REMOLCADOR DE SALVAMENTO LUCHA CONTRA LA CONTAMINACION Y FIFI 68 TPF

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

Alba Jove Rodríguez

Proyecto de fin de grado 15-01

UNIVERSIDADE DA CORUÑA

Escola Politécnica Superior
UNIVERSIDADE DA CORUÑA

DEPARTAMENTO DE INGENIERÍA NAVAL Y OCEÁNICA

GRADO EN INGENIERÍA DE PROPULSIÓN Y SERVICIOS DEL BUQUE

CURSO 2.014-2015

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

Índice

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 pasaríamos 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.

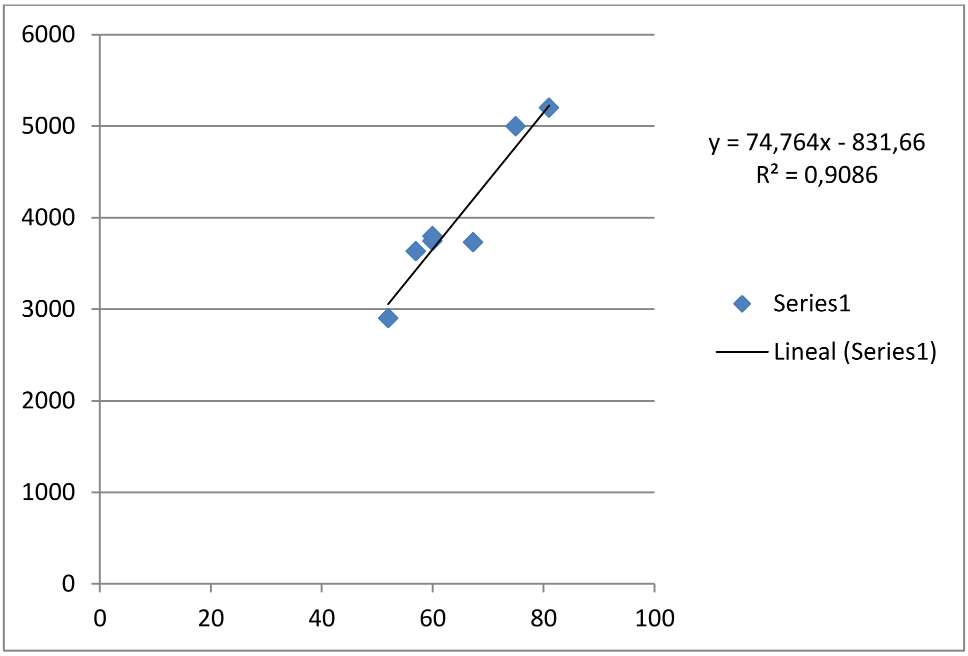
Antes de proceder a los cálculos vamos explicar los requisitos que necesita un remolcador a la hora de calcular la potencia de su planta propulsora.

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.

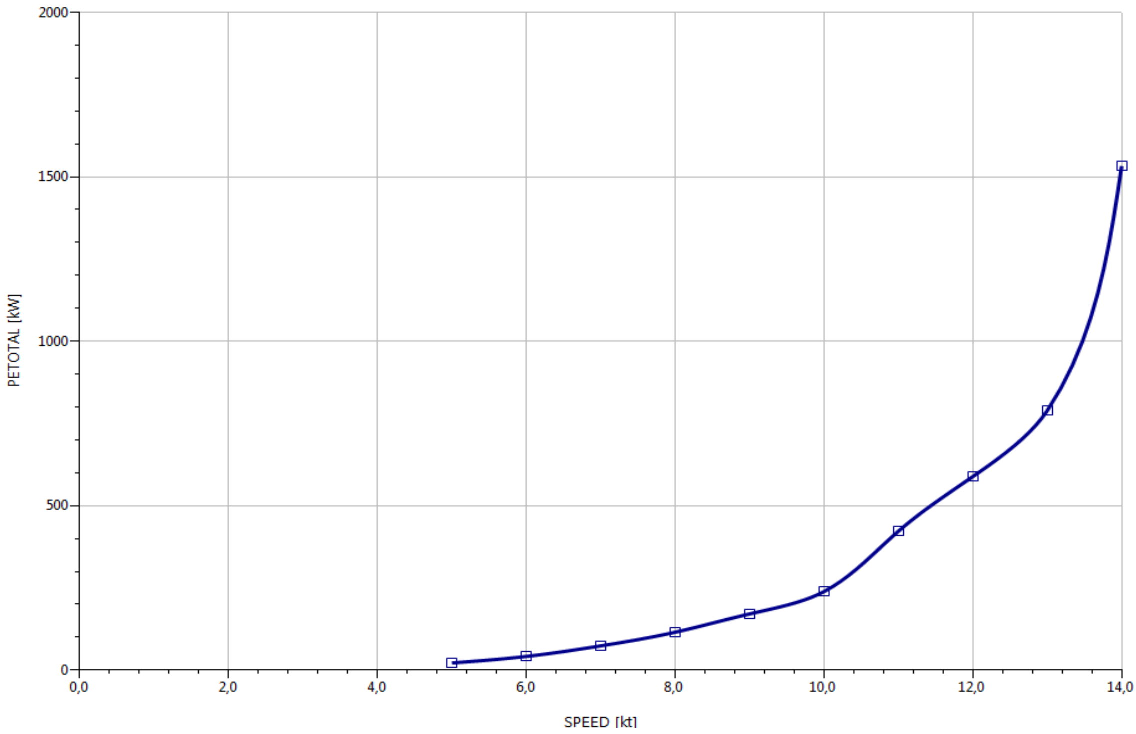
Si recordamos calculamos la potencia necesaria con unas gráficas relacionando la potencia y el tiro de los remolcadores de los buques base.



$$BHP = 74.764TPF - 831.366 = \mathbf{4252.6}\ Kw$$

Y la potencia calculada en aguas libres, mediante el programa Nav-Cad para una navegación de 13 nudos:

Seria 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

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.

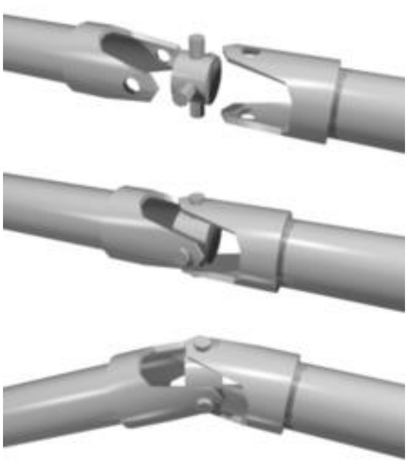


Figura 2. Eje Kardan

4. Calculo 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 Nav-Cad:

- Trabajaremos con el sistema Internacional

Units and formatting

Speed	kt	[0.00]
Length	m	[0.000]
Prop length	mm	[0.0]
Area	m2	[0.0]
Weight	t	[0.00]
Force	kN	[0.00]
Power	kW	[0.0]
Torque	kN·m	[0.00]
Pressure	kPa	[0.00]
TipSpeed	m/s	[0.00]
FuelRate	L/h	[0.00]
Density	kg/m3	[0.00]
Viscosity	m2/s	[0.00000e+0]
Temperature	°C	[0.0]

SI | Imperial | OK | Cancel

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

Project		
Project ID:	Remolcador de sal...	
Description:	68 TPF	
Summary		
Scope:	ITTC-78 (CT)	
Configuration:	Monohull	
Chine type:	Single/hard	
Length on WL:	39,900	m
Displacement:	1472,60	t
Propulsor type:	Propeller	
Count:	2	
Water properties		
Water type:	Salt	
Density:	1026,00	kg/m3
Viscosity:	1,18920e-6	m2/s
Speeds		
Speed [01]	5,00	kt
Speed [02]	6,00	kt
Speed [03]	7,00	kt
Speed [04]	8,00	kt
Speed [05]	9,00	kt
Speed [06]	10,00	kt
Speed [07]	11,00	kt
Speed [08]	12,00	kt
Speed [09]	13,00	kt
Speed [10]	14,00	kt
Design condition		
Design speed:	13,00	kt

- 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, …

Hull		
Configuration:	Monohull	
Chine type:	Single/hard	
General		
Length on WL:	39,900	m
Max beam on WL:	12,500	m
Max molded draft:	5,500	m
Displacement:	1472,60	t
Wetted surface:	645,7	m2
Demi-hull spacing:		m
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]

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

$$Sm = 1.7Lpp * T + \frac{\Delta}{T} = 1.7 * 35.8 * 5.55$$

- Apéndices, en este apartado tenemos que poner los datos sobre el propulsor:

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

- 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.

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

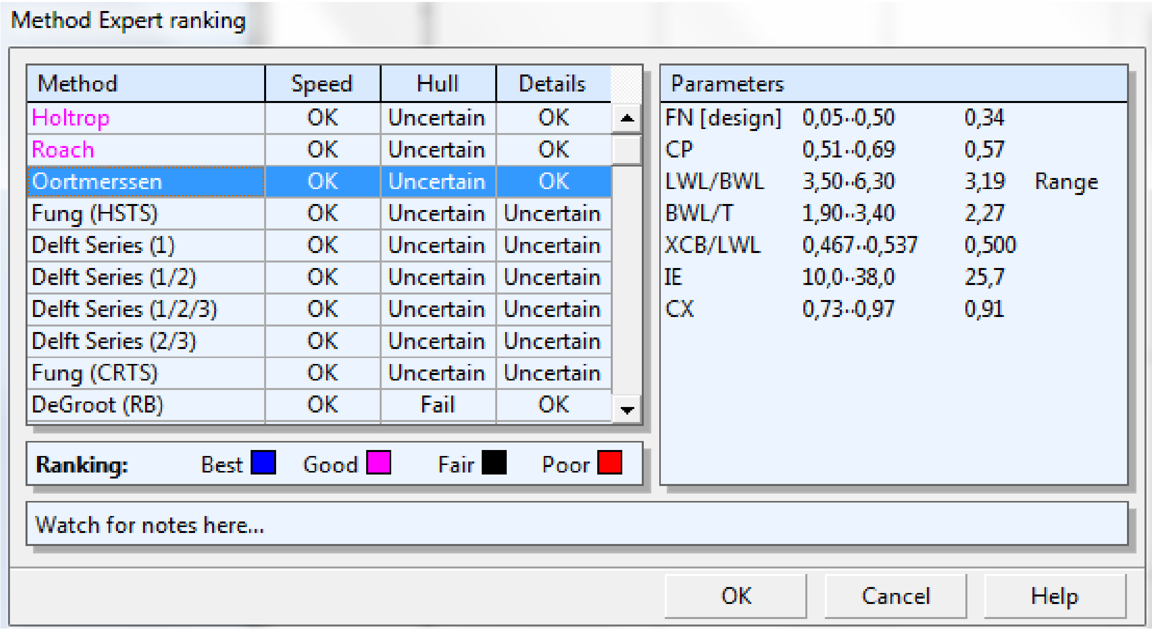
- La ultima pestaña de datos específicos que tenemos es la del margen de mar, en este caso se utilizara un margen de un 15%.

Margin		
Design margin:	15	%
Basis:	Hull drag only	

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:

Vessel drag	Calc	ITTC-78 (CT)
Technique:		Prediction
Prediction:		Oortmerssen
Reference ship:		
Model LWL:	[m]	
Viscous		
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	
Catamaran		
Interference:	Off	
Added drag		
Appendage:	Calc	Holtrop (Compone...
Wind:	Off	
Seas:	Off	
Shallow/channel:	Off	
Margin:	Calc	Hull drag only [15%]

En esta pestaña se elegirá el proceso más adecuado teniendo en cuenta los parámetros y la descripción dada en el apartado de ayuda:



Method	Speed	Hull	Details
Holtrop	OK	Uncertain	OK
Roach	OK	Uncertain	OK
Oortmerssen	OK	Uncertain	OK
Fung (HSTS)	OK	Uncertain	Uncertain
Delft Series (1)	OK	Uncertain	Uncertain
Delft Series (1/2)	OK	Uncertain	Uncertain
Delft Series (1/2/3)	OK	Uncertain	Uncertain
Delft Series (2/3)	OK	Uncertain	Uncertain
Fung (CRTS)	OK	Uncertain	Uncertain
DeGroot (RB)	OK	Fail	OK

Parameters			
FN [design]	0,05··0,50	0,34	
CP	0,51··0,69	0,57	
LWL/BWL	3,50··6,30	3,19	Range
BWL/T	1,90··3,40	2,27	
XCB/LWL	0,467··0,537	0,500	
IE	10,0··38,0	25,7	
CX	0,73··0,97	0,91	

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 Fn 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 these potential errors. Lambda is a parameter used within the Holtrop method and is equal to 1.446 * Cp - 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.

- Oortmerssens

Remarks	A random collection of 93 models of tugs and trawlers tested at NSMB make up the data set. The originally published equations had errors and were corrected by direct communication between HydroComp and Dr. G. van Oortmerssen. [Hull] One confusing aspect of the Oortmerssen method is the use of a "displacement length" (LD) for the speed and hull parameters. This is a figure defined as the average of LWL and some arbitrary LPP. Unfortunately, Oortmerssen's example shows only the value for LD. However, a sensitivity analysis was conducted which showed that humps and hollows in the wave-making curve are increased as LD is a small ratio to LWL. Therefore, LD in NavCad is now taken as 0.98 LWL, which produces wave-making curves that are a bit more conservative on total bare-hull drag. [Resistance] 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 FN of about 0.3.

- Roach

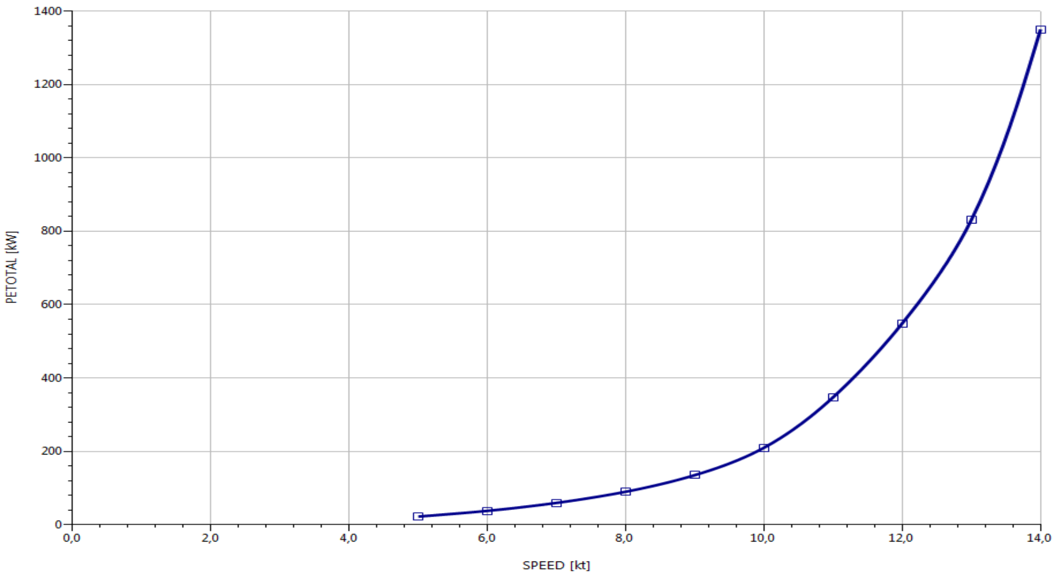
Roach

Reference	Roach, C.D., "Tugboat Design", SNAME New England Section, January 1954
Vessel type	Tugboats
Prediction scope	Resistance: Bare-hull resistance
Parameters	CVOL 3.93‑‑5.23 (LWL / Vol$^{1/3}$) CP(LWL) 0.56‑‑0.68 XCB/LWL 0.479‑‑0.498 LWL/BWL 3.07‑‑4.47 BWL/T 2.34‑‑3.20
Speed range	FN(LWL) 0.27‑‑0.41
Formula error	Not presented
Methodology	2-D CR, ATTC CF, random model tests
Remarks	This series was developed from 11 models, (nominally 11 feet in length) tested at the David Taylor Model Basin. The prediction below FN = 0.27 is made by extending the CR as a function of FN^4.

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

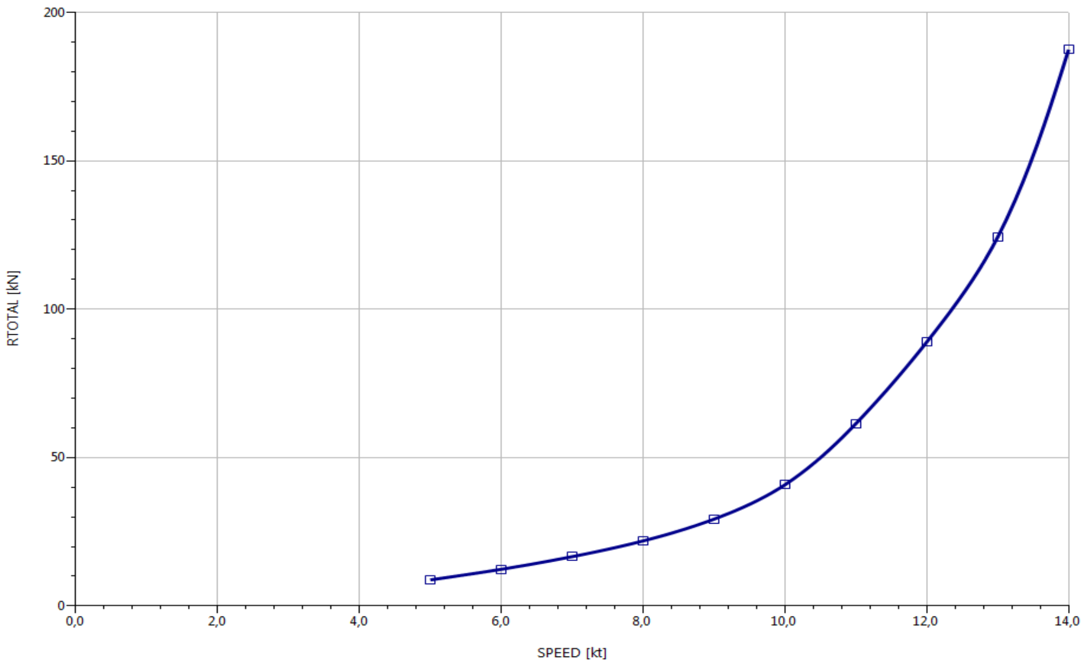
- Potencia efectiva total vs Velocidad



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

$P_{efectiva}$=831.1 Kw

- Resistencia total Vs velocidad

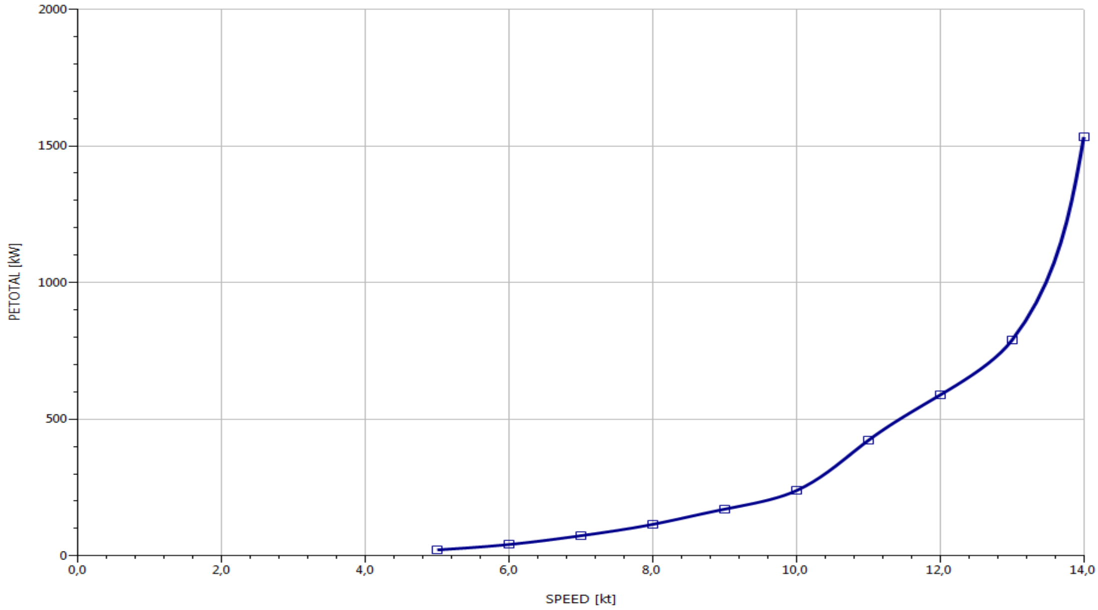


La resistencia total para una velocidad de 13 nudos es:

R_{Total}= *124.27* KN

4.2. Oortmerssens

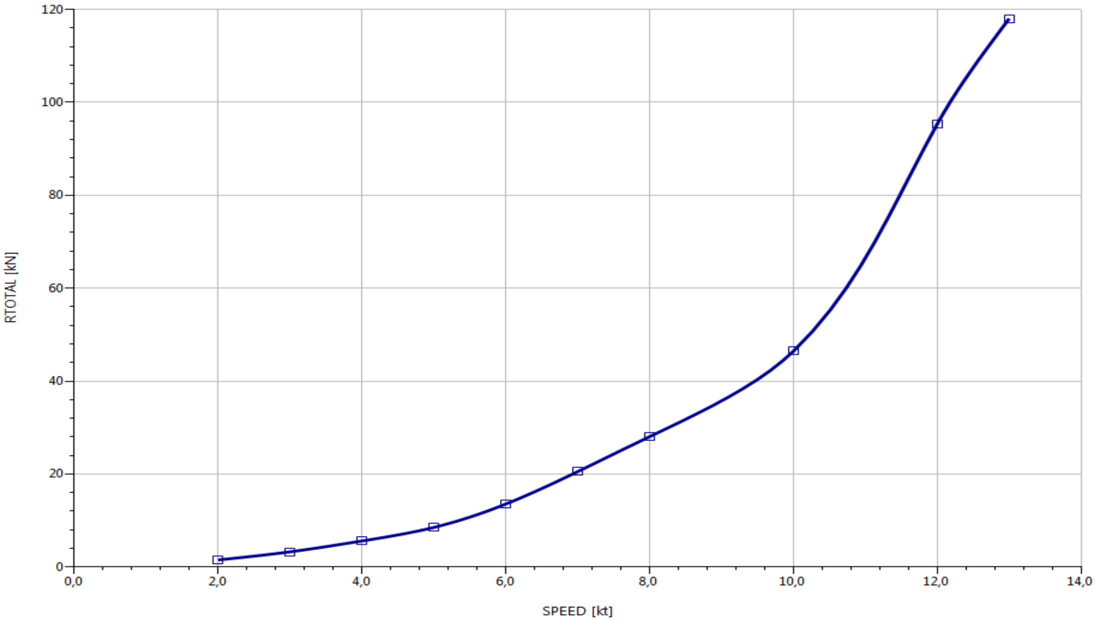
- Potencia efectiva total vs Velocidad



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

$P_{efectiva}$= *789.2* KW

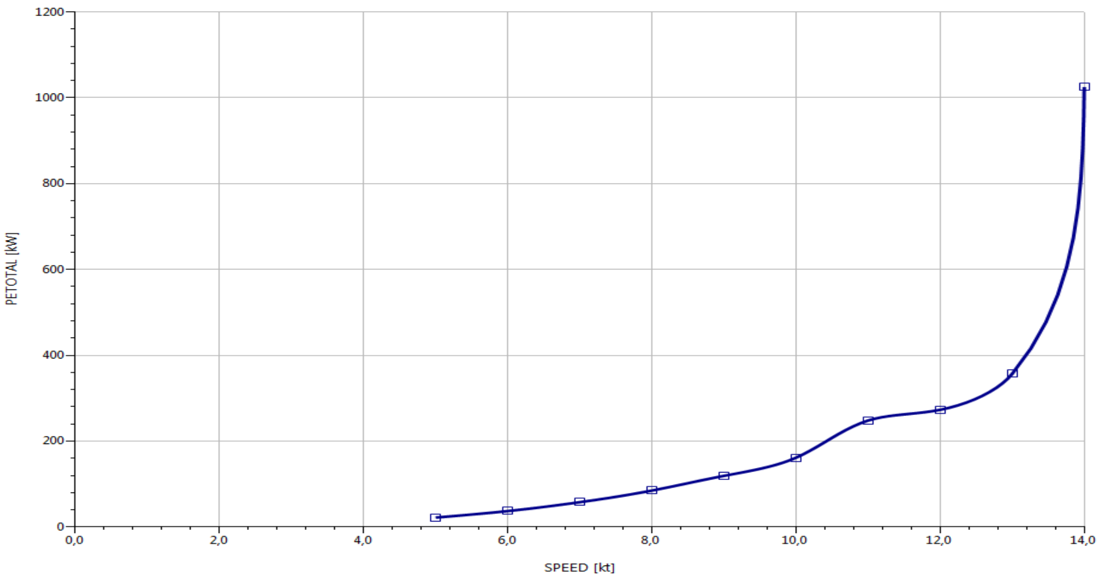
- Resistencia total Vs velocidad



La resistencia total para una velocidad de 13 nudos es:

R_{Total}= *118.01* KN

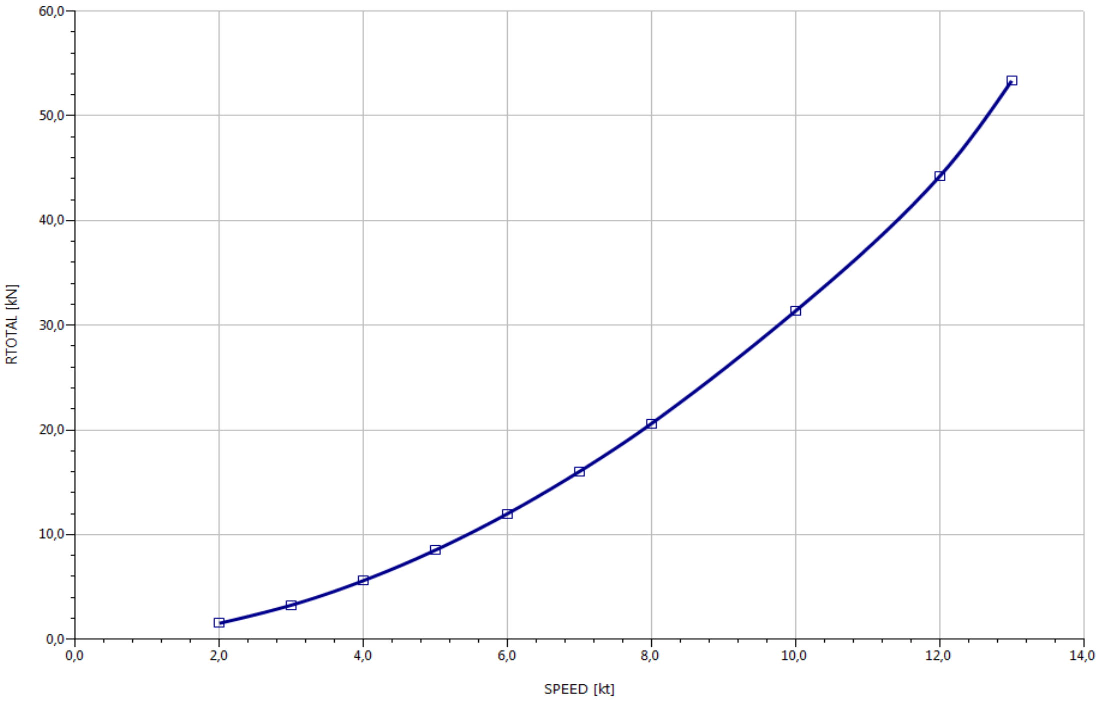
4.3. Roach



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

$P_{efectiva}$= *356.7* KW

- Resistencia total Vs velocidad



La resistencia total para una velocidad de 13 nudos es:

R_{Total}= *53.03* KN

4.4. Resumen

Método de Calculo	Resistencia al avance(KN)	Potencia efectiva(KW)
Holtrop	124.27	831.1
Oortmenssens	118.01	789.2
Roach	53.03	356.7

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 Oortmensenssen, porque estamos trabajando con un remolcador de poca eslora.

Método de Calculo	Resistencia al avance(KN)	Potencia efectiva(KW)
Oortmensenssen	118.01	789.2

Antes de pasar al siguiente punto se debe aclarar que la potencia efectiva esta 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:

$$BHP = EHP * \frac{MM}{\eta 1 * \eta 2 * \eta 3 * \eta 4}$$

- $\eta 1$: 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:

Propulsor		
Count:	2	
Propulsor type:	Propeller series	
Propeller type:	FPP	
Propeller series:	B Series	
Propeller sizing:	No sizing	
Reference prop:		
Blade count:	4	
Expanded area ratio:	0,0000	
Propeller diameter:	0,0	mm
Propeller mean pitch:	0,0	mm
Hub immersion:	0,0	mm

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 para 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 velociadades superiores a los 10 Kn se puede producir cavitación.

5.1. Kaplan 19A

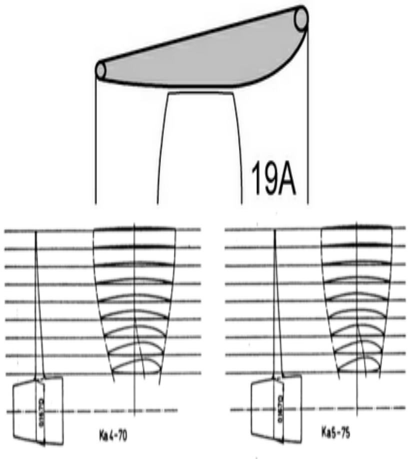
Un resumen de la especificación seria:

- 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:

Kaplan Ka 19A

Top Previous

Reference	Oosterveld, M.W.C., "Wake Adapted Ducted Propellers", Netherlands Ship Model Basin, Publication No. 345, 1970. (Corrected, Sep 1982.)
Configuration	Ducted
Parameters	Number of blades 3··5 Blade area ratio 3 blades: 0.65 4 blades: 0.55··0.70 5 blades: 0.65··0.95 Pitch/Diameter ratio 0.50··1.40 Advance coefficient (J) 0.05··1.50
Remarks	This series was developed from the open-water analysis of the Kaplan series of non-cavitating propellers in a 19A 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 5-bladed propellers in a *Kaplan 19A* nozzle. This is suitable for 0.65 to 0.95 EAR. 

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

Propulsor		
Count:	2	
Propulsor type:	Propeller series	
Propeller type:	CPP	
Propeller series:	Kaplan 19A	
Propeller sizing:	By thrust	
Reference prop:		
Blade count:	3	
Expanded area ratio:	0,6500	
Propeller diameter:	3000,0	mm
Propeller mean pitch:	4192,6	mm
Hub immersion:	3000,0	mm
Engine/gear		
Engine data:	None defined	
Rated RPM:		RPM
Rated power:		kW
Gear efficiency:	0,97	
Gear ratio:	0,820	
Shaft efficiency:	0,97	
Propeller options		
Oblique angle corr:	Off	
Shaft angle to WL:	0,00	deg
Added rise of run:	0,00	deg
Propeller cup:	0,0	mm
KTKQ corrections:	Custom	
Scale correction:		
KT multiplier:	1,00	
KQ multiplier:	1,00	

Como ya explicamos antes tendriamos dos propulsores de la serie Kaplan 19A, aunque la serie es diseñada para 5 palas nosotros vamos hacer el analisis del las 3 palas.

El ratio de area es el recomendado por la serie, el diametro del propulsor es una aproximación basandonos en el buque base.

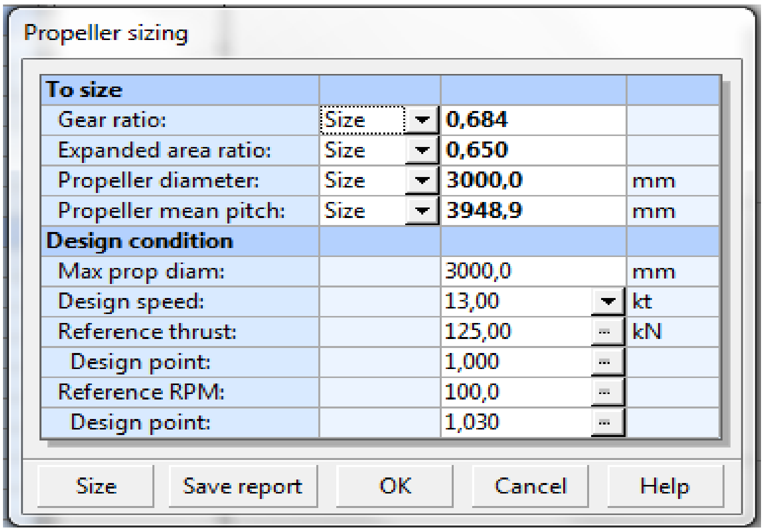
El resto de los valores son aproximaciones del propio Nav-Cad.

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

Hull-propulsor	Calc	
Technique:		Prediction
Prediction:		Holtrop
Reference ship:		
Max prop diam:	[mm]	3000,0
Corrections		
Viscous scale corr:	On	Standard
Rudder location:		Behind propeller
Friction line:		ITTC-57
Hull form factor:		1,366
Corr allowance:		ITTC-78 (v2008)
Roughness [mm]:	Off	
Ducted prop corr:	Off	
Tunnel stern corr:	Off	
Effective diam:	[m]	
Recess depth:	[m]	
System analysis		
Cavitation criteria:		Keller eqn
Analysis type:		Free run
CPP method:		Fixed RPM
Engine RPM:		100,0
Mass multiplier:		
RPM constraint:		
Limit [RPM/s]:		

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 cavitación será el de Keller eqn y las revoluciones fijadas serán 100 rpm.

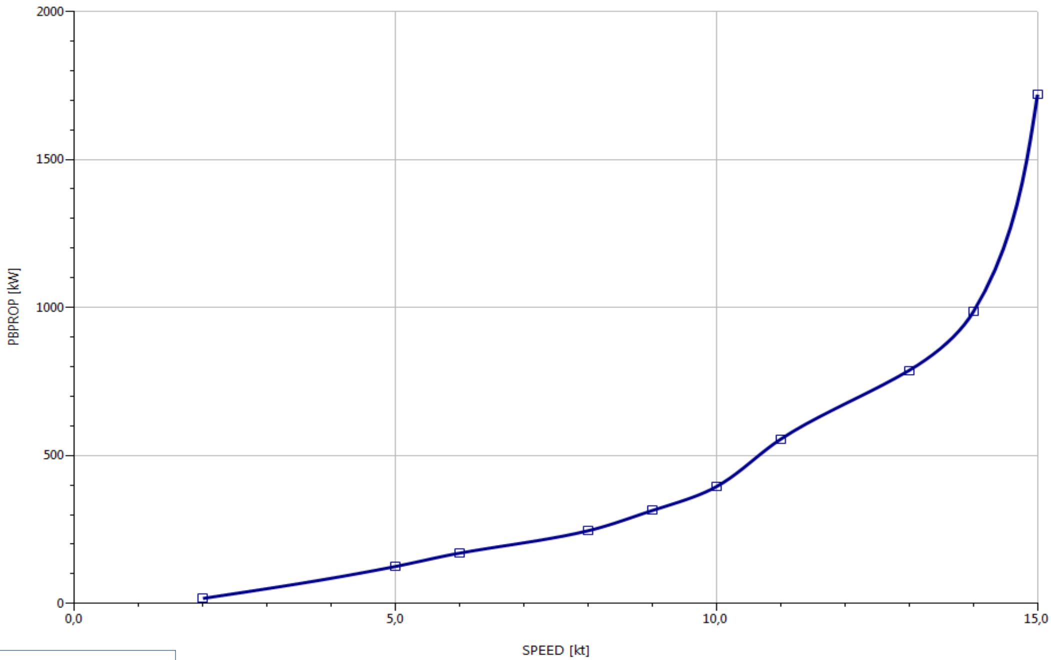
Una vez que tenemos todas las pestañas cubiertas pasamos a diseñar el propulsor, este diseño se realiza en la pestaña propeller sizing, en esta pestaña tenemos el diámetro la velocidad de diseño, las revoluciones de referencia, la resistencia rotal obtenida por el método holtrop,…



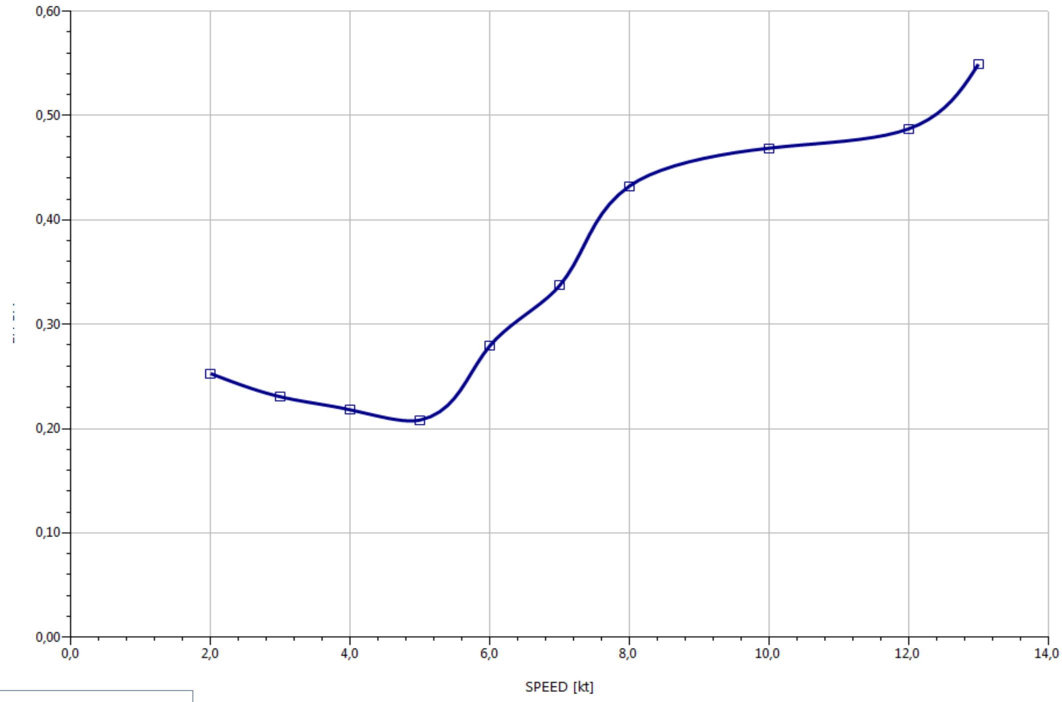
La pestaña anterior seria la correcta para el diseño del propulsor de 3 palas, pero tenemos que tener en cuenta que cuando tengamos que diseñar el propulsor de 4 y 5 palas la expansión de área tendrá que ser calculada (*size*).

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:

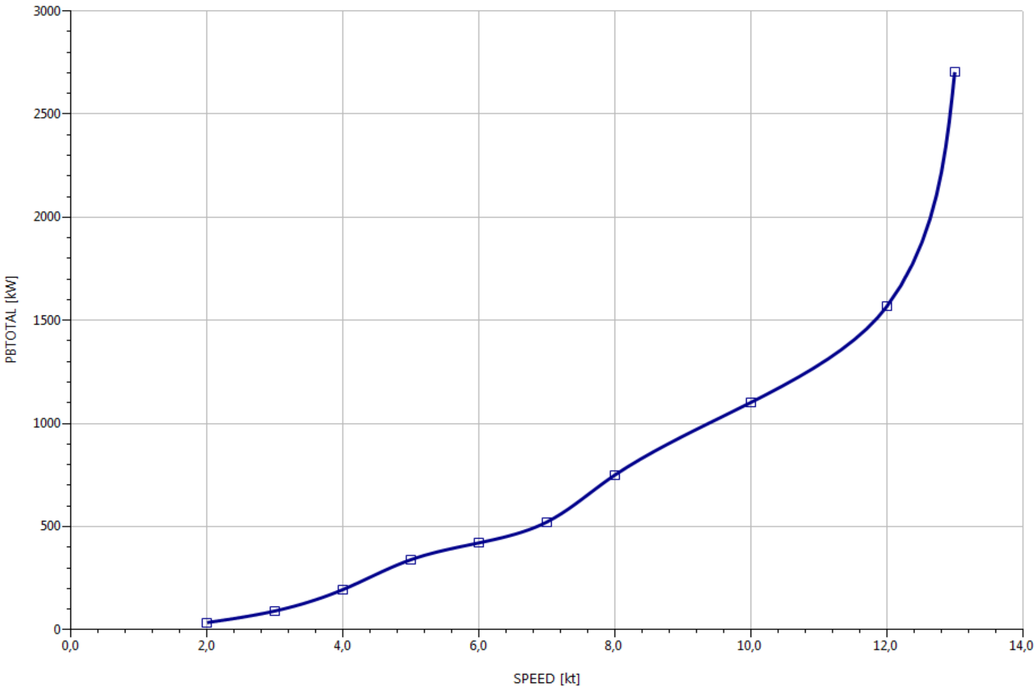


PB: 2629.7 Kw

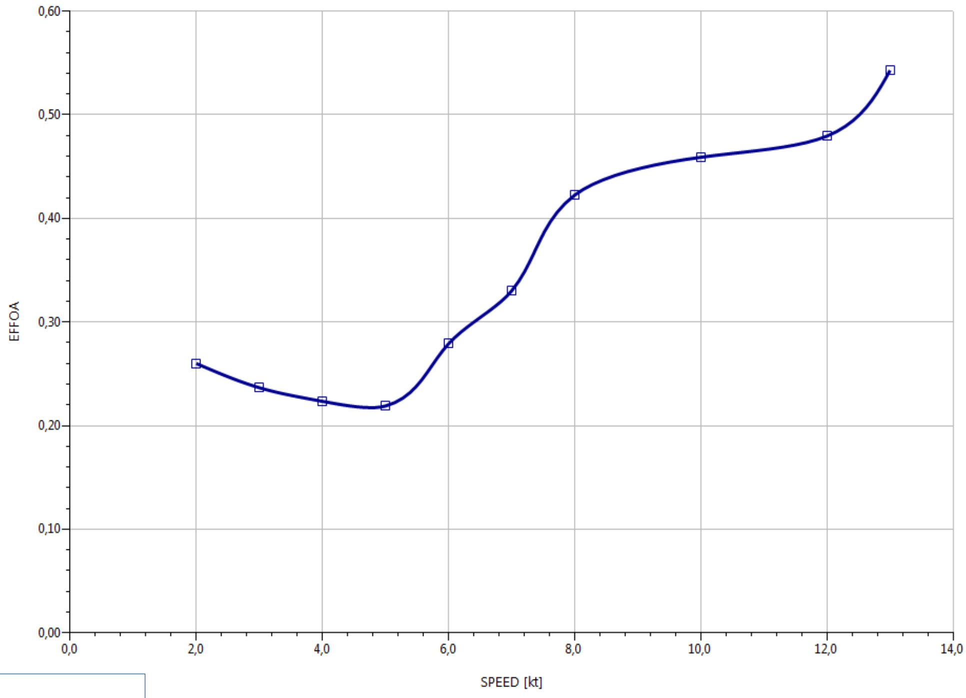


EFFOA: 0.5579

6.2.Propulsor de 4 palas:

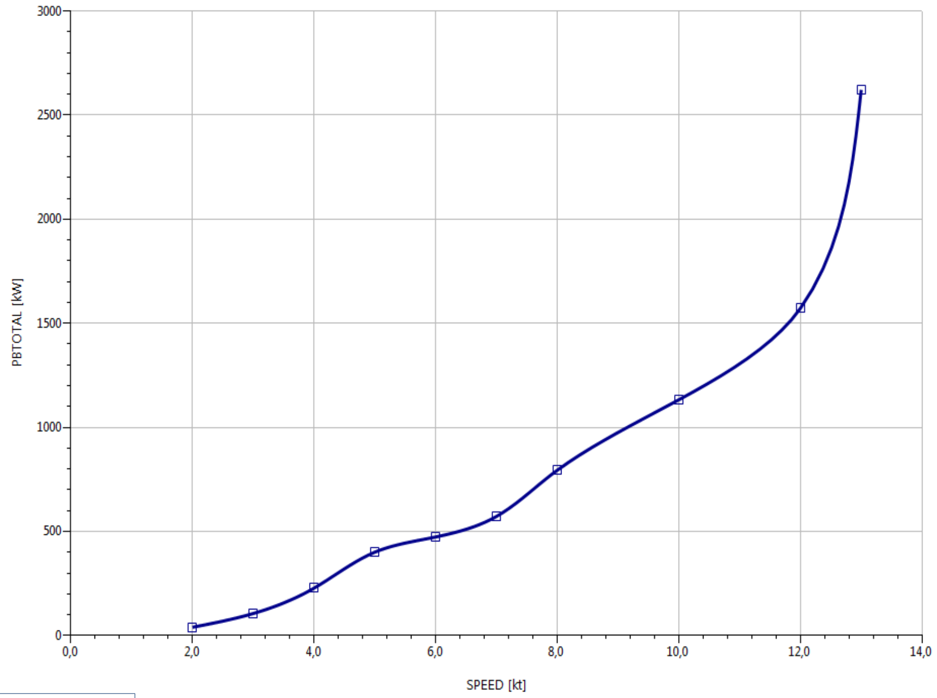


PB: 2665.9 kW

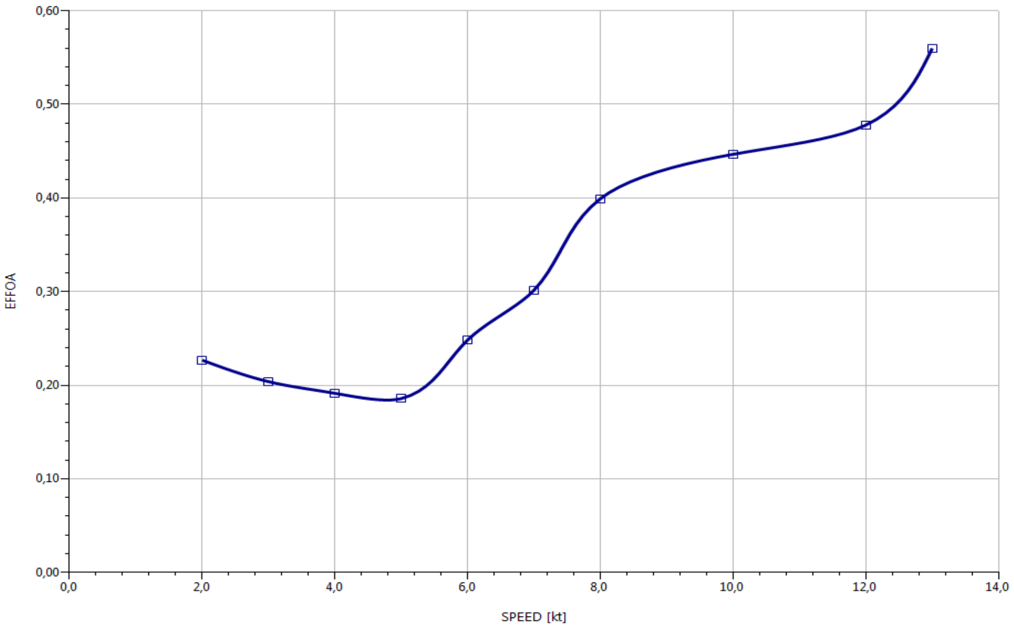


EFFOA: 0.5504

6.3. Propulsor de 5 palas:



PB: 2577.9 Kw



EFFOA: 0.5691

6.4. Resumen

El resumen de los tres anteriores propulsores seria el siguiente:

Nº de Palas	EFFOA	PB TOTAL (Kw)
3	**0.5579**	**2629.7**
4	**0.5504**	**2665.9**
5	**0.5691**	**2577.9**

De todos los propulsores el que menos potencia de freno necesita es el de 5 palas, por los cual 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 suministras a una condición de servicio del 0,85:

$$PB = \frac{2621{,}2}{0{,}85} = 3135 \text{ kw}$$

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 seria:

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

7.2. Motor Wartsila

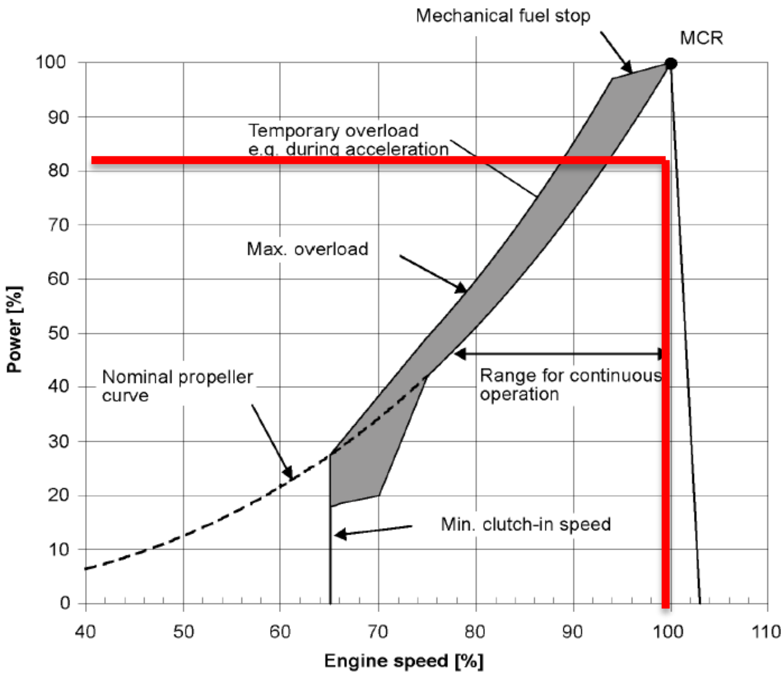
Una vez que sabemos la potencia necesaria nos vamos a la página de Wartsila y nos descargamos el pdf de motores de velocidad media. Al principio de este Pdf(Anexo 5) tenemos la siguiente tabla:

Cylinder con-figuration	Main engines		Generating sets			
	900 rpm	1000 rpm	900 rpm		1000 rpm	
	[kW]	[kW]	[KVA]	[kWe]	[KVA]	[kWe]
6L26	1950	2040	2352	1882	2461	1969
8L26	2600	2720	3136	2509	3281	2625
9L26	2925	3060	3528	2823	3691	2953
12V26	3900	4080	4704	3764	4922	3937
16V26	5200	5440	6273	5018	6562	5250

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:

SRP RUDDERPROPELLER

Technical Data

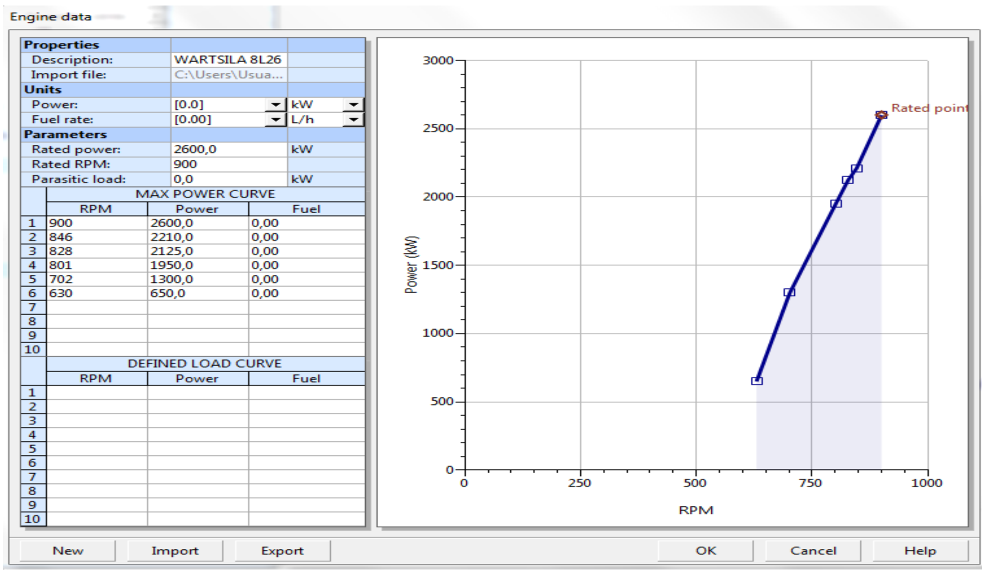
Type	Input Power [kW]	Input speed [rpm]	Propeller ø [m]	Weight [t]*
SRP 0320	150 - 250	1800/2300	0.65 - 0.85	1.50
SRP 170	220 - 350	1800/2000	0.90 - 1.10	1.65
SRP 200	280 - 410	1800/2100	1.00 - 1.20	2.10
SRP 330	400 - 620	1800	1.25 - 1.40	3.60
SRP 440	600 - 840	1600/1800	1.45	7.50
SRP 550	630 - 1000	1000/1200/1500/1800	1.50 - 1.75	9.60
SRP 1210	1150 - 1660	750/900/1000/1200/1600/1800	2.20	17.50
SRP 1512	1500 - 2070	750/900/1000/1200/1600/1800	2.40	21.50
SRP 1515	1750 - 2400	750/900/1000/1200/1600/1800	2.60	27.50
SRP 4000	2100 - 2800	750/900/1000/1200/1600/1800	2.80	31.00
SRP 4600	2500 - 3100	750/900/1000/1200/1600/1800	3.00	35.00
SRP 3030	2850 - 3600	600/750/900/1000	3.40	53.00
SRP 4040	3450 - 4500	600/750/900/1000	3.80	80.00
SRP 4500	4000 - 5400	750/900/1000	4.20	65.00

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

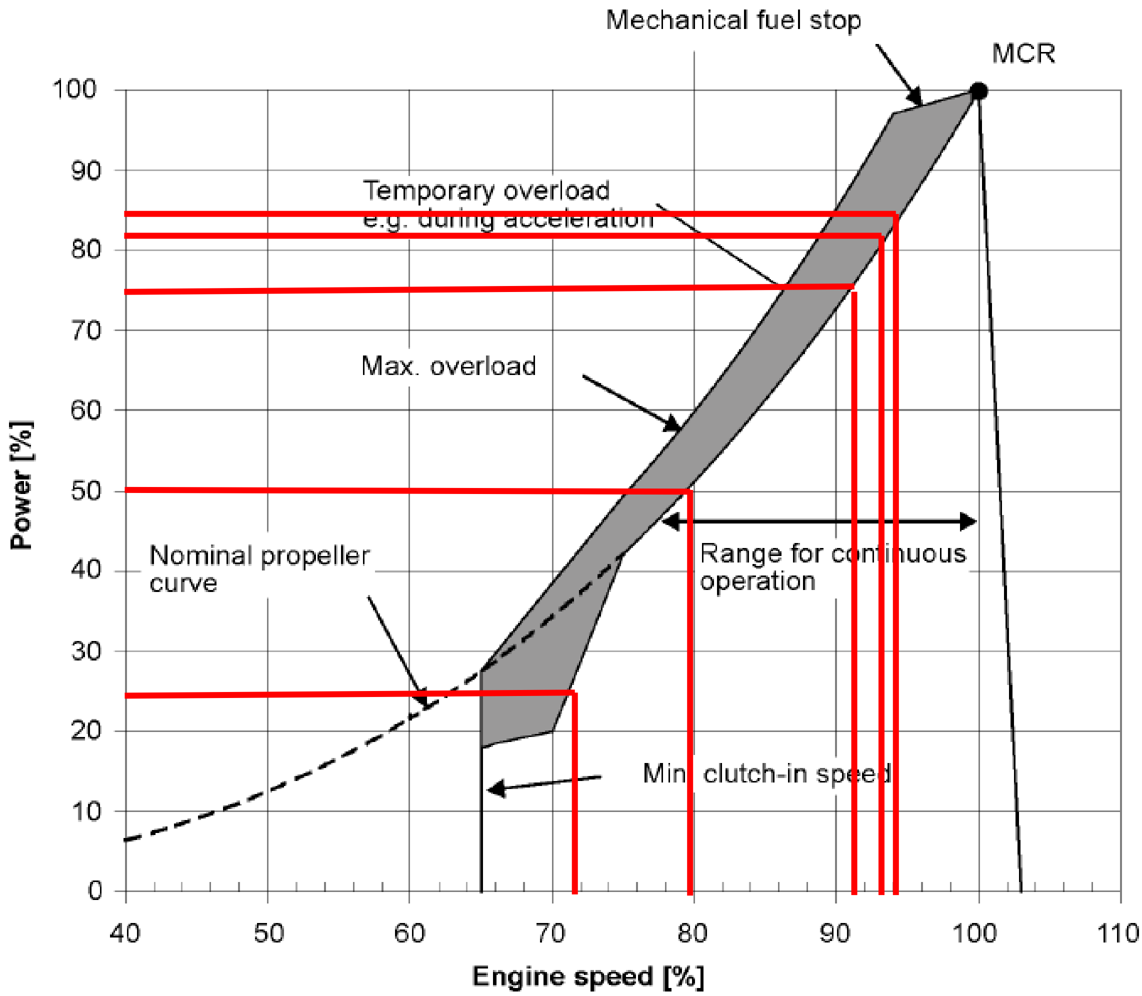
Una vez que tenemos el motor el propulsor, tenemos que definir el motor en el programa pinchando en la hélice y después en Engine Data, Se nos abriría la siguiente pestaña:



De esta pestaña tenemos que cubrir los siguientes valores relacionados con la condición de carga del motor:

	MAX POWER CURVE		
	RPM	Power	Fuel
1	900	2600,0	540,00
2	846	2210,0	537,00
3	828	2125,0	520,00
4	814	1950,0	400,00
5	720	1300,0	300,00
6	640	650,0	120,00
7			
8			
9			
10			

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 antes marcados pasamos a un cálculo estimado del combustible, quedándonos finalmente la siguiente tabla:

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

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:

Blade count:	4
Expanded area ratio:	0,6500
Propeller diameter:	2800,0
Propeller mean pitch:	3809,6
Hub immersion:	3000,0

- **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.

System analysis		
Cavitation criteria:		Keller eqn
Analysis type:		Towing
CPP method:		Variable RPM
Engine RPM:		
Mass multiplier:		
RPM constraint:		
Limit [RPM/s]:		

- **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

Propeller sizing

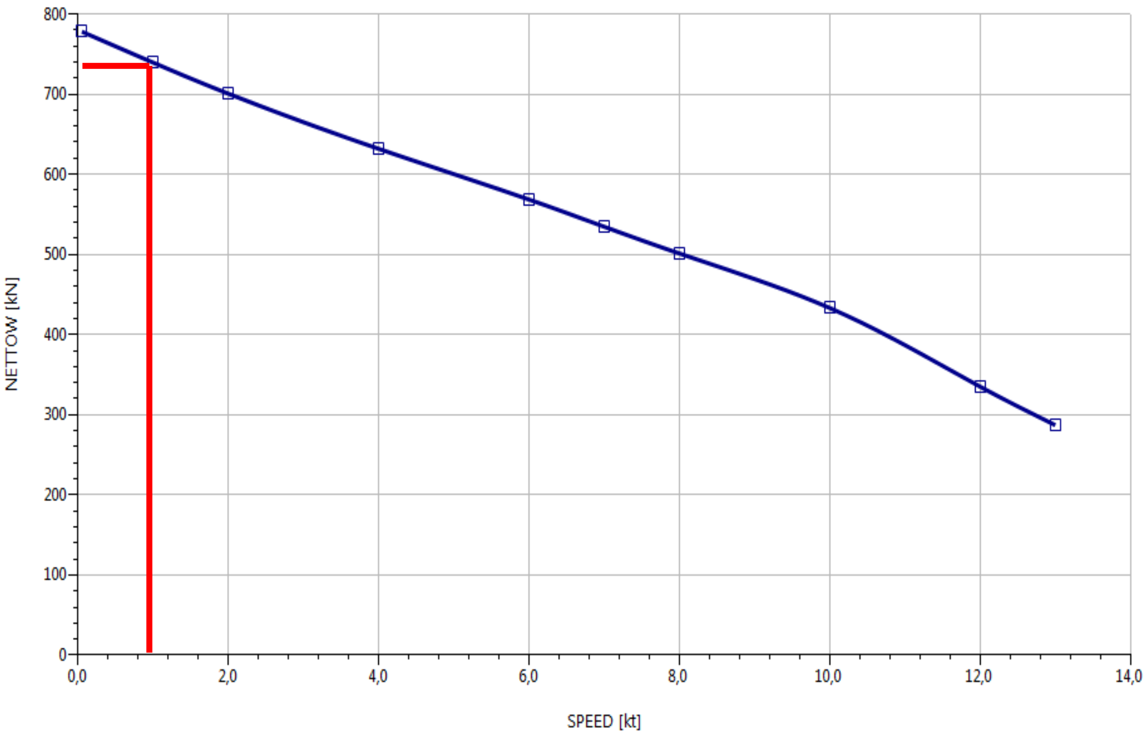
To size			
Gear ratio:	Keep	5,027	
Expanded area ratio:	Keep	0,650	
Propeller diameter:	Keep	2800,0	mm
Propeller mean pitch:	Keep	3809,6	mm
Design condition			
Max prop diam:		3000,0	mm
Design speed:		2,00	kt
Reference power:		2600,0	kW
Design point:		1,000	
Reference RPM:		900,0	
Design point:		1,000	

Size | Save report | OK | Cancel | Help

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 seria:

$$TFP = 709\ KN/9.81 = \ 72\ t$$

Por lo que en principio estés serían los motores que nos cumplen todos los requisitos. A continuación tenemos una gráfica con la tracción dependiendo de la velocidad.

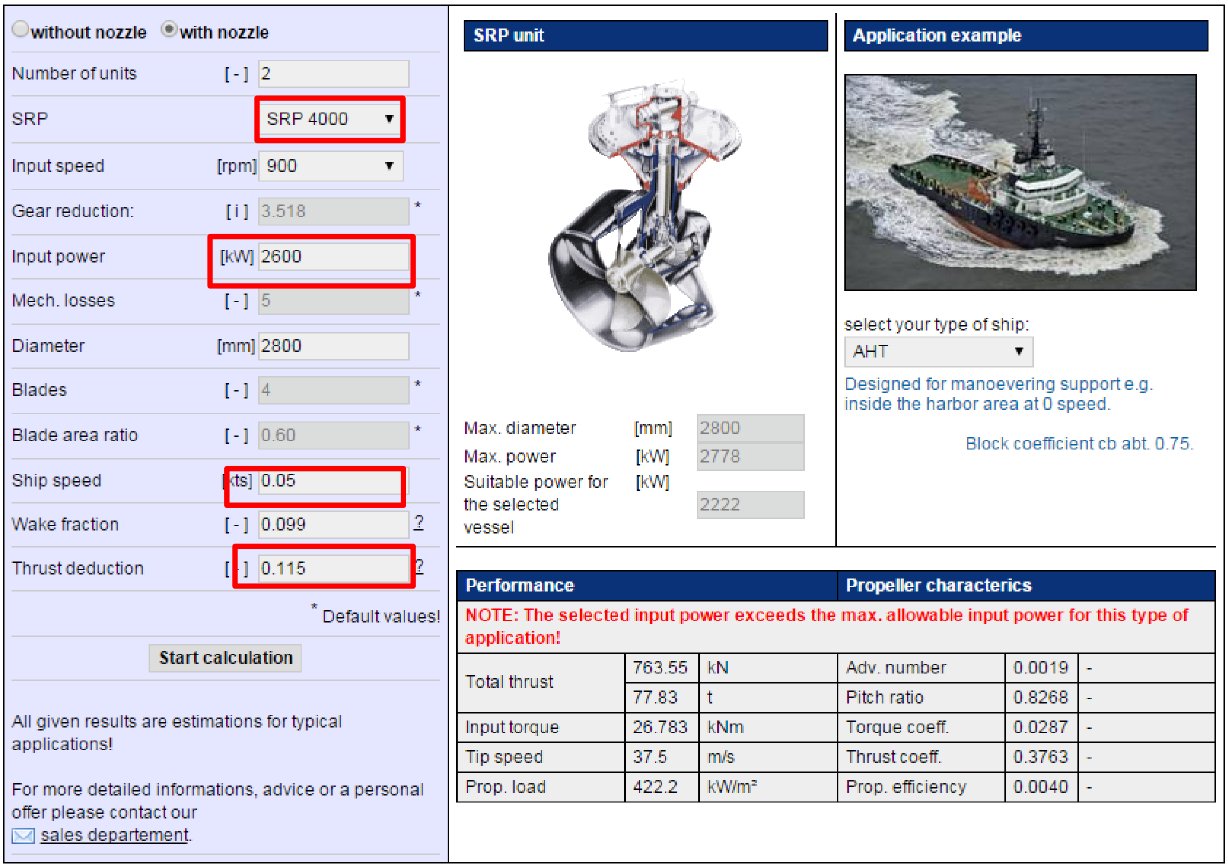


La siguiente tabla seria el rendimiento del propulsor final para la condición de navegación.

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:

Type of vessel		t [-]
Tug designed for high BPs (e.g. Robert Allan designs)		0.06
Intermediate design (e.g. Tugs with high free running speed)		0.09
Vessels designed with a S-shape hull at stern (e.g. for conventional propulsors)		0.12
Thrust deduction acc. inclination angle	[°]	

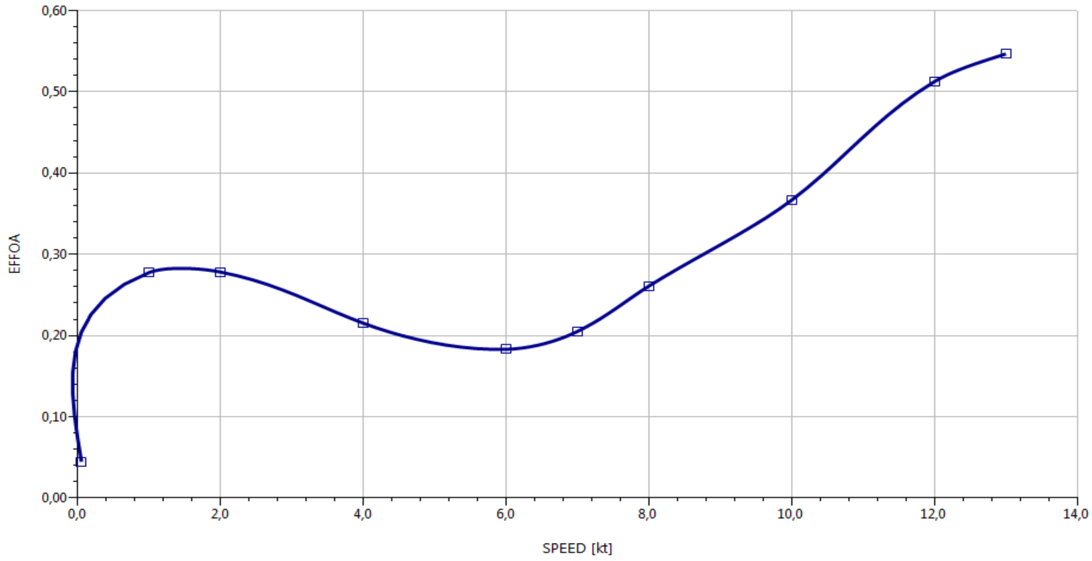
Como nosotros ya hicimos los cálculos en el Nav-Cad nos vamos al report y tomamos el coeficiente correspondiente que se

Una vez que tenemos todos los datos nos encontramos que el tiro que tendríamos con estas condiciones seria 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. Par este cálculo seguimos utilizando el programa Nav-Cad.

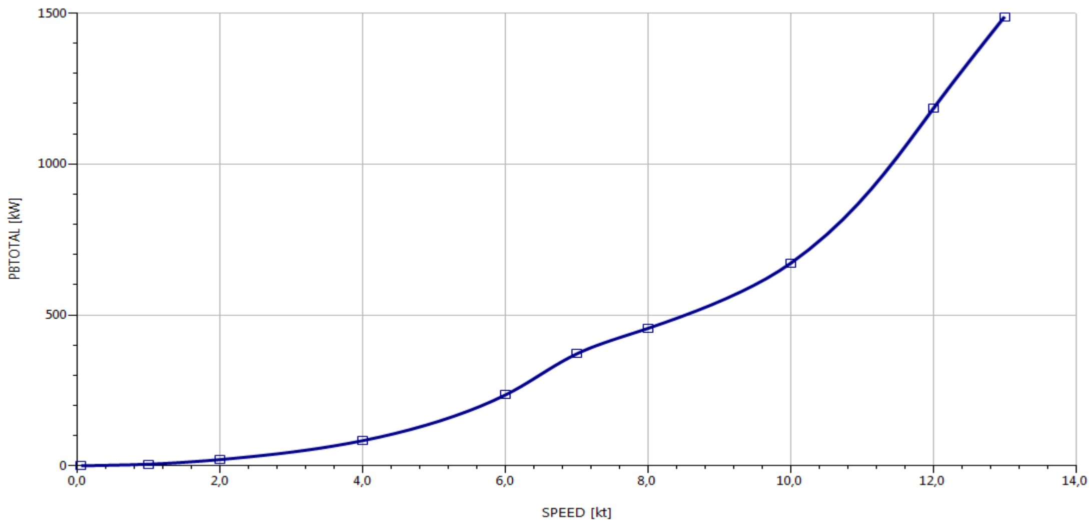
El rendimiento del propulsor para la condición de navegación seria:



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

Potencia (KW)=1488 Kw

Y la gráfica de la potencia seria la siguiente:



10. Timón

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

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

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

Las ventajas de usar este tipo de propulsores seria:

- 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/

10.1. Calculo del timón.

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.

$$\acute{A}rea\ de\ cada\ tim\acute{o}n: (0{,}01 * Lpp * T * (1 + 50 * cb2 * \left(\frac{B}{Lpp}\right) 2)/2 = 3.04m2$$

DIMENSIONES	
Lpp	35.8m
T	5.40
Cb	0.56
B	13

10.1.2. Altura del timón

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

$$Altura\ del\ tim\acute{o}n = \ 2.8 + 0.2 = 3\ m$$

10.1.3. Longitud del timón

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

$$Longitud\ del\ tim\acute{o}n = \frac{3.04}{3} = 1.015\ m$$

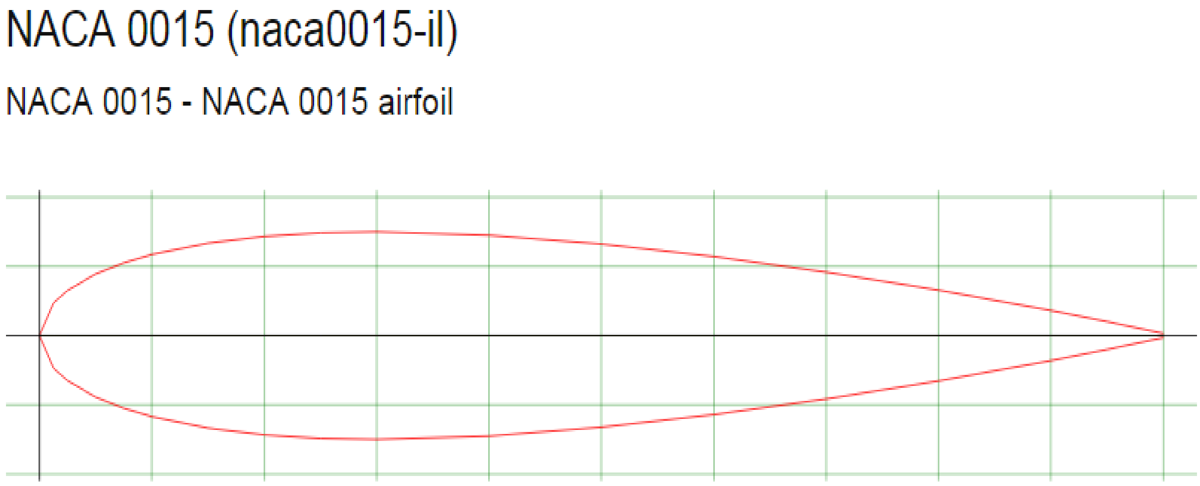
10.1.4. Relación de aspecto

$$Relaci\acute{o}n\ de\ aspecto = \frac{3.0}{1.015} = 2.9\ \ m$$

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.



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/Capitulo 9, Sección 2.

$$CR = 123 * Nr * A * V^2 * K1 * K2 * K3$$

- **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)

$$Vmin = \frac{13 + 20}{3} = \frac{13 + 20}{3} = 11\ kn\ o\ 13Kn$$

- **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.

$$CRav = 132 * 1 * 3.04 * 13\text{^}2 * 1.366 * 1.10 * 1 = 102.3KN$$

CRav=102.3 KN

11.1.2. Fr máxima ciando

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

$$CR = 123 * Nr * \ A * V^2 * K1 * K2 * K3$$

- **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.(Vci)

$$V = 0.5 * Vmin = 6.5\ Kn$$

- **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.

$$CRci = 132 * 1 * 3.04 * 6.5^2 * 1.366 * 1.10 * 1 = 18.5kN$$

CRci= 18.5KN

11.2. Momento

11.2.1. Momento avante

$$Mtr = cr * r = Cr * (b * (\alpha - \frac{Af}{A})$$

- **b** ,sería la manga del timón, pero para el cálculo vamos utilizar la cuerda.(1.015 m)
- $\boldsymbol{\alpha}$, Coeficiente que depende de la marcha avante o ciando

$\boldsymbol{\alpha}av$,0,333
$\boldsymbol{\alpha}$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)

$$Mtr = 102.3\ Kn * (1.015 * (0.33 - 0.608/3.04) = 14.63\ Kn$$

Mtr=14.36 KN

11.2.2. Momento ciando

$$Mtr = cr * r = Cr * (b * (\alpha - \frac{Af}{A})$$

- **b** ,sería la manga del timón, pero para el cálculo vamos utilizar la cuerda.(1.015 m)
- $\boldsymbol{\alpha}$, Coeficiente que depende de la marcha avante o ciando

$\boldsymbol{\alpha}av$,0,333
$\boldsymbol{\alpha}$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)

$$Mtr = 18.5\ Kn * (1.015 * (0.66 - 0.608/3.04) = 8.63\ Kn$$

Mtr= 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 seria la siguiente:

$$Potencia = Mavant\ (KN * m) * \frac{Angulo(rad)}{tiempo(s)} = \ 14.63 * \frac{1.14}{28} = 0.6Kw$$

- Angulo=65º=1.14rad
- Tiempo=28 s

Potencia= 0.6 KW

ANEXO 1

(Report Resistencia al avance)

Resistance

23 jul 2015 10:38
HydroComp NavCad 2012

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

Analysis parameters

Vessel drag		ITTC-78 (CT)
Technique:	[Calc]	Prediction
Prediction:		Holtrop
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 [Holtrop]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	Lambda
Value	0,34	0,57	3,19*	2,27	0,73
Range	0,06··0,40	0,55··0,85	3,90··14,90	2,10··4,00	0,01··0,92

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	0,000112	0,000000	0,000477	0,003930
3,00	0,078	0,147	5,18e7	0,002297	1,366	0,000104	0,000000	0,000477	0,003718
4,00	0,104	0,196	6,90e7	0,002200	1,366	0,000098	0,000000	0,000477	0,003580
5,00	0,130	0,245	8,63e7	0,002128	1,366	0,000094	0,000000	0,000477	0,003479
6,00	0,156	0,293	1,04e8	0,002073	1,366	0,000095	0,000000	0,000477	0,003403
7,00	0,182	0,342	1,21e8	0,002027	1,366	0,000115	0,000000	0,000477	0,003362
8,00	0,208	0,391	1,38e8	0,001989	1,366	0,000200	0,000000	0,000477	0,003395
10,00	0,260	0,489	1,73e8	0,001928	1,366	0,000939	0,000000	0,000477	0,004050
12,00	0,312	0,587	2,07e8	0,001880	1,366	0,003080	0,000000	0,000477	0,006125
+ 13,00 +	0,338	0,636	2,24e8	0,001859	1,366	0,004277	0,000000	0,000477	0,007294

	RESISTANCE AND EFFECTIVE POWER								
SPEED [kt]	RBARE [kN]	RAPP [kN]	RWIND [kN]	RSEAS [kN]	RCHAN [kN]	RMARGIN [kN]	RTOTAL [kN]	PEBARE [kW]	PETOTAL [kW]
2,00	1,38	0,00	0,00	0,00	0,00	0,21	1,58	1,4	1,6
3,00	2,93	0,00	0,00	0,00	0,00	0,44	3,37	4,5	5,2
4,00	5,02	0,00	0,00	0,00	0,00	0,75	5,77	10,3	11,9
5,00	7,62	0,00	0,00	0,00	0,00	1,14	8,77	19,6	22,6
6,00	10,74	0,00	0,00	0,00	0,00	1,61	12,35	33,2	38,1
7,00	14,44	0,00	0,00	0,00	0,00	2,17	16,61	52,0	59,8
8,00	19,05	0,00	0,00	0,00	0,00	2,86	21,90	78,4	90,1
10,00	35,50	0,00	0,00	0,00	0,00	5,33	40,83	182,6	210,0
12,00	77,32	0,00	0,00	0,00	0,00	11,60	88,92	477,3	548,9
+ 13,00 +	108,06	0,00	0,00	0,00	0,00	16,21	124,27	722,7	831,1

	OTHER	
SPEED [kt]	CTLR	CTLT
2,00	0,00101	0,03527
3,00	0,00093	0,03337
4,00	0,00088	0,03213
5,00	0,00085	0,03122
6,00	0,00085	0,03054
7,00	0,00103	0,03017
8,00	0,00180	0,03047
10,00	0,00843	0,03635
12,00	0,02764	0,05497
+ 13,00 +	0,03838	0,06546

Resistance

23 jul 2015 10:38
HydroComp NavCad 2012

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

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***

Resistance

23 jul 2015 10:38
HydroComp NavCad 2012

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:	**0,0 m2**
Strut bossing length:	**0,000 m**
Bossing diameter:	**0,000 m**
Wetted surface:	**0,0 m2**
Hull bossing length:	**0,000 m**
Bossing diameter:	**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**
Projected area:	**0,0 m2**
Wetted surface:	**0,0 m2**
Stabilizer	
Count:	**0**
Root chord:	**0,000 m**
Tip chord:	**0,000 m**
Span:	**0,000 m**
T/C ratio:	**0,000**
LE sweep:	**0,00 deg**
Wetted surface:	**0,0 m2**
Projected area:	**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**
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**
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:	**0,000 m**
Channel side slope:	**0,00 deg**
Hull girth:	**0,000 m**

Resistance

23 jul 2015 10:38
HydroComp NavCad 2012

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

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
HydroComp NavCad 2012

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

Analysis parameters

Vessel drag		ITTC-78 (CT)	Added drag		
Technique:	[Calc]	Prediction	Appendage:	[Calc]	Holtrop (Component)
Prediction:		Roach	Wind:	[Off]	
Reference ship:			Seas:	[Off]	
Model LWL:			Shallow/channel:	[Off]	
Expansion:		Custom	Margin:	[Calc]	Hull drag only [15%]
Friction line:		ITTC-57	**Water properties**		
Hull form factor:	[On]	1,366	Water type:		Salt
Speed corr:	[Off]		Density:		1026,00 kg/m3
Spray drag corr:	[Off]		Viscosity:		1,18920e-6 m2/s
Corr allowance:		0,000477			
Roughness [mm]:	[Off]				

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··4,74	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	0,001928	1,366	0,000001	0,000000	0,000477	0,003112
12,00	0,312	0,587	2,07e8	0,001880	1,366	0,000001	0,000000	0,000477	0,003046
+ 13,00 +	0,338	0,636	2,24e8	0,001859	1,366	0,000114	0,000000	0,000477	0,003131

	RESISTANCE AND EFFECTIVE POWER								
SPEED [kt]	RBARE [kN]	RAPP [kN]	RWIND [kN]	RSEAS [kN]	RCHAN [kN]	RMARGIN [kN]	RTOTAL [kN]	PEBARE [kW]	PETOTAL [kW]
2,00	1,34	0,00	0,00	0,00	0,00	0,20	1,54	1,4	1,6
3,00	2,85	0,00	0,00	0,00	0,00	0,43	3,28	4,4	5,1
4,00	4,89	0,00	0,00	0,00	0,00	0,73	5,62	10,1	11,6
5,00	7,42	0,00	0,00	0,00	0,00	1,11	8,53	19,1	21,9
6,00	10,44	0,00	0,00	0,00	0,00	1,57	12,01	32,2	37,1
7,00	13,95	0,00	0,00	0,00	0,00	2,09	16,04	50,2	57,8
8,00	17,93	0,00	0,00	0,00	0,00	2,69	20,62	73,8	84,9
10,00	27,28	0,00	0,00	0,00	0,00	4,09	31,37	140,3	161,4
12,00	38,45	0,00	0,00	0,00	0,00	5,77	44,22	237,4	273,0
+ 13,00 +	46,38	0,00	0,00	0,00	0,00	6,96	53,34	310,2	356,7

	OTHER	
SPEED [kt]	CTLR	CTLT
2,00	0,00001	0,03427
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

Resistance

23 jul 2015 10:39
HydroComp NavCad 2012

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

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***

Resistance

23 jul 2015 10:39
HydroComp NavCad 2012

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:	**0,0 m2**
Strut bossing length:	**0,000 m**
Bossing diameter:	**0,000 m**
Wetted surface:	**0,0 m2**
Hull bossing length:	**0,000 m**
Bossing diameter:	**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**
Projected area:	**0,0 m2**
Wetted surface:	**0,0 m2**
Stabilizer	
Count:	**0**
Root chord:	**0,000 m**
Tip chord:	**0,000 m**
Span:	**0,000 m**
T/C ratio:	**0,000**
LE sweep:	**0,00 deg**
Wetted surface:	**0,0 m2**
Projected area:	**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**
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**
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:	**0,000 m**
Channel side slope:	**0,00 deg**
Hull girth:	**0,000 m**

Resistance

23 jul 2015 10:39
HydroComp NavCad 2012

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

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 10:36
HydroComp NavCad 2012

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

Analysis parameters

Vessel drag	ITTC-78 (CT)	Added drag	
Technique:	[Calc] Prediction	Appendage:	[Calc] Holtrop (Component)
Prediction:	Oortmerssen	Wind:	[Off]
Reference ship:		Seas:	[Off]
Model LWL:		Shallow/channel:	[Off]
Expansion:	Custom	Margin:	[Calc] Hull drag only [15%]
Friction line:	ITTC-57	**Water properties**	
Hull form factor:	[On] 1,366	Water type:	Salt
Speed corr:	[Off]	Density:	1026,00 kg/m3
Spray drag corr:	[Off]	Viscosity:	1,18920e-6 m2/s
Corr allowance:	0,000477		
Roughness [mm]:	[Off]		

Prediction method check [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	0,34	0,57	3,19*	2,27	0,500	25,7	0,91
Range	0,05··0,50	0,51··0,69	3,50··6,30	1,90··3,40	0,467··0,53	10,0··38,0	0,73··0,97

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	0,002128	1,366	0,000001	0,000000	0,000477	0,003386
3,00	0,078	0,147	5,18e7	0,002073	1,366	0,000429	0,000000	0,000477	0,003737
4,00	0,104	0,196	6,90e7	0,002027	1,366	0,000912	0,000000	0,000477	0,004158
5,00	0,130	0,245	8,63e7	0,001989	1,366	0,001155	0,000000	0,000477	0,004349
6,00	0,156	0,293	1,04e8	0,001957	1,366	0,001375	0,000000	0,000477	0,004524
7,00	0,182	0,342	1,21e8	0,001928	1,366	0,001497	0,000000	0,000477	0,004608
8,00	0,208	0,391	1,38e8	0,001903	1,366	0,003048	0,000000	0,000477	0,006124
10,00	0,260	0,489	1,73e8	0,001880	1,366	0,003523	0,000000	0,000477	0,006568
12,00	0,312	0,587	2,07e8	0,001859	1,366	0,003910	0,000000	0,000477	0,006927
+ 13,00 +	0,338	0,636	2,24e8	0,001841	1,366	0,007778	0,000000	0,000477	0,010770

	RESISTANCE AND EFFECTIVE POWER								
SPEED [kt]	RBARE [kN]	RAPP [kN]	RWIND [kN]	RSEAS [kN]	RCHAN [kN]	RMARGIN [kN]	RTOTAL [kN]	PEBARE [kW]	PETOTAL [kW]
2,00	7,42	0,00	0,00	0,00	0,00	1,11	8,53	19,1	21,9
3,00	11,79	0,00	0,00	0,00	0,00	1,77	13,56	36,4	41,9
4,00	17,86	0,00	0,00	0,00	0,00	2,68	20,54	64,3	74,0
5,00	24,40	0,00	0,00	0,00	0,00	3,66	28,06	100,4	115,5
6,00	32,13	0,00	0,00	0,00	0,00	4,82	36,94	148,7	171,1
7,00	40,40	0,00	0,00	0,00	0,00	6,06	46,46	207,8	239,0
8,00	64,95	0,00	0,00	0,00	0,00	9,74	74,70	367,6	422,7
10,00	82,92	0,00	0,00	0,00	0,00	12,44	95,35	511,9	588,7
12,00	102,62	0,00	0,00	0,00	0,00	15,39	118,01	686,3	789,2
+ 13,00 +	185,05	0,00	0,00	0,00	0,00	27,76	212,80	1332,8	1532,7

	OTHER	
SPEED [kt]	CTLR	CTLT
2,00	0,00001	0,03039
3,00	0,00385	0,03354
4,00	0,00818	0,03732
5,00	0,01036	0,03903
6,00	0,01234	0,04061
7,00	0,01344	0,04136
8,00	0,02735	0,05496
10,00	0,03162	0,05895
12,00	0,03509	0,06217
+ 13,00 +	0,06981	0,09666

Resistance

23 jul 2015 10:36
HydroComp NavCad 2012

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

Hull data

General			Planing		
Configuration:		**Monohull**	*Proj chine length:*		***0,000 m***
Chine type:		**Single/hard**	*Proj bottom area:*		***0,0 m2***
Length on WL:		**39,900 m**	*LCG fwd TR:*	*[XCG/LP 0,000]*	***0,000 m***
Max beam on WL:	[LWL/BWL 3,192]	**12,500 m**	*VCG below WL:*		***0,000 m***
Max molded draft:	[BWL/T 2,273]	**5,500 m**	*Aft station (fwd TR):*		***0,000 m***
Displacement:	[CB 0,523]	**1472,60 t**	*Chine beam:*		***0,000 m***
Wetted surface:	[CWS 5,075]	**645,7 m2**	*Chine ht below WL:*		***0,000 m***
ITTC-78 (CT)			*Deadrise:*		***0,00 deg***
LCB fwd TR:	[XCB/LWL 0,500]	**19,932 m**	*Fwd station (fwd TR):*		***0,000 m***
LCF fwd TR:	[XCF/LWL 0,500]	**19,932 m**	*Chine beam:*		***0,000 m***
Max section area:	[CX 0,913]	**62,8 m2**	*Chine ht below WL:*		***0,000 m***
Waterplane area:	[CWP 0,699]	**348,8 m2**	*Deadrise:*		***0,00 deg***
Bulb section area:		**0,0 m2**	*Propulsor type:*		***Propeller***
Bulb ctr below WL:		**0,000 m**	*Propeller diameter*		***0,0 mm***
Bulb nose fwd TR:		**0,000 m**	*Shaft angle to WL:*		***0,00 deg***
Transom area:	[ATR/AX 0,000]	**0,0 m2**	*Position fwd TR:*		***0,000 m***
Transom beam WL:	[BTR/BWL 0,824]	**10,300 m**	*Position below WL:*		***0,000 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**			

Resistance

23 jul 2015 10:36
HydroComp NavCad 2012

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:	**0,0 m2**
Strut bossing length:	**0,000 m**
Bossing diameter:	**0,000 m**
Wetted surface:	**0,0 m2**
Hull bossing length:	**0,000 m**
Bossing diameter:	**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**
Projected area:	**0,0 m2**
Wetted surface:	**0,0 m2**
Stabilizer	
Count:	**0**
Root chord:	**0,000 m**
Tip chord:	**0,000 m**
Span:	**0,000 m**
T/C ratio:	**0,000**
LE sweep:	**0,00 deg**
Wetted surface:	**0,0 m2**
Projected area:	**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**
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**
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:	**0,000 m**
Channel side slope:	**0,00 deg**
Hull girth:	**0,000 m**

Resistance

23 jul 2015 10:36
HydroComp NavCad 2012

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

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

ANEXO 2

(Report Propulsor)

Propulsion

23 jul 2015 10:48
HydroComp NavCad 2012

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

Analysis parameters

Hull-propulsor interaction			System analysis	
Technique:		Prediction	Cavitation criteria:	Keller eqn
Prediction:	[Calc]	Holtrop	Analysis type:	Free run
Reference ship:			CPP method:	Fixed RPM
Max prop diam:		3000,0 mm	Engine RPM:	
Corrections			Mass multiplier:	
Viscous scale corr:	[On]	Custom	RPM constraint:	
Rudder location:		Behind propeller	Limit [RPM/s]:	
Friction line:		ITTC-57	**Water properties**	
Hull form factor:		1,366	Water type:	Salt
Corr allowance:		0,000477	Density:	1026,00 kg/m3
Roughness [mm]:	[On]	0,15	Viscosity:	1,18920e-6 m2/s
Ducted prop corr:	[Off]			
Tunnel stern corr:	[Off]			
Effective diam:				
Recess depth:				

Prediction method check [Holtrop]

Parameters	FN [design]	CP	LWL/BWL	BWL/T
Value	0,34	0,57	3,19*	2,27
Range	0,06··0,80	0,55··0,85	3,90··14,90	2,10··4,00

Prediction results [System]

	HULL-PROPULSOR				ENGINE	
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]
2,00	21,9	0,0991	0,1018	0,9546	45	17,5
3,00	41,9	0,0980	0,1018	0,9546	63	45,4
4,00	74,0	0,0973	0,1018	0,9546	82	96,6
5,00	115,5	0,0967	0,1018	0,9546	100	173,5
6,00	171,1	0,0963	0,1018	0,9546	100	204,7
7,00	239,0	0,0960	0,1018	0,9546	100	248,8
8,00	422,7	0,0957	0,1018	0,9546	100	357,9
10,00	588,7	0,0953	0,1018	0,9546	100	525,8
12,00	789,2	0,0949	0,1018	0,9546	100	750,5
+ 13,00 +	1532,7	0,0948	0,1018	0,9546	100	1314,9

	POWER DELIVERY							
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	CPPITCH [mm]
2,00	66	2,32	16,7	17,0	34,0	35,0	424,1	1350,3
3,00	91	4,31	43,2	44,1	88,1	90,8	245,3	1350,2
4,00	118	7,08	91,9	93,7	187,5	193,2	153,8	1350,2
5,00	145	10,39	164,9	168,3	336,5	347,0	107,1	1350,3
6,00	145	12,25	194,6	198,6	397,2	409,5	108,9	1632,8
7,00	145	14,89	236,5	241,4	482,7	497,7	104,5	1909,5
8,00	145	21,42	340,2	347,1	694,2	715,7	83,0	2290,4
10,00	145	31,47	499,9	510,1	1020,1	1051,7	70,6	2806,5
12,00	145	44,92	713,4	728,0	1455,9	1501,0	59,4	3330,0
+ 13,00 +	145	78,69	1249,9	1275,4	2550,8	2629,7	36,7	4020,4

	EFFICIENCY		THRUST	
SPEED [kt]	EFFO	EFFOA	THRPROP [kN]	DELTHR [kN]
2,00	0,2770	0,2583	4,75	8,53
3,00	0,2549	0,2375	7,55	13,56
4,00	0,2422	0,2254	11,43	20,53
5,00	0,2305	0,2145	15,62	28,06
6,00	0,3088	0,2871	20,57	36,94
7,00	0,3728	0,3465	25,86	46,45
8,00	0,4765	0,4428	41,58	74,69
10,00	0,5177	0,4808	53,08	95,35
12,00	0,5390	0,5004	65,70	118,02
+ 13,00 +	0,6011	0,5579	118,47	212,80

Propulsion

23 jul 2015 10:48
HydroComp NavCad 2012

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

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	KTN
2,00	**0,2830**	**0,0479**	**0,00779**	**0,59865**	**0,34397**	**1,5245**	**5,7652**	**9,09e6**	**0,0204**
3,00	**0,3047**	**0,0392**	**0,00745**	**0,42181**	**0,26333**	**1,0741**	**4,4136**	**1,27e7**	**0,0162**
4,00	**0,3140**	**0,0354**	**0,00730**	**0,35874**	**0,23576**	**0,91352**	**3,9514**	**1,65e7**	**0,0144**
5,00	**0,3212**	**0,0323**	**0,00717**	**0,31339**	**0,21634**	**0,79804**	**3,626**	**2,01e7**	**0,0129**
6,00	**0,3853**	**0,0425**	**0,00844**	**0,28628**	**0,14756**	**0,729**	**2,4732**	**2,02e7**	**0,0007**
7,00	**0,4497**	**0,0534**	**0,01026**	**0,26425**	**0,11281**	**0,67291**	**1,8908**	**2,03e7**	**-0,0067**
8,00	**0,5141**	**0,0859**	**0,01475**	**0,32513**	**0,10859**	**0,82793**	**1,82**	**2,04e7**	**-0,0038**
10,00	**0,6429**	**0,1097**	**0,02168**	**0,26536**	**0,081573**	**0,67572**	**1,3672**	**2,07e7**	**-0,0064**
12,00	**0,7718**	**0,1357**	**0,03093**	**0,22791**	**0,067297**	**0,58037**	**1,1279**	**2,10e7**	**-0,0136**
+ 13,00 +	**0,8362**	**0,2448**	**0,05420**	**0,35006**	**0,092688**	**0,89141**	**1,5535**	**2,12e7**	**0,0081**

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
2,00	**294,49**	**23,58**	**4,80**	**10,29**	**0,086**	**0,59**	**2,0**	**2,0**	**1098,8**
3,00	**130,57**	**12,12**	**2,46**	**14,35**	**0,088**	**0,96**	**2,0**	**2,0**	**1115,3**
4,00	**73,33**	**7,23**	**1,46**	**18,59**	**0,092**	**1,48**	**2,0**	**2,0**	**1122,4**
5,00	**46,88**	**4,84**	**0,98**	**22,72**	**0,096**	**2,04**	**2,0**	**2,0**	**1128,0**
6,00	**32,52**	**4,83**	**0,97**	**22,74**	**0,112**	**4,41**	**2,0**	**2,0**	**1337,8**
7,00	**23,88**	**4,83**	**0,96**	**22,74**	**0,119**	**5,63**	**2,0**	**2,0**	**1546,9**
8,00	**18,27**	**4,83**	**0,95**	**22,74**	**0,144**	**9,05**	**2,0**	**2,0**	**1813,6**
10,00	**11,68**	**4,83**	**0,92**	**22,74**	**0,157**	**11,55**	**2,0**	**2,0**	**2212,7**
12,00	**8,11**	**4,83**	**0,89**	**22,74**	**0,172**	**14,30**	**2,0**	**2,0**	**2612,9**
+ 13,00 +	**6,90**	**4,83**	**0,87**	**22,74**	**0,260**	**24,93**	**2,8**	**2,8**	**2979,4**

Propulsion

23 jul 2015 10:48
HydroComp NavCad 2012

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

Hull data

General			**Planing**		
Configuration:		**Monohull**	*Proj chine length:*		***0,000 m***
Chine type:		**Single/hard**	*Proj bottom area:*		***0,0 m2***
Length on WL:		**39,900 m**	*LCG fwd TR:*	*[XCG/LP 0,000]*	***0,000 m***
Max beam on WL:	[LWL/BWL 3,192]	**12,500 m**	*VCG below WL:*		***0,000 m***
Max molded draft:	[BWL/T 2,273]	**5,500 m**	*Aft station (fwd TR):*		***0,000 m***
Displacement:	[CB 0,523]	**1472,60 t**	*Chine beam:*		***0,000 m***
Wetted surface:	[CWS 5,075]	**645,7 m2**	*Chine ht below WL:*		***0,000 m***
ITTC-78 (CT)			*Deadrise:*		***0,00 deg***
LCB fwd TR:	[XCB/LWL 0,500]	**19,932 m**	*Fwd station (fwd TR):*		***0,000 m***
LCF fwd TR:	[XCF/LWL 0,500]	**19,932 m**	*Chine beam:*		***0,000 m***
Max section area:	[CX 0,913]	**62,8 m2**	*Chine ht below WL:*		***0,000 m***
Waterplane area:	[CWP 0,699]	**348,8 m2**	*Deadrise:*		***0,00 deg***
Bulb section area:		**0,0 m2**	*Propulsor type:*		***Propeller***
Bulb ctr below WL:		**0,000 m**	*Propeller diameter*		***3000,0 mm***
Bulb nose fwd TR:		**0,000 m**	*Shaft angle to WL:*		***0,00 deg***
Transom area:	[ATR/AX 0,000]	**0,0 m2**	*Position fwd TR:*		***0,000 m***
Transom beam WL:	[BTR/BWL 0,824]	**10,300 m**	*Position below WL:*		***0,000 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**			

Propulsor data

Propulsor				**Propeller options**	
Count:		**2**		Oblique angle corr:	**Off**
Propulsor type:		**Propeller series**		Shaft angle to WL:	**0,00 deg**
Propeller type:		**CPP**		Added rise of run:	**0,00 deg**
Propeller series:		**Kaplan 19A**		Propeller cup:	**0,0 mm**
Propeller sizing:		**By thrust**		KTKQ corrections:	**Custom**
KTKQ file:				Scale correction:	**None**
Blade count:		**3**		KT multiplier:	**1,00**
Expanded area ratio:		**0,6500**	**[Keep]**	KQ multiplier:	**1,00**
Propeller diameter:		**3000,0 mm**	**[Size]**	Blade T/C [0.7R]:	**0,00**
Propeller mean pitch:	[P/D 1,3087]	**3926,1 mm**	**[Size]**	Roughness:	**0,00 mm**
Hub immersion:		**3000,0 mm**		Cav breakdown:	**Off**
Engine/gear				Nozzle L/D:	**0,50**
Engine data:				**Design condition**	
Rated RPM:		**0 RPM**		Max prop diam:	**3000,0 mm**
Rated power:		**0,0 kW**		Design speed:	**13,00 kt**
Gear efficiency:		**0,97**		Reference power:	**0,0 kW**
Gear ratio:		**0,691**	**[Size]**	Design point:	**0,000**
Shaft efficiency:		**0,98**		Reference RPM:	**100,0**
				Design point:	**1,030**

Propulsion

23 jul 2015 10:48
HydroComp NavCad 2012

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

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
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
! = Exceeds recommended cavitation criteria [warning]
!! = Substantially exceeds recommended cavitation criteria [critical]
!!! = Thrust breakdown is indicated [severe]
--- = Insignificant or not applicable

Propulsion

23 jul 2015 10:49
HydroComp NavCad 2012

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]

Parameters	FN [design]	CP	LWL/BWL	BWL/T
Value	**0,34**	**0,57**	**3,19***	**2,27**
Range	**0,06··0,80**	**0,55··0,85**	**3,90··14,90**	**2,10··4,00**

Prediction results [System]

	HULL-PROPULSOR				ENGINE	
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]
2,00	**21,9**	**0,0991**	**0,1018**	**0,9546**	**46**	**17,1**
3,00	**41,9**	**0,0980**	**0,1018**	**0,9546**	**64**	**44,3**
4,00	**74,0**	**0,0973**	**0,1018**	**0,9546**	**83**	**94,5**
5,00	**115,5**	**0,0967**	**0,1018**	**0,9546**	**100**	**165,3**
6,00	**171,1**	**0,0963**	**0,1018**	**0,9546**	**100**	**205,0**
7,00	**239,0**	**0,0960**	**0,1018**	**0,9546**	**100**	**254,3**
8,00	**422,7**	**0,0957**	**0,1018**	**0,9546**	**100**	**366,9**
10,00	**588,7**	**0,0953**	**0,1018**	**0,9546**	**100**	**538,0**
12,00	**789,2**	**0,0949**	**0,1018**	**0,9546**	**100**	**764,1**
+ 13,00 +	**1532,7**	**0,0948**	**0,1018**	**0,9546**	**100**	**1332,9**

	POWER DELIVERY							
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	CPPITCH [mm]
2,00	**65**	**2,28**	**16,2**	**16,6**	**33,1**	**34,1**	**435,3**	**1350,2**
3,00	**90**	**4,25**	**42,2**	**43,0**	**86,0**	**88,7**	**251,3**	**1350,2**
4,00	**117**	**6,99**	**89,8**	**91,6**	**183,3**	**189,0**	**157,3**	**1350,2**
5,00	**141**	**10,16**	**157,1**	**160,3**	**320,6**	**330,5**	**112,4**	**1371,7**
6,00	**141**	**12,60**	**194,9**	**198,9**	**397,8**	**410,1**	**108,7**	**1643,4**
7,00	**141**	**15,63**	**241,7**	**246,7**	**493,4**	**508,6**	**102,2**	**1928,2**
8,00	**141**	**22,55**	**348,7**	**355,9**	**711,7**	**733,7**	**81,0**	**2329,5**
10,00	**141**	**33,06**	**511,4**	**521,9**	**1043,8**	**1076,0**	**69,0**	**2872,5**
12,00	**141**	**46,96**	**726,4**	**741,2**	**1482,4**	**1528,3**	**58,3**	**3417,9**
+ 13,00 +	**141**	**81,91**	**1267,1**	**1293,0**	**2585,9**	**2665,9**	**36,2**	**4140,4**

	EFFICIENCY		THRUST	
SPEED [kt]	EFFO	EFFOA	THRPROP [kN]	DELTHR [kN]
2,00	**0,2843**	**0,2651**	**4,75**	**8,53**
3,00	**0,2612**	**0,2433**	**7,55**	**13,56**
4,00	**0,2478**	**0,2306**	**11,44**	**20,54**
5,00	**0,2420**	**0,2251**	**15,62**	**28,05**
6,00	**0,3083**	**0,2866**	**20,56**	**36,94**
7,00	**0,3648**	**0,3390**	**25,86**	**46,45**
8,00	**0,4648**	**0,4319**	**41,58**	**74,69**
10,00	**0,5060**	**0,4700**	**53,08**	**95,35**
12,00	**0,5294**	**0,4914**	**65,70**	**118,01**
+ 13,00 +	**0,5929**	**0,5504**	**118,47**	**212,81**

Propulsion

23 jul 2015 10:49
HydroComp NavCad 2012

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

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	KTN
2,00	**0,2856**	**0,0488**	**0,00781**	**0,59866**	**0,33515**	**1,5245**	**5,6174**	**6,76e6**	**0,0113**
3,00	**0,3077**	**0,0399**	**0,00749**	**0,42182**	**0,25707**	**1,0741**	**4,3086**	**9,43e6**	**0,0069**
4,00	**0,3171**	**0,0361**	**0,00735**	**0,35887**	**0,23051**	**0,91387**	**3,8636**	**1,22e7**	**0,0051**
5,00	**0,3295**	**0,0340**	**0,00738**	**0,31332**	**0,20608**	**0,79787**	**3,4541**	**1,47e7**	**0,0032**
6,00	**0,3956**	**0,0448**	**0,00915**	**0,28623**	**0,14777**	**0,72887**	**2,4767**	**1,48e7**	**-0,0024**
7,00	**0,4617**	**0,0563**	**0,01135**	**0,26424**	**0,11529**	**0,67289**	**1,9324**	**1,49e7**	**-0,0065**
8,00	**0,5279**	**0,0906**	**0,01637**	**0,32513**	**0,11132**	**0,82794**	**1,8658**	**1,49e7**	**-0,0026**
10,00	**0,6601**	**0,1156**	**0,02401**	**0,26538**	**0,083464**	**0,67578**	**1,3989**	**1,51e7**	**-0,0085**
12,00	**0,7925**	**0,1431**	**0,03410**	**0,2279**	**0,06852**	**0,58035**	**1,1484**	**1,54e7**	**-0,0173**
+ 13,00 +	**0,8587**	**0,2581**	**0,05949**	**0,35006**	**0,093963**	**0,89142**	**1,5749**	**1,55e7**	**0,0089**

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
2,00	**294,49**	**24,02**	**4,88**	**10,20**	**0,089**	**0,80**	**2,0**	**2,0**	**1109,0**
3,00	**130,57**	**12,37**	**2,51**	**14,21**	**0,093**	**1,36**	**2,0**	**2,0**	**1126,4**
4,00	**73,33**	**7,37**	**1,49**	**18,40**	**0,100**	**2,14**	**2,0**	**2,0**	**1133,7**
5,00	**46,88**	**5,09**	**1,03**	**22,15**	**0,108**	**3,08**	**2,0**	**2,0**	**1157,1**
6,00	**32,52**	**5,09**	**1,02**	**22,15**	**0,118**	**4,48**	**2,0**	**2,0**	**1373,8**
7,00	**23,88**	**5,09**	**1,01**	**22,15**	**0,125**	**5,63**	**2,0**	**2,0**	**1588,4**
8,00	**18,27**	**5,09**	**1,00**	**22,15**	**0,154**	**9,05**	**2,0**	**2,0**	**1862,3**
10,00	**11,68**	**5,09**	**0,97**	**22,15**	**0,170**	**11,55**	**2,0**	**2,0**	**2272,1**
12,00	**8,11**	**5,09**	**0,93**	**22,15**	**0,188**	**14,30**	**2,0**	**2,0**	**2683,1**
+ 13,00 +	**6,90**	**5,09**	**0,91**	**22,15**	**0,288**	**24,90**	**3,0**	**3,0**	**3059,3**

Propulsion

23 jul 2015 10:49
HydroComp NavCad 2012

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

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		***3000,0 mm***
Shaft angle to WL:		***0,00 deg***
Position fwd TR:		***0,000 m***
Position below WL:		***0,000 m***

Propulsor data

Propulsor			
Count:		**2**	
Propulsor type:		**Propeller series**	
Propeller type:		**CPP**	
Propeller series:		**Kaplan 19A**	
Propeller sizing:		**By thrust**	
KTKQ file:			
Blade count:		**4**	
Expanded area ratio:		**0,6500**	**[Keep]**
Propeller diameter:		**3000,0 mm**	**[Size]**
Propeller mean pitch:	[P/D 1,3473]	**4041,8 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:		**0,709**	**[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:	**0,0 mm**
KTKQ corrections:	**Custom**
Scale correction:	**None**
KT multiplier:	**1,00**
KQ multiplier:	**1,00**
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**

Propulsion

23 jul 2015 10:49
HydroComp NavCad 2012

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

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
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
! = Exceeds recommended cavitation criteria [warning]
!! = Substantially exceeds recommended cavitation criteria [critical]
!!! = Thrust breakdown is indicated [severe]
--- = Insignificant or not applicable

Propulsion

23 jul 2015 10:50
HydroComp NavCad 2012

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

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	Prediction	Cavitation criteria:	Keller eqn
Prediction:	[Calc] Holtrop	Analysis type:	Free run
Reference ship:		CPP method:	Fixed RPM
Max prop diam:	3000,0 mm	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	[On] Custom	RPM constraint:	
Rudder location:	Behind propeller	Limit [RPM/s]:	
Friction line:	ITTC-57	**Water properties**	
Hull form factor:	1,366	Water type:	Salt
Corr allowance:	0,000477	Density:	1026,00 kg/m3
Roughness [mm]:	[On] 0,15	Viscosity:	1,18920e-6 m2/s
Ducted prop corr:	[Off]		
Tunnel stern corr:	[Off]		
Effective diam:			
Recess depth:			

Prediction method check [Holtrop]

Parameters	FN [design]	CP	LWL/BWL	BWL/T
Value	0,34	0,57	3,19*	2,27
Range	0,06··0,80	0,55··0,85	3,90··14,90	2,10··4,00

Prediction results [System]

	HULL-PROPULSOR				ENGINE	
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]
2,00	21,9	0,0991	0,1018	0,9522	45	19,5
3,00	41,9	0,0980	0,1018	0,9522	64	51,3
4,00	74,0	0,0973	0,1018	0,9522	83	110,0
5,00	115,5	0,0967	0,1018	0,9522	100	194,6
6,00	171,1	0,0963	0,1018	0,9522	100	230,1
7,00	239,0	0,0960	0,1018	0,9522	100	277,9
8,00	422,7	0,0957	0,1018	0,9522	100	387,5
10,00	588,7	0,0953	0,1018	0,9522	100	552,0
12,00	789,2	0,0949	0,1018	0,9522	100	765,6
+ 13,00 +	1532,7	0,0948	0,1018	0,9522	100	1292,3

	POWER DELIVERY							
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	CPPITCH [mm]
2,00	64	2,62	18,6	18,9	37,9	39,0	380,6	1350,2
3,00	90	4,93	48,8	49,8	99,6	102,7	217,1	1350,2
4,00	117	8,15	104,6	106,7	213,5	220,1	135,0	1350,2
5,00	141	11,89	185,0	188,7	377,5	389,1	95,5	1366,3
6,00	141	14,06	218,7	223,2	446,3	460,1	96,9	1661,6
7,00	141	16,98	264,2	269,6	539,2	555,9	93,6	1947,5
8,00	141	23,68	368,4	375,9	751,8	775,0	76,7	2333,4
10,00	141	33,73	524,8	535,5	1070,9	1104,0	67,3	2861,8
12,00	141	46,79	727,8	742,6	1485,3	1531,2	58,2	3395,1
+ 13,00 +	141	78,97	1228,4	1253,5	2507,0	2584,5	37,4	4078,7

	EFFICIENCY		THRUST	
SPEED [kt]	EFFO	EFFOA	THRPROP [kN]	DELTHR [kN]
2,00	0,2492	0,2319	4,75	8,53
3,00	0,2261	0,2101	7,55	13,56
4,00	0,2133	0,1980	11,44	20,54
5,00	0,2061	0,1912	15,62	28,06
6,00	0,2755	0,2555	20,57	36,94
7,00	0,3346	0,3102	25,86	46,45
8,00	0,4412	0,4089	41,58	74,70
10,00	0,4945	0,4581	53,09	95,36
12,00	0,5297	0,4905	65,70	118,01
+ 13,00 +	0,6132	0,5677	118,47	212,80

Propulsion

23 jul 2015 10:50
HydroComp NavCad 2012

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

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	KTN
2,00	0,2882	0,0497	0,00915	0,59865	0,38227	1,5245	6,4235	5,36e6	0,0032
3,00	0,3094	0,0404	0,00879	0,42169	0,29684	1,0738	4,988	7,50e6	-0,0011
4,00	0,3183	0,0364	0,00864	0,35887	0,26779	0,91387	4,4999	9,74e6	-0,0029
5,00	0,3285	0,0338	0,00858	0,31339	0,24203	0,79804	4,067	1,18e7	-0,0043
6,00	0,3944	0,0445	0,01015	0,28628	0,16539	0,729	2,7792	1,19e7	-0,0065
7,00	0,4603	0,0560	0,01226	0,26425	0,12568	0,6729	2,1119	1,19e7	-0,0092
8,00	0,5262	0,0900	0,01709	0,32514	0,11729	0,82797	1,9708	1,20e7	-0,0057
10,00	0,6581	0,1150	0,02435	0,2654	0,085417	0,67583	1,4353	1,21e7	-0,0133
12,00	0,7901	0,1423	0,03377	0,2279	0,068477	0,58035	1,1507	1,23e7	-0,0219
+ 13,00 +	0,8560	0,2565	0,05700	0,35006	0,090864	0,89141	1,5268	1,24e7	0,0039

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
2,00	294,49	24,45	4,97	10,11	0,091	0,97	2,0	2,0	1119,0
3,00	130,57	12,50	2,53	14,14	0,097	1,64	2,0	2,0	1132,4
4,00	73,33	7,43	1,50	18,33	0,106	2,49	2,0	2,0	1137,9
5,00	46,88	5,06	1,02	22,22	0,116	3,40	2,0	2,0	1153,6
6,00	32,52	5,06	1,01	22,22	0,123	4,48	2,0	2,0	1369,6
7,00	23,88	5,06	1,00	22,22	0,131	5,63	2,0	2,0	1583,6
8,00	18,27	5,06	0,99	22,22	0,165	9,05	2,0	2,0	1856,6
10,00	11,68	5,06	0,96	22,22	0,183	11,55	2,0	2,0	2265,1
12,00	8,11	5,06	0,93	22,22	0,205	14,30	2,0	2,0	2674,9
+ 13,00 +	6,90	5,06	0,91	22,22	0,323	25,39	3,0	3,0	3050,0

Propulsion

23 jul 2015 10:50
HydroComp NavCad 2012

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

Hull data

General			Planing		
Configuration:		**Monohull**	*Proj chine length:*		***0,000 m***
Chine type:		**Single/hard**	*Proj bottom area:*		***0,0 m2***
Length on WL:		**39,900 m**	*LCG fwd TR:*	*[XCG/LP 0,000]*	***0,000 m***
Max beam on WL:	[LWL/BWL 3,192]	**12,500 m**	*VCG below WL:*		***0,000 m***
Max molded draft:	[BWL/T 2,273]	**5,500 m**	*Aft station (fwd TR):*		***0,000 m***
Displacement:	[CB 0,523]	**1472,60 t**	*Chine beam:*		***0,000 m***
Wetted surface:	[CWS 5,075]	**645,7 m2**	*Chine ht below WL:*		***0,000 m***
ITTC-78 (CT)			*Deadrise:*		***0,00 deg***
LCB fwd TR:	[XCB/LWL 0,500]	**19,932 m**	*Fwd station (fwd TR):*		***0,000 m***
LCF fwd TR:	[XCF/LWL 0,500]	**19,932 m**	*Chine beam:*		***0,000 m***
Max section area:	[CX 0,913]	**62,8 m2**	*Chine ht below WL:*		***0,000 m***
Waterplane area:	[CWP 0,699]	**348,8 m2**	*Deadrise:*		***0,00 deg***
Bulb section area:		**0,0 m2**	*Propulsor type:*		***Propeller***
Bulb ctr below WL:		**0,000 m**	*Propeller diameter*		***3000,0 mm***
Bulb nose fwd TR:		**0,000 m**	*Shaft angle to WL:*		***0,00 deg***
Transom area:	[ATR/AX 0,000]	**0,0 m2**	*Position fwd TR:*		***0,000 m***
Transom beam WL:	[BTR/BWL 0,824]	**10,300 m**	*Position below WL:*		***0,000 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**			

Propulsor data

Propulsor				Propeller options	
Count:		**2**		Oblique angle corr:	**Off**
Propulsor type:		**Propeller series**		Shaft angle to WL:	**0,00 deg**
Propeller type:		**CPP**		Added rise of run:	**0,00 deg**
Propeller series:		**Kaplan 19A**		Propeller cup:	**0,0 mm**
Propeller sizing:		**By thrust**		KTKQ corrections:	**Custom**
KTKQ file:				Scale correction:	**None**
Blade count:		**5**		KT multiplier:	**1,00**
Expanded area ratio:		**0,6500**	**[Keep]**	KQ multiplier:	**1,00**
Propeller diameter:		**3000,0 mm**	**[Size]**	Blade T/C [0.7R]:	**0,00**
Propeller mean pitch:	[P/D 1,3276]	**3982,8 mm**	**[Size]**	Roughness:	**0,00 mm**
Hub immersion:		**3000,0 mm**		Cav breakdown:	**Off**
Engine/gear				Nozzle L/D:	**0,50**
Engine data:				**Design condition**	
Rated RPM:		**0 RPM**		Max prop diam:	**3000,0 mm**
Rated power:		**0,0 kW**		Design speed:	**13,00 kt**
Gear efficiency:		**0,97**		Reference power:	**0,0 kW**
Gear ratio:		**0,707**	**[Size]**	Design point:	**0,000**
Shaft efficiency:		**0,98**		Reference RPM:	**100,0**
				Design point:	**1,030**

Propulsion

23 jul 2015 10:50
HydroComp NavCad 2012

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

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
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
! = Exceeds recommended cavitation criteria [warning]
!! = Substantially exceeds recommended cavitation criteria [critical]
!!! = Thrust breakdown is indicated [severe]
--- = Insignificant or not applicable

ANEXO 3

(Report TPF)

Propulsion

23 jul 2015 10:55
HydroComp NavCad 2012

Project ID **Remolcador de salvamento**
Description **68 TPF**
File name **Remolcador diseño del propulsor con motor.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:	**Towing**
CPP method:	**Variable 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]

Parameters	FN [design]	CP	LWL/BWL	BWL/T
Value	**0,03***	**0,57**	**3,19***	**2,27**
Range	**0,06··0,80**	**0,55··0,85**	**3,90··14,90**	**2,10··4,00**

Prediction results [System]

	HULL-PROPULSOR				ENGINE			
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]
0,05	1,6	0,1165	0,1018	0,9513	900	2600,0	---	100,0
+ 1,00 +	5,1	0,1012	0,1018	0,9513	900	2600,0	---	100,0
2,00	11,6	0,0991	0,1018	0,9513	900	2600,0	---	100,0
4,00	21,9	0,0973	0,1018	0,9513	900	2600,0	---	100,0
6,00	41,9	0,0963	0,1018	0,9513	900	2600,0	---	100,0
7,00	74,0	0,0960	0,1018	0,9513	900	2600,0	---	100,0
8,00	115,5	0,0957	0,1018	0,9513	900	2600,0	---	100,0
10,00	239,0	0,0953	0,1018	0,9513	900	2600,0	---	100,0
12,00	588,7	0,0949	0,1018	0,9513	900	2600,0	---	100,0
13,00	789,2	0,0948	0,1018	0,9513	900	2600,0	---	100,0

	POWER DELIVERY							
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	CPPITCH [mm]
0,05	179	125,41	2471,6	2522,0	5044,0	5200,0	0,0	3664,5
+ 1,00 +	179	125,41	2471,6	2522,0	5044,0	5200,0	0,0	3671,5
2,00	179	125,41	2471,6	2522,0	5044,0	5200,0	0,0	3682,4
4,00	179	125,41	2471,6	2522,0	5044,0	5200,0	0,0	3715,0
6,00	179	125,41	2471,6	2522,0	5044,0	5200,0	0,0	3763,9
7,00	179	125,41	2471,6	2522,0	5044,0	5200,0	0,0	3795,2
8,00	179	125,41	2471,6	2522,0	5044,0	5200,0	0,0	3831,5
10,00	179	125,41	2471,6	2522,0	5044,0	5200,0	0,0	3920,0
12,00	179	125,41	2471,6	2522,0	5044,0	5200,0	0,0	4030,2
13,00	179	125,41	2471,6	2522,0	5044,0	5200,0	0,0	4093,4

	EFFICIENCY		THRUST		
SPEED [kt]	EFFO	EFFOA	THRPROP [kN]	DELTHR [kN]	NETTOW [kN]
0,05	0,0042	0,0040	433,94	779,49	777,95
+ 1,00 +	0,0813	0,0757	413,37	742,53	739,25
2,00	0,1550	0,1440	393,09	706,12	700,50
4,00	0,2816	0,2612	356,42	640,24	631,71
6,00	0,3844	0,3562	324,01	582,02	568,45
7,00	0,4279	0,3963	309,03	555,11	534,57
8,00	0,4664	0,4319	294,65	529,28	501,22
10,00	0,5286	0,4892	267,02	479,65	433,19
12,00	0,5694	0,5268	239,63	430,45	335,10
13,00	0,5806	0,5371	225,52	405,10	287,09

Propulsion

23 jul 2015 10:55
HydroComp NavCad 2012

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

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	KTN
0,05	**0,0027**	**0,7728**	**0,07976**	**104460**	**3964200**	**266020**	**66672000**	**1,61e7**	**0,3986**
+ 1,00 +	**0,0553**	**0,7361**	**0,07976**	**240,34**	**470,55**	**612,03**	**7913,9**	**1,61e7**	**0,3646**
2,00	**0,1109**	**0,7000**	**0,07976**	**56,872**	**58,406**	**144,82**	**982,3**	**1,61e7**	**0,3306**
4,00	**0,2223**	**0,6347**	**0,07976**	**12,84**	**7,2574**	**32,698**	**122,06**	**1,62e7**	**0,2686**
6,00	**0,3338**	**0,5770**	**0,07976**	**5,1772**	**2,1437**	**13,184**	**36,054**	**1,63e7**	**0,2149**
7,00	**0,3896**	**0,5503**	**0,07976**	**3,6252**	**1,3485**	**9,2314**	**22,68**	**1,63e7**	**0,1910**
8,00	**0,4454**	**0,5247**	**0,07976**	**2,6448**	**0,90256**	**6,7349**	**15,18**	**1,64e7**	**0,1689**
10,00	**0,5570**	**0,4755**	**0,07976**	**1,5324**	**0,46143**	**3,9023**	**7,7605**	**1,66e7**	**0,1292**
12,00	**0,6687**	**0,4267**	**0,07976**	**0,95428**	**0,26672**	**2,43**	**4,4858**	**1,68e7**	**0,0941**
13,00	**0,7246**	**0,4016**	**0,07976**	**0,76497**	**0,20968**	**1,948**	**3,5265**	**1,69e7**	**0,0777**
	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
0,05	**490006,76**	**3,62**	**0,75**	**26,25**	**0,616**	**52,49**	**17,7**	**17,7**	**1967,7**
+ 1,00 +	**1183,49**	**3,62**	**0,75**	**26,25**	**0,609**	**52,12**	**17,4**	**17,4**	**1995,8**
2,00	**294,49**	**3,62**	**0,75**	**26,25**	**0,602**	**51,83**	**17,2**	**17,2**	**2031,0**
4,00	**73,33**	**3,62**	**0,74**	**26,25**	**0,590**	**51,37**	**16,8**	**16,8**	**2118,2**
6,00	**32,52**	**3,62**	**0,73**	**26,25**	**0,577**	**50,81**	**16,3**	**16,3**	**2227,6**
7,00	**23,88**	**3,62**	**0,73**	**26,25**	**0,570**	**50,42**	**16,0**	**16,0**	**2290,2**
8,00	**18,27**	**3,62**	**0,72**	**26,25**	**0,561**	**49,93**	**15,6**	**15,6**	**2357,9**
10,00	**11,68**	**3,62**	**0,70**	**26,25**	**0,541**	**48,58**	**14,5**	**14,5**	**2506,6**
12,00	**8,11**	**3,62**	**0,69**	**26,25**	**0,514**	**46,67**	**13,0**	**13,0**	**2670,1**
13,00	**6,90**	**3,62**	**0,68**	**26,25**	**0,499**	**45,45**	**12,1**	**12,1**	**2756,1**

Propulsion

23 jul 2015 10:55
HydroComp NavCad 2012

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

Hull data

General			Planing		
Configuration:		**Monohull**	*Proj chine length:*		***0,000 m***
Chine type:		**Single/hard**	*Proj bottom area:*		***0,0 m2***
Length on WL:		**39,900 m**	*LCG fwd TR:*	*[XCG/LP 0,000]*	***0,000 m***
Max beam on WL:	[LWL/BWL 3,192]	**12,500 m**	*VCG below WL:*		***0,000 m***
Max molded draft:	[BWL/T 2,273]	**5,500 m**	*Aft station (fwd TR):*		***0,000 m***
Displacement:	[CB 0,523]	**1472,60 t**	*Chine beam:*		***0,000 m***
Wetted surface:	[CWS 5,075]	**645,7 m2**	*Chine ht below WL:*		***0,000 m***
ITTC-78 (CT)			*Deadrise:*		***0,00 deg***
LCB fwd TR:	[XCB/LWL 0,500]	**19,932 m**	*Fwd station (fwd TR):*		***0,000 m***
LCF fwd TR:	[XCF/LWL 0,500]	**19,932 m**	*Chine beam:*		***0,000 m***
Max section area:	[CX 0,913]	**62,8 m2**	*Chine ht below WL:*		***0,000 m***
Waterplane area:	[CWP 0,699]	**348,8 m2**	*Deadrise:*		***0,00 deg***
Bulb section area:		**0,0 m2**	*Propulsor type:*		***Propeller***
Bulb ctr below WL:		**0,000 m**	*Propeller diameter*		***3000,0 mm***
Bulb nose fwd TR:		**0,000 m**	*Shaft angle to WL:*		***0,00 deg***
Transom area:	[ATR/AX 0,000]	**0,0 m2**	*Position fwd TR:*		***0,000 m***
Transom beam WL:	[BTR/BWL 0,824]	**10,300 m**	*Position below WL:*		***0,000 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**			

Propulsor data

Propulsor				Propeller options	
Count:		**2**		Oblique angle corr:	**Off**
Propulsor type:		**Propeller series**		Shaft angle to WL:	**0,00 deg**
Propeller type:		**CPP**		Added rise of run:	**0,00 deg**
Propeller series:		**Kaplan 19A**		Propeller cup:	**0,0 mm**
Propeller sizing:		**By power**		KTKQ corrections:	**Standard**
KTKQ file:				Scale correction:	**Full ITTC**
Blade count:		**4**		KT multiplier:	**1,00**
Expanded area ratio:		**0,6500**	**[Keep]**	KQ multiplier:	**1,00**
Propeller diameter:		**2800,0 mm**	**[Keep]**	Blade T/C [0.7R]:	**Standard**
Propeller mean pitch:	[P/D 1,3606]	**3809,6 mm**	**[Keep]**	Roughness:	**Standard**
Hub immersion:		**3000,0 mm**		Cav breakdown:	**Off**
Engine/gear				Nozzle L/D:	**Standard**
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**

Propulsion

23 jul 2015 10:55
HydroComp NavCad 2012

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

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
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
! = 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)

Resistance

23 jul 2015 10:57
HydroComp NavCad 2012

Project ID **Remolcador de salvamento**
Description **68 TPF**
File name **aguas libres con motor.hcnc**

Analysis parameters

Vessel drag		ITTC-78 (CT)
Technique:	[Calc]	Prediction
Prediction:		Oortmerssen
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 [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	0,34	0,57	3,19*	2,27	0,500	25,7	0,91
Range	0,05··0,50	0,51··0,69	3,50··6,30	1,90··3,40	0,467··0,573	10,0··38,0	0,73··0,97

Prediction results

	SPEED COEFS		ITTC-78 COEFS						
SPEED [kt]	FN	FV	RN	CF	[CV/CF]	CR	dCF	CA	CT
0,05	0,001	0,002	8,63e5	0,004841	1,366	0,000001	0,000000	0,000477	0,007091
1,00	0,026	0,049	1,73e7	0,002735	1,366	0,000001	0,000000	0,000477	0,004213
2,00	0,052	0,098	3,45e7	0,002445	1,366	0,000001	0,000000	0,000477	0,003818
4,00	0,104	0,196	6,90e7	0,002200	1,366	0,000001	0,000000	0,000477	0,003483
6,00	0,156	0,293	1,04e8	0,002073	1,366	0,000429	0,000000	0,000477	0,003737
7,00	0,182	0,342	1,21e8	0,002027	1,366	0,000912	0,000000	0,000477	0,004158
8,00	0,208	0,391	1,38e8	0,001989	1,366	0,001155	0,000000	0,000477	0,004349
10,00	0,260	0,489	1,73e8	0,001928	1,366	0,001497	0,000000	0,000477	0,004608
12,00	0,312	0,587	2,07e8	0,001880	1,366	0,003523	0,000000	0,000477	0,006568
+ 13,00 +	0,338	0,636	2,24e8	0,001859	1,366	0,003910	0,000000	0,000477	0,006927

	RESISTANCE AND EFFECTIVE POWER								
SPEED [kt]	RBARE [kN]	RAPP [kN]	RWIND [kN]	RSEAS [kN]	RCHAN [kN]	RMARGIN [kN]	RTOTAL [kN]	PEBARE [kW]	PETOTAL [kW]
0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0
1,00	0,37	0,00	0,00	0,00	0,00	0,06	0,42	0,2	0,2
2,00	1,34	0,00	0,00	0,00	0,00	0,20	1,54	1,4	1,6
4,00	4,89	0,00	0,00	0,00	0,00	0,73	5,62	10,1	11,6
6,00	11,79	0,00	0,00	0,00	0,00	1,77	13,56	36,4	41,9
7,00	17,86	0,00	0,00	0,00	0,00	2,68	20,54	64,3	74,0
8,00	24,40	0,00	0,00	0,00	0,00	3,66	28,06	100,4	115,5
10,00	40,40	0,00	0,00	0,00	0,00	6,06	46,46	207,8	239,0
12,00	82,92	0,00	0,00	0,00	0,00	12,44	95,35	511,9	588,7
+ 13,00 +	102,62	0,00	0,00	0,00	0,00	15,39	118,01	686,3	789,2

	OTHER	
SPEED [kt]	CTLR	CTLT
0,05	0,00001	0,06364
1,00	0,00001	0,03782
2,00	0,00001	0,03427
4,00	0,00001	0,03126
6,00	0,00385	0,03354
7,00	0,00818	0,03732
8,00	0,01036	0,03903
10,00	0,01344	0,04136
12,00	0,03162	0,05895
+ 13,00 +	0,03509	0,06217

Resistance

23 jul 2015 10:57
HydroComp NavCad 2012

Project ID	**Remolcador de salvamento**
Description	**68 TPF**
File name	**aguas libres con motor.hcnc**

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		***3000,0 mm***
Shaft angle to WL:		***0,00 deg***
Position fwd TR:		***0,000 m***
Position below WL:		***0,000 m***

Resistance

23 jul 2015 10:57
HydroComp NavCad 2012

Project ID **Remolcador de salvamento**
Description **68 TPF**
File name **aguas libres con motor.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:	**3000,0 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 bossing length:	**0,000 m**
Bossing diameter:	**0,000 m**
Wetted surface:	**0,0 m2**
Hull bossing length:	**0,000 m**
Bossing diameter:	**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**
Projected area:	**0,0 m2**
Wetted surface:	**0,0 m2**
Stabilizer	
Count:	**0**
Root chord:	**0,000 m**
Tip chord:	**0,000 m**
Span:	**0,000 m**
T/C ratio:	**0,000**
LE sweep:	**0,00 deg**
Wetted surface:	**0,0 m2**
Projected area:	**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**
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**
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:	**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

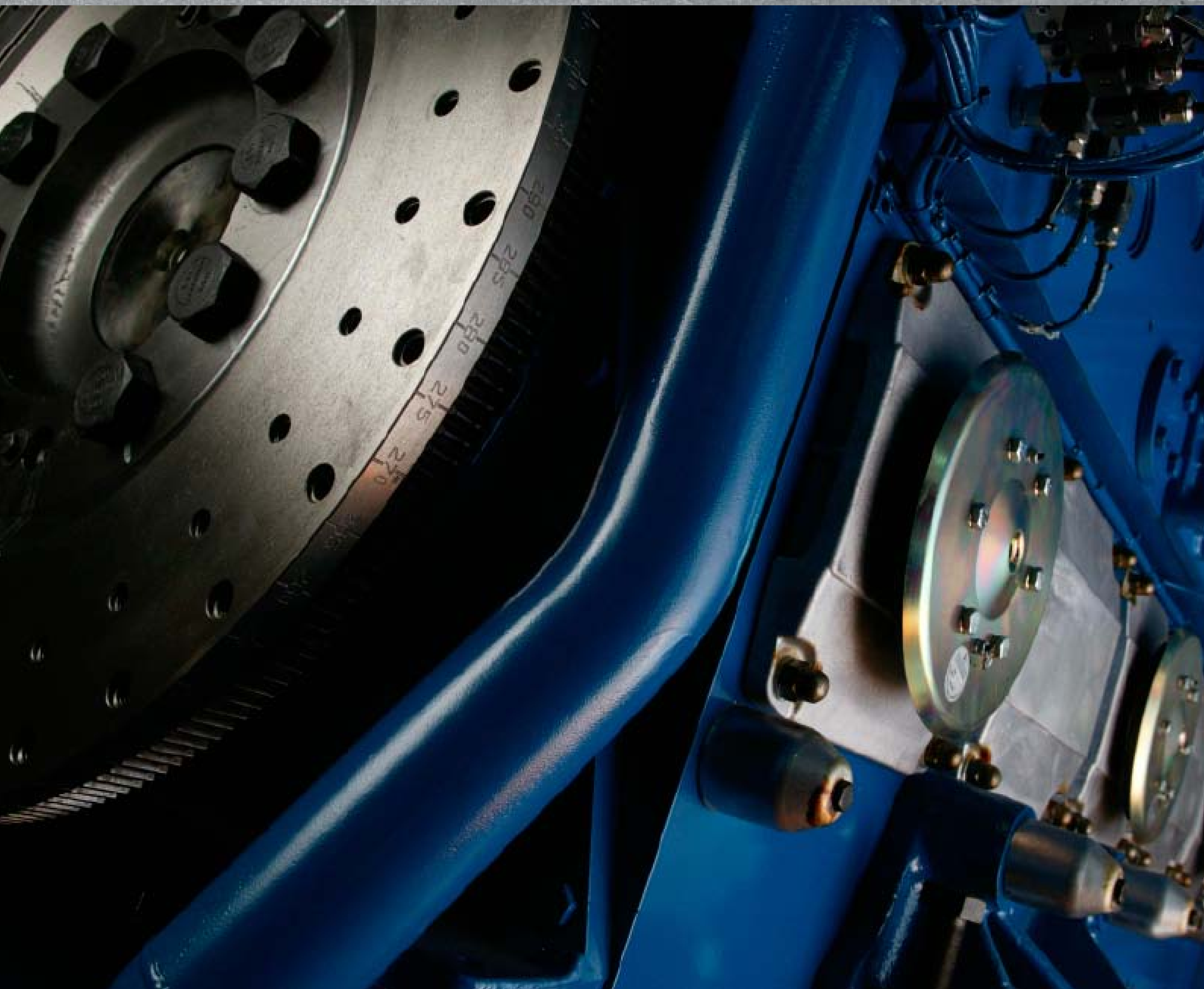
ANEXO 5

(Documentación Motor)

WÄRTSILÄ

WÄRTSILÄ Engines

WÄRTSILÄ 26
PRODUCT GUIDE



Introduction

This Product Guide provides data and system proposals for the early design phase of marine engine installations. 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.

Issue	Published	Updates
1/2013	20.11.2013	Updates throughout the product guide
2/2009	xx.01.2010	Attached drawings updated (Online version).
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

Table of Contents

This page intentionally left blank

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 1.1 Rating table for Wärtsilä 26

Cylinder configuration	Main engines		Generating sets			
	900 rpm	1000 rpm	900 rpm		1000 rpm	
	[kW]	[kW]	[KVA]	[kWe]	[KVA]	[kWe]
6L26	1950	2040	2352	1882	2461	1969
8L26	2600	2720	3136	2509	3281	2625
9L26	2925	3060	3528	2823	3691	2953
12V26	3900	4080	4704	3764	4922	3937
16V26	5200	5440	6273	5018	6562	5250

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:

$$P_e = \frac{P \times c \times 1.2 \times 10^9}{D^2 \times L \times n \times \pi}$$

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.

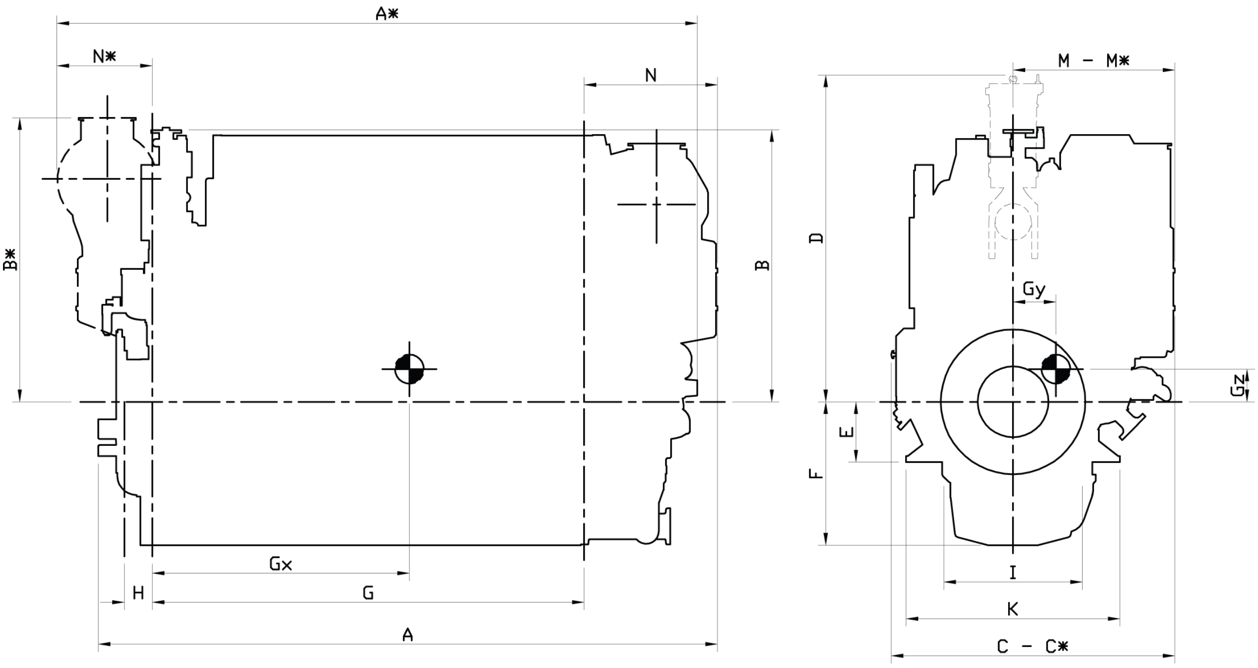
Transverse inclination, permanent (list)	15°
Transverse inclination, momentary (roll)	22.5°
Longitudinal inclination, permanent (trim)	5°
Longitudinal inclination, momentary (pitch)	7.5°

Larger angles are possible with special arrangements.

1.4 Dimensions and weights

1.4.1 Main engines

Figure 1.1 In-line engines (DAAE034755b)



Engine	A*	A	B*	B	C*	C	D	E	F_{wet}	F_{dry}	G
W 6L26	4387	4130	1882	1833	1960	2020	2430	400	950	818	2866
W 8L26	5302	5059	2023	1868	2010	2107	2430	400	950	818	3646
W 9L26	5691	5449	2023	1868	2016	2107	2430	400	950	818	4036

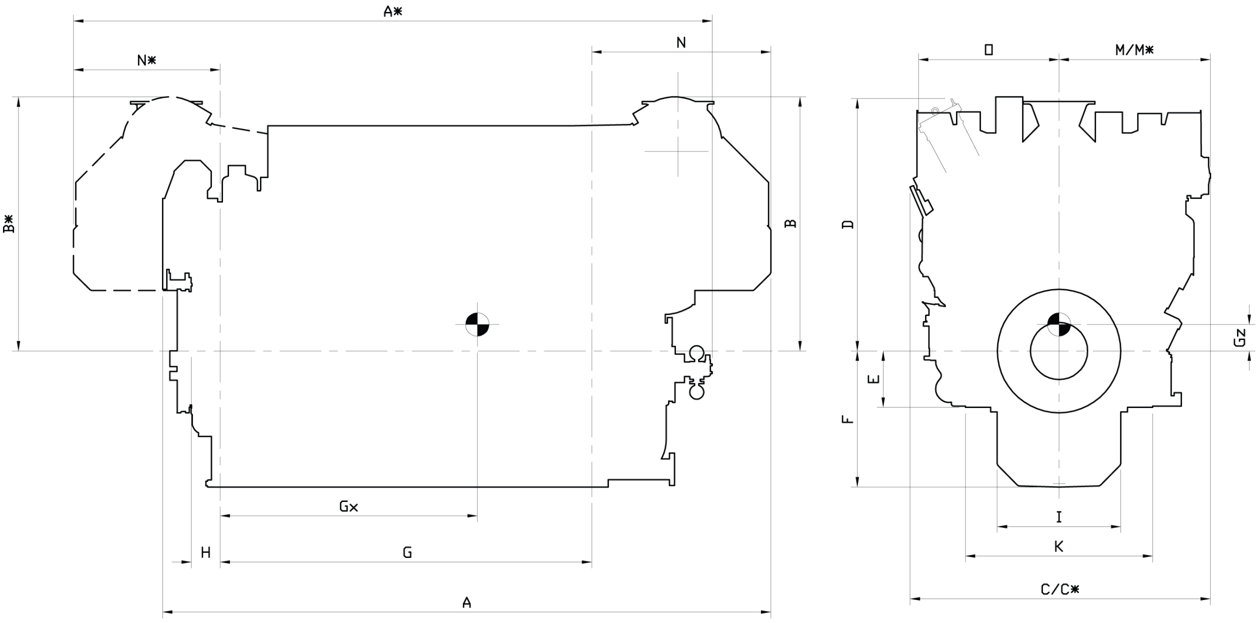
Engine	H	I	K	M*	M	N*	N	Weight	
								dry sump	wet sump
W 6L26	186	920	1420	1103	1171	669	904	17.0	17.2
W 8L26	186	920	1420	1167	1258	794	1054	21.6	21.9
W 9L26	186	920	1420	1167	1258	794	1054	23.3	23.6

Engine	Wet sump						Dry sump					
	Gx *	Gy *	Gz *	Gx	Gy	Gz	Gx *	Gy *	Gz *	Gx	Gy	Gz
W 6L26	1551	90	450	1300	90	450	1551	90	458	1300	90	458
W 8L26	2002	78	457	1704	78	457	2002	78	465	1704	78	465
W 9L26	2204	74	454	1921	74	454	2204	74	462	1921	74	462

* Turbocharger at flywheel end.

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

Figure 1.2 V-engines (DAAE034757b)



Engine	A*	A	B*	B	C*	C	D	E	F_{wet}	F_{dry}	G
W 12V26	5442	5314	2034	2034	2552	2602	2060	460	1110	800	3035
W 16V26	6223	6025	2151	2190	2489	2763	2060	460	1110	800	3875

Engine	H	I	K	M *	M	N *	N	O	Weight	
									dry sump	wet sump
W 12V26	235	1010	1530	1364	1238	1433	1698	1148	28.7	29.0
W 16V26	235	1010	1530	1248	1248	1363	1626	1160	36.1	37.9

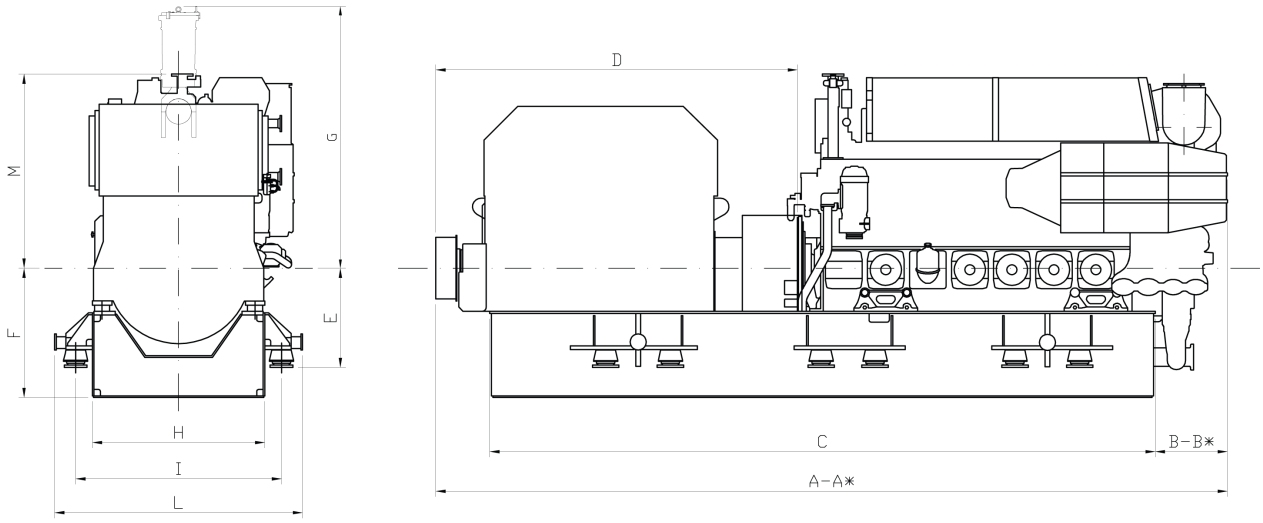
Engine	Wet sump				Dry sump			
	Gx *	Gz *	Gx	Gz	Gx *	Gz *	Gx	Gz
W 12V26	1224	413	1811	413	1224	470	1811	470
W 16V26	1852	548	2258	548	1852	568	2258	568

* 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)



Engine	A	A*	B	B*	C	D	E	F	G	H	I	L	M	Weight
W 6L26	7500	7500	835	702	6000	3200	921	1200	2430	1600	1910	2300	1833	35
W 8L26	8000	8000	835	702	7000	3300	921	1200	2430	1600	1910	2300	1868	45
W 9L26	8500	8500	835	702	7500	3400	921	1300	2430	1600	1910	2300	1868	50
W 12V26	8400	-	1263	-	6700	3600	981	1560	2765	2000	2310	2700	2126**	60
W 16V26	9700	-	1400	-	7730	4000	981	1560	2765	2000	2310	2700	2156**	70

* 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.

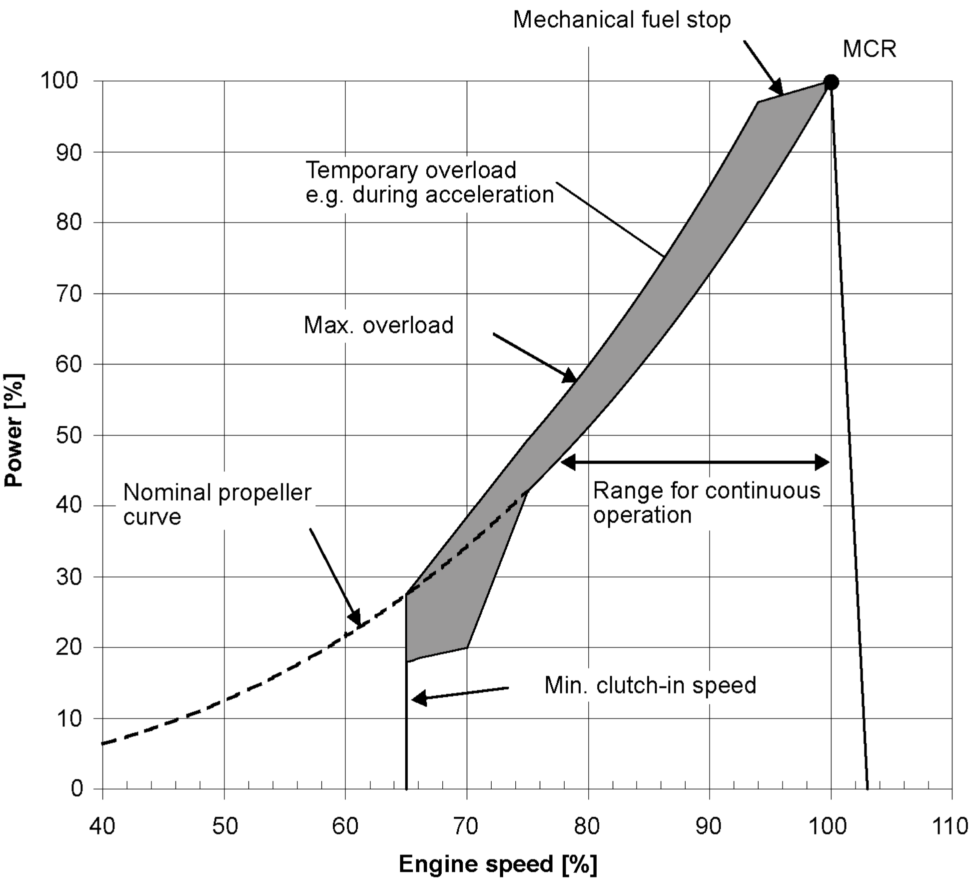
2.1.1 Controllable pitch propellers

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

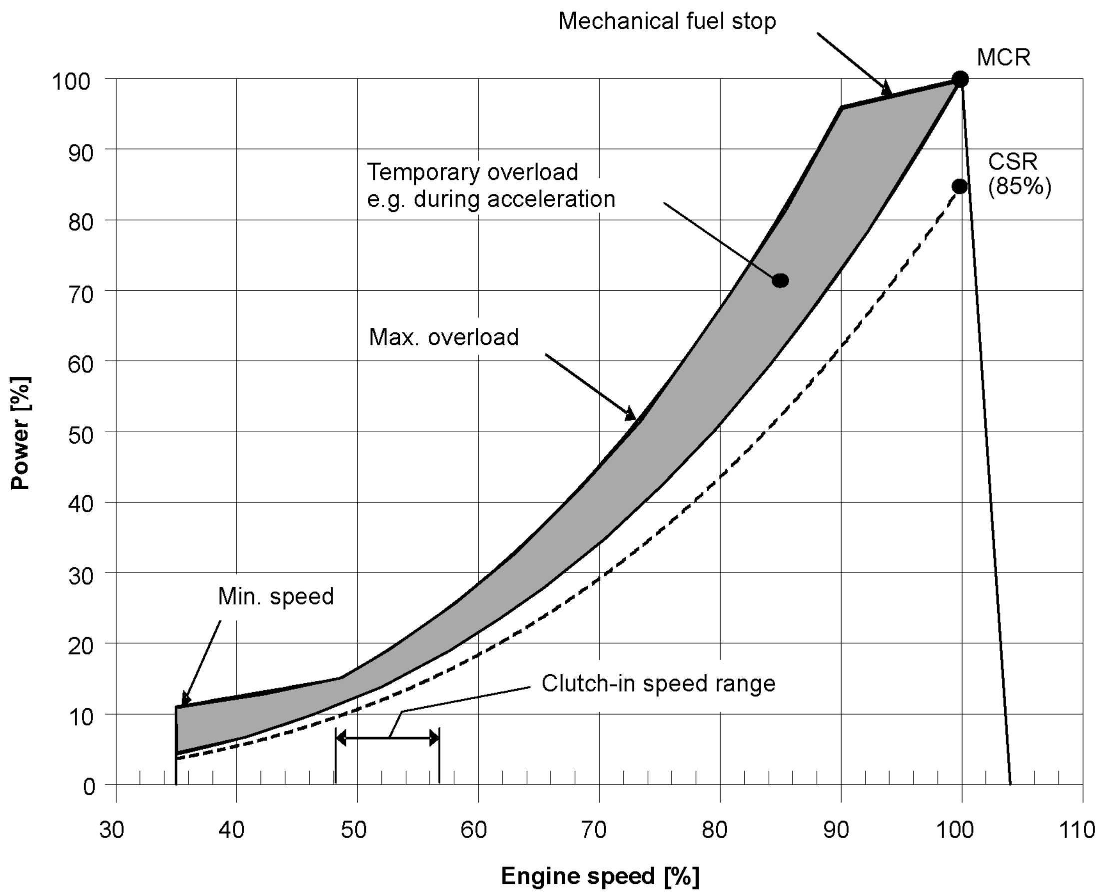
The thrust and power absorption of a given fixed pitch propeller is determined by the relation between ship speed and propeller revolution speed. The power absorption during acceleration, manoeuvring or towing is considerably higher than during free sailing for the same revolution speed. Increased ship 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



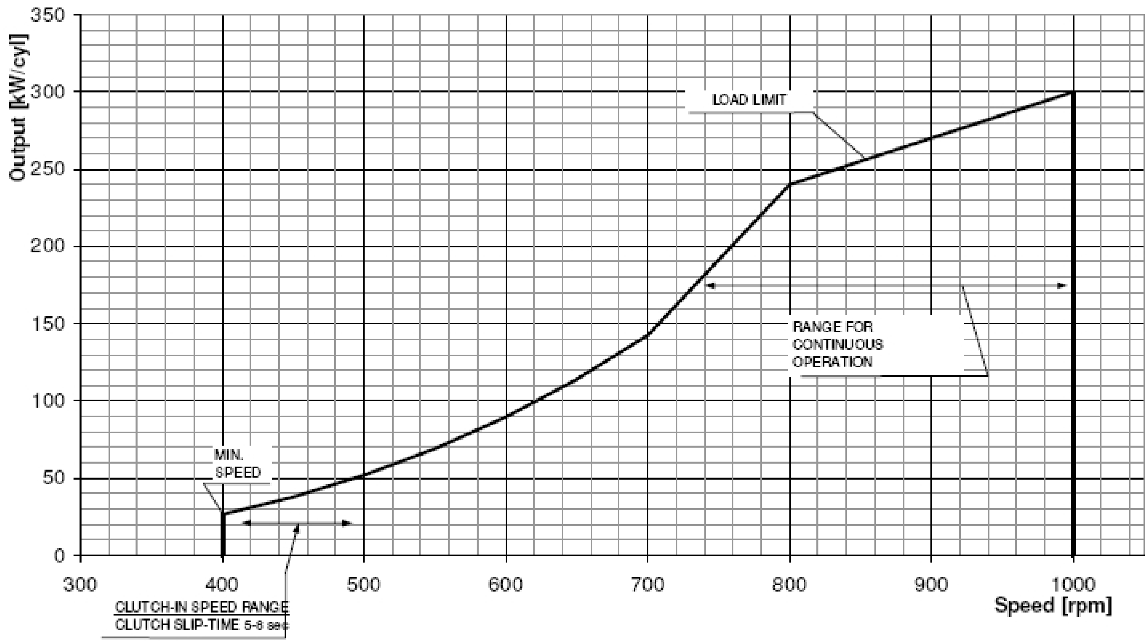
FP propellers in twin screw vessels

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.

Figure 2.3 Operating field for Dredgers



2.2 Loading capacity

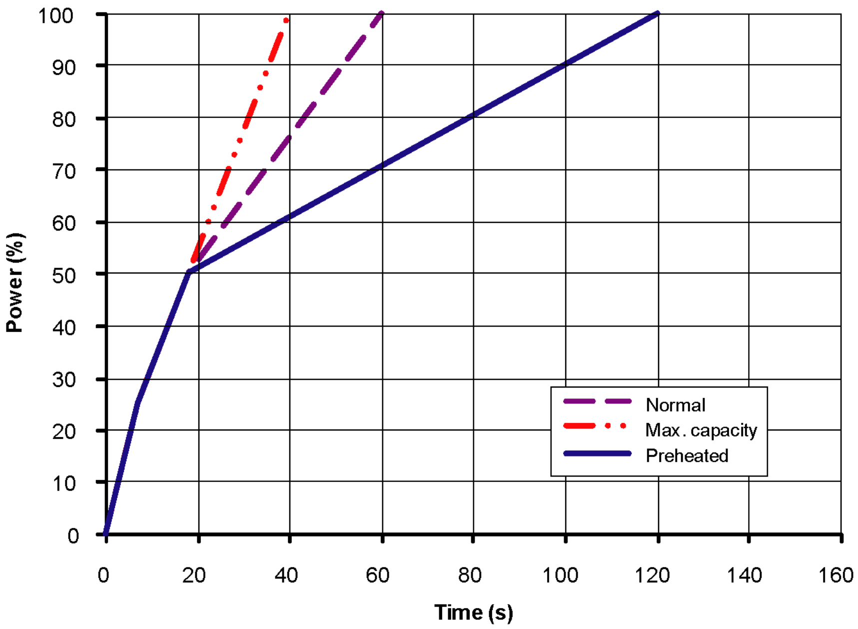
Controlled load increase is essential for highly supercharged diesel engines, because the turbocharger needs time to accelerate before it can deliver the required amount of air. A slower loading ramp than the maximum capability of the engine permits a more even temperature distribution in engine components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

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

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

2.2.1 Mechanical propulsion

Figure 2.4 Maximum recommended load increase rates for variable speed engines



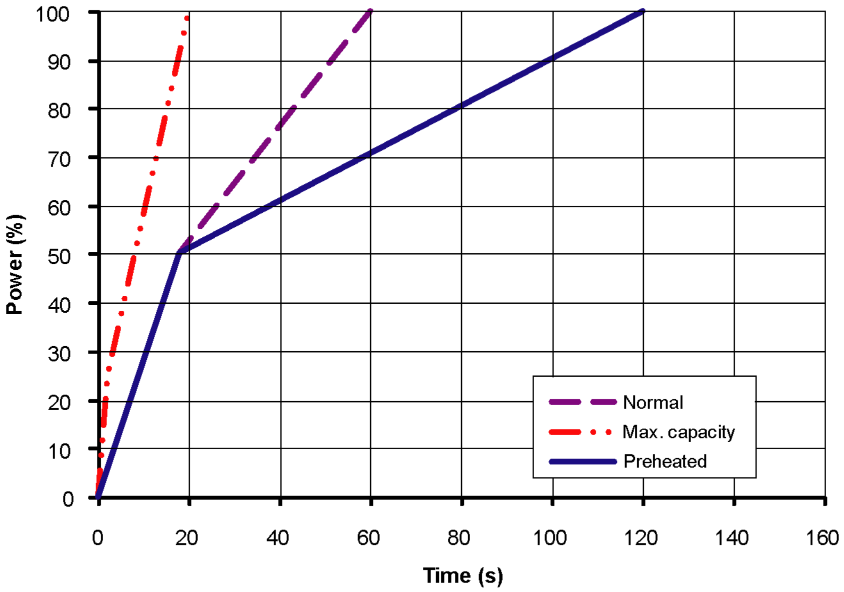
The propulsion control must include automatic limitation of the load increase rate. If the control system has only one load increase ramp, then the ramp for a preheated engine should be used. In tug applications the engines have usually reached normal operating temperature before the tug starts assisting. 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 + 5ºC
- Idling - 5ºC
- High load - 10ºC

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

Wärtsilä 6L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	1950	2040	1950	2040
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
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
Air temperature after 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 75% load	kg/s	3.0	3.4	3.0	3.1
Flow 50% load	kg/s	2.2	2.5	2.0	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	1.6	1.7	1.6	1.7
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	2.0	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

Wärtsilä 6L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	350 + static	350 + static	350 + 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
Capacity of engine driven pump, nom.	m³/h	35	35	35	35
Pressure drop over engine	kPa	210	210	210	210
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.3	0.3	0.3	0.3
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	260 + static	280 + static	260 + static	280 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	42	47	42	47
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	16	16	16	16
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Capacity engine driven seawater pump, max.	m³/h	80	80	80	80
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	1.4	1.4	1.4	1.4

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 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.

3.2 Wärtsilä 8L26

Wärtsilä 8L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	2600	2720	2600	2720
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	5.0	5.4	5.2	5.4
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	5.1	5.6	5.3	5.5
Flow at 85% load	kg/s	4.4	4.9	4.5	4.7
Flow 75% load	kg/s	4.0	4.5	4.0	4.2
Flow 50% load	kg/s	3.0	3.3	2.7	3.1
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	550	550	550	550
Calculated exhaust diameter for 35 m/s	mm	560	578	561	574
Heat balance (Note 3)					
Jacket water	kW	441	474	427	474
Lubricating oil	kW	378	401	367	401
Charge air	kW	849	1002	958	1002
Radiation	kW	122	128	122	128
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	2.1	2.3	2.2	2.3
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	2.0	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	10.3	10.9	10.3	10.9
Clean leak fuel quantity, HFO at 100% load	kg/h	2.1	2.2	2.1	2.2
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	1.6	1.6	1.6	1.6
Oil volume in separate system oil tank, nom.	m³	3.5	3.7	3.5	3.7
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
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	360 + static	370 + static	360 + static	370 + 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

Wärtsilä 8L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Capacity of engine driven pump, nom.	m³/h	45	45	45	45
Pressure drop over engine	kPa	220	220	220	220
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.4	0.4	0.4	0.4
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	270 + static	250 + static	270 + static	250 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
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 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.

3.3 Wärtsilä 9L26

Wärtsilä 9L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	2925	3060	2925	3060
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
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, min	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	2.0	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	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	l	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