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Diseño de la planta propulsora de un buque oceanográfico

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1.- Introducción

El objetivo del TFC es proyectar la planta propulsora de un buque oceanográfico. También se proyectarán los sistemas auxiliares a la propulsión tales como sistema de combustible, sistema de arranque por aire comprimido, sistema de refrigeración y sistema de ventilación en cámara de máquinas. Para ello será necesaria la determinación de las dimensiones principales del buque a partir de unas especificaciones y restricciones dadas por el armador, el cálculo de resistencia al avance, dimensionamiento y compartimentado de la cámara de máquinas, disposición de tanques y balance eléctrico del buque.

Su interés reside en la particularidad de estos buques, el sistema propulsivo debe estar diseñado para diversas condiciones de navegación y en condiciones climáticas muy adversas. Por tanto, el problema abordado es encontrar el sistema propulsivo lo más fiable y polivalente posible.

2.- Datos de proyecto

A continuación, se exponen los requerimientos del armador para el buque a proyectar:

- **Tipo de buque:** Oceanográfico
- **Velocidad:** 14 nudos
- **Clasificación:** Bureau Veritas
- Equipos para pesca de fondo y semipelágica
- Equipos para clasificación e investigación del pescado capturado
- **Arqueo bruto:** 2500 GT
- **Calado máximo:** 5 metros
- Dos hélices transversales con 4 palas controlables para mejora de la maniobrabilidad
- **Autonomía:** 4500 millas náuticas
- **Tripulación:** 45 personas

3.- Estimación de potencia

El punto de partida para el dimensionamiento del buque lo establecen los requisitos del proyecto, que en este caso se supone que vienen del armador en forma de proyecto conceptual.

A partir de estos datos, se establecen las variables del proyecto, que llegarán a definirlo de forma unívoca. Algunas variables son independientes y otras se calcularán a partir de las primeras.

En cualquier caso, se comienza por la investigación de buques similares y fiables que configuren una base de datos de referencia.

A partir de la definición de requisitos y restricciones y la obtención de datos de buques similares, se pasará a definir los conceptos de características y dimensiones principales y estimación de la potencia propulsora.

Más adelante existirán rediseños, es decir, procesos que ya se habían dado como terminados pero que se van a ver afectados por cálculos posteriores, por tanto hay que ser consciente de que los datos obtenidos en este primer paso posiblemente no serán los definitivos por encontrarnos en la primera iteración de la espiral de proyecto.

La forma elegida para enfrentarse a la estimación de las dimensiones aproximadas del buque es el análisis estadístico de bases de datos.

A la hora de utilizar una u otra relación, se huirá de regresiones que tengan una incertidumbre excesiva. Es fundamental antes de comenzar las regresiones el analizar la base de datos. Se aplicará el coeficiente de experiencia para averiguar qué datos son útiles y cuál es la mejor variable a utilizar en el análisis.

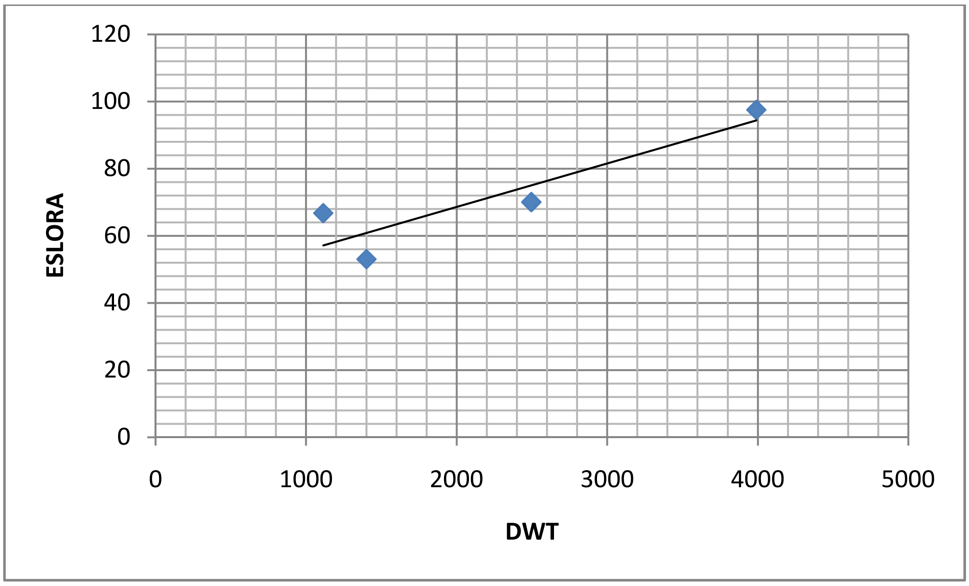
Observando otros buques oceanográficos dotados con los mismos o similares equipos de investigación y con características parecidas al buque del proyecto se puede predecir que dicho buque tendrá unos 70 metros de eslora total, una manga de unos 14 metros, un calado de aproximadamente 4,5 metros y con una potencia propulsiva alrededor de los 2000 kW.

- BASE DE DATOS:

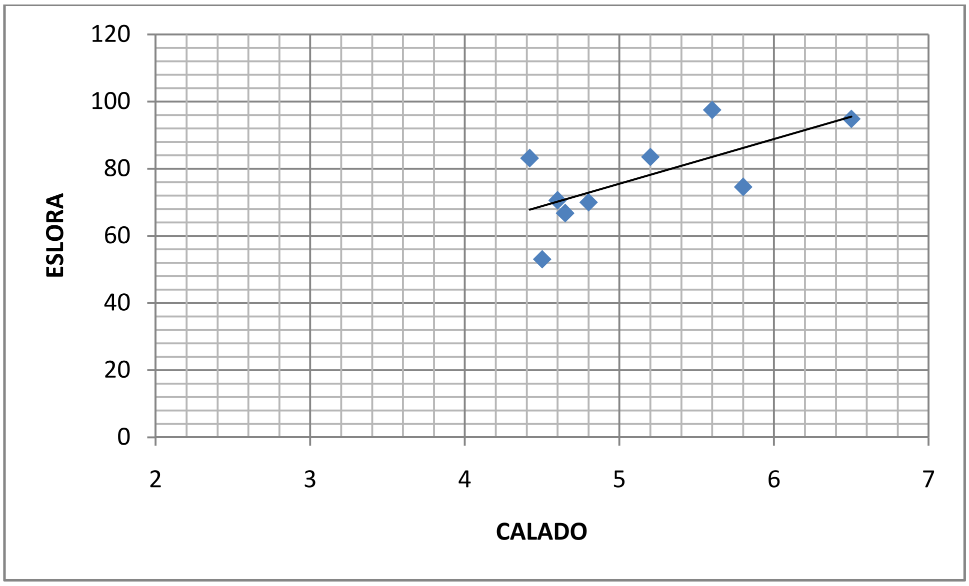
NOMBRE	LOA (m)	B (m)	T (m)	D (m)	BHP (kW)	DWT (GT)	V (nudos)
THALASSA	74,5	14,9	5,8	6	2200		11
HESPERIDES II	83,06	14,33	4,42	5,1	2800		13
GARCIA DEL CID	37,2	8,4	4,7	4,2	1160	285	10
SARMIENTO DE GAMBOA	70,5	15,5	4,6	5,6			15
CORNIDE DE SAABEDRA	66,7	11,25	4,65	5,4	1656	1113	11,1
VIZCONDE DE EZA	53	13	4,5	5	1800	1400	13
FRANCISCO DE PAULA NAVARRO	30,46	7,4	4,26		552		11
EMMA BARDAN	29	7,5	2,6	3,7	900	200	12
MIGUEL OLIVER	70	14,4	4,8	5,8	2000	2495	14
METEOR	97,5	16,5	5,6	6	2300	3990	12
MARIA S. MERIAN	94,8	19,2	6,5				12,2
RONALD H. BROWN	83,5	16	5,2	5,7			12

Tabla 1 Base de datos

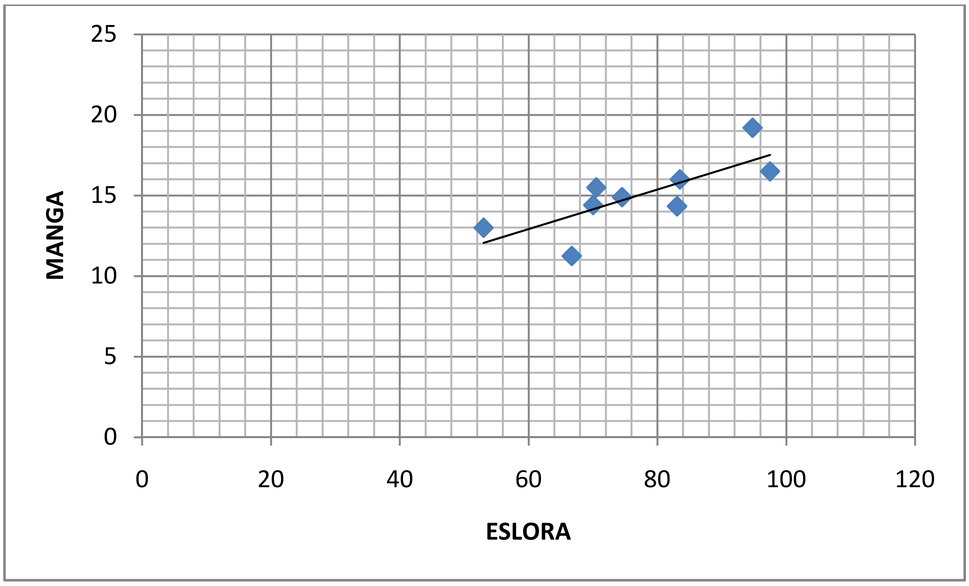
Para saber la bondad de la base de datos se utiliza el coeficiente de determinación R^2. Este valor indica el porcentaje de ajuste que se ha logrado en el modelo lineal mediante la regresión lineal, es decir, el porcentaje de variación de Y que se explica con el comportamiento de X. A mayor porcentaje, mejor es el modelo de predicción del comportamiento de la variable Y. Por este motivo, algunos de los buques de la base de datos no se van a tener en cuenta en las regresiones lineales, la discrepancia entre sus dimensiones y las que se quieren obtener pueden contaminar los resultados.



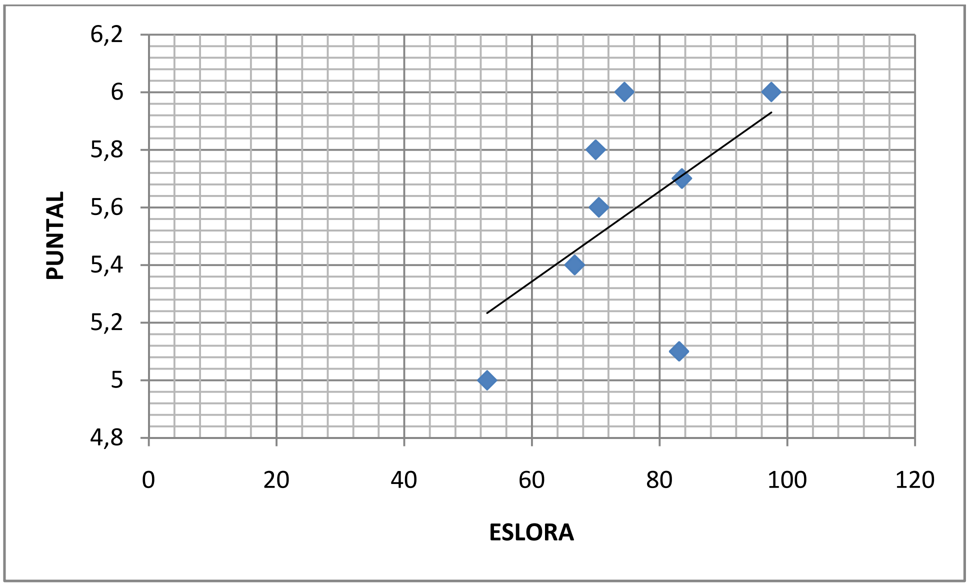
Regresión 1 Eslora vs DWT



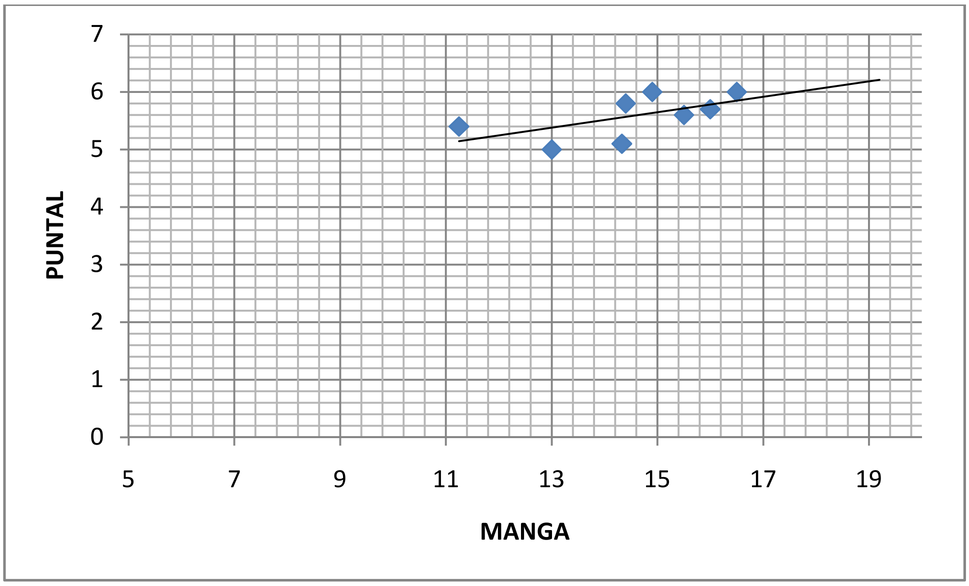
Regresión 2 Eslora vs Calado



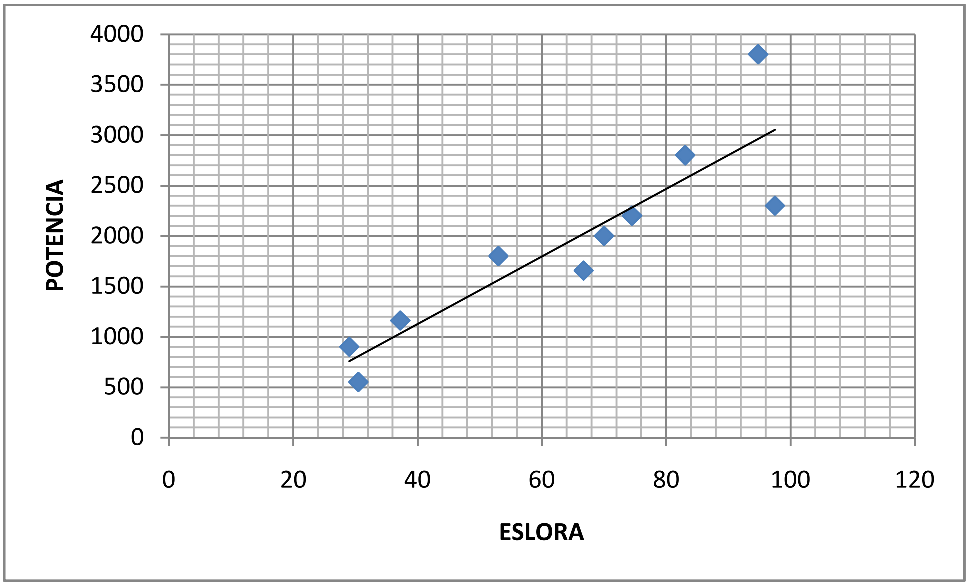
Regresión 3 Manga vs Eslora



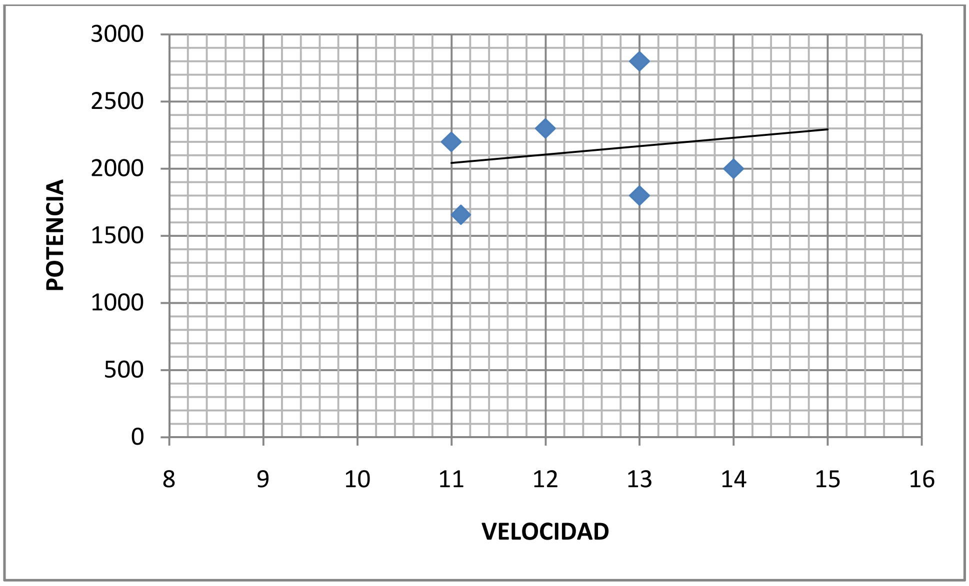
Regresión 4 Puntal vs Eslora



Regresión 5 Puntal vs Manga



Regresión 6 Potencia vs Eslora



Regresión 7 Potencia vs Velocidad

Entrando en las regresiones anteriores con los datos del proyecto (arqueo bruto y velocidad) y teniendo en cuenta restricciones de proyecto como el calado se observa que la eslora será aproximadamente 70 metros, a la espera de comprobar que sea suficiente para la instalación de los servicios necesarios, ésta será la eslora del buque del proyecto.

Una vez conocida la eslora es posible determinar la manga y el calado del buque observando las regresiones que relacionan la eslora con la manga y con el calado, obteniendo así una manga de 14 metros y un calado de 4,8 metros.

El puntal estimado por las regresiones lineales es aproximadamente de 5,2 metros. A falta de comprobar que sea suficiente puntal para ubicar los aparatos de los servicios necesarios.

Por último, también es posible determinar una potencia propulsiva aproximada mediante las regresiones. Se obtiene una potencia de propulsión aproximada de 2100 kW.

Después de esta primera estimación, se pueden definir las características y dimensiones principales del buque tal que así:

- **Eslora:** 70 m
- **Manga:** 14 m
- **Calado:** 4,8 m
- **Puntal:** 5,2 m
- **Velocidad:** 14 kn
- **Arqueo bruto:** 2500 GT
- **Potencia:** 2100 kW

Una vez conocidas las dimensiones del buque han sido introducidas en Maxsurf® las formas de una carena típica de los buques oceanográficos para comprobar si la estimación de potencia es correcta.

A continuación, se presentan las formas típicas que se han escogido:

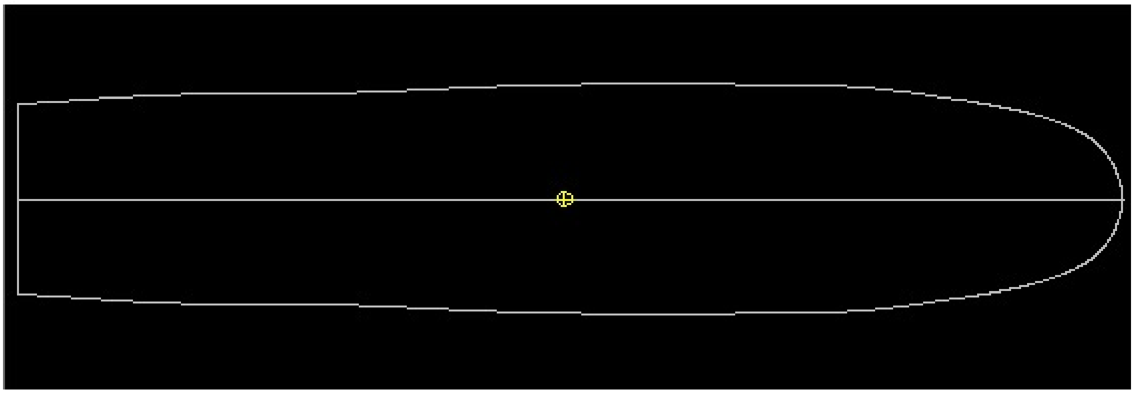


Figura 1 Diseño Maxsurf® en planta

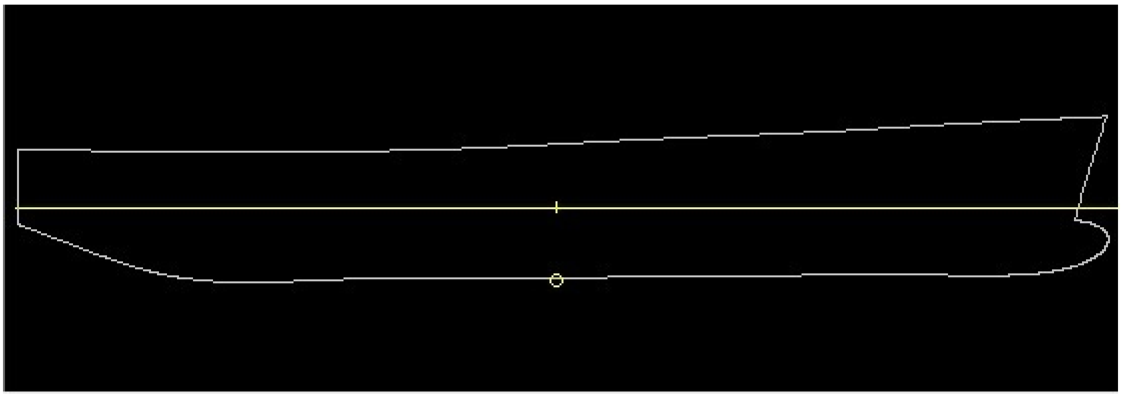


Figura 2 Diseño Maxsurf® vista longitudinal

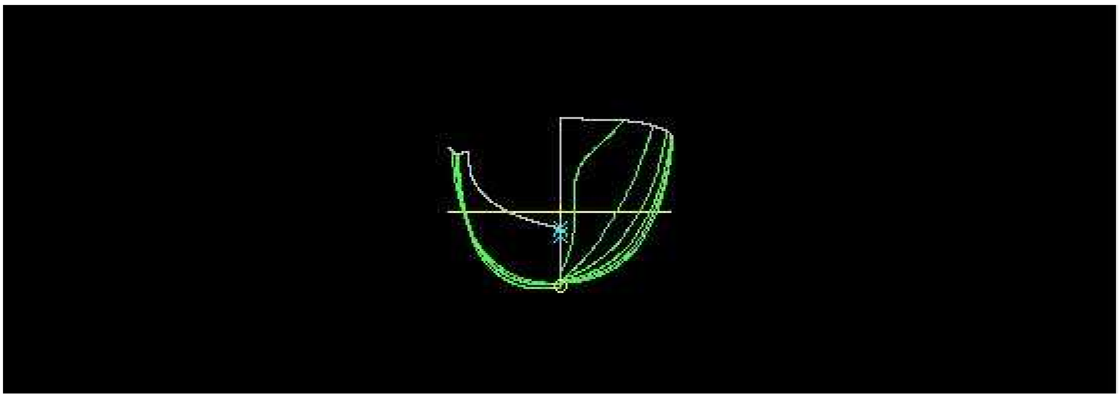


Figura 3 Diseño Maxsurf® vista transversal

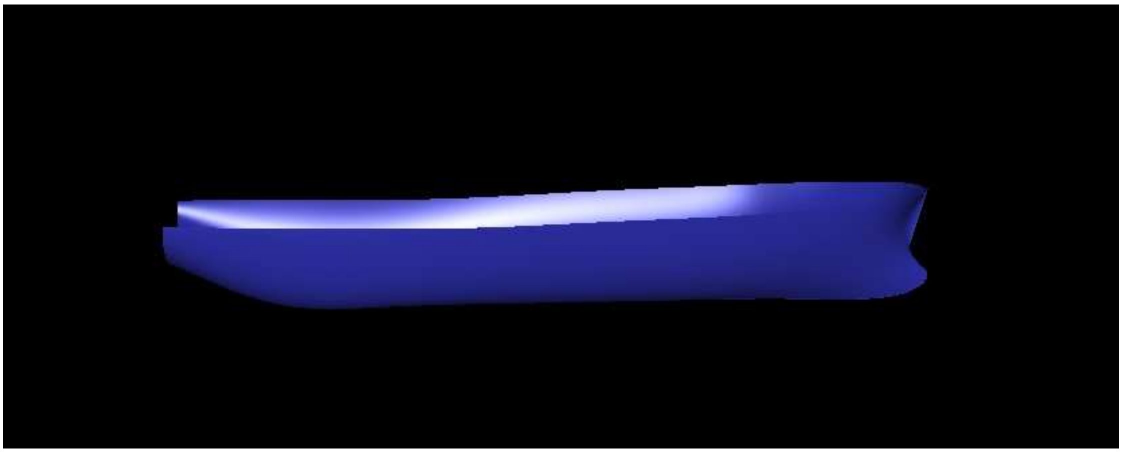


Figura 4 Diseño Maxsurf® renderizado

Una vez hecho el diseño del casco, éste es introducido en el programa Hullspeed® para obtener los datos de potencia necesaria, calculada mediante varios métodos de predicción:

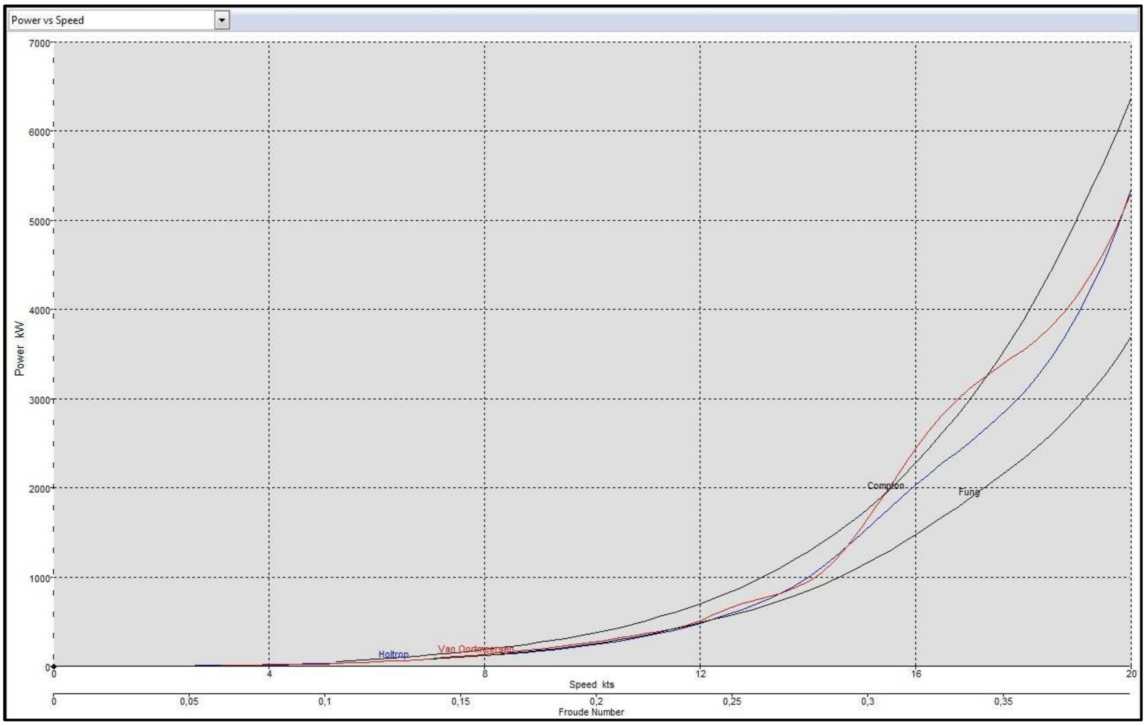


Figura 5 Curva de Potencia vs Velocidad (Hullspeed®)

	Speed (kts)	Holtrop Resist. (N)	Holtrop Power (kW)	Van Oortmeersen Resist. (N)	Van Oortmeersen Power (kW)	Compton Resist. (N)	Compton Power (kW)	Fung Resist. (N)	Fung Power (kW)
1	0	--	--	--	--	--	--	--	--
2	0,5	157,75	0,04	111,03	0,03	--	--	--	--
3	1	575,49	0,3	402,52	0,21	--	--	--	--
4	1,5	1228,55	0,95	857,73	0,66	--	--	--	--
5	2	2104,01	2,16	1469,06	1,51	--	--	--	--
6	2,5	3192,41	4,11	2231,61	2,87	--	--	--	--
7	3	4485,94	6,92	3143,8	4,85	--	--	--	--
8	3,5	5977,85	10,76	4227,01	7,61	--	--	--	--
9	4	7662,01	15,77	5566,83	11,46	--	--	--	--
10	4,5	9532,92	22,07	7300,9	16,9	--	--	--	--
11	5	11585,83	29,8	9542,95	24,55	--	--	--	--
12	5,5	13817,7	39,1	12329,52	34,89	21949,02	62,1	--	--
13	6	16229	50,09	15622,47	48,22	25933,91	80,05	--	--
14	6,5	18826,62	62,95	19339,76	64,67	30229,74	101,08	--	--
15	7	21627,62	77,88	23386,21	84,22	34832,53	125,44	21901,	78,87
16	7,5	24663,34	95,16	27673,82	106,77	39738,38	153,32	25274,	97,52
17	8	27983,19	115,17	32135,36	132,25	45209,63	186,06	29039,	119,51
18	8,5	31657,64	138,43	36744,7	160,68	51083,74	223,38	33240,	145,35
19	9	35779,96	165,66	41442,52	191,88	57333,9	265,46	37840,	175,2
20	9,5	40466,77	197,77	46509,88	227,3	63963,51	312,6	43142,	210,85
21	10	45859,02	235,92	51481,55	264,84	70976,02	365,13	48757,	250,83
22	10,5	52096,86	281,41	58111,92	313,9	80175,6	433,08	54642,	295,16
23	11	59388,12	336,07	64439,35	364,66	90471,34	511,97	61682,	349,05
24	11,5	68041,21	402,54	70563,12	417,46	101602,23	601,09	70084,	414,63
25	12	78049,01	481,82	82712,93	510,61	113600,76	701,3	78919,	487,2
26	12,5	89200,31	573,61	98877,12	635,83	126499,43	813,46	87341,	561,66
27	13	102016,5	682,26	110712,35	740,42	142256,05	951,38	95807,	640,74
28	13,5	117765,4	817,88	118142,46	820,5	159768,05	1109,59	105441	732,29
29	14	138138,5	994,9	131030,89	943,71	178670,52	1286,82	116914	842,04
30	14,5	163633,7	1220,62	158523,07	1182,49	199017,16	1484,56	130268	971,73
31	15	192508,3	1485,52	200891,8	1550,22	220861,7	1704,32	145289	1121,1
32	15,5	221232,3	1764,08	250226,9	1995,28	247285,42	1971,83	161697	1289,3
33	16	246671,9	2030,38	296303,85	2438,91	276666,77	2277,27	179096	1474,1
34	16,5	268098,6	2275,71	332038,34	2818,45	308244,4	2616,48	196970	1671,9
35	17	287289,5	2512,51	355809,05	3111,75	342096,59	2991,82	214910	1879,5
36	17,5	307278,8	2766,36	370856,43	3338,74	378301,62	3405,77	232935	2097,0
37	18	331223,0	3067,13	383196,06	3548,4	419669,09	3886,14	251652	2330,3
38	18,5	361965,0	3444,9	399386,91	3801,05	464902,2	4424,58	272188	2590,4
39	19	402069,7	3930,01	424900,51	4153,17	513158,31	5015,84	295973	2892,9
40	19,5	453964,8	4554,02	463287,53	4647,55	564532,99	5663,21	324556	3255,8
41	20	519987,5	5350,09	516017	5309,24	619121,8	6370,08	359473	3698,5

Tabla 2 Resistencia al avance (Hullspeed®)

De los resultados obtenidos, se descarta:

- El método de Van Oortmensen, por estar basado en la teoría de Havelock's, en la que se sustituye el buque por dos puntos de presión, uno positivo a proa y otro negativo en el codaste, el método presenta inestabilidades en el cálculo de la resistencia residual para números de Froude inferiores a 0,30 (el buque proyectado tiene un número de Froude de 0,27). Además las formas de los buques proyectados a partir de los cuales se ha desarrollado el método, son muy dispares y han quedado un poco desfasadas.

- Método de Compton es un método destinado a buques de vigilancia costera, patruleras y embarcaciones de gran potencia en situación de semiplaneo. Pot tanto, el resultado no se ajustará correctamente a un buque oceanográfico.
- Método de Fung y Liebman, este método es especialmente adecuado para buques de guerra actuales, por ello tampoco se va a tener en cuenta para el estudio de la potencia a instalar en el buque oceanográfico.

El método que se ajusta más en este caso, es el método de Holtrop y Mennen además el buque se ajusta a los rangos de aplicación del método a la perfección. Según este método la potencia efectiva (EHP) necesaria para propulsar el buque a 14 nudos es de 995 kW.

Teniendo en cuenta que el motor propulsor trabaja a un régimen constante del 90% de la potencia nominal, dejando así un margen para otras operaciones o para cuando el buque navegue a plena carga, asumiendo un rendimiento de la línea de ejes del 95% (debido a pérdidas por rozamientos del eje, de la bocina, etc.) y un rendimiento de la hélice del 65%, se llega a la conclusión de que el buque requiere de una potencia propulsiva de 1800 kW para navegar a dicha velocidad.

Queda demostrado así que la estimación de potencia realizada inicialmente por las regresiones es bastante acertada.

4.- Elección del sistema propulsivo

Para la elección del sistema propulsivo se debe tener en cuenta la finalidad a la que el buque está destinado y las distintas situaciones a las que va a estar sometido.

Al tratarse de un buque oceanográfico y sabiendo los equipos de pesca que incorpora se pueden prever distintas situaciones de navegación que deberán tenerse en cuenta al elegir el sistema propulsivo para que éste proporcione el mayor rendimiento posible en las mayores situaciones posibles.

Situación A: el buque en navegación libre, a máxima velocidad, 14 nudos.

Como no requiere de grandes velocidades se pueden descartar los sistemas propulsivos destinados a ese fin, como son los waterjet, hélices de superficie, etc.

Situación B: maniobrando en puerto.

El buque está dotado de 2 hélices transversales para la mejora de la maniobrabilidad de modo que la maniobrabilidad no será un punto decisivo al escoger un sistema propulsivo u otro, de modo que también podría descartarse los azipod, los Voith-Schneider, etc.

Situación C: Arrastrando la red de pesca, faenando.

El sistema propulsivo deberá poder adaptarse para trabajar con el mayor rendimiento posible en un amplio abanico de velocidades (velocidades altas en crucero y bajas faenando).

Situación D: Navegación polar

Los buques oceanográficos suelen estar preparados para una navegación polar entre bloques de hielo de hasta 50 cm de calado. Las velocidades durante estas navegaciones suelen ser muy bajas, distintas a las de crucero o faenando, por lo que también deberá tenerse en cuenta.

Comparando los sistemas propulsivos que poseen otros buques oceanográficos similares se observa que algunos de ellos eran buques destinados a otras tareas, como por ejemplo buques de pesca que han sido reconvertidos en oceanográficos y siguen estando dotados del sistema propulsivo destinado para su primer fin. Este hecho hace que no predomine un solo sistema propulsivo entre todos los buques oceanográficos pero puede usarse de guía para escoger uno u otro.

Teniendo en cuenta todo lo anterior mencionando, se llega a la conclusión de dotar al barco con una sola hélice de palas fijas. Se ha optado por esta solución puesto que se trata del sistema propulsivo más sencillo y barato, que ofrece un rendimiento más que aceptable en todo tipo de navegaciones a las que estará sometido el buque y además, aporta un nivel de fiabilidad adecuado.

Para adaptarse lo mejor posible a las velocidades tan distintas como son la de crucero y la de navegación por los polos se ha optado por utilizar motores eléctricos para hacer girar la hélice, puesto que los motores de combustión interna acoplados directamente no son la opción más adecuada para trabajar a velocidades tan dispares, sobre todo a bajas revoluciones. Para alimentar dichos motores y al resto de equipos del buque (equipos de investigación, servicios, navegación, etc.) se instalarán varios grupos generadores diesel-eléctricos y uno de emergencia situado en un local aparte.

Para la propulsión principal se escoge un innovador sistema diesel-eléctrico con baterías y motores de corriente continua. Un sistema que ya usan no solo buques oceanográficos, sino también el transporte marítimo internacional en general, que se enfrenta a un momento difícil con la escalada de los precios del combustible y las regulaciones ambientales más estrictas.

Los principales beneficios de este sistema son una reducción del 20 al 30% en el consumo de combustible y las emisiones de CO_2 a través de un funcionamiento más eficiente de los motores, aún mayor reducción en otros componentes del escape como el NOx y una reducción en el ruido y las vibraciones producidas en el buque, pudiendo llegar a navegar durante un tiempo determinado, en el caso que fuera necesario, en un modo completamente silencioso con los generadores apagados, utilizando solo la energía almacenada en las baterías.

5.- Determinación de los espacios de cámara de máquinas

Los motores propulsivos se situarán lo más a popa posible del buque de este modo se obtendrá una línea de ejes corta, produciendo menos problemas de alineaciones, vibraciones y ruidos. Como el sistema de propulsión es eléctrico, se podrían distribuir los motores auxiliares a lo largo de la eslora del barco, pero para que la cámara de máquinas sea lo más compacta posible y para que su control esté más focalizado, la cámara de máquinas se encontrará a popa. Estará debidamente compartimentada para que en caso de vía de agua sea posible controlar la situación de la forma más segura. Además, por seguridad, todas las bombas de agua e intercambiadores de calor se situarán en locales distintos al de los motores principales para evitar riesgos en caso de fugas o averías.

La cámara de máquinas dispondrá de dos cubiertas. La inferior donde se situaran los motores propulsores principales y la superior donde irán los grupos generadores diesel-eléctricos. Éstos irán situados en la cubierta superior para que su situación en el buque sea lo más próxima a los motores propulsores, reduciendo así la longitud de los cables y por lo tanto el peso, y sobretodo pérdidas eléctricas.

Además habrá un generador diesel-eléctrico de emergencia situado fuera de cámara de máquinas, en un local distinto, de fácil acceso, donde también se situarán todos los elementos necesarios para el arranque de dicho generador (compresor de emergencia y botella de aire).

En cámara de máquinas también se situarán en distintos locales todos los auxiliares a la propulsión (compresores, depuradoras, bombas, tomas de mar, intercambiadores de calor, tanques auxiliares, talleres, etc.)

6.- Estimación de las dimensiones de cámara de máquinas

Observando las dimensiones de cámara de máquinas de buques similares se llega a la conclusión de que la cámara de máquinas tendrá una eslora aproximada de 13 metros y utilizará toda la manga del buque para poder situar otros equipos, además de los motores principales.

Para hacer una estimación de la eslora de la cámara de máquinas se utiliza la expresión obtenida del "Proyecto básico del buque mercante"

$$L_{CM} = 2{,}53 \cdot L_{pp}^{0{,}34} + 3{,}87x10^{-6} \cdot MCO^{1{,}5}$$

Obteniendo: L_{CM}=13 metros.

La expresión anterior se trata de una fórmula general para todo tipo de buques pero se observa que se asemeja mucho a las dimensiones estimadas.

Puesto que la cámara de máquinas tendrá dos cubiertas en las cuales irán alojados los motores principales y los auxiliares, el puntal de ésta, estará directamente relacionado con las dimensiones de las máquinas, se instalan dos motores eléctricos Indar® de corriente continua de tipo KN-800-S-b-c (cumpliendo la normativa de ruidos y vibraciones transmitidos al agua ICES 209). La potencia de cada motor es de 1000 kW a una velocidad de 0-178 rpm, con una tensión de 725 V cc. Además lleva dos intercambiadores de agua dulce para una temperatura de 32 ºC. Cada motor tiene una altura de 2550 mm. Los motores auxiliares son 4 generadores "Caterpillar® C32" de 1100 kVA capaces de alimentar al buque en la situación de máxima carga con los cuatro motores trabajando al 75% de potencia o 3 de ellos al 100% de carga. Tienen una altura de 2200 mm por lo que el puntal de la cámara de máquinas será capaz de alojar estas máquinas y demás servicios.

Se pueden comprobar estas dimensiones en el plano de disposición general adjunto. (Anexo 1)

7.- Compartimentado de la cámara de máquinas

Para alojar los equipos necesarios y dejar espacio para zonas de trabajo, la cámara de máquinas se compartimentará de la siguiente manera:

- Local principal donde se situarán los motores propulsores principales.

- Local donde se situarán los grupos generadores diesel-eléctricos, en una cubierta superior, encima de los motores principales.

- Local donde estará situado el generador de emergencia, en un local a parte, totalmente independiente, por encima de la línea de flotación.

- Taller mecánico, pañol situado a estribor de cámara de máquinas.

- Taller eléctrico, pañol situado a popa de la cámara de máquinas.

- Local de respetos, pañol situado a popa de la cámara de máquinas.

- Local de baterías, pañol bien ventilado, estanco respecto a la cámara de máquinas y con ventana de alta resistencia para su control. Situado a estribor de la cámara de máquinas.

- Espacio para cuadro eléctrico y demás aparatos eléctricos como el invertidor AC/DC, reguladores de tensión … pegado al mamparo de proa de la cámara de máquinas.

- Pañol de elementos auxiliares del sistema de aire comprimido donde se situarán las botellas y los compresores de arranque de los generadores diesel-eléctricos, situado a babor de la cámara de máquinas.

- Pañol de máquinas auxiliares de propulsión, se instalarán intercambiadores, bombas, purificadoras, tomas de agua, tanques auxiliares y demás equipos auxiliares del buque. Situado a babor de la cámara de máquinas.

Todos estos locales están más detallados en los planos que se presentan en el anexo I.

8.- Elección de la línea de ejes

8.1.- Eje

Compuesta por un solo eje que va desde la hélice hasta la caja de embrague de los motores propulsores principales dispuestos en paralelo, lo que hace una distancia de 15 metros. Sin necesidad de reductora debido a la gran posibilidad de regulación de los motores eléctricos.

Según normativa de Bureau Veritas NR467 "Rules for steel ships – Part C – Machinery – Ch. 1 – Sec 7" el diámetro del eje de empuje y eje de la hélice no será menor que el determinado por la siguiente fórmula:

$$d = F \cdot k \cdot [\frac{P}{n \cdot (1 - Q^4)} \cdot \frac{560}{R_m + 160}]^{1/3}$$

Donde:

- d= Diámetro mínimo requerido.
- Q= Se toma un valor de 0 para ejes macizos.
- F= Factor para el tipo de propulsión, se toma valor 95 para propulsión eléctrica.
- k= Factor para el tipo de eje, 1.1 para el eje porque estará soportado por rodillos y 1.22 para el eje de la hélice.
- n= Velocidad de rotación del eje en rpm, en este caso 178 rpm.
- P= Potencia de la maquinaria de propulsión en kW, en este caso 2000 kW.
- R_m= Tensión mínima específica del material del eje en N/mm^2, se usará acero de aleación por tanto los valores utilizados serán de 800 N/mm^2 para el eje intermedio y 600 N/mm^2 para el eje de la hélice.

Según la fórmula anterior el diámetro del eje será de 205 mm como mínimo, aunque se podrá aumentar hasta 250 mm reduciendo así la carga a la que se somete el material, el diámetro del eje de la hélice será mínimo de 250 mm y fabricados en acero de aleación. Se aplicará un revestimiento metálico para evitar corrosiones con un espesor de 14 mm según la sociedad de clasificación.

Para evitar que entre el agua por el túnel del eje se montará un sistema de estanqueidad.

Se instalarán el suficiente número de casquillos radiales auto-alineables con lubricación por anillo, para fijar el sistema de ejes. Los casquillos de las chumaceras serán de hierro forjado y revestidos con metal blanco. El eje intermedio apoyará en dos cojinetes.

En el pedestal de la chumacera se incorporará un depósito con mirilla para indicación del nivel de aceite. El depósito estará provisto de un serpentín de circulación de agua dulce de refrigeración.

La parte inferior de la chumacera será desmontable y revestida con metal blanco.

En caso de necesidad de sacar el eje se podrá hacer por popa, hacia el exterior, debiendo desmontar anteriormente la pala del timón o por la cámara de máquinas si se quiere evitar desmontar el timón, para ello las bridas del eje no serán de mayor diámetro que el mismo, para poder extraer el eje por la cámara de máquinas, desmontando en primer lugar el eje intermedio acoplado a la caja de embrague.

Entre la caja de embrague y cada motor propulsor se instalará un acoplamiento elástico Vulkan® Rato DG+ con un par nominal de 140 kN·m capaz de soportar el par motor que le transmiten los motores propulsores.

8.2.- Hélice

En este caso, puede ser preferible proyectar la hélice para la condición de arrastre. Se suelen adoptar situaciones de compromiso entre la condición de arrastre y la de navegación libre, pero por la particularidad del proyecto para arrastre conviene examinarlo individualmente.

Selección de la hélice para el buque en condición de arrastre:

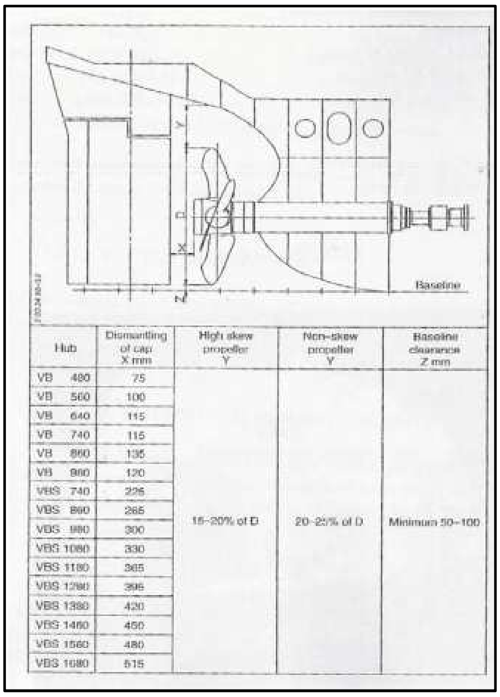
El buque oceanográfico presenta ciertas peculiaridades a la hora de realizar el proyecto de su hélice, pues tiene dos condiciones de operatividad muy distintas:

- Navegación libre: El buque desarrolla la potencia de su motor para que alcance la mayor velocidad posible.
- Arrastre: El buque debe desarrollar la potencia de su motor, a una determinada velocidad (de 3 a 6 nudos) dando la hélice el mayor empuje posible.

Sabiendo la potencia del motor (se suele proyectar la hélice para el 90% de la potencia máxima del motor), las revoluciones (en este caso el punto de proyecto adecuado de la hélice es para el 90% de las rpm existiendo así un cierto margen de aligeramiento aprovechable en la condición de navegación libre), la velocidad del buque en condición de arrastre (suele oscilar entre 3 y 6 nudos) y el coeficiente de estela calculado por Holtrop es:

$$w = C9 \times C20 \times Cv \times \frac{LWL}{TA} \times \left(0.050776 + 0.93405 \times C11 \times \frac{Cv}{1 - CP1}\right) + 0.27915 \times C20 \times$$
$$\times \sqrt{\frac{B}{LWL} \times (1 - CP1)} + C19 \times C20 = \mathbf{0.24}$$

Huelgos y distancias que debe respetar la hélice:



Hub	Dismantling of cap X mm	High skew propeller Y	Non-skew propeller Y	Baseline clearance Z mm
VB 480	75	15-20% of D	20-25% of D	Minimum 50-100
VB 560	100			
VB 640	115			
VB 740	115			
VB 860	135			
VB 980	120			
VBS 740	225			
VBS 860	265			
VBS 980	300			
VBS 1080	330			
VBS 1180	365			
VBS 1280	395			
VBS 1380	420			
VBS 1460	450			
VBS 1560	480			
VBS 1680	515			

Figura 6 Huelgos y distancias de la hélice

A partir de las dimensiones y las formas del buque proyectadas anteriormente, se obtiene:

- Inmersión del eje (h): 3,2 metros
- Diámetro máximo de la hélice (D_{max}): 3 metros
- Número de palas de la hélice (Z): 5 palas

El proceso de cálculo es el siguiente:

$$\mathrm{DHP} = \frac{BHP}{1.026} \times \eta_R \times \eta_M$$

$$Q_{max} = \frac{DHP \times 75}{2\pi n}$$

$$V_A = V(1 - w_T)$$

Se escogen dos relaciones Ae/Ao para las que exista diagrama y que abarque la realción Ae/Ao que se estima vaya a tener la hélice. Se seleccionan los correspondientes diagramas K_T-J, K_Q-J y se sigue el proceso que sigue a continuación.

Se eligen 3 diámetros menores o iguales que $D_{max.}$ Para cada uno de ellos se calcula:

$$J = \frac{V_A}{nD}$$

$$K_Q = \frac{Q_{max}}{\rho n^2 D^5}$$

Cálculos en hoja de cálculo Excel®:

DHP (CV)	2266,666
Qmax (kg·m)	10133,460
Va (m/s)	1,1575
n (rps)	2,670

B5-60:

D (m)	J	Kq	H/D	Kt	T (kg)	Ae/Ao min	Ae/Ao real	Cavitación
2,6	0,166	0,114	1,400	0,550	18739,455	0,383	0,6	NO
2,8	0,154	0,078	1,100	0,450	20622,699	0,374	0,6	NO
3	0,144	0,0555	0,950	0,390	23553,231	0,373	0,6	NO

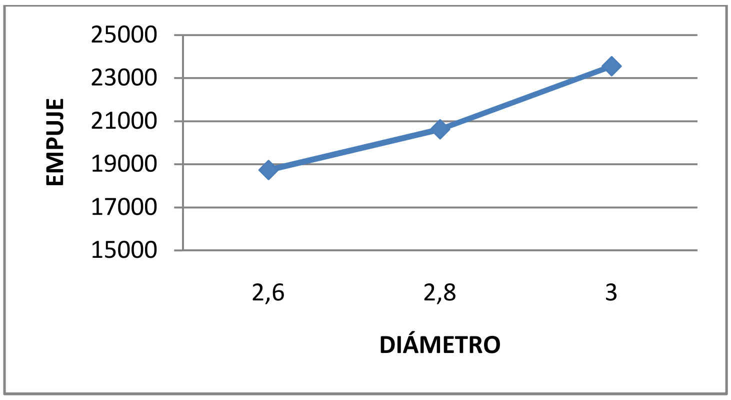


Figura 7 Empuje vs Diámetro de la hélice B5-60

B5-75:

D (m)	J	Kq	H/D	Kt	T (kg)	Ae/Ao min	Ae/Ao real	Cavitación
2,6	0,166	0,114	1,325	0,570	19420,889	0,390	0,75	NO
2,8	0,154	0,078	1,125	0,480	21997,546	0,385	0,75	NO
3	0,144	0,055	0,930	0,400	24157,160	0,377	0,75	NO

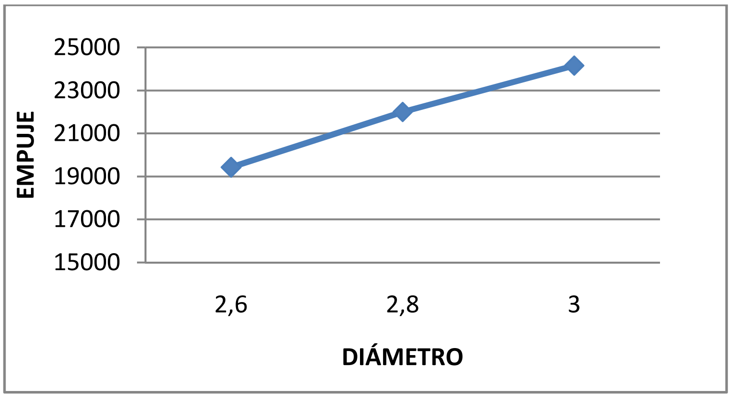


Figura 8 Empuje vs Diámetro de la hélice B5-75

Como se ha visto, la curva T-D no presenta ningún máximo por tanto se toma como diámetro óptimo de la hélice el diámetro máximo de 3 metros. Los parámetros de la hélice obtenida son:

- **Diámetro:** 3 m
- **Empuje máximo:** 24157,16 kg
- **Relación Paso/Diámetro:** 0,93
- **Relación Área expandida/ Área disco:** 0,75

Una vez escogido el propulsor hay que saber si será capaz de dar la velocidad requerida en navegación libre, al pasar de las condiciones de tracción a las condiciones de navegación libre, la velocidad del buque aumenta, aumentando por consiguiente la V_A y J y disminuyendo K_Q. La hélice aumentará las revoluciones hasta las 178 rpm. Se supone el valor de la velocidad, que en este caso es una especificación de proyecto (14 nudos) y se calcula el valor de J, a partir de aquí, se calcula el par, la potencia del motor y la potencia efectiva.

D (m)	3
n' (rps)	2,966
Va' (m/s)	5,401
J'	0,606
Q' (kg·m)	7828,709
DHP' (CV)	1945,707
BHP' (CV)	2107,201
EHP' (CV)	1312,675
EHP' (kW)	965,46

Con el valor de EHP y velocidad, se entra en la curva EHP= f(V) calculada anteriormente por el método de Holtrop y Mennen:

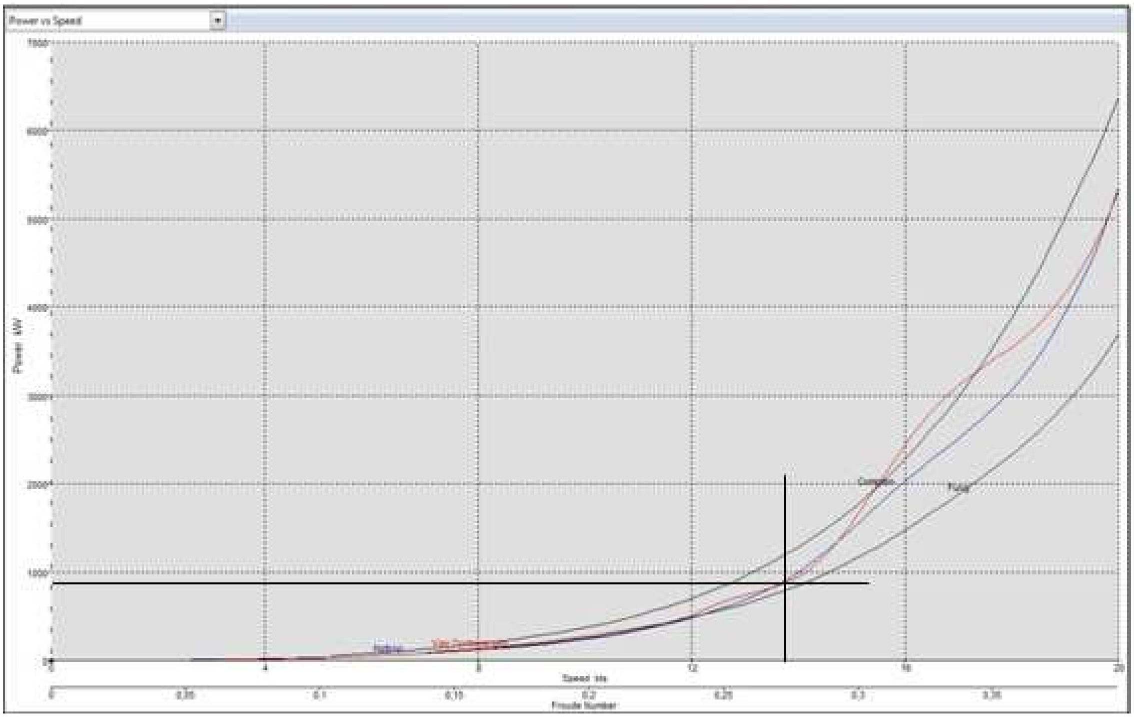


Figura 9 Potencia vs Velocidad de la hélice

Como el punto cae sobre la curva representación de EHP= f(V), la velocidad ensayada es la que realmente dará el barco en navegación libre. Por tanto, se da como seleccionada la hélice óptima para el buque oceanográfico.

9.- Elección y situación de las máquinas propulsoras principales

En cámara de máquinas se situarán los motores propulsores principales. Por la potencia requerida, su tamaño y el espacio disponible se montarán varios motores en paralelo en lugar de uno solo de mayor potencia, obteniendo además un mayor grado de fiabilidad en caso de averiarse cualquiera de ellos. Los motores escogidos son dos Indar® de corriente continua de tipo KN-800-S-b-c de 1000kW cada uno con lo que se tiene un margen por envejecimiento. Para el sistema de transmisión en paralelo, se instalará un Wärtsilä Twin Input-Single Output modelo TCH 240, especialmente diseñado para motores eléctricos. Los motores se situarán lo más a popa posible, dejando espacio suficiente por los dos costados para poder realizar el mayor número de tareas de mantenimiento necesarias sin necesidad de sacar los motores del buque.

La elección de motores de corriente continua, entre otras cosas se debe a que los buques oceanográficos más modernos y avanzados (RSS Discovery, Miguel Oliver, Celtic Explorer…) están utilizando este novedoso sistema de propulsión más silencioso para los trabajos de investigación. El innovador sistema sustituye al tradicional método de propulsión. Es un sistema diesel eléctrico en el que dos motores eléctricos de corriente continua y 1000 kW y sus respectivos reguladores de tensión (para controlar la velocidad de giro del motor) accionan en paralelo la hélice. De esta manera se dota al sistema propulsor de una alta capacidad de regulación de la velocidad, de recuperación de energía y del resto de complejos requerimientos que este buque podrá alcanzar. Con todo esto, es la mejor solución para las operaciones de bajo nivel de ruido y además cumpliendo con la estricta normativa de ruidos y vibraciones transmitidos al agua ICES 209.

Para soportar el peso de los motores principales se pondrán unos refuerzos bajo dichos motores, anclados a los refuerzos de la estructura del buque.

Para dimensionar los refuerzos del polín se deberá tener en cuenta, entre otras cosas, el peso de los motores y las vibraciones que producen, de modo que los refuerzos deberán ser lo suficientemente resistentes para soportar los motores y transmitir los esfuerzos a la estructura.

Según Bureau Veritas, la bancada de las máquinas ha de ser fijada firmemente a la estructura de soporte por medio de pernos de anclaje que se van a distribuir tan uniformemente como sea posible y de un número y tamaño suficientes para una adecuada sujeción.

Cuando las placas de soporte inciden directamente sobre la plancha del fondo interior, los tornillos deben estar equipados con juntas adecuadas para asegurar un ajuste apretado y se disponen con sus cabezas dentro del doble fondo.

El contacto permanente entre placas de soporte y las fundaciones a lo largo de la línea de atornillado se consigue por medio de cuñas de espesor adecuado para un contacto completo.

Se debe tomar especial cuidado para obtener la nivelación y alineación general entre los motores de propulsión y el sistema de ejes.

La situación de la maquinaria propulsora principal se dispone en los planos que se adjuntan. (Anexo I)

10.- Balance eléctrico

Algunos de los datos de consumos del balance eléctrico han sido obtenidos de otros buques similares, como por ejemplo:

- Para los consumidores de habilitación se han obtenido los datos a partir del buque oceanográfico Cornide de Saabedra puesto que tiene unas capacidades de tripulación similar a la del buque proyecto.
- Para los consumidores de mando, vigilancia y ayudas a la navegación, se ha utilizado el buque oceanográfico Sarmiento de Gamboa puesto que se trata de un buque de dimensiones parecidas y destinado a labores muy similares, por lo que irá equipado con los mismos sistemas de navegación.
- Para los consumos más específicos de un buque oceanográfico con estas características (aparatos de pesca de fondo y semipelágica, así como grúas hidráulicas, planta de clasificación y procesado del pescado, gambuzas, laboratorios, etc) los datos han salido del buque oceanográfico Miguel Oliver puesto que se trata de un buque dotado con los mismos equipos que se supone requerirá el buque proyecto.

Para el resto de consumidores eléctricos se han obtenido las especificaciones necesarias en el catálogo del fabricante.

El balance eléctrico se adjunta en el Anexo II.

11.- Elección de las máquinas auxiliares principales

Una vez determinado el balance eléctrico, se eligen cuatro grupos diesel-generadores Caterpillar® C32 de 880 ekW a 1500 rpm y 1100 kVA cada uno para proporcionar energía suficiente al buque en la situación de navegación (es la situación que más energía consume). Para la elección de estos generadores se ha tenido en cuenta que pueden trabajar 3 de ellos a plena carga o los 4 al 75%, por lo que se obtiene así un margen en caso de avería de alguno de ellos o necesidad de realizar el mantenimiento o alguna reparación. Los generadores diesel-eléctricos principales se situarán en una cubierta superior de la cámara de máquinas, lo más cerca posible de los motores eléctricos principales

Para la condición de puerto se ha elegido un generador Caterpillar® C15 de 360 ekW y 450 kVA para poder suministrar la energía necesaria al buque trabajando a un 75% de carga.

Además habrá un generador de emergencia igual que el generador de puerto, que será autosuficiente y estará situado en un local aparte. Éste también estará conectado al cuadro eléctrico de la sala de máquinas para poderlo utilizar en la propulsión en caso de emergencia y conseguir así un sistema aún más fiable.

El combustible que alimenta a estos generadores es Marine Diesel Oíl, entre otras razones se ha escogido este tipo de combustible por ser un producto de fácil suministro en cualquier parte del mundo, éste es un factor importante ya que el buque operará en zonas donde no es probable encontrar suministro de gas hoy en día.

Los generadores escogidos son de la marca Caterpillar®, de la sección de productos marinos, ya que tienen una amplia gama de productos y se han podido escoger los más idóneos para que se adapten a esta situación. En la página oficial se obtienen los datos según el fabricante de consumos, peso, dimensiones, capacidad de aceite, capacidad de agua de refrigeración, consumo de aire, etc. para cada uno de sus modelos.

En los tres casos se instalarán aisladores de vibración, también suministrados por Caterpillar®, con un 95% de eficiencia. Además, se instalarán dentro de cajas insonorizadas para reducir al mínimo el ruido radiado.

El sistema de almacenaje de energía será por baterías de tecnología ion de litio, por su alta densidad de energía que se traduce en mayor carga por unidad de peso, proporcionan un alto voltaje, descargan linealmente y tienen una gran vida útil con el mínimo coste de mantenimiento.

Se instalará el paquete de baterías Intensium Max® IM 20M de la marca Saft® que puede llegar a proporcionar una descarga continua de 1100 kW y el voltaje necesario para mover uno de los motores sin necesidad de los generadores, es decir, sin producir ruidos ni vibraciones durante un tiempo, en caso que fuera necesario, para alguna toma de datos. Para las demás situaciones en las que se necesiten los 2000 kW de propulsión se instalará un convertidor AC/DC Sinvert PV Inverter modelo 2000 MS TL de Siemens® entre los generadores diesel-eléctricos y los motores propulsores.

Las especificaciones de estos productos se adjuntan en el Anexo III.

En los planos que se adjuntan se puede observar la distribución general de dichos generadores (Anexo I).

12.- Cálculo del volumen de los tanques

El buque deberá disponer, por especificaciones de proyecto, de una autonomía de 4500 millas náuticas para realizar sus labores como buque oceanográfico. Factor a tener muy en cuenta ya que, junto con el consumo de los motores, determinarán el volumen de los tanques de combustible.

Al tratarse de una autonomía considerable, dichos tanques ocuparán cierto volumen en el buque que condicionará la disposición general y la distribución de pesos.

Además de los tanques de combustible se deberán tener en cuenta también los tanques de aceite lubricante, tanques de agua técnica, tanques de agua potable, tanques de lastre, etc.

12.1.- Volumen de los tanques de agua potable

El volumen de los tanques de agua se puede estimar mediante la fórmula siguiente:

$$V_{agua} = \mathrm{k} \times \mathrm{N} \times \mathrm{d}$$

Donde:

- k es el consumo diario de agua por persona y día, aproximadamente 150 litros.
- N es el número de personas a bordo, 45 personas
- d es la relación entre autonomía y velocidad del buque.

Al tratarse de un buque oceanográfico se debe tener en cuenta que el buque no estará siempre navegando a velocidad de crucero, como lo hacen los cruceros o cargueros que van de un destino a otro. En este caso el buque sale de puerto hasta llegar al lugar de destino y puede quedarse allí operando durante días, ya sea pescando y procesando el pescado, tomando mediciones del agua de mar, etc. Por lo que en este caso se toma como dato de autonomía alrededor de un mes, lo que supondrá una estimación del volumen de tanques de agua dulce de 200 m^3.

Además, el buque contará con un generador de agua dulce. El agua producida a bordo es agua destilada a baja temperatura, lo que significa que la posible carga biológica que tuviera el agua de mar no ha sido eliminada. Además, la acidez del agua destilada la hace peligrosa para usos industriales. Por esta razón se hace necesario el tratamiento posterior del agua destilada, tanto si va a ser usada en procesos industriales, como si se va a destinar al consumo humano.

12.2.- Volumen del tanque de aceite de lubricación

Para la estimación de los tanques de aceite lubricante de los grupos generadores principales se utilizará la siguiente expresión:

$$V = \frac{1{,}7 \times BHP}{1000}$$

Sabiendo que el buque está equipado con 4 grupos generadores de 880 kW cada uno más un grupo generador de puerto de 360 kW obtenemos un volumen de 6,5 m^3.

Aplicando los siguientes márgenes:

- Márgenes estructurales 2%
- Margen por aspiración de tuberías 5%
- Margen por expansión de gases 4%

Queda un volumen total de aceite de lubricación de 7,2m^3.

12.3.- Volumen de tanques de combustible

Según los datos de proyecto el buque debe poder navegar durante 4500 millas náuticas sin parar en puerto a una velocidad de 14 millas/hora. Esto supone 322 horas de navegación de forma continuada.

Conociendo los datos de los consumos específicos de los grupos generadores facilitados por el fabricante podemos dimensionar los tanques de combustible.

Sabiendo que cada grupo diesel-generador consume 240 litros/hora y que el barco debe ser capaz de navegar durante 322 horas ininterrumpidas obtenemos un valor total de 310000 litros, es decir, 310 m^3.

Aplicando las siguientes correcciones:

- Margen por temperatura 2%
- Margen por puerto 10%
- Margen por poder calorífico 4%
- Margen estructural 2%
- Margen por tuberías 5%
- Margen por expansión de gases 4%

Obtenemos un volumen total de tanques de combustible de 394 m^3.

En este cálculo se ha tenido en cuenta una situación de máxima exigencia, es decir, el buque navegando 24 horas seguidas y con la mayoría de los consumidores a plena carga durante todo el tiempo. Se trata de una situación que no llegará a suceder (excepto en algún caso puntual durante un tiempo concreto) por lo que tomar un volumen de tanques de combustible de 394 m^3 es bastante conservador.

12.4.- Volumen tanques servicio diario

Según el Reglamento SOLAS, Capítulo II-1, Parte C, Regla 26.11 todo buque nuevo debe estar provisto de dos tanques de servicio destinados a cada tipo de combustible utilizado a bordo para la propulsión y los servicios esenciales, o medios equivalentes, cuya capacidad mínima de suministro sea de 8 horas para una potencia continua máxima de la planta propulsora y una carga normal de funcionamiento en el mar de la planta electrógena. Sin embargo lo habitual es darle una capacidad unitaria tal que albergue suficiente combustible para que los motores funcionen 24 horas a la potencia MCR.

Con el tiempo, se forman sólidos de parafina si la temperatura es lo suficientemente baja. Por tanto, se considera hacer pasar las tuberías de retorno de agua de refrigeración por estos tanques para calentar el combustible y evitar esta disociación de parafinas, además se conseguirá enfriar el agua de refrigeración antes de llegar al intercambiador.

Esta reducción de la capacidad del tanque por el espacio que ocuparán las tuberías hay tenerla en cuenta para respetar siempre la consideración de 24 horas de capacidad. En consecuencia, se estima que es necesario aumentar la capacidad de los tanques un 5%.

Es conveniente añadir un margen por temperatura y un margen por poder calorífico. Una vez calculada la capacidad del combustible de los tanques de servicio diario, se obtendrá el volumen del mismo haciendo una corrección del 5% por refuerzos internos del tanque y un 2 % de factor de llenado. La corrección de factor de llenado es una exigencia de MARPOL y dice lo siguiente; "Capacidad del tanque de combustible líquido" es el volumen de un tanque, en m^3, con un nivel de llenado del 98%.

Tendrán los fondos inclinados (10% min.), para permitir el drenaje, en caso que fuera necesario, de los lodos que se acumulen en el tanque. También estarán aislados térmicamente con una capa de 100 mm de lana de mineral de roca.

Por tanto, aplicando las correcciones de los márgenes antes mencionados se llega a un volumen de tanque de servicio diario de 40 m^3.

Estos mismos tanques servirán también como tanque de servicio diario para el generador en puerto, puesto que, aunque no se haya tenido en cuenta para el cálculo, en situación de puerto no tendremos el consumo de la propulsión (que es mucho mayor que el consumo de dicho generador), de modo que podrá utilizarse como tanque de servicio diario para el generador en puerto.

12.5.- Volumen tanque de reboses

La capacidad del tanque de reboses será el necesario para abastecer a los motores durante cinco horas, que hace un total de 640 litros. Aplicando los márgenes, el volumen del tanque de reboses no será inferior a 0,7 m^3.

12.6.- Volumen tanque de lodos

El tanque de lodos almacena los lodos que se obtienen al vaciar el fondo de los tanques de servicio diario, así como los residuos procedentes de las depuradoras de combustible, de aceite y la separadora de sentinas.

Las descargas del tanque de lodos se deben poder enviar a:

- Tanques de recepción en tierra
- Incinerador
- Tanques de aguas aceitosas a través de una manguera con una válvula de no retorno, una válvula de cierre y un sifón.

Este tanque debe poder acoplarse con el conducto de las instalaciones de recepción mediante su conducto de descarga. Para ello, estará provisto de una conexión universal cuyas dimensiones se especifican en el Convenio MARPOL, Anexo I, capítulo III, regla 13 (conexión universal a tierra)

La capacidad del tanque de lodos viene reglamentada por MARPOL (Reglas para la prevención de contaminación por hidrocarburos), la regla 15 (Tanques para residuos de hidrocarburos-fangos). Este distingue a tal efecto las siguientes clasificaciones de buques:

- Buque que no lleva agua de lastre en los tanques de combustible líquido
    - Sin incinerador
    - Con incinerador
- Buque que lleva agua de lastre en los tanques de combustible líquido

Este buque puede llevar agua de lastre en los tanques de combustible líquido y dispondrá de un incinerador. En consecuencia MARPOL prescribe la capacidad mínima de los tanques de fangos en 1 m^3 para buques de arqueo bruto igual a superior a 400 pero inferior a 4000 GT.

Por la peculiaridad del buque oceanográfico, éste operará durante largos períodos de tiempo en zonas especiales como el ártico o el báltico, donde no es posible evacuar ningún tipo de residuo, por tanto, se amplía el volumen de este tanque, con un margen de sobras aprovechando el espacio estructural del doble fondo, hasta los 9 m^3.

12.7.- Volumen tanque aguas aceitosas

Según las especificaciones del proyecto y la posibilidad del buque de pasar largas temporadas en zonas especiales, el tanque de aguas aceitosas tendrá una capacidad de 150 m^3.

12.8.- Volumen tanque agua técnica

Los tanques de agua técnica tendrán una capacidad de 2 a 5 de la capacidad total del circuito de refrigeración.

Según los datos del fabricante, se realiza un dimensionamiento de la capacidad del sistema de refrigeración de los principales consumidores como por ejemplo motores auxiliares de generación de energía eléctrica, compresores, equipos eléctricos de los motores propulsores, etc. y estimando el volumen interior de las tuberías del circuito. Lo que da un total de 3,75 m^3, la capacidad del tanque de agua técnica será de 5 veces ese valor, por tanto, el tanque de agua técnica tendrá un volumen de 18,75 m^3.

12.9.- Comprobación de volúmenes

Para la distribución de los tanques es imprescindible tener en cuenta el espaciado entre cuadernas y los espesores estructurales, por tanto, no siempre el volumen real del tanque coincide con el deseado. Así que a continuación se dispone a la comprobación para que las capacidades de los tanques en el plano sean iguales o superiores a las necesarias, teniendo en cuenta el espaciado entre cuadernas y los espesores estructurales:

Se necesitan las siguientes capacidades:

- Agua dulce potable: 200 m^3
- Aceite lubricación: 7,2 m^3
- Combustible: 394 m^3
- Reboses: 0,7 m^3
- Lodos: 9 m^3
- Tanques servicio diario: 40 m^3
- Aguas aceitosas: 150 m^3
- Agua técnica: 18,75 m^3

Se han obtenido los siguientes volúmenes de los tanques, teniendo en cuenta los espesores de las planchas y los refuerzos:

12.9.1.- Combustible:

- Tanque número 6: 74,14 m^3
- Tanque número 7: 247,9 m^3
- Tanque número 8: 74,14 m^3

Total: 396,18 m^3

12.9.2- Servicio diario:

- Tanque número 9: 25 m^3
- Tanque número 16: 25 m^3

12.9.3.- Agua lastre:

Algunos de los tanques de lastre podrán cargar lastre o combustible según las necesidades de la campaña a realizar. Del tanque número 14 en adelante, los tanques serán polivalentes con lo que se conseguiría aumentar la capacidad de combustible, en caso de ser necesario, en 594,7 m^3.

- Tanque número 1: 68,75 m^3
- Tanque número 2: 68,75 m^3
- Tanque número 3: 80 m^3
- Tanque número 4: 80 m^3
- Tanque número 5: 80 m^3
- Tanque número 13: 30 m^3
- Tanque número 14: 66 m^3
- Tanque número 15: 54,5 m^3
- Tanque número 17: 143,9 m^3
- Tanque número 18: 143,9 m^3
- Tanque número 19: 50 m^3
- Tanque número 20: 50 m^3
- Tanque número 25: 56,4 m^3

Total: 972,2 m^3

12.9.4.- Lodos:

- Tanque número 10: 9 m^3

12.9.5.- Tanque de reboses:

- Tanque número 11: 0,8 m^3

12.9.6.- Aguas aceitosas:

- Tanque número 23: 80 m^3
- Tanque número 24: 80 m^3

Total: 160 m^3

12.9.7.- Agua técnica:

- Tanque número 13: 19 m^3

12.9.8.- Aceite lubricación:

- Tanque número 12: 8,61 m^3

12.9.10.- Agua dulce:

- Tanque número 21: 102 m^3
- Tanque número 22: 102 m^3

Total: 204 m^3

Como se puede comprobar el volumen de los tanques teórico y estructural coinciden salvando los márgenes.

La situación de los tanques se dispone en el plano adjunto. (Anexo I)

13.- Áreas para cuadros eléctricos y de tuberías

Los cuadros eléctricos se situarán en un local situado a proa de cámara de máquinas. Los motores principales, al ser eléctricos, necesitan de protección IP55, asilamiento H, calentamiento F (situados en el cuadro eléctrico, en el mamparo de proa de la cámara de máquinas).

Las tuberías pasarán por el techo y por los costados de cámara de máquinas, siempre y cuando estén bien protegidas de posibles golpes y no entorpezcan las tareas de mantenimiento del personal ni las salidas de emergencia. Se harán aligeramientos en mamparos y se le dará a la geometría de la estructura de los tanques la forma necesaria para el paso de las tuberías.

14.- Distribución general

La disposición general se puede observar con mayor detalle en los planos que adjuntamos al final del proyecto (Anexo 1). El buque estará dividido en varias zonas, dedicadas a tareas diferentes, concretamente se pueden destacar:

- Zona de popa: de 18 metros de longitud, en tres niveles diferentes (fondo cubierta principal y superior) está dedicada a tareas de pesca incluyendo recogida, selección y proceso del pescado, así como almacenamiento.
- Zona de propulsión: los siguientes 13 metros, están dedicados a la propulsión, con los motores propulsores en el fondo y con los auxiliares a la propulsión formando la cámara de máquinas. Los cuatro grupos generadores de energía se sitúan encima, ocupando dos entrepuentes.
- Zona central: Por debajo de la cubierta de francobordo, se ha centralizado toda la habilitación, incluyendo camarotes, espacios comunes y laboratorios en las diferentes cubiertas.
- Zona de proa: está reservada para gambuzas, pañoles y tanques.

A continuación se describe brevemente el contenido de cada una de las cubiertas:

En el doble fondo se encuentran los tanques de combustible, aceite, agua de lastre y dulce y demás, dejando algunos espacios libres para tomas de mar, espacios de sentinas, locales de hélices, etc.

En la cubierta de doble fondo que se encuentra entre la cubierta principal y el doble fondo, se encuentran de popa a proa: el motor eléctrico de la hélice de popa, los motores eléctricos propulsores, taller de electricidad, maquinaria de pesca, centrales hidráulicas para maquinaria de cubierta, taller mecánico, cámara de auxiliares (bombas, intercambiadores de calor, tomas de mar, depuradoras, compresores, tanques auxiliares y demás auxiliares del buque.

En la cubierta principal están situados de popa a proa: local del servo, cámara de control de máquinas y cámara de grupos generadores.

15.- Listado de equipos a tener en consideración

Al tratarse de un buque oceanográfico se deber tener en cuenta que el buque irá dotado con multitud de equipos para poder realizar las tareas a las cuales está destinado el buque y que, por lo tanto, no pueden despreciarse.

Equipos comunes en la mayoría de buques:

- Sistemas de navegación (gps, plotter, sonda, radiocomunicaciones)
- Sistema de amarre y fondeo (anclas, cadenas, cajas de cadenas, molinetes)
- Sistema de lastre y achique (tomas de mar, bombas, válvulas, tuberías, filtros)
- Sistema de gobierno y maniobra (servomotor, timón, hélices transversales)
- Sistema de contraincendios y baldeo (tanque hidróforo, bombas, hidrantes)
- Sistema de combustible y aceite lubricante
- Sistema de refrigeración
- Sistema de ventilación
- Sistema de seguridad y salvamento (embarcaciones auxiliares)
- Sistemas auxiliares (caldera, separadora centrífuga)

Equipos comunes en buques oceanográficos:

- Grúa hidráulicas y pluma
- Sistemas de pesca
    - Portón de popa
    - Tambor de redes
    - Cabrestante
    - Maquinilla de arrastre, maquinilla auxiliar de malletas, maquinilla de sondas, maquinilla oceanográfica eléctrica, pescante
    - Peceras
- Sistema de congelación y conservación del pescado (compresores, túnel de congelación)
- Sistema de procesado y tratamiento del pescado (cinta transportadora de recogida, clasificado y desperdicios)
- Laboratorios

16.- Sistema de combustible

El sistema de combustible se divide en tres subsistemas:

- Sistema de almacenamiento.
- Sistema de trasiego y purificación.
- Sistema presurizado de alimentación.

16.1.- Sistema de almacenamiento:

El buque dispondrá de los siguientes tanques del sistema de combustible (calculados anteriormente):

Combustible:

- Tanque número 6: 74,14 m^3
- Tanque número 7: 247,9 m^3
- Tanque número 8: 74,14 m^3

Total: 396,18 m^3

Tanques polivalentes de agua de lastre o combustible, según necesidades de la campaña:

- Tanque número 13: 30 m^3
- Tanque número 14: 66 m^3
- Tanque número 15: 54,5 m^3
- Tanque número 17: 143,9 m^3
- Tanque número 18: 143,9 m^3
- Tanque número 19: 50 m^3
- Tanque número 20: 50 m^3
- Tanque número 25: 56,4 m^3

Total: 594,7 m^3

Servicio diario:

- Tanque número 9: 25 m^3
- Tanque número 16: 25 m^3

Total: 50 m^3

Lodos:

- Tanque número 10: 9 m^3

Tanque de reboses:

- Tanque número 11: 0,8 m^3

16.2.- Sistema de trasiego y purificación

Sistema de llenado:

En cubierta se ha dispuesto la estación de toma de combustible. La toma de combustible estará conectada de forma que se llenen directamente los tanques almacén. Se dispondrá una toma para los tanques 6, 7 y 8, y otra toma para los tanques polivalentes de lastre o combustible. En caso necesario se pueden llenar también los tanques de servicio diario, aunque normalmente estarán aislados de esta toma mediante bridas de cambio.

Sistema de trasiego y purificación de diesel oíl:

El combustible diesel oíl no necesita otro tratamiento para ser enviado a los motores, que un filtrado final. Sin embargo, es recomendable la instalación de una separadora centrifuga para la eliminación de posibles contenidos de agua.

La configuración del sistema de trasiego y tratamiento de combustible es el siguiente:

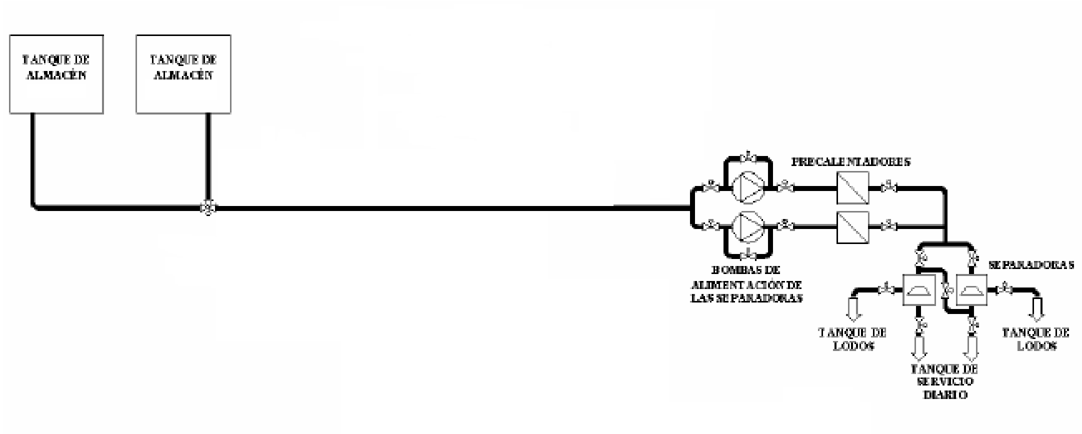


Figura 10 Sistema de trasiego y purificación diesel oil

Se instarán dos purificadoras en paralelo con una capacidad del 100% de la demanda cada una, normalmente trabajarán las dos al 50% pero en el caso de que una se pare por avería o mantenimiento, con una de ellas trabajando a su máxima capacidad será suficiente. Esta configuración se traduce en una mayor seguridad ante el fallo de una de ellas. Serán de tipo autolimpiables.

La capacidad de las depuradoras, teniendo en cuenta que cada una será capaz de llenar el tanque de servicio diario en dos horas, se calculará mediante la siguiente expresión:

$$Q_{purif.} = \frac{Pot.\times c_e \times 24}{\rho \times t} \times 10^{-3} = 3{,}32\ {}^{m^3}/_{h}$$

Las dos bombas de alimentación de las depuradoras, con aspiración en los tanques de almacén y descarga en las purificadoras, serán eléctricas horizontales rotativas. Para que el caudal calculado llegue a las purificadoras, la presión debe ser mayor ya que en el pre-calentador habrá aproximadamente una pérdida de presión de 1,5 bar y se necesita una presión de salida de 3 bar, por tanto las bombas deberán descargar a 4,5 bar. Las tuberías del sistema de combustible serán de cuproníquel 90-10 por su gran resistencia a la corrosión, pueden soportar temperaturas de hasta 300 ºC y velocidades del fluido de 3,5 m/s. Sabiendo que el caudal es de 3,32 m^3/h en cada bomba y diseñando el sistema para que la velocidad del fluido sea de 2 m/s, el diámetro de las tuberías después de las bombas será de 25 mm y el ramal que viene de los tanques almacén antes de la bifurcación será de 50 mm. A la potencia de la bomba además se le sumarán las pérdidas de carga en las tuberías a partir de la fórmula de Darcy-Weisbach y el coeficiente de fricción con la fórmula de Blasius, se tendrá en cuenta el paso por codos y válvulas sumando la longitud equivalente en a la fórmula. Con todo esto, la potencia necesaria en cada bomba será de:

$$Re = D \times v \times \frac{\rho}{\mu}$$

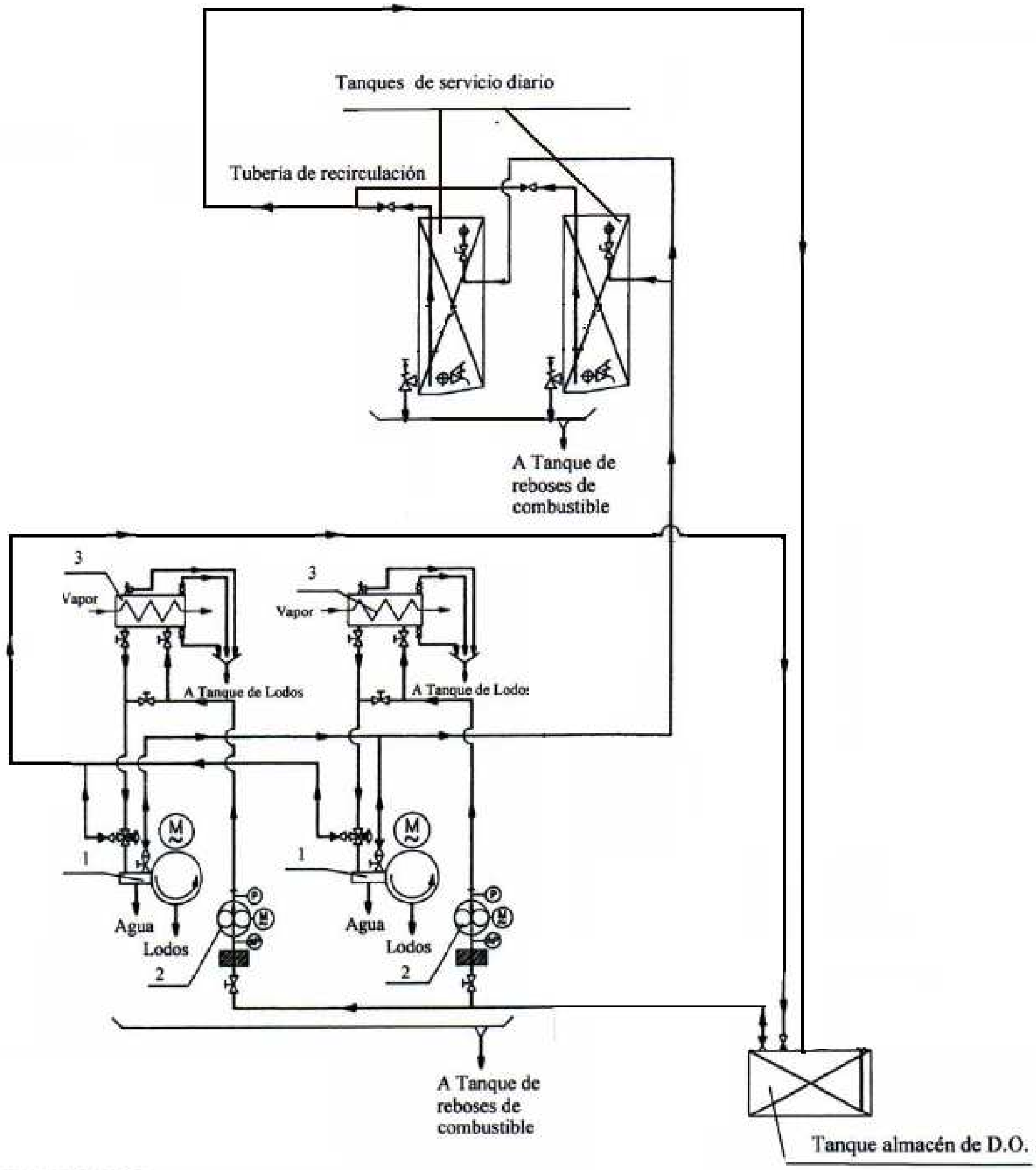
$$f = 0.3164 \times Re^{-0.25}$$

$$h = 0.0826 \times f \times \left({Q^2}/{D^5} \right) \times L$$

$$Pot._{bba} = \frac{Q_{purif.} \times \left(\Delta p + \frac{h}{10} \right)}{\eta_m \times \eta_{elec.}} = 1\ kW$$

La depuradora (mediante la bomba de alimentación de las depuradoras) podrán aspirar del tanque de almacén (por un filtro dúplex) y descargarán en los tanques de servicio diario. Los reboses del tanque de servicio diario pasaran directamente al tanque de reboses de combustible.

En el tanque de servicio diario al que se ha suministrado combustible se debe mantener una temperatura en función de la calidad del combustible utilizado y especificada por el fabricante del motor. A tal efecto, dichos tanques estarán aislados térmicamente con lana mineral de roca de 100 mm.



ELEMENTOS

1.- Purificadora
2.- Bomba purificadora
3.- Calentador de la purificadora

Figura 11 Sistema purificación de diesel oil en detalle

El proceso de trasiego y purificación sería el siguiente; desde el tanque de almacén el combustible es enviado a las separadoras por medio de las bombas de alimentación de las separadoras, que operan a caudal constante. La constancia del flujo de combustible es esencial. El caudal no debe verse afectado por las variaciones del consumo del motor, y en condiciones normales de funcionamiento de la planta es superior a éste, por lo tanto, se monta una tubería de rebose en el tanque de servicio diario.

Entre los tanques de servicio diario y el tanque de almacén se instalará una tubería de recirculación. Además, esta tubería estará conectada a la parte inferior del tanque de servicio diario.

El sistema de trasiego queda de la forma siguiente:

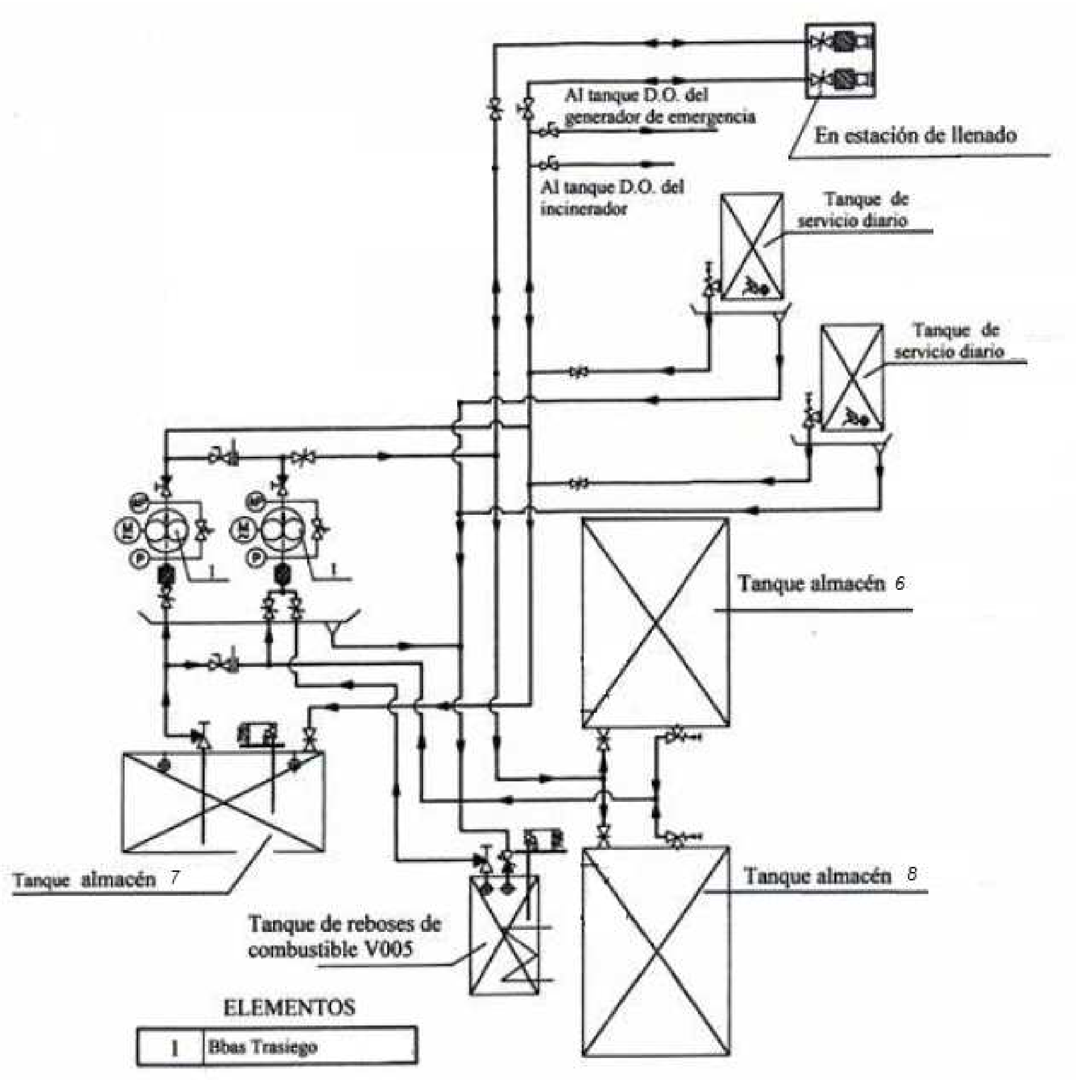


Figura 12 Sistema de trasiego de diesel oil

La potencia de las bombas de trasiego será tal que achique por completo los tanques almacén en 12 horas trabajando las dos simultáneamente:

$$Q_{bba.tr} = \frac{V_{combustible}}{2 \times 12} = 17\ {m^3}/{h}$$

Suponiendo un rendimiento volumétrico de la bomba de 0,6, un salto de presión de trabajo de 3 bar, un rendimiento eléctrico de 0,8 y las pérdidas de carga sumadas al incremento de presión, la potencia absorbida y la necesaria para activar cada bomba es:

$$Pot._{bba.tr.} = \frac{Q_{bba} \times \left(\Delta p + \frac{h}{10}\right)}{\eta_m \times \eta_{elec.}} = 3\ kW$$

16.3.- Sistema presurizado de alimentación.

Constará de una unidad suministradora de combustible para los cuatro motores auxiliares. Dicha unidad constará a su vez de los siguientes equipos:

- Dos bombas de alimentación de combustible, bombas de baja presión.
- Dos bombas de circulación, bombas de alta.
- Un filtro automático.
- Un filtro manual doble.
- Dos calentadores.
- Un viscosímetro.
- Un caudalímetro.
- Un colector de retornos.

Bombas de alimentación

Las bombas de alimentación de combustible aspirarán de los tanques de servicio diario a través de una válvula y descargarán en el tanque regulador (colector de retornos), a través del filtro automático y del caudalímetro. Para el dimensionamiento de estas bombas se ha considerado que han de proporcionar un caudal mínimo de 160 % de la máxima cantidad de diesel consumido por los 4 motores. En definitiva, la unidad suministradora llevará 2 bombas de alimentación, de husillo y resistentes a la temperatura cuyas características se ajusten a las calculadas. Teniendo en cuenta que la presión de suministro ha de ser de 6 bar, que el consumo de cada motor es de 240 l/h, las pérdidas de carga en las tuberías de cuproníquel 90-10 de 20 mm de diámetro y en los elementos del circuito y que los rendimientos volumétricos y eléctricos son de 0,6 y 0,8 respectivamente:

$$Pot._{bba.al.} = \frac{Q_{bba} \times \left(\Delta p + \frac{h}{10}\right)}{\eta_m \times \eta_{elec.}} = 0{,}5\ kW$$

Bombas de circulación

Las bombas de circulación aspirarán del tanque regulador y descargarán en los motores a través de dos calentadores, viscosímetros, y filtros (filtro automático y doble manual; tubería única de 45 mm de diámetro de descarga para los 4 motores y ramales para cada motor de 12 mm de diámetro). Para asegurar que nunca trabaja en vacío, su caudal será superior al consumo de los motores, más específicamente del orden de 3 a 4 veces superior y trabajará a una presión de 10 bar de tal forma que la presión medida en el motor a la altura de las bombas será del orden de 7 a 8 bar. La potencia de dichas bombas será, considerando los mismos rendimientos que en la bomba de baja y las pérdidas de carga, la siguiente:

$$Pot._{bba.circ.} = \frac{Q_{bba} \times \left(\Delta p + \frac{h}{10}\right)}{\eta_m \times \eta_{elec.}} = 1\ kW$$

Colector de retornos

La capacidad del tanque regulador, buffer o de mezclas, será tal que su capacidad de almacenamiento sea la correspondiente a 5 minutos de consumo de los motores, aplicando un margen de hierros del 5%, el volumen será de 0,084 m^3.

Este tanque estará a una presión de servicio de 10 bares. Estará equipado con una válvula de ventilación y controlado por un interruptor de nivel. También estará aislado térmicamente y equipado con un serpentín de calefacción para usarlo en caso necesario, si las temperaturas son muy bajas. La tubería de ventilación estará dirigida hacia abajo, al tanque de reboses.

El derrame de combustible de los motores auxiliares se dirigirá al tanque de reboses de combustible.

A continuación se presenta el esquema del sistema de alimentación de combustible de los motores auxiliares.

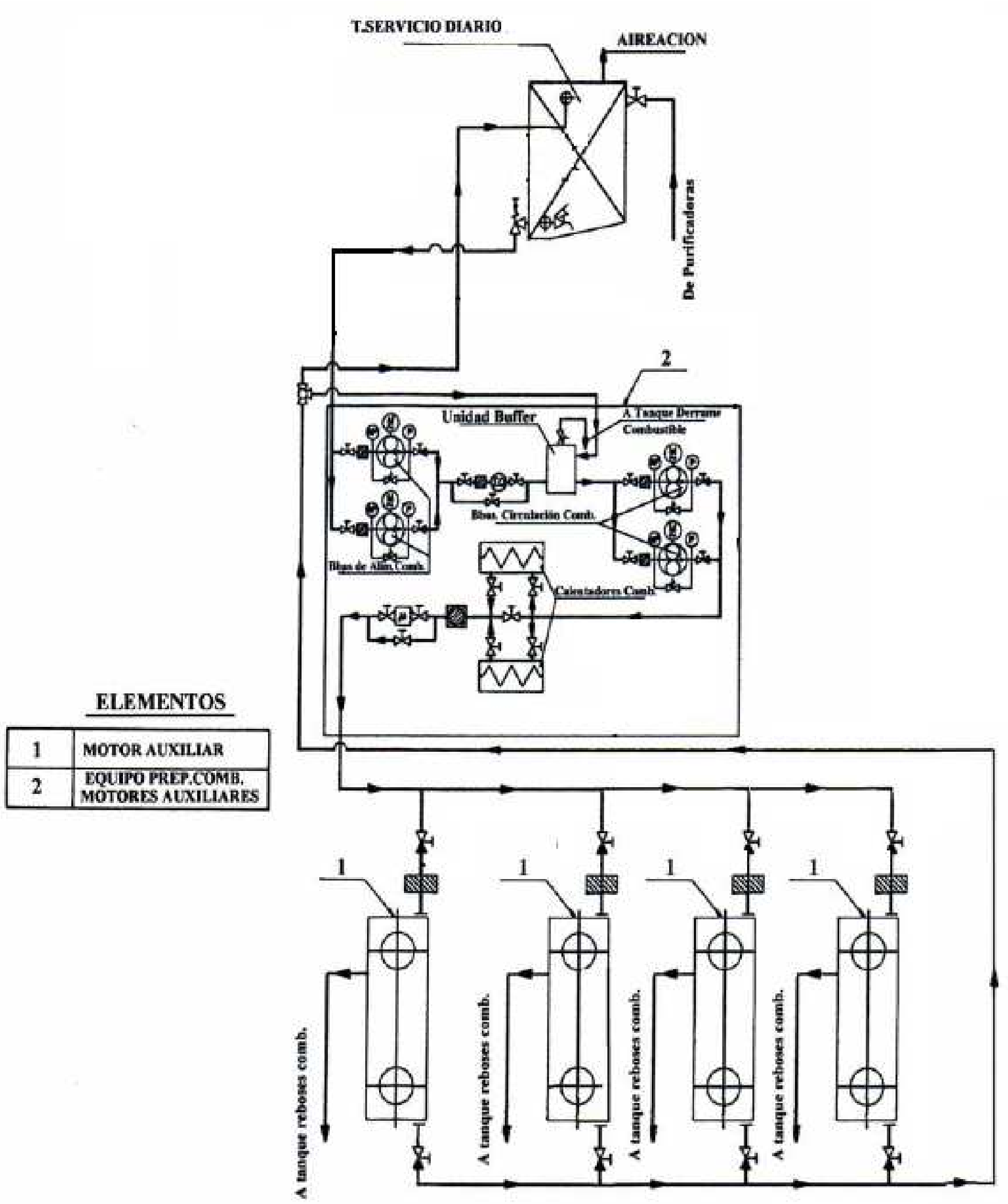


Figura 13 Sistema de alimentación de combustible a los motores auxiliares

16.4.- Alimentación de combustible al generador de emergencia:

Para la alimentación de combustible del generador de emergencia se dispondrá en el local del grupo de emergencia un tanque de diesel oíl.

La bomba de trasiego aspirará del tanque de servicio diario, descargando al tanque anteriormente citado. Desde este, por gravedad, se alimentará al grupo de emergencia.

16.5.- Reboses y respiros de tanques de combustible:

Los tanques almacén de combustible y los de servicio diario de combustible, estarán provistos de tuberías de ventilación de 40 mm de diámetro. Cada tanque almacén de combustible estará provisto de una tubería de ventilación independiente que será dirigida a la cubierta superior y terminarán en cuello de cisne con pantallas apaga-llamas.

El rebose de los tanques de combustible se dirigirá al tanque de reboses. Las tuberías de reboses de cada tanque almacén se reunirán en una principal que se dirigirá al tanque de reboses a través de un dispositivo de alarma.

Alrededor de las tuberías de ventilación de combustible de los servicios de la sala de máquinas, se instalarán bandejas, así como en las tomas de combustible de cubierta.

El tanque de reboses de combustible recogerá también las pérdidas de las bombas de inyección, y los drenajes de las bandejas de goteo, calentadores y filtros.

17.- Sistema de refrigeración

Se dispondrá un sistema de refrigeración centralizado constituido por dos circuitos:

- Circuito abierto de agua salada
- Circuito cerrado de agua dulce

Este sistema se caracteriza por tener solamente un intercambiador de calor refrigerado por agua de mar, mientras que el resto de los intercambiadores, están refrigerados por el circuito de agua dulce.

A continuación, las razones que han motivado a disponer en el buque proyecto un sistema de refrigeración centralizado de agua dulce.

El único líquido refrigerante para ser utilizado a bordo cuya disponibilidad es inmediata, ilimitada y gratuita es el agua de mar, es el refrigerante primario en todos aquellos puntos del buque en los que se realiza algún intercambio de calor. Su uso indiscriminado plantea sin embargo numerosos problemas bien conocidos, ya que el agua de mar es por una parte altamente corrosiva y por otro es el hábitat natural de plantas y animales marinos que pueden crecer y desarrollarse en los conductos por los que circule, con peligro de obstrucciones y en cualquier caso con un inevitable aumento del coste energético de bombeo. A estos problemas se añade la polución química en aguas costeras o confinadas, que en ciertos mares hace aún mayor su corrosión natural.

Como consecuencia de lo anterior la utilización de agua de mar como refrigerante requiere por una parte materiales suficientemente resistentes a su acción y por otra, superficies de intercambio de calor generosamente sobredimensionadas para compensar su inevitable ensuciamiento y consiguiente reducción del coeficiente global de transmisión.

Para solucionar ese problema, se creó un segundo circuito de refrigeración con agua dulce al que fueron añadiéndose componentes que se iban segregando del circuito de agua de mar, con lo que cada vez eran menos los que quedaban en éstos últimos. El desarrollo del sistema ha llegado hasta el punto de que prácticamente todos los servicios de un buque están integrados en el circuito de agua dulce.

Con el circuito centralizado se resuelve simultáneamente el enfriamiento del sistema de motores principales y auxiliares y los problemas del circuito de agua de mar.

Además el control de temperatura puede hacerse de una forma muy fiable y precisa a base de regular termostáticamente la cantidad de agua necesaria para la mezcla en cada momento, con lo que el sistema resultante es notablemente más barato en su mantenimiento y más fácilmente controlable y sin los problemas habituales de los circuitos de agua salada.

En resumen, este sistema tiene las siguientes ventajas frente a un sistema convencional de refrigeración directa con agua salada:

- Abaratamiento de las conducciones y equipo necesario, ya que al tratarse el fluido de agua dulce, la protección de las tuberías y equipos usados frente a la corrosión es mucho menor.
- Mejor mantenimiento.
- Mejor aprovechamiento de la fuente fría.
- Mayor control de la regulación de agua necesaria.

17.1.- Circuito cerrado de agua dulce

Como ya se ha dicho, al circuito cerrado de agua dulce están conectados los enfriadores de calor de todos los equipos.

A la vez, el circuito está refrigerado con agua salada, utilizando para ello un intercambiador de calor.

A continuación se enumeran todos los equipos o sistemas que se encuentra conectados en cámara de máquinas mediante intercambiadores de calor a este circuito, con el fin de refrigerarse:

- Chumacera de apoyo
- Chumacera de empuje
- Motores principales
- Enfriadores de los equipos generadores auxiliares
- Enfriadores de aceite lubricante del embrague hidráulico
- Compresores principales de aire de arranque
- Compresor de aire de servicio y control

Estos intercambiadores de calor descargarán en una conducción común que se dirigirá al enfriador central del sistema.

Se dispondrá un dispositivo a fin de mantener automáticamente la temperatura de agua dulce en la salida del enfriador central en 32º C aproximadamente.

Descripción de los equipos que componen el sistema.

- Dos bombas de circulación eléctricas no auto cebadas verticales, centrifugas. Las pérdidas de carga en el circuito calculadas con la fórmula de Darcy-Weisbach y el coeficiente de fricción con la fórmula de Blasius son de 0,5 bar. Las características de cada bomba son:

$$Pot._{bba.} = \frac{Q_{bba} \times \Delta p}{\eta_m \times \eta_{elec.}} = \frac{\frac{75}{3600} \times 5.5 \times 10^5}{0.75 \times 0.95} \times 10^{-3} = 16.25\ kW$$

- Un enfriador de agua dulce para el circuito centralizado. Será de tipo placas de titanio y tendrá una superficie de enfriamiento apropiada para disipar 5000 kW aproximadamente. (Se instalarán dos en paralelo para el mantenimiento o avería del otro)
- Un tanque de agua técnica para los sistemas centralizados de agua dulce de enfriamiento y equipado con toma para sustancias químicas.
- El sistema de tuberías estará formado por tuberías de cuproníquel 90-10. Los colectores principales tendrán un diámetro de 180 mm, el ramal de entrada y salida de cada bomba de 90 mm y los ramales de cada consumidor variarán según su necesidad de caudal de agua de refrigeración.

A continuación se presenta un esquema del circuito:

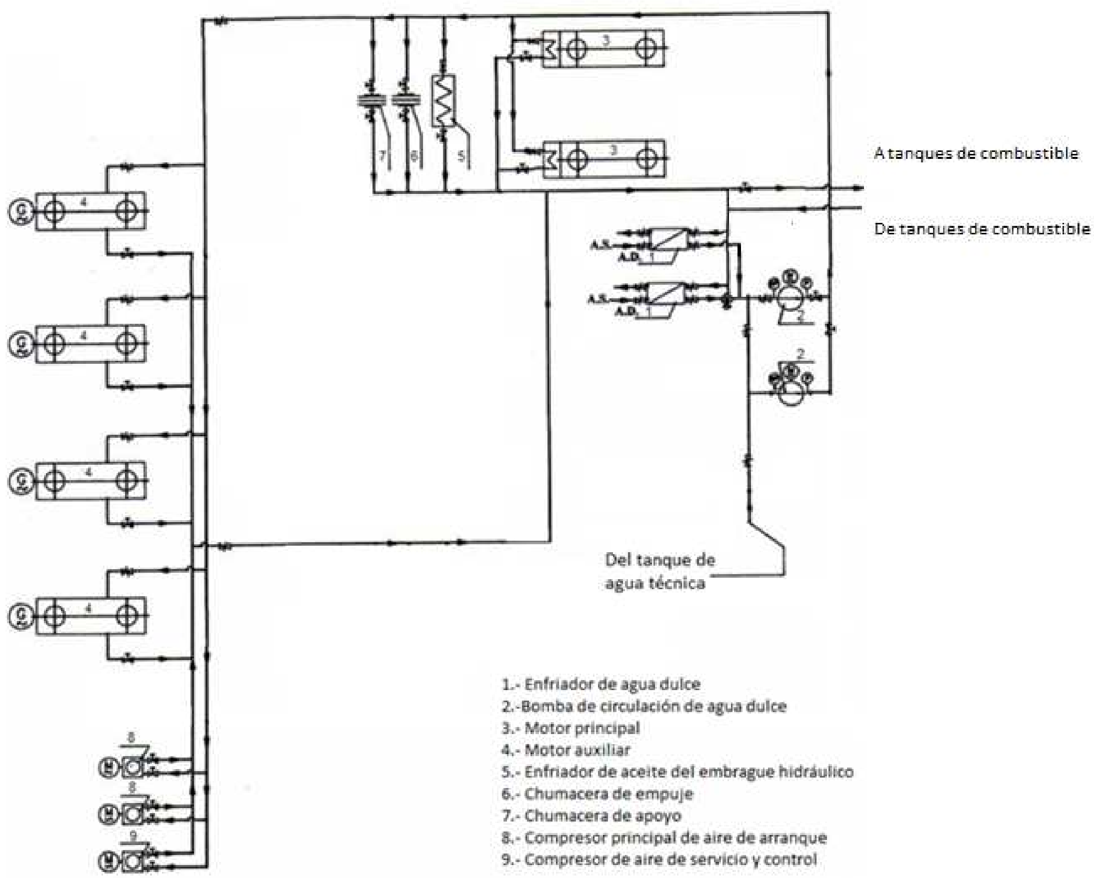


Figura 14 Circuito de refrigeración de agua dulce

17.2.- Circuito abierto de agua salada

El circuito de refrigeración de agua salada evacua el calor del circuito cerrado de agua dulce, luego es la fuente fría de todo el sistema de refrigeración.

La necesidad de refrigeración de este circuito es proporcional a la carga de los motores y esta variará según las condiciones de la navegación. Además, la temperatura del agua de mar puede ser varios grados inferior a la de proyecto con lo que el salto térmico entre el circuito de agua dulce y el de agua salada puede incrementar significativamente su valor, e incluso llegar a duplicarse. Por todo esto, es conveniente disponer la planta de bombeo de forma que pueda adaptarse a las distintas necesidades. A tal efecto, se dispondrán dos bombas de agua salada cada una de ellas con una capacidad unitaria del 60% de la total.

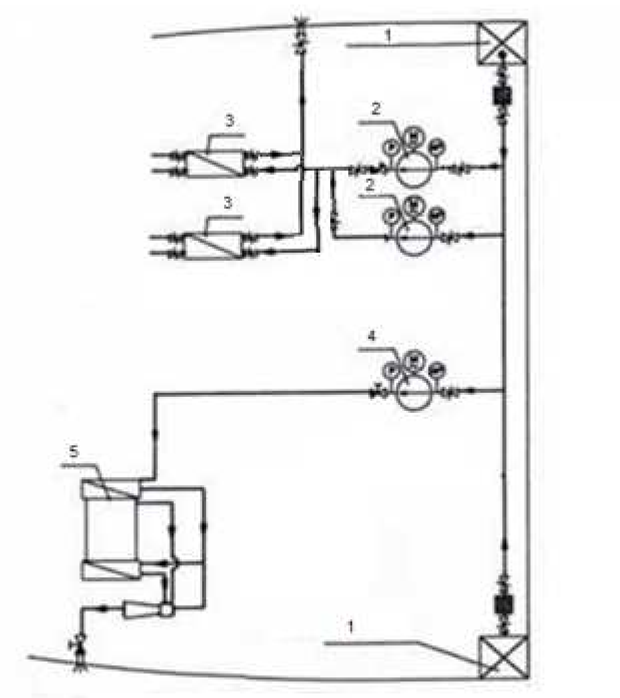
Teniendo en cuenta lo anterior y las recomendaciones del fabricante del motor, se obtiene que el sistema de refrigeración de agua salada cuente con los siguientes equipos:

- Dos bombas eléctricas verticales, centrifugas y no auto cebadas, para el servicio de agua salada del sistema centralizado de refrigeración. Teniendo en cuenta que las pérdidas de carga son de 0,2 bar, las características de cada bomba son:

$$Pot._{bba.} = \frac{Q_{bba} \times \Delta p}{\eta_m \times \eta_{elec.}} = \frac{\frac{150 \times 0.6}{3600} \times 2.2 \times 10^5}{0.75 \times 0.95} \times 10^{-3} = 7.1\ kW$$

- Una bomba eléctrica centrifuga no auto cebada para el servicio de circulación y alimentación del generador de agua dulce.
- El sistema de tuberías estará formado por tuberías de cuproníquel 70-30 por su alta resistencia a la corrosión. Los colectores principales tendrán un diámetro de 180 mm y el ramal de entrada y salida de cada bomba de 90 mm.

A continuación se adjunta un esquema del sistema de circulación de agua salada.



1.- Toma de mar
2.- Bomba de agua salada del sistema de enfriamiento centralizado
3.- Enfriador de agua dulce
4.- Bomba de circulación del eyector y alimentación del generador de agua dulce
5.- Generador de agua dulce

Figura 15 Circuito de refrigeración de agua salada

18.- Sistema de aire comprimido

La mayoría de los motores marinos con potencias superiores a los 300 BHP se ponen en marcha con aire comprimido, por inyección directa del mismo en los cilindros, a través de las válvulas de arranque situadas en las culatas de los cilindros.

La presión nominal de aire de arranque requerida por los fabricantes de motores se fija en 30 bares, aunque los motores puedan llegar a ponerse en marcha con 10 bares o incluso menos, naturalmente con consumos de aire muy altos. El sistema exige la existencia no solo de compresores, sino de botellas que acumulan del aire para permitir durante las maniobras puestas en marcha sucesivas.

Una vez establecida la necesidad de la instalación han ido surgiendo usos adicionales para el aire comprimido, tales como control y actuación de instrumentos, accionamiento de herramientas a mano, limpieza, etc. La presión usual para estos servicios suele ser más reducida, en el orden de 7 a 8 bares. Estos servicios pueden ser alimentados desde las botellas de aire de arranque a través de una estación reductora de presión. Sin embargo, cuando adquieren cierta importancia disponen de compresores con sus correspondientes botellas.

Es normal disponer un pequeño compresor embragado al motor de emergencia, que permitirá rellenar las botellas y así poder arrancar los auxiliares.

Por todas estas razones, el buque proyecto dispondrá de los siguientes sistemas de aire de comprimido:

- Sistema de aire de arranque.
- Sistema de aire de servicio y control.

18.1.- Sistema de aire de arranque

Según la Sociedad de Clasificación:

Para plantas con más de un motor, la capacidad de las botellas de aire de arranque debe ser suficiente para asegurar al menos 3 arranques por motor. Por tanto, la capacidad total no puede ser menor de 12 arranques y no suele exceder los 18.

Debe haber dos o más compresores la suma de ellos será capaz de producir en una hora la cantidad de aire citada anteriormente, cargando las botellas desde la presión atmosférica. La capacidad de cada compresor se suele repartir equitativamente, sin contar el compresor de emergencia.

Uno de los compresores será independiente en este caso, de los generadores y tendrá una capacidad de no menos del 50% del total requerido.

El compresor de emergencia, se debe alimentar por un motor de combustión interna, un motor eléctrico o máquina de vapor.

Por lo menos, debe haber dos botellas con aproximadamente la misma capacidad y con la opción de ser usadas independientemente una de la otra.

Por tanto:

- Se instalarán dos compresores de aire eléctricos de 50 m^3/h aproximadamente cada uno a 30 bares para llenado de los depósitos principales de aire de arranque. Cada compresor será alternativo, lubricado a presión, refrigerado por agua dulce y estarán equipados con filtros de aire con silenciadores, enfriadores, bomba de circulación, manómetros y válvulas de seguridad en cada fase. Los compresores también estarán equipados con sistema de arranque y parada automáticos. Estarán en paralelo y descargarán a cualquiera de los depósitos de aire a través de un separador de agua y aceite con drenaje a sentinas.
- Un compresor diesel manual para el depósito de aire del generador de emergencia en el pañol del generador de emergencia.
- Dos depósitos de aire de arranque para los generadores, de 1 m^3 de capacidad total y presión a 30 bares. Los depósitos estarán fabricados de plancha de acero soldado de acuerdo con la Sociedad de Clasificación. Cada depósito estará provisto de un registro para inspección y limpieza, y de las siguientes válvulas: válvula de descarga para los generadores, válvula para manómetro y también dispondrán de válvula de seguridad.
- Un depósito para el generador de emergencia de máquinas.

18.2.- Sistema de aire de servicio y control

La línea de servicio auxiliar proporcionará aire al sistema de servicio y control mediante una botella de aire a 30 bar que se cargará con los compresores del sistema de aire de arranque y una válvula reductora de 7 bar.

Se proporcionará aire a baja presión a los siguientes servicios:

- Limpieza de sala de máquinas (conexiones para mangueras ubicadas en lugares oportunos).
- Limpieza de la purificadora de combustible
- Tubería de aire de cubierta.
- Laboratorios
- Tubería de aire del taller de máquinas.
- Tanques hidróforos
- Tomas de mar
- Filtros automáticos
- Cámara de hélices de proa
- Local del servomotor

De tal forma que el sistema de aire comprimido queda así:

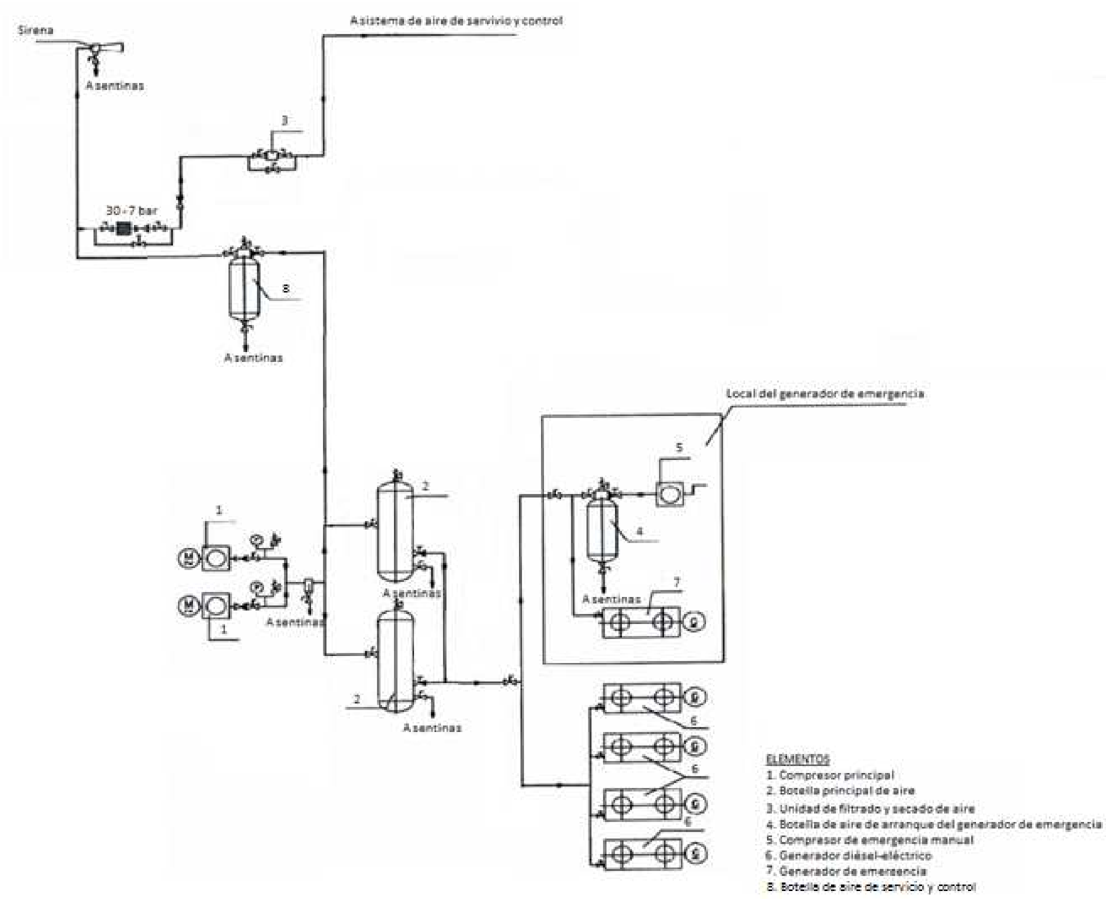


Figura 16 Sistema de aire comprimido

19.- Sistema de ventilación en cámara de máquinas

Para obtener buenas condiciones de funcionamiento en cámara de máquinas y para asegurar un funcionamiento libre de averías se deberá instalar un adecuado sistema de ventilación. La ventilación de la cámara de máquinas cumple tres funciones principales:

- Suministrar a los motores el aire necesario para poder funcionar.
- Renovar el aire de forma que existan unas condiciones de habitabilidad aceptables para la tripulación.
- Refrigerar en cierta medida a los equipos instalados.

El emplazamiento de las tomas de aire de la cámara de máquinas será, de tal forma, que no puedan proyectarse sobre ellas chorros de agua, polvo y gases de exhaustación y por tanto no puedan introducirse en los conductos de ventilación.

El sistema es independiente del sistema de climatización de la habilitación y ventilación de otros locales. Se distribuye de manera uniforme el aire en la cámara de máquinas.

Los conductos estructurales de ventilación están construidos con chapa pintada de acero soldada a los mamparos y de un espesor adecuado.

Los conductos no estructurales se fabricarán con plancha de aceró galvanizado de 1, 1,5 y 2 mm de espesor, dependiendo si la mayor medida del conductor es inferior a 500 mm, entre 500 y 750 mm o superior a este último valor respectivamente. Junto con estas características principales, existen una serie de requisitos que se deben cumplir:

- Ninguna tubería que pueda contener líquidos inflamables deberá estar próxima a los filtros de entrada.
- La caída de presión de diseño recomendada en el sistema de filtración externo debe ser como máximo de 10 mbar.
- La máxima concentración de polvo después del sistema de filtración externo no debería exceder de 3 mg/m^3 de aire.
- Se mantiene una sobrepresión de 0,5 mbar en el ambiente de la cámara de máquinas para facilitar la admisión de los motores.

Para los requerimientos mínimos de ventilación de cámara de máquinas ver la normativa ISO 8861.

A continuación se especifica todos aquellos detalles y cálculos que se han llevado a cabo para dimensionar el sistema de ventilación de cámara de máquinas.

19.1.- Necesidad de aire de combustión

Los motores auxiliares obtienen el aire necesario para la combustión de la cámara de máquinas a través del filtro situado en la admisión de la turbosoplante, que consiste en una turbina movida por los gases de escape. El aire es enfriado y comprimido para aumentar la capacidad de combustión.

La temperatura del aire de combustión debe mantenerse entre 15 ºC y 45 ºC. Se debe suministrar aire en exceso, para evitar una situación puntual de subalimentación, lo cual provocaría una mala combustión.

El consumo de aire de combustión, según las especificaciones del motor, es de 76 m^3/min. Por lo tanto, la cantidad de aire que es necesario introducir para la combustión teniendo en cuenta que hay cuatro generadores instalados es de 18240 m^3/h.

19.2.- Necesidad de aire de refrigeración

Como ya se ha dicho, el aire introducido en la cámara de máquinas sirve también para disipar el calor radiado por los diferentes equipos. La cantidad de aire requerido para refrigeración se calcula a partir del calor emitido "Q" que es necesario evacuar. Para determinar el calor emitido se deben considerar todas las fuentes de calor de este local:

- Motores principales y auxiliares
- Tuberías del sistema de gases de exhaustación
- Alternadores
- Instrumentos eléctricos y sistemas de iluminación
- Calderas
- Tuberías de vapor y de condensación

Se recomienda considerar una temperatura del aire en cámara de máquinas mayor o igual a 35 ºC y una elevación de temperatura de 11 ºC del aire de ventilación.

El caudal de aire necesario para disipar una determinada cantidad de energía calorífica viene dado por la siguiente expresión:

$$q = \frac{Q}{\rho_{av} \times \Delta t_{CM} \times c} \times 3600$$

Siendo:

- q: caudal de aire requerido (m^3/h)
- Q: calor necesario a evacuar (kW)
- ρ_{av}: densidad del aire de ventilación (1,2 kg/m^3)
- Δt_{CM}: diferencia de temperaturas entre cámara de máquinas y aire exterior utilizado para la ventilación (ºC)
- c: calor especifico del aire (1.01 kJ/kg·ºC)

El calor radiado por cada uno de los motores auxiliares es de 107 kW y el calor radiado por cada uno de los alternadores es de 56,2 kW según especificaciones del fabricante.

Además, se estima una aportación de calor radiado a cámara de máquinas por las demás fuentes de 200 kW.

Considerando una diferencia de temperaturas de 10 ºC, el caudal de aire necesario será de 253400 m^3/h.

19.3.- Necesidad de aire de renovación

El número de renovaciones por hora del local depende del volumen del mismo. A continuación se presenta una formula recomendada para calcular el número de renovaciones en función del volumen del local:

$$\frac{R}{h} = -0.0009 \times V + 27.259$$

Si el local contiene motores, es conveniente añadir 2 renovaciones/hora por cada motor.

El volumen de la cámara de máquinas es 1300 m^3, sin tener en cuenta el volumen ocupado por los equipos para obtener así un margen, por lo que se necesitarán 34 renovaciones cada hora. El caudal para aire de renovación será 44200 m^3/h.

Recopilando los cálculos obtenidos en los apartados anteriores, se tiene que:

- Necesidad para aire de combustión: 18240 m^3/h.
- Necesidad para aire de refrigeración: 253400 m^3/h.
- Necesidad para aire de renovación: 44200 m^3/h.

Total: 315840 m^3/h.

Para controlar la cantidad de aire de entrada a la cámara de máquinas, se instalarán cuatro impulsores centrífugos axiales eléctricos de 79000 m^3/h con una presión de 50 mmca y 12,5 kW por unidad, de tal modo que cubran las necesidades de aire para combustión, evacuación de calor y renovación de aire de cámara de máquinas, siendo necesaria según los cálculos del apartado anterior una capacidad conjunta de 315840 m^3/h. Teniendo en cuenta que el buque navegará por zonas árticas, se instalarán dos de los ventiladores en la zona del guardacalor de manera que el aire de entrada se pueda calentar antes de su entrada en cámara de máquinas mediante la transmisión del calor de los gases de escape de los motores auxiliares.

Por otro lado, en lo referente a la extracción, se debe tener en cuenta que el aire suministrado para la combustión sale de la cámara de máquinas por sus propios conductos, por tanto, las necesidades de extracción se reducen al caudal suministrado para la evacuación de calor y el de renovación, es decir, se necesita una capacidad conjunta igual a 297600 m^3/h. Así pues, se instalarán en la parte alta de la cámara de máquinas cuatro extractores centrífugos de 74400 m^3/h, 50 mmca de presión diferencial y 10 kW de potencia por unidad.

Por último, debido a que las baterías de litio no deben alcanzar temperaturas elevadas, se instalará un impulsor axial eléctrico y un extractor en el local de baterías con conductos hacia el exterior con una capacidad de 500 m^3/h a una presión de 50 mmca lo que equivale a 4 renovaciones por hora del local de baterías estanco.

20.- Conclusiones

El proyecto ha consistido en el proyecto preliminar de un buque oceanográfico. El proceso que se ha seguido ha sido en primer lugar reunir información sobre buques oceanográficos existentes y a partir de la base de datos obtenida predeterminar las dimensiones y características principales del buque, después comprobar esos datos mediante técnicas analíticas. Una vez establecidas las características del buque se ha escogido la línea de propulsión más adecuada teniendo en cuenta las peculiaridades del tipo de barco que se está desarrollando. El siguiente paso ha sido el diseño de la cámara de máquinas para que sea capaz de albergar la línea propulsora y los demás equipos auxiliares a la propulsión, escoger y posicionar los elementos de la cámara de máquinas y por último el diseño de los sistemas de combustible, refrigeración, aire comprimido y ventilación.

Posiblemente la conclusión que he podido extraer de este proyecto, es que cuando se trata del diseño naval, no se puede pensar en una sola zona del buque sin tener en cuenta el buque en su conjunto. En este caso desde un inicio, me quería centrar única y exclusivamente en la planta propulsora del buque y en todo caso en su cámara de máquinas. Eso no ha sido posible, ya que es imposible empezar el diseño que pretendía sin hacer al menos un anteproyecto del buque en su totalidad, desde las formas del casco hasta la maquinaria de pesca que montará, desde la distribución de cubiertas hasta tener en cuenta las zonas en las que navegará, y así en un sinfín de peculiaridades del buque que a priori no parecían importantes para el diseño de la planta propulsora. La verdad es que por mucho que se estudie la espiral de proyecto, no se entiende realmente bien su importancia hasta la realización del proyecto naval.

Por otra parte, después de hacer un estudio de la flota de buques oceanográficos, me he dado cuenta de la complejidad de estos buques, por la autonomía que deben tener en situaciones climatológicas extremas con un gran número de tripulantes a bordo, la necesidad de ser lo más polivalentes posible según el tipo de investigación que desarrollen. Además, por su particularidad están abriendo la puerta a otro concepto de propulsión, la propulsión híbrida muy vista en la automoción pero poco desarrollada en la industria naval. Este tipo de propulsión se está expandiendo a otros campos de la explotación naval como el transporte de mercancías y pasajeros, con lo que se consigue un mejor aprovechamiento del combustible, aumentando el rendimiento de la planta y reduciendo las emisiones de contaminantes a la atmósfera.

Se deja la posibilidad a sustituir el sistema de suministro de energía eléctrica por otro más eficiente en un futuro cuando la tecnología lo permita, como por ejemplo cambiar algún generador diesel eléctrico o las baterías por pilas de combustible, un sistema que se ha estudiado durante este proyecto pero que hoy en día no da suficientes garantías para instalarlo.

Como reflexión final también sería interesante en un futuro cambiar el sistema híbrido diesel eléctrico del buque por uno que combine el gas con electricidad, pues parece que aunque hoy en día no es fácil encontrar suministro de gas en algunas regiones, esto cambiará en los próximos años por ser este el sustituto del petróleo al menos hasta encontrar otra fuente de energía alternativa.

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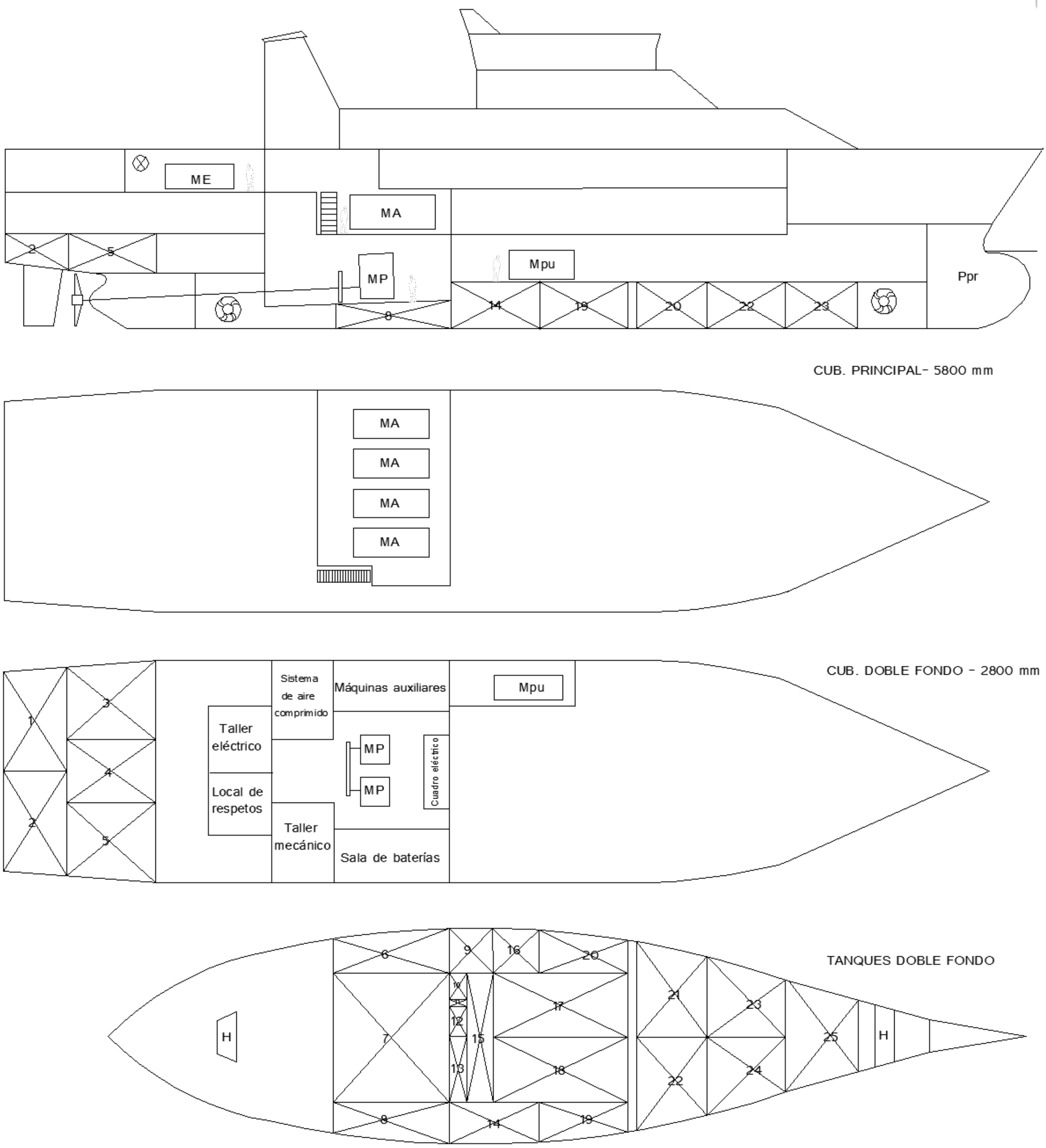
ME
MA
MP
Mpu
Ppr
2
5
8
14
19
20
22
23
CUB. PRINCIPAL- 5800 mm
MA
MA
MA
MA
CUB. DOBLE FONDO - 2800 mm
Sistema de aire comprimido
Máquinas auxiliares
Mpu
Taller eléctrico
Local de respetos
MP
MP
Cuadro eléctrico
Taller mecánico
Sala de baterías
1
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TANQUES DOBLE FONDO
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ANEXO I

PLANO DE DISPOSICIÓN GENERAL

ANEXO II

BALANCE ELÉCTRICO DEL BUQUE

	CONSUMIDOR	CARGA	PUERTO		FONDEADO		NAVEGACIÓN		MANIOBRA		FAENANDO		EMERGENCIA	
			ksr x kn	kW	ksr x kn	KW	ksr x kn	KW	ksr x kn	KW	ksr x kn	KW	ksr x kn	KW
PROPULSIÓN	MOTORES PRINCIPALES	2000	0	0	0	0	1	2000	0,5	1000	0,5	1000	0	0
	HÉLICE TRANSVERSAL PROA	150	0	0	0	0	0	0	1	150	0,2	30	0	0
	HÉLICE TRANSVERSAL POPA	110	0	0	0	0	0	0	1	110	0,2	22	0	0
	SERVOTIMÓN	100	0	0	0	0	0,5	50	0,5	50	0,2	20	0	0
	SEPARADORA CENTRÍGUFA	10	0,2	2	0,2	2	0,5	5	0,1	1	0,2	2	0	0
	BBAS AGUA SALADA	14,2	0,2	2,84	0,5	7,1	0,5	7,1	0,3	4,26	0,4	5,68	1	14,2
	BBAS CONTRA INCENDIOS	7,5	0,5	3,75	0,5	3,75	0,1	0,75	0,3	2,25	0,3	2,25	1	7,5
	BBAS TRASIEGO COMBUSTIBLE	8	1	8	0,5	4	0,5	4	0	0	0,5	4	1	8
	BBAS ACHIQUE	1,1	0,5	0,55	0,5	0,55	0,5	0,55	0,1	0,11	0,5	0,55	1	1,1
	BBAS TRASIEGO ACEITE	1,1	1	1,1	0,5	0,55	0,5	0,55	0	0	1	1,1	1	1,1
	BBAS ALIMENTACIÓN GASOIL MOTORES	3	0	0	0	0	0,5	1,5	1	3	1	3	1	3
	BBAS REFRIGERACIÓN MAQ. CUBIERTA	3	0,2	0,6	0,5	1,5	0,1	0,3	0	0	1	3	0	0
	BBAS REFRIGERACIÓN	33	0	0	0	0	0,5	16,5	0,5	16,5	0,5	16,5	0	0
	BBAS REFRIGERACIÓN CHUMACERA	11	0	0	0	0	0,5	5,5	0,1	1,1	0,5	5,5	0	0
	COMPRESORES DE AIRE DE ARRANQUE	40	0,2	8	0,3	12	0,5	20	0,5	20	0,4	16	1	40
	PRECALENTADOR AGUA	20	1	20	0,3	6	0,5	10	0	0	0	0	1	20
	PRECALENTADOR ACEITE	15	1	15	0,3	4,5	0,5	7,5	0	0	0	0	1	15
	VENTILADORES C.M.	50	0,2	10	0,3	15	1	50	0,4	20	0,6	30	1	50
PLANTA ELÉCTRICA	ALUMBRADOS C.M.	10	0,9	9	0,9	9	1	10	0,5	5	0,9	9	1	10
	ALUMBRADOS INTERIOR	20	0,6	12	0,4	8	1	20	0,6	12	0,5	10	1	20
	ALUMBRADOS EXTERIOR	10	0,2	2	0,5	5	0,5	5	0,2	2	0,8	8	1	10
	CONVERTIDORES FREC.	2	0,5	1	0,5	1	1	2	0,8	1,6	0,8	1,6	1	2
	RECTIFICADORES	5	0,5	2,5	0,5	2,5	1	5	0,8	4	0,8	4	1	5

MANDO Y VIGILANCIA	ALARMAS E INDICADORES	1	0,2	0,2	0,2	0,2	1	1	0,4	0,4	0,4	0,4	1	1
	ANEMÓMETRO	0,1	0,9	0,09	0,9	0,09	1	0,1	0,4	0,04	0,9	0,09	0	0
	CORREDERA	0,5	0	0	0	0	1	0,5	0	0	0,5	0,25	0	0
	GIROSCOPIO	1,5	0	0	0,3	0,45	1	1,5	1	1,5	0,5	0,75	0	0
	GONIÓMETRO	0,1	0	0	0	0	1	0,1	0	0	1	0,1	0	0
	ESTABILIDZADORES	15	0	0	0,5	7,5	1	15	0,5	7,5	0,2	3	0	0
	INTERCOMUNICADORES	2	0,1	0,2	0,2	0,4	1	2	0,7	1,4	0,2	0,4	1	2
	EQUIPO RADIO	7	0,2	1,4	0,1	0,7	1	7	0,4	2,8	0,4	2,8	1	7
	NAVEGACIÓN SATELITE	1	0	0	0,1	0,1	1	1	0,7	0,7	0,7	0,7	1	1
	RADAR	1,5	0	0	0	0	1	1,5	0,5	0,75	0,5	0,75	1	1,5
	PORTÁTILES	5	0,2	1	0,2	1	1	5	1	5	1	5	0	0
	SONDA	1	0,1	0,1	0,5	0,5	1	1	0,5	0,5	1	1	0	0
	SÓNAR	1	1	1	0,5	0,5	1	1	0,5	0,5	1	1	0	0
	PILOTO AUTOMÁTICO	3	0	0	0	0	1	3	0	0	1	3	0	0
	PANTALLAS	1	0,5	0,5	0,2	0,2	1	1	0,5	0,5	1	1	0	0
SISTEMAS AUXILIARES	BBAS A/S LABORATORIOS	2	0,2	0,4	0,5	1	0,5	1	0,1	0,2	1	2	0	0
	BBAS A/D SANITARIA	10	0,5	5	0,5	5	1	10	0,2	2	0,5	5	0	0
	BBAS A/D SANITARIA CALIENTE	7	0,5	3,5	0,5	3,5	1	7	0,2	1,4	0,2	1,4	0	0
	BBAS A/D CALEFACCIÓN	2	0,5	1	0,5	1	1	2	0,2	0,4	0,2	0,4	0	0
	BBAS SERPENTÍN TANQUE LODOS	1	0,1	0,1	0,2	0,2	0,5	0,5	0,1	0,1	0,2	0,2	0	0
	BBA CENTRAL HIDRÁULICA	10	0,5	5	0,5	5	0	0	1	10	1	10	0	0
	BBA DESPERDICIOS TRITURADOS	5	0,5	2,5	0,2	1	1	5	0,1	0,5	0,2	1	0	0
	PLANTA VACÍO	10	0,5	5	0,2	2	0,2	2	0,1	1	0,2	2	0	0
	COMPRESORES CONGELACIÓN	30	0,5	15	0,7	21	1	30	0,2	6	0,8	24	0	0
	BBAS CENTRÍFUGAS CONGELACIÓN	3	0,5	1,5	0,7	2,1	1	3	0,2	0,6	0,8	2,4	0	0

	ELECTROVENTILADORES CONGELACIÓN	3	0,5	1,5	0,7	2,1	1	3	0,2	0,6	0,8	2,4	0	0
	COMPRESORES AIRE ACONDICIONADO	60	0,5	30	0,5	30	1	60	0,2	12	0,4	24	1	60
	BBAS AIRE AOCNDICIONADO	30	0,5	15	0,5	15	1	30	0,2	6	0,4	12	1	30
	GAMBUZAS	5	0,5	2,5	0,5	2,5	0,5	2,5	0,2	1	0,5	2,5	0	0
	ÓSMOSIS INVERSA	20	0	0	0,5	10	0,5	10	0	0	0,2	4	0	0
	APARATOS PESCA	150	0	0	0	0	0	0	0	0	1	150	0	0
	GRÚAS HIDRAULICAS	200	0,2	40	0	0	0	0	0	0	1	200	0	0
HABILITACIÓN	COCINA	2,5	0,4	1	0,4	0,2	0,4	1	0,2	0,5	0,4	1	0	0
	EXTRACOTRES	1	0,4	0,4	0,4	0,2	0,4	0,4	0,2	0,2	0,4	0,4	0	0
	FRIGORÍFICO	1	1	1	1	1	1	1	0,5	0,5	0,5	0,5	0	0
	HORNO	1,5	0,4	0,6	0,4	0,2	0,4	0,6	0,2	0,3	0,2	0,3	0	0
	LAVADORA	1,5	0,2	0,3	0,2	0,3	0,2	0,3	0,2	0,3	0,2	0,3	0	0
	LAVAVAJILLA	3,5	0,2	0,7	0,2	0,2	0,2	0,7	0,2	0,7	0,3	1,05	0	0
	TRITURADORA	1	0,2	0,2	0,2	0,2	0,2	0,2	0,1	0,1	0,5	0,5	0	0
	TV	0,5	0,2	0,1	0,2	0,1	0,2	0,1	0,1	0,05	0	0	0	0
	TOTAL (kW)			235,13		197,89		2432,25		1468,86		1661,77		309,4
	TOTAL (kVA)			293,9125		247,3625		3040,3125		1836,075		2077,2125		386,75

ANEXO III

ESPECIFICACIONES DE LOS EQUIPOS MONTADOS A BORDO

INDAR DCM SERIES

DC Motors

Power range:	From 400 kW up to 4000 kW
Voltage range:	From 400 V up to 1000 V
Protection level:	Up to IP56
Isolation:	H

DESCRIPTION | TECHNICAL DATA | CERTIFICATION

INDAR DCM Series

Main Features	
Power	Up to 4,000 kW
Speed	2p ≥ 4 poles
Voltage	Up to 1,000 V
Temperature Increase Class	F (155 °C) / B (130 °C)
Thermal Insulation Class	Up to class H (180°C)
Other Characteristics	
Construction	Horizontal / vertical
Protection level (IEC 60034-5)	Up to IP≤ 56
Cooling (IEC 60034-6)	IC-01, IC-11, IC-21, IC-31, IC-06, IC-16, IC-26, IC-36, IC-17, IC-27, IC-37, IC-81W, IC-86W, IC-611, IC-616, IC-661 and IC-666
Supports	Bearings
Types of atmosphere	Only safe atmospheres
Main Options	
Lubrication groups, hydrostatic groups, special sensors (vibrations, temperature, speed, etc.), transformers.	

DIESEL GENERATOR SET

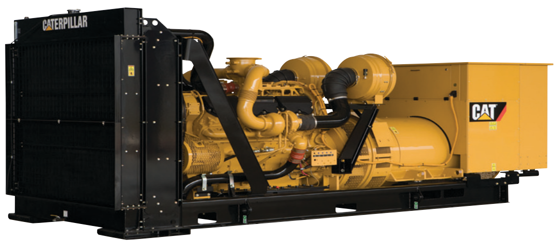


Image shown may not reflect actual package.

STANDBY

880 ekW 1100 kVA
50 Hz 1500 rpm 415 Volts

Caterpillar is leading the power generation marketplace with Power Solutions engineered to deliver unmatched flexibility, expandability, reliability, and cost-effectiveness.

FEATURES

FUEL/EMISSIONS STRATEGY
- Low Emissions

DESIGN CRITERIA
- The generator set accepts 100% rated load in one step per NFPA 110 and meets ISO 8528-5 transient response.

FULL RANGE OF ATTACHMENTS
- Wide range of bolt-on system expansion attachments, factory designed and tested
- Flexible packaging options for easy and cost effective installation

SINGLE-SOURCE SUPPLIER
- Fully prototype tested with certified torsional vibration analysis available

WORLDWIDE PRODUCT SUPPORT
- Cat dealers provide extensive post sale support including maintenance and repair agreements
- Cat dealers have over 1,800 dealer branch stores operating in 200 countries
- The Cat® S•O•S℠ program cost effectively detects internal engine component condition, even the presence of unwanted fluids and combustion by-products

CAT® C32 ATAAC DIESEL ENGINE
- Utilizes ACERT™ Technology
- Reliable, rugged, durable design
- Four-cycle diesel engine combines consistent performance and excellent fuel economy with minimum weight
- Electronic engine control

CAT GENERATOR
- Designed to match the performance and output characteristics of Cat diesel engines
- Single point access to accessory connections
- UL 1446 recognized Class H insulation

CAT EMCP 4 CONTROL PANELS
- Simple user friendly interface and navigation
- Scalable system to meet a wide range of customer needs
- Integrated Control System and Communications Gateway

FACTORY INSTALLED STANDARD & OPTIONAL EQUIPMENT

System	Standard	Optional
Air Inlet	• Single element canister type air cleaner • Service indicator	[ ] Dual element air cleaners [ ] Air inlet adapters
Cooling	• Radiator with guard • Coolant drain line with valve • Fan and belt guards • Cat Extended Life Coolant • Coolant level sensors	[ ] Jacket water heater [ ] Radiator duct flange
Exhaust	• Dry exhaust manifold • Flanged faced outlets	[ ] Stainless steel exhaust flex fittings [ ] Elbows, flanges, expanders & Y adapters
Fuel	• Primary fuel filter with water separator • Secondary fuel filter • Fuel priming pump • Flexible fuel lines • Fuel cooler	
SR5 Generator	• Class H insulation • Cat Digital Voltage Regulator (CDVR) with kVAR/PF control, 3-phase sensing • Reactive droop	[ ] Oversize & premium generators [ ] Winding temperature detectors [ ] Anti-condensation heaters [ ] Bearing temperature detectors
Power Termination	• Bus bar (NEMA or IEC mechanical lug holes) • Top cable entry	[ ] Circuit breakers, UL listed, 3 pole with shunt trip, 100% rated, manual or electrically operated [ ] Circuit breakers, IEC compliant, 3 or 4 pole with shunt trip, manual or electrically operated [ ] Bottom cable entry [ ] Power terminations can be located on the right, left and/or rear as an option. Multiple circuit breaker options
Governor	• ADEM™ A4	[ ] Load Share Module
Control Panels	• EMCP 4.2 • User Interface panel (UIP) - rear mount • AC & DC customer wiring area (right side) • Emergency stop pushbutton	[ ] EMCP 4.3 ... [ ] EMCP 4.4 [ ] Option for right or left mount UIP [ ] Local & remote annunciator modules [ ] Digital I/O Module [ ] Generator temperature monitoring & protection [ ] Remote monitoring software
Lube	• Lubricating oil and filter • Oil drain line with valves • Fumes disposal • Gear type lube oil pump	
Mounting	• Rails - engine / generator / radiator mounting • Rubber anti-vibration mounts (shipped loose)	[ ] Spring-type vibration isolator [ ] IBC Isolators
Starting/Charging	• 24 volt starting motor(s) • Batteries with rack and cables • Battery disconnect	[ ] Battery chargers (10 amp) [ ] 45 amp charging alternator [ ] Oversize batteries [ ] Ether starting aid
General	• Right-hand service • Paint - Caterpillar Yellow (except rails and radiators that are gloss black) • SAE standard rotation • Flywheel and Flywheel housing - SAE No. 0	[ ] CSA certification [ ] EU Declaration of Incorporation [ ] EEC Declaration of Conformity [ ] Seismic Certification per Applicable Building Codes: IBC 2000, IBC 2003, IBC 2006, IBC 2009, CBC 2007

SPECIFICATIONS

CAT GENERATOR

Frame size.. 1402
Excitation.. Internal Excitation
Pitch.. 0.6667
Number of poles.. 4
Number of bearings... 2
Number of Leads.. 006
Insulation....................... UL 1446 Recognized Class H with tropicalization and antiabrasion
- Consult your Caterpillar dealer for available voltages

IP Rating.. IP23
Alignment.. Closed Coupled
Overspeed capability.. 150
Wave form Deviation (Line to Line).......................... 002.00
Voltage regulator............. 3 Phase sensing with selectible volts/Hz
Voltage regulation............Less than +/- 1/2% (steady state)
Less than +/- 1% (no load to full load)
Telephone influence factor............................... Less than 50
Harmonic Distortion.. Less than 5%

CAT DIESEL ENGINE

C32 TA, V-12, 4-Stroke Water-cooled Diesel
Bore.. 145.00 mm (5.71 in)
Stroke... 162.00 mm (6.38 in)
Displacement... 32.10 L (1958.86 in^3)
Compression Ratio... 15.0:1
Aspiration.. TA
Fuel System... MEUI
Governor Type.. ADEM™ A4

CAT EMCP 4 SERIES CONTROLS

EMCP 4 controls including:
- Run / Auto / Stop Control
- Speed and Voltage Adjust
- Engine Cycle Crank
- 24-volt DC operation
- Environmental sealed front face
- Text alarm/event descriptions

Digital indication for:
- RPM
- DC volts
- Operating hours
- Oil pressure (psi, kPa or bar)
- Coolant temperature
- Volts (L-L & L-N), frequency (Hz)
- Amps (per phase & average)
- ekW, kVA, kVAR, kW-hr, %kW, PF

Warning/shutdown with common LED indication of:
- Low oil pressure
- High coolant temperature
- Overspeed
- Emergency stop
- Failure to start (overcrank)
- Low coolant temperature
- Low coolant level

Programmable protective relaying functions:
- Generator phase sequence
- Over/Under voltage (27/59)
- Over/Under Frequency (81 o/u)
- Reverse Power (kW) (32)
- Reverse reactive power (kVAr) (32RV)
- Overcurrent (50/51)

Communications:
- Six digital inputs (4.2 only)
- Four relay outputs (Form A)
- Two relay outputs (Form C)
- Two digital outputs
- Customer data link (Modbus RTU)
- Accessory module data link
- Serial annunciator module data link
- Emergency stop pushbutton

Compatible with the following:
- Digital I/O module
- Local Annunciator
- Remote CAN annunciator
- Remote serial annunciator

TECHNICAL DATA

Open Generator Set - - 1500 rpm/50 Hz/415 Volts	DM9945	
Low Emissions		
Generator Set Package Performance		
Genset Power rating @ 0.8 pf	1100 kVA	
Genset Power rating with fan	880 ekW	
Coolant to aftercooler		
Coolant to aftercooler temp max	49 ° C	120 ° F
Fuel Consumption		
100% load with fan	243.2 L/hr	64.2 Gal/hr
75% load with fan	184.1 L/hr	48.6 Gal/hr
50% load with fan	126.0 L/hr	33.3 Gal/hr
Cooling System[1]		
Air flow restriction (system)	0.12 kPa	0.48 in. water
Air flow (max @ rated speed for radiator arrangement)	883 m^3/min	31183 cfm
Engine Coolant capacity with radiator/exp. tank	226.0 L	59.7 gal
Engine coolant capacity	55.0 L	14.5 gal
Radiator coolant capacity	171.0 L	45.2 gal
Inlet Air		
Combustion air inlet flow rate	76.0 m^3/min	2683.9 cfm
Exhaust System		
Exhaust stack gas temperature	509.2 ° C	948.6 ° F
Exhaust gas flow rate	207.0 m^3/min	7310.1 cfm
Exhaust flange size (internal diameter)	203 mm	8 in
Exhaust system backpressure (maximum allowable)	10.0 kPa	40.2 in. water
Heat Rejection		
Heat rejection to coolant (total)	312 kW	17743 Btu/min
Heat rejection to exhaust (total)	951 kW	54083 Btu/min
Heat rejection to aftercooler	253 kW	14388 Btu/min
Heat rejection to atmosphere from engine	107 kW	6085 Btu/min
Heat rejection to atmosphere from generator	56.2 kW	3196.1 Btu/min
Alternator[2]		
Motor starting capability @ 30% voltage dip	2465 skVA	
Frame	1402	
Temperature Rise	150 ° C	270 ° F
Lube System		
Sump refill with filter	99.0 L	26.2 gal
Emissions (Nominal)[3]		
NOx mg/nm3	1937.6 mg/nm^3	
CO mg/nm3	100.5 mg/nm^3	
HC mg/nm3	11.4 mg/nm^3	
PM mg/nm3	11.6 mg/nm^3	

[1] For ambient and altitude capabilities consult your Cat dealer. Air flow restriction (system) is added to existing restriction from factory.

[2] UL 2200 Listed packages may have oversized generators with a different temperature rise and motor starting characteristics. Generator temperature rise is based on a 40°C ambient per NEMA MG1-32.

[3] Emissions data measurement procedures are consistent with those described in EPA CFR 40 Part 89, Subpart D & E and ISO8178-1 for measuring HC, CO, PM, NOx. Data shown is based on steady state operating conditions of 77°F, 28.42 in HG and number 2 diesel fuel with 35° API and LHV of 18,390 btu/lb. The nominal emissions data shown is subject to instrumentation, measurement, facility and engine to engine variations. Emissions data is based on 100% load and thus cannot be used to compare to EPA regulations which use values based on a weighted cycle.

RATING DEFINITIONS AND CONDITIONS

Meets or Exceeds International Specifications: AS1359, CSA, IEC60034-1, ISO3046, ISO8528, NEMA MG 1-22, NEMA MG 1-33, UL508A, 72/23/EEC, 98/37/EC, 2004/108/EC

Standby - Output available with varying load for the duration of the interruption of the normal source power. Average power output is 70% of the standby power rating. Typical operation is 200 hours per year, with maximum expected usage of 500 hours per year. Standby power in accordance with ISO8528. Fuel stop power in accordance with ISO3046. Standby ambients shown indicate ambient temperature at 100% load which results in a coolant top tank temperature just below the shutdown temperature.

Ratings are based on SAE J1349 standard conditions. These ratings also apply at ISO3046 standard conditions.

Fuel rates are based on fuel oil of 35° API [16° C (60° F)] gravity having an LHV of 42 780 kJ/kg (18,390 Btu/lb) when used at 29° C (85° F) and weighing 838.9 g/liter (7.001 lbs/U.S. gal.). Additional ratings may be available for specific customer requirements, contact your Cat representative for details. For information regarding Low Sulfur fuel and Biodiesel capability, please consult your Cat dealer.

DIMENSIONS

Package Dimensions		
Length	**4474.2 mm**	**176.15 in**
Width	**2010.4 mm**	**79.15 in**
Height	**2173.7 mm**	**85.58 in**
Weight	**6910 kg**	**15,234 lb**

NOTE: For reference only - do not use for installation design. Please contact your local dealer for exact weight and dimensions. (General Dimension Drawing #3497403).

DIESEL GENERATOR SET

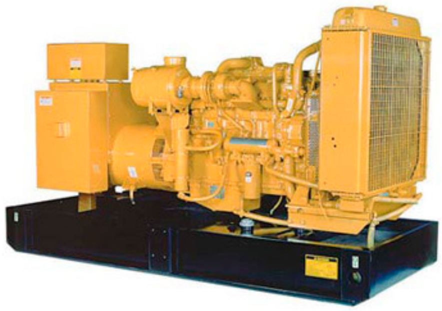


Image shown may not reflect actual package.

STANDBY
280 ekW 350 kVA
50 Hz 1500 rpm 400 Volts

Caterpillar is leading the power generation marketplace with Power Solutions engineered to deliver unmatched flexibility, expandability, reliability, and cost-effectiveness.

FEATURES

FUEL/EMISSIONS STRATEGY
- Low Fuel consumption

FULL RANGE OF ATTACHMENTS
- Wide range of bolt-on system expansion attachments, factory designed and tested
- Flexible packaging options for easy and cost effective installation

COMPLETE, READY-TO-RUN SYSTEM
- Fully configured generator set
- Full range of attachments and options available

ENCLOSURES (optional)
- Weather protective and sound attenuated

SINGLE-SOURCE SUPPLIER
- Fully prototype tested with certified torsional vibration analysis available

WORLDWIDE PRODUCT SUPPORT
- Cat dealers provide extensive post sale support including maintenance and repair agreements
- Cat dealers have over 1,800 dealer branch stores operating in 200 countries
- The Cat® S•O•S^{SM} program cost effectively detects internal engine component condition, even the presence of unwanted fluids and combustion by-products

CAT® 3406C TA DIESEL ENGINE
- High efficiency, four-stroke-cycle engine designed for thousands of trouble-free hours of operation
- Field-proven in thousands of applications

CAT GENERATOR
- Matched to the performance and output characteristics of Cat engines
- Load adjustment module provides engine relief upon load impact and improves load acceptance and recovery time
- UL 1446 Recognized Class H insulation

CAT EMCP 4 CONTROL PANELS
- Simple user friendly interface and navigation
- Scalable system to meet a wide range of customer needs
- Integrated Control System and Communications Gateway•

FACTORY INSTALLED STANDARD & OPTIONAL EQUIPMENT

System	Standard	Optional
Air Inlet	• Light duty air cleaner	[ ] Regular duty canister style, single stage with service indicator [ ] Dual element [ ] Heavy-duty and Muffler [ ] Air Inlet Shut-off
Cooling	• Coolant drain line with valve • Fan and belt guards • Radiator with guard • Coolant drain line with valve • Fan and belt guards • Cat® Extended Life Coolant* • Coolant level sight gauge	[ ] Low coolant level shutdown [ ] Duct flange
Exhaust	• Stainless steel exhaust flex • ANSI style outlet flange, gasket, bolts and mating weld flange; shipped loose	[ ] 10 DBA Industrial muffler [ ] 25 DBA Residential muffler [ ] Critical muffler [ ] Flexible fitting [ ] Elbow kit [ ] Throughwall Installation kit [ ] Manifold and Turbo Guard
Fuel	• Fuel priming pump • Fuel pressure gauge • Primary and secondary fuel filters • Flexible fuel lines	[ ] Water separator [ ] Fuel level switch [ ] Flexible fuel lines [ ] Manual or auto fuel pumps [ ] Single wall tank bases
Generator	• Three phase sensing • Class H insulation • VR6 3-phase sensing voltage regulator with load adjustment module • IP23 Protection • Circuit Breaker IEC, 3-pole • Segregated L.V. (AC/DC) wiring panel	[ ] Anti-condensation heater [ ] Permanent Magnet excitation [ ] RFI Filter [ ] Coastal Protection [ ] Terminal strip connection [ ] Oversize generator [ ] Circuit breaker, UL and IEC Listed, 3 & 4-pole with shunt trip [ ] Multiple breaker capability [ ] Digital Voltage Regulator
Governor	• Hydra-mechanical (3% speed regulation)	[ ] Electronic isochronous governor [ ] Load sharing module
Control Panels	• EMCP 4.1 • User Interface panel (UIP) - rear mount (standard) • Emergency Stop Pushbutton	[ ] EMCP 4.2 [ ] Local & remote annunciator modules [ ] Load share module [ ] Discrete I/O module [ ] Generator temperature monitoring & protection
Lube	• Lubricating oil and filter • Oil drain line with valve piped to edge of base • Fumes disposal piped to front of radiator	[ ] Manual sump pump [ ] Oil temperature sensor
Mounting	• Narrow integral fuel tank base (950L) • Linear vibration isolators between base and engine-generator	[ ] Narrow base [ ] Wide Base [ ] Lifting arch [ ] Oil field skid base
Starting/Charging	• 45 amp charging alternator • 24 volt starting motor • Batteries with rack and cables • Safety shutoff protection	[ ] Battery chargers (5 or 10 amp) [ ] Oversize batteries [ ] Battery disconnect switch [ ] Ether starting aid [ ] Jacket water heater
General		[ ] Enclosures - sound attenuated, weather protective [ ] EU Certificate of Conformance (CE)

SPECIFICATIONS

CAT GENERATOR

Frame size.. LC6114B
Excitation... Self Excitation
Pitch...0.6667
Number of poles...4
Number of bearings..................................... Single bearing
Number of Leads..012
Insulation....................... UL 1446 Recognized Class H with tropicalization and antiabrasion
- Consult your Caterpillar dealer for available voltages
IP Rating..IP23
Alignment...Pilot Shaft
Overspeed capability...150
Wave form Deviation (Line to Line).......................... 002.00
Voltage regulator................................Three phase sensing
Voltage regulation............Less than +/- 1/2% (steady state)
Less than +/- 1% (no load to full load)
Telephone influence factor...............................Less than 50
Harmonic Distortion...Less than 5%

CAT DIESEL ENGINE

3406C TA, I-6, 4-Stroke Water-cooled Diesel
Bore... 137.20 mm (5.4 in)
Stroke.. 165.10 mm (6.5 in)
Displacement...14.64 L (893.39 in^3)
Compression Ratio.. 14.5:1
Aspiration..TA
Governor Type.. Hydra-mechanical

CAT EMCP 4 SERIES CONTROLS

EMCP 4 controls including:
- Run / Auto / Stop Control
- Speed and Voltage Adjust
- Engine Cycle Crank
- 24-volt DC operation
- Environmental sealed front face
- Text alarm/event descriptions

Digital indication for:
- RPM
- DC volts
- Operating hours
- Oil pressure (psi, kPa or bar)
- Coolant temperature
- Volts (L-L & L-N), frequency (Hz)
- Amps (per phase & average)
- ekW, kVA, kVAR, kW-hr, %kW, PF (4.2 only)

Warning/shutdown with common LED indication of:
- Low oil pressure
- High coolant temperature
- Overspeed
- Emergency stop
- Failure to start (overcrank)
- Low coolant temperature
- Low coolant level

Programmable protective relaying functions:
- Generator phase sequence
- Over/Under voltage (27/59)
- Over/Under Frequency (81 o/u)
- Reverse Power (kW) (32) (4.2 only)
- Reverse reactive power (kVAr) (32RV)
- Overcurrent (50/51)

Communications:
- Four digital inputs (4.1)
- Six digital inputs (4.2 only)
- Four relay outputs (Form A)
- Two relay outputs (Form C)
- Two digital outputs
- Customer data link (Modbus RTU) (4.2 only)
- Accessory module data link (4.2 only)
- Serial annunciator module data link (4.2 only)
- Emergency stop pushbutton

Compatible with the following:
- Digital I/O module
- Local Annunciator
- Remote CAN annunciator
- Remote serial annunciator

TECHNICAL DATA

Open Generator Set - - 1500 rpm/50 Hz/400 Volts	DM2269	
Low Fuel Consumption		
Generator Set Package Performance		
Genset Power rating @ 0.8 pf	350 kVA	
Genset Power rating with fan	280 ekW	
Fuel Consumption		
100% load with fan	79.6 L/hr	21.0 Gal/hr
75% load with fan	60.6 L/hr	16.0 Gal/hr
50% load with fan	42.6 L/hr	11.3 Gal/hr
Cooling System[1]		
Air flow restriction (system)	0.12 kPa	0.48 in. water
Air flow (max @ rated speed for radiator arrangement)	522 m^3/min	18434 cfm
Engine Coolant capacity with radiator/exp. tank	57.8 L	15.3 gal
Engine coolant capacity	20.8 L	5.5 gal
Radiator coolant capacity	37.0 L	9.8 gal
Inlet Air		
Combustion air inlet flow rate	19.8 m^3/min	699.2 cfm
Exhaust System		
Exhaust stack gas temperature	596.8 ° C	1106.2 ° F
Exhaust gas flow rate	60.4 m^3/min	2133.0 cfm
Heat rejection to aftercooler	19 kW	1081 Btu/min
Exhaust flange size (internal diameter)	152.4 mm	6.0 in
Exhaust system backpressure (maximum allowable)	6.7 kPa	26.9 in. water
Heat rejection		
Heat rejection to coolant (total)	183 kW	10407 Btu/min
Heat rejection to exhaust (total)	297 kW	16890 Btu/min
Heat rejection to atmosphere from engine	65 kW	3697 Btu/min
Heat rejection to atmosphere from generator	19.8 kW	1126.0 Btu/min
Alternator[2]		
Motor starting capability @ 30% voltage dip	745 skVA	
Frame	LC6114B	
Temperature Rise	130 ° C	234 ° F
Lube System		
Sump refill with filter	38.0 L	10.0 gal
Emissions[3]		
NOx mg/nm3	4261.3 mg/nm^3	
CO mg/nm3	1721.9 mg/nm^3	
HC mg/nm3	24.1 mg/nm^3	
PM mg/nm3	249.3 mg/nm^3	

[1] For ambient and altitude capabilities consult your Cat dealer. Air flow restriction (system) is added to existing restriction from factory.
[2] UL 2200 Listed packages may have oversized generators with a different temperature rise and motor starting characteristics. Generator temperature rise is based on a 40°C ambient per NEMA MG1-32.
[3] Emissions data measurement procedures are consistent with those described in EPA CFR 40 Part 89, Subpart D & E and ISO8178-1 for measuring HC, CO, PM, NOx. Data shown is based on steady state operating conditions of 77°F, 28.42 in HG and number 2 diesel fuel with 35° API and LHV of 18,390 btu/lb. The nominal emissions data shown is subject to instrumentation, measurement, facility and engine to engine variations. Emissions data is based on 100% load and thus cannot be used to compare to EPA regulations which use values based on a weighted cycle.

RATING DEFINITIONS AND CONDITIONS

Meets or Exceeds International Specifications: AS1359, CSA, IEC60034-1, ISO3046, ISO8528, NEMA MG 1-22, NEMA MG 1-33, UL508A, 72/23/EEC, 98/37/EC, 2004/108/EC

Standby - Output available with varying load for the duration of the interruption of the normal source power. Average power output is 70% of the standby power rating. Typical operation is 200 hours per year, with maximum expected usage of 500 hours per year. Standby power in accordance with ISO8528. Fuel stop power in accordance with ISO3046. Standby ambients shown indicate ambient temperature at 100% load which results in a coolant top tank temperature just below the shutdown temperature.

Ratings are based on SAE J1349 standard conditions. These ratings also apply at ISO3046 standard conditions.

Fuel rates are based on fuel oil of 35º API [16º C (60º F)] gravity having an LHV of 42 780 kJ/kg (18,390 Btu/lb) when used at 29º C (85º F) and weighing 838.9 g/liter (7.001 lbs/U.S. gal.). Additional ratings may be available for specific customer requirements, contact your Cat representative for details. For information regarding Low Sulfur fuel and Biodiesel capability, please consult your Cat dealer.

DIMENSIONS

Package Dimensions		
Length	4264.3 mm	167.89 in
Width	1110.0 mm	43.7 in
Height	2150.0 mm	84.65 in
Weight	3464 kg	7,637 lb

NOTE: For reference only - do not use for installation design. Please contact your local dealer for exact weight and dimensions. (General Dimension Drawing #2923096).

Image shown may not reflect actual package

SOUND ATTENUATED ENCLOSURES FOR C32 POWERED GENERATOR SETS

Griffin 50 Hz & 60 Hz

These sound attenuated, factory installed enclosures include a choice of sound suppression mufflers, designed for safety and aesthetic value. Rugged construction provides weather protection and the ability to withstand exposure to the elements.

FEATURES

ROBUST/HIGHLY CORROSION RESISTANT CONSTRUCTION

- Environmentally friendly, polyester powder baked paint in yellow.
- Zinc plated or stainless steel fasteners
- 14 gauge steel construction
- Pitched roof for improved rain ingress protection
- Critical grade internally mounted muffler/exhaust system
- Rated for 120 mph wind loading

EXCELLENT ACCESS

- Control panel mounted on rear of package
- Large cable entry area for ease of installation
- Accommodates rear entry access to power cable lugs or circuit breaker
- Double doors on both sides
- Hinged doors allow 180° opening rotation
- Lube oil and coolant drains piped to exterior of enclosure and terminated drain valves
- Radiator fill cover

SECURITY AND SAFETY

- Lockable access doors with standard key utilization
- Cooling fan and battery charging alternator fully guarded
- Fuel fill, oil fill, and battery can only be reached via lockable access
- Stub-up cover for “rodent proofing”
- Externally mounted emergency stop button
- Designed for spreader-bar lifting to ensure safety

OPTIONS

- Interior lighting system
- White, grey, or beige paint
- Seismic certification per applicable building codes: IBC 2000, IBC 2003, IBC 2006, IBC 2009, CBC 2007
- Tested and analyzed in accordance with: ASCE 7-98, ASCE 7-02, ASCE 7-05, ICC-ES AC-156
- IBC certifiable for 120 mph wind loading

ENCLOSURES

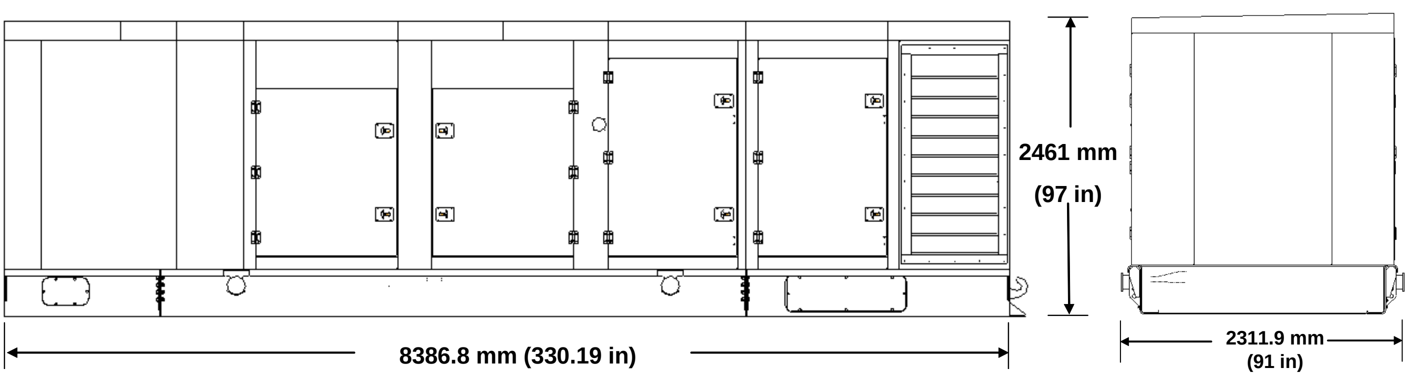
60 Hz Sound Attenuated Enclosure			Strategy	Ambient Capability *		Sound Pressure Levels dBA @ Full Load		
ekW	kVA	SB/PP/CN		°C	°F	1 m	7 m	15 m
1000	1250	SB	Low BSFC	50	122	84.7	80.2	74.1
910	1138	PP	Low BSFC	49	120	84.7	80.2	74.1
830	1038	CN	Low BSFC	51	124	84.7	80.2	74.1
1000	1250	SB	Tier 2	50	122	84.7	80.2	74.1
910	1138	PP	Tier 2	49	120	84.7	80.2	74.1
830	1038	CN	Tier 2	25	77	84.7	80.2	74.1

*Calculated ambient capability

50 Hz Sound Attenuated Enclosure			Strategy	Ambient Capability *		Sound Pressure Levels dBA @ Full Load			
ekW	kVA	SB/PP/CN		°C	°F	1 m	7 m	15 m	10 m**
880	1100	SB	Low BSFC	49	120	84.2	79.6	73.4	78.4
800	1000	PP	Low BSFC	47	117	84.2	79.6	73.4	78.4
728	910	CN	Low BSFC	34	93	84.2	79.6	73.4	78.4
880	1100	SB	Low Emissions	32	90	84.2	79.6	73.4	78.4
800	1000	PP	Low Emissions	35	95	84.2	79.6	73.4	78.4
728	910	CN	Low Emissions	30	86	84.2	79.6	73.4	78.4

*Calculated ambient capability

**According to CE standard Hemispherical data



Note: For reference only – do not use for installation design. Please contact your dealer for exact weights and dimensions.

Package Dimensions and Weights

Length	8386.8 mm	330.2 in
Width	2311.9 mm	91.0 in
Height	2461.0 mm	97.0 in
Approx. Enclosure Weight (with C32 package)	11,217 kg	24,729 lbs

CATERPILLAR®

C15 SOUND ATTENUATED ENCLOSURES

Larne 50 Hz/60 Hz

Picture shown may not reflect actual package.

These sound attenuated, factory installed enclosures incorporate internally mounted super critical level silencers, designed for safety and aesthetic value on integral fuel tank bases or optional fabricated steel bases. These enclosures are of extremely rugged construction to withstand exposure to the elements of weather.

FEATURES

ROBUST/HIGHLY CORROSION RESISTANT CONSTRUCTION

- Factory installed
- Environmentally friendly, polyester powder baked paint
- 14 gauge steel
- Zinc plated or stainless steel fasteners
- Radiator sight window
- Internally mounted super critical exhaust silencing system

EXCELLENT ACCESS

- Large cable entry area for installation ease
- Accommodates rear mounted breaker
- Double doors on both sides
- Vertically hinged doors allow 180° opening rotation
- Lube oil and coolant drains pipes to exterior of enclosure and terminated drain valves
- Radiator fill cover

SECURITY AND SAFETY

- Lockable access doors which give full access to control panel and breaker
- Cooling fan and battery charging alternator fully guarded
- Fuel fill, oil fill, coolant and battery can only be reached via lockable access
- Externally mounted emergency stop button
- Designed for spreader-bar lifting to ensure safety
- Control panel viewing window

OPTIONS

- Yellow or white paint
- Interior lighting system
- Skid base with dragging and fork pockets

CATERPILLAR®

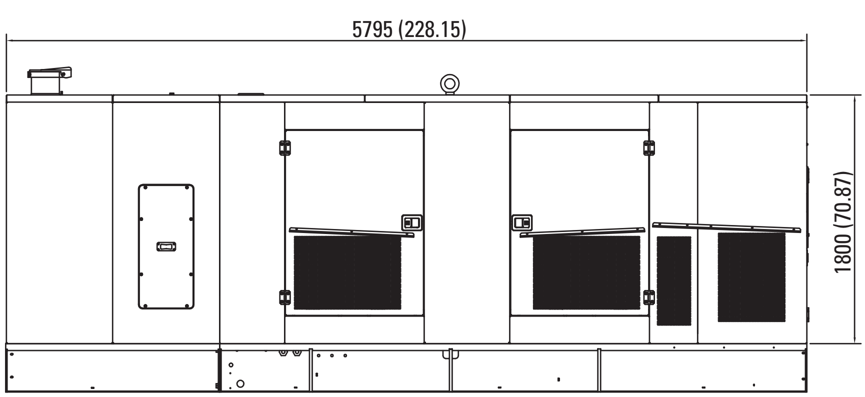
SOUND ATTENTUATED ENCLOSURE OPERATING CHARACTERISTICS

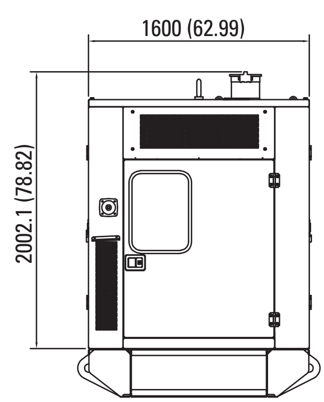
60 Hz SA Enclosure 1 Breaker			Ambient Capability*		Airflow Rate		Sound Pressure Levels dBA @ Full Load			Exhaust Back Pressure	
ekW	kVA	PP/SB	°C	°F	m^3/s	Cfm	1 m	7 m	15 m	in/H_2O	kPa
550	687.5	SB	42	108	11.9	25,215	87.7	76.7	70.7	18.0	4.5
500	625.0	SB	46	115	11.9	25,215	87.0	75.8	69.8	16.0	4.0
455	568.8	PP	44	111	11.9	25,215	86.4	75.2	69.2	14.3	3.6
450	562.5	SB	47	117	9.9	20,978	84.6	74.6	68.6	14.1	3.5
410	512.5	PP	44	111	9.9	20,978	84.2	74.0	68.0	12.5	3.1
400	500.0	SB	50	122	9.9	20,978	84.1	73.9	67.9	12.2	3.0
365	456.3	PP	47	117	9.9	20,978	83.8	73.4	67.4	10.9	2.7
350	437.5	SB	54	129	9.9	20,978	83.7	73.2	67.2	10.4	2.6
320	400.0	PP	50	122	9.9	20,978	83.5	72.9	66.9	9.3	2.3

*Ambient measured with Caterpillar Extended Life Coolant

50 Hz SA Enclosure (Low Emissions)			Ambient Capability*		Airflow Rate		Sound Pressure Levels dBA @ Full Load			Exhaust Back Pressure	
kVA	ekW	PP/SB	°C	°F	m^3/s	Cfm	1 m	7 m	15 m	in/H_2O	kPa
550	440	SB	45	113	7.7	16,315	81.3	70.8	64.8	12.4	3.08
500	400	PP	43	109	7.7	16,315	80.7	70.0	64.0	10.9	2.71
500	400	SB	48	118	7.7	16,315	80.7	70.0	64.0	10.9	2.71
455	364	PP	46	115	7.7	16,315	80.1	69.4	63.4	9.5	2.35
450	360	SB	52	126	7.7	16,315	80.1	69.3	63.3	9.3	2.31
410	328	PP	50	122	7.7	16,315	79.6	68.8	62.8	7.9	1.98
400	320	SB	56	133	7.7	16,315	79.5	68.6	62.6	7.6	1.89
365	292	PP	53	127	7.7	16,315	79.2	68.2	62.2	6.4	1.60

*Ambient measured with Caterpillar Extended Life Coolant





Approximate weight of enclosure package: 4984 kg (10,988 lb). Exact weight is dependent on options.
Enclosure weight includes: sound attenuated enclosure, exhaust system, extended base and generator set.
Caterpillar is pleased to offer these additional generator set enclosure colors: white and yellow.

LEHE6134-01 (8-06)

2013

WÄRTSILÄ SOLUTIONS FOR MARINE AND OIL & GAS MARKETS

WÄRTSILÄ

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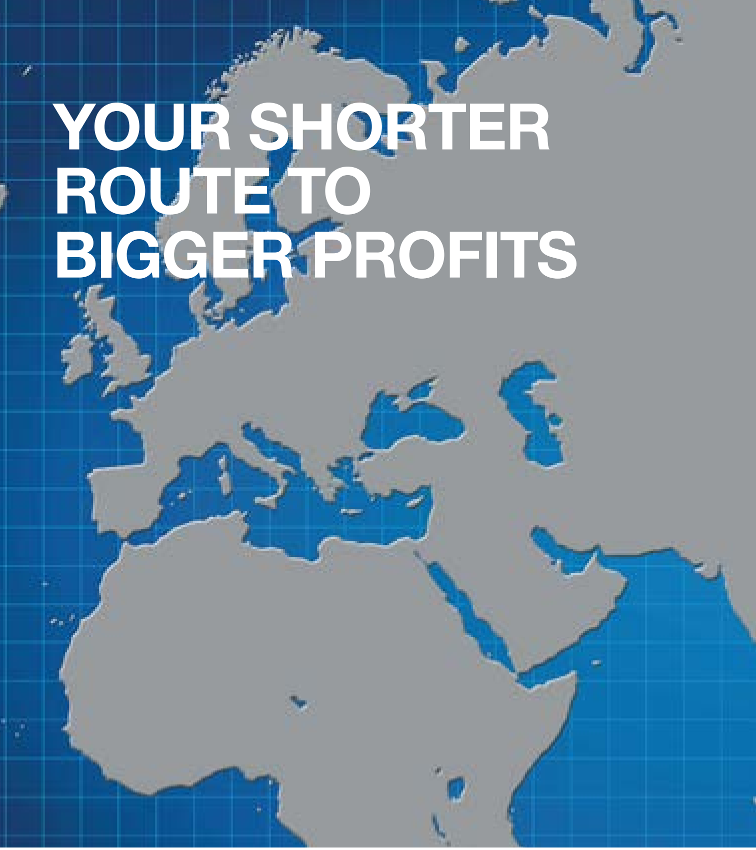
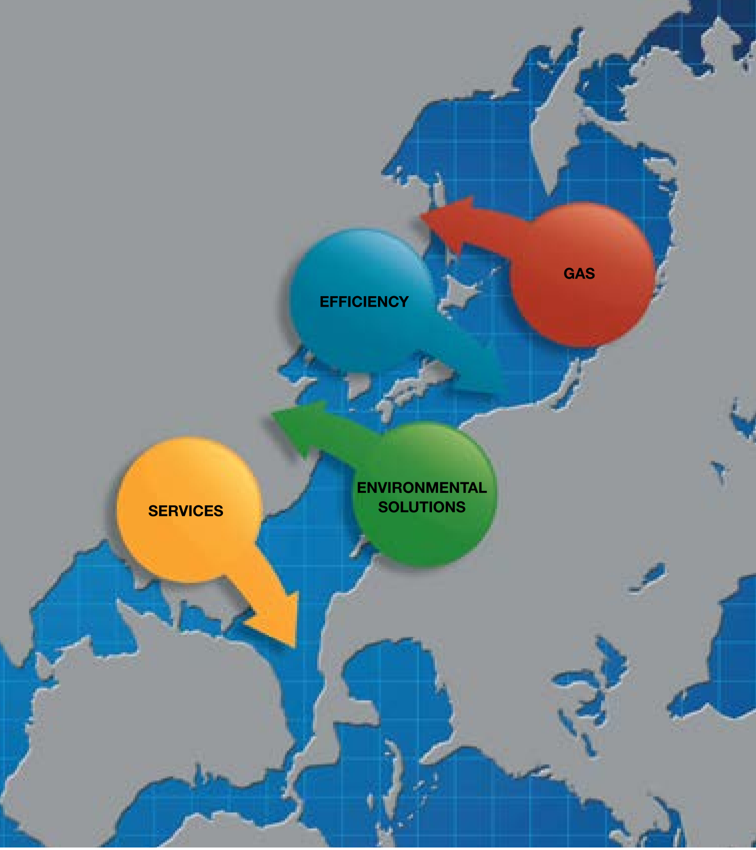
YOUR SHORTER ROUTE TO BIGGER PROFITS



At Wärtsilä we strive constantly to do what is best for you. This includes optimising the lifecycle value of your installations by offering precisely what you need; a promise we can deliver on since we provide the marine industry's most complete portfolio of products, integrated solutions and global services.By prioritising operational efficiency, environmental excellence, fuel flexibility and 24/7 support, we work with you to find your shorter route to robust growth, greater profitability and regulatory compliance. This is why today, every third vessel in the world has a Wärtsilä solution onboard. We help our customers find their shorter route to robust growth and bigger profits by focusing on operational efficiency, environmental excellence, fuel flexibility and services. Let's work together to find the right route for you.



Fuel flexibility

Natural gas is the cleanest fossil fuel in the world. At Wärtsilä, we have for several decades pioneered the development of gas technology. With our gas-fuelled solutions, the combination of high efficiency and low emissions is now unequalled in the marine and oil & gas markets. Wärtsilä's dual-fuel systems give you the chance to select the most suitable fuel or fuels depending on factors such as availability and price. Our dual-fuel (DF) engines are unique in the breadth of their flexibility. They are able to run on natural gas, marine diesel oil, heavy fuel oil, or even on bio fuels.

Environmental excellence

Many of our products are designed to have a direct environmental benefit. By eliminating or reducing polluting discharges and emissions from our customer's processes, we ensure that they can continue to operate in sensitive areas around the world.

We understand the regulatory environments in which our customers operate. Our expertise ensures that the solution provided meets your operating requirements while complying with all relevant environmental legislation. Our years of experience and technology leadership provide a strong basis of support for customers as they strive to maintain a safe and clean operating environment.

Operational efficiency

At Wärtsilä we optimise a vessel's efficiency by looking at the whole picture, starting from the initial design. We study the vessel's power and propulsion systems, the integrated automation systems, and the way that the vessel will be operated and maintained.

Our support also includes retrofit projects that reduce costs and risks, minimise downtime, and improve efficiencies. These retrofits are the product of excellent engineering capabilities, and are designed to extend the lifecycle of the installation.

Lifecycle support

Our global Wärtsilä Services business also serves to improve lifecycle efficiency by preventing the unexpected, lessening the environmental footprint, and optimising performance.

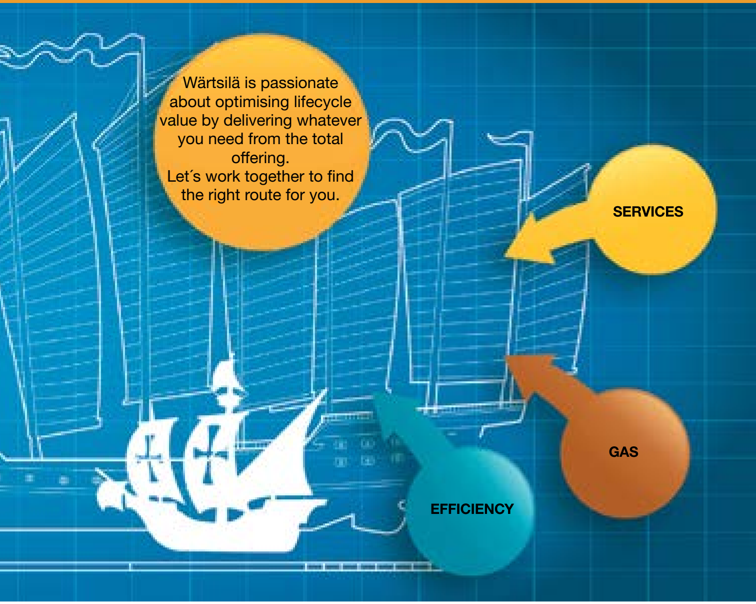
PAST, PRESENT AND FUTURE SUCCESS

SHIP DESIGN PORTFOLIO & SERVICES

With the benefit of 50 years of experience, Wärtsilä Ship Design is able to offer a complete range of options; from fully tailor-made unique designs, to standard, well proven, off-the-shelf designs.

A ship is built to last several decades, and decisions made in the early design stages will have consequences that effect the operation of the vessel throughout its entire lifetime. Wärtsilä takes operational considerations, as well as construction friendliness, into account during the design phase. Wärtsilä's vision is to be its customers' most valued business partner. We will support our customers in optimising their assets with the best designs, high quality products and system solutions, global services, as well as by providing maintenance and operational assistance.

Wärtsilä primarily provides designs for merchant, offshore and special vessels. Offshore construction vessels, anchor handling vessels, platform supply vessels, cable layers, pipe layers, container vessels, chemical tankers, research vessels, and offshore wind farm installation vessels are amongst our references.



We cover the full range of ship design disciplines, including naval architecture, hull optimisation, stability calculations, hull and structural engineering, accommodation and outfitting, machinery and piping engineering, as well as automation and electrical engineering.

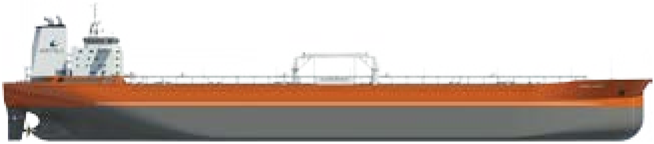
Wärtsilä offers basic designs, including classification drawings, detail design, and optimised 3D production drawings for shipyards worldwide.

Wärtsilä also offers a comprehensive range of marine consultancy services for shipyards or ship owners undertaking newbuilding, conversion, and retrofit projects.

Wärtsilä provides technical, operational and commercial feasibility studies, conceptual and initial designs, the preparation of general arrangements, and all the necessary related documents.

Wärtsilä assists its customers with tenders by preparing tendering documents and presentation material, and by participating in the evaluation processes.

Merchant Vessels



Wärtsilä Aframax – Crude Oil Aframax Tanker

Length overall	253.20 m	Cargo tank capacity (12 tanks)	134,250 m^3
Breadth	44.00 m	Load/discharge rate (manifold)	9,000 m^3/hr
Draught	15.20 m	Bow loading	8,000 m^3/hr

Marlin 2500 Green – Feeder Container Vessel

Length overall, approx	180.00 m	Design speed	18.0 knots
Gross tonnage	22,050 GT	Container capacity, max.	2,554 TEU
Net tonnage	7,760 NT	Fuel oil cons. 18 knots on 9.0 m	44.1 t/day

The environmental friendly feeder container vessel Marlin 2500 Green has dual-fuel and LNG options and is ideally suited to operate in ECAs (Emissions Control Areas)

SK 4226 LNG Conversion – Tanker for Oil Products

Length overall	177.10 m	Power	2 x 5850 kW
Breadth	26.00 m	Main engines	6-cylinder Wärtsilä 50DF
Draught	9.70 m	Speed	17.0 knots

Offshore Vessels

VS 485 PSV MKIII – Platform Supply Vessel

Length overall .... 85.60 m
Breadth .... 20.00 m
Depth .... 8.60 m
Deck area .... 1000 m^2
Power .... 4 x 1665 kW
Speed .... 15.4 knots

VS 4915 SRV – Seismic Research Vessel

Length overall .... 104.60 m
Breadth .... 25.00 / 28.00 m
Depth .... 8.60 m
Streamers 16–18
Endurance .... 60 days
Speed .... 15.0 knots

VS 491 CD AHTS – Anchor Handling vessel

Length overall .... 91.00 m
Breadth .... 22.00 m
Depth to 1st deck .... 9.60 m
Bollard pull .... 300 T
Power .... 2 x 8000 kW
Main engines .... 16-cylinder Wärtsilä 32

Offshore Vessels

VS 4616 PLV – Pipe Layer Vessel

Length overall	146.00 m	Crane	250 T
Breadth	30.00 m	Tensioners w 4 tracks x 2 (total)	550 T
Depth	12.70 m	Carousel	2500 T

VS 4725 DSV – Dive Support Vessel

Length	123.00 m	Cargo area	980.00 m^2
Breadth	24.00 m	Saturation diving up to 300 m	18 divers
Depth to 1st deck	10.50 m	Accommodation	110 POB

VS 4411 DF PSV – Platform Supply Vessel (LNG)

Length overall	89.20 m	Cargo area	968.00 m^2
Breadth moulded	19.00 m	Power	4 x 1521 kWe
Depth to 1st deck	9.00 m	Accommodation	25

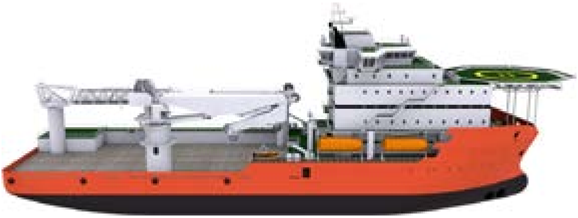
Special Vessels

VS 6208 TR – Trawler/Purse Seiner

Length overall	86.30 m	RSW capacity	3284 m^3
Breadth	17.60 m	Power	1 x 5220 kW
Depth	10.20 m	Speed	17.0 knots

WFIB 3000-50 – Jack-up Crane Barge

Length overall	109.00 m
Breadth	40.00 m
Deadweight (design draft)	5200 T
Gross tonnage	11,800 GT
Max. jackable load approx.	15,100 T
Crane capacity	800 T



VS 4004 MAS – Multipurpose Accommodation Ship

Length overall	112.80 m	Draft designed	5.5 m
Breadth	30.00 m	Generators	4 x 3000 kW
Depth	9.00 m	Accommodation	400

VESSEL AUTOMATION

Wärtsilä Control and Communication Center – 3C

An intelligent integration platform for all crucial onboard systems with flexibility to all types of vessels within the shipping industry, covering the offshore market, container and tanker trade up to ferries and cruise liners.

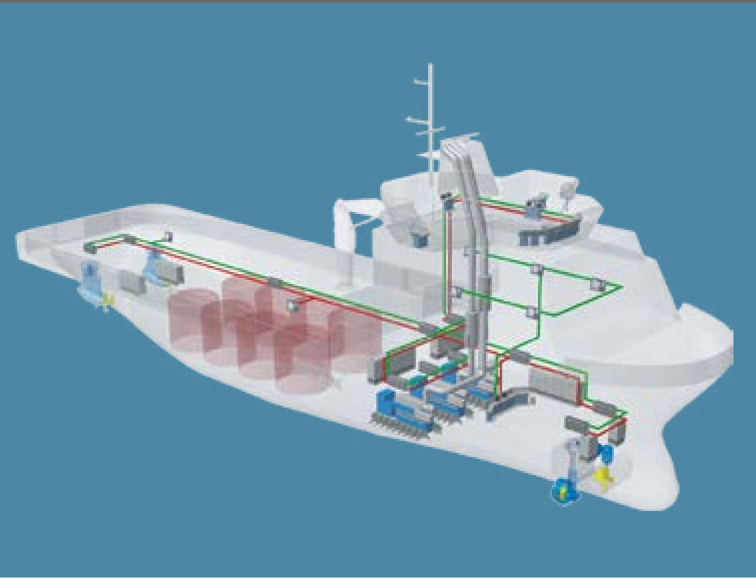
Together with experienced and proven partners Wärtsilä is introducing the Control and Communication Centre – 3C.

Wärtsilä Control & Communication Centre – 3C represents the very latest in fully integrated vessel control systems. It will be a vital link between the bridge and the ship's automation, engines and propulsion control systems, and combines the selection of individual navigation components in one seamless system.

3C consists of multifunction displays covering full workstations with radar, ECDIS and conning, various sensors for target detection, heading, position and further navigation data with standardised user interfaces. 3C is based on know-how and components that are well known for their outstanding precision and reliable design. The control centre fulfils basic IMO requirements as well as highest class notations for one-man bridges. The use of standard hardware and software allows the configuration of modular system solutions, from the tanker or containership through the offshore supply ship and the mega yacht to the cruise ship.

The multifunction displays (widescreen TFT) present:

- Radar including ARPA-Collision avoidance
- Chartradar
- ECDIS with automated route planning, weather chart, and online NAVTEX information
- ECOmeter (power management tool and advisory system for optimum engine configurations to achieve reduced fuel consumption and emissions)
- Sensor health performance monitoring
- Fast and easy access to navigation and automation data from any multifunction display
- Centralised dimming system
- Centralised alarm system
- Single action takeover
- Advanced route planning including weather, safety and ship performance criteria
- Speed pilot (integration with PCS for programmed and planned speed profiles)
- Advanced predictor (for improved precision manoeuvres)
- Optimiser (fleet management, vessel performance monitoring and data collection for later analysis and feedback)
- Common user interface with multiple options for further integration i.e. cargo monitoring



Wärtsilä Integrated Automation Systems

Wärtsilä Integrated Automation System (IAS) comprises all the functionality one can expect from a modern vessel automation system.

Whether the vessel is an ice breaker working in arctic conditions, a ship sailing in tropical seas, or a supply vessel operating in the rough winter storms of the North Sea, the crew must be able to trust the onboard power and automation installations.

Wärtsilä provides a broad assortment of alarm and control systems, from small alarm and monitoring systems (AMS) to advanced Wärtsilä Integrated Automation Systems with an integrated state-of-the-art power management system (PMS).

It opens the possibility for remote analysis of the systems, using satellite connections, the network on-board, and an interface to the Wärtsilä Condition Based Maintenance system (CBM).

Wärtsilä Power Management System

Wärtsilä's Power Management System (PMS) is fully integrated with Wärtsilä Switchboards and the Wärtsilä IAS. The Wärtsilä PMS contains all standard functions, such as load dependant start/stop, load sharing, synchronising, load shedding etc. And a lot more.

With a complete Wärtsilä package (engines, generators, PMS/power distribution, VSD, gears, and propeller/thrusters) one can be sure of having an optimally tuned system that will reduce the risk of bad performance and blackouts.

The Wärtsilä PMS has many advanced options, including control of the patented Wärtsilä Low loss concept (LLC) that will reduce distribution losses, increase the energy availability and save space and installation costs. For use in the offshore market, the Wärtsilä PMS has passed the Hardware-in-Loop (HIL) and other stringent tests from third party verification companies.

Together, Wärtsilä's IAS and PMS and its broad portfolio of products, ensure optimal operation of the vessel.

Wärtsilä Alarm and Monitoring System

Wärtsilä Alarm and Monitoring System (AMS) is part of the automation products that enable our customers to operate their vessels more efficiently and safely. The operator stations are designed for optimal, user-friendly operation and functionality. The system is integrated with Wärtsilä engines and propulsion products to achieve the best lifetime efficiency and reliability in the market.

The alarm and monitoring system monitors machinery and raises alarms for the operator under predefined circumstances. It opens the possibility for remote analysis of the systems, using satellite connections, the network on-board, and an interface to the Wärtsilä Condition Based Maintenance system (CBM).

Wärtsilä Propulsion Control Systems

Wärtsilä Propulsion Control Systems fully support the company's well proven, world-leading propulsion solutions.

All propulsion solutions need a reliable, easy-to-use, control system for manoeuvring the vessel. Wärtsilä has years of experience in electric and electronic control systems that meet varying customer requirements.

User-focused development ensures that both navigators and engineers will find the Wärtsilä Propulsion Control Systems easy to use. The systems are designed in accordance with IMO regulations and the requirements of all leading classification societies. Standardisation of components reduces the cost of engineering, installation and maintenance, while allowing customisation for individual preferences.

A single supplier of the propulsion solution and its control system ensures easy integration and total service.

BALLAST WATER MANAGEMENT SOLUTIONS FOR ALL SHIP TYPES

The IMO Ballast Water Convention was introduced in 2004 to address the Control and Management of Ships' Ballast Water and Sediments. The regulation specifies that all sea going vessels greater than 400 gross registered tonnes need to install a Ballast Water Management System.

In recognising that no one solution will be suitable across all ship types, Wärtsilä is uniquely placed to offer owners & operators a choice of Ballast Water Management Systems (BWMS).

The two Wärtsilä AQUARIUS® BWMS are designed to use a common filter module, and a different disinfection technology. The Wärtsilä AQUARIUS® UV BWMS uses Medium Pressure Ultra Violet (UV), while the Wärtsilä AQUARIUS® EC BWMS uses electro-chlorination technology.

The Wärtsilä AQUARIUS® BWMS range offers the following advantages:

- Proven performance to meet D2
- Low total cost of ownership
- Fully automatic operation
- Condition-based monitoring – optional functionality
- Flexible upscaling and modular design
- Suitable for both new build and retrofit projects
- Technology choice

By virtue of Wärtsilä AQUARIUS® BWMS range modular design, the system's inherent flexibility allows application across the full range of ship types and sizes, for both the new build and retrofit markets. Wärtsilä offers customers a range of flexible supply options, from equipment only, to a full 'turnkey' service covering all phases, from the initial survey through to the project management, supply, installation, and commissioning of the hardware, and continuing with lifecycle after sales service and support.

Wärtsilä AQUARIUS® UV

Wärtsilä AQUARIUS® UV Ballast Water Management Systems (BWMS) provide robust technology for the treatment of ballast water using ultra-violet (UV) irradiation, across the full range of ship operating and environmental conditions.

The Wärtsilä AQUARIUS® UV BWMS uses a simple two stage process involving filtration and UV irradiation. During uptake, seawater is first passed through a 40 micron backwashing screen to remove particulate, sediment, zooplankton and phytoplankton. Disinfection of the filtered sea water is then carried out using medium pressure UV lamps, and controlled by the BWMS control system. Upon discharge, the filter is by-passed but the ballast water is again disinfected with UV treatment before safe discharge back into the sea.

The system has a modular design enabling it to be arranged to suit conditions onboard the ship. The system can be designed and

Wärtsilä AQUARIUS® UV system	Capacity (m^3/h)	Total installed power (kW)
AQ-50-UV	0-50	20
AQ-80-UV	50-80	20
AQ-125-UV	80-125	20
AQ-180-UV	125-180	40
AQ-250-UV	180-250	40
AQ-300-UV	250-300	47
AQ-375-UV	300-375	48
AQ-430-UV	375-430	53
AQ-500-UV	430-500	68
AQ-550-UV	500-550	85
AQ-750-UV	550-750	85
AQ-850-UV	750-850	104
AQ-1000-UV	850-1000	104

Pressure drop	
Normal operation	0.3 barg
Backwash set point	0.8 barg

supplied to treat ballast water covering the full range of ballast pump sizes. There are 13 distinct Wärtsilä AQUARIUS® UV BWMS standard modules available with capacities ranging from 50 m^3/h to 1000 m^3/h. Capacities above 1000 m^3/h up to 6000 m^3/h are achieved by installing multiple modules in parallel.

Available in two configurations for installation in safe environments as well as an explosion proof version for hazardous areas. The flexible scope of supply can include standard modules or part kits that meet the individual requirements of our customers.

All Wärtsilä AQUARIUS® UV BWMS units have been granted IMO Type Approval by The Ministry of Infrastructure and the Environment of The Netherlands in accordance with Resolution MEPC.174(58) G8, and have been tested to meet the D2 performance discharge standard.

Wärtsilä AQUARIUS® EC

Wärtsilä AQUARIUS® EC Ballast Water Management Systems (BWMS) provide robust technology for the treatment of ballast water using in-situ electro-chlorination, across the full range of ship operating and environmental conditions.

The Wärtsilä AQUARIUS® EC BWMS uses a simple and efficient two stage process involving filtration and electro-chlorination (EC). During uptake, seawater is first passed through a 40 micron backwashing screen filter to remove particulate, sediment, zooplankton and phytoplankton. Disinfection of the filtered sea water is then carried out using hypochlorite generated from the side stream EC process, and controlled by the BWMS control system. Upon discharge, the ballast water by-passes the filter and any residual active substance is neutralised using sodium bisulphite, to ensure that the ballast water is safe to discharge back to the sea in full compliance with MARPOL requirements.

Wärtsilä AQUARIUS® EC system	Capacity (m^3/h)	Total Installed power (kW) Installed /Nominal
AQ-250-EC	0–250	28.1 / 24.7
AQ-300-EC	250–300	31.6 / 27.5
AQ-375-EC	300–375	36.7 / 31.6
AQ-430-EC	375–430	40.5 / 34.6
AQ-500-EC	430–500	48.8 / 41.7
AQ-550-EC	500–550	52.4 / 44.6
AQ-750-EC	550–750	66.6 / 55.9
AQ-850-EC	750–850	73.7 / 61.6
AQ-1000-EC	850–1000	87.9 / 73.0
AQ-1200-EC	1000–1200	102.8 / 84.9
AQ-1500-EC	1200–1500	131.7 / 109.3
AQ-2000-EC	1500–2000	188.9 / 155.0
AQ-2400-EC	2000–2400	222.7 / 182.1
AQ-3000-EC	2400–3000	284.1 / 233.3
AQ-3300-EC	3000–3300	309.4 / 253.7

Pressure drop	
Normal operation	0.3 barg
Backwash set point	0.8 barg

The system has a modular design enabling it to be arranged to suit conditions onboard the ship. The system can be designed and supplied to treat ballast water covering the full range of ballast pump sizes. There are 15 distinct Wärtsilä AQUARIUS® EC BWMS standard modules available with capacities ranging from 250 m^3/h to 3300 m^3/h.

System capacities above 3300 m^3/h are achieved by installing multiple modules in parallel.

A flexible scope of supply includes standard modules or part kits to meet the customer's individual requirements.

The Wärtsilä AQUARIUS® EC BWMS received IMO Basic Approval at MEPC 64, with Final Approval following at MEPC 65 in May 2013. Type Approval will follow in 2013.

Wärtsilä Hamworthy Air & Gas Compressors

Wärtsilä is an established supplier of compressor and ejector systems for the oil, gas and petrochemical industries. Our compressors can be configured to suit a diverse range of high pressure applications for both air and other gases: Argon, Biogas, Carbon Dioxide, Helium, Heliox, Hydrogen, Methane, Natural Gas, Nitrogen (both compression and generation).

We offer a range of options, from a basic compressor block to a fully integrated compressor package solution for high pressure air or gas. We are also able to incorporate ancillary items, such as nitrogen generation and air/gas driers, into the scope of supply. The units are designed to comply with European and other International standards for a range of industries and applications.

We offer 2, 3 and 4 stage compressors with inlet pressures up to 7 bar g, and discharge pressures up to 350 bar g.

Wärtsilä Hamworthy CNG Compressors

We offer biogas or natural gas solutions for CNG refueling stations to serve buses, trucks and other vehicles.

CNG is a more environmentally acceptable alternative than petrol, diesel, or propane/LPG, and is significantly lower in price. Our offering covers a range of options, from a basic compressor block to a fully installed and commissioned CNG refueling station that includes the compression module(s), cascade storage, priority panels and fuel dispensers. The units are designed to comply with European and International standards.

We provide systems for either ‘fast fill’ (temperature compensated) or ‘timed fill’ with 200 or 250 bar g filling pressures. The gas composition may be required to ensure correct compressor and material selection.

Wärtsilä Hamworthy Rig Tensioning Compressors

Our rig tensioning compressors and heave compensation compressor packages are fully integrated, lightweight, compact, and engineered for the offshore environment.

The combination of a 4 stage compressor, dryer, and filtration package with a contained cooling system, produces filtered and dry, high pressure air or gas suitable for riser tensioning and other offshore applications. The packages are designed to ensure that upgrades, refurbishment, and servicing can be easily carried out. We also offer high pressure nitrogen booster compressors, along with nitrogen generation systems, for riser tensioning, motion compensation, drill stream compensation and other applications.

These units can be supplied as integrated packages, fully assembled, tested and ready for installation. The module also meets the requirements of the major marine classification societies.

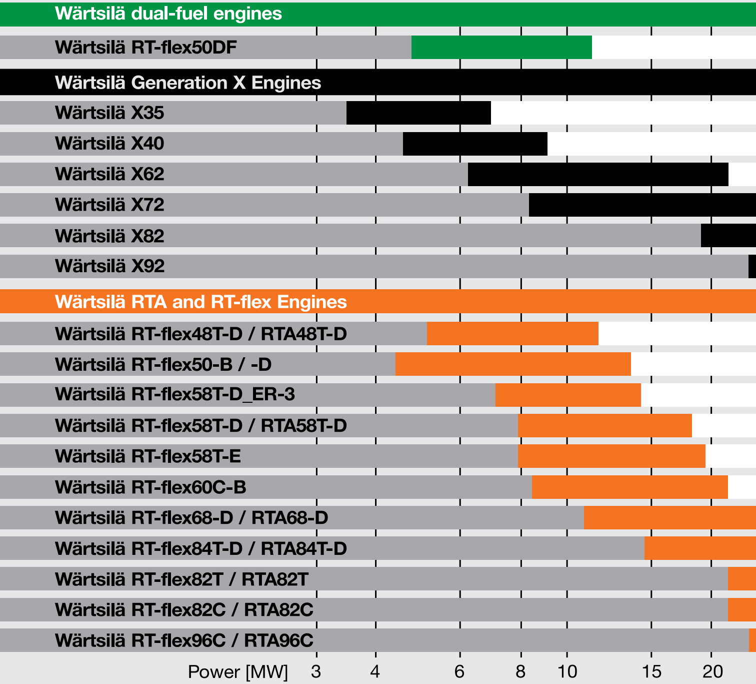
Wärtsilä Hamworthy Seismic Compressors

Our seismic compressors offer an integrated and compact solution to your high-pressure needs.

Wärtsilä Hamworthy seismic compressors feature a low lift concentric valve and generous inter-stage cooling to minimise the amount of absorbed power. This results in very high overall efficiency. Each machinery package includes a choice of drive, skid base and control system, and is engineered to suit your seismic requirements.

The low unit noise and vibration improves reliability and reduces interference with survey results. Flexibility in vessel utilisation is available to contractors and operators via the containerised option. Thanks to the easy access features and simple modular construction, it enables low and easy maintenance. A multiple unit control system provides local and remote operation of two or more compressors.

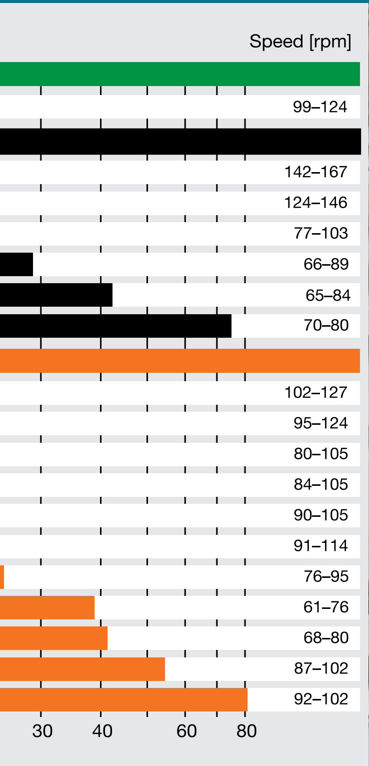
Power Range for Wärtsilä Low-Speed Engines



WÄRTSILÄ LOW-SPEED ENGINES

Wärtsilä low-speed, two-stroke engines are the optimal propulsion solution for merchant vessels with directly driven propellers. Wärtsilä's well proven electronically-controlled common-rail technology plays a key role in enabling ship owners to reduce fuel costs. The benefits to shipowners and operators may be summarised as:

- The optimal power and speed for every operational need
- Competitive capital cost
- Lowest possible fuel consumption over the whole operating range, especially in the part-load range



- Operate on high tensity fuel ISO F 8217:2012/RMK700
- Special tuning for even better part-load fuel consumption
- Low cylinder oil feed rate
- Up to five years between overhauls
- Low maintenance costs through reliability and durability
- Full compliance with NO_X emission control regulations
- Smokeless operation at all running speeds
- Lower steady running speeds
- Reduced maintenance requirements with simpler engine settings

Low Speed Dual-fuel Engine

Driven by emission regulations and recent fuel price developments, the interest in gas as fuel for shipping is increasing. Wärtsilä is the leading provider of medium speed gas and Dual Fuel engines since 2005. A major milestone was recently reached with 2000 engines sold, collectively logging more than 7 million running hours. Wärtsilä Dual Fuel technology for 2-stroke engines is based on the pre-mixed lean burn combustion principle already proven for the Wärtsilä 4-stroke dual fuel engines. The merits of this technology are:

- no additional NO_X reduction technologies are needed to fulfill the IMO Tier III requirements
- gas injection pressure < 10 bar
- simple, reliable and low cost gas supply system

Dimensions and weights

All dimensions are in millimetres and are not binding.

- F1: Min height for vertical removal
- F2: Min height for vertical removal with double-jib crane
- F3: Min height for tilted removal with double-jib crane
- The engine weight is net in metric tonnes (t), without oil and water, and is not binding.

Fuel consumption

All brake specific fuel consumptions (BSFC) are quoted for fuel of lower calorific value 42.7 MJ/kg for liquid fuel and 50.0 MJ/kg for gas fuel, and for ISO standard reference conditions (ISO 15550 and 3046)

For Wärtsilä 2-stroke dual-fuel engines, stepwise tolerances have been introduced for the brake specific fuel consumptions (BSFC):

- +5% tolerance for 100% to 85% engine load
- +6% tolerance for 84% to 65% engine load
- +7% tolerance for 64% to 25% engine load

Wärtsilä RT-flex50DF	IMO Tier III in gas mode
Cylinder bore	500mm
Piston stroke	2050mm
Speed	99-124rpm
Mean effective pressure at R1	17.3 bar
Stroke/bore	4.10

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A (mm)	Length A* (mm)	Weight tonnes
	124 rpm	124 rpm	99 rpm	99 rpm			
	R1	R2	R3	R4			
5	7 200	6 000	5 750	4 775	5 576	6 793	200
6	8 640	7 200	6 900	5 730	6 456	7 670	225
7	10 080	8 400	8 050	6 685	7 336		255
8	11 520	9 600	9 200	7 640	8 216		280

Dimensions (mm)	B	C	D	E	E*
	3 150	1 088	7 646	3 570	1 900
	F1	F2	F3	G	
	9 270	9 250	8 700	1 636	

Brake specific gas consumption (BSGC) in g/kWh

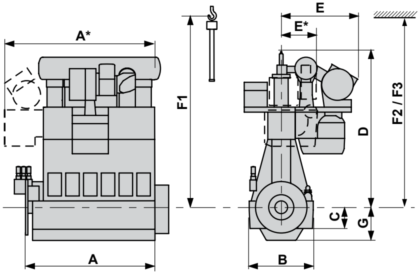
Rating point		R1	R2	R3	R4
BSGC (Gas)	g/kWh	140.8	141.5	140.3	141.0

Brake specific pilot fuel consumption (BSPC) in g/kWh

Rating point		R1	R2	R3	R4
BSPC (Pilot fuel)	g/kWh	2.0	2.4	2.5	3.0

Brake specific fuel consumption (BSFC) in g/kWh

Rating point		R1	R2	R3	R4
BSFC (Diesel)	g/kWh	182.3	182.3	182.3	182.3



Wärtsilä X35	IMO Tier II
Cylinder bore	350 mm
Piston stroke	1550 mm
Speed	142–167 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.43

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	167 rpm		142 rpm			
	R1	R2	R3	R4		
5	4 350	3 475	3 700	3 475	4 398	74
6	5 220	4 170	4 440	4 170	5 010	84
7	6 090	4 865	5 180	4 865	5 622	95
8	6 960	5 560	5 920	5 560	6 234	105

Dimensions mm	B	C	D	E
	2 284	830	5 556	1 605
	F1	F2	F3	G
	6 736	6 736	6 325	1 326

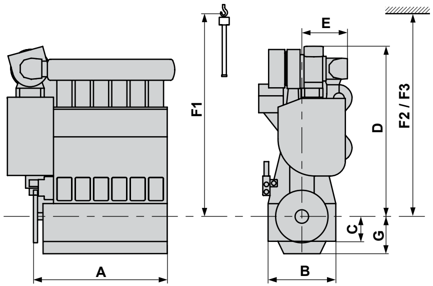
Brake specific fuel consumption (BSFC) in g/kWh

Full load

Rating point		R1	R2	R3	R4
BMEP, bar		21.0	16.8	21.0	19.8
BSFC	Standard Tuning	176	170	176	174

Part load,% of R1	85	70	85	70	60
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	172.4	172.0	171.7	170.5	168.2

For definitions see page 52



Wärtsilä X40	IMO Tier II
Cylinder bore	400 mm
Piston stroke	1770 mm
Speed	124–146 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.43

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	146 rpm		124 rpm			
	R1	R2	R3	R4		
5	5 675	4 550	4 825	4 550	5 107	109
6	6 810	5 460	5 790	5 460	5 807	125
7	7 945	6 370	6 755	6 370	6 507	140
8	9 080	7 280	7 720	7 280	7 207	153

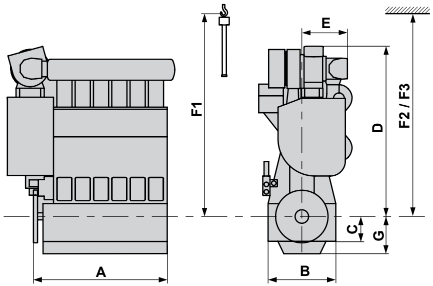
Dimensions mm	B	C	D	E
	2 610	950	6 335	1 660
	F1	F2	F3	G
	7 635	7 635	7 100	1 425

Brake specific fuel consumption (BSFC) in g/kWh

Full load					
Rating point		R1	R2	R3	R4
BMEP, bar		21.0	16.8	21.0	19.8
BSFC	Standard Tuning	174	168	174	172

Part load,% of R1	85	70	85	70	60
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	170.4	170.0	169.7	168.5	166.2

For definitions see page 52



Wärtsilä X62	IMO Tier II
Cylinder bore	620 mm
Piston stroke	2658 mm
Speed	77–103 rpm
Mean effective pressure at R1/R1+	20.5/19.3 bar
Stroke / bore	4.29

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	97 / 103 rpm		77 rpm			
	R1 / R1+	R2 / R2+	R3	R4		
4	10 640	8 000	8 440	6 360	5 895	270
5	13 300	10 000	10 550	7 950	7 000	325
6	15 960	12 000	12 660	9 540	8 110	377
7	18 620	14 000	14 770	11 130	9 215	435
8	21 280	16 000	16 880	12 720	10 320	482

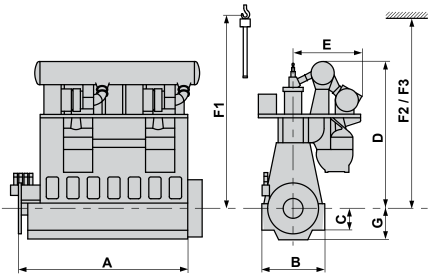
Dimensions mm	B	C	D	E
	4 200	1 360	9 580	3 915
	F1	F2	F3	G
	11 670	11 670	10 800	2 110

Brake specific fuel consumption (BSFC) in g/kWh

Full load					
Rating point		R1/R1+	R2/R2+	R3	R4
BMEP, bar		20.5/19.3	15.4/14.5	20.5	15.4
BSFC	Standard Tuning	167/166	160	167	160

Part load,% of R1/R1+	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	163.4/162.4	163.0/162.0	162.7/161.7	161.5/160.5	158.2/157.4

For definitions see page 52



Wärtsilä X72	IMO Tier II
Cylinder bore	720 mm
Piston stroke	3086 mm
Speed	66–89 rpm
Mean effective pressure at R1/R1+	20.5/19.4 bar
Stroke / bore	4.29

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	84 / 89 rpm		66 rpm			
	R1 / R1+	R2 / R2+	R3	R4		
4	14 440	10 800	11 360	8 480	6 790	407
5	18 050	13 500	14 200	10 600	8 085	481
6	21 660	16 200	17 040	12 720	9 375	561
7	25 270	18 900	19 880	14 840	10 665	642
8	28 880	21 600	22 720	16 960	11 960	716

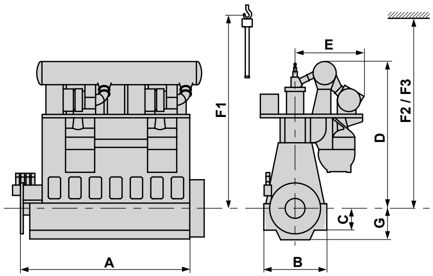
Dimensions mm	B	C	D	E
	4 780	1 575	10 790	4 710
	F1	F2	F3	G
	13 560	13 560	12 580	2 455

Brake specific fuel consumption (BSFC) in g/kWh

Full load					
Rating point		R1/R1+	R2/R2+	R3	R4
BMEP, bar		20.5/19.4	15.4/14.5	20.5	15.4
BSFC	Standard Tuning	167/166	160	167	160

Part load,% of R1/R1+	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	163.4/162.4	163.0/162.0	162.7/161.7	161.5/160.5	158.2/157.4

For definitions see page 52



Wärtsilä X82	IMO Tier II
Cylinder bore	820 mm
Piston stroke	3375 mm
Speed	65–84 rpm
Mean effective pressure at R1/R1+	21.0/19.0 bar
Stroke / bore	4.12

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	76 / 84 rpm		65 rpm			
	R1 / R1+	R2 / R2+	R3	R4		
6	28 500	21 720	24 390	18 600	11 045	805
7	33 250	25 340	28 455	21 700	12 550	910
8	38 000	28 960	32 520	24 800	14 055	1 020
9	42 750	32 580	36 585	27 900	16 500	1 160

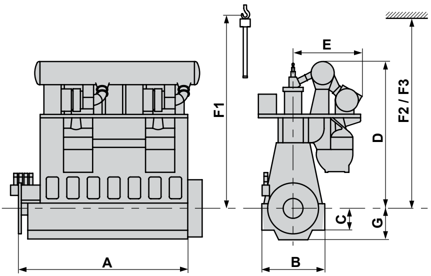
Dimensions mm	B	C	D	E
	5 320	1 800	12 250	5 400
	F1	F2	F3	G
	14 820	14 800	13 800	2 700

Brake specific fuel consumption (BSFC) in g/kWh

Full load						
Rating point			R1/R1+	R2/R2+	R3	R4
BMEP, bar			21.0/19.0	16.0/14.5	21.0	16.0
BSFC	RT-flex	Standard Tuning	165/163	158	165	158

Part load,% of R1/R1+	85	70	85	70	65
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	161.4/159.4	161.0/159.0	160.7/158.7	159.5/157.5	156.2/154.5

For definitions see page 52



Wärtsilä X92	IMO Tier II
Cylinder bore	920 mm
Piston stroke	3468 mm
Speed	70–80 rpm
Mean effective pressure at R1/R1+	21.0/20.0 bar
Stroke / bore	3.77

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	76/80 rpm		70 rpm			
	R1 / R1+	R2 / R2+	R3	R4		
6	36 780	26 520	33 900	24 420	11 630	1 120
7	42 910	30 940	39 550	28 490	13 210	1 260
8	49 040	35 360	45 200	32 560	16 350	1 460
9	55 170	39 780	50 850	36 630	17 850	1 630
10	61 300	44 200	56 500	40 700	19 520	1 790
11	67 430	48 620	62 150	44 770	21 280	1 960
12	73 560	53 040	67 800	48 840	22 870	2 140

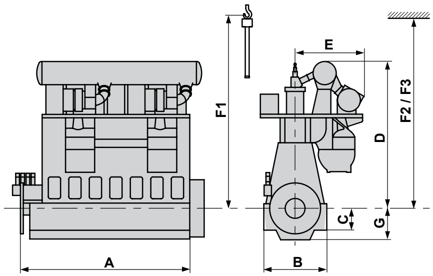
Dimensions mm	B	C	D	E
	5550	1900	12 950	6050
	F1	F2	F3	G
	15 550	15 550	14 800	2930

Brake specific fuel consumption (BSFC) in g/kWh

Full load					
Rating point		R1/R1+	R2/R2+	R3	R4
BMEP, bar		21.0/20.0	15.1/14.4	21.0	15.1
BSFC	Standard Tuning	166.0/165.0	159.0	166.0	159.0

Part load,% of R1/R1+	85	70	85	70	65
Tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	162.4/161.4	162.0/161.0	161.7/160.7	160.5/159.5	157.2/156.4

For definitions see page 52



Wärtsilä RT-flex48T / RTA48T, version D	IMO Tier II
Cylinder bore	480 mm
Piston stroke	2000 mm
Speed	102–127 rpm
Mean effective pressure at R1	19.0 bar
Stroke / bore	4.17

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	127 rpm		102 rpm			
	R1	R2	R3	R4		
5	7 275	5 100	5 825	5 100	5 314	171
6	8 730	6 120	6 990	6 120	6 148	205
7	10 185	7 140	8 155	7 140	6 982	225
8	11 640	8 160	9 320	8 160	7 816	250

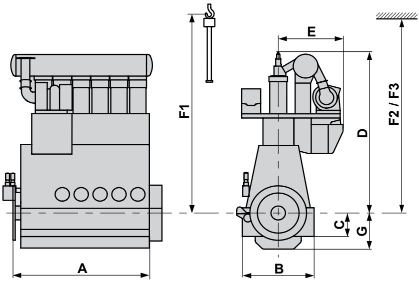
Dimensions mm	B	C	D	E
	3 170	1 085	7 334	3 253
	F1	F2	F3	G
	9 030	9 000	8 790	1 700

Brake specific fuel consumption (BSFC) in g/kWh

Full load						
Rating point			R1	R2	R3	R4
BMEP, bar			19.0	13.3	19.0	16.6
BSFC	RTA		173	167	173	169
	RT-flex	Standard Tuning	170	164	170	166

Part load,% of R1	85	70	85	70	60
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	166.4	166.0	165.7	164.5	162.2

For definitions see page 52



Wärtsilä RT-flex50, version D	IMO Tier II
Cylinder bore	500 mm
Piston stroke	2050 mm
Speed	95–124 rpm
Mean effective pressure at R1	21.0 bar
Stroke / bore	4.10

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Length A* mm	Weight tonnes
	124 rpm		95 rpm				
	R1	R2	R3	R4			
5	8 725	6 650	6 700	5 100	5 576	6 793	200
6	10 470	7 980	8 040	6 120	6 456	7 670	225
7	12 215	9 310	9 380	7 140	7 336		255
8	13 960	10 640	10 720	8 160	8 216		280

Dimensions mm	B	C	D	E	E*
	3 150	1 088	7 646	3 570	1 900
	F1	F2	F3	G	
	9 270	9 250	8 700	1 636	

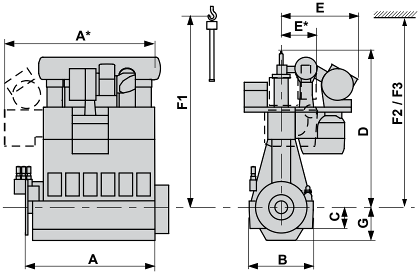
Brake specific fuel consumption (BSFC) in g/kWh

Full load

Rating point			R1	R2	R3	R4
BMEP, bar			21.0	16.0	21.0	16.0
BSFC	RT-flex	Standard Tuning	169	163	169	163

Part load,% of R1	85	70	85	70	60
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	165.4	165.0	164.7	163.5	161.2

For definitions see page 52



Wärtsilä RT-flex50, version B	IMO Tier II
Cylinder bore	500 mm
Piston stroke	2050 mm
Speed	95–124 rpm
Mean effective pressure at R1	20.0 bar
Stroke / bore	4.10

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Length A* mm	Weight tonnes
	124 rpm		95 rpm				
	R1	R2	R3	R4			
5	8 300	6 325	6 375	4 850	5 576	6 793	200
6	9 960	7 590	7 650	5 820	6 456	7 670	225
7	11 620	8 855	8 925	6 790	7 336		255
8	13 280	10 120	10 200	7 760	8 216		280

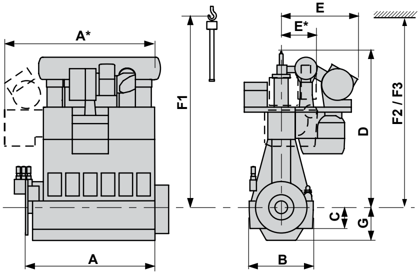
Dimensions mm	B	C	D	E	E*
	3 150	1 088	7 646	3 570	1 900
	F1	F2	F3	G	
	9 270	9 250	8 700	1 636	

Brake specific fuel consumption (BSFC) in g/kWh

Full load						
Rating point			R1	R2	R3	R4
BMEP, bar			20.0	15.0	20.0	15.0
BSFC	RT-flex	Standard Tuning	170	164	170	164

Part load,% of R1	85	70	85	70	60
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	166.4	166.0	165.7	164.5	162.2

For definitions see page 52



Wärtsilä RT-flex58T, version D, ER-3	IMO Tier II
Cylinder bore	550 mm
Piston stroke	2416 mm
Speed	80–105 rpm
Mean effective pressure at R1	20.2 bar
Stroke / bore	4.39

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	105 rpm		80 rpm			
	R1	R2	R3	R4		
5	10 175	7 100	7 750	5 400	6 381	281
6	12 210	8 520	9 300	6 480	7 387	322
7	14 245	9 940	10 850	7 560	8 393	377

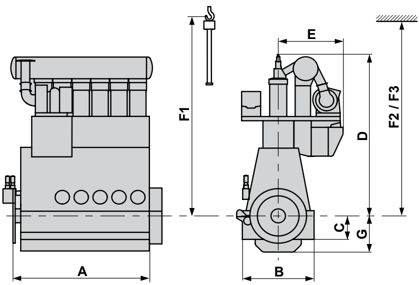
Dimensions mm	B	C	D	E
	3 820	1 300	8 822	3 475
	F1	F2	F3	G
	10 880	10 817	10 124	2 000

Brake specific fuel consumption (BSFC) in g/kWh

Full load						
Rating point			R1	R2	R3	R4
BMEP, bar			20.2	14.1	20.2	14.1
BSFC	RT-flex	Standard Tuning	167.0	161.0	167.0	161.0

Part load,% of R1	85	70	85	70	60
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	163.4	163.0	162.7	161.5	159.2

For definitions see page 52



Wärtsilä RT-flex58T, version E	IMO Tier II
Cylinder bore	580 mm
Piston stroke	2416 mm
Speed	90–105 rpm
Mean effective pressure at R1	21 bar
Stroke / bore	4.17

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	105 rpm		90 rpm			
	R1	R2	R3	R4		
5	11 750	7 900	10 075	7 900	6 381	281
6	14 100	9 480	12 090	9 480	7 387	322
7	16 450	11 060	14 105	11 060	8 393	377
8	18 800	12 640	16 120	12 640	9 399	418

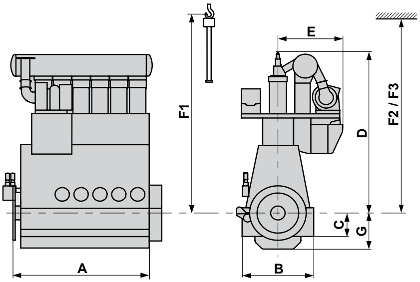
Dimensions mm	B	C	D	E
	3 820	1 300	8 822	3 475
	F1	F2	F3	G
	10 880	10 817	10 124	2 000

Brake specific fuel consumption (BSFC) in g/kWh

Full load						
Rating point			R1	R2	R3	R4
BMEP, bar			21.0	14.1	21.0	16.5
BSFC	RT-flex	Standard Tuning	168	162	168	162

Part load,% of R1	85	70	85	70	60
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	164.4	164.0	163.7	162.5	160.2

For definitions see page 52



Wärtsilä RT-flex58T / RTA58T, version D	IMO Tier II
Cylinder bore	580 mm
Piston stroke	2416 mm
Speed	84–105 rpm
Mean effective pressure at R1	20.2 bar
Stroke / bore	4.17

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	105 rpm		84 rpm			
	R1	R2	R3	R4		
5	11 300	7 900	9 050	7 900	6 381	281
6	13 560	9 480	10 860	9 480	7 387	322
7	15 820	11 060	12 670	11 060	8 393	377
8	18 080	12 640	14 480	12 640	9 399	418

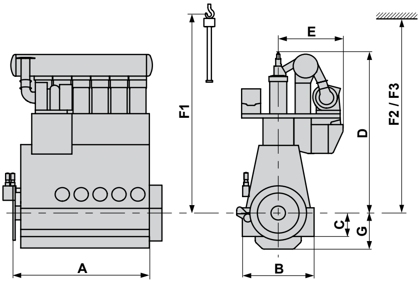
Dimensions mm	B	C	D	E
	3 820	1 300	8 822	3 475
	F1	F2	F2	G
	10 880	10 817	10 124	2 000

Brake specific fuel consumption (BSFC) in g/kWh

Full load						
Rating point			R1	R2	R3	R4
BMEP, bar			20.2	14.1	20.2	17.7
BSFC	RTA		174	168	174	170
	RT-flex	Standard Tuning	169	163	169	165

Part load,% of R1	85	70	85	70	60
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	165.4	165.0	164.7	163.5	161.2

For definitions see page 52



Wärtsilä RT-flex60C, version B	IMO Tier II
Cylinder bore	600 mm
Piston stroke	2250 mm
Speed	91-114 rpm
Mean effective pressure at R1	20.0 bar
Stroke / bore	3.75

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	114 rpm		91 rpm			
	R1	R2	R3	R4		
5	12 100	8 450	9 650	8 450	6 638	268
6	14 520	10 140	11 580	10 140	7 678	322
7	16 940	11 830	13 510	11 830	8 718	377
8	19 360	13 520	15 440	13 520	9 758	428
9	21 780	15 210	17 370	15 210	10 798	480

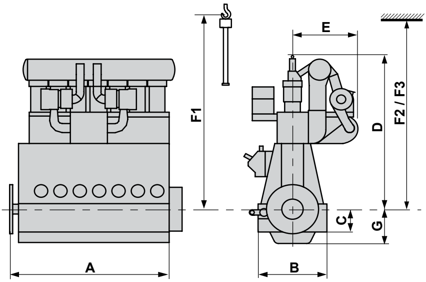
Dimensions mm	B	C	D	E
	3 700	1 300	8 570	3 660
	F1	F2	F3	G
	10 500	10 470	9 770	1 955

Brake specific fuel consumption (BSFC) in g/kWh

Full load						
Rating point			R1	R2	R3	R4
BMEP, bar			20.0	14.0	20.0	17.5
BSFC	RT-flex	Standard Tuning	170	164	170	166

Part load,% of R1	85	70	85	70	60
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	166.4	166.0	165.7	164.5	162.2

For definitions see page 52



Wärtsilä RT-flex68 / RTA68, version D	IMO Tier II
Cylinder bore	680 mm
Piston stroke	2720 mm
Speed	76–95 rpm
Mean effective pressure at R1	20.0 bar
Stroke / bore	4.0

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	95 rpm		76 rpm			
	R1	R2	R3	R4		
5	15 650	10 950	12 500	10 950	7 530	386
6	18 780	13 140	15 000	13 140	8 710	439
7	21 910	15 330	17 500	15 330	9 890	496
8	25 040	17 520	20 000	17 520	11 070	552

Dimensions mm	B	C	D	E
	4 320	1 520	10 400	4 700
	F1	F2	F3	G
	12 545	*	12 014	2 340

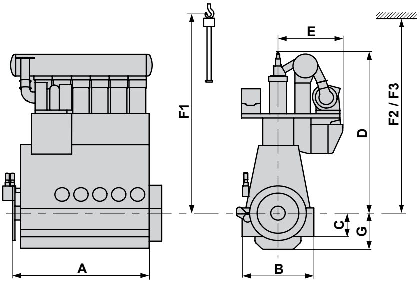
Brake specific fuel consumption (BSFC) in g/kWh

Full load

Rating point			R1	R2	R3	R4
BMEP, bar			20.0	14.0	20.0	17.5
BSFC	RTA		174	168	174	170
	RT-flex	Standard Tuning	169	163	169	165

Part load,% of R1	85	70	85	70	60
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	165.4	165.0	164.7	163.5	161.2

* on request
For definitions see page 52



Wärtsilä RT-flex82T / RTA82T	IMO Tier II
Cylinder bore	820 mm
Piston stroke	3375 mm
Speed	68–80 rpm
Mean effective pressure at R1/R1+	20.0/19.0 bar
Stroke / bore	4.12

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	76 / 80 rpm		68 rpm			
	R1 / R1+	R2 / R2+	R3	R4		
6	27 120	21 720	24 300	21 720	11 045	812
7	31 640	25 340	28 350	25 340	12 550	917
8	36 160	28 960	32 400	28 960	14 055	1 028
9	40 680	32 580	36 450	32 580	16 500	1 167

Dimensions mm	B	C	D	E
	5 320	1 800	12 250	5 400
	F1	F2	F3	G
	14 820	14 800	13 800	2 700

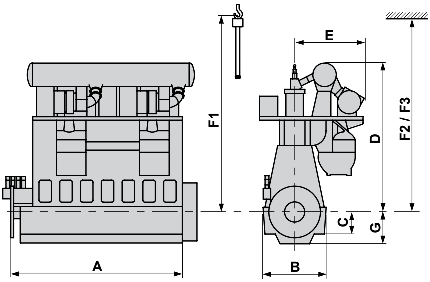
Brake specific fuel consumption (BSFC) in g/kWh

Full load

Rating point			R1/R1+	R2/R2+	R3	R4
BMEP, bar			20.0/19.0	16.0/14.5	20.0	17.9
BSFC	RTA		171.0/169.0	164.0	171.0	164.0
	RT-flex	Standard Tuning	168/166	162	168	165

Part load,% of R1/R1+	85	70	85	70	65
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	164.4/162.4	164.0/162.0	163.7/161.7	162.5/160.5	159.7/157.7

For definitions see page 52



Wärtsilä RT-flex82C / RTA82C	IMO Tier II
Cylinder bore	820 mm
Piston stroke	2646 mm
Speed	87–102 rpm
Mean effective pressure at R1/R1+	20.0/19.0 bar
Stroke / bore	3.23

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	97 / 102 rpm		87 rpm			
	R1 / R1+	R2 / R2+	R3	R4		
6	27 120	21 720	24 300	21 720	11 045	745
7	31 640	25 340	28 350	25 340	12 550	840
8	36 160	28 960	32 400	28 960	14 055	935
9	40 680	32 580	36 450	32 580	16 500	1 005
10	45 200	36 200	40 500	36 200	18 005	1 145
11	49 720	39 820	44 550	39 820	19 510	1 230
12	54 240	43 440	48 600	43 440	21 015	1 335

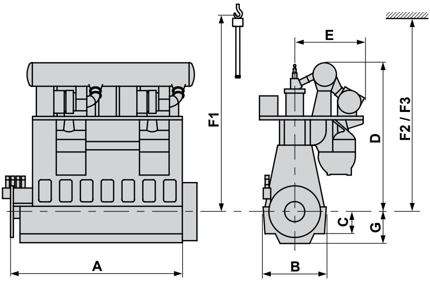
Dimensions mm	B	C	D	E
	4 570	1 600	10 930	5 400
	F1	F2	F3	G
	12 700	12 680	11 680	2 310

Brake specific fuel consumption (BSFC) in g/kWh

Full load						
Rating point			R1/R1+	R2/R2+	R3	R4
BMEP, bar			20.0/19.0	16.0/15.2	20.0	17.9
BSFC	RTA		177/175	171	177	174
	RT-flex	Standard Tuning	173/171	167	173	170

Part load,% of R1/R1+	85	70	85	70	65
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	169.4/167.4	169.0/167.0	168.7/166.7	167.5/165.5	164.7/162.7

For definitions see page 52



Wärtsilä RT-flex84T / RTA84T, version D	IMO Tier II
Cylinder bore	840 mm
Piston stroke	3150 mm
Speed	61–76 rpm
Mean effective pressure at R1	19.0 bar
Stroke / bore	3.75

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	76 rpm		61 rpm			
	R1	R2	R3	R4		
5	21 000	14 700	16 850	14 700	9 695	740
6	25 200	17 640	20 220	17 640	11 195	870
7	29 400	20 580	23 590	20 580	12 695	990
8	33 600	23 520	26 960	23 520	15 195	1 140
9	37 800	26 460	30 330	26 460	16 695	1 260

Dimensions mm	B	C	D	E
	5 000	1 800	12 150	5 105
	F1	F2	F3	G
	14 500	*	*	2 700

Brake specific fuel consumption (BSFC) in g/kWh

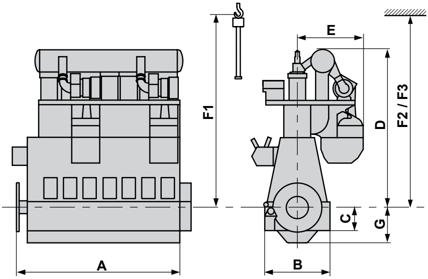
Full load

Rating point			R1	R2	R3	R4
BMEP, bar			19.0	13.3	19.0	16.6
BSFC	RTA		173	167	173	169
	RT-flex	Standard Tuning	171	165	171	167

Part load,% of R1	85	70	85	70	65
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	167.4	167.0	166.7	165.5	162.7

* on request

For definitions see page 52



Wärtsilä RT-flex96C / RTA96C, version B	IMO Tier II
Cylinder bore	960 mm
Piston stroke	2500 mm
Speed	92–102 rpm
Mean effective pressure at R1	18.6 bar
Stroke / bore	2.6

Rated power, principal dimensions and weights

Cyl.	Output in kW at				Length A mm	Weight tonnes
	102 rpm		92 rpm			
	R1	R2	R3	R4		
6	34 320	24 000	30 960	24 000	12 240	1 160
7	40 040	28 000	36 120	28 000	13 920	1 290
8	45 760	32 000	41 280	32 000	16 510	1 470
9	51 480	36 000	46 440	36 000	18 190	1 620
10	57 200	40 000	51 600	40 000	19 870	1 760
11	62 920	44 000	56 760	44 000	21 550	1 910
12	68 640	48 000	61 920	48 000	23 230	2 050
13	74 360	52 000	67 080	52 000	24 910	2 160
14	80 080	56 000	72 240	56 000	26 590	2 300

Dimensions mm	B	C	D	E
	4 480	1 800	10 925	5 380
	F1	F2	F3	G
	12 950	*	*	2 594

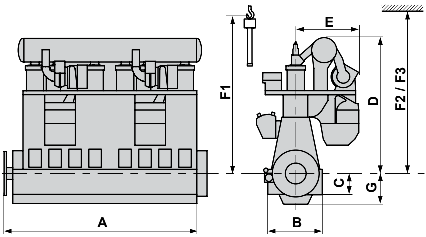
Brake specific fuel consumption (BSFC) in g/kWh

Full load						
Rating point			R1	R2	R3	R4
BMEP, bar			18.6	13.0	18.6	14.4
BSFC	RTA		177	171	177	171
	RT-flex	Standard Tuning	172	166	172	166

Part load,% of R1	85	70	85	70	65
RT-flex tuning variant	Standard	Standard	Delta	Delta	Low-Load
BSFC	168.4	168.0	167.7	166.5	163.7

* on request

For definitions see page 52



Definitions and Notes for Low-Speed Engines

ISO standard reference conditions

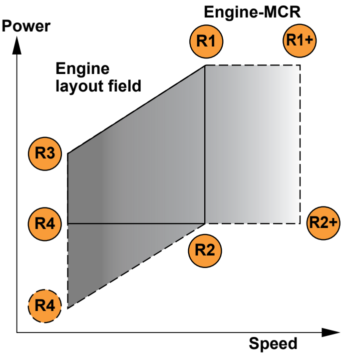
Total barometric pressure at R1 .... 1.0 bar
Suction air temperature .... 25°C
Relative humidity 30%
Cooling water temperature before engine .... 25°C

Emissions

All Wärtsilä low-speed engines included in this booklet are fully compliant with IMO Tier II NO_X limits specified in Annex VI of the MARPOL 73/78. They can also be equipped with a SCR catalyst to meet IMO Tier III NO_X emission levels and a scrubber to reduce SO_X emissions to 0.1% – even with high sulphur fuels.

Rating points for Wärtsilä low-speed engines

The engine layout fields for Wärtsilä low-speed engines are defined by the power/speed rating points R1, R2, R3 and R4 (see diagram to the right). In certain engines, the layout field is extended to the points R1+ and R2+.



R1, or R1+ instead if applicable, is the nominal maximum continuous rating (MCR). Any power and speed within the respective engine layout field may be selected as the Contract-MCR (CMCR) point for an engine.

Cylinder lubrication

The Pulse Lubricating System with electronic control of lubrication timing has been further developed. The guide feed rate for new engines equipped with the Pulse Jet cylinder lubrication system is 0.6 g/kWh. Engines with different lubricating systems might require a higher feed rate. This allows important savings in engine operating costs.

Dimensions and weights

- All dimensions are in millimetres and are not binding.
- F1: Min height for vertical removal
- F2: Min height for vertical removal with double-jib crane
- F3: Min height for tilted removal with double-jib crane
- The engine weight is net in metric tonnes (t), without oil and water, and is not binding.

Fuel consumption

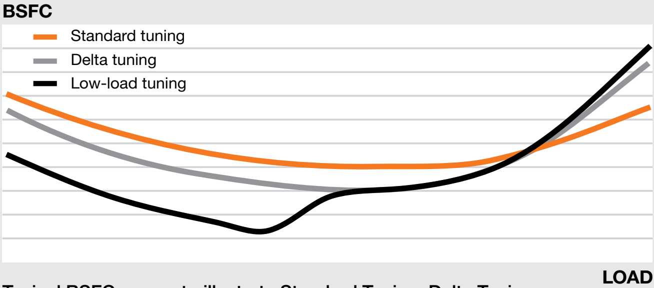
All brake specific fuel consumptions (BSFC) are quoted for fuel of lower calorific value 42.7 MJ/kg, and for ISO standard reference conditions (ISO 15550 and 3046).

BSFC figures for Wärtsilä engines are given with a tolerance of +5% across 40–100% and +7% across 25–39% engine load.

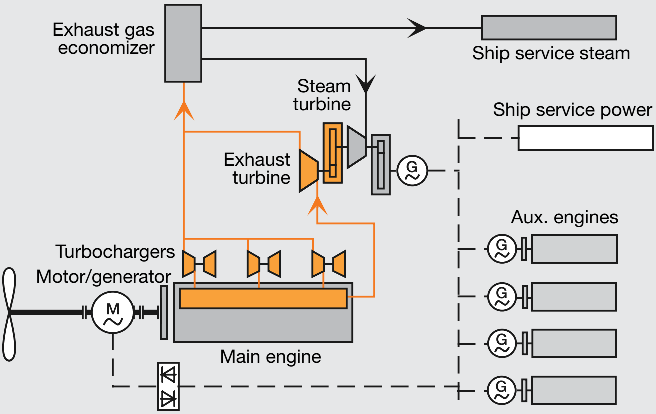
For the Wärtsilä engines X62/72/82/92, RT-flex58T-D ER-3, stepwise tolerances have been introduced for the brake specific fuel consumption (BSFC):

- +5% tolerance for 100% to 85% engine load
- +6% tolerance for 84% to 65% engine load
- +7% tolerance for 64% to 25% engine load

Standard Tuning, Delta Tuning, Low-Load Tuning are available for the electronically-controlled common-rail engines to provide optimum fuel consumption and flexibility for different engine loads. Delta Tuning focuses on reducing fuel consumption in the operating range below 90% engine load. Low-Load Tuning reduces fuel consumption below 75% engine load.



Typical BSFC curves to illustrate Standard Tuning, Delta Tuning and Low-Load Tuning.

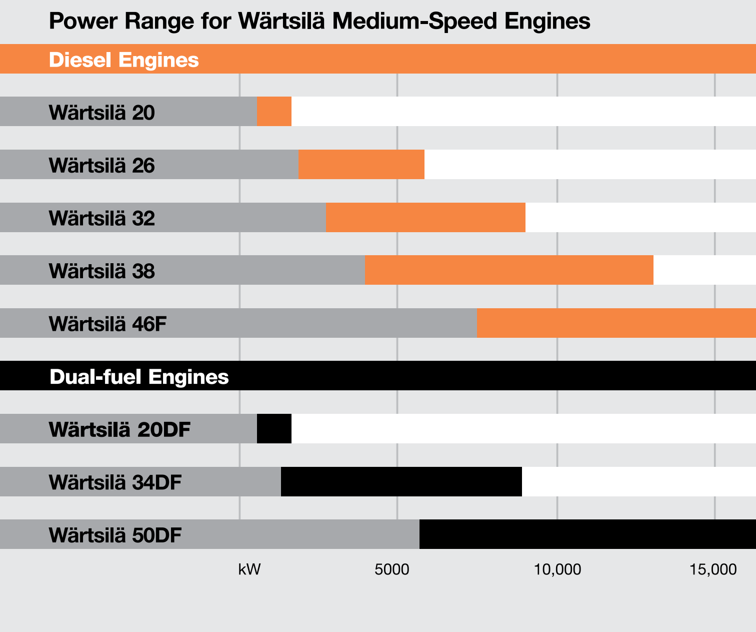


Schematic of a High-Efficiency Waste Heat Recovery plant typical for large container ships.

High-Efficiency Waste Heat Recovery (WHR)

Waste heat recovery is an effective technology for simultaneously cutting exhaust gas emissions and reducing fuel consumption. High-Efficiency Waste Heat Recovery plants can be installed with Wärtsilä engines. This enables up to 12% of the main engine shaft power to be recovered as electrical power for use as additional ship propulsion power and for shipboard services. These WHR plants thus cut exhaust gas emissions and deliver fuel savings of up to 12%.

Steam based WHR has already been successfully fitted in several installations to Wärtsilä RT-flex low-speed marine engines. In the WHR plant, a turbo-generator combines input from a steam turbine and an exhaust gas power turbine to generate electrical power, while steam from the economiser is available for ship service heating. Steam based WHR is recommended for vessels with high installed power.



WÄRTSILÄ MEDIUM-SPEED ENGINES

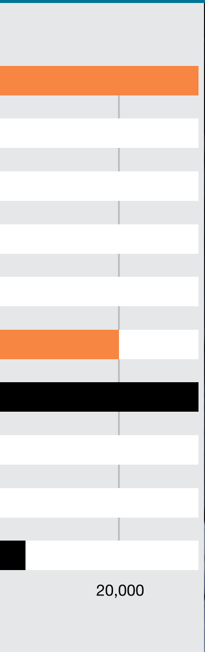
Diesel Engines

The design of the Wärtsilä medium-speed engine range is based on the vast amount of knowledge accumulated over years of successful operation.

Robust engines derived from pioneering heavy fuel technology have been engineered to provide unquestionable benefits for the owners and operators of Wärtsilä engines and generating sets:

- Proven reliability
- Low emissions
- Low operating costs
- Fuel flexibility

Benefits for the shipyard include installation friendliness, embedded automation systems, and built-on modularised auxiliary systems.



Dual-Fuel Engines

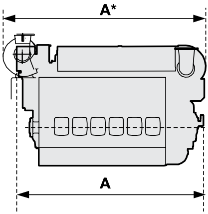
Wärtsilä is continuously developing its portfolio of gas and multi-fuel engines to suit different marine applications, be they offshore oil and gas installations where gaseous fuel is available from the process, or a merchant vessel operating in environmentally sensitive areas. The Wärtsilä engines offer high efficiency, low exhaust gas emissions and safe operation. The innovative multi-fuel technology allows the flexibility to choose between gas and liquid fuel. When necessary, the engines are capable of switching from one fuel to the other without any interruption in power generation.

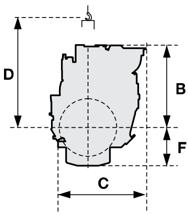
Wärtsilä 20			IMO Tier II
Cylinder bore	200 mm	Fuel specification: Fuel oil	
Piston stroke	280 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	200 kW/cyl	ISO 8217, category ISO-F-RMK 700	
Speed	1000 rpm	SFOC 185 g/kWh at ISO condition	
Mean effective pressure	27.3 bar		
Piston speed	9.3 m/s	Option: Common rail fuel injection.	

Rated power	
Engine type	kW
4L20	800
6L20	1 200
8L20	1 600
9L20	1 800

Dimensions (mm) and weights (tonnes)									
Engine type	A*	A	B*	B	C*	C	D	F	Weight
4L20	–	2 510	–	1 348	–	1 483	1 800	725	7.2
6L20	3 254	3 108	1 528	1 348	1 580	1 579	1 800	624	9.3
8L20	3 973	3 783	1 614	1 465	1 756	1 713	1 800	624	11.0
9L20	4 261	4 076	1 614	1 449	1 756	1 713	1 800	624	11.6

*Turbocharger at flywheel end.
For definitions see page 66.





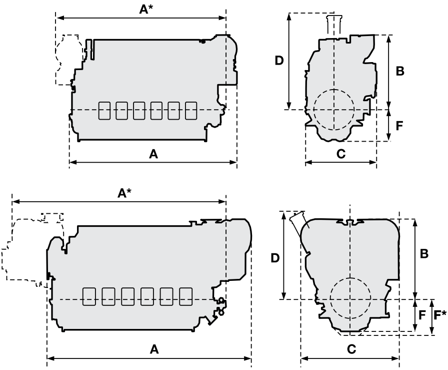
Wärtsilä 26			IMO Tier II
Cylinder bore	260 mm	Fuel specification: Fuel oil	
Piston stroke	320 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	340 kW/cyl	ISO 8217, category ISO-F-RMK 700	
Speed	1000 rpm	SFOC 184 g/kWh at ISO condition	
Mean effective pressure	24 bar		
Piston speed	10.7 m/s		

Rated power	
Engine type	kW
6L26	2 040
8L26	2 720
9L26	3 060
12V26	4 080
16V26	5 440

Dimensions (mm) and weights (tonnes)

Engine type	A*	A	B*	B	C*	C	D	F dry sump	F wet sump	Weight dry sump	Weight wet sump
6L26	4 401	4 175	1 882	1 882	1 951	2 021	2 420	818	950	18.1	18.4
8L26	5 304	4 999	2 019	1 882	2 011	2 102	2 420	818	950	22.0	22.5
9L26	5 703	5 389	2 019	1 882	2 011	2 102	2 420	818	950	23.9	24.8
12V26	5 218	4 968	2 074	2 074	2 453	2 453	2 060	800	1 110	29.2	31.9
16V26	6 223	5 973	2 151	2 151	2 489	2 489	2 060	800	1 110	33.0	36.5

*Turbocharger at flywheel end.
For definitions see page 66.

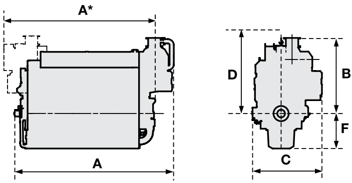


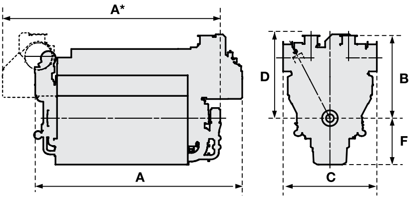
Wärtsilä 32		IMO Tier II	
Cylinder bore	320 mm	Fuel specification: Fuel oil	
Piston stroke	400 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	500, 580 kW/cyl	ISO 8217, category ISO-F-RMK 700	
Speed	750 rpm	SFOC 176 g/kWh at ISO condition	
Mean effective pressure	24.9, 28.9 bar		
Piston speed	10.0 m/s	Option: Common rail fuel injection	

Rated power		
Engine type	500 kW/cyl	580 kW/cyl
6L32	3 000	3 480
7L32	3 500	–
8L32	4 000	4 640
9L32	4 500	5 220
12V32	6 000	6 960
16V32	8 000	9 280
18V32	9 000	–

Dimensions (mm) and weights (tonnes)								
Engine type	A*	A	B*	B	C	D	F	Weight
6L32	4 980	5 260	2 560	2 490	2 305	2 345	1 155	33.3
7L32	5 470	5 750	2 560	2 490	2 305	2 345	1 155	39.0
8L32	5 960	6 245	2 360	2 295	2 305	2 345	1 155	43.4
9L32	6 450	6 730	2 360	2 295	2 305	2 345	1 155	46.8
12V32	6 935	6 615	2 715	2 665	3 020	2 120	1 475	58.7
16V32	8 060	7 735	2 480	2 430	3 020	2 120	1 475	74.1
18V32	8 620	8 295	2 480	2 430	3 020	2 120	1 475	81.2

*Turbocharger at flywheel end.
For definitions see page 66.



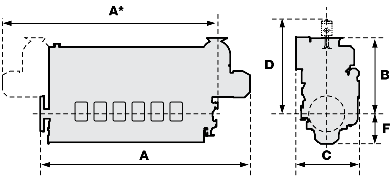


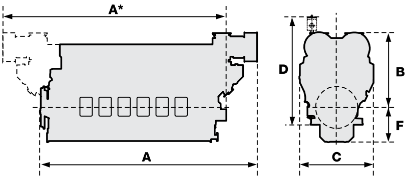
Wärtsilä 38			IMO Tier II
Cylinder bore	380 mm	Fuel specification: Fuel oil	
Piston stroke	475 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	725 kW/cyl	ISO 8217, category ISO-F-RMK 700	
Speed	600 rpm	SFOC 176 g/kWh at ISO condition	
Mean effective pressure	26.9 bar		
Piston speed	9.5 m/s		

Rated power	
Engine type	kW
6L38	4 350
8L38	5 800
9L38	6 525
12V38	8 700
16V38	11 600

Dimensions (mm) and weights (tonnes)								
Engine type	A*	A	B*	B	C	D	F	Weight
6L38	6 345	6 215	2 830	2 830	2 122	3 135	1 115	51
8L38	7 960	7 844	2 996	2 972	2 209	3 135	1 115	63
9L38	8 560	8 444	2 996	2 972	2 209	3 135	1 115	72
12V38	7 461	7 344	3 080	3 080	3 030	2 855	1 435	88
16V38	9 018	8 904	3 281	3 281	3 030	2 855	1 435	110

* Turbocharger at flywheel end.
For definitions see page 66.



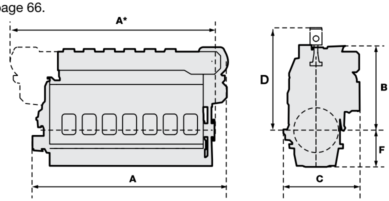


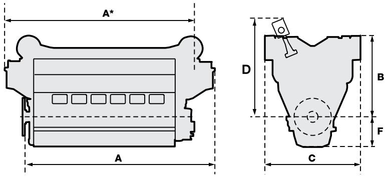
Wärtsilä 46F			IMO Tier II
Cylinder bore	460 mm	Fuel specification: Fuel oil	
Piston stroke	580 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	1200 kW/cyl	ISO 8217, category ISO-F-RMK 700	
Speed	600 rpm	SFOC 170 g/kWh at ISO condition	
Mean effective pressure	24.9 bar	Option: Lubricating oil module integrated on engine.	
Piston speed	11.6 m/s		

Rated power	
Engine type	kW
6L46F	7 200
7L46F	8 400
8L46F	9 600
9L46F	10 800
12V46F	14 400
14V46F	16 800
16V46F	19 200

Dimensions (mm) and weights (tonnes)							
Engine type	A*	A	B	C	D	F	Weight
6L46F	8 430	8 620	3 500	2 930	3 750	1 430	97
7L46F	9 260	9 440	3 800	2 950	3 750	1 430	113
8L46F	10 080	10 260	3 800	2 950	3 750	1 430	124
9L46F	10 900	11 080	3 800	2 950	3 750	1 430	140
12V46F	10 080	10 150	3 820	4 050	3 800	1 620	173
14V46F	11 650	11 729	4 243	4 678	3 800	1 620	216
16V46F	12 700	12 779	4 243	4 678	3 800	1 620	233

* Turbocharger at flywheel end.
For definitions see page 66.



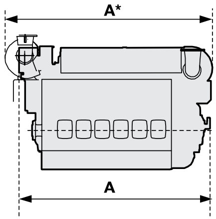


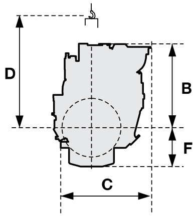
Wärtsilä 20DF		IMO Tier II	
Cylinder bore	200 mm	Fuel specification: Fuel oil	
Piston stroke	280 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	176 kW/cyl	ISO 8217, category ISO-F-DMX, DMA and DMB	
Speed	1200 rpm		
Mean effective pressure	20.0 bar	Natural gas, Methane number: 80 LHV: min. 28 MJ/Nm^3, 5.5 bar BSEC 8510 kJ/kWh	
Piston speed	11.2 m/s		

Rated power	
Engine type	kW
6L20DF	1 056
8L20DF	1 408
9L20DF	1 584

Engine dimensions (mm) and weights (tonnes)							
Engine type	A*	A	B	C	D	F	Weight
6L20DF	3 254	3 108	1 698	1 829	1 800	624	9.5
8L20DF	3 973	3 783	1 815	1 963	1 800	624	11.2
9L20DF	4 261	4 076	1 799	1 963	1 800	624	11.8

For definitions see page 66.



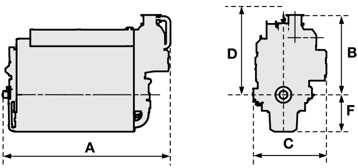


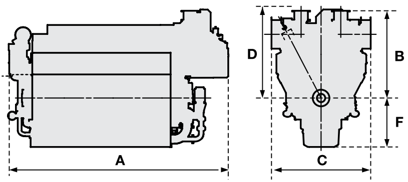
Wärtsilä 34DF			IMO Tier II
Cylinder bore	340 mm	Fuel specification: Fuel oil	
Piston stroke	400 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	500 kW/cyl	ISO 8217, category ISO-F-DMX, DMA and DMB	
Speed	750 rpm		
Mean effective pressure	22.0 bar	Natural gas, Methane number: 80 LHV: min. 28 MJ/Nm^3, 5.5 bar BSEC 7280 kJ/kWh	
Piston speed	10.0 m/s		

Rated power	
Engine type	kW
6L34DF	3 000
9L34DF	4 500
12V34DF	6 000
16V34DF	8 000

Engine dimensions (mm) and weights (tonnes)						
Engine type	A	B	C	D	F	Weight
6L34DF	5 280	2 550	2 385	2 345	1 155	34
9L34DF	6 750	2 550	2 385	2 345	1 155	47
12V34DF	6 615	2 665	3 020	2 120	1 475	59
16V34DF	7 735	2 430	3 020	2 120	1 475	75

For definitions see page 66.





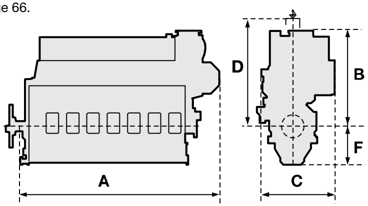
Wärtsilä 50DF			IMO Tier II
Cylinder bore	500 mm	Fuel specification: Fuel oil	
Piston stroke	580 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	950, 975 kW/cyl	ISO 8217, category ISO-F-DMX, DMA and DMB	
Speed	500, 514 rpm		
Mean effective pressure	20.0 bar	Natural gas, Methane number: 80 LHV: min. 28 MJ/Nm^3, 5.5 bar BSEC 8510 kJ/kWh	
Piston speed	9.7, 9.9 m/s		

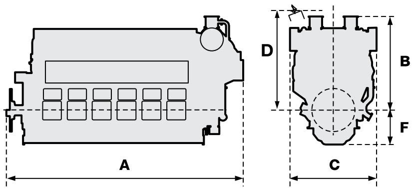
Rated power				
Engine type	50 Hz		60 Hz	
	Engine kW	Gen. kW	Engine kW	Gen. kW
6L50DF	5 700	5 500	5 850	5 650
8L50DF	7 600	7 330	7 800	7 530
9L50DF	8 550	8 250	8 775	8 470
12V50DF	11 400	11 000	11 700	11 290
16V50DF	15 200	14 670	15 600	15 050
18V50DF	17 100	16 500	17 550	16 940

Generator output based on a generator efficiency of 96.5%.

Engine dimensions (mm) and weights (tonnes)						
Engine type	A	B	C	D	F	Weight
6L50DF	8 115	3 580	2 850	3 820	1 455	96
8L50DF	9 950	3 600	3 100	3 820	1 455	128
9L50DF	10 800	3 600	3 100	3 820	1 455	148
12V50DF	10 465	4 055	3 810	3 600	1 500	175
16V50DF	12 665	4 055	4 530	3 600	1 500	220
18V50DF	13 725	4 280	4 530	3 600	1 500	240

For definitions see page 66.





Definitions and Notes for Medium-Speed Engines

Engine dimensions

A* Total length of the engine when the turbocharger is located at the flywheel end.

A Total length of the engine when the turbocharger is located at the free end.

B Height from the crankshaft centreline to the highest point.

B* Height from the crankshaft centreline to the highest point when the turbocharger is located at the flywheel end.

C Total width of the engine.

C* Total width of the engine when the turbocharger is located at the flywheel end.

D Minimum height from the crankshaft centreline when removing a piston.

F Distance from the crankshaft centreline to the bottom of the oil sump.

Dimensions and weights

- Dimensions are in millimetres and weights are in metric tonnes. Indicated values are for guidance only and are not binding.
- Cylinder configurations: L = in-line and V = v-form.

Specific fuel oil consumption

- At ISO standard reference conditions
- Lower calorific value of fuel 42 700 kJ/kg
- Tolerance 5%
- Without engine driven pumps
- At 85% load.

ISO standard reference conditions

Total barometric pressure	....1.0 bar
Suction air temperature	....25°C
Charge air, or scavenge air, cooling water temperature	....25°C
Relative humidity	....30%

WÄRTSILÄ AUXPAC

Wärtsilä Auxpac generating sets are available in a selected range as pre-engineered and pre-commissioned auxiliary generating sets. The common baseframe is optimised for the package, which together with the compact design of the engine and the selected generator, offers unmatched power-to-space and power-to-weight ratios. Other benefits of pre-engineering include readily available documentation, which also includes models in Tribon® format, and short lead-times. Auxpac generating sets are offered only as 400 V/690 V–50 Hz and 450 V/690 V–60 Hz in the power range 500 kW to 2800 kW.

Pre-Engineered Medium-Speed Generating Sets

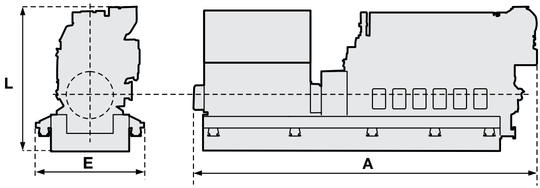
Main data of generators	60 Hz	50 Hz		
Voltage	450, 690 V	400, 690 V	Fuel specification:	
Protection class	IP 23, IP 44 *	IP 23, IP 44 *	Fuel oil	700 cSt/50°C
Temperature rise and isolation	Class F	Class F	ISO 8217, category ISO-F-RMK 55	
Cooling	Air, water *	Air, water *	* Option	

60 Hz

	Output		Dimensions (mm) and weights (tonnes)			
Type	kWe	kVA	A	E	L	Weight
520W4L20	520	650	3 837	1 720	2 243	13.4
645W4L20	645	806	4 390	1 720	2 243	14.0
760W6L20	760	950	4 988	1 720	2 243	17.0
875W6L20	875	1 094	5 048	1 720	2 243	17.3
975W6L20	975	1 219	5 158	1 720	2 243	17.9
1050W6L20	1 050	1 313	5 083	1 920	2 243	19.1
1200W8L20	1 200	1 500	5 758	1 920	2 490	21.2
1400W8L20	1 400	1 750	5 900	1 920	2 474	21.5
1600W9L20	1 600	2 000	6 513	1 920	2 474	23.6
1800W6L26	1 800	2 250	6 422	2 246	2 938	31.7
2100W8L26	2 100	2 625	7 664	2 332	3 025	41.7
2400W8L26	2 400	3 000	7 744	2 332	3 025	42.3
2700W9L26	2 700	3 375	8 799	2 332	3 090	46.8

50 Hz

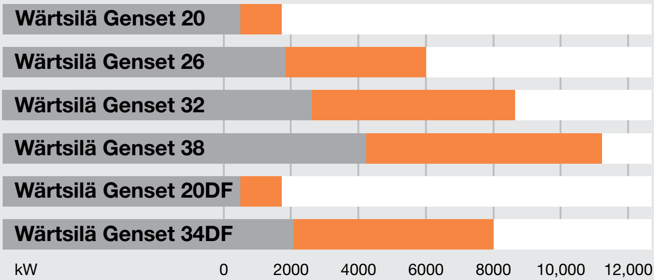
	Output		Dimensions (mm) and weights (tonnes)			
Type	kWe	kVA	A	E	L	Weight
520W4L20	520	650	3 648	1 770	2 243	13.0
670W4L20	670	838	3 837	1 770	2 243	13.6
790W6L20	790	988	4 988	1 770	2 243	16.2
860W6L20	860	1 075	5 048	1 770	2 243	16.9
1000W6L20	1 000	1 250	5 158	1 770	2 243	17.5
1140W6L20	1 140	1 425	5 288	1 770	2 243	18.1
1350W8L20	1 350	1 688	5 758	1 920	2 490	21.7
1550W9L20	1 550	1 938	6 163	1 920	2 474	22.9
1700W9L20	1 700	2 125	6 513	1 920	2 474	24.4
1950W6L26	1 950	2 438	6 422	2 246	2 938	31.7
2250W8L26	2 250	2 813	7 644	2 332	3 025	41.7
2550W9L26	2 550	3 188	8 809	2 332	3 090	46.5
2850W9L26	2 850	3 563	8 809	2 332	3 090	46.5



WÄRTSILÄ GENSETS

A wide range of generating sets, comprising the generator and diesel engine mounted on a common baseframe, are available for both service power generation and for diesel-electric propulsion. All generating sets listed in this section are based on medium-speed diesel engines designed for operating on heavy fuel oil. These generating sets are resiliently mounted and the generator voltage can be selected in all cases, except for the Auxpac generating sets, which are Low Voltage only. Larger diesel generators are delivered for separate mounting of the diesel engine and generator.

Power Range for Wärtsilä Gensets



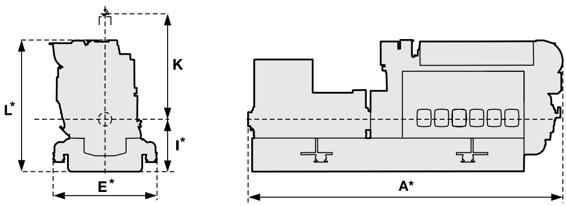
Wärtsilä Genset 20			IMO Tier II
Cylinder bore	200 mm	Generator voltage	0.4–13.8 kV
Piston stroke	280 mm	Generator efficiency	0.95–0.96
Cylinder output	185, 200 kW/cyl	Fuel specification: Fuel oil	
Speed	900, 1000 rpm	700 cSt/50°C	7200 sR1/100°F
Mean effective pressure	27.3, 28.0 bar	ISO 8217, category ISO-F-RMK 700	
Piston speed	8.4, 9.3 m/s	SFOC 187 g/kWh at ISO condition	

Option: Common rail fuel injection.

Rated power				
	60 Hz		50 Hz	
Engine type	185 kW/cyl, 900 rpm		200 kW/cyl, 1000 rpm	
	Eng. kW	Gen. kW	Eng. kW	Gen. kW
4L20	740	700	800	760
6L20	1 110	1 055	1 200	1 140
8L20	1 480	1 405	1 600	1 520
9L20	1 665	1 580	1 800	1 710

Dimensions (mm) and weights (tonnes)						
Engine type	A*	E*	I*	K	L*	Weight*
4L20	4 910	1770/1920	990	1 800	2338	14.0
6L20	5 325	1770/1920/2070	895/975/1025	1 800	2243/2323/2373	16.8
8L20	6 030	1920/2070	1025/1075	1 800	2474/2524	20.7
9L20	6 535	2070/2300	1075/1125	1 800	2524/2574	23.8

* Dependent on generator type and size.
For definitions see page 77.

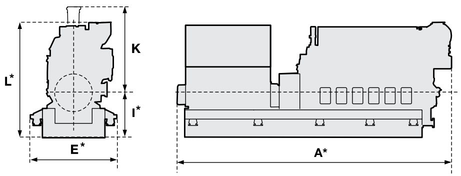


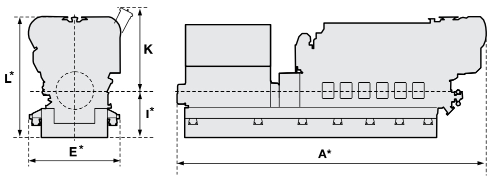
Wärtsilä Genset 26			IMO Tier II
Cylinder bore	260 mm	Generator voltage	0.4–13.8 kV
Piston stroke	320 mm	Generator efficiency	0.95–0.96
Cylinder output	325, 340 kW/cyl	Fuel specification: Fuel oil	
Speed	900, 1000 rpm	700 cSt/50°C	7200 sR1/100°F
Mean effective pressure	23.0, 25,5 bar	ISO 8217, category ISO-F-RMK 700	
Piston speed	9.6, 10.7 m/s	SFOC 184 g/kWh at ISO condition	

Rated power				
Engine type	60 Hz		50 Hz	
	325 kW/cyl, 900 rpm		340 kW/cyl, 1000 rpm	
	Eng. kW	Gen. kW	Eng. kW	Gen. kW
6L26	1 950	1 870	2 040	1 960
8L26	2 600	2 495	2 720	2 610
9L26	2 925	2 810	3 060	2 940
12V26	3 900	3 745	4 080	3 915
16V26	5 200	4 990	5 440	5 220

Dimensions (mm) and weights (tonnes)						
Engine type	A*	E*	I*	K	L*	Weight*
6L26	7 500	2 300	1 200	2 430	3 081	40
8L26	8 000	2 300	1 200	2 430	3 219	45
9L26	8 500	2 300	1 200	2 430	3 219	50
12V26	8 400	2 700	1 560	2 765	3 634	60
16V26	9 700	2 700	1 560	2 765	3 711	70

* Dependent on generator type and size.
For definitions see page 77.





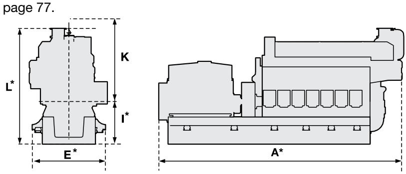
Wärtsilä Genset 32			IMO Tier II
Cylinder bore	320 mm	Generator voltage	0.4–13.8 kV
Piston stroke	400 mm	Generator efficiency	0.95–0.97
Cylinder output	480, 500, 550, 580 kW/cyl	Fuel specification: Fuel oil	
Speed	720, 750 rpm	700 cSt/50°C	7200 sR1/100°F
Mean effective pressure	24.9, 28.9 bar	ISO 8217, category ISO-F-RMK 700	
Piston speed	9.6, 10.0 m/s	SFOC 176 g/kWh at ISO condition	

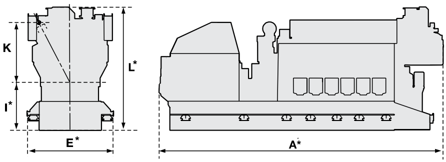
Options: Common rail fuel injection, crude oil.

Rated power								
Engine type	60 Hz/720 rpm				50 Hz/750 rpm			
	480 kW/cyl		550 kW/cyl		500 kW/cyl		580 kW/cyl	
	Engine kW	Gen. kW	Engine kW	Gen. kW	Engine kW	Gen. kW	Engine kW	Gen. kW
6L32	2 880	2 760	3300	3170	3 000	2 880	3480	3340
7L32	3 360	3 230	–	–	3 500	3 360	–	–
8L32	3 840	3 690	4 400	4 220	4 000	3 840	4 640	4 450
9L32	4 320	4 150	4 950	4 750	4 500	4 320	5 220	5 010
12V32	5 760	5 530	6 600	6 340	6 000	5 760	6 960	6 680
16V32	7 680	7 370	8 800	8 450	8 000	7 680	9 280	8 910
18V32	8 640	8 290	–	–	9 000	8 640	–	–

Dimensions (mm) and weights (tonnes)						
Engine type	A*	E*	I*	K	L*	Weight*
6L32	8 345	2 290	1 450	2 345	3 940	57
7L32	9 215	2 690	1 650	2 345	4 140	69
8L32	9 755	2 690	1 630	2 345	3 925	77
9L32	10 475	2 890	1 630	2 345	3 925	84
12V32	10 075	3 060	1 700	2 120	4 365	96
16V32	11 175	3 060	1 850	2 120	4 280	121
18V32	11 825	3 360	1 850	2 120	4 280	133

* Dependent on generator type and size.
Generator output based on a generator efficiency of 96%.
Final measurements might differ depending on selected turbocharger execution.
For definitions see page 77.



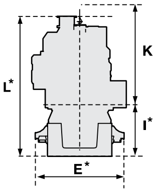


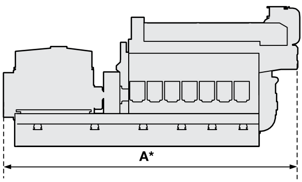
Wärtsilä Genset 38			IMO Tier II
Cylinder bore	380 mm	Generator voltage	0.4–13.8 kV
Piston stroke	475 mm	Generator efficiency	0.95–0.98
Cylinder output	725 kW/cyl	Fuel specification: Fuel oil	
Speed	600 rpm	700 cSt/50°C	7200 sR1/100°F
Mean effective pressure	26.9 bar	ISO 8217, category ISO-F-RMK 700	
Piston speed	9.5 m/s	SFOC 177 g/kWh at ISO condition	

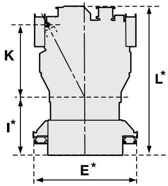
Rated power		
Engine type	50 Hz, 60 Hz	
	Eng. kW	Gen. kW
6L38	4 350	4 200
8L38	5 800	5 600
9L38	6 525	6 300
12V38	8 700	8 400
16V38	11 600	11 200

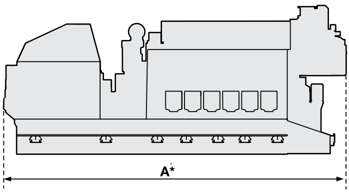
Dimensions (mm) and weights (tonnes)						
Engine type	A*	E*	I*	K	L*	Weight*
6L38	9 600	2 900	1 655	3 135	4 485	90
8L38	12 000	2 900	1 705	3 135	4 475	110
9L38	12 300	3 100	1 805	3 135	4 575	130
12V38	11 900	3 600	2 015	2 855	4 945	160
16V38	13 300	3 800	2 015	2 855	5 120	200

* Dependent on generator type and size.
For definitions see page 77.







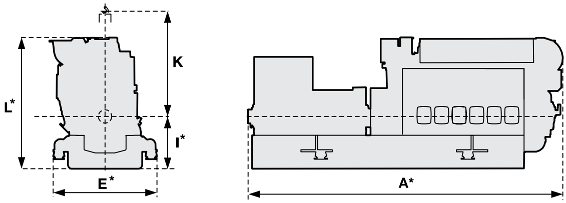


Wärtsilä Genset 20DF			IMO Tier II
Cylinder bore	200 mm	Fuel specification: Fuel oil	
Piston stroke	280 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	146/176 kW/cyl	ISO 8217, category ISO-F-DMX, DMA and DMB	
Speed	1000/1200 rpm		
Mean effective pressure	20.0 bar	Natural gas, Methane number: 80 LHV: min. 28 MJ/Nm^3, 5.5 bar BSEC 8450 kJ/kWh	
Piston speed	9.3/11.2 m/s		
Generator voltage	0.4–13.8 kV		
Generator efficiency	0.95–0.96		

Rated power				
Engine type	60 Hz		50 Hz	
	176 kW/cyl, 1200 rpm		146 kW/cyl, 1000 rpm	
	Engine kW	Gen. kW	Engine kW	Gen. kW
6L20DF	1 056	1 014	876	841
8L20DF	1 408	1 352	1 168	1 121
9L20DF	1 584	1 521	1 314	1 261

Dimensions (mm) and weights (tonnes)						
Engine type	A*	E	I*	K	L*	Weight
6L20DF	5 325	2 070	900/980/1030	1 800	2 688	17
8L20DF	6 030	2 070	1030/1080	1 800	2 824	20.9
9L20DF	6 535	2 300	1080/1130	1 800	2 874	24

For definitions see page 77.



Wärtsilä Genset 34DF		IMO Tier II	
Cylinder bore	340 mm	Fuel specification: Fuel oil	
Piston stroke	400 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	480, 500 kW/cyl	ISO 8217, category ISO-F-DMX, DMA and DMB	
Speed	720, 750 rpm		
Mean effective pressure	22.0 bar	Natural gas, Methane number: 80 LHV: min. 28 MJ/Nm^3, 5.5 bar BSEC 7280 kJ/kWh	
Piston speed	9.6, 10.0 m/s		
Generator voltage	0.4–13.8 kV		
Generator efficiency	0.95–0.97		

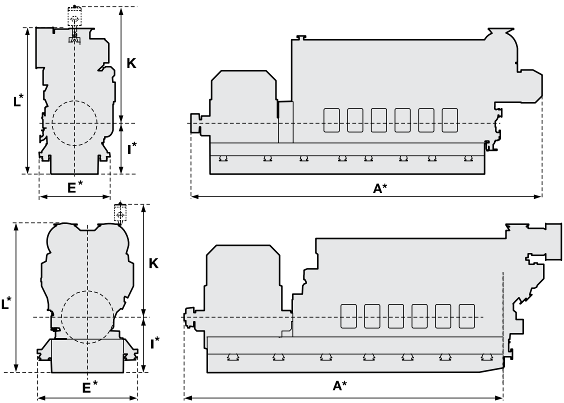
Rated power

Engine type	60 Hz		50 Hz	
	480 kW/cyl, 720 rpm		500 kW/cyl, 750 rpm	
	Engine kW	Gen. kW	Engine kW	Gen. kW
6L34DF	2 880	2 770	3 000	2 890
9L34DF	4 320	4 150	4 500	4 320
12V34DF	5 760	5 530	6 000	5 770
16V34DF	7 680	7 370	8 000	7 680

Dimensions (mm) and weights (tonnes)

Engine type	A*	E*	I*	K	L*	Weight
6L34DF	8 700	2 290	1 450	2 345	4 000	55
9L34DF	10 475	2 890	1 630	2 345	4 180	84
12V34DF	10 075	3 060	1 700	2 120	4 365	96
16V34DF	11 175	3 060	1 850	2 120	4 280	121

* Dependent on generator type.
Generator output based on a generator efficiency of 96%.
For definitions see page 77.



Definitions and Notes for Generating sets

Generating set dimensions

A Total length of the generating set.

E Total width of the generating set.

I Distance from the bottom of the common baseframe to the crankshaft centreline.

K Minimum height from the crankshaft centreline when removing a piston.

L Total height of the generating set.

Dimensions and weights

Dimensions are in millimetres and weights are in metric tonnes. Indicated values are for guidance only and are not binding.
Cylinder configurations: L = in-line, and V = V-form.

Specific fuel oil consumption

- At ISO standard reference conditions
- Lower calorific value of fuel 42 700 kJ/kg
- Tolerance 5%
- Without engine driven pumps
- At 85% load.

ISO standard reference conditions

Total barometric pressure	1.0 bar
Suction air temperature	25°C
Charge air, or scavenge air, cooling water temperature	25°C
Relative humidity	30%

ENGINE AUXILIARY SYSTEMS

All auxiliary equipment needed for the diesel engines can be delivered by Wärtsilä. Some equipment can be built onto the engine, and the rest can be delivered separately or grouped in modules.

Depending on the engine type and application, a lubricating oil pump, HT- and LT-cooling water pumps, fuel pump, oil filters and coolers, prelubricating oil pump and thermostatic valves can be added to the engine.

Stand-by pumps, seawater pumps, central coolers, starting air vessels, lubricating oil automatic filters, exhaust gas silencers and boilers are typically delivered for separate mounting.

Standardised modular auxiliary units

- Fuel oil booster
- Fuel oil separating
- Lubricating oil separating
- Cooling water preheating
- Starting air compressors
- Oil mist separator
- Oily water bilge separator

Maximum compatibility is ensured when auxiliary systems are delivered together with the main propulsion engines and diesel generator sets. Whenever necessary, the auxiliary systems are tailored to optimise the operating performance for a specific trade. The systems are specified to minimise building costs and operating costs for a specific combination of main and auxiliary engines.

Fuel booster unit.

Customised modular auxiliary units are available on request.

Module consisting of preheater, cooling water thermostatic valves, lubricating oil automatic filter, pre-lubricating oil pump and fuel oil booster unit.

Fuel oil transfer pump module with heater.

Oil mist separator module.

EXHAUST GAS CLEANING

Due to existing regulations on emissions to air from the International Maritime Organisation (IMO), and with the European Union working towards an alignment with IMO MARPOL Annex VI, marine industry operators need to decide on the best means for achieving compliance. With a Wärtsilä Exhaust Gas Cleaning Systems installed, you will comply with all existing and proposed regulations from the IMO. Avoiding costly distillate fuel with a typical payback of less than 2 years, Wärtsilä's exhaust gas cleaning solutions are designed to provide flexibility and reliable operations wherever you operate. The systems are suitable for both new buildings and the retrofitting of existing vessels having either 2-stroke or 4-stroke engines, as well as for oil-fired boilers.

We can also provide the complete ship design and a variety of pump systems. Having the largest installed base of any marine scrubber supplier and a dedicated test laboratory has enabled Wärtsilä to optimise their products to be reliable, easy to operate, and easy to install.

Wärtsilä Hybrid Scrubber System

In addition to closed and open loop systems, Wärtsilä provides hybrid solutions. These solutions have the flexibility to operate in both open and closed loop.

The hybrid approach enables operation in closed loop mode when required, for instance whilst in port and during maneuvering using NaOH as a buffer. When at sea the switch can be made to open loop using only seawater.

Wärtsilä Open Loop Scrubber System

Our scrubber system is based on the same technology as that used in Wärtsilä Hamworthy's inert gas systems for more than 50 years. The system operates in an open loop utilising seawater to remove SO_X from the exhaust.

Exhaust gas enters the scrubber and is sprayed with seawater in three different stages. The sulphur oxide in the exhaust reacts with water and forms sulphuric acid. Chemicals are not required since the natural alkalinity of seawater neutralises the acid.

Wash water from the scrubber is treated and monitored at the inlet and outlet to ensure that it conforms with the MEPC 184(59) discharge criteria. It can then be discharged into the sea with no risk of harm to the environment.

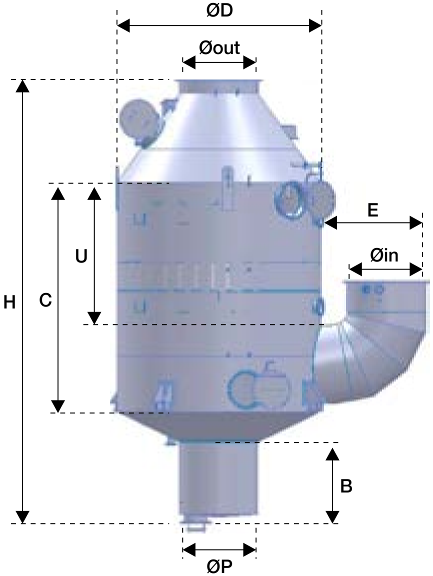
Wärtsilä Closed Loop Scrubber System

The system operates in a closed loop, i.e. the wash water is being circulated within the scrubber. Exhaust gas enters the scrubber and is sprayed with fresh water that has been mixed with caustic soda (NaOH). The sulphur oxides in the exhaust react with this mixture and are thereby neutralised.

A small bleed-off is extracted from the closed loop and treated to fulfil requirements stipulated by the IMO.

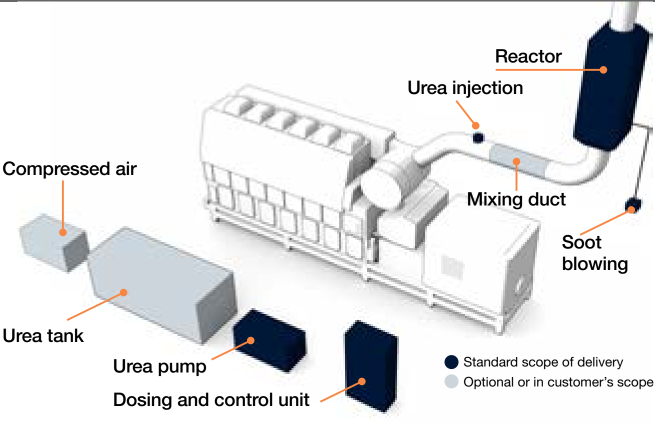
Cleaned effluents can be safely discharged overboard with no harm to the environment.

If operation in zero discharge mode is requested, the effluent can be led to a holding tank for scheduled and periodical discharge.



Wärtsilä closed loop scrubber system

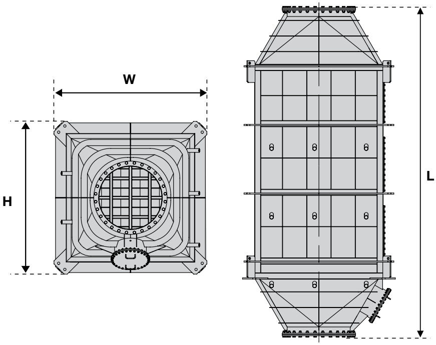
Scrubber type	Capacity (kg/s)	ØD (mm)	ØP (mm)	Øin (mm)	Øout (mm)	H (mm)	C (mm)	B (mm)	E (mm)	Weight dry (kg)	Weight wet (kg)
WM 92	1.46	920	378	365	385	4 400	3 113	459	765	1 100	1 300
WM 98	1.66	980	402	385	400	4 500	3 133	483	785	1 200	1 400
WM 104	1.88	1 040	427	410	430	4 600	3 159	506	810	1 300	1 500
WM 111	2.14	1 110	456	440	460	4 700	3 190	533	840	1 400	1 600
WM 118	2.43	1 180	484	465	485	4 800	3 215	561	865	1 500	1 800
WM 125	2.73	1 250	513	495	520	4 900	3 246	588	895	1 600	1 900
WM 133	3.10	1 330	546	525	550	5 000	3 276	619	925	1 800	2 000
WM 141	3.49	1 410	579	560	585	5 100	3 312	650	960	1 900	2 300
WM 149	3.90	1 490	611	590	620	5 200	3 343	682	990	2 000	2 400
WM 158	4.40	1 580	648	625	655	5 300	3 378	717	1 025	2 200	2 600
WM 167	4.93	1 670	685	660	700	5 400	3 414	752	1 060	2 400	2 800
WM 177	5.55	1 770	726	700	735	5 500	3 455	791	1 100	2 600	3 100
WM 187	6.20	1 870	767	740	775	5 700	3 496	830	1 140	2 800	3 400
WM 198	6.97	1 980	812	785	820	5 900	3 542	873	1 185	3 100	3 700
WM 209	7.78	2 090	857	830	870	6 000	3 588	916	1 230	3 400	4 100
WM 221	8.72	2 210	907	875	915	6 200	3 633	962	1 275	3 700	4 500
WM 233	9.72	2 330	956	925	970	6 400	3 684	1 009	1 325	4 000	4 900
WM 246	10.85	2 460	1 009	975	1 020	6 500	3 735	1 060	1 375	4 300	5 300
WM 259	12.06	2 590	1 062	1025	1 070	6 700	3 786	1 111	1 425	4 700	5 800
WM 273	13.42	2 730	1 120	1080	1 135	6 900	3 843	1 165	1 480	5 100	6 300
WM 287	14.87	2 870	1 177	1140	1 190	7 100	3 904	1 220	1 540	5 500	6 900
WM 302	16.50	3 020	1 239	1195	1 255	7 300	3 960	1 278	1 595	6 000	7 500
WM 317	18.21	3 170	1 300	1255	1 315	7 500	4 021	1 337	1 655	6 500	8 200
WM 333	20.14	3 330	1 366	1320	1 380	7 700	4 088	1 399	1 720	7 100	8 900
WM 350	22.30	3 500	1 435	1385	1 455	7 900	4 154	1 465	1 785	7 700	9 700
WM 367	24.57	3 670	1 505	1 450	1 525	8 200	4 220	1 532	1 850	8 300	10 600
WM 385	27.09	3 850	1 579	1600	1 525	8 400	4 297	1 602	1 925	9 000	11 500
WM 403	29.75	4 030	1 653	1595	1 670	8 700	4 368	1 672	1 995	9 800	12 500
WM 422	32.69	4 220	1 731	1675	1 755	8 900	4 450	1 746	2 075	10 600	13 500
WM 442	35.93	4 420	1 813	1750	1 835	9 200	4 526	1 824	2 150	11 500	14 700
WM 462	39.34	4 620	1 895	1830	1 920	9 500	4 608	1 902	2 230	12 400	15 900
WM 483	43.09	4 830	1 981	1910	2 005	9 700	4 690	1 984	2 310	13 400	17 300
WM 505	47.20	5 050	2 071	2010	2 100	10 000	4 792	2 070	2 410	14 500	18 700
WM 527	51.51	5 270	2 161	2085	2 190	10 300	4 868	2 156	2 485	15 700	20 200
WM 550	56.22	5 500	2 255	2175	2 285	10 600	4 960	2 245	2 575	16 900	21 900
WM 574	61.36	5 740	2 354	2275	2 385	11 000	5 062	2 339	2 675	18 300	23 700
WM 599	66.96	5 990	2 456	2370	2 490	11 300	5 159	2 437	2 770	19 700	25 600
WM 624	72.81	6 240	2 559	2470	2 590	11 600	5 261	2 534	2 870	21 200	27 700
WM 650	79.17	6 500	2 665	2575	2 700	12 000	5 368	2 635	2 975	22 900	29 800
WM 677	86.06	6 770	2 776	2680	2 810	12 400	5 475	2 741	3 080	24 600	32 200
WM 705	93.51	7 050	2 891	2790	2 930	12 700	5 588	2 850	3 190	26 500	34 700
WM 733	101.29	7 330	3 006	2900	3 045	13 100	5 700	2 959	3 300	28 500	37 400
WM 762	109.69	7 620	3 125	3015	3 165	13 500	5 817	3 072	3 415	30 600	40 200
WM 792	118.74	7 920	3 248	3135	3 290	13 900	5 940	3 189	3 535	32 900	43 200
WM 822	128.16	8 220	3 371	3255	3 415	14 300	6 062	3 306	3 655	35 200	46 400
WM 853	138.29	8 530	3 498	3375	3 540	14 800	6 185	3 427	3 775	37 800	49 800
WM 885	149.16	8 850	3 629	3500	3 675	15 200	6 312	3 552	3 900	40 400	53 400
WM 918	160.82	9 180	3 764	3635	3 810	15 600	6 450	3 681	4 035	43 300	57 200
WM 951	172.93	9 510	3 900	3765	3 950	16 100	6 583	3 809	4 165	46 300	61 200
WM 985	185.89	9 850	4 036	3900	4 090	16 500	6 720	3 942	4 300	49 400	65 400



Wärtsilä NO_X Reducer (NOR)

The Wärtsilä NO_X Reducer (NOR) is an emissions after-treatment system based on the Selective Catalytic Reduction (SCR) technology for Nitrogen Oxide (NO_X) reduction. The system is compliant with various NO_X emission reduction needs, such as the IMO Tier III rules. It is available for the Wärtsilä medium-speed engine portfolio for both newbuild and retrofits.

The size of the NOR is optimised in terms of performance and costs. The main component of the NOR installation is the reactor with a soot blowing system and the catalyst elements. Other modular essential parts of the NOR system are a urea pumping system, a urea dosing system, a control system and a urea injection system.



Wärtsilä NO_X Reducer (NOR)

Engine power output kW	Reactor size	Reactor W mm	Reactor H mm	Reactor L mm	Reactor weight (including catalyst elements) kg	Mixing duct total length (includes straight length)* mm
<400	1	840	840	3000	1100	3000
401–550	2	840	1000	3000	1200	3200
551–700	3	1000	1000	3116	1500	3400
701–900	4	1000	1160	3116	1600	3600
901–1100	5	1160	1160	3230	2000	3800
1101–1350	6	1160	1320	3230	2100	3900
1351–1600	7	1320	1320	3346	2500	3900
1601–1850	8	1320	1480	3346	2600	4200
1851–2150	9	1480	1480	3460	3000	4100
2151–2450	10	1480	1640	3460	3100	4500
2451–2800	11	1640	1640	3578	3500	4300
2801–3150	12	1640	1800	3578	3600	4000
3151–3600	13	1800	1800	3692	4100	4400
3601–4000	14	1800	1960	3692	4200	4200
4001–4400	15	1960	1960	3808	4700	4000
4401–4800	16	1960	2120	3808	4800	4300
4801–5300	17	2120	2120	3924	5300	4100
5301–5850	18	2120	2280	3924	5400	4400
5851–6300	19	2280	2280	4040	5900	4300
6301–6800	20	2280	2440	4040	6000	4600
6801–7400	21	2440	2440	4156	6600	4400
7401–8000	22	2440	2600	4156	6800	4700
8001–8600	23	2600	2600	4270	7300	4500
8601–9200	24	2600	2760	4270	7500	4800
9201–9900	25	2760	2760	4420	8300	4600
9901–10600	26	2760	2920	4420	8500	4900
10601–11200	27	2920	2920	4688	9400	4700
11201–11900	28	2920	3080	4688	9600	4600
11901–12700	29	3080	3080	4716	10500	4800
12701–13400	30	3080	3240	4716	10700	5100
13401–14200	31	3240	3240	4866	11700	4900
14201–15000	32	3240	3400	4866	11900	5100
15001–15800	33	3400	3400	5014	12800	5400
15801–16600	34	3400	3560	5014	13000	4900
16601–17500	35	3560	3560	5162	14000	5100
17501–18400	36	3560	3720	5162	14300	5300
18401–19300	37	3720	3720	5412	17300	5500
19301–20200	38	3720	3880	5412	17500	5700
20201–21200	39	3880	3880	5560	20600	5900
21201–22200	40	3880	4040	5560	20900	6200

*The length of the mixing duct is case dependant. The figures are indicative.

Wärtsilä Hamworthy Flare Gas Recovery

The Wärtsilä Hamworthy technology safely captures and handles flare gas, which can then be re-utilised for other purposes.

Flaring gas emits some 400 million tons of CO_2 annually to the atmosphere, and has a notable impact on the environment. Our Flare Gas Recovery System offers a substantial reduction in such emissions. It allows the previously flared gas to be available for re-utilisation as fuel or export gas re-injected, as feed for boilers, and for many other gas related applications.

The closing of the flare line during normal operations results in significantly decreased flare tip wear, allowing it to typically last for the lifetime of the field. The concept comprises flare header isolation equipment, a gas recovery system, and a reliable flare gas ignition system.

Our systems can be designed to meet the specific process conditions of the plant.

Wärtsilä Hamworthy Flare Gas Ignition

Our Flare Gas Ignition System ensures the safe and reliable ignition of the flare whenever required.

The Wärtsilä Hamworthy system is suitable for all flare tips and may ignite several flares on a single flare deck. It is installed at a safe distance from the flare stack, with a guide pipe leading to the flare tip. The system combines high reliability and availability over the lifetime of the facility with low maintenance requirements, and is easily retrofitted into existing installations.

Pilot burners are not necessary, and there is no heat sensitive equipment, such as cables, instrumentation and electrodes, on the flare deck.

Our Hydrocarbon Gas Blanketing Systems are already used onboard numerous projects in the North Sea and West Africa.

Wärtsilä Hamworthy Hydrocarbon Blanketing Systems

Wärtsilä Hamworthy's Hydrocarbon Blanketing System eliminates the environmental damage and economic loss caused by emissions of gas vented to the atmosphere in a conventional process

This Wärtsilä Hamworthy system utilises hydrocarbon gas as a blanket gas in the cargo tanks, and recovers the off gas. Its primary application is in FPSOs. The blanket gas prevents the intrusion of oxygen into the cargo tank atmosphere, thus creating a closed system.

During loading, surplus gas from the cargo is recovered and recycled into the process plant by means of a blower/ejector/compressor. When offloading, the hydrocarbon blanket gas is supplied to maintain pressure in the cargo tanks. All the hydrocarbons are recovered to the process, and emissions into the atmosphere are eliminated during normal operation.

The first VOC condensation system with zero emissions was installed on the shuttle tanker Stena Alexita, operated by ExxonMobil in the North Sea oil fields.

Wärtsilä Hamworthy VOC Recovery

Our field proven VOC recovery system is self supplied with energy and results in zero Volatile Organic Compounds (VOC) emissions.

These emissions from the global sea transportation of crude oil and associated products, account for a total of more than 5 million tonnes per year. The Wärtsilä Hamworthy VOC plant ensures that cargo tank pressures are maintained low enough to keep the vent valve closed. This prevents VOC from being emitted to the atmosphere, and the gas is instead fed to the VOC recovery module, where it is treated by compression and condensation. The liquefied gas is then fed to the VOC fuel tank.

We have also developed a system for VOC recovery in offshore oil loading applications. It exceeds the Norwegian authorities' requirements for Non-Methane Volatile Organic Compounds (NMVOCs) by reducing VOC emissions by 100 per cent, including methane, which is not currently specified in the regulatory requirements.

Wärtsilä GasReformer

This solution makes it possible to utilise gaseous fuels that either contain large amounts of heavier hydrocarbons or vary in their composition. Gases that were previously considered as waste can now be converted into a valuable resource of energy. Together with Wärtsilä dual-fuel (DF) engines, this is the most efficient and flexible solution for utilising associated gas or volatile organic compounds (VOCs) recovered from oil production.

The main application area is in offshore oil and gas production. Wärtsilä GasReformer has been developed and designed to meet the standards of the oil & gas industry and is the first of its kind in the world.

The technology is based on steam reforming (SR), a catalytic process known from the petrochemical industry and refineries, where traditionally hydrogen is produced from various hydrocarbon feeds. The Wärtsilä GasReformer exploits the same catalytic process but operates under different conditions. In the Wärtsilä GasReformer the methane number (MN) of any fuel gas is improved to 100 ± 5 by converting the heavier hydrocarbons to synthesis gas (H_2 + CO) and finally to methane (CH_4).

Environmental excellence

Offshore gas flaring is increasingly recognised as a major environmental problem, contributing more than 1% of global CO_2 emissions, not to mention the valuable resources that go to waste.

The associated gas, separated from crude oil, is traditionally flared and not utilised because it varies in composition, and contains a lot of heavier hydrocarbons. Generally it is considered as waste or an unreliable source of energy.

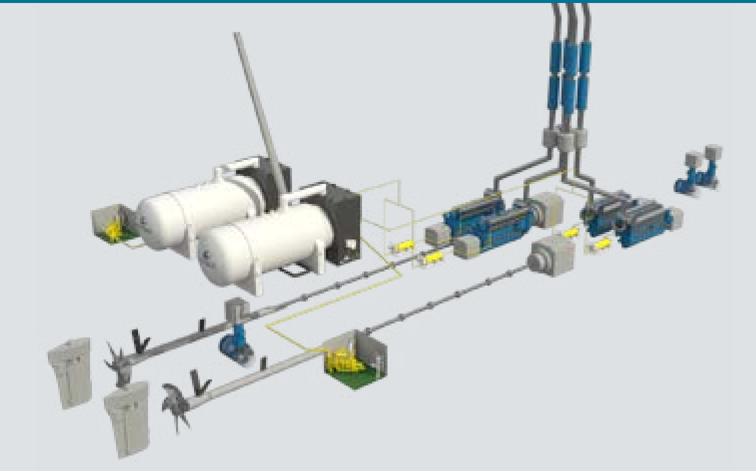
With the Wärtsilä GasReformer, this undesired gas can be reliably and efficiently utilised by Wärtsilä dual-fuel engines. When utilising associated gas or recovered VOCs as a reliable source of energy, the operator can achieve self-sufficiency in terms of energy supply and thus the need for fuel bunkering, a costly operation in offshore locations, decreases. With an 8 MW Wärtsilä GasReformer combined with a dual-fuel engine utilising associated gas, the operator can reduce the need for bunkered fuel oil by about 20 tons per day. With a Wärtsilä DF engine the system produces electricity with an overall efficiency of up to 44.5%.

Key benefits

- Reduction of CO_2 emissions
- No need for flaring
- Flare gas can be utilised for power production
- Low NO_X emissions from proven dual-fuel engines
- Dual-fuel engines can operate at full load and efficiency
- Operator can change gas source during operation
- Decreased carbon footprint for operating company

Product Specification for 8 MW* GasReformer		
Pressure	5–9.5 barg	
Desulfurisation adsorbent (ZnO)	1.5 m^3	
Desulfurisation temperature	200–400°C	
Reformer catalyst ($Ni/MgAl_2O_4$)	1.3 m^3	
Reformer temperature	350–420°C	
Electrical heater	99 kW	
Steam flow rate	233 kg/h/MW*	
Flow values (for an example case)	Inlet gas	Product
MN	46	104
LHV	46 MJ/kg	35 MJ/kg
Flow rate	207 kg/h/MW*	271 kg/h/MW*

* shaft power of DF engine



Wärtsilä LNGPac

Natural gas is becoming increasingly viable as a propulsion fuel in marine applications. Wärtsilä is a leader in developing dual-fuel engine and LNG fuel system technologies that have enabled this change. We offer the LNG fuel system on its own, as well as a part of a complete propulsion system. Wärtsilä Hamworthy can deliver LNG fuel gas systems for propulsion and power generation for any applicable types of ship or engine.

Standard solution

Bunkering takes place from the bunkering station to the LNG tank via an insulated pipe. The LNG tank connection space compartment is mounted directly on the LNG tank. The tank connection space contains all the piping penetrations through the tank shell, as well as all heating media connections to the LNG evaporators.

The process inside the tank connection space includes all the connections and valves between the tank and the Pressure Build-up Evaporator (PBE), and between the tank and the Main Gas Evaporator (MGE), together with the evaporators themselves. The evaporators are heated by glycol-water that is circulated within a glycol-water heating unit.

Wärtsilä is proposing as a standard a proven design with no rotating machine with a pressurised vacuum insulated tank type C.

Customised solution

The LNGPac gas supply system can be customised to the needs of each project on a case to case basis by Wärtsilä Fuel Gas Handling's expert team. Some dedicated engineering has to be performed at the beginning of the project to match the specific operational requirements, safety regulations, and the rules of each classification society qualifying the vessel.

Type LNGPac	Geometric volume	Net volume (90%)*	Diameter	Tank length	Tank room	Total length	LNGPac empty weight**	LNGPac max operating weight*	Theoretical Max. Autonomy
	[m^3]	[m^3]	[m]	[m]	[m]	[m]	[ton]	[ton]	[MWh]
LNGPac 105	105	100	3.5	16.7	2.5	19.2	47	94	244
LNGPac 145	145	130	4.0	16.9	2.5	19.4	62	127	318
LNGPac 194	194	175	4.3	19.1	2.7	21.8	77	164	427
LNGPac 239	239	215	4.3	23.1	2.7	25.8	90	198	525
LNGPac 284	284	256	4.3	27.1	3.0	30.1	104	231	625
LNGPac 280	280	252	4.8	21.3	3.0	24.3	105	233	616
LNGPac 308	308	277	4.8	23.4	3.0	26.4	113	252	677
LNGPac 339	339	305	5.0	23.5	3.0	26.5	119	271	745

* Indicative only to be confirmed by Classification society for each project. Possible values from 75% till 95%
** Not contractual indicative only

Wärtsilä Hamworthy LNG Liquefaction

Our industry leading natural gas liquefaction solutions combine high energy efficiency and plant reliability with operational robustness, flexibility, and ease of operation.

Wärtsilä Hamworthy's innovative LNG production plant solutions suitable for small to medium size liquefaction capacities, are based on well proven equipment and process control principles.

Wärtsilä Hamworthy has also developed the energy efficient NewMR liquefaction technology for even lower capacities than our usual small and mid-scale LNG plants. For production capacities below 50 tonnes per day, the NewMR technology uses a mixed refrigerant in combination with standard equipment to achieve low investment costs and fast manufacture of the liquefaction unit. In the growing liquid biogas fuel market, this technology adds to the value chain.

Wärtsilä Hamworthy LNG Regasification

Our portfolio of LNG regasification technologies represents an industry benchmark in terms of energy efficiency, robustness, and operational flexibility. The units are available either as multi-skid deliveries, or as complete turnkey and single-lift topside modules.

We have delivered and put into operation numerous floating LNG regasification plants based on either closed loop regasification technology, using steam with water/glycol as the intermediate heating medium, or open loop regasification technology using sea water with propane as the intermediate heating medium. We have also delivered modularised regasification plants for jetty installations. These facilitate a much shorter construction time compared to the traditional land based LNG regasification terminal project.

Wärtsilä Hamworthy LNG Reliquefaction

Wärtsilä Hamworthy is an established leading designer, developer, and supplier of energy efficient LNG Boil-Off Gas (BOG) reliquefaction plants that are reliable, safe, robust and flexible.

Wärtsilä has by far the highest number of BOG reliquefaction plants installed in the global LNG carrier fleet. They offer owners and operators unsurpassed lifecycle efficiency, and are backed by a full range of complementary services, including operation & maintenance training, remote monitoring & diagnostics, and customised service and support agreements.

Wärtsilä Hamworthy has commercialised and improved reliquefaction technology since it was originally patented by Kværner and licensed by Hamworthy in the late 1990s.

Our boil-off gas (BOG) reliquefaction plants have been installed on numerous vessels, including the entire Q-Flex fleet of 216,000 m^3 LNG carriers. The 31 Wärtsilä Hamworthy LNG BOG reliquefaction plants delivered to the Q-Flex fleet are installed on ships driven by slow speed diesel propulsion engines. The process is based on the reversed nitrogen Brayton cycle refrigeration technology, combined with a process solution for separating nitrogen from the BOG. We have also delivered the same type of systems to a number of LNG carriers with dual-fuel diesel electric (DFDE) propulsion. The liquefaction of BOG on LNG carriers results in increased cargo deliveries, and allows owners and operators to choose the optimal propulsion system and operating profile.

We work closely with our customers to develop technological solutions that meet their needs for increased fuel flexibility, energy efficiency, and environmental performance in today’s fast changing LNG market.

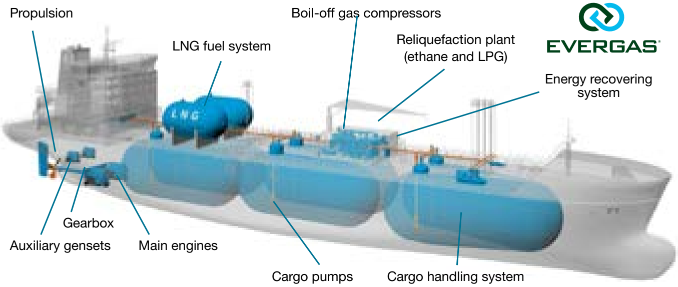
Wärtsilä Hamworthy LNG Receiving Terminals

Wärtsilä Power Plant Division together with Wärtsilä Gas Solution are providing complete LNG receiving terminals based on a EPCIC contract philosophy.

The scope of work includes design, detailed eng., process simulation, control system, electrical and automation to operation and service agreement.

A typical gas receiving terminal will include Jetty construction and receiving systems, Unloading arms, LNG processing and Boil Off Gas handling, Regasification of the LNG to pipeline or power plant condition, storage tanks, electrical and instrumentation, control and automation system.

Wärtsilä can offer in addition to above operation assistance including long term service agreement to the complete gas receiving terminal.



Design of the Liquefied Natural Gas (LNG) Carrier of size 27.500 m^3 contracted at SOE in China. Wärtsilä will supply a comprehensive solutions package including the cargo handling package, the dual-fuel engines and propulsion equipment for a series of vessels being built for Danish operator Evergas, a leading transporter of petrochemical gases and natural gas liquids .

Wärtsilä Hamworthy Cargo Handling Package

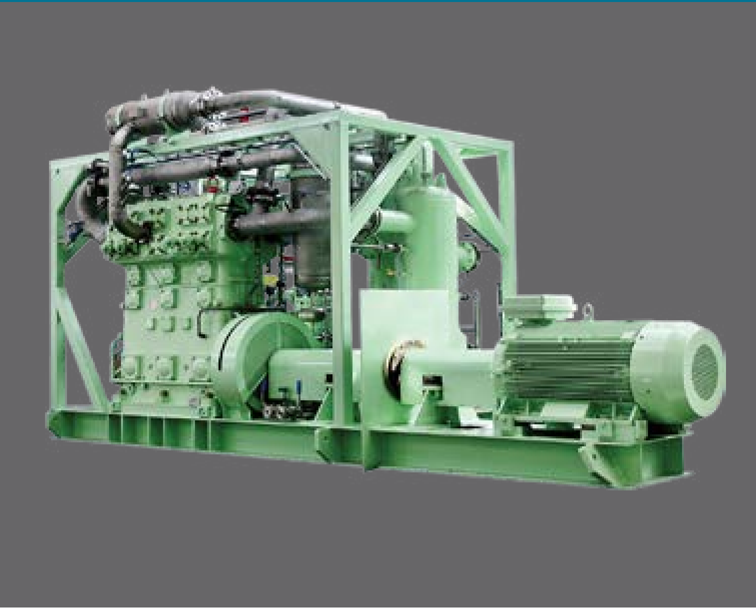
There is a growing demand for small scale transport of LNG – main reason for the growing market is to reach end users that are located in areas where pipelines are not feasible or economical. The end users are typical power generation plants, land based industry and fuel for vehicles, but also the ships which are utilizing LNG as fuel (bunkering).

Wärtsilä has developed Cargo Handling System that is designed in accordance with WO&GS long experience in delivery of such systems for LPG, LEG and LNG carriers.

The scope available can include:

- Cargo Handling System
- Boil-of gas handling
- Cargo Tank Design and complete Tank delivery,
- Ship Design
- LNG Fuel supply system

Wärtsilä Ship Design provides designs for small size LNG Carriers for carrying LNG only or as Multi Gas Carriers able to carry all types of gas cargoes in addition to LNG. Ship size is typically between 4000 and 40.000 m^3. Ship size is typically between 4000 and 40.000 m^3.



Wärtsilä Hamworthy
LPG & Ethylene Cargo Handling

Our reliable and innovative LPG & Ethylene cargo handling technology is vital for gas carriers and includes reliquefaction plants.

For LPG and Ethylene carriers we offer services, including the engineering of complete cargo handling systems, tank design and the supply of cargo handling equipment, such as reliquefaction and cooling systems for liquid gas, inert gas plants and nitrogen generator systems, deepwell and booster pumps. All equipment is designed and engineered in-house.

We have recently developed newly patented cargo handling reliquefaction technology that provides owners with numerous operational and cost benefits. The system has been developed for larger LPG carriers, typically ships above 60,000 m^3, and is aimed at reducing installation, operation and maintenance costs.

Wärtsilä Hamworthy LPG Cooling and Reliquefaction

We have built up a number of references for the supply of our LPG cooling and reliquefaction plants onboard LPG FPSOs.

The high pressure LPG liquid stream requires cooling before it is expanded into the cargo tanks by the installed cooling plant. Our reliquefaction plants can be designed for operation on LPG with high ethane content in the LPG liquid phase, and ensure that the cargo condition is at low pressure and temperatures down to -50°C in the cargo tanks.

Our supply of the world's largest LPG handling system to Chevron's Sanha LPG FPSO, with a storage capacity for 135,000 m^3, put us at the forefront of gas liquid cargo handling systems in this specialised market. The scope of equipment supply included large propane and butane cooling and reliquefaction plants, comprising skid-mounted units, a total of five cooling units served the reliquefaction plant, with two as the second stage in a cascade system.

Wärtsilä Tank Control Systems for Whessoe Products

If your product is LNG, LPG or ammonia, Wärtsilä Tank Control Systems can provide an application-specific solution for your business needs. Today, the liquid gas industry is driven by the economics of operational scale. In order to apply efficient business management, while adhering to stringent safety regulations, operations personnel must have access to correct information.

Throughout the production cycle, from storage to distribution, the availability of precise data is essential, and it needs to be relayed to the control room in real time.

Whether your operation is large or small, our solutions are custom designed to suit your requirements. They can operate independently, or be interconnected within a plant-wide system. Our vast experience, research, instrumentation technology, and service support will add value to your business.

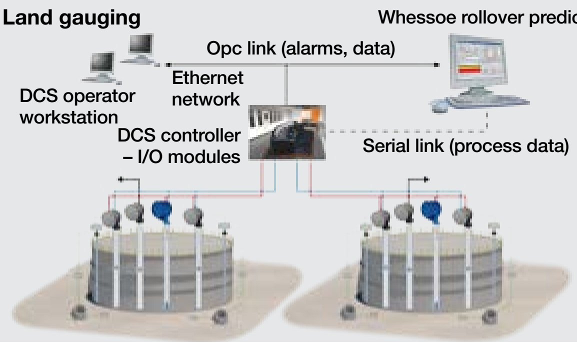
Marine Gauging

LNG secondary tank gauging systems:

- World leaders in LNG marine gauging, more than 320 vessels supplied worldwide
- FLIV isolation valves

Product and chemical carriers

- LPG level gauging
- Alarm systems
- Supervisory control and data acquisition system



Liquefied Natural Gas (LNG)

Total LNG tank gauging system:
Our total LNG storage tank instrumentation solution comprises the following, fully integrated system components:

- SIL-3 certified servo level gauges
- High/high level alarm gauges
- Product temperature probes
- Fully automatic LTD gauges
- Leak detection and cooling temperature transmitter system
- PC based SCADA package
- Roll-over predictive alarm software
- LNG sampling system.

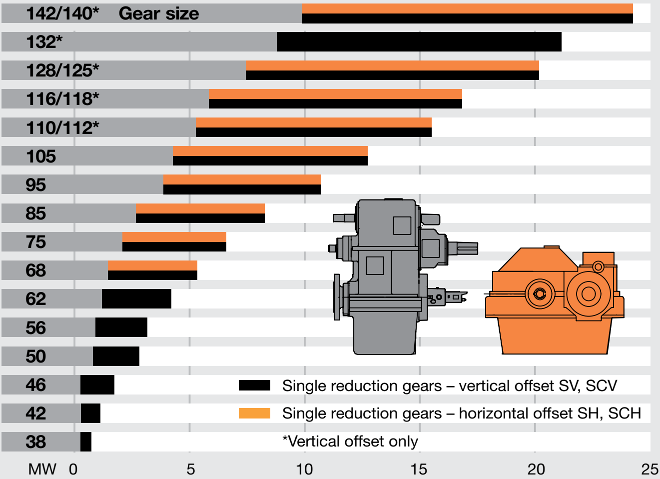
The entire system communicates via a redundant communication link.

Liquefied Petroleum Gas (LPG)

Wärtsilä Tank Control Systems lead the industry in liquefied gas storage instrumentation and safety systems. We offer complete pressurised tank solutions for LPG and liquefied chemical gases (vinyl chloride, ethylene, propylene, butadiene, ammonia, etc.). These include level gauging or safety shut-off valves systems with hydraulic panel remote, that enable the full protection, control, and supervision of the storage plant.

Wärtsilä Tank Control Systems is a key player in LPG cavern storage applications. We have developed, in close collaboration with key customers, a unique and dedicated range of products that meet the specific needs of this type of storage.

WÄRTSILÄ REDUCTION GEARS – OUTPUT RANGE



REDUCTION GEARS

The core function of a reduction gearbox is to reduce the main engine speed to the optimum propeller speed. Wärtsilä gears have been designed to meet the highest standards of operational efficiency, reliability and low noise and vibration.

Gear configurations

The gears can be supplied with built in multidisc clutches. Single input, single output gears are available with vertical or horizontal offsets of the shafts. Twin input single output gears can be delivered with up to 3.8 m horizontal offsets.

Power take-off (PTO)

All Wärtsilä gears can be supplied with one or more PTOs for driving the shaft alternator, compressor or pump. For single vertical and horizontal gears, the standard PTO is primary driven. For twin input-single output gears the PTO is optionally primary or secondary driven.

- A primary driven PTO is rotating whenever the engine is rotating.
- A secondary driven PTO is rotating whenever the propeller shaft is rotating.

Two speed PTOs are available on request.

Wärtsilä gear type SCV128.

Power take-in (PTI)

Most Wärtsilä gears can be supplied with a combined PTO/PTI. In PTI mode the shaft alternator can also be used as an electric motor.

PTI is normally used for the following operation modes:

- PTI “Booster” mode is used when the main power of the engine is too small, in order to increase the total propulsion power. For this mode, no clutches are required on the gear.
- PTI “Take me home” mode is used in case of emergency, if the prime mover is out of operation. For this mode a minimum of 2 clutches are required on the gear.

Two speed PTOs are available on request.

Integrated or separate hydraulic system for gear and CP propeller

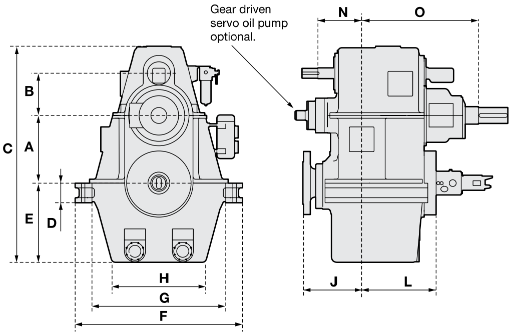
Most Wärtsilä gears are purpose-designed with an integrated hydraulic system for both the gear and the CP propeller. As the separate hydraulic power unit for the CP propeller is superfluous, both installation costs for the yard and operational costs for the owner are reduced. For safety reasons the gear mechanically drives the main pump for the propeller. All gears can also be interfaced to a separate hydraulic power unit.

Wärtsilä Single Input Reduction Gears

Wärtsilä vertical offset gears – dimensions

SV/ SCV size	A	B Std-Max	C	D	E	F	G	H	J	L	N	O SCV/SV	Weight tonnes*
SCV38	380	290	1305	115	465	1000	750	530	340	538	230	650	2.1
SCV42	420	320	1435	125	510	1500	830	585	530	558	255	715	2.7
SCV46	460	350	1570	140	560	1580	910	640	570	595	280	785	3.4
SCV50	500	380	1724	150	590	1340	1024	720	470	592	420	1035	4.2
SCV56	560	410	1848	160	645	1500	1110	800	530	650	450	1100	6.0
SCV62	620	440-470	2210	180	740	1580	1240	880	570	662	350	1150	7.0
SCV68	680	460-510	2370	200	800	1720	1360	960	625	720	370	1250	8.5
SCV75	750	480-530	2460	220	880	1850	1480	1040	660	800	450	1300/1095	10.0
SCV85	850	510-560	2720	250	1000	2100	1680	1178	730	915	550	1470/1220	14.5
SCV95	950	580-630	3025	280	1145	2350	1880	1327	800	1025	450	1640/1350	20.0
SCV105	1050	600	3328	250	1124	2628	2192	1668	1410	624	618	970	26.0
SV112	1120	600	3550	260	1198	2804	2272	1772	1500	660	655	800	29.0
SCV112	1120	700	3650	260	1198	2804	2272	1772	1500	660	595	1800	31.0
SV118	1180	600	3610	300	1190	2824	2268	1758	1520	716	655	827	32.0
SCV118	1180	700	3710	300	1190	2824	2268	1758	1520	716	595	1800	35.0
SV125	1250	600	3805	300	1325	2954	2396	1888	1600	808	635	860	35.0
SCV125	1250	700	3905	300	1325	2954	2396	1888	1600	808	595	1950	38.0
SV132	1320	600	3940	300	1390	3084	2516	2018	1630	850	665	875	38.0
SCV132	1320	700	4040	300	1390	3084	2516	2018	1630	850	610	2020	42.0
SV140	1400	600	4250	350	1500	3250	2600	2150	1700	900	720	920	44.0
SCV140	1400	700	4350	350	1500	3250	2600	2150	1700	900	680	2200	47.0

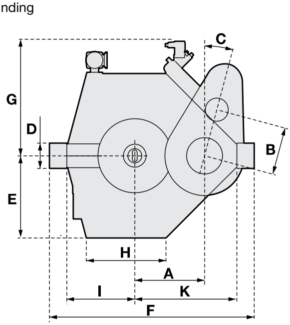
* Not binding

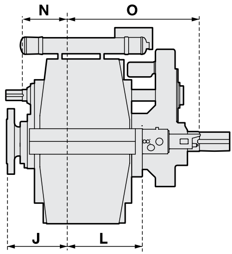


Wärtsilä horizontal offset gears – dimensions

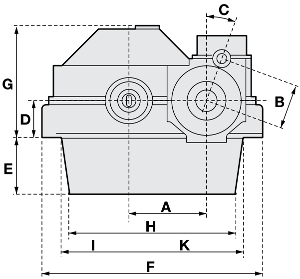
SH/ SCH size	A	B	C	D	E	F	G	H	I	J	K	L	N	O SCH/ SH	Weight tonnes*
SCH68	680	510	0	100	700	2000	840	650	515	570	1095	730	500	1245	10
SCH75	750	530	15	280	885	2230	1220	865	735	660	1115	800	515	1670	12.5
SCH85	850	580	15	320	1000	2495	1440	970	830	730	1245	915	550	1800	16.5
SCH95	950	580	15	450	750	2710	1520	2250	830	1215	1420	540	700	1640	21
SCH105	1050	630	20	500	771	2995	1658	2195	910	1405	1545	560	750	1700/ 1510	30
SCH110	1100	670	20	500	810	3150	1850	2320	950	1450	1630	610	790	1750	33
SCH116	1160	670	20	550	850	3300	2240	2500	1015	1535	1715	725	830	1100/ 1800	40
SCH128	1280	740	20	590	1550	3640	1960	2675	1090	1600	1870		915	1915	50
SCH142	1420	820	20	620	1720	4040	2180	2970	1380	1700	2240		1015	2100	55

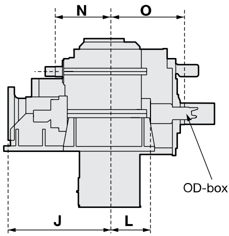
* Not binding





SH/SCH 75–85





SH/SCH 95–142

Wärtsilä Twin Input-Single Output Reduction Gears

Wärtsilä TCH range gears

Gear type	Engine offset (mm)	Engine type
TCH190	1900	Wärsilä 20
TCH240	2400	Electric motors
TCH250	2500	W26 (L-version)
TCH270	2700	W32 (L-version) and W34DF (L-version)
TCH310	3100	W12V26, W16V26, W38 (L-version)
TCH350	3500	W12V32, W6L46F, W6L50DF
TCH370	3700	W16V32, W18V32,W8L46F, W9L46F, W8L50DF, W9L50DF
TCH380	3800	W12V34DF, W16V34DF, W12V38, W16V38, W18V38

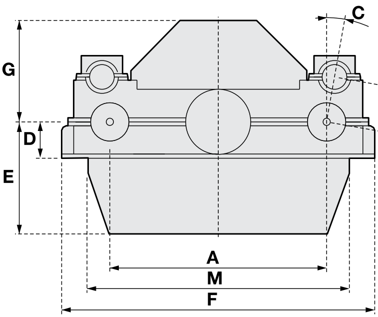
Please verify engine offset given in the latest engine product guide, ch 18.1 “Crankshaft distances”

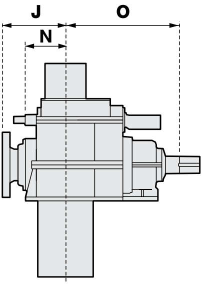
Wärtsilä gear type TCH370-S63.

Wärtsilä TCH range gears – dimensions

TCH size	A	B	C	D	E	F	G	J	M	N	O	Weight tonnes*
TCH190	1900	460	10	320	980	2750	890	555	2300	360	995	15
TCH240	2400	490	20	450	1315	3580	1455	730	3135	570	1220	20
TCH250	2500	530	12.5	450	1400	3700	1150	800	3230	570	1290	28
TCH270	2700	580	10	500	1330	3900	1690	880	3410	600	1560	28
TCH310	3100	630	10	500	1550	4430	1400	880	3730	565	1570	34
TCH350	3500	580	10	700	1855	5370	1630	1270	4380	790	2140	50
TCH370	3700	630	10	700	1855	5565	1645	1270	4580	880	2140	60
TCH380	3800	730	10	760	2015	5800	1760	1380	4770	860	2300	70

* Not binding





INERT GAS

The Shuttle tanker 'Dan Cisne' is equipped with a Wärtsilä Moss inert gas generator system.

Wärtsilä is a market leader in the development, design, manufacture and servicing of advanced inert gas and nitrogen solutions for marine and offshore oil and gas applications.

Our leading-edge, customised solutions ensure high quality and advanced levels of safety for vessels operating in regulated areas. We are certified by ISO 9001:2000, ISO 14001:2004 and OHSAS 18001:2007.

Our strong reputation in inert gas solutions is based on over 50 years experience and unique full-scale R&D facilities located in Moss, Norway. Our references include over 2500 vessels installed with our inert gas equipment.

Performance testing of inert gas systems can be executed in the company's own test hall in Moss, the only facility tailor-made for this purpose in the world today.

Wärtsilä Moss systems are vital systems to ensure a high level of safety for vessels where they are installed. Consequently, product quality is always the number one priority.

All our systems are designed based on compact modules, offering important savings in space and installation cost both for newbuildings and for retrofit on existing vessels.

Wärtsilä Moss AS personnel in combination with Wärtsilä Aftersales ensures our customers a global network for lifetime support. This is vital to secure uninterrupted operation, further we also offer Service Agreements, product training and system upgrades to support our

customers in their efforts to optimize operational performance as well as cost. Spare Part Department in Moss will provide anticipated spares on short notice.

Inert gas system for gas carriers

- High turbulent burner giving high quality inert gas.
- Compact, vertical designed generator which can be installed at any direction inside the ship and inert gas quality is independent of ships motion.
- Automatic fresh water cleaning system after use of inert gas generator.
- The blower units supplying combustion air are either of two stage centrifugal fan type or of the roots blower type with electric motors.
- First stage is an inert gas cooler unit which cools down the inert gas to 5°C removing most of the water by condensation. Indirect cooling using low amount of refrigerant.
- Second stage adsorption dryer deliver inert gas with dew point of -45°C.
- Continuous operation.
- For smaller systems the drying may be of the heatless type.
- Using environment friendly refrigerant which complies with all class societies environmental regulations.

Wärtsilä Moss Flue Gas System

The Wärtsilä Moss Flue Gas System are tailor made for use onboard crude oil carriers.

Benefits of the Moss design

- Unique concentric venturi scrubber design based on more than 50 years of experience
- Minimum space requirement
- High efficiency
- Low maintenance cost
- Safe and easy operation
- Scrubber unit
- Combining three scrubbing principles for high efficiency calling and cleaning: venturi scrubbing, wet filter and spray section
- Concentric arrangement independent of ships pitching and rolling
- Internally coated with GRE and venturi tube in corrosion and heat resistant steel

Wärtsilä Moss Mult-Inert™ System

The Wärtsilä Moss Mult-Inert™ System are vital systems to ensure a high level of safety for use onboard tankers intended to carry both crude oil and refined products, and combine into one compact unit where quality is the number one priority.

The Wärtsilä Moss Mult-Inert™ System can run as an inert gas generator or, when the boilers are in use, as a flue gas system. They are designed based on compact modules, offering savings in space and installation cost for newbuild and retrofit vessels.

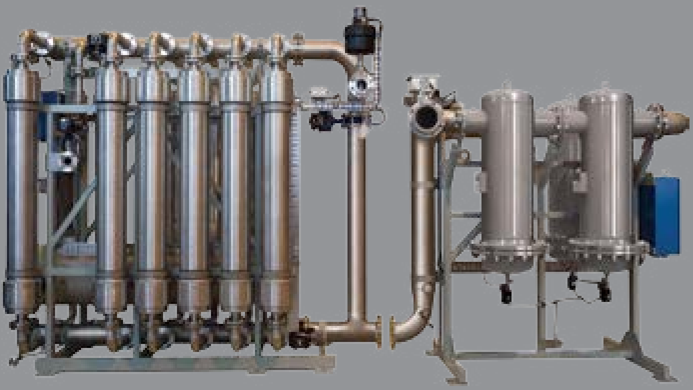
When discharging crude oil or less refined petroleum products, our Mult-Inert™ Generator System can be run in flue gas mode as the boilers are run to heat the cargo. The cargo is less sensitive to contamination. When discharging more sensitive cargo, the system can be switched to inert gas generator mode burning marine fuel.

Wärtsilä Moss Inert Gas Generator

The Wärtsilä Moss Inert Gas Generator are vital systems to ensure a high level of safety for vessels to prevent the atmosphere in cargo tanks or bunkers from coming into the explosive range.

The burner/scrubber unit requires less requires less deck space than any other known design. This is due to the location of the combustion chamber concentrically inside the scrubber unit. Other benefits of this design are that the unit does not require any special direction of orientation inside the ship and that the inert gas quality will not be affected by the ship's pitching and rolling.

The unique Moss high turbulent burner ensures an almost complete combustion with a rugged simple design and no moving parts. Heat/corrosion resistant steel is used for all surfaces exposed to heat and/or sea water.

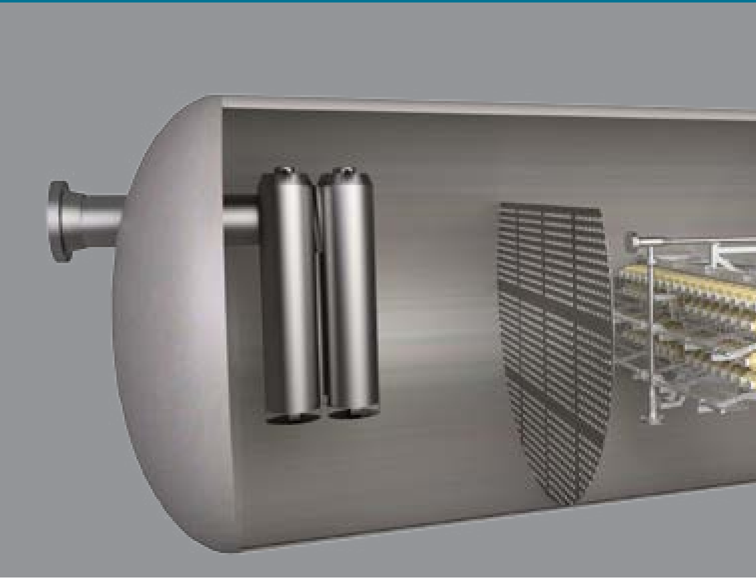


Wärtsilä Moss Nitrogen Generators

Our nitrogen generators are designed for their flexibility and efficiency. The system is particularly suited for marine and offshore applications, where the demand for high quality and challenging specifications is present. We always adapt to our customer`s needs, and are capable of installing our systems into the most challenging locations.

They are also designed to deliver various purities in the same system, giving our customers even greater flexibility. We supply niche, supplementary, small volume systems with capacities from 10 to 6000 Nm^3/h at purities from 95 to 99.9% nitrogen.

For the offshore market, Wärtsilä Moss nitrogen generation systems supply dry and oil-free inert gas for purging pressurizing and blanketing functions for various topside applications.



Wärtsilä Vessel Internal Electrostatic Coalescer

The Vessel Internal Electrostatic Coalescer (VIEC®) operates at high water cut and is the natural choice for processes which struggle to reach specifications.

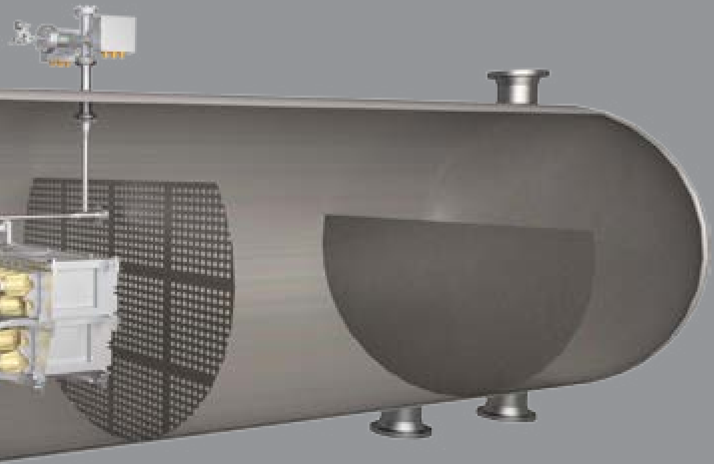
Experience from several offshore/onshore installations have shown that VIEC® greatly improves both oil and produced water quality. VIEC® can also provide oil specifications for export at low viscosity.

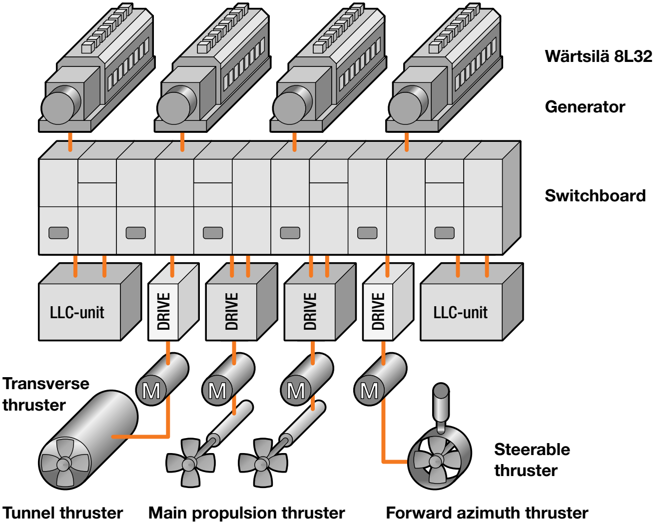
VIEC® solves the problems often associated with emulsion and capacity limits in separators. It enhances the speed and efficiency of the separation process by forcing small water droplets to merge and form larger, faster sedimenting drops.

Until the development of VIEC®, electrostatic coalescer technology had been unavailable for use in inlet separators.

VIEC® enables less separation stages and heavy-oil separation by exposing the emulsion of water in oil to an electrostatic field.

Wärtsilä is actively developing new and innovative products to make oil and water separation more efficient, cost-effective, and environmentally safe. Through Wärtsilä know-how our state of the art technology is designed to improve the separation, quality of oil and water.





Wärtsilä Electric Propulsion System

The Wärtsilä electric propulsion system incorporates state-of-the-art technology in every integrated component, and has a unique system configuration to maximise safety and efficiency.

The Wärtsilä Low Loss Concept (Wärtsilä LLC) is a patented solution developed to achieve the highest redundancy and to reduce the number of installed components in the system. The concept is by nature very flexible and can be designed to fit any configuration of power generation and propulsion units available, as well as serving all electric power consumers onboard. The higher efficiency and system redundancy results in lower fuel consumption, thereby reducing operating costs.

The Wärtsilä Low Loss Concept (LLC) covers all power application requirements from 5 MW to 70 MW installed power generation in both the Low Voltage and Medium Voltage versions.

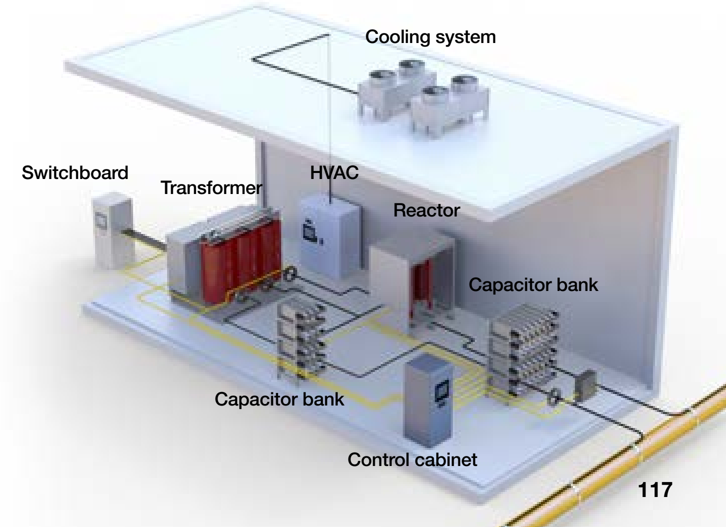
With the introduction of the Wärtsilä Medium Voltage Power Drive, Wärtsilä is now able to offer medium voltage Low Loss Concept solutions to the larger marine electric propulsion market and also Low Loss Concept Quattro (LLC Quattro) solutions for the rig market.

Wärtsilä Direct Electric Heating

The presence of wax and hydrates in subsea flow lines is a major concern in the offshore industry. Wärtsilä Direct Electric Heating (Wärtsilä DEH) is based on using the thermally insulated flow line as part of the electric circuit, and allowing the electrical losses to heat the contents of the pipe. Wärtsilä DEH is a cost efficient and environmentally sustainable flow assurance method that replaces the use of chemicals.

Wärtsilä DEH is today a mature technology that has been used for 13–14 years in Norway. Wärtsilä DEH is also being used in West African installations. Wärtsilä has participated in the development of Wärtsilä DEH since the nineties, and today undertakes the design and supply of the complete topside Wärtsilä DEH package.

The topside package comprises tailor made MV components that control the current in the flow line, convert the load from single phase to a symmetrical 3-phase load, and compensate for the low power factor. Wärtsilä delivers electric and optic protection and control packages that have been specially developed for Wärtsilä DEH. The Wärtsilä DEH package can be installed in suitable indoor locations, or in outdoor locations within a steel or aluminium module with HVAC or water cooling. Wärtsilä DEH deliveries always include a special power system analysis to ensure its integrity with the platform system. Wärtsilä DEH has been used for flow lines of up to 42 km, and with a power requirement of up to 12 MW.



Wärtsilä Medium Voltage Power Drive

Wärtsilä Medium Voltage Power Drive is especially designed for marine and offshore applications. The modular design allows easy installation and maintenance.

The Wärtsilä Power Drive is available in 12, 18 and 24 pulse configurations, and harmonic currents and voltages injected to the switchboard of a marine application are kept well below the requirements of international standards. The drive is water cooled and the cooling water cabinet, including the de-ionising unit, can be delivered as an integrated or stand-alone solution.

Together with Wärtsilä's patented medium voltage Low Loss Concept (LLC), the introduction of next generation medium voltage power drives brings increased efficiency and redundancy to the larger marine electric propulsion market, with the added benefit of reduced weight and space requirements.

Product name	**MVPD800066**
Supply voltage	6 600 VAC
Motor voltage	6 000 VAC
Motor power normal duty	8 000 kW (pf > 0.88 and motor efficiency > 0.97)
Apparent output power normal duty	9 400 kVA
Max. output frequency	200 Hz (higher with derating)
Control	Vector control/PWM output
Switchboard connection	Direct with LLC or propulsion transformer
Cooling method	De-ionized fresh water
External cooling water	10–38°C fresh or salt water
Protection	IP44
Dimensions converter (mm)	5 100 x 1 200 x 2 370 (width x depth x height)
Dimensions cooling unit (mm)	1 000 x 1 200 x 2 370 (width x depth x height)

Wärtsilä Low Voltage Power Drive

Designed for lifetime operation in a maritime environment, this is the world's most compact, low voltage (690V) frequency converter with excellent performance in the control of propulsion motors, pump applications, compressors, mooring and winches, and drilling operations. The drive is water cooled and can be directly connected to the ship's cooling water system. Other important features are the redundant design and interchangeable power modules, which give an easy and efficient service concept.

Wärtsilä passive rectifier

The Wärtsilä Power Drive can be delivered with a diode rectifier in a 12, 18 or 24 pulse configuration, very well suited to either a Wärtsilä LLC system or a standard transformer solution.

Wärtsilä active front end rectifier

The Wärtsilä Power Drive can also be delivered with an active rectifier front end which allows for energy flow in both directions, eliminating the need for transformers and braking resistors. Direct Current Control and a network filter give small ripple currents and very low harmonic distortion well below international standards.

Multidrive systems, DC sources

The Wärtsilä Power Drive can also be delivered as a multidrive system, where the inverters are connected to the same DC-link. Combined with our patented electronic DC breakers, these work independently. The multidrive system can be connected to the main grid through either active or diode rectifiers, and can also allow for DC-sources such as batteries and fuel cells.

	Wärtsilä passive rectifier drive		**Wärtsilä active front end rectifier drive**	
Power (kW)	Width (mm)	Weight (kg)	Width (mm)	Weight (kg)
800	900	800	900	1 500
1500	900	900	1 500	2 300
2850	1 500	1 400	3 000	4 500
3800	2 100	1 900	5 100	6 800
5500	2 700	2 300	6 600	8 500

All cabinets have 1 000 mm depth and 2 051 mm height.

SWITCHBOARDS

Wärtsilä low and medium voltage switchboard systems are optimised for marine use.

When developing our switchboard systems, the need for easy installation and maintenance is a key consideration. The system is module-based and, therefore, very flexible. Later extensions can also be easily added.

Wärtsilä Marine Switchboard – LV

Technical data

Rated voltage (V) .... ≤ 690
Short circuit test IEC 439–1
  Surge current (peak) kA 176
  Prospective current (RMS) kA 80
  Thermal rated current (1s) 80
  Bus bar (A) 4000

Wärtsilä MSS36 Switchboard – LV

Technical data

Rated voltage (V)	≤ 690
Short circuit test IEC 439–1	
Surge current (peak) kA	220
Prospective current (RMS) kA	87
Thermal rated current (1s)	87
Rated current	
Bus bar (A)	4000
Lead-down bar MCC (A)	1100
Enclosure IEC 529/947–1	
Doors closed	IP 4L2
All doors open	IP 20
Air and creepage current distances IEC	664
Flame arc test IEC 298 prospective current (RMS) kA	87

Wärtsilä Opera Switchboard – MV

Technical data

Rated voltage (kV)	7.2	12	17.5
Insulation level			
50 Hz/1 min (kV RMS)	20	28	38
1.2/50 μs(kV peak)	60	75	75
Rated current			
Bus bars (A)			3150
Droppers (A)			2500
Short circuit current			
Thermal (kA)			42 (1 sec)
Dynamic (kA)			106 (peak)
Flame arc test IEC 298			40 kA 0.15 sec 31.5 kA 1 sec

PROPELLERS

Wärtsilä Controllable Pitch Propellers

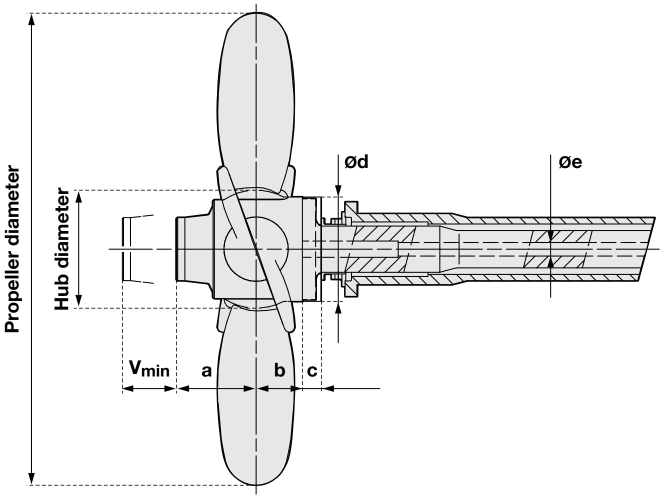
Wärtsilä controllable pitch propellers offer excellent performance and manoeuvrability. For ships with frequent port calls, Wärtsilä CP propellers are the ideal choice for diesel mechanic propulsion, in combination with both medium-speed and low-speed diesel engines.

Full power is available in heavy and light conditions through automatic pitch adjustment. Engine overload is avoided in all conditions. CP propellers permit optimised skew angles to minimise noise and vibrations.The combinator curve can be shaped to avoid ship and machinery resonances, and to assure optimum operation of the complete propulsion system.

- Compact, well proven, strong hub designs
- Few components, robust design
- Small overhang weight
- Accurate stepless hydraulic pitch control
- Reduced hydraulic power requirement
- Easy to install, delivered as a pre-assembled complete system
- Underwater replacement of blades

Wärtsilä CP propellers are all of standard hub design, customised to suit the customer's needs by applying wake-adapted propeller designs and ship-construction related shaft designs.
CP propellers are manufactured in the following hub types:

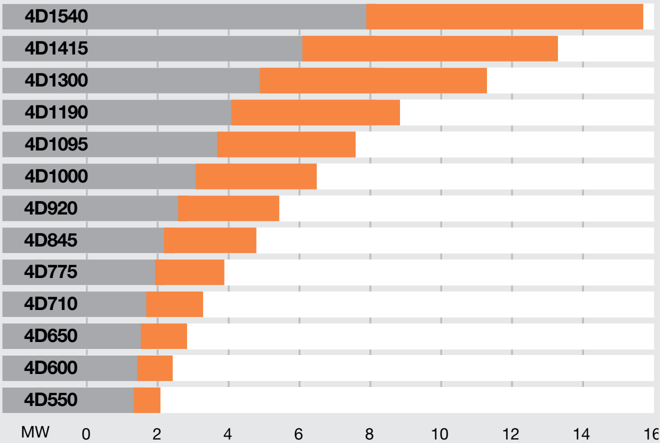
Type	Material	Hub diameter	Special features
Wärtsilä D-hub	CuNiAl Bronze	550–1540 mm	One piece hub casting with integrated hub-cover for extra rigidity. Available for all applications.
Wärtsilä E-hub	CuNiAl Bronze	1000–2085 mm	Heavy duty and ice applications.
Wärtsilä F-hub	CuNiAl Bronze	1000–1680 mm	Full feathering hub.
Wärtsilä CPS-hub	Stainless steel	1080–1900 mm	For ice applications.
Special installations	CuNiAl Bronze	330–2800 mm	Navy installations 5-bladed propeller



Dimensions of Wärtsilä D-hub (in mm

Type	Hub diameter	Dimensions (mm)					
		a	b	c	d	e	v_{min}
4D550	550	402	219	100	506	65	320
4D600	600	432	238	107	546	65	335
4D650	650	467	258	114	586	65	365
4D650	650	467	258	114	586	100	365
4D710	710	506	280	120	636	100	385
4D775	775	550	304	135	690	100	405
4D845	845	574	332	143	745	100	410
4D920	920	631	361	154	824	100	435
4D1000	1000	674	392	162	884	115	460
4D1095	1095	735	427	182	963	115	490
4D1190	1190	798	465	194	1052	115	525
4D1300	1300	859	508	207	1137	130	575
4D1415	1415	933	551	283	1229	130	610
4D1540	1540	1016	600	300	1332	130	655

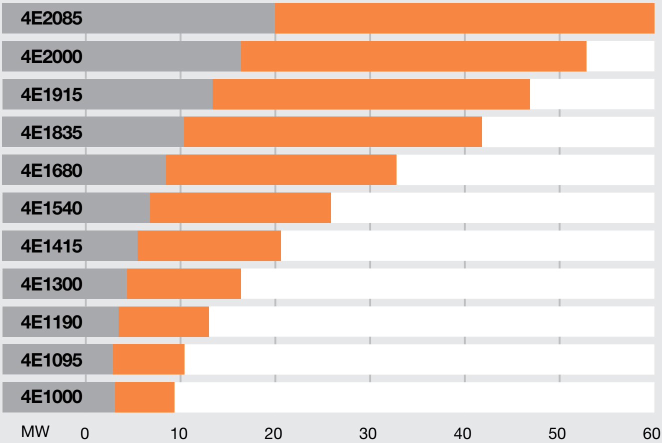
Propeller hub range for Wärtsilä D-hub



Dimensions of Wärtsilä E-hub (in mm

Type	Hub diameter	Dimensions (mm)					
		a	b	c	d	e	V_{min}
4E1000	1000	884	433	236	926	115	245
4E1095	1095	961	470	256	1014	115	260
4E1190	1190	1042	502	272	1096	115	275
4E1300	1300	1128	548	295	1201	130	295
4E1415	1415	1225	589	314	1298	130	320
4E1540	1540	1338	638	337	1415	160	345
4E1680	1680	1457	686	362	1544	160	375
4E1835	1835	1576	745	394	1679	160	400
4E1915	1915	1643	777	414	1752	160	415
4E2000	2000	1717	810	429	1825	190 (160	435
4E2085	2085	1785	846	454	1907	190 (160	450

Propeller hub range for Wärtsilä E-hub

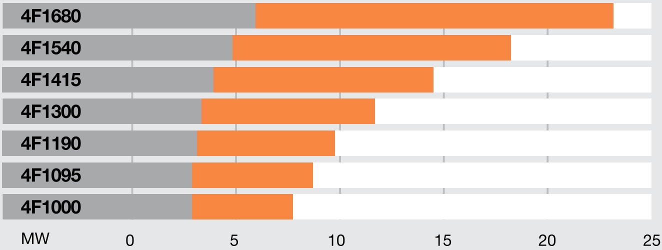


Dimensions of Wärtsilä F-hub (in mm)

Type	Hub diameter	Dimensions					
		a	b	c	d	e	v_{min}*
4F1000	1000	1172	433	236	926	115	435
4F1095	1095	1275	470	256	1014	115	495
4F1190	1190	1383	502	272	1096	115	565
4F1300	1300	1503	548	295	1201	130	555
4F1415	1415	1631	589	314	1298	130	630
4F1540	1540	1780	638	337	1415	160	720
4F1680	1680	1936	686	362	1544	160	815

* V min will decrease if pitch astern is more than 15 degrees

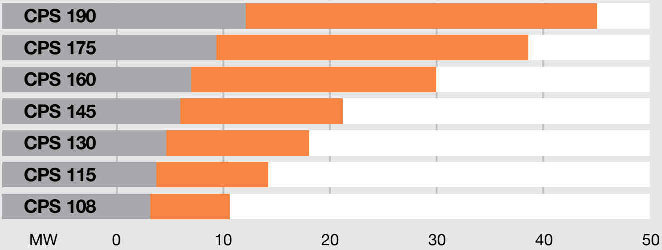
Propeller hub range for Wärtsilä F-hub



Dimensions of Wärtsilä CPS-hub (in mm)

Type	Hub diameter	Dimensions					
		a	b	c	d	e	v_{min}*
CPS 108	1080	980	440	205	810	130	120
CPS 115	1150	1050	470	227	850	130	200
CPS 130	1300	1195	535	240	960	130	245
CPS 145	1450	1320	600	255	1080	130	280
CPS 160	1600	1285	662	298	1314	160	25
CPS 175	1750	1320	700	310	1425	160	65
CPS 190	1900	1475	785	355	1560	160	105

Propeller hub range for Wärtsilä CPS-hub



Wärtsilä Fixed Pitch Propellers

Each ship's hull has its own characteristics. In order to achieve the highest possible total efficiency of the vessel, the propeller must be a perfect match with the engine and the hull. A fixed pitch propeller is the choice when optimum efficiency, reliability and robustness are required. Fixed pitch propellers are usually installed for ocean sailing vessels, for example

- Container vessels
- Tankers
- Bulk carriers
- Dry cargo vessels

Wärtsilä FP propellers for all ship types guarantee maximum efficiency and minimum noise and vibration levels due to tailor-made designs with the latest available technology.

Material

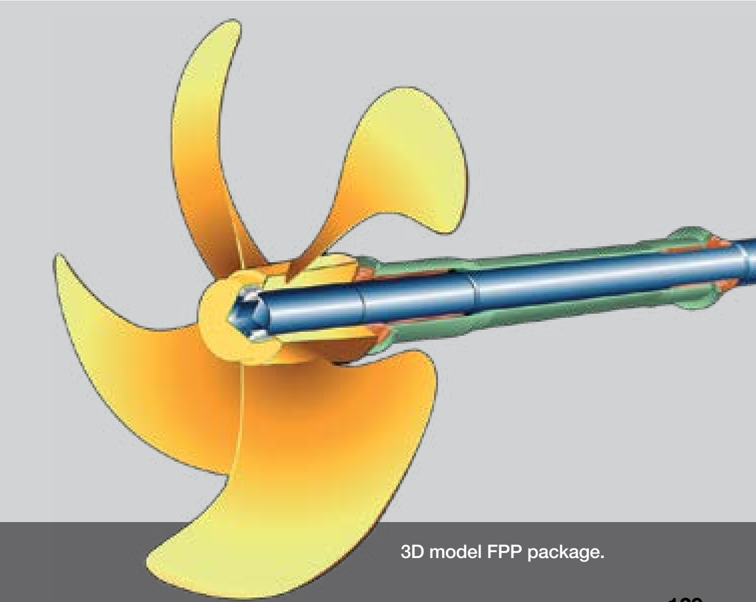
Wärtsilä's patented Cunial material provides excellent casting, machining and fatigue properties. An additional advantage is the

good repairability. Wärtsilä FP propellers can be made to meet all requirements for the number and size of the blades.

FP propeller packages

The following propeller items can also be included in the package supplied:

- Hydrodynamic consultancy
- Alignment calculations
- Jackload calculations
- Whirling calculations
- Build-up propellers
- Propeller caps
- Hydraulic nut/ring
- Hydraulic mounting tools
- Ropeguard
- Netcutters
- Sterntubes
- Torque measurement device
- Turning device
- Thrust bearing
- Earthing device
- Shaft locking device
- Shaft brake



3D model FPP package.

Wärtsilä Fixed Pitch Propellers for Diameters 1000 to 3500 mm

Wärtsilä has developed complete propulsion systems based on fixed pitch propellers, for propeller diameters up to 3500 mm.

The most common ship types for this application are:

- Luxury yachts
- Government owned ships
- Ships designed for inland waterways
- Other special ships with diesel mechanic propulsion

For fixed pitch propulsion system the following characteristics apply:

- Tailor-made propellers with 3, 4, 5, 6 and 7 blades in ISO class II, I and S accuracy
- Open propeller or propeller in 19A or Wärtsilä HP nozzle
- Shafting system complete with sterntube, seals and bearings

STEERABLE THRUSTERS

With steerable thrusters thrust can be applied in any direction, resulting in superior manoeuvrability. Wärtsilä steerable thrusters are durable and reliable.

- High thrust-to-power ratio
- Modular flexible design or compact standard design
- Fixed pitch propeller or controllable pitch propeller
- With or without nozzle
- Variable propeller diameter
- Maintenance friendly
- Low operating costs

Wärtsilä Compact Thrusters

- Easy mounting by welding
- Robust design
- High thrust-to-power ratio
- Standardised Z- or L-drive design
- Diesel or electric driven up to 3000 kW
- Maintenance friendly
- Optional mounting can

The Wärtsilä modular thruster range:

Wärtsilä Modular Thrusters

- Flexible design, L-drive and Z-drive
- Various shaft arrangements
- Diesel or electric driven up to 5500 kW
- Optional mounting can available

Wärtsilä Retractable Thrusters

- L-drive and Z-drive
- Retraction system with cylinders or spindles
- Electric driven up to 4500 kW

Wärtsilä Underwater Demountable Thrusters

- L-drive and Z-drive
- Stable three-wire handling
- Electric driven up to 5500 kW

Wärtsilä compact thruster.

Wärtsilä retractable steerable thruster.

Wärtsilä modular steerable thruster.

Wärtsilä underwater demountable steerable thrusters.

Wärtsilä containerised steerable thrusters.

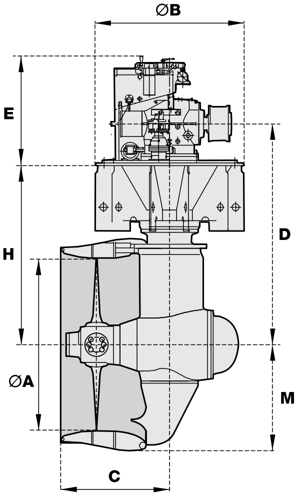
Wärtsilä compact thrusters

Thruster type FS/CS	Engine power	Engine speed	Reduction ratio	Propeller speed	Propeller diameter	Bollard pull based on two installations
	kW	rpm		rpm	mm	In nozzle tonnes
175	1080	1000	2.770	361	1600	33
					1800	36
200	1200	1000	3.447	290	1900	40
					2100	42
225	1600	1000	3.650	274	2100	52
					2300	55
250	1800	1000	3.895	257	2400	61
					2600	63
	2040	1000	3.895	257	2400	67
					2600	69
275	2500	1000	4.084	245	2600	80
	2600[1]					83
300	2720	1000	4.592	218	2800	90
					3000	93
	2960[1]	1000	4.592	218	2800	95
					3000	99

1 Indicated values are maximum power levels available on request.

Variations per type
- Two different propeller diameters.
- Controllable pitch propeller (CS or fixed pitch propeller (FS.
- Propellers in nozzle or open propeller.
- Reduction ratios optimised for application.
- Weld-in stembox or can-mounted.
- Soft on/off clutch or modulating clutch.

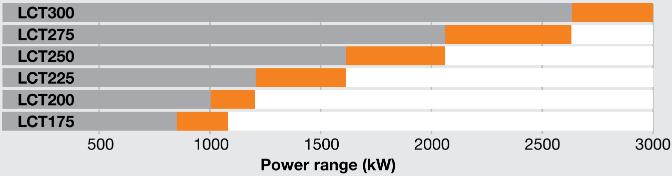
Remarks
- The propellers are designed for bollard pull condition in tug boat application.
- Bollard pull calculations are based on two installations, 100% MCR power and 2% thrust deduction.
- Selections are valid for classification without ice class; final selection is subjected to rules of classification societies.
- Thrusters with controllable pitch propellers improve manoeuverability and efficiency over the complete speed range, and protect the engine against overload.
- Thrusters with controllable pitch propellers are very suitable for constant speed operation.
- The weld-in stembox provides easy installation and maximum stiffness of the construction in the vessel.
- The can-mounted thruster provides the possibility to install or remove the thruster while the ship is afloat.
- Modulating clutches (MCD improve manoeuverability for thrusters with fixed pitch propellers at low speeds.
- Low duty (LD modulates between 0 and idle engine speed. Heavy duty (HD modulates between 0 and maximum engine speed.



Wärtsilä compact thruster dimensions

Thruster type FS/CS	A mm	B mm	C mm	D mm	E mm	H mm	M mm
175	1600	1600	1200	2100	910	1743	985
	1800		1230	2200		1843	1110
200	1900	1900	1300	2500	1200	2048	1180
	2100		1350	2600		2148	1305
225	2100	2100	1400	2630	1210	2168	1305
	2300		1450	2830		2368	1425
250	2400	2100	1525	3100	1435	2512	1485
	2600		1575	3200		2612	1615
275	2600	2850	1665	3500	1465	2890	1615
	2800		1765	3620		3010	1735
300	2800	2850	1770	3700	1465	3090	1735
	3000		1870	3850		3090	1860

Wärtsilä compact thruster range



Wärtsilä retractable thruster selection up to 2000 kW

Electric motor									
Max. MCR motor power	kW	1000		1200		1600		2000	
	HP	1360		1632		2176		2720	
Frequency	Hz	50	60	50	60	50	60	50	60
Nominal motor speed	rpm	1000	1200	1000	900	1000[1]	900	750	720
Thruster type		**175**		**200**		**225**		**250**	
Propeller diameter	mm	1700		1900		2100		2400	
Reduction ratio		2.643	3.154	2.929	2.929	3.308	2.923	2.714	2.714
Propeller speed	rpm	378	380	341	307	302	307	276	265
Max. thrust at zero knots									
in nozzle	kN	165		200		260		320	

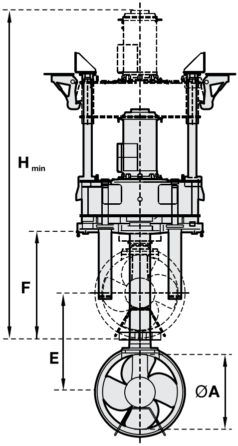
1 Power max. 1500 kW

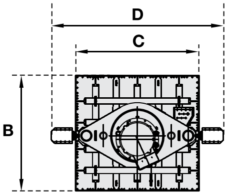
Variations per type
Fixed pitch propeller (FS) or controllable pitch propeller (CS). Reduction ratios optimised for DP application. L-drive and Z-driveconfigurations available.

Remarks
The above information is for vertical E-drive and is subject to change without prior notice. The propellers are designed for bollard pull condition at 100% MCR power, uni-directional, in DP application. Final selection depends on the chosen classificatin society. Selections are not valid for classification with iceclass.

Wärtsilä retractable thruster dimensions

Thruster type		A mm	B mm	C mm	D mm	E mm	F mm	H_{min} mm	Estimated motor height mm	Weight unit kg	Weight auxiliaries kg
175	FS CS	1700	2700 2850	2950	4050	2200	2400	7700	1850	18000 19000	2000 2500
200	FS CS	1900	2850 3000	3050	4160	2450	2700	8600	1900	20000 21000	2000 2500
225	FS CS	2100	3300 3450	3590	4625	2650	3000	9000	2000	22000 23000	2000 2500
250	FS CS	2400	3710 3710	3666	4625	3000	3370	10000	2200	34000 32000	2000 2500





NOTES
For information only, subject to change without prior notice.
Minimum total height of the thruster unit depends on selected electric motor.
Weight of unit is empty and without electric motor.
Dimensions can be changed for better fit in the vessel's structure.

Wärtsilä modular thrusters for over 2000 kW

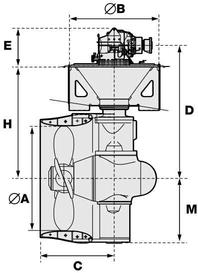
Thruster type			1510[1]	2500	2510[1]	3500[1]		3510	
Power (input speed	Z-drive	kW	2265	3065	3270	3650	4500	4265	5000
		rpm	1200	900	900	900	720	900	720
	L-drive	kW	2300	2490	2850	3850	4500	4500	5500
		rpm	720	720	720	720	470	720	600
Propeller diameter in nozzle		mm	2700	3000	3200	3600		3900	

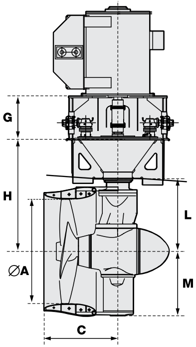
Remarks
Power indications are maximum power levels valid for DP application and the indicated input speeds / propeller diameters. Other input speeds and propeller diameters available on request. For main propulsion or combined DP/main appliciation, lower power levels may be applicable. All types available in underwater mountable configuration, types marked with 1 available in retractable configuration.

Wärtsilä modular thruster dimensions

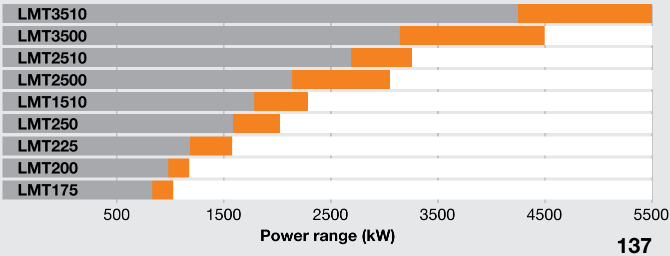
Thruster type FS/CS	A mm standard	B mm	C mm	D min. (PAL mm)	E mm	G mm (L-drive)	H min. mm	L mm	M mm
1510	2700	2850	1900	3500	1470	1200	2890	2100	1620
2500	3000	3100	2000	3900	1250	1350	3900	2300	1880
2510	3200	3100	2035	4000	1250	1350	4000	2410	1910
3500	3600	3100	2550	4300	1340	1500	3500	2510	2225
3510*	3900	3100	2735	4800	1340	1500	4000	3010	2415

Remarks
Dimensions are based on thrusters with nozzle.
*Available with FPP. Also available in 8° tilted version, table dimensions are applicable to standard version.





Wärtsilä modular thruster range



Wärtsilä Transverse Thrusters

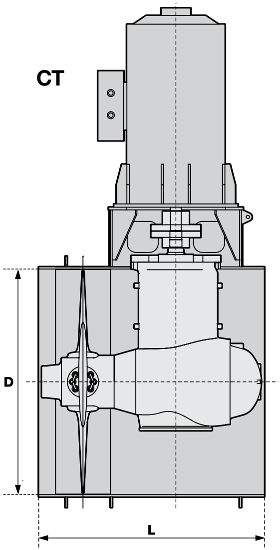
Bevel-gear driven propeller in a transverse tunnel.

- Controllable or fixed pitch propeller
- Maximum thrust with small diameter
- Robust reliable design
- Easy installation
- Standard and demountable versions available
- Applications for dynamic positioning and manoeuvring purposes

Wärtsilä CT/FT 125-CT/FT 300 M types

Type	Electr. freq.	Rational frequency		Max. power (kW) [1]		D	L	Mass[2]
	(Hz)	Input (rpm)	Output (rpm)	Manoeuv-ring	Dynamic positioning	(mm)	(mm)	(kg)
CT/FT125 H	60	1755	519	614	404	1250	1550	2800
	50	1465	433	516	341			
CT/FT150 H	60	1755	430	880	589	1500	1800	4200
	50	1465	359	735	492			
CT/FT175 H	60	1755	379	1025	713	1750	2000	5900
	50	1465	316	900	595			
CT/FT175 M	60	1170	371	995	995	1750	1926	5600
	50	975	309	829	829			
CT/FT200 H	60	1170	263	1115	742	2000	2250	8100
	50	1465	329	1394	928			
CT/FT200 M	60	1170	324	1515	1227	2000	2181	7550
	50	975	270	1262	1022			
CT/FT225 H	60	1170	287	1785	1201	2250	2350	11500
	50	975	239	1487	1001			
CT/FT225 M	60	880	266	1649	1478	2250	2285	10600
	50	975	295	1827	1502			
CT/FT250 H	60	1170	265	2175	1458	2500	2550	13800
	50	975	221	1813	1215			
CT/FT250 M	60	880	233	1998	1599	2500	2482	12700
	50	975	259	2213	1754			
CT/FT275 H	60	880	216	2532	1735	2750	2800	17800
	50	975	239	2805	1923			
CT/FT275 M	60	880	238	2569	2241	2750	2704	15600
	50	735	199	2145	1858			
CT/FT300 H	60	880	216	3145	2454	3000	3000	22700
	50	735	180	2625	2035			
CT/FT300 M	60	705	210	3405	2657	3000	2916	22500
	50	735	219	3550	2771			

1) Max. power is dependent on sailing profile and classification society requirements.
2) Includes a standard tunnel with e-motor support.


CT
D
L

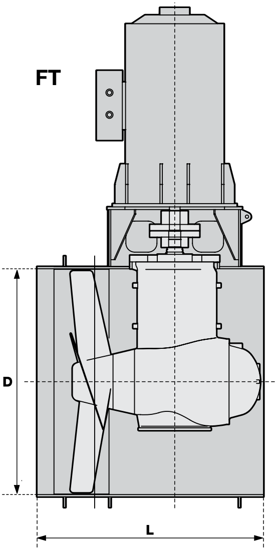

FT
D
L

Photo courtesy of Austal

WATERJETS

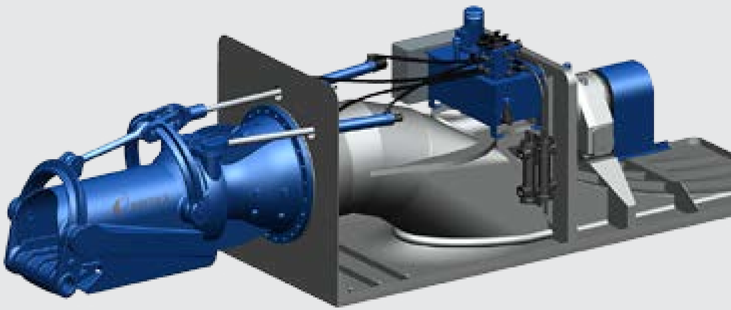
Waterjet propulsion is the most successful and efficient method of propulsion for vessels having speeds in excess of 30 knots, or where there is a likelihood of the vessel operating in shallow waters where propulsors protruding from the hull cannot be used. Wärtsilä has successfully installed waterjets in various high-speed vessels, landing craft and other applications that require shallow water access, high manoeuvrability or low noise and vibration levels. In addition, Wärtsilä's Waterjet and Refined Propeller (WARP) system offers a solution for craft with a versatile operating requirement of around 30 knots. Usually about one third of the total vessel power is linked to two propellers with the rest of the power used for the central boost waterjet. The advantage is a reduced vessel draft with an optimised propeller diameter for efficient cruising at around 20 knots. For top vessel speeds of around 30 knots, the propellers and the waterjet are designed to jointly achieve the thrust required. Wärtsilä is a market leader in WARP systems with several Navy, Ferry and Yacht applications in operation with both controllable & fixed pitch propeller – waterjet combinations.

Waterjet Types

Wärtsilä has a unique portfolio of waterjet types available. The right waterjet for your application will be selected based on the operating profile and the required ship interface. The operating profile will determine the type of pump to be selected. For high power dense, high speed applications above 50 knots, a non-axial E-type pump design is available, delivering optimal performance for extreme vessels. For applications that require optimum propulsion efficiency for design speeds below 45–50 knots, our axial geometry waterjet designs are the perfect answer. Our axial waterjet design is the most compact and most lightweight waterjet design available in the full stainless high-end waterjet market, offering extra thrust and manoeuvring properties at the low end of the speed range for top acceleration.

"Plug and Play" Wärtsilä Midsize Jet

For ease of installation with minimum ship interfaces, waterjet sizes up to the 810 can be delivered in an easy install package with all auxiliary systems pre-mounted. The waterjet inlet duct is included in the scope of supply with impeller shaft and bearings delivered pre-aligned on a ready-to-install skid. The design has all oil-lubricated or oil-containing parts mounted inboard of the vessel, and it is the



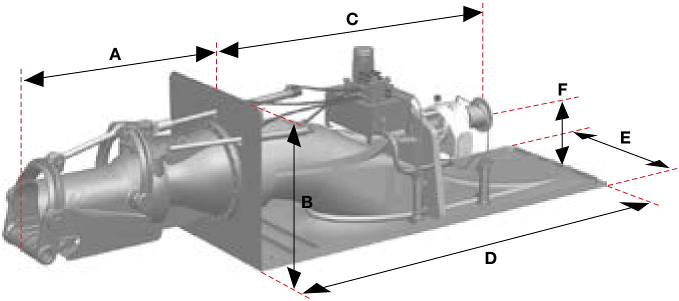
The most compact, easy to install waterjet package available on the market with a stainless steel impeller and a unique stainless steel stator section for top vessel performance long after the initial newbuild sea trials. Other system materials are optimised for use with lightweight aluminium or composite crafts.

only easy install waterjet package on the market with a compact steering and reversing assembly not extending outside the transom mounting flange diameter. Aluminium materials are avoided for the stator bowl, and the full stainless stator section with the stainless impeller and shaft provides optimum resistance against abrasive wear of the stator blades. Deterioration of the stator blade profile should be avoided wherever possible, since they play an important role in the largest energy transformation taking place in a jet system. For vessels requiring top performance – also long after the initial newbuild sea trials – a stainless stator section will deliver real added value.

Dimension table for pre-assembled midsize jets

		Waterjet size				
		510	**570**	**640**	**720**	**810**
A	mm	1400	1550	1750	1950	2200
A (When in reverse)	mm	1500	1700	1900	2100	2400
B	mm	1000	1100	1200	1350	1550
C	mm	2300	2600	2800	3100	3600
D	mm	3000	3400	3800	4200	4800
E	mm	1100	1200	1400	1400	1400
F	mm	510	570	640	720	810
Weight steering*	kg	1450	1800	2450	3000	4000
Weight booster	kg	1050	1300	1800	2250	3000
Entrained water	l	400	600	800	1150	1650

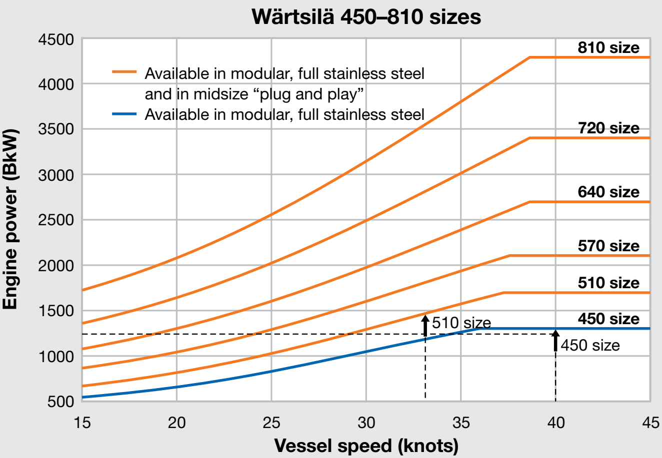
* Without oil and entrained water.

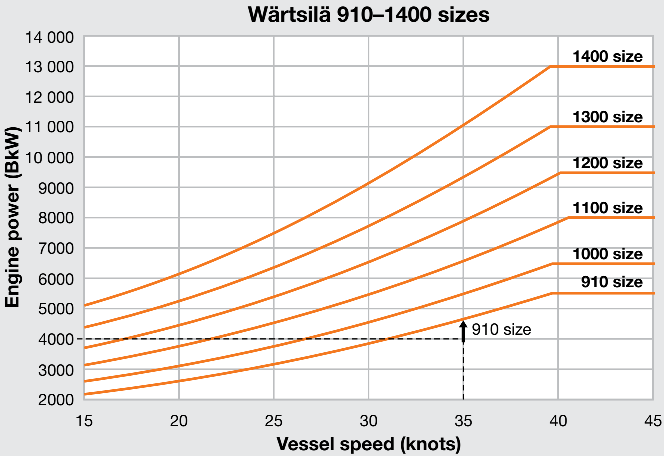


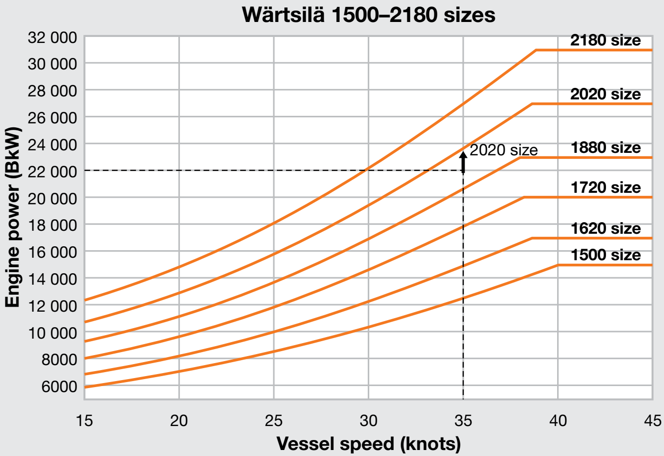
Waterjet size selection
The graphs below indicate the jet size required based on the relation between the engine power and the design speed of the vessel. For instance a ship with four 1250 kW engines and a corresponding vessel speed of 33 knots will need four 510 size waterjets. A ship with a design speed of 40 knots at 1250 kW power can use 450 size waterjets. The correct jet size is thus indicated by the line above the intersection of the power and the corresponding vessel speed (see examples in the graphs below).

We are available from the earliest design stages of the vessel to work with you on an optimised propulsion system. Please contact us for an optimised jet selection based on specific vessel design parameters, operating profile or for details of waterjets above 50 knots or 30 000 kW. DXF/DWG format general arrangement drawings of the most often used sizes are available.

Additional design information can be found in the "Waterjets Product guide", which can be downloaded from
www.wartsila.com/en/propulsors/wartsila-waterjets/waterjets

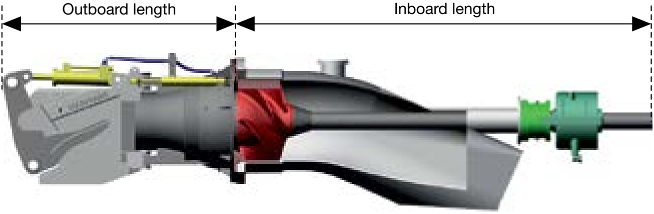



Wärtsilä 910–1400 sizes
14 000
13 000
12 000
11 000
10 000
9000
8000
7000
6000
5000
4000
3000
2000
Engine power (BkW)
15
20
25
30
35
40
45
Vessel speed (knots)
1400 size
1300 size
1200 size
1100 size
1000 size
910 size
910 size


Wärtsilä 1500–2180 sizes
32 000
30 000
28 000
26 000
24 000
22 000
20 000
18 000
16 000
14 000
12 000
10 000
8000
6000
Engine power (BkW)
15
20
25
30
35
40
45
Vessel speed (knots)
2180 size
2020 size
2020 size
1880 size
1720 size
1620 size
1500 size

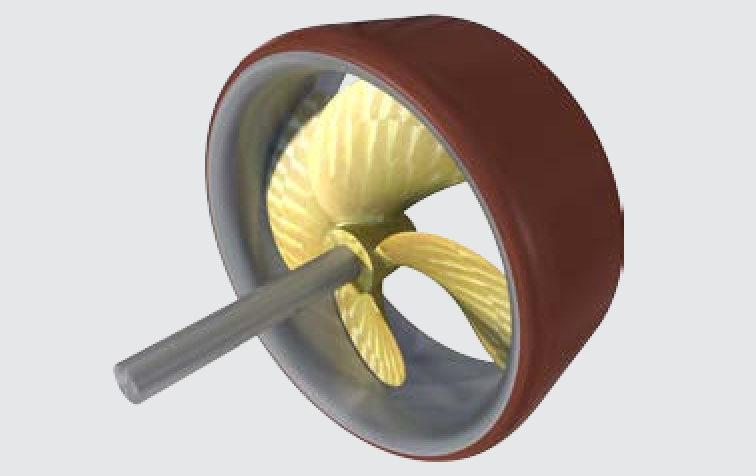
Wärtsilä Axial Jet Series, 6-Bladed Waterjets

Generic weights and dimensions for the most often used waterjet sizes



Waterjet size	Outboard length mm	Inboard length mm 1)	Transom flange	Weight steering kg	Weight Booster kg
510	1300	2300	655	624	424
570	1450	2600	730	835	560
640	1650	2900	820	1200	842
720	1800	3200	920	1590	1110
810	2050	3600	1035	2260	1590
910	2300	4050	1165	3170	2235
1000	2500	4400	1280	4165	2885
1100	2800	4750	1405	5290	3670
1200	3000	5300	1535	6708	4679
1300	3250	5650	1665	8789	6172
1400	3500	6050	1790	10 950	7608
1500	3750	6550	1920	13 120	9170
1620	4050	7000	2075	17 050	11 988
1720	4250	6800	2200	20 390	14 333
1880	4650	8050	2405	23 960	17 160
2020	5000	8550	2585	32 380	22 530

Note
1) Inboard length may vary depending on the optimised shape of the inlet duct.



Wärtsilä High Performance Nozzle

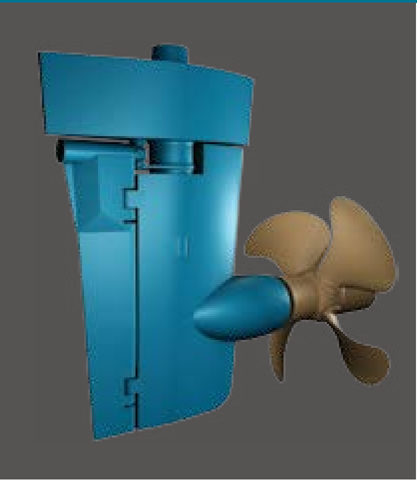
Fitting a nozzle increases the thrust at relatively low ship speeds. Significant savings can be achieved in terms of fuel consumption, depending on the number of revolutions and the capacity of the engine. The improved Wärtsilä High Performance nozzle, type HPN, combined with Wärtsilä propellers, can provide up to 5% more thrust than conventional nozzles in bollard pull condition. The nozzle profile offers a double profiled cross section at the inlet side of the nozzle.

Energopac Rudder

Energopac is the optimised propulsion and manoeuvring solution for coastal and sea going vessels. The key objective is to reduce the vessel's fuel consumption by integrating both propeller and rudder design. Each Energopac is designed to fit the vessel and to meet its specific requirements; this allows Energopac to be optimised fully for energy efficiency, whilst not compromising on either manoeuvrability or comfort levels.

Fuel savings

Energopac reduces fuel consumption because it reduces flow separation behind the propeller hub in an effective way. Extended



studies show that for the same course-keeping capabilities, Energopac will create less drag than conventional rudder systems.

Especially when using small – corrective – steering forces to keep your vessel on course, the difference in rudder resistance is significant. The high-lift performance of Energopac requires smaller steering angles and consequently reduces rudder resistance.

Design space

The application of Energopac gives more freedom to create high efficiency from conflicting requirements. High performance propeller designs are often a compromise between increased efficiency and reduced vibration levels. Energopac allows for a propeller design, that gives the optimal balance between these requirements.

Typical applications

Energopac will effectively reduce the operational costs for any vessel with a considerable share of free sailing time in its operational profile. Additionally, it will work very well for propellers with a relatively large propeller hub.

The potential savings are large for vessels with highly loaded controllable pitch propeller systems, such as RoRo-vessels, ferries, container / multipurpose vessels, and vessels with an ice class notation.

Cost savings with Energopac

The reduction in fuel consumption depends very much on the vessel type, the operational profile of the vessel, and also on the reference propeller and rudder. For any application, the power savings can be estimated by Wärtsilä. The estimate is based on the vessel design, operational profile and other requirements.

Proven savings in required power for a vessel's trial speed vary between 2–9% with Energopac.

Wärtsilä is a market leading technology and service provider of safe, reliable, environmentally sound pump solutions for the marine, oil & gas and petrochemical industries.

We specialise in innovative and often highly customised designs for liquid cargo handling. We offer engineering expertise, high quality products and an enviable reputation, meaning our customers can be confident their operations are in safe hands.

CARGO PUMPS

Wärtsilä Svanehøj Deepwell Cargo Pumps

Wärtsilä Svanehøj Deepwell cargo pumps have been developed to achieve the highest possible efficiencies in both gas and product/chemical applications, and to meet the latest environmental legislation.

For LPG, ammonia, ethylene/chemical and LNG Carriers, Wärtsilä Svanehøj deepwell cargo pumps are intended for four basic designs

- Fully pressurised tankers, with the cargo at ambient temperatures and a tank pressure of up to 18 bar.
- Fully refrigerated atmospheric tankers, with the cargo cooled down to the saturation temperature, like -48°C.
- Semi-refrigerated tankers, with the cargo maintained in liquefied form by a combined cooling/pressure process at temperatures down to -104°C.
- LNG tankers, with the cargo cooled down to -163°C

For oil and chemical tankers we offer both cargo lubricated and oil lubricated pumps for oil and chemical tankers. These pumps are designed to handle all kinds of cargo while meeting IMO and all major classification society requirements.

In addition to deepwell cargo pumps, we also offer all necessary components for the complete cargo pumping system. These include portable cargo pumps, electrical switchboards, frequency converters, explosion proof electrical motors, and cargo control systems.

We have the engineering capabilities to supply a custom made turnkey solution, plus our in-house production facilities enable full scale testing of the cargo pumps. Even pumps of more than 30 meters can be tested in our String test tower.

Wärtsilä Svanehøj Booster Pumps

Wärtsilä is the leading manufacturer of Svanehøj cargo booster pumps for LPG, CO_2, ammonia and ethylene/chemical carriers. Our cargo booster pumps are delivered as complete units (i.e. mounted on a base plate) and to meet market requirements we have four models of horizontal booster pumps available, all with basic design features such as:

- Cargo temperature range, ambient to -104°C
- Manufactured in stainless steel AISI 304
- Double mechanical sealing system
- Self-regulating seal fluid pressure
- Heavy duty gauges with isolation needle valve
- Flanged connections according to international standards ANSI or EN1092
- Skid-mounted with flexible spacer
- Coupling and explosion-proof electric motor
- Meeting the requirements of all common international classification societies
- Meeting “Green Passport” requirements

Wärtsilä Svanehøj Portable Pumps

Wärtsilä Svanehøj hydraulically driven portable pumps are widely used in oil product and chemical tanker applications.

Our single-stage centrifugal portable pumps are mounted with mechanical shaft seals and a hydraulic motor, built together in an acid-proof housing and protected in such a way that the pump stands submersion into most liquids.

The hydraulically driven portable cargo pumps have an outer diameter that is less than a standard 12” butterworth hatch and can, therefore, be submerged into the cargo tank.

The pumps can be connected either to the ship’s hydraulic system or to a hydraulic power pack unit via a ring line. They are easy to connect using quick couplings, while the manoeuvring of the pump by a flow regulating valve makes for fast and trouble-free handling

Wärtsilä Hamworthy Offshore Booster Pumps

For FPSO’s and FSU’s where higher discharge presures are required due to e.g. unloading via a remote bouy, a separate Booster Skid can be applied on the forward part of the vessel.

This has been a popular and successful application on our deliveries for conversions of ex. seagoing Tankers as the original piping can be utilized all the way up to the Booster Skid.

The Booster Skid can be combined with both Deepwell Cargo Pumps and traditional Pump Room System.

The actual Booster Pumps are in-line heavy duty centrifugal pumps with dual suction impeller and double vulute casing assuring both axial and radial balance, and in order to handle the inlet pressure from main cargo pumps we have developed a special balanced mechanical seal arrangement for this purpose.

Wärtsilä Hamworthy Deepwell Offshore Process and Cargo Pumps

For FPSOs/FSOs requiring a distributed pump system, the Wärtsilä Svanehøj range of electrically driven deepwell pumps represents an efficient and cost effective crude handling system. In providing the long term benefits of lower maintenance and less downtime, our deepwell pumps also use less energy than other comparable distributed pump systems.

Our shaft lubrication system enables less onboard maintenance to the electric system. The pump housing is easily dismantled, and cards on the converters are easily interchanged. During the operational phase, the electrical equipment offers environmental sustainability, since CO_2 emissions are minimal due to the higher efficiency and lower power utilisation, and there is no risk of hydraulic oil spills.

Wärtsilä Svanehøj deepwell process and cargo pumps are designed for continuous operation with pumping mediums such as crude oil and produced water and oil. The type OPC pumps can be delivered according to API 610, and are designed with a capacity from 20–1800 m^3/h.

The Wärtsilä Hamworthy system include compact and space-saving configurations for optimal pump room layouts

Wärtsilä Hamworthy Pump Room Systems

Wärtsilä Hamworthy's extensive experience, coupled with its ongoing research and development programme, ensures that our pump room systems meet current and anticipated customer requirements, for liquid cargo vessel design and operation.

The traditional pump room system is characterised by a separate room for pumping equipment located between the engine room and the cargo hold – an arrangement that provides easy access to all key components for regular inspection and maintenance.

Our pump room system components include the following;

- Cargo Pumps
- Ballast Pumps
- Stripping & Capacity Regulating System
- Stripping Pump
- Crude Oil Washing & Tank Cleaning Pumps
- Crude Booster Pumps
- Cargo Control System

Wärtsilä Svanehøj deepwell ballast pumps have been installed on a number of FPSOs, as well as onboard chemical and products tankers

BALLAST PUMPS

Wärtsilä Svanehøj Deepwell Ballast Pumps

Wärtsilä Svanehøj Deepwell Ballast Pumps are a single suction in-line centrifugal pump, designed for reliable and efficient operation and consisting of a submerged pump head, transmission to deck, and an electric motor. The compact design of the pump ensures low weight handling.

The pump is designed for direct-on-line starting and can also be operated with a frequency converter or other means of variable speed regulation. The motor will be delivered with a PTB certificate and class certificate where required.

Wärtsilä Hamworthy In-Line Ballast Pumps

Wärtsilä Hamworthy In-Line Ballast Pumps are suitable for all type of vessels, with capacity range from 100 m^3/hr to 5,000 m^3/hr. Suction performance (NPSHr) is the most crucial factor for pump selection and our ballast pumps can meet the stringent requirement by using a single suction close impeller (C2G model), or double suction close impeller (CA model).

Wärtsilä Hamworthy has more than 25 years experience in the design and manufacture of external fire fighting systems

FIRE FIGHTING

Wärtsilä Hamworthy Firewater Pump Packages

Wärtsilä has developed various system solutions to meet requirements for fire pump package installations. All Wärtsilä Hamworthy units meet NFPA 20 and class requirements. Wärtsilä can supply various configurations of fire pump packages .

Wärtsilä Hamworthy External Fire Fighting (Fi-Fi) Systems

Wärtsilä utilises the most advanced computer software in designing the water spray system, achieving optimal performance and ensure safety of the crews during fire fighting mode.

Our system offering includes all main items, such as pumps, monitor, gearbox and control system, in a single package. This secures total integration and compliance with technical and regulatory requirements. Auxiliary equipment to enhance the vessel's capability in disaster relief operations, such as foam mixing and oil dispersant systems, can also be included within our scope of delivery. Our quality assurance system is certified according to ISO-9001 and is approved by all major classification societies.

The Wärtsilä Hamworthy range of deepwell seawater lifting and fire pumps has been designed specifically for the offshore market

Wärtsilä Hamworthy Fire Water Pumps

Depending on the configuration Wärtsilä can supply fire pumps according to NFPA 20 up to 5000 m^3 capacity.

Our in-line pumps used for fire pumps have a wide range from 600 m^3/h to 5000 m^3/h. Double suction impellers with low NPSHr enables the pump to operate at 150% capacity without cavitations. We supply pressure available to 18 bar.

SEAWATER LIFT PUMPS

Wärtsilä Hamworthy Deepwell Seawater Lift Pumps

Our seawater lift pumps feature a capacity of up to 2300 m^3/hr with a differential pressure of up to 180 mlc. These pumps are driven by dry mounted explosion-proof electric motors via a pipestack with a transmission shaft and seawater lubricated bearings.

For seawater lift and fire pumps installed in caissons, Wärtsilä offers an inflatable intermediate support system. The caisson installed deepwell pump is typically delivered for FPSOs, semi-submersible production units and platforms, and is available according to API 610 upon request.

Wärtsilä Hamworthy
In-Line Seawater Lift Pump

Wärtsilä Hamworthy
Engine Room Pump

Wärtsilä Hamworthy In-Line Seawater Lift Pumps

Wärtsilä has vast experience in delivering Wärtsilä Hamworthy in-line seawater lift pumps ranging from 400 ~ 5000 m^3/h at 8 ~ 10 bar with low NPSHr to meet the specification requirement by FPSO, FLNG and Offshore Drilling vessels.

The pump can be directly coupled to an electric motor within a safe area or through a cardan shaft installed in the pump room.

We are able to supply pump casing and impeller materials such as nickel, aluminum, bronze or super duplex.

Wärtsilä Hamworthy pumps are designed with various configurations of inlet and outlet nozzles to suit piping installation in a limited room space.

GENERAL SERVICE CENTRIFUGAL PUMPS

Wärtsilä Hamworthy Engine Room Pumps

A simple design and few components ensure that Wärtsilä Hamworthy centrifugal pumps are cost-effective and reliable

We offer a complete range of **ballast pumps** for all types of vessels, with capacities ranging from 100 m^3/hr to 5,000 m^3/hr. The single suction close impeller (C2G model), or double suction close impeller (CA model) enable high suction performance (low NPSHr).

The Wärtsilä Hamworthy **C2G pump** is a single-suction in-line centrifugal pump providing reliable and efficient operation. The compact design means less weight and easier handling, and offers both high suction performance and a low power requirement.

The **CA single stage centrifugal pump** is available in both vertical and horizontal designs for capacities from 380 m^3/hr to 6000 m^3/hr at total heads up to 50 m.w.g.

The **CB single stage centrifugal pumps** are available in both vertical and horizontal designs for capacities from 500 m^3/h to 7,000 m^3/h at total heads up to 200 m.w.g.

Model CG is noted for its robust construction and operating reliability. Its unique hydraulic design gives a compact profile with modest space requirements and less weight for easier handling.

Dolphin pumps meet the increasing need for alternative forms of pump construction. The range is based on a single entry pump covering capacities from 10 to 500 m^3/h, and a larger capacity double entry pump which extends the capability to 2500 m^3/h, sufficient to cover any marine pumping duty likely to occur.

Wärtsilä Hamworthy Replacement Pumps

We have bronze, vertical pumps from our C2G range, covering capacities from 15 m^3/hr to over 800 m^3/hr at heads of up to 40 m, complete with motor, ready now for immediate dispatch.

We can let you know if we have a suitable pump in stock that meets your requirements, we can also supply you with a price together with a data sheet and drawing. We also have a wide range of engine room pump spares available upon request.

The pumps come with the following stock features:

- Bronze pump and motor complete
- Makers certificate
- Pre-packed ISPM compliant packing

SHIPHAM VALVES

Established in 1798, Shipham Valves supplies non-ferrous, composite and high alloy valve solutions for handling seawater and other severe fluids. For 80 years a key supplier to the British Royal Navy and Ministry of Defence, Shipham Valves has become a global leader in the design and manufacture of valves for handling seawater in fire fighting and cooling lines in the oil & gas, FPSO, and petrochemical industries. Shipham offers the most diverse range of valves by type, material and size, of any single valve manufacturer in the world, providing gate, globe, ball, swing check, dual plate check, butterfly and hydrant valves, in sizes from 1/2" to 88" and in materials from bronze to zirconium.

Shipham Valves
ESTABLISHED 1798
a Wärtsilä company

www.shipham-valves.com

JOHN MILLS VALVES

Established in 1828, John Mills Valves supplies bronze and aluminium bronze gate, globe, check, strainers and ball valves for seawater service in the marine, oil and gas, nuclear, MOD, water treatment and chemical industries. In addition to our standard valve range we also manufacture specialty valves such as mud boxes, gland cocks, sight glasses, sounding cocks and storm valves. With our complete in-house facilities including pattern shop and Lloyd's approved foundry, we can take a product from your design drawings to a fully built and tested valve ready for despatch in as little as 24 hours. John Mills is the preferred supplier for many of the world's oil & gas operators and engineering valve houses for non-ferrous valves due to our reputation for quality and on-time delivery.

John Mills Valves

a Wärtsilä company

www.johnmills-valves.com

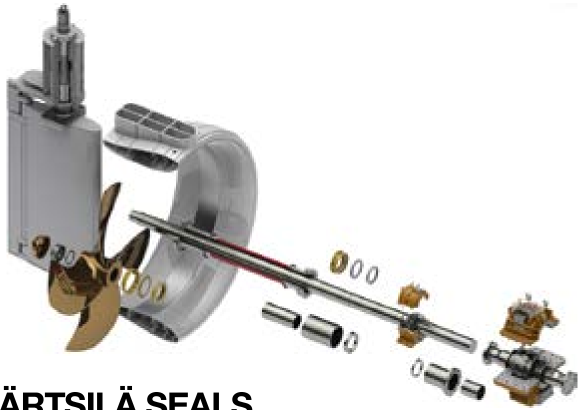
ROBERT CORT VALVES

Robert Cort Valves has over 70 years' experience in the design, manufacture and supply of Through Conduit Gate & API 6D Trunnion Mounted Ball Valves and Actuators. The Robert Cort range of pipeline valves is available in sizes from 2" to 60" diameter and in pressure classes from 150 up to 2500, supplied with manual gearbox operation as standard or actuated for MOV, GOV, emergency shutdown applications and pressure protection systems. With an enviable product population installed worldwide by major oil and gas end users, Cort continues to support its clients' assets with extensive servicing, repair, and spares availability.

CORT®

a Wärtsilä company

www.robertcort.co.uk



WÄRTSILÄ SEALS, BEARINGS, STERNTUBES & OTHERS

Our seals and bearing products portfolio is the most comprehensive in the market, and we continuously develop innovative, environmentally compliant and longer lasting products.

By offering a complete sterntube package including seals and bearings that are all manufactured by Wärtsilä, we can offer a lifecycle solution and best customer service with the quickest response times.

Wärtsilä sealing solutions

Our comprehensive range of marine seals is designed for use in various propulsion applications covering both commercial and military vessels. Bespoke solutions can also be designed for special applications, such as tidal turbines or industrial applications.

Wärtsilä bearing solutions

Our comprehensive bearing portfolio includes traditional white-metal and latest generation composites for use with oil or water lubricated sterntube applications. We also offer a range of intermediate shaft, thrust and generator bearings.

Wärtsilä stern tube solutions

Our products cover both oil or water lubricated systems and can be packaged in accordance with the customer's specification.

Other Wärtsilä seals & bearings products

Wärtsilä water supply, filtration & temperature control systems.

Hydraulic coupling nuts and bolts

Wärtsilä Sealing Solutions

Wärtsilä special applications seals

Wärtsilä has extensive experience with customers having both specialised and original requirements. This has allowed us to develop our expertise in the creation and validation of bespoke sealing solutions. The fields of application are widespread, and include industrial, renewable power generation, and heavy lift vessel applications.

Tidal Turbines
Wärtsilä Oceanguard: Aft Face Seal, **OFS3H-N**, (125–1000 mm)
Wärtsilä Sternguard: Aft Lip Seal, **OLS4-P**, (286–1172 mm)

Wärtsilä stern tube seals – water lubricated

OPEN WATER LUBRICATION (70–1040 mm)

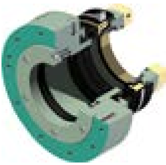
Fwd	**Commercial & Military**
	Wärtsilä Enviroguard: Standard, Fwd Face Seal, **WFS1R-F**, (70–450 mm)
	Wärtsilä Enviroguard: Standard, Fwd Face Seal, **WFS1R-P**, (70–450 mm)
	Wärtsilä Enviroguard: Shock, Fwd Face Seal, **WFS10-P-M**, (150–1040 mm) (shock compatible)
	Wärtsilä Enviroguard: Shock, Fwd Face Seal, **WFS10-F-M**, (150–1040 mm) (shock compatible)
	Wärtsilä Enviroguard: Shock, Fwd Face Seal, **WFS10-F-EM**, (250–900 mm) (shock compatible Fwd face seal with packing)
	Commercial Only
	Wärtsilä Enviroguard: Composite, Fwd Face Seal, **WFS1R-P-L**, (110–410 mm)
	Wärtsilä Enviroguard: Composite, Fwd Face Seal, **WFS1H-P-L**, (460–-820 mm)

CLOSED WATER LUBRICATION (320–1140 mm)

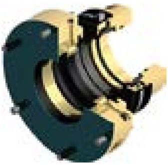
Ice Class
Wärtsilä Iceguard: Fwd Face Seal, **WFS1O-P-MX**, (320–1140 mm)
Wärtsilä Iceguard: Aft Face Seal, **WFS1O-P-MY**, (320 -1140 mm)

Wärtsilä stern tube seals – oil lubricated

OFS3H-N



WFS1R-P-L



WFS1R-P

WFS10-F-EM

SEALS, BEARINGS & STERNTUBES

STANDARD

Fwd	**Inland Waterways & Coastal**
	Wärtsilä Sternguard: Fwd Face Seal, **OFS1R-N-Z**, (50–320 mm)
	Wärtsilä Sternguard: Fwd Compact Lip Seal, **OLS2-P-C**, (136–362 mm)
	Conventional Commercial
	Wärtsilä Sternguard: Fwd Lip Seal, **OLS2-P**, (80–1172 mm)
	Wärtsilä Sternguard: Fwd Face Seal, **OFS1HW-F Seaqual**, (205–1004 mm)
	Wärtsilä Sternguard: Fwd Face Seal, **OFS1HW-P Seaqual**, (205–1004 mm)
	Wärtsilä Sternguard: Fwd Face Seal, **OFS1HW-N Seaqual**, (66–1029 mm)
	Special & Offshore
	Wärtsilä Sternguard: Fwd Face Seal, **OFS1HW-F Seaqual**, (205–1004 mm)
	Wärtsilä Sternguard: Fwd Face Seal, **OFS1HW-P Seaqual**, (205–1004 mm)
	Wärtsilä Sternguard: Fwd Face Seal, **OFS1HW-N Seaqual**, (66–1029 mm)
Aft	**Inland Waterways & Coastal**
	Wärtsilä Sternguard: Aft Face Seal, **OFS1R-N**, (50–320 mm)
	Wärtsilä Sternguard: Aft Compact Lip Seal, **OLS3-P-C**, (136–362 mm)
	Conventional Commercial
	Wärtsilä Sternguard: Aft Lip Seal, **OLS3-P**, (80–1172 mm)
	Wärtsilä Sternguard: Aft Lip Seal, **OLS4-P**, (286–1172 mm) (extra redundancy-stand-by)
	Wärtsilä Sternguard: Aft Face Seal, **OFS1H-F Seaqual**, (205–1004 mm)
	Wärtsilä Sternguard: Aft Face Seal, **OFS1H-N Seaqual**, (205–1004 mm)
	Wärtsilä Sternguard: Aft Face Seal, **OFS1H-P Seaqual**, (205–1004 mm)
	Special & Offshore
	Wärtsilä Sternguard: Aft Face Seal, **OFS1H-F Seaqual**, (205–1004 mm)
	Wärtsilä Sternguard: Aft Face Seal, **OFS1H-N Seaqual**, (205–1004 mm)
	Wärtsilä Sternguard: Aft Face Seal, **OFS1H-P Seaqual**, (205–1004 mm)

ANTI-POLLUTION

Aft	**Merchant**
	Wärtsilä Airguard: Aft Lip Seal, **OLS3A-P**, (286–1172 mm)
	Wärtsilä Airguard: Aft Lip Seal, **OLS4A-P**, (286–1172 mm) (extra redundancy)

OLS3-P

ABRASION RESISTANT

Aft	**Inland Waterways & Coastal**
	Wärtsilä Sternguard: Aft Face Seal, **OFS1R-N-X**, (50–320 mm)
	Dredgers
	Wärtsilä Sandguard: Aft Lip Seal, **OLS3W-P**, (286–1172 mm)
	Wärtsilä Sandguard: Aft Lip Seal, **OLS4W-P**, (286–1172 mm) (extra redundancy)

OFS1H-F-Seaqual

ABRASION RESISTANT & ANTI-POLLUTION

Aft	**Cruise, Ferry & Offshore**
	Wärtsilä Oceanguard: Aft Face Seal, **OFS3H-P**, (400–760 mm)
	Dredgers & Ocean Going
	Wärtsilä Sandguard: Aft Lip Seal, **OLS3AW-P**, (286–1172 mm)
	Wärtsilä Sandguard: Aft Lip Seal, **OLS4AW-P**, (286–1172 mm) (extra redundancy)

Wärtsilä bulkhead seals

STANDARD

Commercial & Military
Wärtsilä Floodguard: Standard Bulkhead Face seal, **WFB1-F-M**, (50–680 mm)

HIGH SPEED

Commercial & Military
Wärtsilä Floodguard: High-Speed Bulkhead Face seal, **WFB1-F-MS**, (50–680 mm)

Wärtsilä submarine seals

SUBMARINE

Wärtsilä Diveguard: Single Barrier Fwd Face seal, **WFS1H-P-M**, (200–700 mm)
Wärtsilä Diveguard: Tandem Barrier Fwd Face seal, **WFS2H-P-M**, (200–700 mm)

Wärtsilä waterjet seals

WATERJETS

Commercial
Wärtsilä Jetguard: Standard, Waterjet Face Seal, **WFS1R-P-J**, (110–410 mm)
Wärtsilä Jetguard: Composite, Waterjet Face Seal, **WFS1R-P-LJ**, (110–410 mm)
Military
Wärtsilä Jetguard: Standard, Shock, Waterjet Face Seal, **WFS1R-P-M**, (120–380 mm) (shock compatible)
Wärtsilä Jetguard: Waterjet Face Seal, **WFS1R-F-M**, (120–380 mm) (shock compatible)

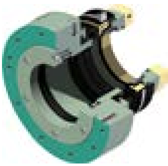
WATERJET HUBS

Wärtsilä Hubguard: Compact, Face Seal, **OFS1H-N-CJ**, (50–300 mm) (oil lubricated waterjet hubs)
Wärtsilä Hubguard: Standard, Face Seal, **OFS1H-NJ**, (70–510 mm) (oil lubricated waterjet hubs)

WFB1-F-M

WFS1H-P-M

WFS1R-F-M



WFS1R-P-LJ

Wärtsilä thruster / pod seals

THRUSTERS

Aft	**Standard**
	Wärtsilä Sternguard: Aft, Compact, Lip Seal, **OLS3-P-C**, (136–362 mm)
	Wärtsilä Sternguard: Aft, Lip Seal, **OLS3-P**, (80–1172 mm)
	Wärtsilä Sternguard: Aft, Face Seal, **OFS1H-N-C**, (205–1004 mm)
	Anti-Pollution
	Wärtsilä Airguard: Aft, Lip Seal, **OLS3A-P**, (286 -1172 mm)
	Wärtsilä Oceanguard: Aft, Face Seal, **OFS3H-P**, (125–1060 mm)
	Pressure compensation
	Wärtsilä Oceanguard: Aft, Face Seal, **OFS3H-N-D**, (125–700 mm)
	Wärtsilä Oceanguard: Aft, Face Seal, **OFS3H-P-D**, (125 -700 mm)

ELECTRIC PODS

Aft	**Standard**
	Wärtsilä Sternguard: Aft, Lip Seal, **OLS4-P**, (286–1172 mm) (extra redundancy-stand-by)
	Abrasion Resistant & Anti-Pollution
	Wärtsilä Oceanguard: Aft, Face Seal, **OFS3H-P**, (400–760 mm)

Wärtsilä rudder / stabiliser seals

RUDDER STOCKS (155–710 mm)

Oil Lubricated
Wärtsilä Steerguard: Standard Lip Seal, **KLR2-P**, (155–710 mm)
Wärtsilä Steerguard: Standard Lip Seal, **KLR3-P**, (155–710 mm) (extra redundancy)

RUDDER STOCKS & STABILISERS (50–1300 mm)

Grease or Water Lubricated
Wärtsilä Steerguard: Small Range, Standard, Face Seal, **JFZ1R-N**, (50–320 mm)
Wärtsilä Steerguard: Mid Range, Standard, Face Seal, **GFR1R-P**, (320–530 mm)
Wärtsilä Steerguard: Large Range, Shock, Face Seal, **GFR1R-P-M**, (530–1300 mm)

OLS3-P

OFS1H-N-C-Seaqual

GFR1R-P-M

Wärtsilä Bearing Solutions

Wärtsilä stern tube bearings (oil & water)

OIL LUBRICATED

Commercial
Wärtsilä Sternsafe: Standard White Metal, **OMS-N**, (136–1172 mm) (un-split oil lubricated white metal bearing)
Wärtsilä Sternsafe: Composite, **OCS-N**, (70–1100 mm) (un-split oil lubricated composite bearing, mainly retrofits)
Wärtsilä Sternsafe: Composite, **OCS-N-X**, (200–1100 mm) (un-split oil lubricated composite bearing)

WATER LUBRICATED

Commercial & Military
Wärtsilä Envirosafe: Composite, **WCS-N-M**, (70–1100 mm) (un-split water lubricated composite bearing)
Wärtsilä Envirosafe: Composite, **WCS-P-M**, (200–1100 mm) (split water lubricated composite bearing)
Wärtsilä Envirosafe: Composite, **WCS-F-M**, (300–1100 mm) (split water lubricated composite bearing) O housing

Wärtsilä rudder / stabiliser bearings

STANDARD

Commercial & Military Rudder
Wärtsilä Steersafe: un-split oil lubricated composite bearing, **JCR-N**, (70–1200 mm)

DRY RUNNING CAPABILITY

Commercial & Military Rudder
Wärtsilä Steersafe: un-split oil lubricated composite bearing, **DCR-N**, (70–705 mm)

WCS-N-M

OMS-N

DCR-N

Wärtsilä intermediate shaft bearings

STANDARD

Commercial (up to 0.8 Mpa) Wärtsilä Standard intermediate Shaft Bearing
Self-aligning and forced lubrication, **OPSY-F**, (126–825 mm)
Self-aligning and self-lubrication, **OPSQ-F**, (126–825 mm)

HIGH LOAD

Commercial (0.8–1.5 Mpa) Wärtsilä High Load Intermediate Shaft Bearing
High load and forced lubrication, **OPSQ-F-X**, (271–800 mm)

Wärtsilä thrust bearings

Commercial & Military Wärtsilä Thrust Bearing
Forced lubrication (axial) with optional external lubrication, **OBSY-F**, (110–560 mm)
Self-lubrication (axial and radial loads) with optional external lubrication, **OBSQ-F**, (110–560 mm)

Wärtsilä generator bearings

Commercial & Military Wärtsilä Generator Bearing
Side flanged type, **OGSS-F**, (80–500 mm)
Central flanged type, **OGSC-F**, (80–500 mm)
Pedestal type, **OGSP-F**, (250–800 mm)

OPSQ-F

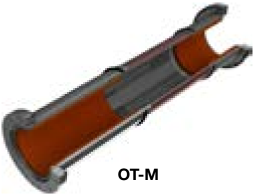
OBSQ-F

OGSP-F

Wärtsilä Stern Tube Solutions

Our packages are all designed to meet certain standards and can be customised to suit specific applications. Options include oil lubricated sterntubes with white metal or composite bearings or water lubricated sterntubes with composite bearings.

OT



OT-M

Wärtsilä Other Seals & Bearings Products

Wärtsilä water quality systems

Pumped water flush supply systems with various filtration and temperature control options to improve and increase life of the seal and bearing products installed. Systems are adapted to suit applications either by filtering to required standards in silty/ gritty water environments or controlling closed water temperature in ice-class type applications. Suitable for both open and closed water lubricated sterntubes.

WYS-M

WATER QUALITY SYSTEMS

Flush Supply & Filtration
Wärtsilä Water Quality System: open water (clear), **WYS-M**
Wärtsilä Water Quality System: open water (high performance- silty), **WYS-MX**
Flush Supply, Filtration & Temperature Control
Wärtsilä Water Quality System: closed water system, **WQS-M**

Wärtsilä hydraulic equipment

Hydraulic couplings, nuts and bolts designed for easy handling and trouble free operation made from the highest quality steel in accordance with existing classification rules.

OHSM-B

ON

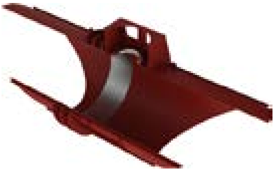
HYDRAULIC EQUIPMENT

Hydraulic Couplings
Wärtsilä Hydraulic Coupling: with flange, **OHSM**, (100–800 mm)
Wärtsilä Hydraulic Coupling: with flange and longer body, **OHSM-B**, (100–800 mm)
Wärtsilä Hydraulic Coupling: with flange in sleeve, **OHSM-V**, (100–800 mm)
Wärtsilä Hydraulic Coupling: without flange, **OHSN**, (100–800 mm) (no reamer bolts required)
Hydraulic Nuts
Wärtsilä Hydraulic Nut: propeller nut, **ON**
Hydraulic Bolts
Wärtsilä Hydraulic Bolt: for shaft coupling flanges, **OS**

Wärtsilä steel fabrication

Tunnels, rudders & nozzles manufactured to customers' specifications.

Wärtsilä nozzle



Wärtsilä tunnel

Wärtsilä rudders

All of our products can be described using an acronym:

Example of **W F S 1 O - P - M * * ***

Lubrication: W = Water

Product type: F = Face seal

Position: S = Shaft

No. of sealing interfaces: 1

Seal spring type or basic F: O = Omega springs

Serviceability: P = Serviceable with shaft in-situ

Additional features: M = Shock compatible

WÄRTSILÄ SEALS AND BEARINGS DESCRIPTIVE PRODUCT NAMES (WFS1O-P-M*)**

W F S 1 O - P - M * * *

Lubrication (internal operating)
D = Dry, grease, oil or water
G = Grease or water
J = Grease, oil or water
K = Grease or oil
O = Oil
W = Water

Product type
C = Composite bearing
F = Face seal
L = Lip seal
M = White metal bearing
P = Line shaft/plummer bearing
Y = Flush supply & filtration system
Q = Flush supply, filtration & temperature control
T = Stern tube
H = Hydraulic coupling
N = Hydraulic nut
S = Hydraulic bolt
B = Thrust bearing
G = Generator bearing

Position (if applicable)
B = Bulkhead
R = Rudder
S = Shaft
Z = Stabilizer or rudder

No. of sealing interfaces (seals only) **or Composite bearing material designation**
Sealing interfaces:
1, 2, 3 or 4 (as applicable)
Bearing material:
01, 02, 03 etc. (as applicable)

Seal spring type or basic function (seals, line/shaft/thrust/ generator bearings only)
A = Air flush
H = Helical spring
O = Omega spring
Q = Self oil lubrication
R = Rubber bellows/body
W = Water flush
Y = Forced oil lubrication
AW = Air and water flush
M = Flange mounted
N = No flange
C = Central flange
S = Side flanged
P = Pedestal

Serviceability (if applicable)
F = Replaceable and serviceable with shaft in-situ
N = Non serviceable in-situ
P = Serviceable with shaft in-situ

Additional features (if applicable)
C = Compact
D = Damper/lip system
E = Emergency packing
L = Lightweight composite
M = Shock compatible
S = High speed
X = High performance
Y = Outboard water
Z = Inboard oil
B = Longer body
V = Flange in sleeve
J = Jet version

Wärtsilä Serck Como Thermal Desalinations Plants
with Multi-Stage-Flash technology.

Utilising its experience since its foundation in 1841 in Germany, Wärtsilä Serck Como develops, manufactures and sells

- Thermal desalination plants for
  - Marine and
  - Land based applications
- As well as condensation plants which are
  - Water-cooled or
  - Air-cooled

THERMAL DESALINATION PLANTS

Wärtsilä Serck Como has build more than 300 desalination plants with a capacity up to 3300 t/day/ship that are used mainly on cruise ships to supply freshwater for passengers. Our technology utilises the waste heat of main engine to evaporate water under vacuum and to produce the distillate. The MSF-process (Multi-Stage-Flash) is the most reliable evaporation principle in the world and very easy and stable to operate.

Wärtsilä Serck Como Fresh Water Generators.

In 2012 we developed a new design for a small capacity freshwater generator (up 30 t/day) that is especially designed for merchant ships and offshore applications.

For land based applications, thermal desalination plants are ideal to utilise the waste heat of a power station in order to produce water of very high quality (distillate) that can be utilized, for example, as boiler feed water. We offer a very wide range of technology (MSF, MED, TVC, MVC) for different applications

STEAM CONDENSERS

Our steam condensers create a vacuum behind the steam turbine and hence increase the efficiency of the plant. Steam condensers are also necessary to close the water cycle behind the steam turbine. We offer water cooled or air-cooled design depending on customer needs for a capacity of usually up to 30 t/h.

OILY WATER SYSTEMS

Wärtsilä Oily Water Separator

The Wärtsilä oily water separator (OWS) gives the operator effective control over all bilge and sludge media as well as over any discharges made into the sea. The technology behind the Wärtsilä OWS is a combination of optimised traditional methods and innovative new solutions.

The separator consists of a four-stage, emulsion-breaking unit, in which each stage handles one key component of the sludge and bilge mix. It can handle input flows with an oil content of between 0 and 100%, making it the most versatile separator on the market.

All Wärtsilä units have successfully passed USCG / IMO type approval in accordance with 46 CFR §162.050 and MEPC.107(49). The amount of oil in the water after treatment is guaranteed to be less than 5 ppm.

Technical data	OWS 500	OWS 1000	OWS 2500
Capacity, max, m^3/day	12	24	60
Length, mm	1185	2344	3210
Width, mm	765	1100	1400
Height, mm	1715	1855	1855
Weight, dry, kg	510	650	950
Weight, wet, kg	775	1950	2700
Power, kW	10	10	10

Wärtsilä Bilge Water Guard

The Wärtsilä Bilge Water Guard (BWG) is a fully automated, bilge discharge monitoring system which constantly oversees and monitors the oil content in all discharges overboard. Should the oil content rise above the set limit, the flow will be re-routed back to the bilge tank. The system logs the discharge quantity and oil content as well as time and location of the ship. All data is stored in memory for later retrieval.

The system is enclosed in a locked, tamper-proof cabinet and all accesses are logged in memory. For both crew members and ship management, the Wärtsilä BWG provides a priceless safety net that makes compliance with the applicable regulations evident.

Wärtsilä Oily Water Treatment

Wärtsilä Oily Water Treatment (OWT) unit is a compact unit for Power Plants. In the oily water treatment unit the oily water is treated to clean the water fraction in order to allow its discharge to the nature while separated bottom solids and lighter oily sludge is pumped to the sludge tank. The disposal method for the oily water or sludge should be environmentally acceptable. Typically special disposal companies or local industry are used, if approved by the authorities.

Wärtsilä Slop Water Cleaning

Wärtsilä Slop Water Cleaning (SWC) is designed to clean mud or water (deck washing water or rain) contaminated with slop or drilling mud from offshore units - particularly drilling rigs and drilling ships.
The unit will significantly reduce drill slop sent onshore for treatment by as much as 80-90%.

The main benefits for an SWC system include;

- Small footprint
- Easy to retrofit and install during operation, no yard time needed
- OPEX (payback time less than 1 year)
- Cost competitive
- Environmentally sound
- Proven technology

ADVANCED WASTE WATER PROCESSING

Wärtsilä Hamworthy Membrane Bioreactor (MBR) Systems

Wärtsilä Hamworthy's innovative MBR system is an evolution of the company's proven sewage treatment technology for handling grey and black water waste. The technology is an advanced wastewater treatment process based on biological degradation and membrane separation. It delivers the highest quality discharge without requiring the generation or addition of chemicals hazardous to the maritime or shipboard environment.

Wärtsilä Hamworthy miniMBR Systems

Wärtsilä Hamworthy miniMBR systems are smaller, more compact versions of the company's innovative MBR technology for handling grey and black water waste. By building on our successful experiences and working closely with our customers, we have been able to optimise the miniMBR system to produce an effective compact package. It is ideal for use on smaller cruise and naval vessels, plus ferries with up to a 200 complement, as well as FPSOs and accommodation platforms.

WASTE WATER PROCESSING

Wärtsilä Hamworthy Sewage Treatment Plants

Wärtsilä Hamworthy's market-leading sewage treatment plants offer easy-to-install, trouble-free systems for some of the harshest environments on the planet.

Optimised for the treatment of black and grey wastewater flows, and suitable for conventional gravity and vacuum fed collection systems, all plants in our STA-C and ST-C range are controlled automatically. This allows unattended operation, with reduced maintenance requirements and lower long-term operating costs. The systems are compact and modular in design, suitable for between-deck installations, and are adaptable to customer new build specifications. The STA-C and ST-C series sewage treatment plants are certified to meet IMO MEPC 159(55) guidelines, and are recognised by leading shipbuilders.

VACUUM SYSTEM TECHNOLOGY

Wärtsilä Hamworthy Vacuum Toilets

Wärtsilä Hamworthy vacuum toilets use air to drive waste from the toilet to the treatment tank or intermediate collection tank. This contemporarily styled toilet has a built-in vacuum breaker and flush memory, is simple to install, and is supplied ready to connect. The control mechanism can be accessed without removing the bowl. By using only approximately 1 litre of water, the amount of wastewater is dramatically reduced.

Wartsila Hamworthy Vacuum Collection System

The Wärtsilä Hamworthy vacuum collection system uses differential air pressure to transport sewage from the toilet bowls, and other sanitary fittings, to the Sewage Treatment Plant (STP) or independent collection tank. Ejectors can be mounted direct to the STP for modular construction without the need for a separate collection tank, and only a small amount of flush water is needed compared to conventional gravity systems.

MARINE LIFECYCLE SOLUTIONS AND FINANCIAL SERVICES

The Wärtsilä Marine Lifecycle Solutions (MLS) team, backed by Wärtsilä Development & Financial Services (WDFS) comprises a global team of project developers, financial professionals and carbon finance experts.

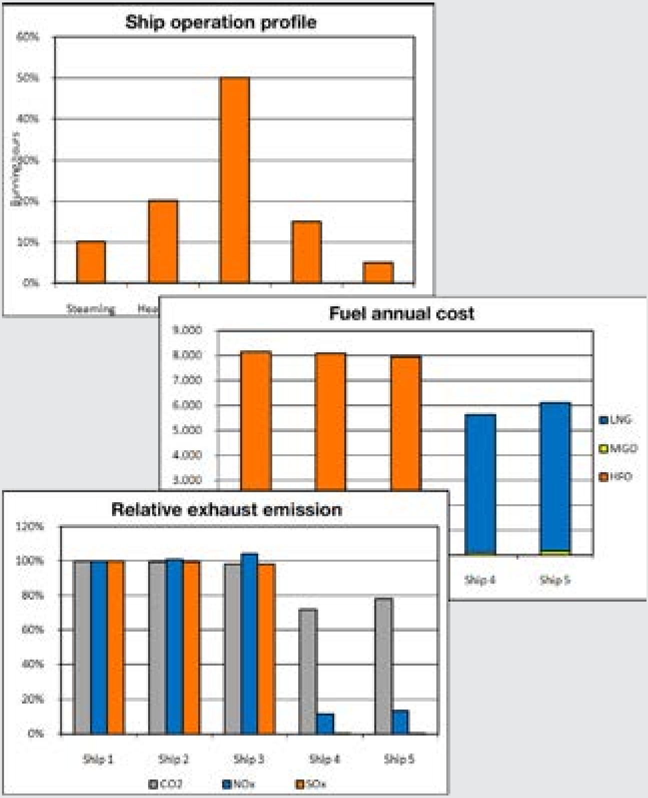
WDFS supports Wärtsilä's clients with advice and assistance in deal structuring and financing. Through its strong relationships with both local and international financing institutions, including export credit agencies (ECA), commercial banks, and development banks, WDFS is uniquely situated to structure financing to suit each customer's requirements. A manufacturing presence in several countries provides a competitive advantage for accessing ECA-backed funding). MLS also offers financial advisory services, including financial modelling and feasibility studies. With the broad scope of services offered by WDFS, including project development, assistance with the most appropriate financial structure, and long-term support agreements, Wärtsilä can serve as a long-term partner to its customers.

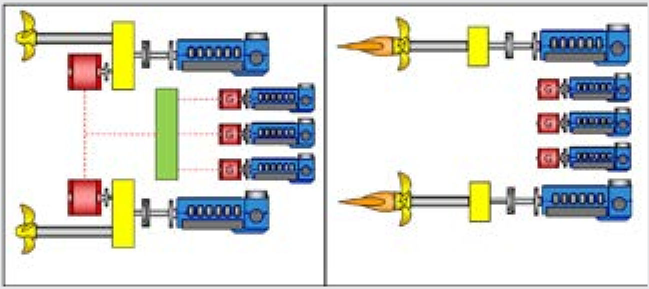
Solutions Comparison Tools

Wärtsilä has established a new approach to the lifecycle of a vessel by being involved at all stages, from the initial ship design to new buildings or repowering of the complete propulsion system, and finally providing support services for the ship. Essential to effective lifecycle performance is the efficiency of the propulsion system.

According to Wärtsilä, everything starts from the interaction between the hull and the propulsors. Significant savings can be achieved by optimising the propeller design and matching it with the prime movers. Engine selection is another key element in improving overall efficiency. Wärtsilä offers configurations that allow engines to run at or close to optimum efficiency. These propulsion packages are developed according to the mission profile of the vessel, as defined by the end-user.

Wärtsilä develops solution comparison tools where solutions can be compared in terms of fuel consumption, emissions, investment cost, payback time, and profitability. We can help customers to select the solution that best meets their needs, taking into consideration the ship operation profile and the selected machinery concepts.


Ship operation profile
60%
50%
40%
30%
20%
10%
0%
Steaming
Fuel annual cost
9.000
8.000
7.000
6.000
5.000
4.000
3.000
LNG
MGO
HFO
Ship 4
Ship 5
Relative exhaust emission
120%
100%
80%
60%
40%
20%
0%
Ship 1
Ship 2
Ship 3
Ship 4
Ship 5
CO2
NOx
SOx



Service Agreements – Tailored to Your Specific Needs

Wärtsilä is an experienced operator, with a proven track record in operation and maintenance services. Globally, more than 17 GW of generating capacity in both marine and land based installations – a total of more than 500 installations – is covered by Wärtsilä's asset management and other service agreements.

A service agreement ensures reliability and efficiency throughout all facets of the operations. By guaranteeing full performance and operational accountability, we can free you from many day-to-day operational concerns so that you can focus on your core business.

Asset Management

A comprehensive form of asset management and an efficient business solution to control your operations. The agreement can be tailored to your needs covering full operations, management and maintenance services as well as providing performance guarantees for the installation.

Maintenance agreement

Maintenance planning and service crews are available from Wärtsilä's extensive global network, wherever and whenever needed. We offer fixed prices for inspections, technical support, spare parts, training, and maintenance work. Performance guarantees are available.

Technical Management agreement

We offer inspections, expert assistance and monthly reporting as well as exchange programme planning. We can also provide you with technical support and training through maintenance planning, online condition monitoring and competence development programmes.

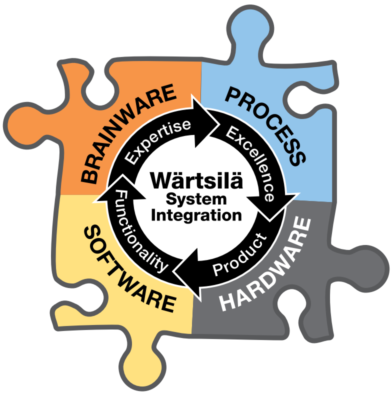
Supply agreement

This agreement provides access to our global parts distribution network, and allows you to order and receive spare parts 24/7, including reconditioned components. We can also guarantee the availability of a global network of trained and skilled service professionals with the training and tools needed.

SYSTEM INTEGRATION

Wärtsilä has the broadest product portfolio on the market. We are highly skilled system integrators, and we have unique competencies that enable us to successfully follow and support marine and offshore projects throughout their lifecycle. Our comprehensive, integrated solutions are designed to mitigate completion risks, optimise efficiency, and minimise operating risks for the resource owner. This not only lowers costs, but also allows owners and operators to concentrate on their core business. This facilitates their ability to focus on creating value in the shipping and oil & gas markets, which is the core business of the asset owner.

The trends that are shaping the marine and offshore industries' business environments are creating a demand for more complex and sophisticated vessels. There is an increasing preference for full diesel electric, hybrid propulsion systems, and dual-fuel electric (LNG fuelled) vessels. These systems offer more flexibility, a higher level of redundancy, and a reduction in both fuel consumption and emissions. More advanced vessels require an integrated approach to vessel design and the configuration of the propulsion systems to ensure optimal performance and lifecycle efficiency. The more sophisticated the vessel design, the more complex are its systems. There are more interfaces between the various components, and good co-ordination between them is essential for a successful new building project. This inevitably means that in order to avoid added risk and building delays, an experienced systems integrator is absolutely essential. The choice of Wärtsilä, as a single supplier for the design, engineering, and systems integration of the main equipment, will ensure an optimised solution. This will also provide better risk control during the new building phase.



PROJECT MANAGEMENT

Wärtsilä's project management team is a reliable and professional partner in delivering Wärtsilä marine and offshore solutions. Wärtsilä's capabilities provide wide scope flexibility for the specific needs of each customer. The best project management solution and responsibility interface can be found through close collaboration between the customer and Wärtsilä.

Investment project decisions are becoming more demanding in our fast changing world. The project requirements in the modern environment can create a degree of uncertainty as regards the schedule, scope and other objectives. Wärtsilä's project management team has the competences, methods and systems to deliver effective marine and offshore solutions, and to manage these complexity and integration risks for the benefit of the customer. Wärtsilä's project

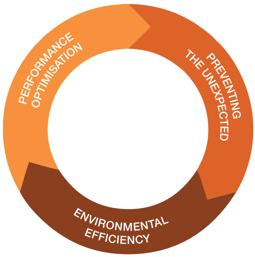
teams work closely with customers and key stakeholders to ensure successful and on-time delivery of the project. Construction sites are staffed through centrally coordinated global resource pools of experienced and proven site management and supervision personnel. Within the agreed scope of services, the assigned site management mobilises all construction site management activities and supervises qualified sub-contractors in the execution of the work. The delivery is verified by a project-specific QA/QC (quality assurance/quality control) programme, and validated during the test and commissioning phase managed by an experienced commissioning team.

The Wärtsilä project management gate model is based on the PMI process. Many of Wärtsilä's senior Project Managers are certified Project Managers (PMI).

WÄRTSILÄ SERVICES: LIFECYCLE EFFICIENCY SOLUTIONS

Wärtsilä Services supports its customers by offering the most comprehensive portfolio of services in the industry, thereby optimising their operations and the lifecycle performance of their installations. Our services network is the broadest in the industry, consisting of more than 11,000 service professionals in over 160 locations in more than 70 countries. We offer expertise, local availability, responsiveness, and environmentally sound actions for all customers, regardless of the make of their equipment.

We offer lifecycle efficiency solutions in the following areas of expertise: ● Engine Services ● Boiler services ● Environmental services ● Service Projects ● Propulsion services ● Electrical & automation services ● Service Agreements ● Training Services



Our services cover everything needed to maintain continuous and efficient operations, including basic support, parts supply, field service, technical support, condition based maintenance, installation and commissioning, performance optimisation including upgrades and conversions, environmental compliance solutions, technical information and online support. The choice available to you extends from essential repairs to a variety of comprehensive, customised long-term service agreements, including performance and operations & management agreements. Optimising your operations and preventing the unexpected is our shared passion. We serve you whenever, wherever.

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WÄRTSILÄ TWO-STROKE ENGINE LICENSEES

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Viking Grace

Wärtsilä supplied the propulsion machinery for the ‘Viking Grace’, the world’s first LNG powered passenger vessel. Thanks to Wärtsilä’s dual-fuel technology, the vessel can operate without restrictions in SECA and NECA sulphur and nitrogen monitoring areas.

Viking Line and Wärtsilä have for a long time successfully cooperated on ship propulsion systems. Over the years Wärtsilä has been the main supplier of diesel engines for Viking Line’s new vessels.

“*It is in our best interests to co-operate with Wärtsilä since they are experts in the development of new types of engines and the use of alternative fuels, thereby lowering specific fuel consumption and enhancing environmentally safe operations. Wärtsilä is a close, domestic supplier who offers us the opportunity to collaborate in improving our operations and engine maintenance capabilities, through technical training and field testing. All this is very important, especially now that Viking Line is entering a new era of gas-electric driven operation.*”
Tony Öhman, Technical Director in charge of Marine Operations and Newbuilding at Viking Line

First LNG-powered passenger vessel entered service in January 2013

Photo: Harald Valderhaug

Viking Prince

Wärtsilä has the ability to offer total concept solutions that include the design of the vessel, the propulsion plant, and the electrical and automation system, as well as a host of fuel saving and environmentally sustainable options.

The ‘Viking Prince’ is a Wärtsilä VS 489 Gas PSV design and features excellent energy efficiency, a unique hull form, fuel flexibility, and outstanding vessel performance in areas such as fuel economy and cargo capacity. Wärtsilä’s unique gas-electric propulsion system includes two 6-cylinder in-line Wärtsilä 34DF dual-fuel main engines and Wärtsilä’s Low Loss Concept (LLC) solution, while the auxiliary generating sets are powered by two 6-cylinder in-line Wärtsilä 20DF dual-fuel engines.

All Eidesvik’s gas PSVs are designed by Wärtsilä and utilize Wärtsilä’s unique dual-fuel technology. Wärtsilä’s scope of supply for Viking Prince includes dual-fuel main engines and generating sets, the electrical power and propulsion system, integrated automation, and the power management system. The vessel is fitted for use in arctic waters with ‘winterization’ and de-icing solutions.

The Viking Prince, running on environmentally friendly LNG dual-fuel engines, entered service in March 2012

Provalys

When taken into service in 2006, the 154,000 m^3 LNG carrier 'Provalys' was the largest LNG carrier in existence. The ship is propelled by dual-fuel engines and electric propulsion. The heart of the system is four dual-fuel engines; three 12-cylinder and one 6-cylinder Wärtsilä 50DF, giving a combined output of 39.9 MW.

The electric power is supplied to an electric propulsion system, as with the diesel-electric propulsion systems on modern cruise ships.

The solution offers LNG carriers a number of significant advantages, including lower overall fuel consumption, fuel flexibility, and reduced emissions.

This modern LNG carrier has clearly demonstrated the advantages of gas fuel propulsion, made possible by Wärtsilä's pioneering efforts in dual-fuel engine technology.

First large size LNG carrier powered by Wärtsilä 50DF engines

Bit Viking

In 2011, the first ever marine conversion of Wärtsilä 46 engines to Wärtsilä 50DF dual-fuel engines was carried out on the product tanker 'Bit Viking', owned by Tarbit Shipping of Sweden. It also represented the first Wärtsilä 50DF dual-fuel marine installation with mechanical propulsion.

By operating on LNG, the Bit Viking is one of the most environmentally friendly product tankers in the world. Its emissions of CO_2 have been reduced by some 25%, while emissions of particulates have also been dramatically lowered, and NO_X emissions are significantly cut. When using LNG fuel, SO_X emissions are eliminated entirely.

"Wärtsilä's unique expertise and experience with dual-fuel technology, as well as with fuel conversion projects, were the main reasons for us choosing them. We appreciate the technological efficiency of the Wärtsilä solutions and the expert way in which this conversion project has been handled."
Anders Hermansson Technical Manager, Tarbit Shipping

First vessel ever to undergo a conversion by Wärtsilä from Heavy Fuel Oil (HFO) to Liquefied Natural Gas (LNG) operation

Nordica

Wärtsilä has carried out modification work for two of the company's vessels belonging to Finland-based Arctia Offshore Oy. The turnkey project involved the fitting of combined Wärtsilä NOx Reducer (NOR) and Oxidation Catalysts (OXI) to the MSV Fennica and MSV Nordica.

Both multi-functional vessels are based on a modified icebreaker design. The ships have be converted to enable the use of Ultra Low Sulphur Diesel fuel. The work involved fitting the combined Wärtsilä NOR/OXI solution to each of the eight engines that drive the two vessels.

The emission control device consists of a combined abatement system designed to reduce nitrogen oxides (NOx) and to enable the oxidation of carbon monoxide and unburned hydrocarbons. The NOR is a customized solution specifically engineered to meet the EPA's emission standards. Retrofitting two of its icebreakers with state-of-the art catalytic converters opens up a whole new market for the Finnish company Arctia Shipping.

Retrofitting engines with catalytic converter technology for environmental compliance

MV Twister

The Wärtsilä AQUARIUS® UV Ballast Water Management System (BWMS) was installed onboard the 'MV Twister', a Chemgas BV owned LPG carrier, as part of the Type Approval process.

The MV Twister is designed to transport gas and chemical products along shallow rivers. A fast BWMS installation process was therefore essential to reduce the downtime impact on the vessel's operations. For retrofit applications and upgrades, where space availability can be a determining factor, the modular configuration of Wärtsilä's AQUARIUS® range was a particular advantage and the entire installation process took just 3 weeks.

With the trial period successfully completed, and full compliance with the IMO D2 performance standard had been demonstrated, the Wärtsilä AQUARIUS® was awarded Type Approval in accordance with the requirements of the 2004 IMO Convention for the control and management of ships' ballast water and sediments. The Wärtsilä AQUARIUS® UV was the first BWMS to have been fully endorsed and type approved by the Flag Administration of the Netherlands.

Certified ballast water management for flexible installation

Jolly Diamante

Wärtsilä has supplied the open loop scrubber systems for four new 45,000 dwt Ro-Ro ships for Italian owner Ignazio Messina & Co. The vessels will burn residual fuel oil, and the scrubbers ensure that the 0.1% fuel-sulphur content emission regulations can be met. These vessels are the first of their type to gain the RINA's Green Plus notation, and the Wärtsilä open loop scrubber systems are all MED certified.

The 'Jolly Diamante', owned by Ignazio Messina & Co, was the first ever vessel to operate commercially with a scrubber system when it entered service in December 2011. By 'future-proofing' the vessel for stringent sulphur regulations, the need to meet the significant price differential for costly distillate fuel when the regulations enter force in 2015, can be avoided. Each ship will feature five open loop scrubbers and will be housed within the ship funnel casings. The equipment also includes a control system, a combined wash-water treatment plant, and a new range of super duplex stainless steel pumps supplied by Wärtsilä Hamworthy's Singapore plant.

SuperSpeed 2

Wärtsilä will supply four exhaust gas cleaning systems to retrofit the Ro-pax ferry 'SuperSpeed 2' for the Norwegian cruise and ferry operator, Color Line. The installation is expected to be carried out during docking of the vessel in spring 2014. The four separate Wärtsilä open loop scrubber systems will ensure the ship's full compliance with the International Maritime Organization's (IMO) MARPOL Annex VI regulations, and with EU Directive 2055/33/EC. Furthermore, Color Line has the intention to install the Wärtsilä system on three additional vessels. By significantly reducing the emissions of sulphur oxides (SOx) and particulates from the engines' exhaust, the 'SuperSpeed 2' will be able to operate without restrictions in designated Emission Control Areas (ECAs).

"We take environmental issues seriously. Since 2009, all Color Line ships have maintained an environmental balance sheet that details emissions to air, and discharges to water and harbours. We believe that the Wärtsilä exhaust gas cleaning systems will significantly enhance our efforts in striving for sustainable operations,"
Jan-Helge Pile, Senior Vice President, Marine Operations in Color Line.

IMC Ferries

Wärtsilä, the marine industry's leading solution provider, and Deltamarin, the foremost design company in the cruise and ferry market, have together introduced an innovative series of ferry designs.

Cost efficient solutions

The savings generated by the parametric approach are considerable. The industrial engineering of ship systems and the serial effect caused by pre-designed modules enable investment cost savings of approximately 15%. Operating costs are also reduced, since compared to the current generation of ferries built 5 to 10 years ago, the fuel economy has been improved by some 15%.

Observing new environmental rules

IMC ferries offers solutions that make it possible to fulfill the latest and upcoming safety and emission regulations. The concept offers a wide range of environmentally and economically sound solutions tailored specifically to your needs.

Prepared for conventional as well as future fuels, including LNG

MV Shansi

Wärtsilä will supply propulsion packages for 24 new vessels being built for the Singapore based China Navigation Co. Pte. Ltd (CNCo). The ships are being built at the Chengxi and Zhejiang Ouhua shipyards in China, and the contracts were signed with Wärtsilä licensee Hudong Heavy Machinery (HHM) in 2012 and during the first half of 2013.

All vessels will be fitted with electronically controlled Wärtsilä 2-stroke common-rail main engine systems, Wärtsilä Fixed Pitch Propellers (FPP) as well as Wärtsilä Seals and Bearings. In March 2013, the first vessel of the S-Class series, the “MV Shansi”, was successfully delivered.

“The propulsion system selected for our new S-class series fully meets our requirements. The first operational results from the MV Shansi have been very successful. They show that the Wärtsilä RT-flex common-rail engines enable us to operate the vessel very efficiently over a very wide operating range at different speeds. The fuel consumption of the S-class is even better than we expected in the design phase,”
Mr Martin Cresswell, Fleet Director at CNCo.

Wärtsilä propulsion packages feature high efficiency and low fuel consumption solutions

Nganhurra FPSO

With a continued emphasis on safer and more environmentally friendly cargo pumping systems, Woodside specified Wärtsilä Hamworthy electric driven deepwell cargo pumps for its 142,000 dwt FPSO Nganhurra, which measures 260 m in length and 46 m in breadth. Woodside Energy Ltd operates the FPSO Nganhurra at the Enfield site off Western Australia.

Wärtsilä Svanehøj's electric-driven deepwell pump system with a common control system and independent pumps for each cargo tank gives the maximum flexibility during any operational phase. Using frequency converters means that the pumps can operate at optimum performance during any unloading conditions. This again results in higher total system efficiency and hence lowers the power consumption. Using electric motors directly as the drive force also increases system efficiency compared with alternative systems. Wärtsilä Svanehøj's electrical-driven deepwell cargo pump systems also require limited space for the equipment installation.

The Nganhurra FPSO is also equipped with Wärtsilä Hamworthy cargo lift pumps, cargo booster pumps, slop pumps, skimming pump, tank cleaning pump and ballast pumps.

Cargo Handling System supplied for the 900,000-barrel storage capacity FPSO Nganhurra

P-63 FPSO

Wärtsilä's P-63 FPSO contract with the Brazilian industrial group QUIP includes commissioning, start-up and operational supervision. The complete package consists of 3 power modules designed and produced with Wärtsilä as the EPC contractor. Each module has two 18-cylinder Wärtsilä 50DF engines with alternators and all required auxiliary equipment. Oil production is scheduled to begin in 2013.

"For a project of this importance, it is essential that the strategic partners we work with have not only the technology needed, but also field proven experience and support capabilities required for reliable long-term success. Wärtsilä has an outstanding track record in multi-fuel technology, as well as in providing ongoing technical support. We have every confidence in the company's ability to provide the needed technical solution, and we are sure it will minimise both our operating costs and environmental footprint. We also value the company as a trusted strategic partner with the resources to provide on-going operational support."
Miguelangelo Thomé, CEO, QUIP

First FPSO to utilise gas engines to produce more than 100 MWe of power

West Java FSRU

Wärtsilä supplied a liquefied natural gas regasification system for the West Java FSRU for Golar LNG. The project saw the existing LNG carrier Khannur converted into a floating terminal that can be situated either offshore, or at a purpose-built jetty/pier.

The West Java FSRU receives LNG from offloading LNG carriers, and the Wärtsilä Hamworthy LNG regasification systems provide gas send-out through pipelines to shore. The West Java FSRU is Indonesia's first LNG regasification terminal. As Wärtsilä Hamworthy's technology is based on an intermediate closed propane loop, using seawater as the heating medium for vaporising LNG, the equipment has a high level of efficiency. It therefore requires less fuel and operating costs than steam-based systems to regasify the LNG.

In total Wärtsilä has delivered 6 similar systems to Golar LNG, and another 4 are under construction. The liquefied natural gas regasification system for the West Java FSRU Project is similar in design to the latest of these projects: the LNG carrier Golar Freeze which was converted into an FRSU, chartered to Dubai Supply Authority and Shell and moored permanently alongside a purpose-built jetty within Jebel Ali port.

Wärtsilä Hamworthy LNG regasification unit designed for high level of efficiency

Heidrun FSU

Wärtsilä will supply inert gas systems, deepwell pumps and fire water packages to a permanent FSU to serve the Heidrun Oil & Gas Field. Crude oil output of the field will be loaded to the FSU vessel through subsea pipeline and underwater hoses. The oil will be lifted from the FSU vessel to shuttle tankers through offloading hose-strings.

Wärtsilä Moss inert gas systems prevent the gas mixture in the FSU's cargo tanks or bunkers from reaching a range where explosions could occur. Inert gas maintains the oxygen content of the tank atmosphere below 8 per cent, thus making the air and hydrocarbon gas mixture in the tank too lean to ignite. The Wärtsilä Hamworthy pumping equipment meets and exceeds local and international standards. Furthermore, the electrically driven systems feature low noise levels, high system efficiency, and simple maintenance.

Since its acquisition of Hamworthy in 2012, Wärtsilä has expanded its offering to the offshore oil & gas sector to include a complete range of liquid cargo handling products including inert gas systems, pumps and gas reliquefaction plants.

Wärtsilä to supply inert gas systems for three new Oil & Gas sector vessels

WSD 1000

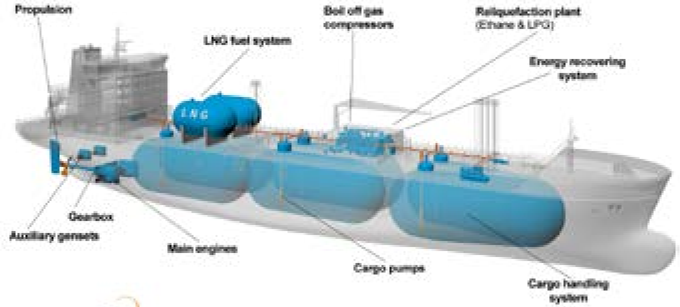
This unique WSD 1000 design is tailored to meet the specific requirements and operational modes demanded in complex offshore applications. The vessels will be built by a subsidiary of Nam Cheong Limited, Malaysia's largest offshore support vessel builder, in one of its subcontracted yards, Fujian Mawei Shipbuilding Ltd, in China.

For each of the four vessels, this comprehensive solution contract comprises the basic customized design, the main power generation system, the propulsion system, the Wärtsilä Low Loss Concept (LLC) electrical system and the automation system. The order follows the successful execution of a similar MPSV order in 2011 for Bumi Armada Berhad featuring a Wärtsilä ship design and fully integrated Wärtsilä machinery, electrical and automation systems.

"We wanted to 'Asianise' the design to make it more suitable for Asia Pacific. Through consultation with our customer Bumi Armada, which has extensive experience in the Asian trade, and Wärtsilä, whom we have been working closely with for over a decade, we decided on the WSD 1000."

Leong Seng Keat, CEO, Nam Cheong Holdings

Wärtsilä to design and power four new offshore support vessels



WÄRTSILÄ

EVERGAS

Dragon 27 500

Wärtsilä will supply a comprehensive solutions package for a series of Liquefied Natural Gas (LNG) Carriers for Danish operator Evergas, a leading transporter of petrochemical gases and natural gas liquids. In addition to LNG, the ships will be able to carry and reliquefy Ethane and LPG.

The vessels will be built by Sinopacific Offshore Engineering at their yard in Qidong, China. The scope of work supplied by Wärtsilä will enable these vessels to achieve the operational and fuel efficiency needed to optimize their operating costs, while at the same time complying with the upcoming Tier III environmental regulations. The Wärtsilä technology provides operational flexibility and redundancy, since it allows the possibility to utilize various conventional fuels in addition to LNG.

“We have enjoyed a lengthy and trusted relationship with Wärtsilä. This, together with Wärtsilä’s relentless efforts in understanding and adapting to our demands, has enabled us to successfully achieve a total integrated solution. I am convinced that our DRAGON 27500 series will be a benchmark in the LNG carrier markets.”

Martin Ackermann, CEO, Evergas

Wärtsilä to supply integrated solutions for new series of environmentally sustainable LNG carriers

Wärtsilä is a global leader in complete lifecycle power solutions for the marine and energy markets. By emphasising technological innovation and total efficiency, Wärtsilä maximises the environmental and economic performance of the vessels and power plants of its customers.

In 2012, Wärtsilä's net sales totalled EUR 4.7 billion with approximately 18,900 employees. The company has operations in nearly 170 locations in 70 countries around the world. Wärtsilä is listed on the NASDAQ OMX Helsinki, Finland.

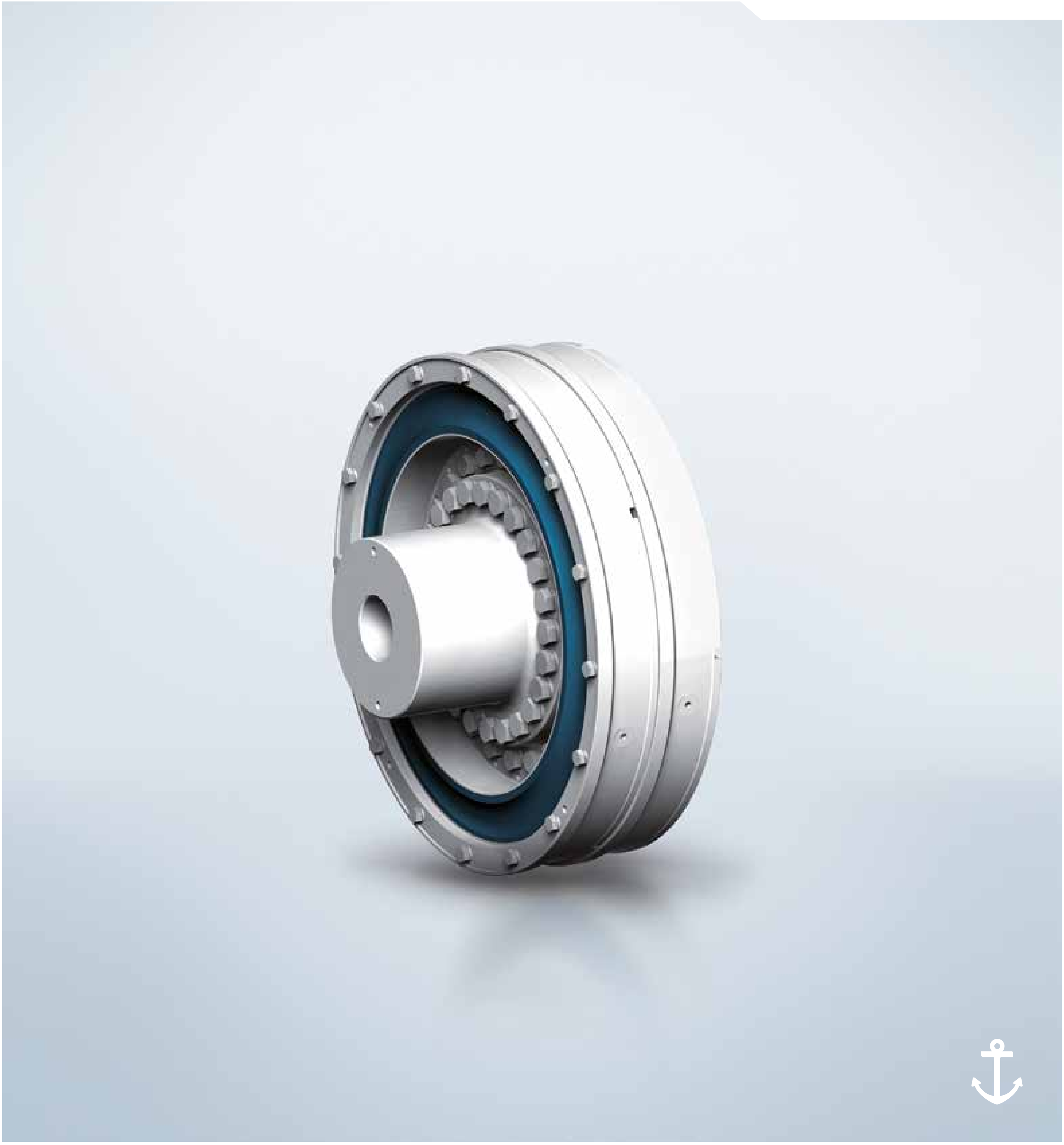
SP-EN-DBAC136254 / 07.2013

WARTSILA.COM

VULKAN COUPLINGS

RATO DG+

TECHNISCHE DATEN / TECHNICAL DATA



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07/2013

Das Handsymbol kennzeichnet Seiten, auf denen es eine Veränderung zur Vorgängerversion gibt.

The hand symbol appears on pages which differ from the previous catalogue version.

INHALTSVERZEICHNIS
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EIGENSCHAFTEN UND BESCHREIBUNG
CHARACTERISTICS AND DESCRIPTION

RATO DG+ Kupplungen / RATO DG+ Couplings

Drehmoment: 27,50 – 142,00 kNm / Torque range: 27.50 – 142.00 kNm

Hochelastische RATO DG+ Kupplungen

Die **RATO DG+** Kupplung ist speziell für starr aufgestellte Diesel-, Gas- und Elektromotoren mit der Forderung nach mittlerer Dreh- und Verlagerungsnachgiebigkeit entwickelt worden. Die **RATO DG+** zeichnet sich wie alle neuentwickelten ACOTEC-Produkte durch eine gesteigerte Leistungsfähigkeit in den wesentlichen technischen Daten aus. Das bewährte Konstruktionsprinzip der Standard RATO DG wurde nochmals optimiert und in Verbindung mit der innovativer Compound- und Vulkanisations- und Prüftechnologie zur leistungsgesteigerten DG+ Ausführung weiterentwickelt. Mit dieser Leistungssteigerung geht ein nicht unerheblicher kommerzieller Vorteil einher, da bei identischen Leistungsanforderungen eine kleinere **RATO DG+** Kupplung statt der bislang verwendeten Standard **RATO DG** eingesetzt werden kann.

Die zur Verfügung stehenden Drehsteifigkeiten bieten die Möglichkeit einer optimalen Abstimmung mit Hinblick auf stationäres und transientes Drehschwingungsverhalten. In der Tradition der VULKAN-Kupplungen wurde eine spielfreie Elementausführung realisiert. Dies führt zu sehr gutem Übertragungsverhalten bezüglich der Regelung bei Be- und/oder Entlastung der Kupplung. Bei Stoßbeanspruchungen – wie z. B. Kurzschlüssen u. a. – bietet die anschlagfreie Gestaltung des elastischen Elements einen sehr wirksamen Schutz der Wellenleitung vor Überlastungen.

Zudem hat die **RATO DG+** gegenüber Kupplungen mit druckbeanspruchtem Elastomerkörpern, die üblicherweise in vergleichbaren Anwendungen eingesetzt werden, den Vorzug einer linearen Drehfederkennlinie, die mit einer definierten Steifigkeit unabhängig vom Betriebszustand eine sichere Auslegung der Kupplung ermöglicht. Der optimierte Querschnitt der **RATO DG+** lässt darüber hinaus eine exzellente Belüftung der Kupplung zu und stellt auf diese Weise die größtmögliche thermische Belastbarkeit sicher.

Die **RATO DG+** ist von allen führenden internationalen Klassifikationsgesellschaften zertifiziert.

Highly Flexible RATO DG+ Couplings

The **RATO DG+** coupling has been developed especially for rigidly installed diesel and gas engines and electric motors with the requirement of medium rotational and displacement flexibility. Like all newly developed ACOTEC products the **RATO DG+** is characterized by enhanced performance with regard to the technical specifications. The proven construction principle of the standard RATO DG has been optimized yet again, and in conjunction with the innovative compound and vulcanization and test technology, it has undergone advanced development to obtain the enhanced performance DG+ design. In addition, the **RATO DG+** has yet another significant commercial benefit since a small size coupling may be used for the same power requirements.

The available stiffnesses enable a customized tuning of the system with respect to both the transient and steady-state torsional vibration response. In the tradition of VULKAN couplings, a backlash-free torque transmission is achieved. This leads to an exact torque transmission (important for governor stability) during the loading/unloading of the coupling. The absence of a torque-limiting device in the coupling protects the connected machinery from the effects of shock loads, e. g. short circuits.

A decisive benefit of the **RATO DG+**, when compared with couplings with elastomer bodies subjected to pressure loads that are used in similar applications, is the linear torsional stiffness characteristic, which enables safe design of the coupling on account of the defined stiffness independent of the operating condition. The cross-section of the **RATO DG+** permits excellent ventilation of the coupling and ensures the maximum possible thermal load capacity.

The **RATO DG+** has been certified by all leading international classification agencies.

RATO DG+ Kupplungen

RATO DG+ Couplings

Die **RATO DG+** Kupplung besteht in der Basisbaureihe 2200 aus den elastischen Elementen, dem Winkelring und der Nabe.

The basic **RATO DG+**, series 2200, consists of flexible elements, intermediate clamping ring and hub.

LISTE DER TECHNISCHEN DATEN

LIST OF TECHNICAL DATA

Baugröße	Baugruppe	Nenn-dreh-moment	Max. Dreh-moment₁	Max. Dreh-moment₂	Max. Dreh-moment-bereich	Zul. Wech-seldreh-moment	Zul. Verlust-leistung	Zul. Drehzahl	Zul. axialer Wellenver-satz	Zul. radialer Kupplungs-versatz	Axiale Feder-steife	Radiale Feder-steife	Dynamische Drehfeder-steife	Verhält-nismäßige Dämpfung
Size	Dimension Group	Norminal Torque	Max. Torque$_1$	Max. Torque$_2$	Max. Torque Range	Perm. Vibratory Torque	Perm. Power Loss	Perm. Rotational Speed	Perm. Axial Shaft Dis-placement	Perm. Radial Coupling Displacement	Axial Stiffness	Radial Stiffness	Dynamic Torsional Stiffness	Relative Damping
		T_{KN} kNm	T_{Kmax1} kNm	T_{Kmax2} kNm	ΔT_{max} kNm	T_{KW} kNm	P_{KV50} kW	n_{Kmax} 1/min	ΔK_a mm	ΔK_r mm	$C_{ax\,1.0}$ kN/mm	C_{rdyn} kN/mm	C_{Tdyn} 1)3) kNm/rad nominal	ψ 2) nominal
									IMPORTANT 1): $C_{Tdyn\ warm}$, $C_{Tdyn\ la}$, ψ_{warm} are to be considered!					
A 2K1S		27,5	40,5	165,0	38,5	10,00			3,1	1,0	2,7	15,0	350	1,00
A 2K1M	A 2K10	35,0	52,0	210,0	49,5	12,60	0,51	1600	3,1	0,5	3,6	21,0	480	1,13
A 2K1H		36,0	67,0	216,0	63,5	12,60			1,6	0,5	5,2	29,0	700	1,13
A 2KDS		55,0	81,0	330,0	77,5	20,00			3,1	1,0	5,4	30,0	700	1,00
A 2KDM	A 2KD0	70,0	104,0	420,0	99,0	25,20	1,02	1600	3,1	0,5	7,2	42,0	960	1,13
A 2KDH		72,0	134,0	432,0	127,5	25,20			1,6	0,5	10,4	58,0	1400	1,13
A 3D1S		44,0	64,5	264,0	61,0	16,00			3,6	1,2	3,0	17,5	580	1,00
A 3D1M	A 3D10	55,0	82,5	330,0	79,5	20,00	0,59	1350	3,6	0,6	4,2	23,5	780	1,13
A 3D1H		56,0	106,0	336,0	102,0	20,00			1,8	0,6	6,0	34,0	1100	1,13
A 3DDS		88,0	129,0	528,0	122,0	32,00			3,6	1,2	6,0	35,0	1160	1,00
A 3DDM	A 3DD0	110,0	165,0	660,0	159,0	40,00	1,18	1350	3,6	0,6	8,4	47,0	1560	1,13
A 3DDH		112,0	212,0	672,0	204,0	40,00			1,8	0,6	12,0	68,0	2200	1,13
A 3E1S		56,0	82,5	336,0	77,5	20,00			3,8	1,2	3,3	19,2	685	1,00
A 3E1M	A 3E10	70,0	105,0	420,0	99,0	25,00	0,58	1250	3,8	0,6	4,6	27,0	990	1,13
A 3E1H		71,0	134,0	426,0	127,5	25,00			1,9	0,6	6,7	38,5	1410	1,13
A 3EDS		112,0	165,0	672,0	155,0	40,00			3,8	1,2	6,6	38,5	1370	1,00
A 3EDM	A 3ED0	140,0	210,0	840,0	198,5	50,00	1,16	1250	3,8	0,6	9,2	54,0	1980	1,13
A 3EDH		142,0	268,0	852,0	255,0	50,00			1,9	0,6	13,4	77,0	2820	1,13

Siehe Erläuterung der Technischen Daten

1) VULKAN empfiehlt die zusätzliche Berücksichtigung von $C_{Tdyn\ warm}$ (0,7), $C_{Tdyn\ la}$ (1,35) und ψ_{warm} (0,7) für die Berechnung der Drehschwingungen in der Anlage.
Durch die Eigenschaft des Werkstoffs Naturkautschuk sind Toleranzen der aufgeführten Daten für C_{Tdyn} von ± 15 % möglich.
2) Bedingt durch die physikalischen Eigenschaften der elastischen Elemente sind Toleranzen der aufgeführten Daten für ψ, von 0 % bis -30 % für die M, H Elemente bzw., von 0 % bis -45 % für die S Elemente möglich.
3) Andere Steifigkeitsgrade auf Anfrage.

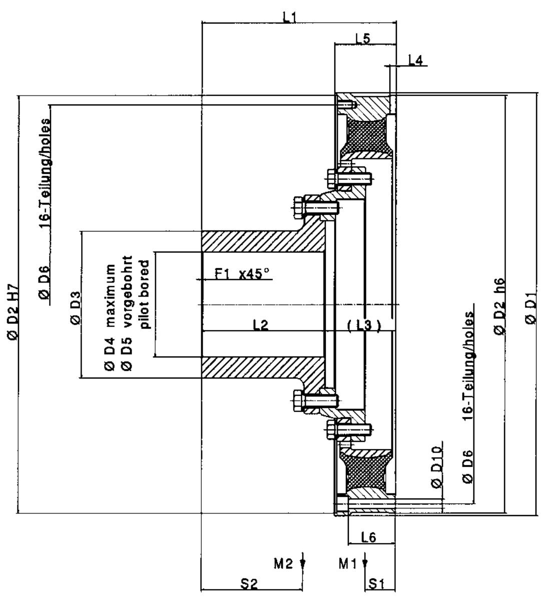
See Explanation of Technical Data

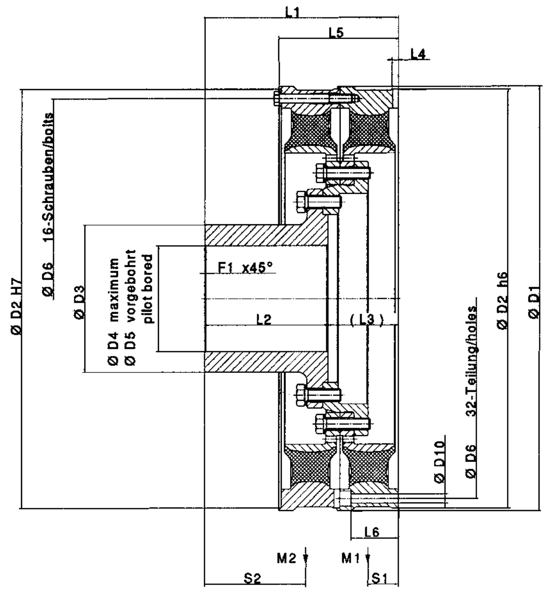
1) VULKAN recommend that the values $C_{Tdyn\ warm}$ (0.7), $C_{Tdyn\ la}$ (1.35) and ψ_{warm} (0.7) be additionally used when the installations of torsional vibrations are calculated.
The properties of the natural rubber mean that tolerances of ± 15 % with respect to the data given for C_{Tdyn} are possible.
2) Because of the physical properties of the elastic elements, tolerances of 0 % to -30 % for the M, H elements and 0 % to -45 % for the S elements with respect to the data given for ψ are possible.
3) Different stiffness-grades on request.

ABMESSUNGEN/MASSENTRÄGHEITSMOMENTE/MASSEN

DIMENSIONS/MASS-MOMENTS OF INERTIA/MASSES

RATO DG+ Baureihe / Series 2200





Baugruppe	Abmessungen														Massenträgheitsmoment		Masse		Schwerpunktsabstand	
Dimension Group	Dimensions														Mass moment of inertia		Mass		Distance to center of gravity	
	D_1	D_2	D_3	D_4 max	D_5 vorgeb. pilot bored	D_6 L_{kr}	D_{10}	L_1	L_2	L_3	L_4	L_5	L_6	F_1 x 45°	J_1 [kgm²]	J_2	m_1 [kg]	m_2	s_1 [mm]	s_2
A 2K10	870	860	306,0	220,0	110,0	820,0	20,0	394,00	250,0	144,0	12,0	123	94,0	2,0	17,5	9,9	107,00	259,0	59,0	205,0
A 2KD0	870	860	306,0	220,0	110,0	820,0	20,0	394,00	250,0	144,0	12,0	241	94,0	2,0	37,3	14,1	229,00	307,0	123,0	209,0
A 3D10	1010	995	357,0	255,0	150,0	950,0	22,0	463,00	300,0	163,0	16,0	137	106,0	3,0	33,8	21,5	154,00	404,0	67,0	248,0
A 3DD0	1010	995	357,0	255,0	150,0	950,0	22,0	463,00	300,0	163,0	16,0	269	106,0	3,0	72,1	30,6	328,00	482,0	138,0	254,0
A 3E10	1085	1070	385,0	275,0	160,0	1025,0	24,0	485,00	310,0	175,0	16,0	147	114,0	3,0	47,3	32,0	186,00	503,0	72,0	260,0
A 3ED0	1085	1070	385,0	275,0	160,0	1025,0	24,0	485,00	310,0	175,0	16,0	289	114,0	3,0	101,0	45,7	395,00	603,0	148,0	265,0

Maße in mm

Alle Massen und Massenträgheitsmomente beziehen sich auf vorgebohrte Naben.

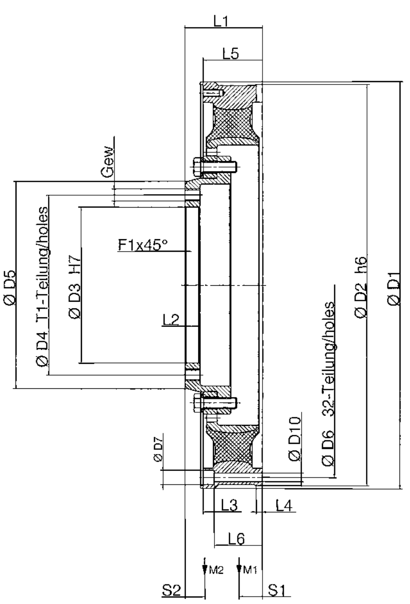
Dimensions in mm

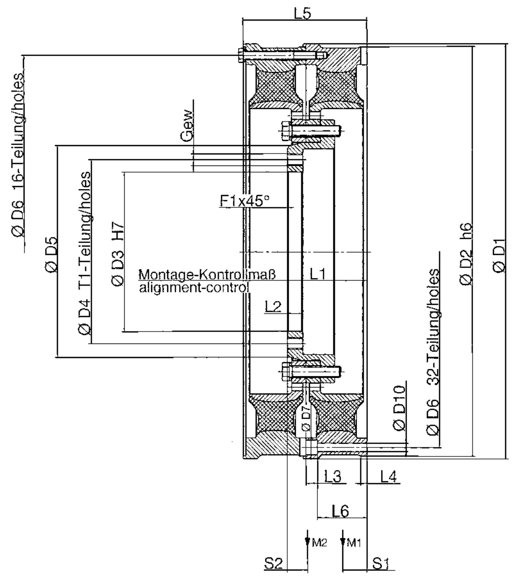
All masses and mass moments of inertia refer to pilot bored hubs.

ABMESSUNGEN/MASSENTRÄGHEITSMOMENTE/MASSEN

DIMENSIONS/MASS-MOMENTS OF INERTIA/MASSES

RATO DG+ Baureihe / Series 2300





Baugruppe Dimension Group	Abmessungen / Dimensions																	Massenträgheitsmoment / Mass moment of inertia		Masse / Mass		Schwerpunktsabstand / Distance to center of gravity	
	D_1	D_2	D_3	D_4	D_5 vorgeb. pilot bored	D_6	D_7	D_{10}	L_1	L_2	L_3	L_4	L_5	L_6	F_1	T_1	Gew.	J_1 [kgm²]	J_2 [kgm²]	m_1 [kg]	m_2 [kg]	s_1 [mm]	s_2 [mm]
A 2K10	870	860	350,0	410,0	464,0	820,0	32,0	20,0	154,00	35,0	24,0	12,0	123	94,0	2,0	20	M27	19,8	6,9	121,00	97,0	61,0	63,0
A 2KD0	870	860	350,0	410,0	464,0	820,0	32,0	20,0	154,00	35,0	24,0	12,0	241	94,0	2,0	20	M27	39,5	11,1	242,00	146,0	120,0	41,0
A 3D10	1010	995	410,0	470,0	530,0	950,0	35,0	22,0	173,00	40,0	26,0	16,0	137	106,0	2,0	24	M30	38,1	14,4	173,00	153,0	68,0	71,0
A 3DD0	1010	995	410,0	470,0	530,0	950,0	35,0	22,0	173,00	40,0	26,0	16,0	269	106,0	2,0	24	M30	76,2	23,5	346,00	231,0	134,0	46,0
A 3E10	1085	1070	445,0	515,0	580,0	1025,0	38,0	24,0	185,00	42,0	28,0	16,0	147	114,0	2,0	24	M33	53,4	21,5	209,00	193,0	73,0	74,0
A 3ED0	1085	1070	445,0	515,0	580,0	1025,0	38,0	24,0	185,00	42,0	28,0	16,0	289	114,0	2,0	24	M33	106,8	34,8	418,00	291,0	144,0	48,0

Maße in mm

Alle Massen und Massenträgheitsmomente beziehen sich auf vorgebohrte Naben.

Dimensions in mm

All masses and mass moments of inertia refer to pilot bored hubs.

ERLÄUTERUNGEN DES PRODUKTCODES
EXPLANATIONS OF THE PRODUCT CODE

RATO DG+

Alle VULKAN Couplings Produkte sind mit einem Produktcode gekennzeichnet. Dieser Code setzt sich aus verschiedenen Parameter-Angaben zusammen und ermöglicht es, unsere Produkte eindeutig zu identifizieren.

RATO DG+

All VULKAN Couplings products are identified by a product code. This code consists of several parameters and it enables the clear identification of all products.

Beispiel eines RATO DG+ Produktcodes

Hier haben wir den Code am Beispiel einer RATO DG+ (A 2K1S), Größe 2K, 1-reihig, Elementsteifigkeit S, Baureihe 2200 entschlüsselt dargestellt.

Example of a RATO DG+ product code

We have decoded here the product code of a RATO DG+ (1 A2K1S), Size 2K, 1 row, Element stiffness S, Series 2200.

Komplettkupplung Complete coupling	**Baugröße (Liste der technischen Daten)** Size (List of technical data)				**Kennzeichen gemäß Abmessungen/ Massenträgheits-momente/Massen** Keys according to Dimensions/ Mass-Moments of Inertia/Masses	**Kennzeichnung** Key
1	**A**	**2K**	**1**	**S**	**02**	**G**
	Produktfamilie Product family	**Größenbezeichnung** Size code	**Elementreihen** Element rows	**Elementsteifigkeit** Element stiffness	**Baureihe** Series	**RATO DG+** RATO DG+
		2K 3D 3E	1 = 1 Reihe/1 row D = Dual/dual	S M H	02 = 2200 04 = 2300	

NOTIZEN
NOTICE

GÜLTIGKEITSKLAUSEL

Die vorliegende Broschüre ersetzt alle vorherigen Ausgaben, ältere Drucke verlieren ihre Gültigkeit. VULKAN ist berechtigt, aufgrund neuerer Entwicklungen die in dieser Broschüre enthaltenen Daten entsprechend anzupassen und zu verändern. Die neuen Daten gelten nur für nach der Änderung bestellte Kupplungen. Es liegt im Verantwortungsbereich des Anwenders dafür zu sorgen, dass ausschließlich die aktuelle Katalogversion verwendet wird. Der jeweils aktuelle Stand ist auf der Webseite von VULKAN unter www.vulkan.com jederzeit abrufbar.

Die Angaben in dieser Broschüre beziehen sich auf den technischen Standard gültig im Hause VULKAN und stehen unter den in den Erläuterungen definierten Bedingungen. Es liegt allein im Entscheidungs- und Verantwortungsrahmen des Systemverantwortlichen für die Antriebslinie, entsprechende Rückschlüsse auf das Systemverhalten zu ziehen.

VULKAN Drehschwingungsanalysen berücksichtigen in der Regel nur das rein mechanische Schwingungsersatzsystem. Als reiner Komponentenhersteller übernimmt VULKAN mit der Analyse des Drehschwingungssystems (stationär, transient) nicht die Systemverantwortung! Die Genauigkeit der Analyse hängt von der Genauigkeit der verwendeten bzw. der VULKAN zur Verfügung gestellten Daten ab.

Änderungen aufgrund des technischen Fortschritts sind vorbehalten. Bei Unklarheiten bzw. Rückfragen kontaktieren Sie bitte VULKAN.

Stand: 07/2013

VALIDITY CLAUSE

The present catalogue shall replace all previous editions, any previous printings shall no longer be valid. Based on new developments, VULKAN reserves the right to amend and change any details contained in this catalogue respectively. The new data shall only apply with respect to couplings that were ordered after said amendment or change. It shall be the responsibility of the user to ensure that only the latest catalogue issue will be used. The respective latest issue can be seen on the website of VULKAN on www.vulkan.com.

The data contained in this catalogue refer to the technical standard as presently used by VULKAN with defined conditions according to the explanations. It shall be the sole responsibility and decision of the system administrator for the drive line to draw conclusions about the system behaviour.

VULKAN torsional vibration analysis usually only consider the pure mechanical mass-elastic system. Being a component manufacturer exclusively, VULKAN assumes no system responsibility with the analysis of the torsional vibration system (stationary, transiently)! The accuracy of the analysis depends on the exactness of the used data and the data VULKAN is provided with, respectively.

Any changes due to the technological progress are reserved. For questions or queries please contact VULKAN.

Status: 07/2013

CATERPILLAR®

PRODUCT NEWS

Engine Division

Cat® Generator Set Vibration Isolators

Market:	Electric Power
Application:	Cat® C9, C15, C18 and C27 package generator sets, both U.S. and European sourced and all 3600 series package generator sets.
Description:	All Cat® C9, C15, C18 and C27 package generator sets utilize linear vibration isolators between the engine generator and the base. These isolators comply with the requirements of up to and including Seismic Zone 4 as stated below: All Caterpillar® C9, C15, C18 and C27 package generator sets incorporate rubber-type isolators between the engine generator and the base. These isolators are over 95% efficient (85% for C27) in reducing vibration transmission. External isolation is not required. The design is deflection restraint limiting and will withstand high loads in any plane. The design of these isolators satisfies shear and axial load criteria to comply with the 1994 Uniform Building Code (UBC) Seismic Zone 4 requirements. The isolators use a proprietary rubber compound, which is highly resilient and exhibits high fatigue life. The compound is resistant to water, heat and aging and is impervious to oil, water, antifreeze and diesel fuel. All 3600 series generator sets use vertically restrained spring isolators between the generator set base and the foundation. These spring isolators also comply with the Uniform Building Code (UBC) Seismic Zone 4 requirements.
Features/Benefits:	The above statement can be used to demonstrate compliance with Seismic requirements.
Availability:	C9, C15, C18 and C27 : Effective immediately 3600 series product: Effective immediately 3500 series product: Available as a Special Engineering Request (SER). Please contact the Application Support Center at (765) 448-2400 or email them at applicationsupport@cat.com for more information.

CAT Elastomer Vibration Isolator as found on C9, C15, C18 and C27 Gensets

Inversores trifásicos para plantas fotovoltaicas conectadas a la red

SINVERT 350 M – SINVERT 1700 MS
SINVERT 500 M TL – SINVERT 2000 MS TL

Plantas fotovoltaicas conectadas a la red con la máxima producción y durabilidad, ¡durante 25 años y más!

La gama SINVERT le permite alcanzar estos objetivos tan ambiciosos. Porque nuestros inversores se basan en componentes estándar de Siemens de eficacia probada, como el PLC SIMATIC S7 y los convertidores de frecuencia MASTERDRIVE y SINAMICS.

Resumen de ventajas

- Rendimiento > 98 %
- Disponible como unidades individuales o en contenedor
- Conectividad a Ethernet de serie
- Mayor vida útil gracias al inteligente sistema maestro-esclavo
- Rendimiento óptimo de la planta fotovoltaica
- Elevado nivel de calidad gracias al uso de componentes industriales probados y a más de 20 años de experiencia

SINVERT PV Inverter

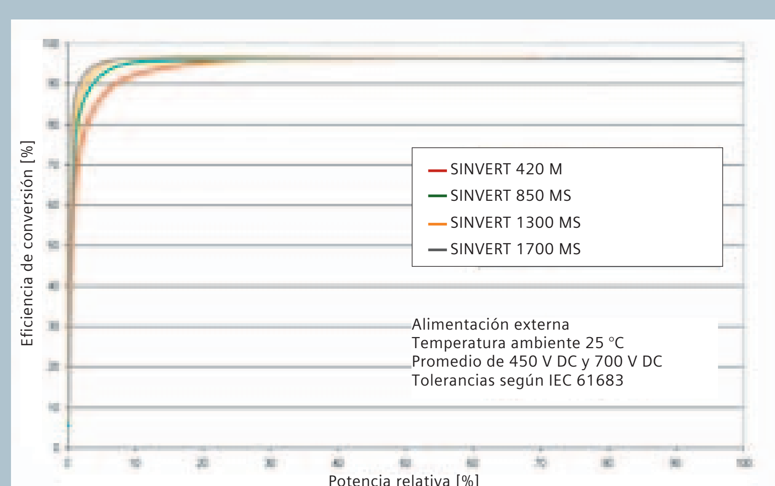
Answers for environment.

SIEMENS

Datos técnicos

Datos técnicos de los inversores SINVERT PV									
Modelo de inversor *		350 M	420 M	700 MS	850 MS	1000 MS	1300 MS	1400 MS	1700 MS
Entrada DC									
Tensión en el punto de máxima potencia	V	450 – 750							
Tensión máx. de empleo	V	820 (opc. 900 V)							
Tensión máx. del sistema	V	900 (dno debe superarse)							
Potencia de entrada	kW	373	465	746	930	1119	1395	1492	1860
Corriente de entrada	A	820	1022	1640	2044	2460	3066	3280	4088
N.° de entradas DC		4	4	8	8	12	12	16	16
Corriente máx. por entrada DC	A	250							
Salida AC									
Conexión de red	3 ~ 230/400 V; 50 Hz (60 Hz opc.)								
Capacidad nominal	kW	357	435	714	870	1071	1305	1428	1740
Corriente de salida	A	518	630	1036	1260	1554	1890	2072	2520
Rendimiento									
eta EU	%	95,5	95,7	96	96,2	96,1	96,2	96,1	96,3
Máx. rendimiento	%	96,5							
Otros datos									
N.° de unidades	Uds.	1	1	2	2	3	3	4	4
Dimensiones (Al x An x P) por unidad	mm	2000 x 2700 x 800							
Peso por unidad	kg	2025	2540	2025	2540	2025	2540	2025	2540
Temperatura ambiente	°C	0 – 50							
Altitud de instalación	Hasta 1000 m								
Humedad máx. del aire	%	85 (sin condensación)							

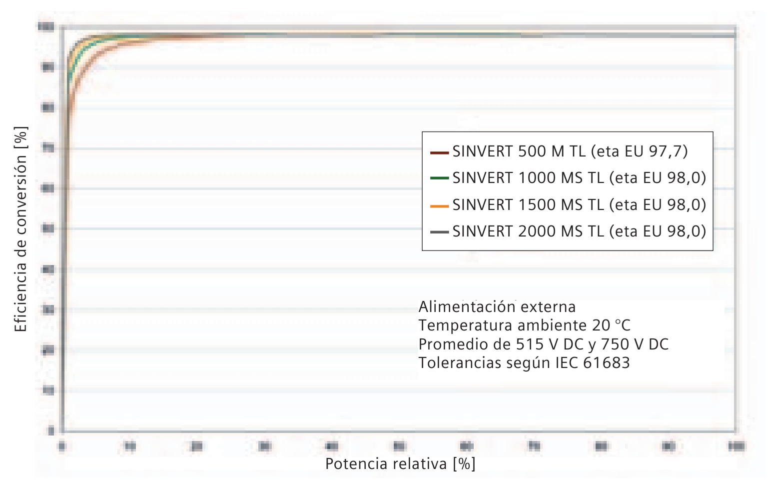
* M = Maestro
MS = Sistema maestro-esclavo



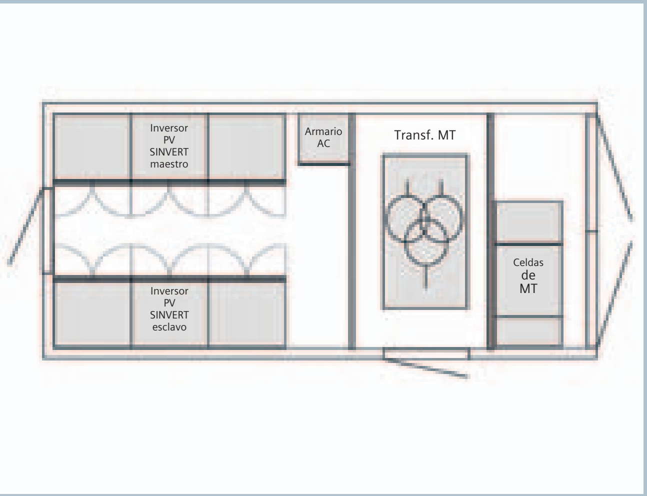
Curva de eficiencia de SINVERT
420 M/850 MS/1300 MS/1700 MS

Datos técnicos de los inversores SINVERT PV, serie sin transformador (TL)					
Modelo de inversor *		500 M TL	1000 MS TL	1500 MS TL	2000 MS TL
Entrada DC					
Tensión en el punto de máxima potencia	V	515 – 750			
Tensión máx. del sistema	V	900 (1000 V CC opcionales)			
Potencia de entrada	kW	513	1026	1539	2052
Corriente de entrada	A	1000	2000	3000	4000
N.° de entradas DC		4	8	12	16
Corriente máx. por entrada DC	A	250	250	250	250
Salida AC					
Conexión de red		3 ~ 328 V; 50 Hz (60 Hz opc.)			
Capacidad nominal	kW	500	1000	1500	2000
Corriente de salida	A	881	1762	2643	3524
Rendimiento					
eta EU	%	97,7	98,0	98,0	98,0
Máx. rendimiento	%	98,2			
Otros datos					
N.° de unidades	St.	1	2	3	4
Dimensiones (Al x An x P) por unidad	mm	2000 x 2718 x 834			
Peso por unidad	kg	1700			
Temperatura ambiente	°C	0 – 50			
Altitud de instalación		Hasta 1000 m			
Humedad máx. del aire	%	85 (sin condensación)			

* M = Maestro
MS = Sistema maestro-esclavo



Curva de eficiencia de SINVERT
500 M TL/1000 MS TL/1500 MS TL/2000 MS TL



Ejemplo:
Estación de 1 MW en contenedor con SINVERT 1000 MS TL
y componentes de media tensión

Referencias

Fotos: Gehrlicher Solar AG

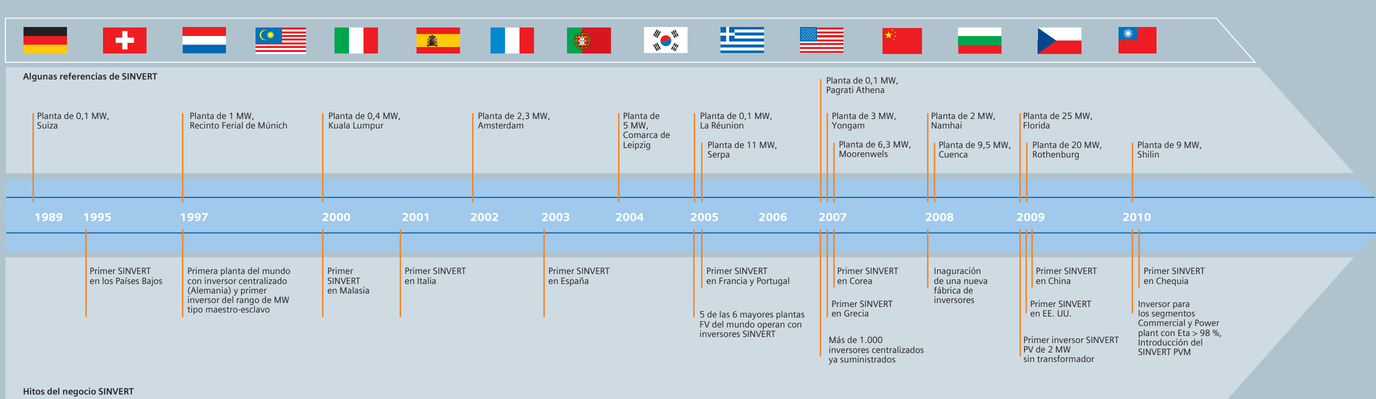
Central fotovoltaica de 21 MW en Rothenburg, Alemania (diciembre de 2009)

- Soluciones en contenedor con 10 x SINVERT 2000 MS TL
- Componentes de media tensión
- Cajas de generador
- Software de monitorización PV WinCC

Central fotovoltaica de 25 MW en Florida, EE. UU. (noviembre de 2009)

- Soluciones en contenedor con
  - 13 x SINVERT 1700 MS
  - 1 x SINVERT 1400 MS
  - 1 x SINVERT 1300 MS
- Componentes de media tensión

Más de 20 años de experiencia con convertidores FV



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Ficha Técnica

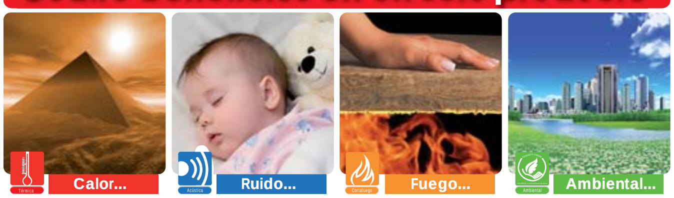
LANAS MINERALES STANDAR

Lana Mineral de Roca en diferentes presentaciones diseñada como aislamiento térmoacustico y protección al fuego, resiste una temperatura de operacion de 750ºC. Ampliamente utilizados como sustrato en cultivos hidropónicos.

Especificaciones Técnicas

Unidad	Lana Mineral Estandar
Conductividad térmica	0.25 BTU. plg/pie².hr ºF a Tm 100 ºF
Resistencia térmica	R= 12 a 3 plg de espesor
Tº de utilización	Hasta 750ºC
Norma	ASTM C 764-02 Type II

Cuatro beneficios en un solo producto



Soluciones de aislamiento

Descripción

La Lana Mineral Estandar consiste en finas fibras minerales muy elásticas y esponjosas, procesadas con y/o sin aceite lubricante y sin aglutinar, empacadas a granel en sacos de polietileno, es incombustible, no despide humos ni gases tóxicos, no corrosiva, no despide olores, no es hábitat para bacterias y hongos, es 100% libre de asbestos.

Aplicaciones

- Material para aislamiento térmico y acústico muy eficiente y económico, indicada para una amplia variedad de aplicaciones industriales, comerciales y residenciales.
- Usado para aislamiento de calor, empacando y rellenando equipos comerciales y domésticos como calentadores de agua, hornos comerciales y del hogar, hornos de pintura, estufas, baños turcos, saunas, silenciadores, entre otros.
- La Lana Mineral Estandar sin aceite es utilizada para aplicaciones criogénicas en tanques, cold boxes y torres de enfriamiento.
- A baja temperatura se emplea en equipos comerciales y domésticos como enfriadores, congeladores, botelleros, cuartos fríos, refrigeradores.
- En la industria y la construcción se utiliza para el aislamiento térmico y acústico de particiones metálicas, divisiones de cartón, yeso, cabinas de sonido, pisos y paredes acústicas, como relleno de los casetones, debajo de los pisos entablados, entre otros.
- En la industria automotriz se utiliza como aislamiento acústico de silenciadores.
- En la agricultura se utiliza combinada con la tierra para mejorar la aireación del terreno y la retención de agua.

  En la hidroponía como sustratos hidropónicos..

La Lana Mineral de Roca es el aislante más utilizado en el mundo en el campo industrial y comercial por su excelente desempeño térmico, absorción acústica, resistencia al fuego; además de ser amigable con el medio ambiente.

Ventajas

- Aislamiento eficiente y económico, muy fácil de instalar y manipular, se adapta fácilmente a formas caprichosas, curvas o irregulares, se deja prensar y comprimir conservando sus propiedades térmicas y acústicas.
- La Lana Mineral Estandar: Lana suelta, granulada, bruta y molida puede utilizarse hasta temperaturas continuas de 750ºC.
- Químicamente inerte, no es hábitat de ninguna forma de vida, (hongos, bacterias, insectos o roedores), no despide ni absorbe olores, es 100% libre de asbesto.
- Es incombustible.
- Por ser totalmente inorgánica no corroe ni ataca los substratos donde es aplicada.
- Por su bajo contenido de cloruros es compatible con el acero inoxidable.

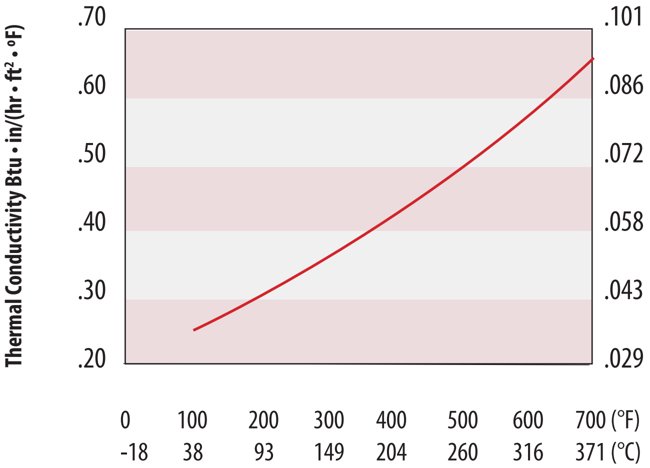
Coeficiente de transmisión de calor K

Tº media ºF	Tº media ºC	Densidad Kg/m³	K BTU plg/pie². hr ºF	K K Cal m/m.²hr.°C
100	38	100	0.25	0.031
200	93	100	0.36	0.045
300	149	144	0.38	0.047
400	204	144	0.47	0.058
500	260	144	0.58	0.072

Recomendaciones para la densidad

Temperatura ºC	Densidad Kg/m³
< -50	140
Hasta 200	80
De 200 a 450	100
De 450 a 650	140

Gráfica de la conductividad térmica (k)*



Conductividad térmica

Tº media ºF	Tº media ºC	K BTU. plg/pie². hr.°F
-300	-184	0.10
-250	-157	0.11
-150	-101	0.14
-50	-406	0.18
0	-18	0.20
100	38	0.25
125	52	0.28
150	66	0.30
200	93	0.36
250	121	0.35
300	149	0.38
400	204	0.47
500	260	0.58

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INTERNATIONAL STANDARD

ISO 8861

Second edition
1998-05-15

Shipbuilding — Engine-room ventilation in diesel-engined ships — Design requirements and basis of calculations

Construction navale — Ventilation du compartiment machines des navires à moteurs diesels — Exigences de conception et bases de calcul

Reference number
ISO 8861:1998(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8861 was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 3, *Piping and machinery*.

This second edition cancels and replaces the first edition (ISO 8861:1988), of which it constitutes a technical revision.

Annex A of this International Standard is for information only.

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Shipbuilding — Engine-room ventilation in diesel-engined ships — Design requirements and basis of calculations

1 Scope

This International Standard specifies design requirements and suitable calculation methods for the ventilation of the engine room in diesel-engined ships, for normal conditions in all waters.

Annex A provides guidance and good practice in the design of ventilation systems for ships' engine rooms.

NOTE — Users of this International Standard should note that, while observing the requirements of the standard, they should at the same time ensure compliance with such statutory requirements, rules and regulations as may be applicable to the individual ship concerned.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 31-1:1992, *Quantities and units — Part 1: Space and time*.

ISO 31-3:1992, *Quantities and units — Part 3: Mechanics*.

ISO 31-4:1992, *Quantities and units — Part 4: Heat*.

ISO 3046-1:1995, *Reciprocating internal combustion engines — Performance — Part 1: Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods*.

ISO 3258:1976, *Air distribution and air diffusion — Vocabulary*.

3 Definitions

For the purposes of this International Standard, the definitions given below, together with those in ISO 31-1, ISO 31-3, ISO 31-4, ISO 3046-1 and ISO 3258, apply.

3.1 engine room: Space containing main propulsion machinery, boiler(s), diesel generator(s) and major electrical machinery, etc.

3.2 ventilation: Provision of air to an enclosed space to meet the needs of the occupants and/or the requirements of the equipment therein.

3.3 service standard power: The continuous brake power which the engine manufacturer declares that an engine is capable of delivering, using only the essential dependent auxiliaries, between the normal maintenance intervals stated by the manufacturer and under the following conditions:

a) at a stated speed at the ambient and operating conditions of the engine application;

b) with the declared power adjusted or corrected as determined by the manufacturer to the stated ambient and operating conditions of the engine application;

c) with the maintenance prescribed by the engine manufacturer being carried out. [ISO 3046-1:1995]

See A.1 in annex A of ISO 3046-1:1995.

4 Design conditions

The outside ambient air temperature shall be taken as + 35 °C.

Temperature rise from air intake to air passing from the engine room up to the casing entrance shall be max. 12,5 K.

The capacity of the ventilation plant should be such as to provide comfortable working conditions in the engine room, to supply the necessary combustion air to the diesel engine(s) and boiler(s), and to prevent heat-sensitive apparatus from overheating.

In order to meet these requirements, the air should be distributed to all parts of the engine room, so that pockets of stagnant hot air are avoided. Special considerations should be given to areas with great heat emission and to all normal working areas, where reasonably fresh and clean outdoor air should be provided through adjustable inlet devices.

When arranging the air distribution, all normal conditions at sea and in harbour for in-service machinery shall be taken into account.

5 Airflow calculation

5.1 Total airflow

The total airflow Q to the engine room shall be at least the larger value of the two following calculations.

a: $Q = q_c + q_h$ as calculated according to 5.2 and 5.3 respectively.

b: $Q = 1{,}5 \times q_c$, i.e. the airflow for combustion + 50 %. The total airflow to the engine room shall not be less than the airflow for combustion [engine(s) and boiler(s)] plus 50 %.

Combustion air to, and heat emission from, all equipment installed within the casing and funnel shall not be taken into account.

The calculations shall be based on simultaneous maximum rating of main propulsion diesel engine(s), diesel generator engine(s), boiler(s) and other machinery under normal sea conditions, and on a temperature increase of 12,5 K.

The calculations should, to the greatest possible extent, be based on information from the manufacturers. Guidance values given in this International Standard should be used only when manufacturers' information is not available.

In order to ensure satisfactory air distribution, combustion air to, and heat emission from, main propulsion diesel engine(s), diesel generator engine(s), generator(s), boiler(s), and possibly other machinery with considerable heat emission, shall be calculated separately including other conditions as necessary.

Spaces separated from the main engine room, such as individual auxiliary engine rooms, boiler rooms and separator rooms, shall also be calculated separately.

5.2 Airflow for combustion

5.2.1 Sum of airflow for combustion

The sum of the airflow for combustion, q_c, shall be calculated, in cubic metres per second, as follows:

$$q_c = q_{dp} + q_{dg} + q_b$$

where

q_{dp} is the airflow for combustion for main propulsion diesel engine(s), in cubic metres per second (see 5.2.2);

q_{dg} is the airflow for combustion for diesel generator engine(s), in cubic metres per second (see 5.2.3);

q_b is the airflow for combustion for boiler(s), in cubic metres per second (see 5.2.4), if relevant under normal sea conditions.

5.2.2 Airflow for combustion for main propulsion diesel engine(s)

The airflow for combustion for the main propulsion diesel engine(s), q_{dp}, shall be calculated, in cubic metres per second, as follows:

$$q_{dp} = \frac{P_{dp} \times m_{ad}}{\rho}$$

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