing stability - general heeling arm
GZ m
Heel to Starboard deg.
GZ = 0,076 m
Heel to Starboard = 0,286 deg.
Area (from zero heel) = 0,008343 m. deg.
Stability
GZ
DF point = 81,6 deg.
Angle of vanishing stability - general heeling arm
GZ area between limits type 1 - general heeling arm
GZ area between limits type 2 - general heeling arm
Ratio of areas type 1 - general heeling arm
Ratio of areas type 2 - general wind heeling arm (gust)
Ratio of areas type 2 - general wind heeling arm (steady)
Combined criteria (ratio of areas type 1) - general heeling arm
Combined criteria (ratio of areas type 2a) - general heeling arm
Max GZ = 25,998 m at 110,9 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	70,0	80,0	90,0
GZ m	-8,862	-6,226	-3,235	-0,017	3,201	6,193	8,832	11,143	13,148	14,867	16,400	17,593	21,121
Area under GZ curve from zero heel m.deg	139,5850	63,9466	16,3551	-0,0316	16,0140	63,2426	138,6638	238,7844	360,5235	500,6819	657,5810	826,5050	1018,7177
Displacement t	9960	9961	9960	9960	9960	9960	9960	9960	9960	9960	9960	9959	9959
Draft at FP m	44,774	44,231	44,022	44,047	44,022	44,229	44,774	45,551	46,723	48,275	50,128	55,717	n/a
Draft at AP m	44,774	44,231	44,022	44,047	44,022	44,229	44,774	45,551	46,723	48,275	50,128	55,717	n/a
WL Length m	54,568	53,586	52,400	52,400	52,400	53,584	54,568	54,800	54,689	54,559	54,525	54,486	53,692
Beam max extents on WL m	16,653	29,077	31,022	38,613	31,022	29,074	16,652	14,498	17,080	29,565	27,248	62,550	61,600
Wetted Area m^2	3635,256	3588,496	3420,447	3139,807	3420,419	3587,670	3634,493	3657,670	3638,609	3658,027	3678,995	3594,397	3398,627
Waterpl. Area m^2	489,463	564,450	686,421	654,918	686,421	564,542	489,505	483,006	488,543	543,961	584,403	679,587	837,351
Prismatic coeff. (Cp)	0,381	0,385	0,386	0,387	0,386	0,385	0,381	0,375	0,367	0,354	0,339	0,335	0,352
Block coeff. (Cb)	0,270	0,150	0,141	0,116	0,141	0,150	0,270	0,328	0,306	0,203	0,245	0,108	0,104
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,001	-0,001	-0,001	-0,001
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	24,475	25,987	25,065	22,649	19,142	14,929	10,220	5,198	0,017
Area under GZ curve from zero heel m.deg	1247,7946	1502,0548	1759,0166	1998,5759	2208,2753	2379,1037	2505,1802	2582,4595	2608,6035
Displacement t	9960	9960	9960	9960	9960	9960	9960	9960	9960
Draft at FP m	-10,470	-17,953	-18,154	-18,904	-19,554	-19,712	-19,711	-19,711	-19,711
Draft at AP m	-10,470	-17,953	-18,154	-18,904	-19,554	-19,712	-19,711	-19,711	-19,711
WL Length m	51,070	47,356	22,378	20,000	18,754	10,000	10,000	10,000	10,000
Beam max extents on WL m	62,550	44,512	43,250	27,770	22,884	18,417	13,970	10,154	10,000
Wetted Area m^2	3756,003	4021,726	4337,522	4319,633	4402,778	4468,379	4468,371	4468,360	4376,809
Waterpl. Area m^2	715,396	556,689	252,049	157,528	105,485	93,243	85,933	81,996	80,750
Prismatic coeff. (Cp)	0,364	0,401	0,419	0,435	0,441	0,442	0,442	0,442	0,442
Block coeff. (Cb)	0,095	0,125	0,121	0,184	0,222	0,259	0,329	0,451	0,469
LCB from zero pt. (+ve fwd) m	-0,001	-0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,002	0,002	0,000	0,000	0,000	0,000	0,000	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = 0,055 m)		4	n/a
Deck Edge (immersion pos = 0,055 m)		4,1	n/a
DF point	Downflooding point	82,4	0
DF point	Downflooding point	81,6	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	81,6	Pass	+16,62
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	139,4348	Pass	+8592,94
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	257,6869	m.deg	595,2481	Pass	+131,00
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	69,57	Pass	+131,90
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	512,74	Pass	+294,42
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	69,57	Pass	+73,92
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	9,11	Pass	+84,82
	Area 1 shall not be less than (>=)	5,1600	m.deg	595,2481	Pass	+11435,82
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

EQUILIBRIO CONDICIÓN DE CARGA Nº2

Draft Amidships m	44,015
Displacement t	9938
Heel deg	0,1
Draft at FP m	44,056
Draft at AP m	43,974
Draft at LCF m	44,015
Trim (+ve by stern) m	-0,082
WL Length m	52,4
Beam max extents on WL m	38,613
Wetted Area m^2	3241,37
Waterpl. Area m^2	654,92
Prismatic coeff. (Cp)	0,386
Block coeff. (Cb)	0,115
Max Sect. area coeff. (Cm)	1,155
Waterpl. area coeff. (Cwp)	0,343
LCB from zero pt. (+ve fwd) m	0,03

LCF from zero pt. (+ve fwd) m	0
KB m	27,569
KG fluid m	11,608
BMt m	2,646
BML m	18,18
GMt corrected m	18,606
GML m	34,14
KMt m	30,215
KML m	45,749
Immersion (TPc) tonne/cm	6,713
MTc tonne.m	68,684
RM at 1deg = GMt.Disp.sin(1) tonne.m	3227,218
Max deck inclination deg	0,1092
Trim angle (+ve by stern) deg	-0,095

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº2

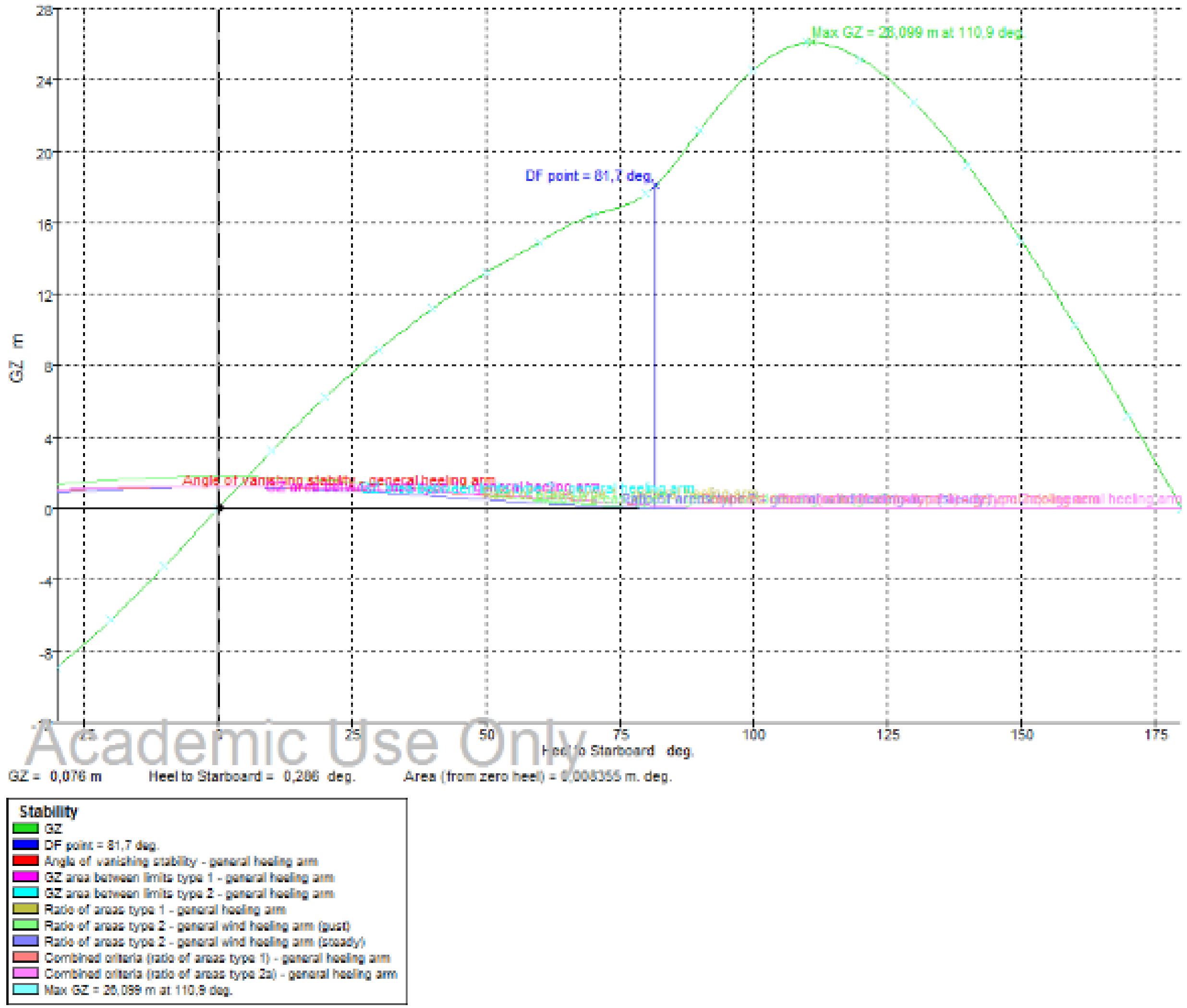
Loadcase - Condición de Carga N.2. Damage Case - Intact

Fixed Trim = 0 m (+ve by stern)

Specific gravity = 1,025; (Density = 1,025 tonne/m^3)

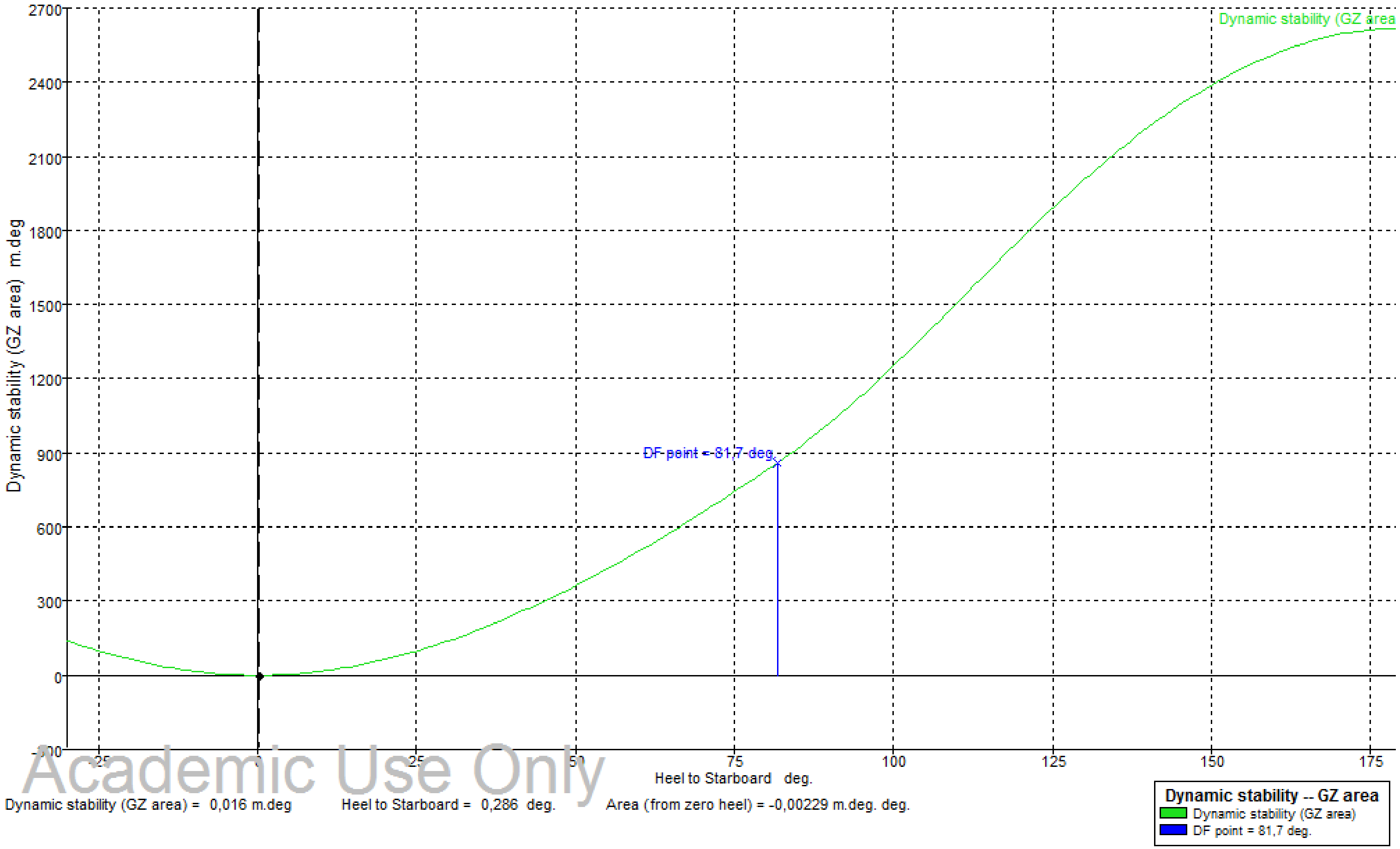
Fluid analysis method: Use corrected VCG

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
Lightship	1	1210,080	1210,080			0,030	0,040	28,520	0,000	User Specified
Peso Pienso Ø6mm	1	253,630	253,630			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	1	134,360	134,360			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	0,5	36,690	18,345			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5886,262	5886,262	2029,745	2029,745	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	672,225	672,225	231,802	231,802	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	0%	184,681	0,000	180,176	0,000	-2,130	2,134	26,600	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	0%	184,681	0,000	180,176	0,000	-2,130	-2,134	26,600	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	90%	17,493	15,744	20,580	18,522	0,000	2,050	37,725	2,546	IMO A.749(18)
MGO Nº2	90%	17,493	15,744	20,580	18,522	0,000	-2,050	37,725	2,546	IMO A.749(18)
Agua Potable	90%	10,161	9,145	10,161	9,145	-2,900	0,000	37,320	1,697	IMO A.749(18)
Aguas Grises	10%	2,260	0,226	2,205	0,221	3,600	0,150	36,645	1,295	IMO A.749(18)
Correccion Corrimiento Pienso(-	-1	0,423	-0,423			1,313	0,000	47,780	0,000	User Specified
Correccion Corrimiento Pienso(+	1	0,423	0,423			4,080	0,000	47,780	0,000	User Specified
Total Loadcase			9938,328	4354,913	3978,755	0,057	0,017	11,864	8,083	
FS correction								0,001		
VCG fluid								11,865		


Max GZ = 26,099 m at 110,9 deg.
DF point = 81,7 deg.
Angle of vanishing stability - general heeling arm
GZ m
Heel to Starboard deg.
Academic Use Only
GZ = 0,076 m
Heel to Starboard = 0,206 deg.
Area (from zero heel) = 0,008355 m. deg.
Stability
GZ
DF point = 81,7 deg.
Angle of vanishing stability - general heeling arm
GZ area between limits type 1 - general heeling arm
GZ area between limits type 2 - general heeling arm
Ratio of areas type 1 - general heeling arm
Ratio of areas type 2 - general wind heeling arm (gust)
Ratio of areas type 2 - general wind heeling arm (steady)
Combined criteria (ratio of areas type 1) - general heeling arm
Combined criteria (ratio of areas type 2a) - general heeling arm
Max GZ = 26,099 m at 110,9 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**	**70,0**	**80,0**	**90,0**
GZ m	-8,890	-6,246	-3,242	-0,017	3,208	6,213	8,859	11,176	13,187	14,904	16,437	17,641	21,194
Area under GZ curve from zero heel m.deg	139,9989	64,1187	16,3888	-0,0317	16,0469	63,4132	139,0749	239,5019	361,6056	502,1428	659,4112	828,7526	1021,5647
Displacement t	9938	9939	9938	9938	9938	9938	9938	9938	9938	9938	9938	9938	9937
Draft at FP m	44,724	44,191	43,990	44,015	43,990	44,190	44,724	45,494	46,656	48,197	50,021	55,537	n/a
Draft at AP m	44,724	44,191	43,990	44,015	43,990	44,190	44,724	45,494	46,656	48,197	50,021	55,537	n/a
WL Length m	54,552	53,522	52,400	52,400	52,400	53,521	54,552	54,798	54,700	54,568	54,532	54,492	53,706
Beam max extents on WL m	16,578	24,092	31,203	38,613	31,203	24,092	16,577	14,446	17,080	29,565	27,248	62,550	61,600
Wetted Area m^2	3628,341	3580,964	3414,550	3136,641	3414,523	3580,116	3627,582	3651,235	3630,657	3649,690	3672,915	3587,100	3395,206
Waterpl. Area m^2	492,240	567,609	684,995	654,918	684,994	567,708	492,280	485,871	490,461	543,440	585,228	682,882	837,476
Prismatic coeff. (Cp)	0,380	0,384	0,386	0,386	0,386	0,384	0,380	0,375	0,367	0,354	0,339	0,335	0,352
Block coeff. (Cb)	0,271	0,181	0,140	0,116	0,140	0,181	0,271	0,329	0,305	0,203	0,245	0,107	0,104
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,001	-0,001	-0,001	-0,001
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,000	0,000	0,000	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	**100,0**	**110,0**	**120,0**	**130,0**	**140,0**	**150,0**	**160,0**	**170,0**	**180,0**
GZ m	24,570	26,088	25,176	22,733	19,220	14,989	10,261	5,219	0,017
Area under GZ curve from zero heel m.deg	1251,4955	1506,7325	1764,7669	2005,3065	2215,8082	2387,3417	2513,9273	2591,5211	2617,7707
Displacement t	9938	9938	9938	9938	9938	9938	9938	9938	9938
Draft at FP m	-10,640	-18,064	-18,323	-19,122	-19,817	-19,974	-19,974	-19,974	-19,974
Draft at AP m	-10,640	-18,064	-18,323	-19,122	-19,817	-19,974	-19,974	-19,974	-19,974
WL Length m	51,118	47,422	22,360	20,000	18,935	10,000	10,000	10,000	10,000
Beam max extents on WL m	62,550	47,366	43,103	27,602	22,715	18,286	13,880	10,154	10,000
Wetted Area m^2	3749,157	4011,270	4328,063	4312,291	4397,184	4462,899	4462,814	4462,667	4371,311
Waterpl. Area m^2	717,866	560,666	248,720	158,098	105,412	93,243	85,933	81,996	80,750
Prismatic coeff. (Cp)	0,364	0,401	0,420	0,436	0,442	0,443	0,443	0,443	0,443
Block coeff. (Cb)	0,095	0,117	0,121	0,186	0,225	0,261	0,332	0,452	0,471
LCB from zero pt. (+ve fwd) m	-0,001	-0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,003	0,002	0,000	0,000	0,000	0,000	0,000	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = 0,055 m)		4	n/a
Deck Edge (immersion pos = 0,055 m)		4,2	n/a
DF point	Downflooding point	82,4	0
DF point	Downflooding point	81,7	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	81,7	Pass	+16,73
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	139,8880	Pass	+8621,20
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	258,7990	m.deg	597,0743	Pass	+130,71
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	69,48	Pass	+131,60
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	513,24	Pass	+294,80
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	69,48	Pass	+73,70
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	9,08	Pass	+84,87
	Area 1 shall not be less than (>=)	5,1600	m.deg	597,0743	Pass	+11471,21
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

EQUILIBRIO CONDICIÓN DE CARGA Nº3

Draft Amidships m	43,861
Displacement t	9835
Heel deg	0,1
Draft at FP m	43,899
Draft at AP m	43,823
Draft at LCF m	43,861
Trim (+ve by stern) m	-0,076
WL Length m	52,4
Beam max extents on WL m	38,613
Wetted Area m^2	3226,346
Waterpl. Area m^2	654,92
Prismatic coeff. (Cp)	0,383
Block coeff. (Cb)	0,115
Max Sect. area coeff. (Cm)	1,155
Waterpl. area coeff. (Cwp)	0,343
LCB from zero pt. (+ve fwd) m	0,028
LCF from zero pt. (+ve fwd) m	0

KB m	27,397
KG fluid m	11,24
BMt m	2,674
BML m	18,37
GMt corrected m	18,832
GML m	34,528
KMt m	30,071
KML m	45,768
Immersion (TPc) tonne/cm	6,713
MTc tonne.m	68,745
RM at 1deg = GMt.Disp.sin(1) tonne.m	3232,463
Max deck inclination deg	0,1419
Trim angle (+ve by stern) deg	-0,0883

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº3

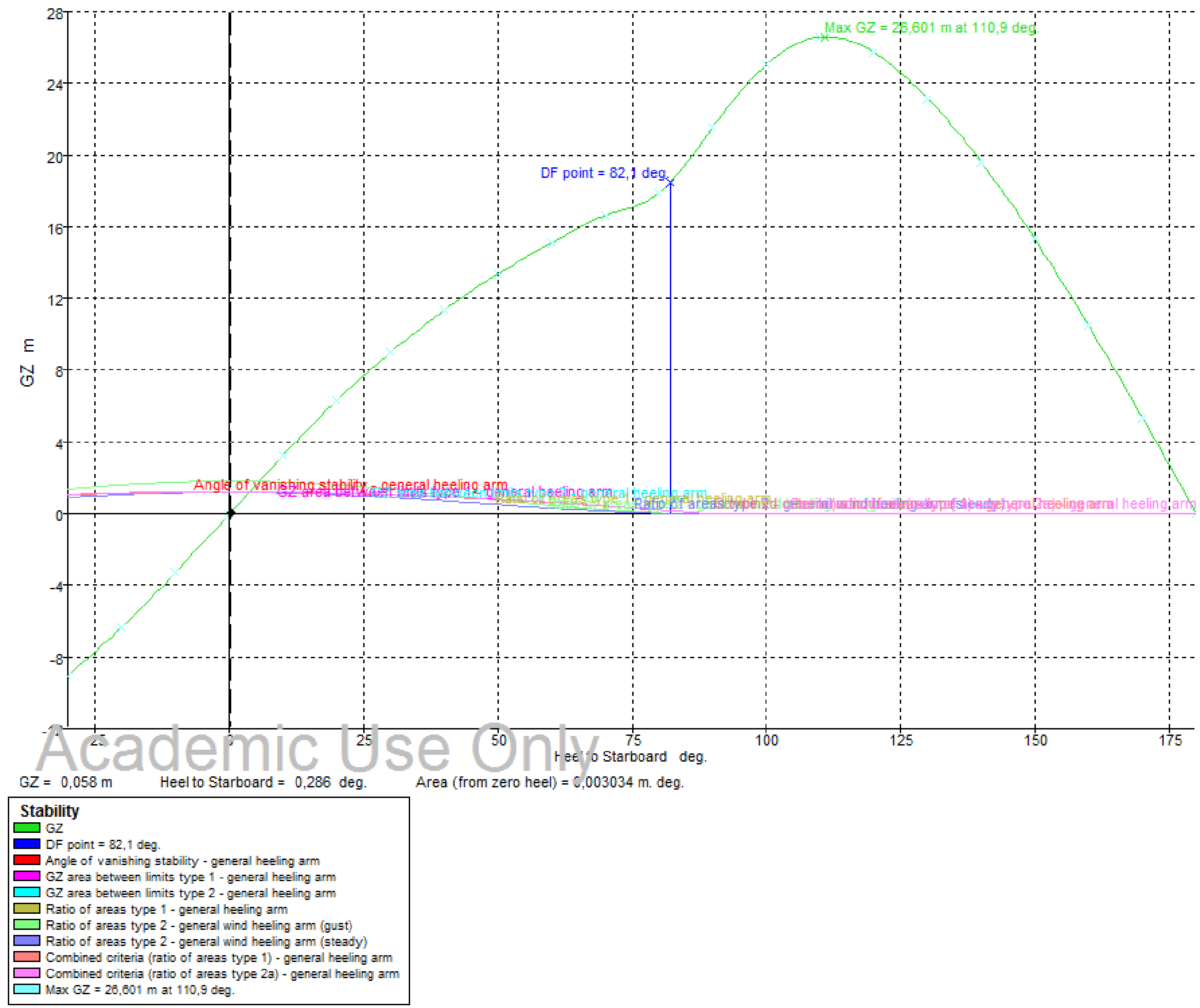
Loadcase - Condición de Carga N.3. Damage Case - Intact

Fixed Trim = 0 m (+ve by stern)

Specific gravity = 1,025; (Density = 1,025 tonne/m^3)

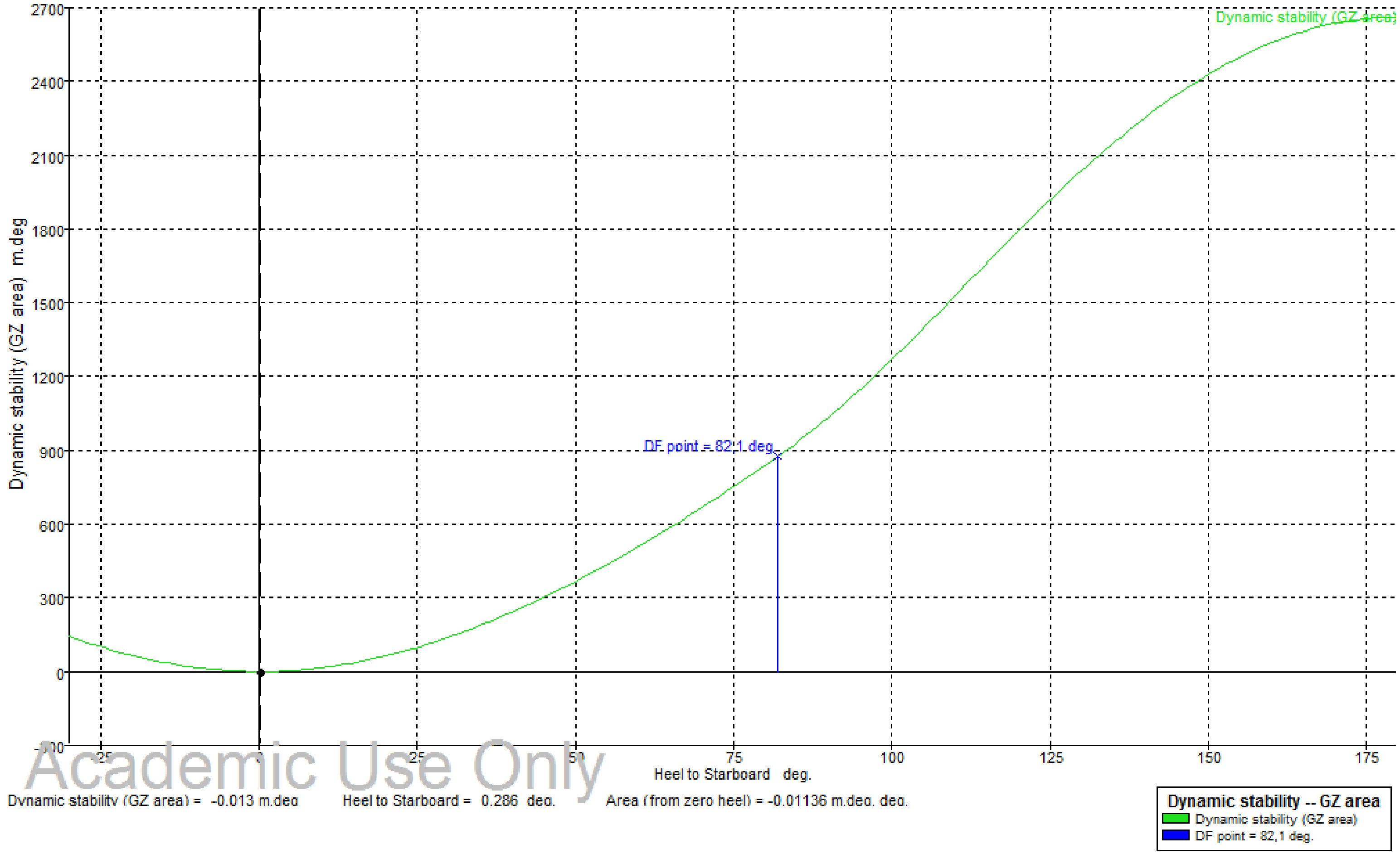
Fluid analysis method: Use corrected VCG

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
Lightship	1	1210,080	1210,080			0,030	0,040	28,520	0,000	User Specified
Peso Pienso Ø6mm	1	253,630	253,630			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	0,5	134,360	67,180			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	0	36,690	0,000			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5886,262	5886,262	2029,745	2029,745	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	672,225	672,225	231,802	231,802	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	0%	184,681	0,000	180,176	0,000	-2,130	2,134	26,600	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	0%	184,681	0,000	180,176	0,000	-2,130	-2,134	26,600	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	50%	17,493	8,746	20,580	10,290	0,000	2,050	37,225	2,546	IMO A.749(18)
MGO Nº2	50%	17,493	8,746	20,580	10,290	0,000	-2,050	37,225	2,546	IMO A.749(18)
Agua Potable	50%	10,161	5,080	10,161	5,080	-2,900	0,000	37,000	1,697	IMO A.749(18)
Aguas Grises	40%	2,260	0,904	2,205	0,882	3,600	0,150	36,780	1,295	IMO A.749(18)
Correccion Corrimiento Pienso(-	-1	2,027	-2,027			-1,820	2,250	49,150	0,000	User Specified
Correccion Corrimiento Pienso(+	1	2,027	2,027			1,820	2,250	49,150	0,000	User Specified
Total Loadcase			9835,423	4354,913	3958,888	0,053	0,036	11,498	8,083	
FS correction								0,001		
VCG fluid								11,499		


Max GZ = 26,601 m at 110,9 deg.
DF point = 82,1 deg.
Angle of vanishing stability - general heeling arm
GZ m
Heel to Starboard deg.
Academic Use Only
GZ = 0,058 m
Heel to Starboard = 0,286 deg.
Area (from zero heel) = 0,003034 m. deg.
Stability
GZ
DF point = 82,1 deg.
Angle of vanishing stability - general heeling arm
GZ area between limits type 1 - general heeling arm
GZ area between limits type 2 - general heeling arm
Ratio of areas type 1 - general heeling arm
Ratio of areas type 2 - general wind heeling arm (gust)
Ratio of areas type 2 - general wind heeling arm (steady)
Combined criteria (ratio of areas type 1) - general heeling arm
Combined criteria (ratio of areas type 2a) - general heeling arm
Max GZ = 26,601 m at 110,9 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	70,0	80,0	90,0
GZ m	-9,042	-6,363	-3,300	-0,036	3,228	6,294	8,979	11,332	13,367	15,085	16,624	17,884	21,557
Area under GZ curve from zero heel m.deg	142,6002	65,3543	16,7526	-0,0663	16,0315	63,9032	140,5825	242,3853	366,1892	508,5459	667,6275	839,0621	1034,8721
Displacement t	9835	9836	9835	9835	9835	9835	9835	9835	9835	9835	9835	9835	9835
Draft at FP m	44,492	44,005	43,841	43,861	43,841	44,004	44,491	45,228	46,341	47,826	49,521	54,699	n/a
Draft at AP m	44,492	44,005	43,841	43,861	43,841	44,004	44,491	45,228	46,341	47,826	49,521	54,699	n/a
WL Length m	54,478	53,229	52,400	52,400	52,400	53,228	54,478	54,740	54,748	54,607	54,565	54,519	53,775
Beam max extents on WL m	16,229	29,238	32,065	38,613	32,065	29,238	16,228	14,203	17,080	29,565	27,482	62,550	61,600
Wetted Area m^2	3596,428	3543,339	3384,877	3121,646	3384,847	3542,477	3595,736	3621,301	3594,522	3610,622	3644,309	3553,051	3379,002
Waterpl. Area m^2	505,139	584,169	676,853	654,918	676,852	584,269	505,174	498,884	499,932	541,194	589,079	698,256	838,065
Prismatic coeff. (Cp)	0,378	0,382	0,383	0,383	0,383	0,382	0,378	0,373	0,365	0,353	0,339	0,335	0,354
Block coeff. (Cb)	0,275	0,148	0,135	0,115	0,135	0,148	0,275	0,333	0,304	0,202	0,242	0,107	0,103
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,001	-0,001	-0,001	-0,001
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,017	0,000	0,000	0,000	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	25,040	26,584	25,720	23,150	19,611	15,299	10,480	5,340	0,036
Area under GZ curve from zero heel m.deg	1269,0381	1529,1044	1792,4252	2037,8095	2252,2974	2427,3845	2556,6084	2635,9101	2662,8597
Displacement t	9834	9835	9835	9835	9835	9835	9835	9835	9835
Draft at FP m	-11,446	-18,580	-19,162	-20,135	-21,047	-21,213	-21,217	-21,217	-21,217
Draft at AP m	-11,446	-18,580	-19,162	-20,135	-21,047	-21,213	-21,217	-21,217	-21,217
WL Length m	51,277	47,726	36,800	20,000	19,702	10,000	10,000	10,000	10,000
Beam max extents on WL m	62,550	47,250	42,376	26,826	21,924	36,027	13,455	10,154	10,000
Wetted Area m^2	3717,396	3964,752	4275,573	4277,702	4366,072	4433,097	4436,862	4436,828	4345,277
Waterpl. Area m^2	729,275	576,027	231,321	166,558	110,147	96,082	85,933	81,996	80,750
Prismatic coeff. (Cp)	0,364	0,402	0,426	0,442	0,450	0,452	0,452	0,452	0,452
Block coeff. (Cb)	0,094	0,117	0,123	0,192	0,236	0,135	0,349	0,461	0,481
LCB from zero pt. (+ve fwd) m	-0,001	-0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,008	0,002	0,000	0,002	0,000	0,000	0,000	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Dynamic stability (GZ area) = -0.013 m.deg   Heel to Starboard = 0.286 deg.   Area (from zero heel) = -0.01136 m.deg. deg.

Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = 0,055 m)		4,3	n/a
Deck Edge (immersion pos = 0,055 m)		4,5	n/a
DF point	Downflooding point	82,7	0
DF point	Downflooding point	82,1	0

Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	82,1	Pass	+17,24
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	142,1071	Pass	+8759,55
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	263,9736	m.deg	605,3397	Pass	+129,32
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	69,06	Pass	+130,20
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	514,77	Pass	+295,98
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	69,06	Pass	+72,65
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	8,96	Pass	+85,07
	Area 1 shall not be less than (>=)	5,1600	m.deg	605,3397	Pass	+11631,39
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

EQUILIBRIO CONDICIÓN DE CARGA Nº4.

Draft Amidships m	44,097
Displacement t	9994
Heel deg	0,1
Draft at FP m	44,091
Draft at AP m	44,104
Draft at LCF m	44,097
Trim (+ve by stern) m	0,013
WL Length m	52,4
Beam max extents on WL m	38,613
Wetted Area m^2	3249,324
Waterpl. Area m^2	654,919
Prismatic coeff. (Cp)	0,388
Block coeff. (Cb)	0,116
Max Sect. area coeff. (Cm)	1,155
Waterpl. area coeff. (Cwp)	0,343
LCB from zero pt. (+ve fwd) m	-0,005
LCF from zero pt. (+ve fwd) m	0

KB m	27,66
KG fluid m	11,455
BMt m	2,631
BML m	18,079
GMt corrected m	18,837
GML m	34,284
KMt m	30,291
KML m	45,739
Immersion (TPc) tonne/cm	6,713
MTc tonne.m	69,359
RM at 1deg = GMt.Disp.sin(1) tonne.m	3285,419
Max deck inclination deg	0,0944
Trim angle (+ve by stern) deg	0,0155

ESTABILIDAD A GRANDES ÁNGULOS. CONDICIÓN DE CARGA Nº4

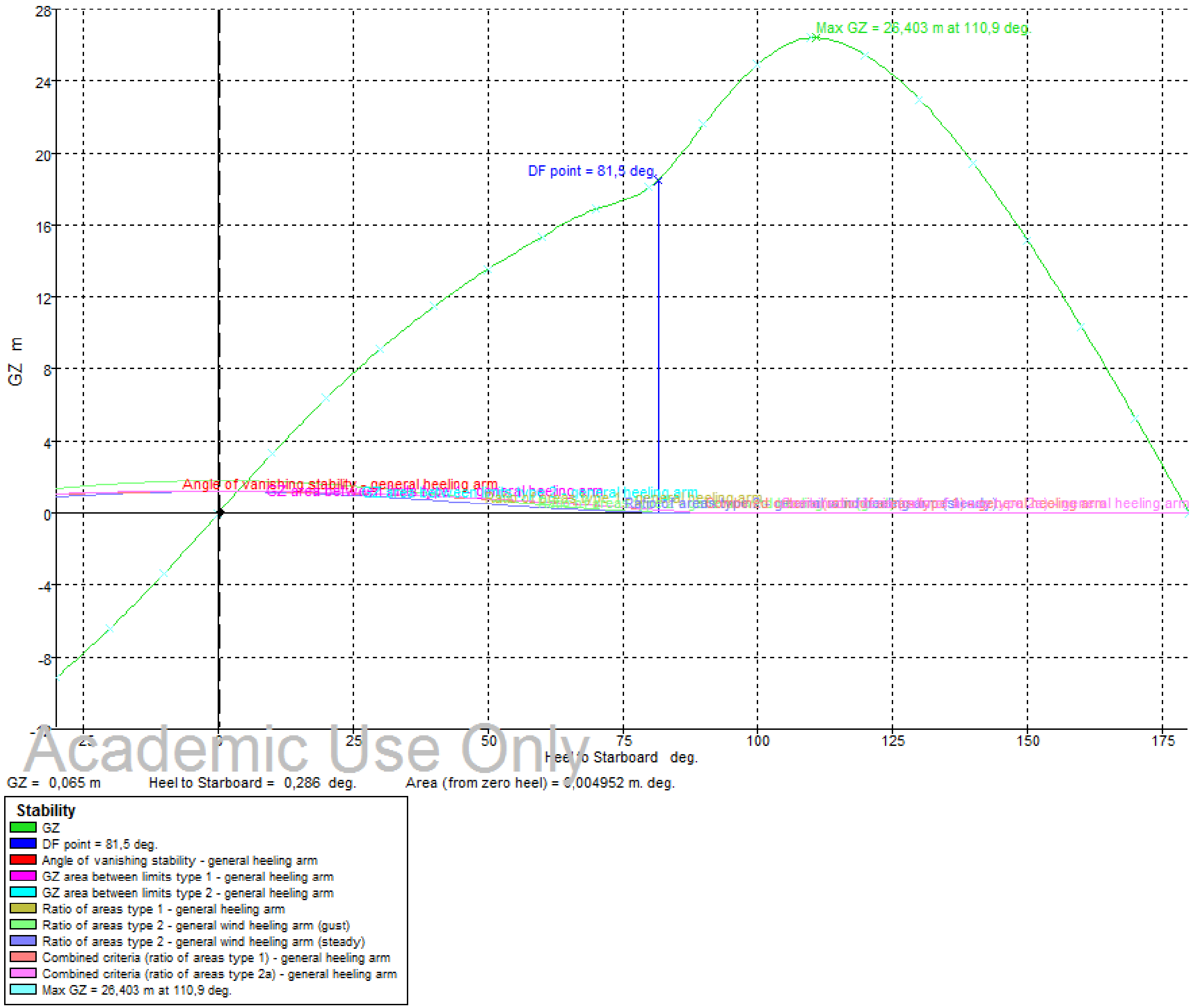
Loadcase - Condición de Carga N.4. Damage Case - Intact

Fixed Trim = 0 m (+ve by stern)

Specific gravity = 1,025; (Density = 1,025 tonne/m^3)

Fluid analysis method: Use corrected VCG

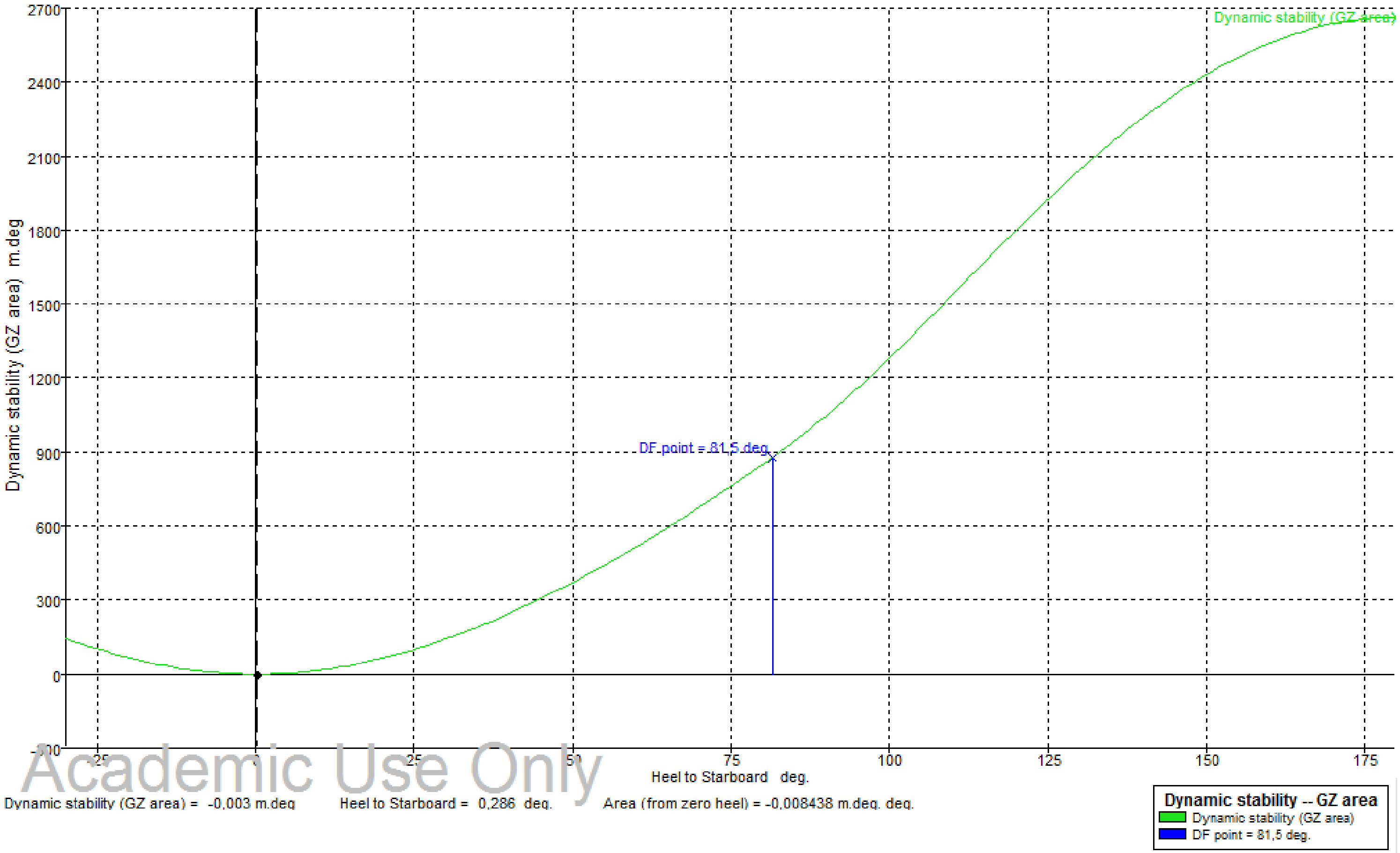
Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	1210,080	1210,080			0,030	0,040	28,520	0,000	User Specified
Peso Pienso Ø6mm	0,5	253,630	126,815			-1,090	1,880	49,620	0,000	User Specified
Peso Pienso Ø4mm	0	134,360	0,000			0,000	-2,760	48,870	0,000	User Specified
Peso Pienso Ø2,5mm	0	36,690	0,000			3,240	0,000	47,620	0,000	User Specified
Habilitación y miscelanea	1	10,000	10,000			0,000	0,000	55,700	0,000	User Specified
Lastre Solido 1	100%	5886,262	5886,262	2029,745	2029,745	0,000	0,000	3,304	0,000	User Specified
Lastre Solido 2	100%	672,225	672,225	231,802	231,802	0,000	0,000	8,099	0,000	User Specified
Lastre 11	100%	135,510	135,510	132,205	132,205	-2,130	2,134	13,100	0,000	Maximum
Lastre 12	100%	135,524	135,524	132,219	132,219	2,130	2,134	13,100	0,000	Maximum
Lastre 13	100%	135,510	135,510	132,205	132,205	-2,130	-2,134	13,100	0,000	Maximum
Lastre 14	100%	135,524	135,524	132,219	132,219	2,130	-2,134	13,100	0,000	Maximum
Lastre 21	100%	193,586	193,586	188,864	188,864	-2,130	2,134	21,600	0,000	Maximum
Lastre 22	100%	193,606	193,606	188,884	188,884	2,130	2,134	21,600	0,000	Maximum
Lastre 23	100%	193,586	193,586	188,864	188,864	-2,130	-2,134	21,600	0,000	Maximum
Lastre 24	100%	193,606	193,606	188,884	188,884	2,130	-2,134	21,600	0,000	Maximum
Lastre 31	100%	184,681	184,681	180,176	180,176	-2,130	2,134	31,370	0,000	Maximum
Lastre 32	100%	184,700	184,700	180,195	180,195	2,130	2,134	31,370	0,000	Maximum
Lastre 33	100%	184,681	184,681	180,176	180,176	-2,130	-2,134	31,370	0,000	Maximum
Lastre 34	100%	184,700	184,700	180,195	180,195	2,130	-2,134	31,370	0,000	Maximum
Lastre 41	100%	8,905	8,905	8,688	8,688	-2,130	2,134	36,370	0,000	Maximum
Lastre 42	100%	8,906	8,906	8,689	8,689	2,130	2,134	36,370	0,000	Maximum
Lastre 43	100%	8,905	8,905	8,688	8,688	-2,130	-2,134	36,370	0,000	Maximum
Lastre 44	0%	8,906	0,000	8,689	0,000	2,130	-2,134	36,140	0,000	Maximum
MGO Nº1	10%	17,493	1,749	20,580	2,058	0,000	2,050	36,725	2,546	IMO A.749(18)
MGO Nº2	10%	17,493	1,749	20,580	2,058	0,000	-2,050	36,725	2,546	IMO A.749(18)
Agua Potable	10%	10,161	1,016	10,161	1,016	-2,900	0,000	36,680	1,697	IMO A.749(18)
Aguas Grises	90%	2,260	2,034	2,205	1,985	3,600	0,150	37,005	1,295	IMO A.749(18)
Correccion Corrimiento Pienso(-	-1	4,628	-4,628			-2,580	1,960	49,970	0,000	User Specified
Correccion Corrimiento Pienso(+	1	4,628	4,628			2,580	1,960	49,970	0,000	User Specified
Total Loadcase			9993,860	4354,913	4299,815	-0,009	0,031	11,454	8,083	
FS correction								0,001		
VCG fluid								11,455		



Max GZ = 26,403 m at 110,9 deg.
DF point = 81,5 deg.
Angle of vanishing stability - general heeling arm
GZ m
Heel to Starboard deg.
Academic Use Only
GZ = 0,065 m
Heel to Starboard = 0,286 deg.
Area (from zero heel) = 0,004952 m. deg.
Stability
GZ
DF point = 81,5 deg.
Angle of vanishing stability - general heeling arm
GZ area between limits type 1 - general heeling arm
GZ area between limits type 2 - general heeling arm
Ratio of areas type 1 - general heeling arm
Ratio of areas type 2 - general wind heeling arm (gust)
Ratio of areas type 2 - general wind heeling arm (steady)
Combined criteria (ratio of areas type 1) - general heeling arm
Combined criteria (ratio of areas type 2a) - general heeling arm
Max GZ = 26,403 m at 110,9 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	70,0	80,0	90,0
GZ m	-9,131	-6,412	-3,340	-0,031	3,280	6,354	9,078	11,465	13,539	15,321	16,899	18,105	21,605
Area under GZ curve from zero heel m.deg	143,9233	66,0124	16,9572	-0,0557	16,3532	64,7894	142,2462	245,2151	370,5241	514,9153	676,6006	850,6157	1047,8419
Displacement t	9995	9995	9994	9994	9994	9994	9994	9993	9994	9994	9994	9993	9994
Draft at FP m	44,854	44,293	44,070	44,097	44,070	44,292	44,852	45,641	46,829	48,396	50,293	55,998	n/a
Draft at AP m	44,854	44,293	44,070	44,097	44,070	44,292	44,852	45,641	46,829	48,396	50,293	55,998	n/a
WL Length m	54,593	53,684	52,400	52,400	52,400	53,682	54,593	54,800	54,673	54,547	54,514	54,477	53,669
Beam max extents on WL m	16,772	29,238	30,741	38,613	30,741	29,238	16,769	14,580	15,557	29,565	27,248	62,550	61,600
Wetted Area m^2	3646,377	3600,738	3431,020	3144,732	3430,988	3599,816	3645,350	3667,744	3650,146	3670,951	3688,455	3605,718	3404,050
Waterpl. Area m^2	484,979	559,454	687,919	654,918	687,920	559,572	485,115	478,582	485,978	544,619	583,119	674,431	837,152
Prismatic coeff. (Cp)	0,381	0,386	0,387	0,388	0,387	0,386	0,381	0,376	0,367	0,354	0,340	0,335	0,352
Block coeff. (Cb)	0,268	0,150	0,142	0,116	0,142	0,150	0,269	0,327	0,336	0,203	0,245	0,108	0,104
LCB from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,001	-0,001	-0,001	-0,001
LCF from zero pt. (+ve fwd) m	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,000	0,000	0,000
Max deck inclination deg	30,0000	20,0000	10,0000	0,0000	10,0000	20,0000	30,0000	40,0000	50,0000	60,0000	70,0000	80,0000	90,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Heel to Starboard deg	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
GZ m	24,919	26,398	25,419	22,984	19,415	15,145	10,372	5,282	0,031
Area under GZ curve from zero heel m.deg	1281,5599	1540,1106	1800,8773	2043,8808	2256,6512	2429,9168	2557,8404	2636,3016	2662,9327
Displacement t	9994	9994	9994	9994	9994	9994	9994	9994	9994
Draft at FP m	-10,204	-17,780	-17,895	-18,563	-19,148	-19,305	-19,303	-19,303	-19,303
Draft at AP m	-10,204	-17,780	-17,895	-18,563	-19,148	-19,305	-19,303	-19,303	-19,303
WL Length m	50,993	47,254	22,400	20,000	18,381	10,000	10,000	10,000	10,000
Beam max extents on WL m	62,550	44,490	43,474	28,031	23,144	18,621	14,110	10,154	10,000
Wetted Area m^2	3766,539	4037,434	4351,936	4330,828	4414,288	4476,934	4476,863	4476,811	4385,361
Waterpl. Area m^2	711,169	551,120	257,140	155,684	107,609	93,243	85,933	81,996	80,750
Prismatic coeff. (Cp)	0,364	0,400	0,417	0,433	0,438	0,439	0,439	0,439	0,439
Block coeff. (Cb)	0,095	0,125	0,120	0,182	0,219	0,255	0,324	0,448	0,467
LCB from zero pt. (+ve fwd) m	-0,001	-0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000
LCF from zero pt. (+ve fwd) m	0,000	0,002	0,001	0,000	0,000	0,000	0,000	0,000	0,000
Max deck inclination deg	100,0000	110,0000	120,0000	130,0000	140,0000	150,0000	160,0000	170,0000	180,0000
Trim angle (+ve by stern) deg	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000



Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = 0,055 m)		3,8	n/a
Deck Edge (immersion pos = 0,055 m)		4	n/a
DF point	Downflooding point	82,2	0
DF point	Downflooding point	81,5	0

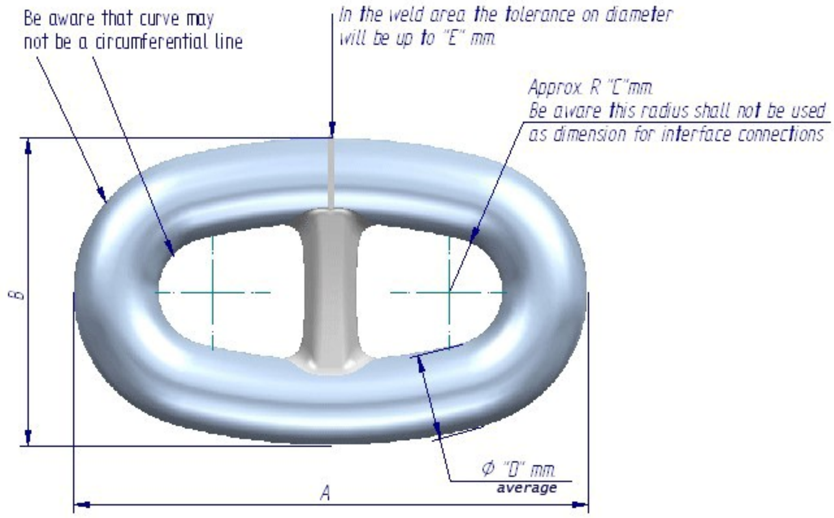
Code	Criteria	Value	Units	Actual	Status	Margin %
GZ curve criteria	Angle of downflooding	70,0	deg	81,5	Pass	+16,45
GZ curve criteria	Angle of vanishing stability	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	Angle of vanishing stability - general heeling arm	90,0	deg	180,0	Pass	+100,00
Heeling arm criteria (stand alone)	GZ area between limits type 1 - general heeling arm	1,6040	m.deg	143,3628	Pass	+8837,83
Heeling arm criteria (stand alone)	GZ area between limits type 2 - general heeling arm	264,5046	m.deg	614,2511	Pass	+132,23
Heeling arm criteria (stand alone)	Ratio of areas type 1 - general heeling arm	30,00	%	69,93	Pass	+133,10
Heeling arm criteria (stand alone)	Ratio of areas type 2 - general wind heeling arm	130,00	%	516,71	Pass	+297,47
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 1) - general heeling arm				Pass	
	Area1 / Area2 shall be greater than (>)	40,00	%	69,93	Pass	+74,82
	GZ(intersection) / GZ(max) shall be less than (<)	60,00	%	8,84	Pass	+85,27
	Area 1 shall not be less than (>=)	5,1600	m.deg	614,2511	Pass	+11804,09
Heeling arm, combined criteria (stand alone)	Combined criteria (ratio of areas type 2a) - general heeling arm				Pass	

VICINAY SESTAO

DATA SHEET

QUALITIES	CLASS. SOCIETY	TYPE	STUD
R4	GL-R4	STUD CHAIN	102 COMMON LINK

COMMON LINK FOR 142 mm. STUD CHAIN
Material Quality: GL-R4
Project: SparFish



DIMENSIONS IN mm. (Approx.)

A	B	C	D	E
852	511	88.8	142	163

WEIGHT & LOADS

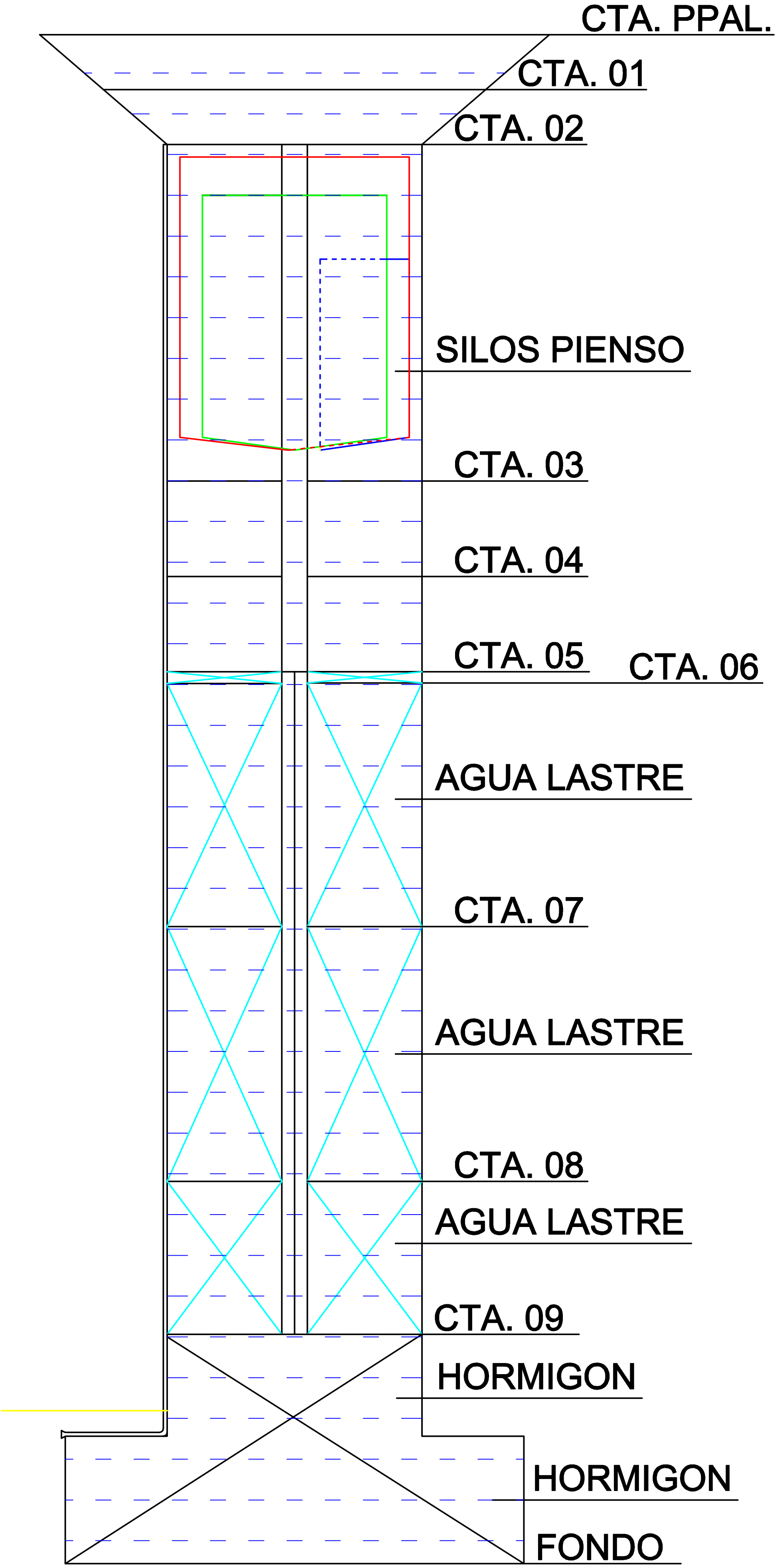
WEIGHT PER METER (Approx.)	KG.	LBS.
WEIGHT IN AIR	441.6	973.5
SUBMERGED WEIGHT	384.2	847

LOADS	kN	Kips
MINIMUM LOAD BEARING CAPACITY	18033	4054
PROOF LOAD >	14216	3196

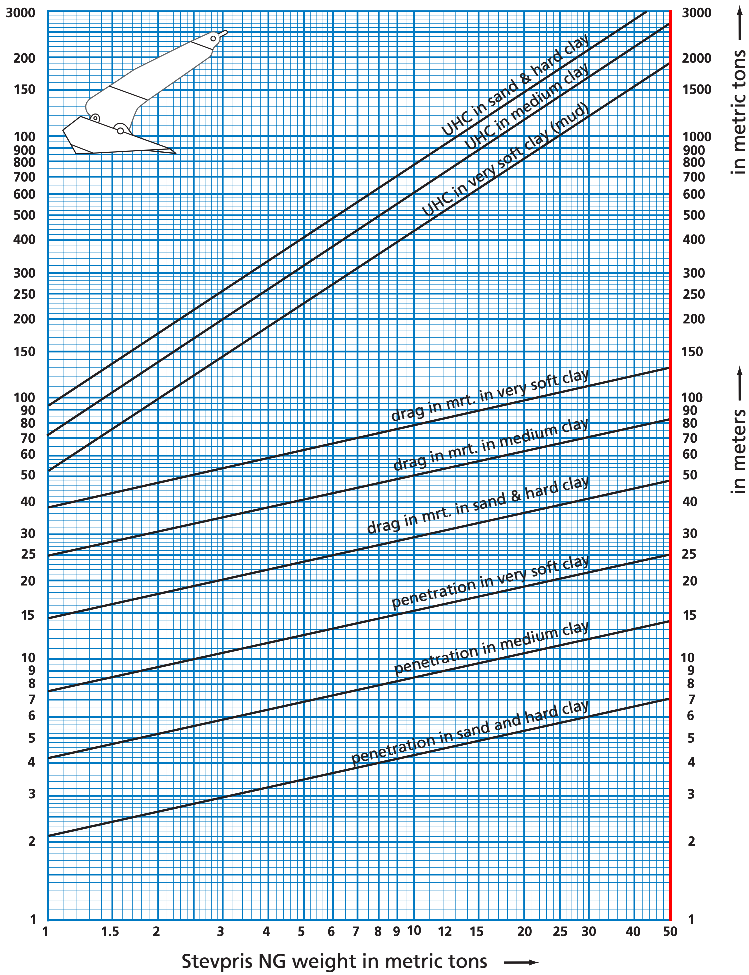
MECHANICAL PROPERTIES

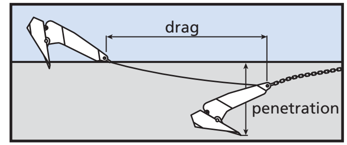
TENSILE	MIN. YIELD STRESS	580	Mpa
	MIN. TENSILE STRENGHT	860	Mpa
	MIN. ELONGATION	12	%
	MIN. REDUCTION OF AREA	50	%

		BASE MATERIAL	WELD ZONE
CHARPY	AT -20 ºC.	50 J (Average)	36 J (Average)


CTA. PPAL.
CTA. 01
CTA. 02
SILOS PIENSO
CTA. 03
CTA. 04
CTA. 05
CTA. 06
AGUA LASTRE
CTA. 07
AGUA LASTRE
CTA. 08
AGUA LASTRE
CTA. 09
HORMIGON
HORMIGON
FONDO

Stevpris New Generation UHC chart





Example: loading 70% of ultimate holding capacity corresponds with 48% of maximum drag and 80% of maximum penetration at ultimate holding capacity.

anchor load as % of UHC	drag % max drag	penetration as % max penetration
70	48	80
60	37	68
50	27	55
40	18	42
30	9	23