REMOLCADOR DE SALVAMENTO LUCHA CONTRA LA CONTAMINACION Y FIFI 68 TPF

Cuaderno 2: Predicción de potencia y diseño de propulsores y timones

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Proyecto de fin de grado 15-01
DEPARTAMENTO DE INGENIERÍA NAVAL Y OCEÁNICA

GRADO EN INGENIERÍA DE PROPULSIÓN Y SERVICIOS DEL BUQUE

CURSO 2014-2015

PROYECTO NÚMERO 15-01

TIPO DE BUQUE: REMOLCADOR DE SALVAMENTO LUCHA CONTRA LA CONTAMINACION Y FIFI I 68 TPF

CLASIFICACIÓN, COTA Y REGLAMENTOS DE APLICACIÓN: Bureau Veritas, Hull, mach, salvage tug...

CARACTERÍSTICAS DE LA CARGA: EQUIPO KOSEQ DE LUCHA CONTRA LA CONTAMINACION DEL MAR

VELOCIDAD Y AUTONOMÍA: 13 nudos y 2500 millas en condiciones de servicio y buque na mar

SISTEMAS Y EQUIPOS DE CARGA / DESCARGA

Los habituales en este tipo de buques

PROPULSIÓN: DIESEL MECANICA PROPULSORES AXIMUTALES

TRIPULACIÓN Y PASAJE: 12 tripulantes.

OTROS EQUIPOS E INSTALACIONES: UNIDAD EMPUJADORA TRANSVERSAL EN PROA, EQUIPO CI FIFI, EQUIPO DE REMOLQUE

Ferrol, Setiembre de 2014

ALUMNO: D. Alba Jove Rodríguez
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**ANEXO 1 (REPORT RESISTENCIA AL AVANCE)**

**ANEXO 2 (REPORT PROPULSOR)**

**ANEXO 3 (REPORT TPF)**

**ANEXO 4 (REPORT AGUAS LIBRES)**

**ANEXO 5 (DOCUMENTACIÓN MOTOR)**
1. Introducción

En este cuaderno se va explicar cómo se calcularían los propulsores y los timones a partir de la resistencia al avance del buque.

Este proceso consiste en analizar la resistencia al avance en aguas libres y teniendo en cuenta el tiro del remolcador, a partir de ahí podemos saber la potencia necesaria.

Una vez que sabemos los puntos anteriores pasaremos a la elección de los motores y por último los propulsores.

Todo esto se realiza con los siguientes programas:

- NavCad
- Hidro-Online

Todo esto será calculado a partir de las Rpas del Buque, y de las dimensiones calculadas en el anterior Cuaderno:

RPAs:

- 13 nudos de navegación
- 68 toneladas de tracción a punto fijo

Dimensiones:

| Dimensiones Principales del Remolcador de 68TPF |
|---------------------|--------|
| Lpp                 | 35,80  |
| B                   | 13,00  |
| CB                  | 0,56   |
| D                   | 6,40   |
| Δ                   | 1472,59|
| T                   | 5,40   |
| Fn                  | 0,36   |
| Cm                  | 0,87   |
| Cp                  | 0,63   |
| Cf                  | 0,81   |
| BP(Kw)              | 4466   |

El buque constara propulsión diésel, con unos propulsores azimutales.
2. **Potencia necesaria.**

Antes de proceder a los cálculos vamos explicar los requisitos que necesita un remolcador a la hora de calcular la potencia de su planta propulsora.

Un remolcador de salvamento tiene principalmente dos situaciones de navegación:

- Cuando navega en aguas libres, que la única oposición es la resistencia al avance
- Cuando navega en condiciones de remolque, que aunque la velocidad es menor, la potencia necesaria es mayor

Una aproximación de estas dos potencias fueron calculadas en el cuaderno 1.

Si recordamos calculamos la potencia necesaria con unas gráficas relacionando la potencia y el tiro de los remolcadores de los buques base.

\[
y = 74.764x - 831.66 \\
R^2 = 0.9086
\]

\[
BHP = 74.764TPF - 831.366 = 4252.6 Kw
\]
Y la potencia calculada en aguas libres, mediante el programa Nav-Cad para una navegación de 13 nudos:

Sería aproximadamente de 789.2 Kw, mediante el método Oortmerssen.

Esta diferencia de potencias de aproximadamente 3500 Kw es debido principalmente al tiro necesario en el remolcador y a sus sistemas auxiliares.

Una vez que tenemos analizado las potencias que necesarias, vamos pasar al cálculo real de estas potencias mediante los dos programas nombrados anteriormente y se dimensionara el propulsor óptimo para esta potencia.

Normalmente existe un motor y un propulsor óptimos para cada buque y su velocidad de servicio.

En este cuaderno vamos hacer los cálculos para poder ajustar el motor y el propulsor más eficiente, para las distintas condiciones de navegación del remolcador.
3. **Planteamiento de la planta propulsora:**

Nuestra planta propulsora va disponer de dos motores diésel de velocidad media de wartisila.

A ellos se acoplaran unos schottel. La gama de schottel va ser la SRP por ser la recomendada para estos buques, y una vez que tengamos el motor y las revoluciones ya poder escoger este.

A la hora del cálculo del propulsor tenemos que tener que los schottel son de cuatro palas.

![Figura 1. Schottel](image1)

El acoplamiento entre el motor el schottel es mediante un eje kardan, consiste en un eje el cual permite unir dos ejes no lineales. Su objetivo principal es transmitir el movimiento de rotación de un eje al otro a pesar de no estar en la misma línea.

![Figura 2. Eje Kardan](image2)
4. **Calcolo de la resistencia al avance del buque:**

En este apartado se calculará la potencia necesaria para poder superar la resistencia al avance del buque, como ya se nombró anteriormente el programa utilizado es el NavCad:

- Trabajaremos con el sistema Internacional

- Condiciones, en este apartado definiremos el tipo de buque, monocasco, eslora de flotación, ITTc, desplazamiento, tipo de propulsores, numero de propulsores, rango de velocidades...

```sql
<table>
<thead>
<tr>
<th>Project</th>
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<tbody>
<tr>
<td>Project ID:</td>
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<td>Description:</td>
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<table>
<thead>
<tr>
<th>Summary</th>
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<tr>
<td>Scope:</td>
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<tr>
<td>Configuration:</td>
</tr>
<tr>
<td>Chine type:</td>
</tr>
<tr>
<td>Length on WL:</td>
</tr>
<tr>
<td>Displacement:</td>
</tr>
<tr>
<td>Propulser type:</td>
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<td>Count:</td>
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<table>
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<tr>
<th>Water properties</th>
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<tr>
<td>Water type:</td>
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<tr>
<td>Density:</td>
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<td>Viscosity:</td>
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<tr>
<th>Speeds</th>
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<tbody>
<tr>
<td>Speed [01]:</td>
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<td>Speed [02]:</td>
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<td>Speed [03]:</td>
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<td>Speed [04]:</td>
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<td>Speed [05]:</td>
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<td>Speed [08]:</td>
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<td>Speed [09]:</td>
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<tr>
<td>Speed [10]:</td>
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<tr>
<th>Design condition</th>
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<tbody>
<tr>
<td>Design speed:</td>
</tr>
</tbody>
</table>
```
- Casco, en este apartado principalmente se definen las dimensiones principales del buque, eslora entre flotaciones, manga máxima de flotación calado, desplazamiento, superficie mojada, bulbo, estampa, espejo, ...

<table>
<thead>
<tr>
<th>Hull</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration:</td>
<td>Monohull</td>
</tr>
<tr>
<td>Chine type:</td>
<td>Single/hard</td>
</tr>
<tr>
<td>General</td>
<td></td>
</tr>
<tr>
<td>Length on WL:</td>
<td>39,900 m</td>
</tr>
<tr>
<td>Max beam on WL:</td>
<td>12,500 m</td>
</tr>
<tr>
<td>Max molded draft:</td>
<td>5,500 m</td>
</tr>
<tr>
<td>Displacement:</td>
<td>1472,60 t</td>
</tr>
<tr>
<td>Wetted surface:</td>
<td>645,7 m2</td>
</tr>
<tr>
<td>Demi-hull spacing:</td>
<td></td>
</tr>
<tr>
<td>ITTC-78 (CT)</td>
<td></td>
</tr>
<tr>
<td>LCB fwd TR:</td>
<td>19,932 m</td>
</tr>
<tr>
<td>LCF fwd TR:</td>
<td>19,932 m</td>
</tr>
<tr>
<td>Max section area:</td>
<td>62,8 m2</td>
</tr>
<tr>
<td>Waterplane area:</td>
<td>348,3 m2</td>
</tr>
<tr>
<td>Bulb section area:</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Bulb ctr below WL:</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Bulb nose fwd TR:</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Transom area:</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Transom beam WL:</td>
<td>10,300 m</td>
</tr>
<tr>
<td>Transom immersion:</td>
<td>1,500 m</td>
</tr>
<tr>
<td>Half entrance angle:</td>
<td>25,67 deg</td>
</tr>
<tr>
<td>Bow shape factor:</td>
<td>1,0 [WL flow]</td>
</tr>
<tr>
<td>Stern shape factor:</td>
<td>1,0 [WL flow]</td>
</tr>
</tbody>
</table>

- El área mojada se calcula mediante la fórmula de Denny (apuntes hidrostática y hidrodinámica):

\[
Sm = 1.7Lpp \times T + \frac{\Delta}{T} = 1.7 \times 35.8 \times 5.55
\]

- Apéndices, en este apartado tenemos que poner los datos sobre el propulsor:
- Condiciones meteorológicas, este apartado del Nav-Cad no se va tener en cuenta ya que las Rpas nos están aportando un margen de mar para englobar todas estas condiciones meteorológicas.

<table>
<thead>
<tr>
<th><strong>Appendage</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition</td>
<td>Component</td>
<td></td>
</tr>
<tr>
<td>Percent of hull drag</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td><strong>Planing influence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCE fwd TR:</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>VCE below WL:</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td><strong>Shafting</strong></td>
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<td></td>
</tr>
<tr>
<td>Count:</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Max prop diameter:</td>
<td>0</td>
<td>mm</td>
</tr>
<tr>
<td>Shaft angle to WL:</td>
<td>0</td>
<td>deg</td>
</tr>
<tr>
<td>Exposed shaft length:</td>
<td>0,000</td>
<td>m</td>
</tr>
<tr>
<td>Shaft diameter:</td>
<td>0,000</td>
<td>m</td>
</tr>
<tr>
<td>Wetted surface:</td>
<td>0,0</td>
<td>m²</td>
</tr>
<tr>
<td>Strut bossing length:</td>
<td>0,000</td>
<td>m</td>
</tr>
<tr>
<td>Bossing diameter:</td>
<td>0,000</td>
<td>m</td>
</tr>
<tr>
<td>Wetted surface:</td>
<td>0,0</td>
<td>m²</td>
</tr>
<tr>
<td>Hull bossing length:</td>
<td>0,000</td>
<td>m</td>
</tr>
<tr>
<td>Bossing diameter:</td>
<td>0,000</td>
<td>m</td>
</tr>
<tr>
<td>Wetted surface:</td>
<td>0,0</td>
<td>m²</td>
</tr>
</tbody>
</table>

| **Wind**               |     |     |
| Wind speed:            | 0,00 | kt  |
| Angle off bow:         | 0,00 | deg |
| Gradient correction:   | Off |     |
| **Exposed hull**       |     |     |
| Transverse area:       | 0,0 | m²  |
| VCE above WL:          | 0,000 | m   |
| Profile area:          | 0,0 | m²  |

| **Superstructure**     |     |     |
| Superstructure shape:   | Cargo ship |     |
| Transverse area:        | 0,0 | m²  |
| VCE above WL:           | 0,000 | m   |
| Profile area:           | 0,0 | m²  |

| **Seas**               |     |     |
| Significant wave ht:    | 0,000 | m   |
| Modal wave period:      | 0,0 | sec |

| **Shallow/channel**     |     |     |
| Water depth:            | 0,000 | m   |
| Type:                   | Shallow water |     |
| Channel width:          | m   |     |
| Channel side slope:     | deg |     |
| Hull girth:             | m   |     |
• La última pestaña de datos específicos que tenemos es la del margen de mar, en este caso se utilizara un margen de un 15%.

<table>
<thead>
<tr>
<th>Margin</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Design margin:</td>
<td>15</td>
</tr>
<tr>
<td>Basis:</td>
<td>Hull drag only</td>
</tr>
</tbody>
</table>

Una vez que tenemos adjuntados los datos específicos del buque, y las condiciones impartidas por los Rpas, pasamos a cubrir la pestaña de condiciones de cálculo:
En esta pestaña se elegirá el proceso más adecuado teniendo en cuenta los parámetros y la descripción dada en el apartado de ayuda:

Si nos basamos en la ayuda y en los parámetros los tres métodos de cálculo que tenemos que analizar son los siguientes:

- Holtrop

**Remarks**

A random collection of 334 models of tankers, bulk carriers, cargo ships, fishing vessels, tugs, container ships and military craft make up the data set.

[Resistance]

Widely regarded as a complete and reliable method for cruiser stern ships. It seems to underpredict resistance for transom stern craft. (Use of the speed-dependent form factor correction improves this tendency.)

The regression is derived with a speed-dependent relationship using the Havelock wave shape as its foundation. The basis for the use of the Havelock theory is currently out of favor, as a speed-dependent analysis like Havelock has trouble matching the typical Cw/Cr curve shape below Fv of about 0.3

An additional parameter – lambda – has been added to the data check for this method. Anecdotal experience and testing by HydroComp have identified combinations of hull parameters that produce significant errors with the **Holtrop** method, and lambda has proven to be an indicator of those potential errors. Lambda is a parameter used within the **Holtrop** method and is equal to 1.445 * Cw - 0.03 * L/B. A recommended upper limit for lambda has been developed by HydroComp and is used in the data check and the Method Expert ranking.
Una vez explicado el proceso de selección de los métodos de cálculo, se mostrará las gráficas “Potencia efectiva total vs velocidad” y “Resistencia total vs Velocidad”, para cada uno de los tres métodos.
4.1. Holtrop

- Potencia efectiva total vs Velocidad

La potencia efectiva total para una velocidad de 13 nudos es:

\[ P_{\text{efectiva}} = 831.1 \text{ Kw} \]

- Resistencia total Vs velocidad

La resistencia total para una velocidad de 13 nudos es:

\[ R_{\text{Total}} = 124.27 \text{ KN} \]
4.2. Oortmerssens

- Potencia efectiva total vs Velocidad

![Diagrama de potencia efectiva total vs velocidad]

La potencia efectiva total para una velocidad de 13 nudos es:

\[ P_{\text{efectiva}} = 789.2 \text{ kW} \]

- Resistencia total Vs velocidad

![Diagrama de resistencia total vs velocidad]

La resistencia total para una velocidad de 13 nudos es:

\[ R_{\text{Total}} = 118.01 \text{ KN} \]
4.3. Roach

La potencia efectiva total para una velocidad de 13 nudos es:

\[ P_{\text{efectiva}} = 356.7 \text{ KW} \]

- Resistencia total Vs velocidad

La resistencia total para una velocidad de 13 nudos es:

\[ R_{\text{Total}} = 53.03 \text{ KN} \]
4.4. Resumen

<table>
<thead>
<tr>
<th>Método de Calculo</th>
<th>Resistencia al avance(KN)</th>
<th>Potencia efectiva(KW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holtrop</td>
<td>124.27</td>
<td>831.1</td>
</tr>
<tr>
<td>Oortmenssens</td>
<td>118.01</td>
<td>789.2</td>
</tr>
<tr>
<td>Roach</td>
<td>53.03</td>
<td>356.7</td>
</tr>
</tbody>
</table>

Una vez analizado los tres métodos que se podrían adaptar para realizar los cálculos, tenemos que eliminar dos de ellos.

El proceso elegido para la elección del método es el siguiente:

- Analizamos los parámetros

En los tres métodos en solamente se nos desvía un parámetro por lo que en este apartado no podemos eliminar ninguno de los métodos.

- Leemos las especificación de cada método

**Holtrop**: el método de holtrop se basa en \( cp \), como el parámetro es correcto este sería uno de los métodos que más se nos ajustase.

**Oortmenssens**: es un método diseñando para remolcadores de poca eslora, por lo que también sería un método que se nos podría adaptar.

**Roach**: Este será el primer método a eliminar, porque en la especificación tenemos que fue un diseño para 11 modelos.

Una vez que tenemos que tanto Holtrop como Oortmenssen son dos métodos que se nos adaptan a los cálculos de nuestro remolcador, elegimos Oortmenssennsen, porque estamos trabajando con un remolcador de poca eslora.

<table>
<thead>
<tr>
<th>Método de Calculo</th>
<th>Resistencia al avance(KN)</th>
<th>Potencia efectiva(KW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oortmenssens</td>
<td>118.01</td>
<td>789.2</td>
</tr>
</tbody>
</table>
Antes de pasar al siguiente punto se debe aclarar que la potencia efectiva está relacionada con la potencia que se entrega al propulsor, pero la potencia del motor (BHP) en aguas libres es más alta que esta porque se tienen que tener en cuenta los siguientes rendimientos:

\[ BHP = EHP \times \frac{MM}{\eta_1 \times \eta_2 \times \eta_3 \times \eta_4} \]

- \( \eta_1 \): Rendimiento de la hélice
- \( \eta_2 \): Rendimiento del casco
- \( \eta_3 \): Rendimiento rotativo relativo
- \( \eta_4 \): Rendimiento mecánico

5. Propulsor

Una vez calculada la resistencia al avance, y la potencia efectiva tenemos que pasar al siguiente paso que sería estimar que propulsor necesitaría nuestro buque.

La primera pestaña que nos encontramos en el Nav-Cad en referencia al propulsor es la siguiente:
En esta pestaña tenemos que definir el número de propulsores y sus características.

Nuestro buque tendrá 2 propulsores.

Los propulsores son de paso variable, esto es debido principalmente a las condiciones de navegación que está sometido nuestro buque.

En puntos anteriores ya vimos que un remolcador de salvamento tiene dos condiciones de navegación diferenciadas, que es cuando está navegando en aguas libres y en operación de remolque.

Cuando el buque navega en operación de remolque, la velocidad de avance es muy baja, influyendo esto en la hélice ya que está absorbiendo un par muy grande debido a que las rpm que se están suministrando en el motor son las mismas. En la primera solución que puedes pensar es en que se suministre un par más pequeño, pero el motor se sobrecarga.

La única solución que tenemos para controlar las dos situaciones de operación es montar propulsores de paso variable.(CPP)

Serie de propulsor, el programa Nav-Cad nos ofrece 4 series de las cuales elegimos la Kaplan 19A, porque si leemos la especificación dada, nos dice que son una serie usada en remolcadores, y además se adapta a diferentes condiciones de navegación. En el anexo 1 va adjuntada la ayuda con respecto a las series Kaplan.

De las series Kaplan las elegida es la Kaplan 19A, estas series están diseñadas para usarse en toberas, con ello trae la desventaja de que a velocidades superiores a los 10 Kn se puede producir cavitación.

5.1. Kaplan 19A

Un resumen de la especificación sería:

- Permiten propulsores de 3 a 5 palas
- Son una serie recomendada para una helice de 5 palas (nostros analizaremos los rendimienros de 3-5 palas)
- Al principio la formula contenia errores pero Nav-Cad ya lo tubo en cuenta
- Tienen una buena reacción frente a la cavitación
- De todas la serie Kaplan son las que tienen la punta más afilada.
Las cuales podemos comprobar en la ayuda del Nav-Cad:

<table>
<thead>
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<tbody>
<tr>
<td>Configuration</td>
<td>Ducted</td>
</tr>
</tbody>
</table>

**Parameters**
- Number of blades: 3-5
- Blade area ratio: 3 blades: 0.65
  - 4 blades: 0.65 - 0.70
  - 5 blades: 0.67 - 0.65
- Pitch/Diameter ratio: 0.50 - 1.40
- Advance coefficient: (J) 0.05 - 1.50

**Remarks**
- This series was developed from open water analysis of the series of non-canting propellers in a accelerating nozzle. No scale correction is applied. Discrete blade area ratios are allowed for three and five bladed propellers, but NavCad fits a linear interpolation to allow for a range of blade area ratios for your bladed propellers.
- The original publication had a number of formula errors which were corrected by the authors in 1982 (but not put into general publication). NavCad uses the corrected values.
- HydroComp has developed an extension for the prediction of thrust and torque for 3-bladed propellers in a accelerating nozzle. This is suitable for 0.65 to 0.95 ERP.
6. Estimación de potencia en aguas libres

Cuando hablamos de la potencia en aguas libres estamos hablando de la potencia al freno (BHP), por lo tanto aquí ya se van tener en cuenta todos los rendimientos.

En este punto el programa a usar es Nav-Cad, por lo tanto solamente tenemos que seguir cubriendo todas las pestañas necesarias.

Como ya explicamos antes tendriamos dos propulsores de la serie Kaplan 19A, aunque la serie es diseñada para 5 palas nosotros vamos hacer el análisis del las 3 palas.
El ratio de área es el recomendado por la serie, el diámetro del propulsor es una aproximación basándonos en el buque base.

El resto de los valores son aproximaciones del propio Nav-Cad.

Una vez que tenemos las características del propulsor, tenemos que pasar a la pestaña donde tenemos que asignar las condiciones de cálculo.

El método que mejor se adapta en los diferentes parámetros es Holtrop, El factor de forma es calculado mediante el método estándar, el criterio de cavitation será el de Keller eqn y las revoluciones fijadas serán 100 rpm.

Una vez que tenemos todas las pestañas cubiertas pasamos a diseñar el propulsor, este diseño se realiza en la pestaña propeller sizing, en esta pestaña tenemos el diámetro, la velocidad de diseño, las revoluciones de referencia, la resistencia rotal obtenida por el método holtrop,...
La pestaña anterior sería la correcta para el diseño del propulsor de 3 palas, pero tenemos que tener en cuenta que cuando tengamos que diseñar el propulsor de 4 y 5 palas la expansión de área tendrá que ser calculada (size).

Una vez que tenemos todos estos parámetros tenemos que comparar las potencias necesarias para cada uno de los propulsores.

**6.1. Propulsor de 3 palas:**

![Graph showing power output vs speed](image)

PB: 2629.7 Kw
6.2. Propulsor de 4 palas:

EFFOA: 0.5579

PB: 2665.9 kW
6.3. Propulsor de 5 palas:

**EFFOA:** 0.5504

**PB:** 2577.9 Kw
6.4. Resumen

El resumen de los tres anteriores propulsores sería el siguiente:

<table>
<thead>
<tr>
<th>Nº de Palas</th>
<th>EFFOA</th>
<th>PB TOTAL (Kw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.5579</td>
<td>2629.7</td>
</tr>
<tr>
<td>4</td>
<td>0.5504</td>
<td>2665.9</td>
</tr>
<tr>
<td>5</td>
<td>0.5691</td>
<td>2577.9</td>
</tr>
</tbody>
</table>

De todos los propulsores el que menos potencia de freno necesita es el de 5 palas, por los cuales sería el propulsor ideal para este buque. Pero en nuestro caso estamos condicionados, ya que nuestros schottel son de 4 palas.

Recordemos que la potencia que se debe suministrar a una condición de servicio del 0,85:

\[
P_B = \frac{2621.2}{0.85} = 3135 \text{ kw}
\]

Si comparamos esta potencia final con la potencia calculada en el cuaderno anterior es mucho menor debido al tiro necesario del remolcador.

En el siguiente apartado se realizara una estimación de potencia en función de la tracción a punto fijo.
7. Estimación de potencia en condiciones de remolque.

Para el cálculo del tiro vamos necesitar los siguientes puntos:

- Rectas de Regresión
- Guía Wartsila
- Schottel
- Programa Nav-Cad

7.1. Rectas de regresión.

La potencia estimada en las rectas de regresión es de 4252.6 KW, pero nuestro buque va ser diseñado para dos motores por lo que la potencia necesaria por cada uno de este motor sería:

\[ P(KW) = \frac{4252.6}{2} = 2126.3KW \]

7.2. Motor Wartsila

Una vez que sabemos la potencia necesaria nos vamos a la página de Wartsila y nos descargamos el pdf de motores de velocidad media. Al principio de este Pdf (Anexo 5) tenemos la siguiente tabla:

<table>
<thead>
<tr>
<th>Cylinder configuration</th>
<th>Main engines</th>
<th>900 rpm</th>
<th>1000 rpm</th>
<th>Generating sets</th>
<th>900 rpm</th>
<th>1000 rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Kw]</td>
<td>[Kw]</td>
<td></td>
<td>[KVA]</td>
<td>[kWe]</td>
<td>[KVA]</td>
</tr>
<tr>
<td>6L26</td>
<td>1950</td>
<td>2040</td>
<td>2352</td>
<td>2461</td>
<td>1969</td>
<td></td>
</tr>
<tr>
<td>8L26</td>
<td>2600</td>
<td>2720</td>
<td>3136</td>
<td>3281</td>
<td>2625</td>
<td></td>
</tr>
<tr>
<td>9L26</td>
<td>2925</td>
<td>3060</td>
<td>3528</td>
<td>3691</td>
<td>2953</td>
<td></td>
</tr>
<tr>
<td>12V26</td>
<td>3900</td>
<td>4080</td>
<td>4704</td>
<td>4922</td>
<td>3937</td>
<td></td>
</tr>
<tr>
<td>16V26</td>
<td>5200</td>
<td>5440</td>
<td>6273</td>
<td>6562</td>
<td>5250</td>
<td></td>
</tr>
</tbody>
</table>

Lo recomendable es elegir una potencia un poco superior a la calculada por lo que el motor que mejor se nos adapta es 8L26 de 900 rpm.
Antes de introducir este valor en el programa tenemos que comprobar si este motor puede trabajar a esta potencia en el paralelogramo de diseño.

\[
Power[\%] = \frac{2126.3}{2600} = 0.8178 = 81.78\% 
\]

Por lo que sí podría trabajar a este régimen de trabajo.

7.3. **Elección del propulsor:**

Una vez que sabemos el motor tenemos que irnos a la página de schottel para saber que propulsor se nos adapta y saber sus características para después sustituirlo en el programa Nav-Cad.

En la propia página vemos que nos recomiendan la gama de schottell SRP para remolcadores, tenemos los siguientes:
El propulsor que se nos adapta tanto en la potencia como en las rpm es el SRP 4000, del cual sabemos que su diámetro es de 2800 mm.

7.4. Nav-Cad

7.4.1. Motor

Una vez que tenemos el motor el propulsor, tenemos que definir el motor en el programa pinchando en la hélice y después en Engine Data, Se nos abriría la siguiente pestaña:
De esta pestaña tenemos que cubrir los siguientes valores relacionados con la condición de carga del motor:

<table>
<thead>
<tr>
<th>RPM</th>
<th>Power</th>
<th>Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>900</td>
<td>2600,0</td>
</tr>
<tr>
<td>2</td>
<td>846</td>
<td>2210,0</td>
</tr>
<tr>
<td>3</td>
<td>828</td>
<td>2125,0</td>
</tr>
<tr>
<td>4</td>
<td>814</td>
<td>1950,0</td>
</tr>
<tr>
<td>5</td>
<td>720</td>
<td>1300,0</td>
</tr>
<tr>
<td>6</td>
<td>640</td>
<td>650,0</td>
</tr>
</tbody>
</table>

Sabiendo las condiciones de potencia al 85%, 81,78%, 75%, 50% y 25%. Una vez que tenemos estas potencias nos vamos a la gráfica del motor para hélices de paso controlable para saber las revoluciones.
Una vez que tenemos las potencias y las revoluciones a los distintos rangos anteriores marcados pasamos a un cálculo estimado del combustible, quedándonos finalmente la siguiente tabla:

<table>
<thead>
<tr>
<th>% de funcionamiento</th>
<th>Potencia (KW)</th>
<th>Revoluciones (rpm)</th>
<th>Combustible</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>2600</td>
<td>900</td>
<td>540</td>
</tr>
<tr>
<td>85%</td>
<td>2210</td>
<td>846</td>
<td>537</td>
</tr>
<tr>
<td>81.78% (c.f)</td>
<td>2125</td>
<td>828</td>
<td>520</td>
</tr>
<tr>
<td>75%</td>
<td>1950</td>
<td>814</td>
<td>400</td>
</tr>
<tr>
<td>50%</td>
<td>1300</td>
<td>720</td>
<td>300</td>
</tr>
<tr>
<td>25%</td>
<td>650</td>
<td>640</td>
<td>120</td>
</tr>
</tbody>
</table>

El cálculo del combustible se hace a partir del consumo reflejado en las tablas del motor para los distintos rangos de funcionamiento sabiendo que este rango se da en (g/Kw*h).

Una vez que tenemos el motor definido tenemos que comprobar si este motor nos va dar el tiro necesario. Recordemos que este remolcador tendrá 68 TPF.

**7.4.2. Calculo para 68 Tpf**

En este apartado seguimos trabajando con el programa Navcad, solamente tenemos que realizar unos cambios de todo lo calculado anteriormente:

- Como sabemos que vamos trabajar con un schottel que es un propulsor de 4 palas, y que tienen un diámetro de 2800 mm:
• **System analysis:** Simplemente tenemos que decirle al programa que ahora los cálculos se van realizar por el tiro del remolcador y que las rpm van ser variables.

![](image)

• **Propeller sizing:** En este apartado esta sería la pestaña más importante ya que tenemos que designar la potencia el radio las rpm y la velocidad

![](image)

Para un mejor calculo vamos bajar el rango de velocidades, y la velocidad mínima que tenemos ahora es de 0.05 Kn. Para esta velocidad y el motor funcionando al 100% tenemos que la tracción conseguida sería:

\[
TFP = \frac{709 \text{ KN}}{9.81} = 72 \text{ t}
\]
Por lo que en principio serían los motores que nos cumplen todos los requisitos. A continuación tenemos una gráfica con la tracción dependiendo de la velocidad.

La siguiente tabla sería el rendimiento del propulsor final para la condición de navegación.
8. HydraOnline

HydraOnline es un programa para el cálculo del tiro del remolcador, este programa nos lo ofrece la propia página web de schottel, con solamente registrarse.

Una vez registrado los datos a cubrir son los siguientes:

- **SRP 4000** es el schottel que mejor se adaptaba a nuestro motor de wartsila 8L26.
- **Input power**, sería la potencia de cada uno de nuestros motores.
- **Diameter**, es el diámetro que tiene este tipo de schottel.
- **Thrust deduction**, es un coeficiente que está relacionado con el empuje, el propio programa nos da unas aproximaciones:
Como nosotros ya hicimos los cálculos en el Nav-Cad nos vamos al report y tomamos el coeficiente correspondiente que se

Una vez que tenemos todos los datos nos encontramos que el tiro que tendríamos con estas condiciones sería de aproximadamente 78t, más alto que el que tendríamos que cumplir y también más alto que el calculado por el programa Nav-Cad, pero no es un valor muy fuera del rango.
9. Predicción aguas libres con el motor elegido.

Una vez que vemos que el motor tenemos que ver cuál sería la potencia necesaria por nuestro buque cuando navega en aguas libres. Para este cálculo seguimos utilizando el programa Nav-Cad.

El rendimiento del propulsor para la condición de navegación sería:

La potencia al freno necesaria para la condición de navegación dada por los rpas sería:

Potencia (KW)=1488 Kw

Y la gráfica de la potencia sería la siguiente:
10. Timón

Cuando hablamos de timones estamos hablando de los aparatos de gobierno que dotarán de maniobrabilidad al buque.

Nuestro buque no llevará timones porque nuestro schottel (srp) combina la propulsión y el gobierno azimutal.

Su rotación de 360 ° de la hélice timón permite que toda la potencia de entrada está disponible para maniobrar.

Las ventajas de usar este tipo de propulsores sería:

- Máxima maniobrabilidad
- Máxima eficacia
- Operación económica
- Instalación para ahorrar espacio
- Mantenimiento sencillo
- Alta fiabilidad
- Optimizada en términos de la cavitación y vibración
- Diseño fiable
- Hélice de paso variable o fija
- Conducción Z o L

Tendríamos toda la información sobre los SRP en el siguiente enlace:

http://www.schottel.de/es/propulsion-marina/srp-helice-timon/


Ya explicamos en el apartado anterior que nos es necesario timón en nuestro buque pero aun así realizaremos los cálculos. Para ello usaremos:

- Proyecto básico del buque mercante.
- Sociedad de clasificación Bureau Veritas (Parte B/Capítulo 9/Sección 1)
10.1.1. Área del timón.

Área de cada timón: 
\[ \text{Area de cada timón: } (0.01 \times L_{pp} \times T \times (1 + 50 \times c_b^2 \times \left(\frac{B}{L_{pp}}\right)^2)/2 = 3.04m^2 \]

<table>
<thead>
<tr>
<th>DIMENSIONES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lpp</td>
</tr>
<tr>
<td>T</td>
</tr>
<tr>
<td>Cb</td>
</tr>
<tr>
<td>B</td>
</tr>
</tbody>
</table>

10.1.2. Altura del timón

La altura del timón será la suma del diámetro de nuestro propulsor más un margen de 0,2.

\[ \text{Altura del timón} = 2.8 + 0.2 = 3 \, m \]

10.1.3. Longitud del timón

La longitud del timón sería la relación que existe entre el área y la atura:

\[ \text{Longitud del timón} = \frac{3.04}{3} = 1.015 \, m \]

10.1.4. Relación de aspecto

\[ \text{Relación de aspecto} = \frac{3.0}{1.015} = 2.9 \, m \]

10.1.5. Geometría del timón.

Para los perfiles de los timones se usan los perfiles aeronáuticos NACA. Para este buque escogemos la serie 0015 que son simétricos. Las coordenadas de estos perfiles se dan en porcentajes de la cuerda, es decir, de la longitud del perfil.
Para poder ver el perfil de nuestro perfil usamos el programa airfoiltools.

**NACA 0015 (naca0015-il)**

**NACA 0015 - NACA 0015 airfoil**

11. **Servomotor**

11.1. **FR máxima**

11.1.1. **Fr máxima avante**

Para calcular el par vamos a guiarnos por el Bureau Veritas, Parte B/Capítulo 9, Sección 2.

\[
CR = 123 \times Nr \times A \times V^2 \times K1 \times K2 \times K3
\]

- **Nr**: Es un coeficiente de navegación. Depende de si el buque navega en zonas costeras o en zonas protegidas. En este caso el buque navegara en zonas costeras tomaremos Nr=1.

- **V**, Para el cálculo de esta velocidad tenemos: Vmin definida en el reglamento Bureau Veritas.(Vav)

\[
V_{min} = \frac{13 + 20}{3} = \frac{13 + 20}{3} = 11 \text{ kn o } 13 Kn
\]

- **K1**, factor de forma, utilizamos el dado en el programa Nav-Cad, 1.366

- **K2**, Coeficiente que depende del tipo de perfil. Para perfil NACA 00xy es 1,10 para marcha avante y 0,80 para marcha atrás.
- **K3**, Coeficiente que depende de la posición del timón respecto a la estela del propulsor. Se tomará igual a uno. 

\[ CR_{av} = 132 \times 1 \times 3.04 \times 13^2 \times 1.366 \times 1.10 \times 1 = 102.3 KN \]

**CRav=102.3 KN**

11.1.2. Fr máxima ciando

Para calcular el par vamos a guiarnos por el Bureau Veritas, Parte B/Capítulo 9, Sección 2.

\[ CR = 123 \times Nr \times A \times V^2 \times K1 \times K2 \times K3 \]

- **Nr**: Es un coeficiente de navegación. Depende de si el buque navega en zonas costeras o en zonas protegidas. En este caso el buque navegará en zonas costeras tomaremos Nr=1.
- **V**, Para el cálculo de esta velocidad tenemos:
  - Vmin definida en el reglamento Bureau Veritas.(Vci)
  \[ V = 0.5 \times V_{min} = 6.5 Kn \]
- **K1**, factor de forma, utilizamos el dado en el programa Nav-Cad, 1.366
- **K2**, Coeficiente que depende del tipo de perfil. Para perfil NACA 00xy es 1,10 para marcha avante y 0,80 para marcha atrás.
- **K3**, Coeficiente que depende de la posición del timón respecto a la estela del propulsor. Se tomará igual a uno.

\[ CR_{ci} = 132 \times 1 \times 3.04 \times 6.5^2 \times 1.366 \times 1.10 \times 1 = 18.5 kN \]

**CRci= 18.5KN**
11.2. Momento

11.2.1. Momento avante

\[ M_{tr} = cr \times r = Cr \times (b \times (\alpha - \frac{Af}{A})) \]

- \( b \), sería la manga del timón, pero para el cálculo vamos utilizar la cuerda. (1.015 m)
- \( \alpha \), Coeficiente que depende de la marcha avante o ciando
  \[ \alpha_{av}, 0.333 \]
  \[ \alpha_{ci}, 0.66 \]

- \( Af \), Área de la porción de área del timón situada a proa de la línea centro de la mecha del timón, en m² (20% del área total según Proyecto Básico del Buque Mercante)

\[ M_{tr} = 102.3 \, Kn \times (1.015 \times (0.33 - 0.608/3.04)) = 14.63 \, Kn \]

\[ M_{tr} = 14.36 \, Kn \]

11.2.2. Momento ciando

\[ M_{tr} = cr \times r = Cr \times (b \times (\alpha - \frac{Af}{A})) \]

- \( b \), sería la manga del timón, pero para el cálculo vamos utilizar la cuerda. (1.015 m)
- \( \alpha \), Coeficiente que depende de la marcha avante o ciando
  \[ \alpha_{av}, 0.333 \]
  \[ \alpha_{ci}, 0.66 \]

- \( Af \), Área de la porción de área del timón situada a proa de la línea centro de la mecha del timón, en m² (20% del área total según Proyecto Básico del Buque Mercante)

\[ M_{tr} = 18.5 \, Kn \times (1.015 \times (0.66 - 0.608/3.04)) = 8.63 \, Kn \]

\[ M_{tr} = 8.63 \, Kn \]
11.3. Potencia del servomotor

Con los momentos del timón ya se puede calcular la potencia necesaria del servomotor. Se va realizar el cálculo a partir de lo que nos determine el reglamento SOLAS.

El reglamento SOLAS exige para el aparato de gobierno principal un cambio de timón desde una posición de 35° a un lado hasta otra de 35° al lado opuesto hallándose el buque navegando a la velocidad máxima de servicio marcha avante y con su calado máximo en agua salada, y en las mismas condiciones, desde una posición de 35° a cualquiera de ambas bandas hasta otra de 30° a la banda opuesta, sin que ello lleve más de 28 segundos.

La fórmula sería la siguiente:

\[
\text{Potencia} = M_{\text{avant}} \left( KN \cdot m \right) \cdot \frac{\text{Angulo(rad)}}{\text{tiempo(s)}} = 14.63 \cdot \frac{1.14}{28} = 0.6 \text{Kw}
\]

- Angulo=65°=1.14rad
- Tiempo=28 s

Potencia= 0.6 KW
ANEXO 1

(Report Resistencia al avance)
### Analysis parameters

**Vessel drag**
- **Technique:** [Calc] Prediction
- **Prediction:** Holtrop
- **Reference ship:** Custom
- **Model LWL:** ITTC-57
- **Friction line:** ITTC-78
- **Hull form factor:** [On] 1.366
- **Speed corr:** [Off]
- **Spray drag corr:** [Off]
- **Corr allowance:** 0.000477
- **Roughness [mm]:** [Off]

**Added drag**
- **Appendage:** [Calc] Holtrop (Component)
- **Wind:** [Off]
- **Seas:** [Off]
- **Shallow/channel:** [Off]
- **Margin:** [Calc] Hull drag only [15%]

### Water properties
- **Type:** Salt
- **Density:** 1026.00 kg/m³
- **Viscosity:** 1.18920e-6 m²/s

### Prediction method check [Holtrop]

<table>
<thead>
<tr>
<th>Parameters</th>
<th>FN [design]</th>
<th>CP</th>
<th>LWL/BWL</th>
<th>BWL/T</th>
<th>Lambda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>0.34</td>
<td>0.57</td>
<td>3.19*</td>
<td>2.27</td>
<td>0.73</td>
</tr>
<tr>
<td>Range</td>
<td>0.06··0.40</td>
<td>0.55··0.85</td>
<td>3.90··14.90</td>
<td>2.10··4.00</td>
<td>0.01··0.92</td>
</tr>
</tbody>
</table>

### Prediction results

#### SPEED COEFS

<table>
<thead>
<tr>
<th>SPEED [kt]</th>
<th>FN</th>
<th>FV</th>
<th>RN</th>
<th>CF</th>
<th>[CV/CF]</th>
<th>CR</th>
<th>dCF</th>
<th>CA</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00</td>
<td>0.052</td>
<td>0.098</td>
<td>3.45e7</td>
<td>0.002445</td>
<td>1.366</td>
<td>0.000112</td>
<td>0.000000</td>
<td>0.000477</td>
<td>0.003930</td>
</tr>
<tr>
<td>3.00</td>
<td>0.078</td>
<td>0.147</td>
<td>5.18e7</td>
<td>0.002297</td>
<td>1.366</td>
<td>0.000104</td>
<td>0.000000</td>
<td>0.000477</td>
<td>0.003718</td>
</tr>
<tr>
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<td>0.104</td>
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<td>0.002200</td>
<td>1.366</td>
<td>0.000098</td>
<td>0.000000</td>
<td>0.000477</td>
<td>0.003580</td>
</tr>
<tr>
<td>5.00</td>
<td>0.130</td>
<td>0.245</td>
<td>8.63e7</td>
<td>0.002128</td>
<td>1.366</td>
<td>0.000094</td>
<td>0.000000</td>
<td>0.000477</td>
<td>0.003479</td>
</tr>
<tr>
<td>6.00</td>
<td>0.156</td>
<td>0.293</td>
<td>1.04e8</td>
<td>0.002073</td>
<td>1.366</td>
<td>0.000095</td>
<td>0.000000</td>
<td>0.000477</td>
<td>0.003403</td>
</tr>
<tr>
<td>7.00</td>
<td>0.182</td>
<td>0.342</td>
<td>1.21e8</td>
<td>0.002027</td>
<td>1.366</td>
<td>0.000115</td>
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#### RESISTANCE AND EFFECTIVE POWER

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### Hull data

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<td>Configuration:</td>
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<td>Chine type:</td>
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<td>[XCG/LP 0,000]</td>
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<td>Length on WL:</td>
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<td>Max beam on WL:</td>
<td>[LWL/BWL 3,192] 12,500 m</td>
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<td>Max molded draft:</td>
<td>[BWL/T 2,273] 5,500 m</td>
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<td>Displacement:</td>
<td>[CB 0,523] 1472,60 t</td>
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<tr>
<td>ITTC-78 (CT)</td>
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<td>Aft station (fwd TR):</td>
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# Resistance

**Project ID** Remolcador de salvamento  
**Description** 68 TPF  
**File name** remolcador 68tpf.hcnc

## Appendage data

### General
- **Definition:** Component
- **Percent of hull drag:** 0,00 %

### Planing influence
- **LCE fwd TR:** 0,000 m
- **VCE below WL:** 0,000 m

### Shafting
- **Count:** 2
- **Max prop diam:** 0,0 mm
- **Shaft angle to WL:** 0,00 deg
- **Exposed shaft length:** 0,000 m
- **Shaft diameter:** 0,000 m
- **Wetted surface:** 0,000 m
- **Strut bossing length:** 0,000 m
- **Bosser diameter:** 0,000 m
- **Wetted surface:** 0,000 m
- **Wetted surface:** 0,000 m

### Skeg/Keel
- **Count:** 0
- **Type:** Skeg
- **Mean length:** 0,000 m
- **Mean width:** 0,000 m
- **Height aft:** 0,000 m
- **Height mid:** 0,000 m
- **Height fwd:** 0,000 m

### Strut (per shaft line)
- **Count:** 0
- **Root chord:** 0,000 m
- **Tip chord:** 0,000 mm
- **Span:** 0,000 m
- **T/C ratio:** 0,000
- **Projected area:** 0,0 m2
- **Wetted surface:** 0,0 m2

### Rudder
- **Count:** 0
- **Rudder location:** Behind propeller
- **Type:** Balanced foil
- **Root chord:** 0,000 m
- **Tip chord:** 0,000 m
- **Span:** 0,000 m
- **T/C ratio:** 0,000
- **LE sweep:** 0,00 deg
- **Projected area:** 0,0 m2
- **Wetted surface:** 0,0 m2

### Bilge keel
- **Count:** 0
- **Mean length:** 0,000 m
- **Mean base width:** 0,000 m
- **Mean projection:** 0,000 m
- **Wetted surface:** 0,0 m2

### Tunnel thruster
- **Count:** 0
- **Diameter:** 0,000 m

### Stabilizer
- **Count:** 0
- **Root chord:** 0,000 m
- **Tip chord:** 0,000 m
- **Span:** 0,000 m
- **T/C ratio:** 0,000
- **Projected area:** 0,0 m2
- **Wetted surface:** 0,0 m2

### Dynamic multiplier:
- **1,00**

### Environment data

### Wind
- **Wind speed:** 0,00 kt
- **Angle off bow:** 0,00 deg
- **Gradient correction:** Off

### Seas
- **Significant wave ht:** 0,000 m
- **Modal wave period:** 0,0 sec

### Shallow/channel
- **Water depth:** 0,000 m
- **Type:** Shallow water
- **Channel width:** 0,000 m
- **Channel side slope:** 0,00 deg
- **Hull girth:** 0,000 m
Symbols and values

- FN = Froude number [LWL]
- FV = Froude number [VOL]
- RN = Reynolds number [LWL]
- CF = Frictional resistance coefficient
- CV/CF = Viscous/frictional resistance coefficient ratio [dynamic form factor]
- CR = Residuary resistance coefficient
- dCF = Added frictional resistance coefficient for roughness
- CA = Correlation allowance [dynamic]
- CT = Total bare-hull resistance coefficient
- RBARE = Bare-hull resistance
- RAPP = Additional appendage resistance
- RWIND = Additional wind resistance
- RSEAS = Additional sea-state resistance
- RCHAN = Additional shallow/channel resistance
- RMARGIN = Resistance margin
- RTOTAL = Total vessel resistance
- CTLR = Telfer residuary resistance coefficient
- CTLT = Telfer total bare-hull resistance coefficient
- PEBARE = Bare-hull effective power
- PETOTAL = Total effective power

+ = Design speed indicator
* = Exceeds parameter limit
Resistance
23 jul 2015 10:39
Project ID Remolcador de salvamento
Description 68 TPF
File name remolcador 68tpf.hcnc

Analysis parameters
Vessel drag ITTC-78 (CT)
Technique: [Calc] Prediction
Prediction: Roach
Reference ship: Model LWL:
Expansion: Custom
Friction line: ITTC-57
Hull form factor: [On] 1,366
Speed corr: [Off]
Spray drag corr: [Off]
Corr allowance: 0,000477
Roughness [mm]: [Off]

Added drag
Appendage: [Calc] Holtrop (Component)
Wind: [Off]
Seas: [Off]
Shallow/channel: [Off]
Margin: [Calc] Hull drag only [15%]

Water properties
Water type: Salt
Density: 1026,00 kg/m3
Viscosity: 1,18920e-6 m2/s

Prediction method check [Roach]
Parameters FN [design] CVOL CP XCB/LWL LWL/BWL BWL/T
Value
0,34 3,54* 0,57 0,500 3,19 2,27
Range
0,27··0,41 3,93··5,23 0,56··0,68 0,479··0,498 3,07··4,4 7 2,34··3,20

Prediction results
SPEED COEFS ITTC-78 COEFS
SPEED [kt] FN FV RN CF [CV/CF] CR dCF CA CT
2,00 0,052 0,098 3,45e7 0,002445 1,366 0,000001 0,000000 0,000477 0,003818
3,00 0,078 0,147 5,18e7 0,002297 1,366 0,000001 0,000000 0,000477 0,003616
4,00 0,104 0,196 6,90e7 0,002200 1,366 0,000001 0,000000 0,000477 0,003483
5,00 0,130 0,245 8,63e7 0,002128 1,366 0,000001 0,000000 0,000477 0,003386
6,00 0,156 0,293 1,04e8 0,002073 1,366 0,000001 0,000000 0,000477 0,003309
7,00 0,182 0,342 1,21e8 0,002027 1,366 0,000001 0,000000 0,000477 0,003247
8,00 0,208 0,391 1,38e8 0,001989 1,366 0,000001 0,000000 0,000477 0,003195
10,00 0,260 0,489 1,73e8 0,001880 1,366 0,000001 0,000000 0,000477 0,003046
12,00 0,312 0,587 2,07e8 0,001859 1,366 0,000001 0,000000 0,000477 0,003131
+ 13,00 + 0,338 0,636 2,24e8 0,001839 1,366 0,000001 0,000000 0,000477 0,003131

RESISTANCE AND EFFECTIVE POWER
2,00 1,34 0,00 0,00 0,00 0,00 0,00 0,00 1,54 1,4 1,6
3,00 2,85 0,00 0,00 0,00 0,00 0,00 0,00 3,28 4,4 5,1
4,00 4,89 0,00 0,00 0,00 0,00 0,00 0,00 5,62 10,1 11,6
5,00 7,42 0,00 0,00 0,00 0,00 0,00 0,00 8,53 19,1 21,9
6,00 10,44 0,00 0,00 0,00 0,00 0,00 0,00 12,01 32,2 37,1
7,00 13,95 0,00 0,00 0,00 0,00 0,00 0,00 16,04 50,2 57,8
8,00 17,93 0,00 0,00 0,00 0,00 0,00 0,00 20,62 73,8 84,9
10,00 27,28 0,00 0,00 0,00 0,00 0,00 0,00 31,37 140,3 161,4
12,00 38,45 0,00 0,00 0,00 0,00 0,00 0,00 44,22 237,4 273,0
+ 13,00 + 46,38 0,00 0,00 0,00 0,00 0,00 0,00 53,34 310,2 356,7

OTHER
SPEED [kt] CTLR CTTL
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3,00 0,00001 0,03245
4,00 0,00001 0,03126
5,00 0,00001 0,03039
6,00 0,00001 0,02970
7,00 0,00001 0,02915
8,00 0,00001 0,02868
10,00 0,00001 0,02793
12,00 0,00001 0,02734
+ 13,00 + 0,00102 0,02810
### Hull data

#### General
- **Configuration:** Monohull
- **Chine type:** Single/hard
- **Length on WL:** 39,900 m
- **Max beam on WL:** [LWL/BWL 3,192] 12,500 m
- **Max molded draft:** [BWL/T 2,273] 5,500 m
- **Displacement:** [CB 0,523] 1472,60 t
- **Wetted surface:** [CWS 5,075] 645,7 m²

#### ITTC-78 (CT)
- **LCB fwd TR:** [XCB/LWL 0,500] 19,932 m
- **LCF fwd TR:** [XCF/LWL 0,500] 19,932 m
- **Max section area:** [CX 0,913] 62,8 m²
- **Waterplane area:** [CWP 0,699] 348,8 m²
- **Bulb section area:** 0,0 m²
- **Bulb ctr below WL:** 0,000 m
- **Bulb nose fwd TR:** 0,000 m
- **Transom area:** [ATR/AX 0,000] 0,0 m²
- **Transom beam WL:** [BTR/BWL 0,824] 10,300 m
- **Transom immersion:** [TTR/T 0,273] 1,500 m
- **Half entrance angle:** 25,67 deg
- **Bow shape factor:** [WL flow] 1,0
- **Stern shape factor:** [WL flow] 1,0

#### Planing
- **Proj chine length:** 0,000 m
- **Proj bottom area:** 0,0 m²
- **LCG fwd TR:** [XCG/LP 0,000] 0,000 m
- **VCG below WL:** 0,000 m
- **Aft station (fwd TR):** 0,000 m
- **Chine beam:** 0,000 m
- **Chine ht below WL:** 0,000 m
- **Deadrise:** 0,00 deg
- **Fwd station (fwd TR):** 0,000 m
- **Chine beam:** 0,000 m
- **Chine ht below WL:** 0,000 m
- **Deadrise:** 0,00 deg
- **Propulsor type:** Propeller
- **Propeller diameter:** 0,0 mm
- **Shaft angle to WL:** 0,00 deg
- **Position fwd TR:** 0,000 m
- **Position below WL:** 0,000 m
### Appendage data

#### General
- **Definition:** Component
- **Percent of hull drag:** 0.00 %

#### Planing influence
- **LCE fwd TR:** 0.000 m
- **VCE below WL:** 0.000 m

#### Shafting
- **Count:** 2
- **Max prop diam:** 0.0 mm
- **Shaft angle to WL:** 0.00 deg
- **Exposed shaft length:** 0.000 m
- **Shaft diameter:** 0.000 m
- **Wetted surface:** 0.0 m²
- **Strut bosses diam:** 0.000 m
- **Wetted surface:** 0.0 m²
- **Bosss diam:** 0.000 m
- **Wetted surface:** 0.0 m²
- **Hull bosses diam:** 0.000 m
- **Wetted surface:** 0.0 m²

#### Strut (per shaft line)
- **Count:** 0
- **Root chord:** 0.000 m
- **Tip chord:** 0.000 mm
- **Span:** 0.000 m
- **T/C ratio:** 0.000
- **Projected area:** 0.0 m²
- **Wetted surface:** 0.0 m²
- **Exposed palm depth:** 0.000 m
- **Exposed palm width:** 0.000 m

#### Rudder
- **Count:** 0
- **Rudder location:** Behind propeller
- **Type:** Balanced foil
- **Root chord:** 0.000 m
- **Tip chord:** 0.000 m
- **Span:** 0.000 m
- **T/C ratio:** 0.000
- **LE sweep:** 0.00 deg
- **Projected area:** 0.0 m²
- **Wetted surface:** 0.0 m²

#### Skeg/Keel
- **Count:** 0
- **Type:** Skeg
- **Mean length:** 0.000 m
- **Mean width:** 0.000 m
- **Height aft:** 0.000 m
- **Height mid:** 0.000 m
- **Height fwd:** 0.000 m

#### Stabilizer
- **Count:** 0
- **Root chord:** 0.000 m
- **Tip chord:** 0.000 m
- **Span:** 0.000 m
- **T/C ratio:** 0.000
- **Projected area:** 0.0 m²
- **Wetted surface:** 0.0 m²
- **Dynamic multiplier:** 1.00

#### Bilge keel
- **Count:** 0
- **Mean length:** 0.000 m
- **Mean base width:** 0.000 m
- **Mean projection:** 0.000 m
- **Projected area:** 0.0 m²
- **Wetted surface:** 0.0 m²

#### Tunnel thruster
- **Count:** 0
- **Diameter:** 0.000 m

#### Sonar dome
- **Count:** 0
- **Wetted surface:** 0.0 m²

#### Miscellaneous
- **Count:** 0
- **Drag area:** 0.0 m²
- **Drag coef:** 0.00

### Environment data

#### Wind
- **Wind speed:** 0.00 kt
- **Angle off bow:** 0.00 deg
- **Gradient correction:** Off

#### Seas
- **Significant wave ht:** 0.000 m
- **Modal wave period:** 0.0 sec

#### Exposed hull
- **Transverse area:** 0.0 m²
- **VCE above WL:** 0.000 m
- **Profile area:** 0.0 m²

#### Shallow/channel
- **Water depth:** 0.000 m
- **Type:** Shallow water
- **Channel width:** 0.000 m
- **Channel side slope:** 0.00 deg
- **Hull girth:** 0.000 m

#### Superstructure
- **Superstructure shape:** Cargo ship
- **Transverse area:** 0.0 m²
- **VCE above WL:** 0.000 m
- **Profile area:** 0.0 m²
# Resistance

**Project ID**  Remolcador de salvamento  
**Description**  68 TPF  
**File name**  remolcador 68tpf.hcnc

## Symbols and values

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<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tr>
<td>FV</td>
<td>Froude number [VOL]</td>
</tr>
<tr>
<td>RN</td>
<td>Reynolds number [LWL]</td>
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<tr>
<td>CF</td>
<td>Frictional resistance coefficient</td>
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<td>CV/CF</td>
<td>Viscous/frictional resistance coefficient ratio [dynamic form factor]</td>
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<tr>
<td>CR</td>
<td>Residuary resistance coefficient</td>
</tr>
<tr>
<td>dCF</td>
<td>Added frictional resistance coefficient for roughness</td>
</tr>
<tr>
<td>CA</td>
<td>Correlation allowance [dynamic]</td>
</tr>
<tr>
<td>CT</td>
<td>Total bare-hull resistance coefficient</td>
</tr>
<tr>
<td>RBARE</td>
<td>Bare-hull resistance</td>
</tr>
<tr>
<td>RAPP</td>
<td>Additional appendage resistance</td>
</tr>
<tr>
<td>RWIND</td>
<td>Additional wind resistance</td>
</tr>
<tr>
<td>RSEAS</td>
<td>Additional sea-state resistance</td>
</tr>
<tr>
<td>RCHAN</td>
<td>Additional shallow/channel resistance</td>
</tr>
<tr>
<td>RMARGIN</td>
<td>Resistance margin</td>
</tr>
<tr>
<td>RTOTAL</td>
<td>Total vessel resistance</td>
</tr>
<tr>
<td>CTLR</td>
<td>Telfer residuary resistance coefficient</td>
</tr>
<tr>
<td>CTLT</td>
<td>Telfer total bare-hull resistance coefficient</td>
</tr>
<tr>
<td>PEBARE</td>
<td>Bare-hull effective power</td>
</tr>
<tr>
<td>PETOTAL</td>
<td>Total effective power</td>
</tr>
</tbody>
</table>

- + = Design speed indicator
- * = Exceeds parameter limit
### Analysis parameters

<table>
<thead>
<tr>
<th>Vessel drag</th>
<th>Added drag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique: [Calc] Prediction</td>
<td>Appendage: [Calc] Holtrop (Component)</td>
</tr>
<tr>
<td>Prediction:</td>
<td>Wind: [Off]</td>
</tr>
<tr>
<td>Reference ship:</td>
<td>Seas: [Off]</td>
</tr>
<tr>
<td>Model LWL:</td>
<td>Shallow/channel: [Off]</td>
</tr>
<tr>
<td>Expansion: Custom</td>
<td>Margin: [Calc] Hull drag only [15%]</td>
</tr>
<tr>
<td>Friction line: ITTC-57</td>
<td></td>
</tr>
</tbody>
</table>

#### Hull form factors
- [On] 1,366
- [Off]

#### Speed corr
- [Off]
- [On]

#### Spray drag corr
- [Off]
- [On]

#### Corr allowance
- 0,000477

#### Roughness [mm]
- [Off]

### Prediction method check [Oortmerssen]

#### Parameters
- **FN (design):** 0.34
- **CP:** 0.57
- **LWL/BWL:** 3.19
- **BWL/T:** 2.27
- **XCB/LWL:** 0.50
- **IE:** 25.7
- **CX:** 0.91

#### Value
- **Value:** 0.05 - 0.50
- **Range:** 0.51 - 0.69

### Prediction results

#### SPEED COEFS
- **SPEED:** [kt]
- **FN:** 0.0552, 0.078, 0.104, 0.130, 0.156, 0.182, 0.208, 0.260, 0.312, 0.338, 0.338
- **FV:** 0.0098, 0.147, 0.196, 0.245, 0.293, 0.342, 0.391, 0.489, 0.587, 0.636

#### ITTC-78 COEFS
- **SPEED:** [kt]
- **FN:** 3.45e7, 5.18e7, 6.90e7, 8.63e7, 1.04e8, 1.21e8, 1.38e8, 1.73e8, 2.07e8, 2.24e8
- **FV:** 0.002128, 0.002073, 0.002027, 0.001989, 0.001957, 0.001928, 0.001903, 0.001880, 0.001859, 0.001841

### Water properties
- **Water type:** Salt
- **Density:** 1026.00 kg/m³
- **Viscosity:** 1.18920e-6 m²/s

### Resistence and effective power

#### RESISTANCE AND EFFECTIVE POWER
- **SPEED:** [kt]
- **RBARE:** 7.42, 11.79, 17.86, 24.40, 32.13, 40.40, 64.95, 82.92, 102.62, 185.05
- **RAPP:** 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00

### Other

#### SPEED
- **SPEED:** [kt]
- **CTRL:** 0.00001, 0.00385, 0.00018, 0.00103, 0.00123, 0.00134, 0.00273, 0.00316, 0.00350, 0.00698
- **CTLT:** 0.03039, 0.03354, 0.03732, 0.03903, 0.04061, 0.04136, 0.05496, 0.05895, 0.06217, 0.09666
Hull data

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<thead>
<tr>
<th>General</th>
<th>Planing</th>
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<tbody>
<tr>
<td>Configuration: Monohull</td>
<td>Proj chine length: 0,000 m</td>
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<tr>
<td>Chine type: Single/hard</td>
<td>Proj bottom area: 0,0 m²</td>
</tr>
<tr>
<td>Length on WL: 39,900 m</td>
<td>LCG fwd TR: [XCG/LP 0,000] 0,000 m</td>
</tr>
<tr>
<td>Max beam on WL: [LWL/BWL 3,192] 12,500 m</td>
<td>VCG below WL: 0,000 m</td>
</tr>
<tr>
<td>Max molded draft: [BWL/T 2,273] 5,500 m</td>
<td>Aft station (fwd TR): 0,000 m</td>
</tr>
<tr>
<td>Displacement: [CB 0,523] 1472,60 t</td>
<td>Chine beam: 0,000 m</td>
</tr>
<tr>
<td>Wetted surface: [CWS 5,075] 645,7 m²</td>
<td>Chine ht below WL: 0,000 m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hull data</th>
<th>Planing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proj chine length: 0,000 m</td>
</tr>
<tr>
<td></td>
<td>Proj bottom area: 0,0 m²</td>
</tr>
<tr>
<td></td>
<td>LCG fwd TR: [XCG/LP 0,000] 0,000 m</td>
</tr>
<tr>
<td></td>
<td>VCG below WL: 0,000 m</td>
</tr>
<tr>
<td></td>
<td>Aft station (fwd TR): 0,000 m</td>
</tr>
<tr>
<td></td>
<td>Chine beam: 0,000 m</td>
</tr>
<tr>
<td></td>
<td>Chine ht below WL: 0,000 m</td>
</tr>
<tr>
<td></td>
<td>Deadrise: 0,00 deg</td>
</tr>
<tr>
<td></td>
<td>Fwd station (fwd TR): 0,000 m</td>
</tr>
<tr>
<td></td>
<td>Chine beam: 0,000 m</td>
</tr>
<tr>
<td></td>
<td>Chine ht below WL: 0,000 m</td>
</tr>
<tr>
<td></td>
<td>Deadrise: 0,00 deg</td>
</tr>
<tr>
<td></td>
<td>Propulsor type: Propeller</td>
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<tr>
<td></td>
<td>Propeller diameter 0,0 mm</td>
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<tr>
<td></td>
<td>Shaft angle to WL: 0,00 deg</td>
</tr>
<tr>
<td></td>
<td>Position fwd TR: 0,000 m</td>
</tr>
<tr>
<td></td>
<td>Position below WL: 0,000 m</td>
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</table>

Report ID20150723-1036 HydroComp NavCad 2012 12.02.019 S1002.539
## Resistance

**Project ID:** Remolcador de salvamento  
**Description:** 68 TPF  
**File name:** remolcador 68tpf.hcnc

### Appendage data

#### General

<table>
<thead>
<tr>
<th>Definition</th>
<th>Component</th>
<th>Percent of hull drag:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0,00 %</td>
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#### Planing influence

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>LCE fwd TR</td>
<td>0,000 m</td>
</tr>
<tr>
<td>VCE below WL</td>
<td>0,000 m</td>
</tr>
</tbody>
</table>

#### Shafting

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>2</td>
</tr>
<tr>
<td>Max prop diam</td>
<td>0,0 mm</td>
</tr>
<tr>
<td>Shaft angle to WL</td>
<td>0,00 deg</td>
</tr>
<tr>
<td>Exposed shaft length</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Shaft diameter</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Wetted surface</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Strut bossing length</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Bossing diameter</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Wetted surface</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Hull bossing length</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Bossing diameter</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Wetted surface</td>
<td>0,0 m2</td>
</tr>
</tbody>
</table>

#### Strut (per shaft line)

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Count</td>
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</tr>
<tr>
<td>Root chord</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Tip chord</td>
<td>0,000 mm</td>
</tr>
<tr>
<td>Span</td>
<td>0,000 m</td>
</tr>
<tr>
<td>T/C ratio</td>
<td>0,000</td>
</tr>
<tr>
<td>Projected area</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Wetted surface</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Exposed palm depth</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Exposed palm width</td>
<td>0,000 m</td>
</tr>
</tbody>
</table>

#### Rudder

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Count</td>
<td>0</td>
</tr>
<tr>
<td>Rudder location</td>
<td>Behind propeller</td>
</tr>
<tr>
<td>Type</td>
<td>Balanced foil</td>
</tr>
<tr>
<td>Root chord</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Tip chord</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Span</td>
<td>0,000 m</td>
</tr>
<tr>
<td>T/C ratio</td>
<td>0,000</td>
</tr>
<tr>
<td>LE sweep</td>
<td>0,00 deg</td>
</tr>
<tr>
<td>Projected area</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Wetted surface</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Wetted surface</td>
<td>0,0 m2</td>
</tr>
</tbody>
</table>

#### Skeg/Keel

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>0</td>
</tr>
<tr>
<td>Type</td>
<td>Skeg</td>
</tr>
<tr>
<td>Mean length</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Mean width</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Height aft</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Height mid</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Height fwd</td>
<td>0,000 m</td>
</tr>
</tbody>
</table>

#### Stabilizer

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
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</tr>
<tr>
<td>Root chord</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Tip chord</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Span</td>
<td>0,000 m</td>
</tr>
<tr>
<td>T/C ratio</td>
<td>0,000</td>
</tr>
<tr>
<td>LE sweep</td>
<td>0,00 deg</td>
</tr>
<tr>
<td>Projected area</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Wetted surface</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Dynamic multiplier</td>
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</tr>
</tbody>
</table>

#### Bilge keel

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>0</td>
</tr>
<tr>
<td>Mean length</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Mean base width</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Mean projection</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Wetted surface</td>
<td>0,0 m2</td>
</tr>
</tbody>
</table>

#### Tunnel thruster

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>0</td>
</tr>
<tr>
<td>Diameter</td>
<td>0,000 m</td>
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</tbody>
</table>

#### Sonar dome

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>0</td>
</tr>
<tr>
<td>Wetted surface</td>
<td>0,0 m2</td>
</tr>
</tbody>
</table>

#### Miscellaneous

<table>
<thead>
<tr>
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<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Drag area</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>Drag coef</td>
<td>0,00</td>
</tr>
</tbody>
</table>

### Environment data

#### Wind

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed</td>
<td>0,00 kt</td>
</tr>
<tr>
<td>Angle off bow</td>
<td>0,00 deg</td>
</tr>
<tr>
<td>Gradient correction</td>
<td>Off</td>
</tr>
</tbody>
</table>

#### Seas

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant wave ht</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Modal wave period</td>
<td>0,0 sec</td>
</tr>
</tbody>
</table>

#### Shallow/channel

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water depth</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Type</td>
<td>Shallow water</td>
</tr>
<tr>
<td>Channel width</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Channel side slope</td>
<td>0,00 deg</td>
</tr>
<tr>
<td>Hull girth</td>
<td>0,000 m</td>
</tr>
</tbody>
</table>

#### Superstructure

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superstructure shape</td>
<td>Cargo ship</td>
</tr>
<tr>
<td>Transverse area</td>
<td>0,0 m2</td>
</tr>
<tr>
<td>VCE above WL</td>
<td>0,000 m</td>
</tr>
<tr>
<td>Profile area</td>
<td>0,0 m2</td>
</tr>
</tbody>
</table>
## Symbols and values

- **FN** = Froude number [LWL]
- **FV** = Froude number [VOL]
- **RN** = Reynolds number [LWL]
- **CF** = Frictional resistance coefficient
- **CV/CF** = Viscous/frictional resistance coefficient ratio [dynamic form factor]
- **CR** = Residuary resistance coefficient
- **dCF** = Added frictional resistance coefficient for roughness
- **CA** = Correlation allowance [dynamic]
- **CT** = Total bare-hull resistance coefficient
- **RBARE** = Bare-hull resistance
- **RAPP** = Additional appendage resistance
- **RWIND** = Additional wind resistance
- **RSEAS** = Additional sea-state resistance
- **RCHAN** = Additional shallow/channel resistance
- **RMARGIN** = Resistance margin
- **RTOTAL** = Total vessel resistance
- **CTLR** = Telfer residuary resistance coefficient
- **CTLT** = Telfer total bare-hull resistance coefficient
- **PEBARE** = Bare-hull effective power
- **PETOTAL** = Total effective power

* = Exceeds parameter limit

+ = Design speed indicator
ANEXO 2

(Report Propulsor)
**Hull-propulsor interaction**

- **Technique:** Prediction
- **Prediction:** [Calc] Holtrop
- **Reference ship:**
- **Max prop diam:** 3000.0 mm

** Corrections **

- **Viscous scale corr:** [On] Custom
- **Rudder location:** Behind propeller
- **Friction line:** ITTC-57
- **Hull form factor:** 1,366
- **Corr allowance:** 0,000477
- **Roughness [mm]:** [On] 0,15
- **Ducted prop corr:** [Off]
- **Tunnel stern corr:** [Off]
- **Effective diam:**
- **Recess depth:**

**System analysis**

- **Cavitation criteria:** Keller eqn
- **Analysis type:** Free run
- **CPP method:** Fixed RPM
- **Engine RPM:**
- **Mass RPM:**
- **Mass constraint:** Limit [RPM/s]:

**Water properties**

- **Water type:** Salt
- **Density:** 1026,00 kg/m³
- **Viscosity:** 1,18920e-6 m²/s

**Prediction method check [Holtrop]**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>FN [design]</th>
<th>CP</th>
<th>LWL/BWL</th>
<th>BWL/T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>0,34</td>
<td>0,57</td>
<td>3,19*</td>
<td>2,27</td>
</tr>
<tr>
<td>Range</td>
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<td>0,55··0,85</td>
<td>3,90··14,90</td>
<td>2,10··4,00</td>
</tr>
</tbody>
</table>

**Prediction results [System]**

<table>
<thead>
<tr>
<th>SPEED [kt]</th>
<th>PETOTAL [kW]</th>
<th>WFT</th>
<th>THD</th>
<th>EFFR</th>
<th>RPMENG [RPM]</th>
<th>PBPROP [kW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,00</td>
<td>21,9</td>
<td>0,0991</td>
<td>0,1018</td>
<td>0,9546</td>
<td>45</td>
<td>17,5</td>
</tr>
<tr>
<td>3,00</td>
<td>41,9</td>
<td>0,0980</td>
<td>0,1018</td>
<td>0,9546</td>
<td>63</td>
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<td>4,00</td>
<td>74,0</td>
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<td>0,1018</td>
<td>0,9546</td>
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<td>0,1018</td>
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<td>0,1018</td>
<td>0,9546</td>
<td>100</td>
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<td>0,1018</td>
<td>0,9546</td>
<td>100</td>
<td>525,8</td>
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<tr>
<td>12,00</td>
<td>789,2</td>
<td>0,0949</td>
<td>0,1018</td>
<td>0,9546</td>
<td>100</td>
<td>750,5</td>
</tr>
<tr>
<td>+ 13,00 +</td>
<td>1532,7</td>
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<td>0,1018</td>
<td>0,9546</td>
<td>100</td>
<td>1314,9</td>
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</table>

<table>
<thead>
<tr>
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#### CAVITATION

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Report ID 20150723-1048
## Symbols and values

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<td>Brake power per propulsor</td>
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<tr>
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<td>PITCHFC</td>
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- + = Design speed indicator
- * = Exceeds recommended parameter limit
- ! = Exceeds recommended cavitation criteria [warning]
- !! = Substantially exceeds recommended cavitation criteria [critical]
- !!! = Thrust breakdown is indicated [severe]
- --- = Insignificant or not applicable
### Hull-propulsor interaction

**Technique:** Prediction  
**Prediction:** [Calc] Holtrop  
**Reference ship:**  
**Max prop diam:** 3000.0 mm

### Corrections

**Viscous scale corr:** [On] Custom  
**Rudder location:** Behind propeller  
**Friction line:** ITTC-57  
**Hull form factor:** 1,366  
**Corr allowance:** 0,000477  
**Roughness [mm]:** [On] 0,15  
**Ducted prop corr:** [Off]  
**Tunnel stern corr:** [Off]  
**Effective diam:**  
**Recess depth:**

### System analysis

**Cavitation criteria:** Keller eqn  
**Analysis type:** Free run  
**CPP method:** Fixed RPM  
**Engine RPM:**  
**Mass RPM:**  
**RPM constraint:** Limit [RPM/s]:

### Water properties

**Water type:** Salt  
**Density:** 1026,00 kg/m³  
**Viscosity:** 1,18920e-6 m²/s

### Prediction method check [Holtrop]

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### Prediction results [System]

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### Propulsion Project

**Project ID**: Remolcador de salvamento  
**Description**: 68 TPF  
**File name**: Remolcador diseño del propulsor.hcnc

#### Prediction results [Propulsor]

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### CAVITATION

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<td>39,900 m</td>
<td>[XCG/LP 0,000] 0,000 m</td>
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<td>[CWS 5,075] 645,7 m²</td>
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### ITTC-78 (CT)

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<td>LCF fwd TR:</td>
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<td>Bulb nose fwd TR:</td>
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## Propulsor data

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## Engine/gear

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Design point: 1,030
**Symbols and values**

- **SPEED** = Vessel speed
- **FN** = Froude number [LWL]
- **FV** = Froude number [VOL]
- **PETOTAL** = Total vessel effective power
- **WFT** = Taylor wake fraction coefficient
- **THD** = Thrust deduction coefficient
- **EFFR** = Relative-rotative efficiency
- **RPMENG** = Engine RPM
- **PBPROP** = Brake power per propulsor
- **QPROP** = Propulsor open water torque
- **PDPROP** = Delivered power per propulsor
- **PSPROP** = Shaft power per propulsor
- **PSTOTAL** = Total vessel shaft power
- **PBTOTAL** = Total vessel brake power
- **TRANSP** = Transport factor
- **FUEL** = Fuel rate per engine
- **LOADENG** = Percentage of engine max available power at given RPM
- **RPMPROP** = Propulsor RPM
- **EFFO** = Propulsor open-water efficiency
- **EFFOA** = Overall propulsion efficiency \([-\text{PETOTAL}/\text{PSTOTAL}]\)
- **THRPROP** = Open-water thrust per propulsor
- **DELTHR** = Total vessel delivered thrust
- **NETTOW** = Total vessel net tow pull
- **CPPITCH** = Operational pitch of CPP

  - **J** = Propulsor advance coefficient
  - **KT** = Propulsor thrust coefficient [horizontal, if in oblique flow]
  - **KQ** = Propulsor torque coefficient
  - **KTJ2** = Propulsor thrust loading ratio
  - **KQJ3** = Propulsor torque loading ratio
  - **CTH** = Horizontal component of bare-hull resistance coefficient
  - **CP** = Propulsor thrust loading coefficient
  - **RNPROP** = Propeller Reynolds number at 0.7R
  - **KTN** = Nozzle thrust coefficient

- **SIGMAV** = Cavitation number of propeller by vessel speed
- **SIGMAN** = Cavitation number of propeller by RPM
- **SIGMA07R** = Cavitation number of blade section at 0.7R
- **TIPSPEED** = Propeller circumferential tip speed
- **MINBAR** = Minimum expanded blade area ratio recommended by selected cavitation criteria
- **PRESS** = Average propeller loading pressure
- **CAVAVG** = Average predicted back cavitation percentage
- **CAVMAX** = Peak predicted back cavitation percentage [if in oblique flow]
- **PITCHFC** = Minimum recommended pitch to avoid face cavitation

  - **+** = Design speed indicator
  - **!** = Exceeds recommended parameter limit
  - **!!** = Substantially exceeds recommended cavitation criteria [critical]
  - **!!!** = Thrust breakdown is indicated [severe]
  - **---** = Insignificant or not applicable
### Propulsion

**Project ID:** Remolcador de salvamento  
**Description:** 68 TPF  
**File name:** Remolcador diseño del propulsor.hcnc

#### Analysis parameters

**Hull-propulsor interaction**

- **Technique:** Prediction
- **Prediction:** [Calc] Holtrop
- **Reference ship:**
- **Max prop diam:** 3000,0 mm

**Corrections**

- **Viscous scale corr:** [On] Custom
- **Rudder location:** Behind propeller
- **Friction line:** ITTC-57
- **Hull form factor:** 1,366
- **Corr allowance:** 0,000477
- **Roughness [mm]:** [On] 0,15
- **Ducted prop corr:** [Off]
- **Tunnel stern corr:** [Off]
- **Effective diam:**
- **Recess depth:**

**System analysis**

- **Cavitation criteria:** Keller eqn
- **Analysis type:** Free run
- **CPP method:** Fixed RPM
- **Engine RPM:**
- **Mass multiplier:**
- **RPM constraint:** Limit [RPM/s]:

**Water properties**

- **Water type:** Salt
- **Density:** 1026,00 kg/m3
- **Viscosity:** 1,18920e-6 m2/s

#### Prediction method check [Holtrop]

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#### Prediction results [System]

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### Prediction results [Propulsor]

#### Propulsion Coefficients

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<th>MINBAR [kPa]</th>
<th>PRESS [kPa]</th>
<th>CAVAVG [%]</th>
<th>CAVMAX [%]</th>
<th>PITCHFC [mm]</th>
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## Hull data

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<td>Wetted surface</td>
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**Planing**

| Proj chine length     | 0,000 m |
| Proj bottom area      | 0,0 m² |
| LCG fwd TR            | [XCG/LP 0,000] |
| VCG below WL          | 0,000 m |
| Aft station (fwd TR)  | 0,000 m |
| Chine beam            | 0,000 m |
| Chine ht below WL     | 0,000 m |
| Deadrise              | 0,00 deg |
| Fwd station (fwd TR)  | 0,000 m |
| Chine beam            | 0,000 m |
| Chine ht below WL     | 0,000 m |
| Deadrise              | 0,00 deg |
| Proj chine length     | 0,000 m |
| Proj bottom area      | 0,0 m² |
| LCG fwd TR            | [XCG/LP 0,000] |
| VCG below WL          | 0,000 m |
| Aft station (fwd TR)  | 0,000 m |
| Chine beam            | 0,000 m |
| Chine ht below WL     | 0,000 m |
| Deadrise              | 0,00 deg |
| Fwd station (fwd TR)  | 0,000 m |
| Chine beam            | 0,000 m |
| Chine ht below WL     | 0,000 m |
| Deadrise              | 0,00 deg |

**ITTC-78 (CT)**

| LCB fwd TR            | 19,932 m |
| LCF fwd TR            | 19,932 m |
| Max section area      | 62,8 m² |
| Waterplane area       | 348,8 m² |
| Bulb section area     | 0,0 m² |
| Bulb ctr below WL     | 0,000 m |
| Bulb nose fwd TR      | 0,000 m |
| Transom area          | 0,0 m² |
| Transom beam WL       | 10,300 m |
| Transom immersion     | 1,500 m |
| Half entrance angle   | 25,67 deg |
| Bow shape factor      | 1,0 | [WL flow] |
| Stern shape factor    | 1,0 | [WL flow] |

## Propulsion data

**Propulsion**

| Count                  | 2 |
| Propulsion type        | Propeller series |
| Propeller type         | CPP |
| Propeller series       | Kaplan 19A |
| Propeller sizing       | By thrust |
| KTKQ file              | |
| Blade count            | 5 |
| Expanded area ratio    | 0,6500 | [Keep] |
| Propeller diameter     | 3000,0 mm | [Size] |
| Propeller mean pitch   | 3982,8 mm | [Size] |
| Hub immersion          | 3000,0 mm |

**Engine/gear**

| Engine data            | |
| Rated RPM              | 0 RPM |
| Rated power            | 0,0 kW |
| Gear efficiency        | 0,97 |
| Gear ratio             | 0,707 | [Size] |
| Shaft efficiency       | 0,98 |

### Propeller options

- **Oblique angle corr:** Off
- **Shaft angle to WL:** 0,00 deg
- **Added rise of run:** 0,00 deg
- **Propeller cup:** None
- **KT multiplier:** 1,00
- **KQ multiplier:** 1,00
- **Scale correction:** Custom
- **Blade T/C [0.7R]:** 0,00
- **Roughness:** 0,00 mm
- **Cav breakdown:** Off
- **Nozzle L/D:** 0,50

### Design condition

- **Max prop diam:** 3000,0 mm
- **Design speed:** 13,00 kt
- **Reference power:** 0,0 kW
- **Design point:** 0,000
- **Reference RPM:** 100,0
- **Design point:** 1,030
### Symbols and values

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<th>Description</th>
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<td>Vessel speed</td>
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<td>Froude number [LWL]</td>
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<tr>
<td>FV</td>
<td>Froude number [VOL]</td>
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<td>PETOTAL</td>
<td>Total vessel effective power</td>
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<td>WFT</td>
<td>Taylor wake fraction coefficient</td>
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<td>THD</td>
<td>Thrust deduction coefficient</td>
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<td>EFFR</td>
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<td>RPMENG</td>
<td>Engine RPM</td>
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<td>Propulsor open water torque</td>
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<td>PDPROP</td>
<td>Delivered power per propulsor</td>
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<td>PSPROP</td>
<td>Shaft power per propulsor</td>
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<td>PSTOTAL</td>
<td>Total vessel shaft power</td>
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<td>Total vessel brake power</td>
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<td>Propulsor open-water efficiency</td>
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<td>Overall propulsion efficiency ([-PETOTAL/PSTOTAL])</td>
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<td>Open-water thrust per propulsor</td>
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<tr>
<td>DELTHR</td>
<td>Total vessel delivered thrust</td>
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<td>J</td>
<td>Propulsor advance coefficient</td>
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<tr>
<td>KT</td>
<td>Propulsor thrust coefficient [horizontal, if in oblique flow]</td>
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<tr>
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<td>Propulsor torque coefficient</td>
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<td>Cavitation number of propeller by vessel speed</td>
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<td>Cavitation number of propeller by RPM</td>
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<td>SIGMA07R</td>
<td>Cavitation number of blade section at 0.7R</td>
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<td>Propeller circumferential tip speed</td>
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<td>Average predicted back cavitation percentage</td>
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<td>CAVMAX</td>
<td>Peak predicted back cavitation percentage [if in oblique flow]</td>
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<tr>
<td>PITCHFC</td>
<td>Minimum recommended pitch to avoid face cavitation</td>
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</table>

+ = Design speed indicator  
* = Exceeds recommended parameter limit  
! = Exceeds recommended cavitation criteria [warning]  
!! = Substantially exceeds recommended cavitation criteria [critical]  
!!! = Thrust breakdown is indicated [severe]  
--- = Insignificant or not applicable
ANEXO 3

(Report TPF)
### Analysis parameters

**Hull-propulsor interaction**
- **Technique**: Prediction
- **Prediction**: [Calc] Holtrop
- **Reference ship**: Max prop diam:
  - 3000,0 mm

**Corrections**
- **Viscous scale corr**: [On] Custom
- **Rudder location**: Behind propeller
- **Friction line**: ITTC-57
- **Hull form factor**: 1,366
- **Corr allowance**: 0,000477
- **Roughness [mm]**: [On] 0,15
- **Ducted prop corr**: [Off]
- **Tunnel stern corr**: [Off]
- **Effective diam**:
- **Recess depth**:

### System analysis
- **Cavitation criteria**: Keller eqn
- **Analysis type**: Towing
- **CPP method**: Variable RPM
- **Engine RPM**:
- **Mass multiplier**:
- **Water properties**
  - **Water type**: Salt
  - **Density**: 1026,00 kg/m³
  - **Viscosity**: 1,18920e-6 m²/s

### Prediction method check [Holtrop]

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### Prediction results [System]

#### HULL-PROPULSOR ENGINE

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#### POWER DELIVERY

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#### EFFICIENCY THRUST

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<th>EFFOA [kN]</th>
<th>THRPROP [kN]</th>
<th>DELTHR [kN]</th>
<th>NETTOW [kN]</th>
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### PROPULSOR COEFS

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<th>SIGMA07R</th>
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<th>MINBAR</th>
<th>PRESS [kPa]</th>
<th>CAVAVG [%]</th>
<th>CAVMAX [%]</th>
<th>PITCHFC [mm]</th>
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<td><strong>Max molded draft:</strong></td>
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<td><strong>Displacement:</strong></td>
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<td>[CB 0,523] 1472,60 t</td>
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<td><strong>Wetted surface:</strong></td>
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<td>[CWS 5,075] 645,7 m²</td>
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#### ITTC-78 (CT)

| **LCB fwd TR:** [XCB/LWL 0,500] 19.932 m | **Fwd station (fwd TR):** |
| **LCF fwd TR:** [XCF/LWL 0,500] 19.932 m | 0,000 m                  |
| **Max section area:** [CX 0,913] 62,8 m² | **Chine beam:** 0,000 m   |
| **Waterplane area:** [CWP 0,699] 348,8 m² | **Chine ht below WL:** 0,000 m |
| **Bulb section area:** 0,0 m² | **Deadrise:** 0,00 deg    |
| **Bulb ctr below WL:** 0,000 m | **Propulsor type:** Propeller |
| **Bulb nose fwd TR:** 0,000 m | **Propeller diameter:** 3000,0 mm |
| **Transom area:** [ATR/AX 0,000] 0,0 m² | **Shaft angle to WL:** 0,00 deg |
| **Transom beam WL:** [BTR/BWL 0,824] 10,300 m | **Position fwd TR:** 0,000 m |
| **Transom immersion:** [TTR/T 0,273] 1,500 m | **Position below WL:** 0,000 m |
| **Half entrance angle:** 25,67 deg |
| **Bow shape factor:** [WL flow] 1,0 |
| **Stern shape factor:** [WL flow] 1,0 |

### Propulsor data

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<th><strong>Propeller options</strong></th>
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<tr>
<td><strong>Propulsor type:</strong> Propeller series</td>
<td><strong>Shaft angle to WL:</strong> 0,00 deg</td>
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<td><strong>Propeller type:</strong> CPP</td>
<td><strong>Added rise of run:</strong> 0,00 deg</td>
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<td><strong>Propeller series:</strong> Kaplan 19A</td>
<td><strong>Propeller cup:</strong> 0,0 mm</td>
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<td><strong>KTKQ corrections:</strong> Full ITTC</td>
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<td><strong>KTQ file:</strong></td>
<td><strong>Scale correction:</strong></td>
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<td><strong>KQ multiplier:</strong> 1,00</td>
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<td><strong>Propeller diameter:</strong> 2800,0 mm [Keep]</td>
<td><strong>Blade T/C [0.7R]:</strong> Standard</td>
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<td><strong>Propeller mean pitch:</strong> [P/D 1,3606] 3809,6 mm [Keep]</td>
<td><strong>Roughness:</strong> Standard</td>
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<td><strong>Hub immersion:</strong> 3000,0 mm</td>
<td><strong>Cav breakdown:</strong> Off</td>
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### Engine/gear

| **Engine data:** WARTSILA 8L26 | **Design condition** |
| **Rated RPM:** 900 RPM | **Max prop diam:** 3000,0 mm |
| **Rated power:** 2600,0 kW | **Design speed:** 1,00 kt |
| **Gear efficiency:** 0,97 | **Reference power:** 2600,0 kW |
| **Gear ratio:** 5,027 [Keep] | **Design point:** 1,000 |
| **Shaft efficiency:** 0,98 | **Reference RPM:** 900,0 |

**Design point:** 1,000
Symbols and values

SPEED = Vessel speed
FN = Froude number [LWL]
FV = Froude number [VOL]
PETOTAL = Total vessel effective power
WFT = Taylor wake fraction coefficient
THD = Thrust deduction coefficient
EFFR = Relative-rotative efficiency
RPMENG = Engine RPM
PBPROP = Brake power per propulsor
QPROP = Propulsor open water torque
PDPROP = Delivered power per propulsor
PSPROP = Shaft power per propulsor
PSTOTAL = Total vessel shaft power
PBTOTAL = Total vessel brake power
TRANSP = Transport factor
FUEL = Fuel rate per engine
LOADENG = Percentage of engine max available power at given RPM
RPMPROP = Propulsor RPM
EFFO = Propulsor open-water efficiency
EFFOA = Overall propulsion efficiency [=PETOTAL/PSTOTAL]
THRPROP = Open-water thrust per propulsor
DELTHR = Total vessel delivered thrust
NETTOW = Total vessel net tow pull
CPPITCH = Operational pitch of CPP
    J = Propulsor advance coefficient
    KT = Propulsor thrust coefficient [horizontal, if in oblique flow]
    KQ = Propulsor torque coefficient
    KTJ2 = Propulsor thrust loading ratio
    KQJ3 = Propulsor torque loading ratio
    CTH = Horizontal component of bare-hull resistance coefficient
    CP = Propulsor thrust loading coefficient
    RNPROP = Propeller Reynolds number at 0.7R
    KTN = Nozzle thrust coefficient
SIGMAV = Cavitation number of propeller by vessel speed
SIGMAN = Cavitation number of propeller by RPM
SIGMA07R = Cavitation number of blade section at 0.7R
TIPSPEED = Propeller circumferential tip speed
MINBAR = Minimum expanded blade area ratio recommended by selected cavitation criteria
PRESS = Average propeller loading pressure
CAAVAVG = Average predicted back cavitation percentage
CAVMAX = Peak predicted back cavitation percentage [if in oblique flow]
PITCHFC = Minimum recommended pitch to avoid face cavitation

+ = Design speed indicator
* = Exceeds recommended parameter limit
! = Exceeds recommended cavitation criteria [warning]
!!! = Substantially exceeds recommended cavitation criteria [critical]
!!! = Thrust breakdown is indicated [severe]
--- = Insignificant or not applicable
ANEXO 4

(Report Aguas Libres)
### Analysis parameters

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### Water properties
- **Water type**: Salt
- **Density**: 1026,00 kg/m³
- **Viscosity**: 1,18920e-6 m²/s

### Analysis results

#### Prediction method check [Oortmerssen]

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#### Prediction results

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#### RESISTANCE AND EFFECTIVE POWER

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Report ID20150723-1057  HydroComp NavCad 2012 12.02.0019.S1002.539
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### Report Information

- **Resistance**: HydroComp NavCad 2012
- **Project ID**: Remolcador de salvamento
- **Description**: 68 TPF
- **File name**: aguas libres con motor.hcnc
- **Report ID**: 20150723-1057
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<td>FN = Froude number [LWL]</td>
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<td>FV = Froude number [VOL]</td>
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<td>RN = Reynolds number [LWL]</td>
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<tr>
<td>CR = Residuary resistance coefficient</td>
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<tr>
<td>dCF = Added frictional resistance coefficient for roughness</td>
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<tr>
<td>CA = Correlation allowance [dynamic]</td>
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<tr>
<td>CT = Total bare-hull resistance coefficient</td>
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<tr>
<td>RBARE = Bare-hull resistance</td>
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<td>RAPP = Additional appendage resistance</td>
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<tr>
<td>RWIND = Additional wind resistance</td>
</tr>
<tr>
<td>RSEAS = Additional sea-state resistance</td>
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<tr>
<td>RCHAN = Additional shallow/channel resistance</td>
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<tr>
<td>RMARGIN = Resistance margin</td>
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<tr>
<td>RTOTAL = Total vessel resistance</td>
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<tr>
<td>CTRLR = Telfer residuary resistance coefficient</td>
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<tr>
<td>CTLT = Telfer total bare-hull resistance coefficient</td>
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<td>PEBARE = Bare-hull effective power</td>
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<td>PETOTAL = Total effective power</td>
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+ = Design speed indicator
* = Exceeds parameter limit
ANEXO 5

(Documentación Motor)
Introduction

This Product Guide provides data and system proposals for the early design phase of marine engine installa-
tions. For contracted projects specific instructions for planning the installation are always delivered. Any
data and information herein is subject to revision without notice. This 1/2013 issue replaces all previous
issues of the Wärtsilä 26 Project Guides.

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<td>2/2009</td>
<td>xx.01.2010</td>
<td>Attached drawings updated (Online version).</td>
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| 1/2009  | 26.11.2009  | Technical data added for IMO Tier 2 engines, Compact Silencer System added,
                  | Chapter Exhaust Emissions updated and several other minor updates       |

Wärtsilä, Ship Power Technology

Vaasa, November 2013

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1. Main Data and Outputs

The Wärtsilä 26 is a 4-stroke, non-reversible, turbocharged and intercooled diesel engine with direct fuel injection.

- Cylinder bore: 260 mm
- Stroke: 320 mm
- Piston displacement: 17.0 l/cyl
- Number of valves: 2 inlet valves and 2 exhaust valves
- Cylinder configuration: 6, 8 and 9 in-line; 12 and 16 in V-form
- V angle: 55°
- Direction of rotation: clockwise, counter-clockwise on request
- Speed: 900, 1000 rpm
- Mean piston speed: 9.6, 10.7 m/s

1.1 Maximum continuous output

<table>
<thead>
<tr>
<th>Cylinder configuration</th>
<th>Main engines 900 rpm [kW]</th>
<th>Main engines 1000 rpm [kW]</th>
<th>Generating sets 900 rpm [KVA]</th>
<th>Generating sets 1000 rpm [KVA]</th>
<th>Generating sets 900 rpm [kWe]</th>
<th>Generating sets 1000 rpm [kWe]</th>
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<tbody>
<tr>
<td>6L26</td>
<td>1950</td>
<td>2040</td>
<td>2352</td>
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<td>3060</td>
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<tr>
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<td>4080</td>
<td>4704</td>
<td>3764</td>
<td>4922</td>
<td>3937</td>
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<tr>
<td>16V26</td>
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<td>5440</td>
<td>6273</td>
<td>5018</td>
<td>6562</td>
<td>5250</td>
</tr>
</tbody>
</table>

The generator outputs are calculated for an efficiency of 96.5% and a power factor of 0.8. The maximum fuel rack position is mechanically limited to 110% of the continuous output for engines driving generators.

The mean effective pressure $p_e$ can be calculated as follows:

$$p_e = \frac{P \times c \times 1.2 \times 10^6}{D^2 \times L \times n \times \pi}$$

where:

- $p_e$ = mean effective pressure [bar]
- $P$ = output per cylinder [kW]
- $n$ = engine speed [rpm]
- $D$ = Cylinder diameter [mm]
- $L$ = length of piston stroke [mm]
- $c$ = operating cycle (4)
1.2 Reference conditions

The output is available up to a charge air coolant temperature of max. 38°C and an air temperature of max. 45°C. For higher temperatures, the output has to be reduced according to the formula stated in ISO 3046-1:2002 (E).

The specific fuel oil consumption is stated in the chapter Technical data. The stated specific fuel oil consumption applies to engines without engine driven pumps, operating in ambient conditions according to ISO 15550:2002 (E). The ISO standard reference conditions are:

- total barometric pressure: 100 kPa
- air temperature: 25°C
- relative humidity: 30%
- charge air coolant temperature: 25°C

Correction factors for the fuel oil consumption in other ambient conditions are given in standard ISO 3046-1:2002.

1.3 Operation in inclined position

Max. inclination angles at which the engine will operate satisfactorily.

- Transverse inclination, permanent (list) .......... 15°
- Transverse inclination, momentary (roll) ......... 22.5°
- Longitudinal inclination, permanent (trim) ...... 5°
- Longitudinal inclination, momentary (pitch) .... 7.5°

Larger angles are possible with special arrangements.
1.4 Dimensions and weights

1.4.1 Main engines

Figure 1.1 In-line engines (DAAE034755b)

<table>
<thead>
<tr>
<th>Engine</th>
<th>A*</th>
<th>A</th>
<th>B*</th>
<th>B</th>
<th>C*</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F_{wet}</th>
<th>F_{dry}</th>
<th>G</th>
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<tr>
<td>W 6L26</td>
<td>4387</td>
<td>4130</td>
<td>1882</td>
<td>1833</td>
<td>1960</td>
<td>2020</td>
<td>2430</td>
<td>400</td>
<td>950</td>
<td>818</td>
<td>2866</td>
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<tr>
<td>W 8L26</td>
<td>5302</td>
<td>5059</td>
<td>2023</td>
<td>1868</td>
<td>2010</td>
<td>2107</td>
<td>2430</td>
<td>400</td>
<td>950</td>
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<tr>
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<td>5691</td>
<td>5449</td>
<td>2023</td>
<td>1868</td>
<td>2016</td>
<td>2107</td>
<td>2430</td>
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<td>950</td>
<td>818</td>
<td>4036</td>
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<table>
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<tr>
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<th>H</th>
<th>I</th>
<th>K</th>
<th>M*</th>
<th>M</th>
<th>N*</th>
<th>N</th>
<th>Weight</th>
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<tbody>
<tr>
<td></td>
<td>dry sump</td>
<td></td>
<td>wet sump</td>
<td></td>
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<td></td>
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<tr>
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<td>1054</td>
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<td>1167</td>
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<td>794</td>
<td>1054</td>
<td>23.3</td>
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<table>
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<tr>
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<th>Gy *</th>
<th>Gz *</th>
<th>Gx</th>
<th>Gy</th>
<th>Gz</th>
<th>Gx *</th>
<th>Gy *</th>
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<th>Gy</th>
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<td>W 9L26</td>
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<td>454</td>
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<td>74</td>
<td>462</td>
<td>1921</td>
<td>74</td>
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* Turbocharger at flywheel end.

All dimensions in mm. Weight in metric tons with liquids (wet sump) but without flywheel.
### 1. Main Data and Outputs

#### Figure 1.2 V-engines (DAAE034757b)

<table>
<thead>
<tr>
<th>Engine</th>
<th>A*</th>
<th>A</th>
<th>B*</th>
<th>B</th>
<th>C*</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F&lt;sub&gt;wet&lt;/sub&gt;</th>
<th>F&lt;sub&gt;dry&lt;/sub&gt;</th>
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<tbody>
<tr>
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<td>1110</td>
<td>800</td>
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<tr>
<td>W 16V26</td>
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<td>800</td>
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<thead>
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<th>I</th>
<th>K</th>
<th>M*</th>
<th>M</th>
<th>N*</th>
<th>N</th>
<th>O</th>
<th>Weight</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>dry sump</td>
<td>wet sump</td>
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<tr>
<td>W 16V26</td>
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</table>

* Turbocharger at flywheel end.
All dimensions in mm. Weight in metric tons with liquids (wet sump) but without flywheel.
1.4.2 Generating sets

Figure 1.3 Generating sets (DAAE034758b)

<table>
<thead>
<tr>
<th>Engine</th>
<th>A</th>
<th>A*</th>
<th>B</th>
<th>B*</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
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<th>I</th>
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<tr>
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<td>702</td>
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<td>8500</td>
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<td>702</td>
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<td>2700</td>
<td>215°</td>
<td>70</td>
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</table>

* Turbocharger at flywheel end. ** TC inclination 30°

All dimensions in mm. Weight in metric tons with liquids (wet sump) but without flywheel.

**NOTE!** Generating set dimensions are for indication only, based on low voltage generators. Final generating set dimensions and weights depend on selection of generator and flexible coupling.
2. Operating Ranges

2.1 Engine operating range

Below nominal speed the load must be limited according to the diagrams in this chapter in order to maintain engine operating parameters within acceptable limits. Operation in the shaded area is permitted only temporarily during transients. Minimum speed is indicated in the diagram, but project specific limitations may apply.

2.1.1 Controllable pitch propellers

An automatic load control system is required to protect the engine from overload. The load control reduces the propeller pitch automatically, when a pre-programmed load versus speed curve ("engine limit curve") is exceeded, overriding the combinator curve if necessary. The engine load is derived from fuel rack position and actual engine speed (not speed demand).

The propulsion control must also include automatic limitation of the load increase rate. Maximum loading rates can be found later in this chapter.

The propeller efficiency is highest at design pitch. It is common practice to dimension the propeller so that the specified ship speed is attained with design pitch, nominal engine speed and 85% output in the specified loading condition. The power demand from a possible shaft generator or PTO must be taken into account. The 15% margin is a provision for weather conditions and fouling of hull and propeller. An additional engine margin can be applied for most economical operation of the engine, or to have reserve power.

Figure 2.1 Operating field for CP propeller

2.1.2 Fixed pitch propellers

The thrust and power absorption of a given fixed pitch propeller is determined by the relation between ship speed and propeller revolution speed. The power absorption during acceleration, manoeuvring or towing is considerably higher than during free sailing for the same revolution speed. Increased ship resistance, for
reason or another, reduces the ship speed, which increases the power absorption of the propeller over the whole operating range.

Loading conditions, weather conditions, ice conditions, fouling of hull, shallow water, and manoeuvring requirements must be carefully considered, when matching a fixed pitch propeller to the engine. The nominal propeller curve shown in the diagram must not be exceeded in service, except temporarily during acceleration and manoeuvring. A fixed pitch propeller for a free sailing ship is therefore dimensioned so that it absorbs max. 85% of the engine output at nominal engine speed during trial with loaded ship. Typically this corresponds to about 82% for the propeller itself.

If the vessel is intended for towing, the propeller is dimensioned to absorb 95% of the engine power at nominal engine speed in bollard pull or towing condition. It is allowed to increase the engine speed to 101.7% in order to reach 100% MCR during bollard pull.

A shaft brake should be used to enable faster reversing and shorter stopping distance (crash stop). The ship speed at which the propeller can be engaged in reverse direction is still limited by the windmilling torque of the propeller and the torque capability of the engine at low revolution speed.

**Figure 2.2 Operating field for FP Propeller**

**FP propellers in twin screw vessels**

Requirements regarding manoeuvring response and acceleration, as well as overload with one engine out of operation must be very carefully evaluated if the vessel is designed for free sailing, in particular if open propellers are applied. If the bollard pull curve significantly exceeds the maximum overload limit, acceleration and manoeuvring response can be very slow. Nozzle propellers are less problematic in this respect.

**2.1.3 Dredgers**

Mechanically driven dredging pumps typically require a capability to operate with full torque down to 70% or 80% of nominal engine speed. This requirement results in significant de-rating of the engine.
2.2 Loading capacity

Controlled load increase is essential for highly supercharged diesel engines, because the turbocharger needs time to accelerate before it can deliver the required amount of air. A slower loading ramp than the maximum capability of the engine permits a more even temperature distribution in engine components during transients.

The engine can be loaded immediately after start, provided that the engine is pre-heated to a HT-water temperature of 60…70ºC, and the lubricating oil temperature is min. 40 ºC.

The ramp for normal loading applies to engines that have reached normal operating temperature.

2.2.1 Mechanical propulsion

The propulsion control must include automatic limitation of the load increase rate. If the control system has only one load increase ramp, then the ramp for a preheated engine should be used. In tug applications the
Engines have usually reached normal operating temperature before the tug starts assisting. The “emergency” curve is close to the maximum capability of the engine.

If minimum smoke during load increase is a major priority, slower loading rate than in the diagram can be necessary below 50% load.

Large load reductions from high load should also be performed gradually. In normal operation the load should not be reduced from 100% to 0% in less than 15 seconds. When absolutely necessary, the load can be reduced as fast as the pitch setting system can react (overspeed due to windmilling must be considered for high speed ships).

2.2.2 Diesel electric propulsion and auxiliary engines

Figure 2.5 Maximum recommended load increase rates for engines operating at nominal speed

In diesel electric installations loading ramps are implemented both in the propulsion control and in the power management system, or in the engine speed control in case isochronous load sharing is applied. If a ramp without knee-point is used, it should not achieve 100% load in shorter time than the ramp in the figure. When the load sharing is based on speed droop, the load increase rate of a recently connected generator is the sum of the load transfer performed by the power management system and the load increase performed by the propulsion control.

The “emergency” curve is close to the maximum capability of the engine and it shall not be used as the normal limit. In dynamic positioning applications loading ramps corresponding to 20-30 seconds from zero to full load are however normal. If the vessel has also other operating modes, a slower loading ramp is recommended for these operating modes.

In typical auxiliary engine applications there is usually no single consumer being decisive for the loading rate. It is recommended to group electrical equipment so that the load is increased in small increments, and the resulting loading rate roughly corresponds to the “normal” curve.

In normal operation the load should not be reduced from 100% to 0% in less than 15 seconds. If the application requires frequent unloading at a significantly faster rate, special arrangements can be necessary on the engine. In an emergency situation the full load can be thrown off instantly.

Maximum instant load steps

The electrical system must be designed so that tripping of breakers can be safely handled. This requires that the engines are protected from load steps exceeding their maximum load acceptance capability. The maximum permissible load step is 30% MCR. The resulting speed drop is less than 10% and the recovery time to within 1% of the steady state speed at the new load level is max. 5 seconds.

When electrical power is restored after a black-out, consumers are reconnected in groups, which may cause significant load steps. The engine can be loaded in three steps up to 100% load, provided that the steps are 0-30-65-100. The engine must be allowed to recover for at least 7 seconds before applying the following load step, if the load is applied in maximum steps.
Start-up time

A diesel generator typically reaches nominal speed in about 20...25 seconds after the start signal. The acceleration is limited by the speed control to minimise smoke during start-up.

2.3 Operation at low load and idling

The engine can be started, stopped and operated on heavy fuel under all operating conditions. Continuous operation on heavy fuel is preferred rather than changing over to diesel fuel at low load operation and manoeuvring. The following recommendations apply:

Absolute idling (declutched main engine, disconnected generator)

- Maximum 10 minutes if the engine is to be stopped after the idling. 3-5 minutes idling before stop is recommended.
- Maximum 6 hours if the engine is to be loaded after the idling.

Operation below 20 % load on HFO or below 10 % load on MDF

- Maximum 100 hours continuous operation. At intervals of 100 operating hours the engine must be loaded to minimum 70 % of the rated output.

Operation above 20 % load on HFO or above 10 % load on MDF

- No restrictions.

2.4 Low air temperature

In cold conditions the following minimum inlet air temperatures apply:

- Starting + 5°C
- Idling - 5°C
- High load - 10°C

If the engine is equipped with a two-stage charge air cooler, sustained operation between 0 and 40% load can require special provisions in cold conditions to prevent too low engine temperature.

For further guidelines, see chapter Combustion air system design.
3. Technical Data

3.1 Wärtsilä 6L26

Table 3.1

<table>
<thead>
<tr>
<th>Cylinder output</th>
<th>AE/DE IMO Tier 2</th>
<th>AE/DE IMO Tier 2</th>
<th>ME IMO Tier 2</th>
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<td>325</td>
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<td>rpm</td>
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<td>1000</td>
<td>900</td>
</tr>
<tr>
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<td>1990</td>
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<tr>
<td>Mean effective pressure</td>
<td>MPa</td>
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<td>2.4</td>
<td>2.55</td>
</tr>
</tbody>
</table>

Combustion air system (Note 1)

| Flow of air at 100% load | kg/s | 3.7   | 4.1 | 3.9 | 4.1 |
| Temperature at turbocharger intake, max. | °C | 45    | 45  | 45  | 45  |
| Temperature at air cooler, nom. (TE601) | °C | 55    | 55  | 55  | 55  |

Exhaust gas system (Note 2)

| Flow at 100% load | kg/s | 3.8   | 4.2 | 4.0 | 4.2 |
| Flow at 85% load | kg/s | 3.3   | 3.7 | 3.4 | 3.5 |
| Flow at 75% load | kg/s | 3.0   | 3.4 | 3.0 | 3.1 |
| Flow at 50% load | kg/s | 2.2   | 2.5 | 2.1 | 2.3 |
| Temp. after turbo, 100% load (TE517) | °C | 329   | 312 | 306 | 312 |
| Temp. after turbo, 85% load (TE517) | °C | 326   | 304 | 311 | 313 |
| Temp. after turbo, 75% load (TE517) | °C | 337   | 311 | 326 | 327 |
| Temp. after turbo, 50% load (TE517) | °C | 342   | 320 | 327 | 322 |
| Backpressure, max. | kPa | 3.0   | 3.0 | 3.0 | 3.0 |
| Exhaust gas pipe diameter, min | mm | 500   | 500 | 500 | 500 |
| Calculated exhaust diameter for 35 m/s | mm | 486   | 501 | 487 | 502 |

Heat balance (Note 3)

| Jacket water | kW | 331   | 356 | 320 | 356 |
| Lubricating oil | kW | 284   | 301 | 275 | 300 |
| Charge air | kW | 636   | 751 | 719 | 751 |
| Radiation | kW | 91    | 96  | 91  | 96  |

Fuel system (Note 4)

| Pressure before injection pumps (PT101) | kPa | 700±50 | 700±50 | 700±50 | 700±50 |
| Engine driven pump capacity at 12 cSt (MDF only) | m³/h | 2.9   | 3.2   | 2.9   | 3.2   |
| Fuel flow to engine (without engine driven pump), approx. | m³/h | 1.5   | 1.7   | 1.5   | 1.7   |
| HFO temperature before engine, max. (TE 101) | °C | 140   | 140   | 140   | 140   |
| MDF viscosity, min | cSt | 2.0   | 2.0   | 2.0   | 2.0   |
| MDF temperature before engine, max. (TE 101) | °C | 45    | 45    | 45    | 45    |
| Fuel consumption at 100% load | g/kWh | 187   | 190   | 188   | 190   |
| Fuel consumption at 85% load | g/kWh | 185   | 188   | 185   | 187   |
| Fuel consumption at 75% load | g/kWh | 189   | 191   | 188   | 190   |
| Fuel consumption at 50% load | g/kWh | 198   | 202   | 189   | 192   |
| Clean leak fuel quantity, MDF at 100% load | kg/h | 7.7   | 8.2   | 7.8   | 8.2   |
| Clean leak fuel quantity, HFO at 100% load | kg/h | 1.5   | 1.6   | 1.6   | 1.6   |

Lubricating oil system (Note 5)

| Pressure before bearings, nom. (PT201) | kPa | 450   | 450   | 450   | 450   |
| Pressure after pump, max. | kPa | 800   | 800   | 800   | 800   |
| Suction ability including pipe loss, max. | kPa | 30    | 30    | 30    | 30    |
| Priming pressure, nom. (PT201) | kPa | 80    | 80    | 80    | 80    |
| Temperature before bearings, nom. (TE201) | °C | 68    | 68    | 68    | 68    |
| Temperature after engine, approx. | °C | 78    | 78    | 78    | 78    |
| Pump capacity (main), engine driven | m³/h | 60    | 66    | 60    | 66    |
| Pump capacity (main), stand-by | m³/h | 55    | 55    | 55    | 55    |
| Priming pump capacity, 50Hz/60Hz | m³/h | 11 / 13 | 11 / 13 | 11 / 13 | 11 / 13 |
| Oil volume, wet sump, nom. | m³ | 1.3   | 1.3   | 1.3   | 1.3   |
| Oil volume in separate system oil tank, nom. | m³ | 2.6   | 2.8   | 2.6   | 2.8   |
| Oil consumption (100% load), approx. | g/kWh | 0.5   | 0.5   | 0.5   | 0.5   |
| Crankcase ventilation flow rate | l/min/cyl | 150   | 150   | 150   | 150   |
| Crankcase backpressure (max) | kPa | 0.3   | 0.3   | 0.3   | 0.3   |
| Oil volume in speed governor | l | 1.4 / 2.0 | 1.4 / 2.0 | 1.4 / 2.0 | 1.4 / 2.0 |
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#### 3. Technical Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AE/DE IMO Tier 2</th>
<th>AE/DE IMO Tier 2</th>
<th>ME IMO Tier 2</th>
<th>ME IMO Tier 2</th>
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<tr>
<td>Cylinder output kW/cyl</td>
<td>325</td>
<td>340</td>
<td>325</td>
<td>340</td>
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<tr>
<td>Engine speed rpm</td>
<td>900</td>
<td>1000</td>
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#### High temperature cooling water system

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Pressure at engine, after pump, nom. (PT401) kPa</td>
<td>350 + static</td>
</tr>
<tr>
<td>Pressure at engine, after pump, max. (PT401) kPa</td>
<td>350 + static</td>
</tr>
<tr>
<td>Temperature before cylinders, approx. (TE401) °C</td>
<td>81</td>
</tr>
<tr>
<td>HT-water out from the engine, nom (TE402) °C</td>
<td>91</td>
</tr>
<tr>
<td>Capacity of engine driven pump, nom. m³/h</td>
<td>35</td>
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<tr>
<td>Pressure drop over engine kPa</td>
<td>210</td>
</tr>
<tr>
<td>Pressure drop in external system, max kPa</td>
<td>60</td>
</tr>
<tr>
<td>Pressure from expansion tank kPa</td>
<td>70...150</td>
</tr>
<tr>
<td>Water volume in engine m³</td>
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#### Low temperature cooling water system

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tr>
<td>Pressure at engine, after pump, nom. (PT471) kPa</td>
<td>280 + static</td>
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<tr>
<td>Pressure at engine, after pump, max. (PT471) kPa</td>
<td>280 + static</td>
</tr>
<tr>
<td>Temperature before engine (TE471) °C</td>
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<tr>
<td>Capacity of engine driven pump, nom. m³/h</td>
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<tr>
<td>Pressure drop in external system, max. kPa</td>
<td>60</td>
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<tr>
<td>Pressure drop over charge air cooler kPa</td>
<td>50</td>
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<td>Pressure drop over oil cooler kPa</td>
<td>16</td>
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<tr>
<td>Pressure from expansion tank kPa</td>
<td>70...150</td>
</tr>
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<td>Capacity engine driven seawater pump, max. m³/h</td>
<td>80</td>
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#### Starting air system (Note 6)

<table>
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<tr>
<td>Pressure, nom. kPa</td>
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<td>Pressure, max. kPa</td>
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<td>Low pressure limit in air vessels kPa</td>
<td>1800</td>
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<tr>
<td>Starting air consumption, start (successful) Nm³</td>
<td>1.4</td>
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#### Notes:

- **Note 1** At ISO 3046-1 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Tolerance 5%.
- **Note 2** At ISO 3046-1 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5% and temperature tolerance 20°C.
- **Note 3** The heat balances are made for ISO 3046/1 standard reference conditions. The heat balances include engine driven pumps (two cooling water + one lubricating oil pumps).
- **Note 4** According to ISO 3046/1, lower calorific value 42 700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%. The fuel consumption at 85% load is guaranteed and the values at other loads are given for indication only.
- **Note 5** The speed governor oil volume depends on the speed governor type.
- **Note 6** At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed  
AE = Auxiliary engine driving generator  
DE = Diesel-Electric engine driving generator

Subject to revision without notice.
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<table>
<thead>
<tr>
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<tr>
<td><strong>Cylinder output</strong></td>
<td>kW/cyl</td>
<td>325</td>
<td>340</td>
<td>325</td>
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<td><strong>Engine speed</strong></td>
<td>rpm</td>
<td>900</td>
<td>1000</td>
<td>900</td>
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<tr>
<td><strong>Engine output</strong></td>
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<td>2600</td>
<td>2720</td>
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<tr>
<td><strong>Mean effective pressure</strong></td>
<td>MPa</td>
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**Combustion air system (Note 1)**

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<tr>
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<th>kg/s</th>
<th>°C</th>
<th>°C</th>
<th>MPa</th>
<th>°C</th>
<th>°C</th>
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</thead>
<tbody>
<tr>
<td><strong>Flow of air at 100% load</strong></td>
<td>5.0</td>
<td>45</td>
<td>45</td>
<td>5.2</td>
<td>45</td>
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<tr>
<td><strong>Temperature at turbocharger intake, max.</strong></td>
<td></td>
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<tr>
<td><strong>Air temperature after air cooler, nom. (TE601)</strong></td>
<td>55</td>
<td></td>
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**Exhaust gas system (Note 2)**

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<th>°C</th>
<th>°C</th>
<th>MPa</th>
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<tr>
<td><strong>Flow at 100% load</strong></td>
<td>5.4</td>
<td>5.2</td>
<td>4.2</td>
<td>4.7</td>
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<tr>
<td><strong>Flow at 85% load</strong></td>
<td>4.4</td>
<td>3.7</td>
<td>4.5</td>
<td>4.7</td>
</tr>
<tr>
<td><strong>Flow at 75% load</strong></td>
<td>4.0</td>
<td>3.3</td>
<td>4.5</td>
<td>4.7</td>
</tr>
<tr>
<td><strong>Temp. after turbo, 100% load (TE517)</strong></td>
<td>329</td>
<td>312</td>
<td>306</td>
<td>312</td>
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<tr>
<td><strong>Temp. after turbo, 85% load (TE517)</strong></td>
<td>326</td>
<td>304</td>
<td>311</td>
<td>313</td>
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<td><strong>Temp. after turbo, 75% load (TE517)</strong></td>
<td>337</td>
<td>311</td>
<td>326</td>
<td>327</td>
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<td><strong>Temp. after turbo, 50% load (TE517)</strong></td>
<td>342</td>
<td>320</td>
<td>327</td>
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<tr>
<td><strong>Backpressure, max.</strong></td>
<td>3.0</td>
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<td><strong>Exhaust gas pipe diameter, min</strong></td>
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<tr>
<td><strong>Calculated exhaust diameter for 35 m/s</strong></td>
<td>562</td>
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**Heat balance (Note 3)**

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<tr>
<th></th>
<th>kW</th>
<th>m³/h</th>
<th>kW</th>
<th>°C</th>
<th>°C</th>
<th>°C</th>
<th>MPa</th>
<th>°C</th>
<th>°C</th>
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<tr>
<td><strong>Jacket water</strong></td>
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<td>474</td>
<td>427</td>
<td>474</td>
<td>417</td>
<td>401</td>
<td>367</td>
<td>401</td>
<td>375</td>
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<tr>
<td><strong>Lubricating oil</strong></td>
<td>378</td>
<td>401</td>
<td>367</td>
<td>401</td>
<td>375</td>
<td>401</td>
<td>367</td>
<td>401</td>
<td>375</td>
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<tr>
<td><strong>Charge air</strong></td>
<td>849</td>
<td>1002</td>
<td>968</td>
<td>1002</td>
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<tr>
<td><strong>Radiation</strong></td>
<td>122</td>
<td>128</td>
<td>122</td>
<td>128</td>
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**Fuel system (Note 4)**

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<thead>
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<th>m³/h</th>
<th>kW</th>
<th>°C</th>
<th>°C</th>
<th>°C</th>
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<tr>
<td><strong>Pressure before injection pumps (PT101)</strong></td>
<td>700±50</td>
<td>700±50</td>
<td>700±50</td>
<td>700±50</td>
<td>700±50</td>
<td>700±50</td>
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<td><strong>Fuel flow to engine (without engine driven pump), approx.</strong></td>
<td>3.7</td>
<td>4.1</td>
<td>3.7</td>
<td>4.1</td>
<td>3.7</td>
<td>4.1</td>
</tr>
<tr>
<td><strong>HFO viscosity before engine</strong></td>
<td>2.1</td>
<td>2.3</td>
<td>2.2</td>
<td>2.3</td>
<td>2.2</td>
<td>2.3</td>
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<td><strong>HFO temperature before engine, max. (TE 101)</strong></td>
<td>140</td>
<td>140</td>
<td>140</td>
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<tr>
<td><strong>MDF viscosity, min</strong></td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
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<td><strong>MDF temperature before engine, max. (TE 101)</strong></td>
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<td>45</td>
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<tr>
<td><strong>Fuel consumption at 100% load</strong></td>
<td>187</td>
<td>190</td>
<td>188</td>
<td>190</td>
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<td><strong>Fuel consumption at 85% load</strong></td>
<td>185</td>
<td>188</td>
<td>185</td>
<td>187</td>
<td>185</td>
<td>187</td>
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<tr>
<td><strong>Fuel consumption at 75% load</strong></td>
<td>189</td>
<td>191</td>
<td>188</td>
<td>190</td>
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<td>190</td>
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<tr>
<td><strong>Fuel consumption at 50% load</strong></td>
<td>198</td>
<td>202</td>
<td>189</td>
<td>192</td>
<td>189</td>
<td>192</td>
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<tr>
<td><strong>Clean leak fuel quantity, MDF at 100% load</strong></td>
<td>10.3</td>
<td>10.9</td>
<td>10.3</td>
<td>10.9</td>
<td>10.3</td>
<td>10.9</td>
</tr>
<tr>
<td><strong>Clean leak fuel quantity, HFO at 100% load</strong></td>
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<td>2.2</td>
<td>2.1</td>
<td>2.2</td>
<td>2.1</td>
<td>2.2</td>
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**Lubricating oil system (Note 5)**

<table>
<thead>
<tr>
<th></th>
<th>kPa</th>
<th>m³/h</th>
<th>kW</th>
<th>°C</th>
<th>°C</th>
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<tbody>
<tr>
<td><strong>Pressure before bearings, nom. (PT201)</strong></td>
<td>450</td>
<td>450</td>
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<td><strong>Pressure after pump, max.</strong></td>
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<td><strong>Suction ability including pipe loss, max.</strong></td>
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<td><strong>Priming pressure, nom. (PT201)</strong></td>
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<td><strong>Temperature before bearings, nom. (TE201)</strong></td>
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<td><strong>Temperature after engine, approx.</strong></td>
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<td>78</td>
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<td><strong>Pump capacity (main), engine driven</strong></td>
<td>81</td>
<td>90</td>
<td>81</td>
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<td><strong>Pump capacity (main), stand-by</strong></td>
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<td>75</td>
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<tr>
<td><strong>Priming pump capacity, 50Hz/60Hz</strong></td>
<td>16 / 19</td>
<td>16 / 19</td>
<td>16 / 19</td>
<td>16 / 19</td>
<td>16 / 19</td>
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<tr>
<td><strong>Oil volume, wet sump, nom.</strong></td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
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<tr>
<td><strong>Oil volume in separate system oil tank, nom.</strong></td>
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<td>3.7</td>
<td>3.5</td>
<td>3.7</td>
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<td><strong>Oil consumption (100% load), approx.</strong></td>
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<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td><strong>Crankcase ventilation flow rate</strong></td>
<td>150</td>
<td>150</td>
<td>150</td>
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<td>150</td>
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<td><strong>Crankcase backpressure (max)</strong></td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
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<tr>
<td><strong>Oil volume in speed governor</strong></td>
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<td>1.4 / 2.0</td>
<td>1.4 / 2.0</td>
<td>1.4 / 2.0</td>
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</table>

**High temperature cooling water system**

<table>
<thead>
<tr>
<th></th>
<th>kPa</th>
<th>m³/h</th>
<th>kW</th>
<th>°C</th>
<th>°C</th>
</tr>
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<tbody>
<tr>
<td><strong>Pressure at engine, after pump, nom. (PT401)</strong></td>
<td>360 + static</td>
<td>370 + static</td>
<td>360 + static</td>
<td>370 + static</td>
<td>360 + static</td>
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<tr>
<td><strong>Pressure at engine, after pump, max. (PT401)</strong></td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td><strong>Temperature before cylinders, approx. (TE402)</strong></td>
<td>81</td>
<td>81</td>
<td>81</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td><strong>HT-water out from the engine, nom. (TE402)</strong></td>
<td>91</td>
<td>91</td>
<td>91</td>
<td>91</td>
<td>91</td>
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</table>

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### Wärtsilä 26 - Product Guide
#### 3. Technical Data

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<tr>
<th>Cylinder output</th>
<th>kW/cyl</th>
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<th>AE/DE IMO Tier 2</th>
<th>ME IMO Tier 2</th>
<th>ME IMO Tier 2</th>
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<tr>
<td>Engine speed</td>
<td>rpm</td>
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<td>340</td>
<td>325</td>
<td>340</td>
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<tr>
<td>Capacity of engine driven pump, nom.</td>
<td>m³/h</td>
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<td>45</td>
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<td>Pressure drop over engine</td>
<td>kPa</td>
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<tr>
<td>Pressure drop in external system, max</td>
<td>kPa</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Pressure from expansion tank</td>
<td>kPa</td>
<td>70...150</td>
<td>70...150</td>
<td>70...150</td>
<td>70...150</td>
</tr>
<tr>
<td>Water volume in engine</td>
<td>m³</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

#### Low temperature cooling water system

| Pressure at engine, after pump, nom. (PT471) | kPa | 270 + static | 250 + static | 270 + static | 250 + static |
| Temperature before engine (TE471) | °C | 25...38 | 25...38 | 25...38 | 25...38 |
| Capacity of engine driven pump, nom. | m³/h | 56 | 62 | 56 | 62 |
| Pressure drop in external system, max. | kPa | 60 | 60 | 60 | 60 |
| Pressure drop over charge air cooler | kPa | 50 | 50 | 50 | 50 |
| Pressure drop over oil cooler | kPa | 18 | 18 | 18 | 18 |
| Pressure from expansion tank | kPa | 70...150 | 70...150 | 70...150 | 70...150 |
| Capacity engine driven seawater pump, max. | m³/h | 120 | 120 | 120 | 120 |

#### Starting air system (Note 6)

| Pressure, nom. | kPa | 3000 | 3000 | 3000 | 3000 |
| Pressure, max. | kPa | 3300 | 3300 | 3300 | 3300 |
| Low pressure limit in air vessels | kPa | 1800 | 1800 | 1800 | 1800 |
| Starting air consumption, start (successful) | Nm³ | 1.8 | 1.8 | 1.8 | 1.8 |

### Notes:

- **Note 1**: At ISO 3046-1 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Tolerance 5%.
- **Note 2**: At ISO 3046-1 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5% and temperature tolerance 20°C.
- **Note 3**: The heat balances are made for ISO 3046/1 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).
- **Note 4**: According to ISO 3046/1, lower calorific value 42 700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%. The fuel consumption at 85% load is guaranteed and the values at other loads are given for indication only.
- **Note 5**: Starting air consumption depends on the speed governor type.
- **Note 6**: At manual starting the consumption may be 2...3 times lower.

**ME** = Engine driving propeller, variable speed  
**AE** = Auxiliary engine driving generator  
**DE** = Diesel-Electric engine driving generator

Subject to revision without notice.
### 3.3 Wärtsilä 9L26

<table>
<thead>
<tr>
<th>Wärtsilä 9L26</th>
<th>AE/DE IMO Tier 2</th>
<th>AE/DE IMO Tier 2</th>
<th>ME IMO Tier 2</th>
<th>ME IMO Tier 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder output kW/cyl</td>
<td>325</td>
<td>340</td>
<td>325</td>
<td>340</td>
</tr>
<tr>
<td>Engine speed rpm</td>
<td>900</td>
<td>1000</td>
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<tr>
<td>Engine output kW</td>
<td>2925</td>
<td>3060</td>
<td>2925</td>
<td>3060</td>
</tr>
<tr>
<td>Mean effective pressure MPa</td>
<td>2.55</td>
<td>2.4</td>
<td>2.55</td>
<td>2.4</td>
</tr>
</tbody>
</table>

#### Combustion air system (Note 1)
- Flow of air at 100% load kg/s: 5.6, 6.1, 5.8, 6.0
- Temperature at turbocharger intake, max. °C: 45, 45, 45, 45
- Air temperature after air cooler, nom. (TE601) °C: 55, 55, 55, 55

#### Exhaust gas system (Note 2)
- Flow at 100% load kg/s: 5.7, 6.2, 6.0, 6.2
- Flow at 85% load kg/s: 5.0, 5.5, 5.1, 5.3
- Flow 75% load kg/s: 4.5, 5.1, 4.6, 4.7
- Flow 50% load kg/s: 3.3, 3.8, 3.1, 3.5
- Temp. after turbo, 100% load (TE517) °C: 329, 312, 306, 312
- Temp. after turbo, 85% load (TE517) °C: 326, 304, 311, 313
- Temp. after turbo, 75% load (TE517) °C: 337, 311, 326, 327
- Temp. after turbo, 50% load (TE517) °C: 342, 320, 327, 322
- Backpressure, max. kPa: 3.0, 3.0, 3.0, 3.0
- Exhaust gas pipe diameter, mm: 600, 600, 600, 600
- Calculated exhaust diameter for 35 m/s mm: 595, 611, 597, 610

#### Heat balance (Note 3)
- Jacket water kW: 496, 534, 481, 534
- Lubricating oil kW: 425, 451, 413, 451
- Charge air kW: 955, 1127, 1078, 1127
- Radiation kW: 137, 144, 137, 144

#### Fuel system (Note 4)
- Pressure before injection pumps (PT101) kPa: 700±50, 700±50, 700±50, 700±50
- Engine driven pump capacity at 12 cSt (MDF only) m³/h: 3.7, 4.1, 3.7, 4.1
- Fuel flow to engine (without engine driven pump), approx. m³/h: 2.4, 2.6, 2.4, 2.6
- HFO viscosity before engine cSt: 16...24, 16...24, 16...24, 16...24
- HFO temperature before engine, max. (TE 101) °C: 140, 140, 140, 140
- MDF viscosity, min cSt: 2.5, 2.0, 2.0, 2.0
- MDF viscosity, max. °C: 45, 45, 45, 45
- Fuel consumption at 100% load g/kWh: 187, 190, 188, 190
- Fuel consumption at 85% load g/kWh: 185, 188, 185, 187
- Fuel consumption at 75% load g/kWh: 189, 191, 188, 190
- Fuel consumption at 50% load g/kWh: 198, 202, 189, 192
- Clean leak fuel quantity, MDF at 100% load kg/h: 11.6, 12.3, 11.6, 12.3
- Clean leak fuel quantity, HFO at 100% load kg/h: 2.3, 2.5, 2.3, 2.5

#### Lubricating oil system (Note 5)
- Pressure before bearings, nom. (PT201) kPa: 450, 450, 450, 450
- Pressure after pump, max. kPa: 800, 800, 800, 800
- Suction ability including pipe loss, max. kPa: 30, 30, 30, 30
- Priming pressure, nom. (PT201) kPa: 80, 80, 80, 80
- Temperature before bearings, nom. (TE201) °C: 68, 68, 68, 68
- Temperature after engine, approx. °C: 78, 78, 78, 78
- Pump capacity (main), engine driven m³/h: 81, 90, 81, 90
- Pump capacity (main), stand-by m³/h: 75, 75, 75, 75
- Priming pump capacity, 50Hz/60Hz m³/h: 16 / 19, 16 / 19, 16 / 19, 16 / 19
- Oil volume, wet sump, nom. m³: 1.7, 1.7, 1.7, 1.7
- Oil volume in separate system oil tank, nom. m³: 3.9, 4.1, 3.9, 4.1
- Oil consumption (100% load), approx. g/kWh: 0.5, 0.5, 0.5, 0.5
- Crankcase ventilation flow rate l/min/cyl: 150, 150, 150, 150
- Crankcase backpressure (max) kPa: 0.3, 0.3, 0.3, 0.3
- Oil volume in speed governor m³: 1.4 / 2.0, 1.4 / 2.0, 1.4 / 2.0, 1.4 / 2.0

#### High temperature cooling water system
- Pressure at engine, after pump, nom. (PT401) kPa: 360 + static, 350 + static, 360 + static, 350 + static
- Pressure at engine, after pump, max. (PT401) kPa: 500, 500, 500, 500
- Temperature before cylinders, approx. (TE401) °C: 81, 81, 81, 81
- HT-water out from the engine, nom (TE402) °C: 91, 91, 91, 91