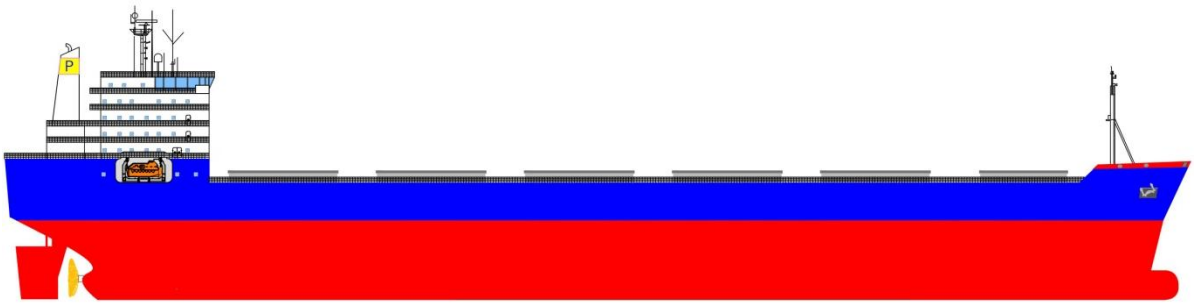
UNIVERSIDADE DA CORUÑA

BULK CARRIER TIPO PANAMAX DE 70.000 TPM



Caderno 6

PREDICIÓN DE POTENCIA E DESEÑO DE PROPULSORES E TEMÓN

AUTOR : **PEDRO OJEA GONZÁLEZ**

PROXECTO NÚMERO: **16-10P**

Escola Politécnica Superior

UNIVERSIDADE DA CORUÑA

DEPARTAMENTO DE ENXEÑERÍA NAVAL E OCEÁNICA

CURSO 2.015-2016

PROXECTO NÚMERO: 16 - 10 P

TIPO DE BUQUE : BULKCARRIER TIPO PANAMAX DE 70.000 TPM.

CLASIFICACIÓN , COTA Y REGLAMENTOS DE APLICACIÓN : ABS, SOLAS, MARPOL, REGLAMENTO PARA LA NAVEGACIÓN EN AGUAS DEL CANAL DE PANAMÁ, SUEZ.

CARACTERÍSTICAS DE LA CARGA: 70.000 TPM. GRAN, MINERAL, CARBÓN.

VELOCIDAD Y AUTONOMÍA: 14.5 NUDOS EN CONDICIÓNS DE SERVIZO. 85% MCR E 15% DE MARXE DE MAR. 11.000 MILLAS Á VELOCIDADE DE SERVIZO.

SISTEMAS Y EQUIPOS DE CARGA / DESCARGA : ESCOTILLAS DE ACCIONAMENTO HIDRÁULICO. SEN GRÚAS.

PROPULSIÓN : UN MOTOR DUAL FUEL (DIÉSEL/LNG) ACOPLADO A UNHA HÉLICE DE PASO FIXO.

TRIPULACIÓN Y PASAJE : 25 PERSOAS.

OTROS EQUIPOS E INSTALACIONES : OS HABITUAIS NESTE TIPO DE BUQUE.

ALUMNO: PEDRO OJEA GONZÁLEZ

Ferrol, 3 de Marzo de 2016

ÍNDICE

1. Introdución.

Neste caderno abordaremos os principais cálculos necesarios para a propulsión e manobra do noso buque. Calcularemos a potencia necesaria para mover o buque e de aí poderemos comezar a buscar o motor principal que necesitamos.

Posteriormente escolleremos o noso propulsor, é dicir, a nosa hélice comprobando que sexa a que mellor se adapta ás nosas necesidades. Unha vez feito isto pasaremos a deseñar o temón que permitirá manobrar ao noso buque.

Aproveitaremos estes cálculos do temón para dimensionar tamén o servomotor que o deberá mover.

Características do buque:

Eslora entre perpendiculares	206,38	m
Manga	32,25	m
Puntal	21,56	m
Calado	14,58	m
Coeficiente de bloque	0,88	
Toneladas de peso morto	70000	t
Desprazamento	87500	t
Velocidade de servizo	14,5	kn
Tripulantes	25	persoas

2. Estimación da potencia propulsora.

Como xa fixemos no Caderno 1, estimamos a potencia necesaria para propulsar o noso buque mediante o programa NavCad. Primeiro facemos un estudo da resistencia ao avance obtendo que a resistencia total do noso buque son 1117.43 kN. Despois disto, realizamos o estudo de propulsión, sempre utilizando o método de Holtrop, que é o que se adoita usar para este tipo de buques, e obtemos como resultado unha potencia ao freo necesaria de 9521.3 kW.

Os resultados extraídos do NavCad anéxanse como Anexo I.

Como xa temos a potencia ao freo, para obter a potencia total que necesitamos para escoller motor deberemos recordar que queremos que o motor traballe ao 85% polo que debemos escoller un motor cunha potencia de:

$$P_{motor} = 9521.3/0.85 = 11201.5 \text{ kW}$$

3. Elección do motor.

Unha vez vista a potencia necesaria imos a escoller o motor. De momento, a tecnoloxía dual fuel non está moi estendida e as principais casas de fabricantes están comezando a equipar buques con este tipo de tecnoloxía e a variedade de motores non é moi grande.

Imos facer unha introdución ao que son os motores dual fuel.

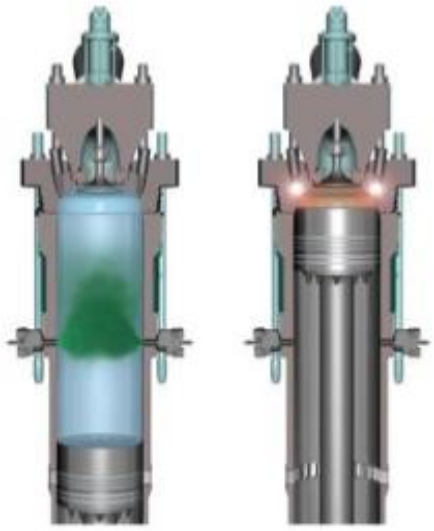
Durante os últimos anos o gas comezou a ter unha importancia maior no que se refire a combustible para buques mercantes. Isto débese, sen dúbida, ao todos os beneficios que ten respecto ao combustible diésel xa que o gas permite reducir as emisións de óxido de nitróxeno NO_x , de óxidos de xofre SO_x, de partículas en suspensión e de dióxido de carbono CO_2, gas causante do efecto invernadoiro. Ademais ten unha previsión moi favorable sobre a cantidade de gas da que se vai a poder dispoñer de forma sinxela e adsequible.

O fabricante Wärtsilä é o que maior gama de motores dual fuel ten, sexan motores de velocidade alta como de baixa velocidade, sendo estes últimos os que nos van a interesar a nós.

Moitos destes motores de baixa velocidade están aínda en fase de deseño e probas tal e como sucede co motor que debo escoller para o noso caso.

Winterthur Gas & Diesel Ltd (WinGD), empresa dependente de Wärtsilä desenrolou unha nova tecnoloxía dual fuel de baixa presión para motores lentos de dous tempos. Estes motores cumpren de forma ampla coas esixencias da OMI TIER III, a máis restritiva das limitacións da OMI sobre emisións.

A tecnoloxía dual fuel de baixa presión baséase no principio de mestura pobre onde o combustible e o aire se mesturan previamente e se queiman nunha proporción aire/combustible relativamente alta. Na figura que vemos a continuación móstrase como no motor de dous tempos DF o gas se mestura co aire de barrido na metade da carreira e ao final da compresión a carga de aire e combustible quéimase pola inxección de combustible pilotado con unha cantidade de menos do 1% da entrada de combustible a plena carga. Para que a ignición sexa estable en todas as condicións, o combustible pilotado inxéctase nunhas precámaras.

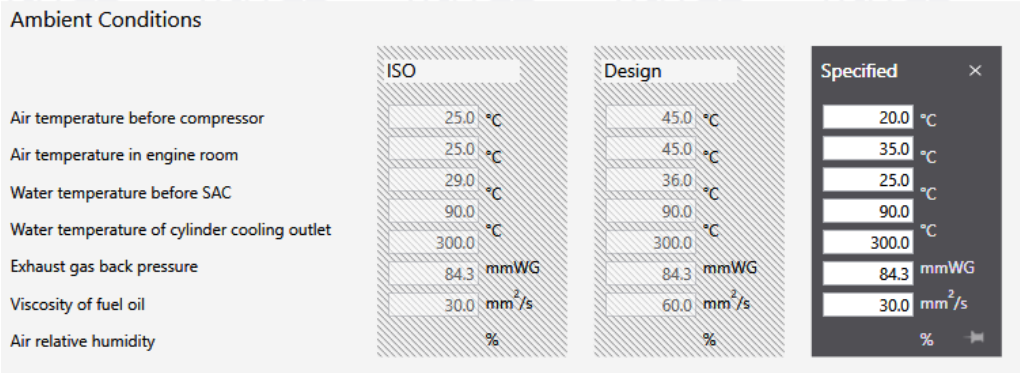


Este tipo de tecnoloxía de mestura pobre ten unha gran vantaxe xa que reduce a formación de NO_x ata un 90% en comparación coa combustión dun motor diésel ou dun motor a gas de inxección directa a alta presión. Isto fai que non necesitemos sistemas ou medidas adicionais para cumprir co nivel III da OMI sobre límites de emisións de NO_x .

Outro dos beneficios da tecnoloxía de baixa presión DF é loxicamente, a baixa presión necesaria. Isto débese a que a mestura do gas co aire de admisión se fai antes de que comece a compresión, polo que presión necesaria é menor de 16 bares, todo o contrario do que pasa nos sistemas de inxección de gas a alta presión que poden chegar a necesitar ata 300 bar. Desta forma, evitamos a instalación complexa e custosa dos equipos para alcanzar esta presión.

O motor escollido para este proxecto é o motor Wärtsilä X52DF na súa configuración de 8 cilindros.

Grazas a un programa de General Technical Data facilitado a través dun correo pola empresa Winterthur Gas & Diesel dependente de Wärtsilä podemos coñecer todos parámetros de funcionamento en tres tipos de condicións diferentes que serán as seguintes:



Ademais calcularemos todos os parámetros para 13 distintas cargas do motor sendo 25%, 30%, 40%, 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95%, 100% e 110%.

Como Anexo II inclúese o report extraído do programa.

Como datos máis importantes a destacar do motor veremos os seguintes:

Como xa dixen é un motor de 8 cilindros e neste caso de dous tempos, con unha potencia a MCR (Maximum Continuous Rating) de 11920 kW a 105 rpm e con unha potencia a CSR (Continuous Service Rating) de 10132 kW a 99.5 rpm sendo isto o 85% da carga do motor.

Tendo en conta que a nosa potencia necesaria eran 9521kW o réxime ao que traballará este motor será 9521/11920=0.8 é dicir, ao 80%.

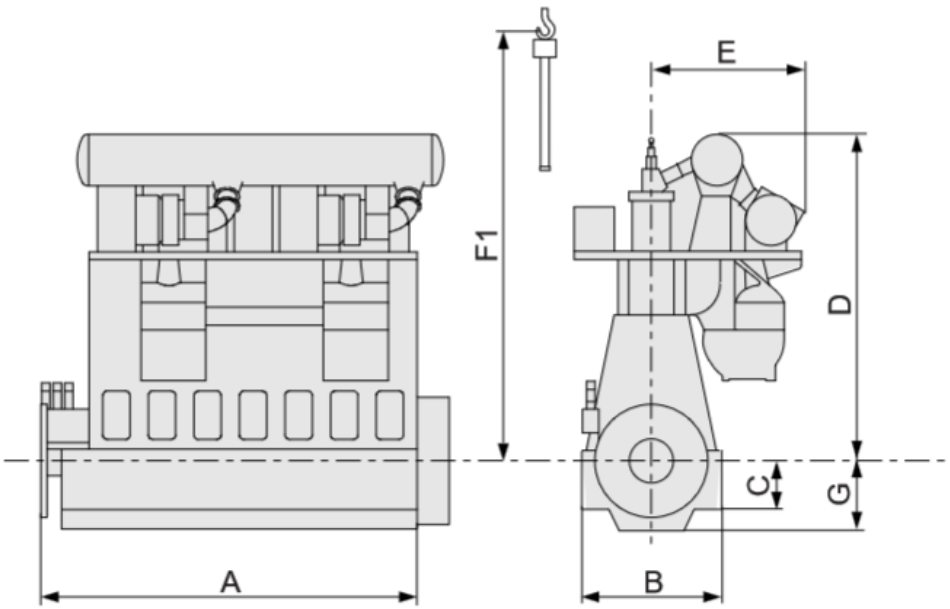
Conta con un turbocompresor da empresa ABB modelo A165-L.

O diámetro do pistón mide 520 mm mentres que a carreira é de 2315 mm. Traballa a unha presión media indicada de 17.32 bares e con unha velocidade lineal do pistón de 8.1 m/s.

Mide 8730 mm de longo e pesa 323 toneladas.

Cumpre coas regras IMO TIER II, en modo diésel, e IMO TIER III en modo gas, regras establecidas por MARPOL e referentes a emisión de óxidos de nitróxeno NO_x.

Por último engadimos o debuxo do motor coas súas dimensións:



Dimensions
In mm with a tolerance of approx. ± 10mm

A	8730	mm
B	3514	mm
C	1205	mm
D	8444	mm
E	3445	mm
F1	10250	mm
G	1910	mm

4. Elección do propulsor.

Mediante o programa NavCad e xa cos datos do motor imos dimensionar o noso propulsor.

Escollemos o tipo de hélices da serie B de Wageningen, e imos a probar con distinto número de palas para ver cal é a configuración coa que obtemos un maior rendemento da hélice.

A continuación vemos as capturas do programa NavCad para cada un dos casos:

- Con 4 palas obtemos un rendemento de 0.7067.

Propulsor		
Count:	1	
Propulsor type:	Propeller series	
Propeller type:	FPP	
Propeller series:	B Series	
Propeller sizing:	By power	
Reference prop:		
Blade count:	4	
Expanded area ratio:	0,9220	
Propeller diameter:	7000,0	mm
Propeller mean pitch:	5534,8	mm
Hub immersion:	11,1	mm
Engine/gear		
Engine data:	Motor X52DF	
Rated RPM:	105	RPM
Rated power:	11920,0	kW
Gear efficiency:	1,000	
Load correction:	Off	
Gear ratio:	1,261	
Shaft efficiency:	0,970	

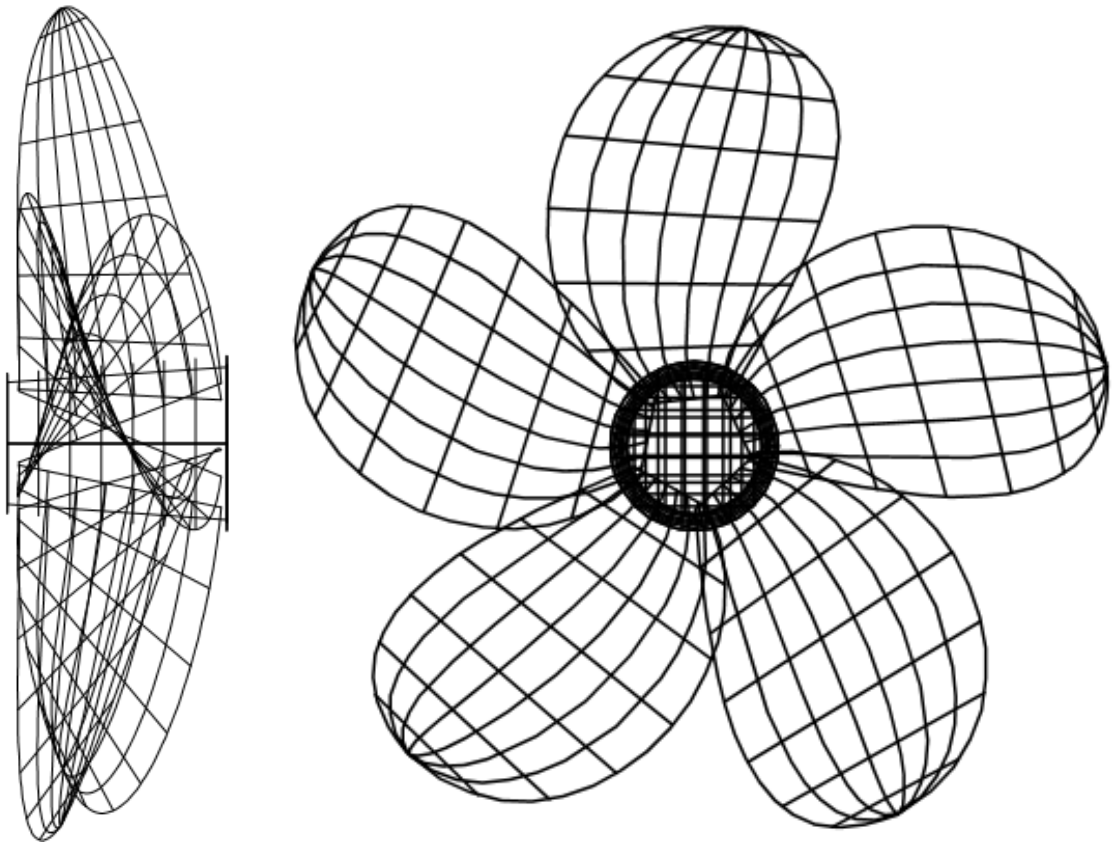
- Con 5 palas obtemos un rendemento de 0.7194.

Propulsor		
Count:	1	
Propulsor type:	Propeller series	
Propeller type:	FPP	
Propeller series:	B Series	
Propeller sizing:	By power	
Reference prop:		
Blade count:	5	
Expanded area ratio:	1,0189	
Propeller diameter:	7000,0	mm
Propeller mean pitch:	5689,5	mm
Hub immersion:	11,1	mm
Engine/gear		
Engine data:	Motor X52DF	
Rated RPM:	105	RPM
Rated power:	11920,0	kW
Gear efficiency:	1,000	
Load correction:	Off	
Gear ratio:	1,299	
Shaft efficiency:	0,970	

- Con 6 palas obtemos un rendemento de 0.7151.

Propulsor		
Count:	1	
Propulsor type:	Propeller series	
Propeller type:	FPP	
Propeller series:	B Series	
Propeller sizing:	By power	
Reference prop:		
Blade count:	6	
Expanded area ratio:	1,0500	
Propeller diameter:	7000,0	mm
Propeller mean pitch:	5732,6	mm
Hub immersion:	11,1	mm
Engine/gear		
Engine data:	Motor X52DF	
Rated RPM:	105	RPM
Rated power:	11920,0	kW
Gear efficiency:	1,000	
Load correction:	Off	
Gear ratio:	1,325	
Shaft efficiency:	0,970	

Polo tanto chegamos a conclusión de que a mellor opción é a de instalar unha hélice de 5 palas, cun diámetro de 7 metros, diámetro establecido a partir das limitacións do casco, e cun paso medio de 5.732 metros.
Do propio programa NavCad obtemos a representación da hélice.



4.1. Claras da hélice co codaste.

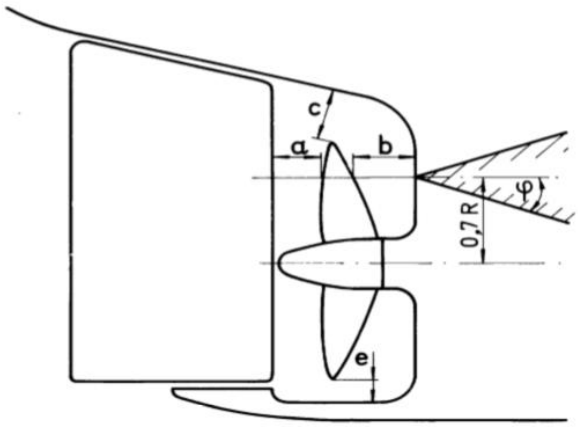
No regramento da nosa Sociedade de Clasificación non establece nada respecto as claras da hélice co codaste, por iso, neste caso imos utilizar para este apartado o regramento de DNV, do que extraemos a seguinte táboa:

Table C1 Minimum clearances	
For single screw ships:	*For twin screw ships:*
$a \geq 0{,}2\ R$ (m)	
$b \geq (0{,}7 - 0{,}04\ Z_p)\ R$ (m)	
$c \geq (0{,}48 - 0{,}02\ Z_p)\ R$ (m)	$c \geq (0{,}6 - 0{,}02\ Z_p)\ R$ (m)
$e \geq 0{,}07\ R$ (m)	

Sendo:

- R: o radio da hélice.
- Zp: o número de palas da hélice.

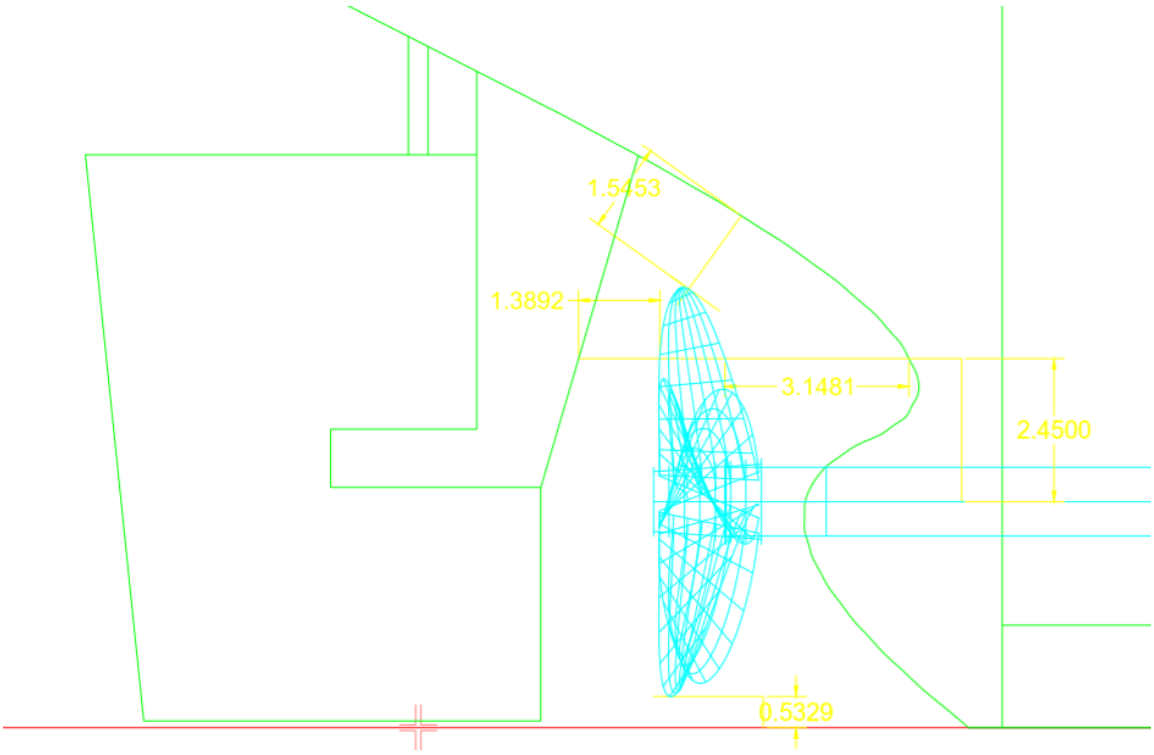
Ademais, os valores *a*, *b*, *c* e *e* son os que se representan na seguinte imaxe:



Para o noso caso deberemos cumprir as seguintes limitacións:

- $a \geq 0.2*3.5 = 0.7$ m
- $b \geq (0.7-0.04*5)*3.5 = 1.75$ m
- $c \geq (0.48-0.02*5)*3.5 = 1.33$ m
- $e \geq 0.07*3.5 = 0.245$ m

Tras comprobar que cumprimos todos os requisitos vemos agora o deseño que nos queda:



5. Dimensionamento do temón.

Para escoller o tipo de temón recorremos á nosa base de datos, na cal podemos observar que case todos os temóns son de tipo semisuspendido polo que para o noso caso escolleremos o mesmo tipo, ademais será tamén semicompensado.

Para dimensionar a área do temón imos tomar que esta é o 2% de L_{pp}*T, xa que no libro *El Proyecto Básico del Buque Mercante* dinos que os valores normais son entre 1.5 e 2.5 %.

Polo tanto:

$$A_{temón}=0.02*206.38*14.58 = 60.18\ m^2$$

Ademais, este libro dinos que a área de compensación, é dicir, a área do temón que se encontra a proa da do seu eixo de xiro debe ser aproximadamente o 20% da área do temón e a lonxitude desta área non será nunca maior do 35% da lonxitude do temón.

Tamén nos di que a relación de aspecto, é dicir, o cociente entre a altura e a lonxitude media do temón, adoita ser próxima a 1.5.

Con todos este datos imos deseñar o noso temón.

Cos datos da área e da relación de aspecto temos dúas ecuacións con dúas incógnitas, o que nos dará unha primeira aproximación do que pode ser o noso temón.

$h*l=60.18$

$h/l=1.5$

Resolvemos e,

$h=9.5$

$l=6.33$

Como por culpa do brazo que sostén o temón imos ter que restar área imos a darlle ao noso temón unha altura de 9.7 metros e unha lonxitude de 6.3 metros.

Finalmente, tras deseñalo, quedounos o seguinte:

Área total=62.04 m^2

Área de compensación = 13.1 m^2 (21% do total)

Altura= 9.7 metros

Lonxitude media= 6.75

Lonxitude área de compensación= 1.55 metros (23%<35%)

6. Dimensionamento do servomotor.

Para dimensionar a potencia debemos seguir unha serie de pasos:

- Calcular a forza sobre o temón.
- Calcular o momento torsor que xera esa forza sobre a mecha.
- Dimensionar a mecha do temón.

6.1. Cálculo da forza sobre o temón.

O regramento de ABS danos a seguinte fórmula:

$$CR = n \cdot k_R \cdot k_c \cdot k_l \cdot A \cdot V_R^2 \quad kN$$

Sendo:

- n=0.132
- k_R: $(b^2/A_t + 2)/3$, pero nunca superior a 1.33

- b: Altura media da área do temón en metros.
- A_t: Suma da superficie do temón , A, e a área do vástago do temón ou o corno do temón dentro de la extensión del perfil del temón, en m^2.
- A: Área total proxectada do temón.
- k_c: Coeficiente que depende da sección do temón.
- k_l: Coeficiente que se extrae da seguinte táboa:

Coefficient k_ℓ *(2012)*

Rudder/Propeller Layout	k_ℓ
Rudders outside propeller jet	0.8
Rudders behind a fixed propeller nozzle	1.15
Steering nozzles and azimuthing thrusters	1.15
All others	1.0

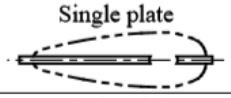
- V_R: Velocidade do buque en nós.
  - Para marcha avante, V_R é igual a V_d ou V_{min} , a que sexa menor.
  - Para marcha atrás, V_R é igual a V_a, $0.5V_d$ ou $0.5V_{min}$, a que sexa menor.
- V_d: Velocidade de deseño, en nós.
- V_a: Velocidade de ciado máxima, en nós.
- $V_{min}=(V_d+20)/3$

Para nos cada un destes coeficientes valerá:

- n=0.132
- $k_R=(b^2/A_t + 2)/3=$ 1.11
- b= 9.7 metros
- A_t = 70.81 m^2
- A: 62.04 m^2

- k_c: No noso caso imos escoller un perfil NACA. Polo tanto para a marcha avante k_c=1.1 e para a marcha atrás k_c=0.8

Coefficient k_c for Ordinary Rudders *(2014)*

	Profile Type	k_c	
		Ahead Condition	*Astern Condition*
1	Single plate 	1.0	1.0
2	NACA-OO GÖttingen 	1.1	0.80

- k_l: Para o noso caso será 1.15.

Coefficient k_ℓ (2012)

Rudder/Propeller Layout	k_ℓ
Rudders outside propeller jet	0.8
Rudders behind a fixed propeller nozzle	1.15
Steering nozzles and azimuthing thrusters	1.15
All others	1.0

- V_R: Velocidade do buque en nós.
  - Para marcha avante, V_R=11.5 kn
  - Para marcha atrás, V_R=5.75 kn
- V_d: 14.5 kn
- V_a: 7 kn
- V_{min}=(14.5+20)/3=11.5 kn

Polo tanto, a forza sobre o temón para marcha avante quedaramos:

C_{Rav}=1520.74 kN

E para a marcha atrás:

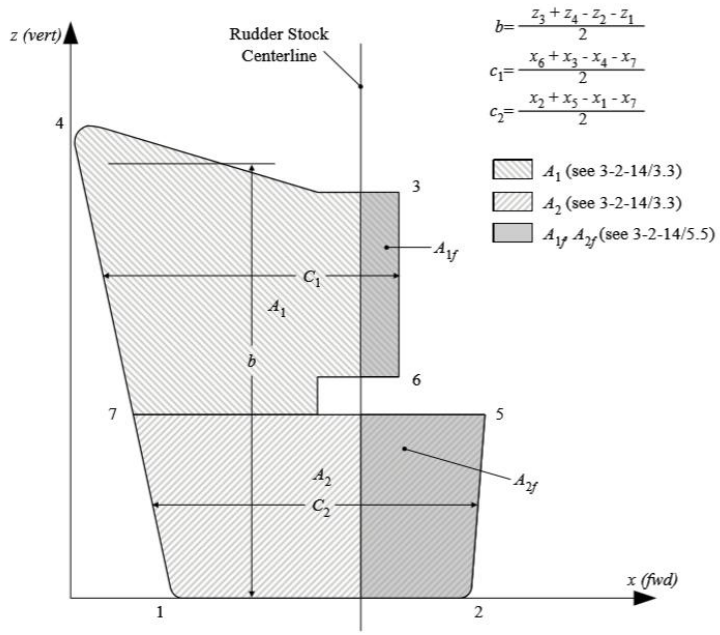
C_{Rat}=276.5 kN

Como temos un temón con un corte na parte pola que está suspendido, a forza podemos calculala para cada un das subáreas do noso temón da seguinte forma:

$C_{R1}=C_R*(A_1/A)$

$C_{R2}=C_R*(A_2/A)$

Sendo A_1 e A_2 as indicadas na seguinte figura:



E tendo as seguintes medidas:

A_1=34.02 m^2

A_2= 28.02 m^2

Polo tanto, en marcha avante:

$C_{R1}=C_{Rav}*(A_1/A)=1520.74*(34.02/62.04)=833.91$ kN

$C_{R2}=C_{Rav}*(A_2/A)= 1520.74*(28.02/62.04)=686.83$ kN

e en marcha atrás:

$C_{R1}=C_{Rat}*(A_1/A)=276.5*(34.02/62.04)=151.62$ kN

$C_{R2}=C_{Rat}*(A_2/A)= 276.5*(28.02/62.04)=124.88$ kN

6.2. Cálculo do momento torsor.

Seguimos de novo o que nos di o regramento de ABS que nos dá a seguinte fórmula:

$Q_R=C_{R1}*r_1+ C_{R2}*r_2$

e este nunca debe ser menor na marcha avante que Q_{Rmin}.

Sendo:

- Q_{Rmin} = $0.1C_R(A_1c_1+ A_2c_2)/A$
- r_1 = $c_1(\alpha-k_1)$
- r_2 = $c_2(\alpha-k_2)$
- c_1,c_2 = a anchura media das partes A_1 e A_2 como se mostra na figura anterior.
- α = coeficiente que se obtén da seguinte táboa:

Coefficient α *(2014)*

Rudder Position or High-lift	α		
	Ahead Condition	*Astern Condition*	
Located behind a fixed structure, such as a rudder horn	0.25	0.55	
Located where no fixed structure forward of it	0.33	0.75 (hollow profile)	0.66 (non-hollow)
High-Lift Rudders (see 3-2-14/Table 1B)	Special consideration (0.40 if unknown)	Special consideration	

- k_1 e k_2 = A_{1f}/A_1 e A_{2f}/A_2 sendo A_{1f} e A_{2f} as áreas do temón situadas a proa do eixo da mecha en cada unha das partes como se indica na figura anterior.

Polo tanto, para o noso temón quédanos o seguinte:

- α=0.25 para marcha avante e 0.55 para atrás.
- c_1=6.4
- c_2=7
- k_1=0.138
- k_2=0.3
- r_{1av}=6.4*(0.25-0.138)=0.7168
- r_{2av}=7*(0.25-0.3)=-0.35
- r_{1at}=6.4*(0.55-0.138)=2.6368
- r_{2at}=7*(0.55-0.3)=1.75
- $Q_{Rmin\ av}$=0.1*1520.74*(34.02*6.4+28.02*7)/62.04=1014.48 kNm
- $Q_{Rmin\ av}$=0.1*276.5*(34.02*6.4+28.02*7)/62.04=184.45 kNm

E finalmente os nosos momentos torsores serán:

Q_{Rav}=833.91*0.7168+683.86*(-0.35)=358.39 kNm

Q_{Rat}=151.62*2.6368+124.88*1.75=618.33 kNm

Como vemos, o momento en marcha avante é menor que o momento mínimo que calculamos polo que tomaremos como valor do momento o do momento mínimo. Pola contra, na marcha atrás, o momento que nos dá é superior ao momento mínimo e polo tanto colleremos ese.

Q_{Rav}=1014.48 kNm

Q_{Rat}=618.33 kNm

6.3. Cálculo da mecha do temón.

O regramento de ABS danos a seguinte fórmula para calcular o diámetro da mecha:

$$S=N_u\sqrt[3]{Q_R K_s} \quad \text{mm}$$

Sendo:

- $N_u=42$
- $K_S=(n_y/Y)^e$
- $n_y=235\ N/mm^2$
- $Y=450\ N/mm^2$
- $e=1$

Como momento torsor imos coller o maior dos que calculamos, é dicir, o momento de marcha avante.

Polo tanto:

$$K_S=(235/450)^1=0.52$$

$$S=42*\sqrt[3]{1014.48 * 0.52} = 339 \text{ mm}$$

6.4. Cálculo da potencia do servo.

O regramento internacional SOLAS dinos no seu Capítulo II-1, Parte C, regra 29 o seguinte:

> *O aparato de goberno principal e a mecha do temón:*
>
> *1 terán resistencia suficiente e permitirán o goberno do buque á velocidade máxima de servizo en marcha avante, o cal deberá quedar demostrado;*
>
> *2 permitirán o cambio do temón dende unha posición de 35° a unha banda ata outra de 35° á banda oposta encontrándose o buque navegando á velocidade máxima de servizo en marcha avante e con seu calado máximo en auga salgada, e, dadas as mesmas condicións, dende unha posición de 35° a calquera de ambas bandas ata outra de 30° á banda oposta, sen que iso leve máis de 28 segundos.*

Polo tanto, para obter a potencia necesaria que debe ter o servo deberemos facer o seguinte:

$$P = \frac{Q_R * w}{\eta}$$

Para calcular a velocidade angular aplicamos a seguinte fórmula:

$$w = \frac{65^\circ}{28\ s} * \frac{2\pi rad}{360^\circ} = 0.0405 \text{ rad/s}$$

Para o rendemento do servomotor imos supor un rendemento baixo do 60% o que fará que vaiamos a ter sempre un sobredimensionamento que fará de factor de seguridade.

Polo que,finalmente:

$$P = \frac{1014.48*0.0405}{0.6} = 68.47 \text{ kW}$$

7. Elección do perfil do temón.

Partindo da nosa elección dun perfil NACA agora imos a realizar o seu dimensionamento. Para comezar debemos entender que os perfís NACA son unha serie de perfís aerodinámicos desenrolados polo Comité Consultivo Nacional de Aeronáutica, en inglés National Advisory Committee for Aeronautics (NACA). A forma das superficies dos perfís descríbese despois da palabra NACA con un código numérico. Os números deste código utilízanse en ecuacións xa dadas para calcular as seccións transversais do propio perfil. A nos interésannos as chamadas series de 4 díxitos e máis concretamente aquelas que son simétricas, é dicir, as que os seus primeiros dous números son ceros.

Estes dous primeiros números corresponden á comba do perfil e á distancia en proporción a lonxitude da corda á cal se encontra do borde de ataque.

Os dous segundos números corresponden ao grosor do perfil respecto da súa lonxitude.

O noso temón ten unha corda media de 6.75 metros e temos unha mecha de 339 mm. Escollendo un perfil NACA 0018 teríamos un grosor do 18% da nosa corda, é dicir, 1.215 metros, grosor no que perfectamente colle a nosa mecha.

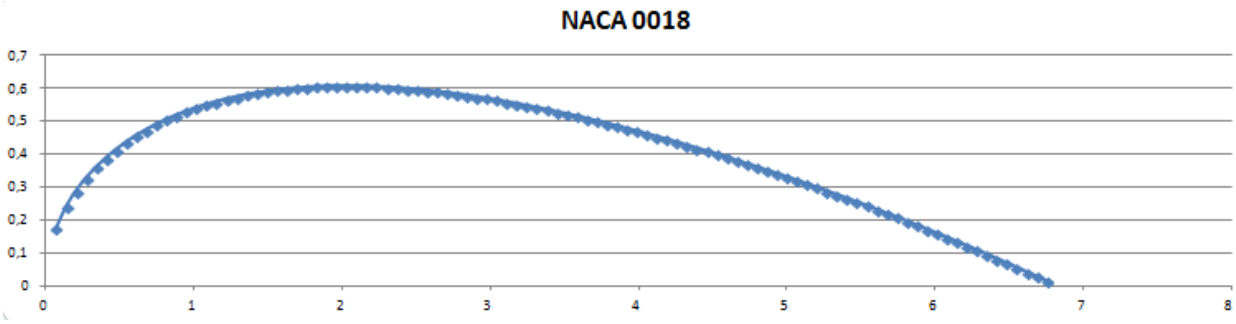
Agora aplicamos a seguinte fórmula para obter a sección transversal do perfil:

$$y_t = 5tc\left[0.2969\sqrt{\frac{x}{c}} + (-0.1260)\left(\frac{x}{c}\right) + (-0.3516)\left(\frac{x}{c}\right)^2 + 0.2843\left(\frac{x}{c}\right)^3 + (-0.1015)\left(\frac{x}{c}\right)^4\right]$$

Sendo:

- c: lonxitude da corda.
- x: posición ao longo da corda dende 0 ata c.
- y_t: espesor á distancia x correspondente.
- t: o espesor máximo en relación á lonxitude da corda, no noso caso 0.18.

Calculando para 100 valores equiespaciados da corda o seu grosor obtivemos o seguinte perfil:


NACA 0018
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
0
1
2
3
4
5
6
7
8

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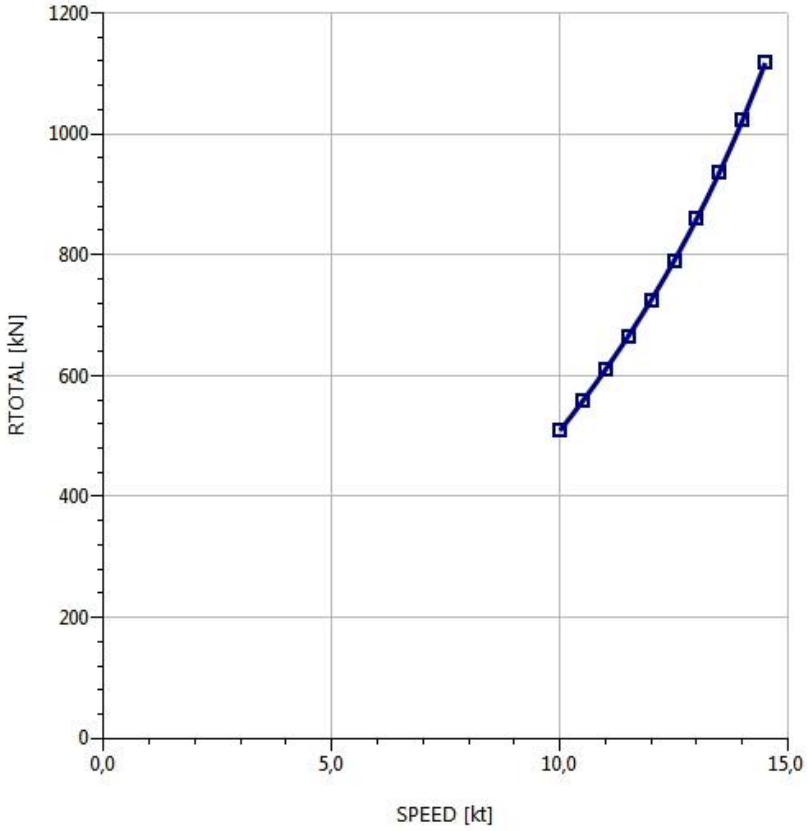
ANEXO I.

Gráfica da resistencia en función da velocidade.



Datos do cálculo da resistencia.

Resistance

9 may 2016 11:16
HydroComp NavCad 2014

Project ID
Description
File name **datos 1.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]	**1,179**	
Speed corr:	[Off]		
Spray drag corr:	[Off]		
Corr allowance:		**0,000176**	
Roughness [mm]:	[On]	**0,15**	

Added drag		
Appendage:	[Calc]	**Percentage**
Wind:		**[Off]**
Seas:		**[Off]**
Shallow/channel:		**[Off]**
Towed:		**[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	**0,16**	**0,85**	**6,63**	**2,21**	**1,03**
Range	**0,06··0,26**	**0,55··0,85**	**3,90··14,90**	**2,10··4,00**	**0,01··1,07**

Prediction results

	SPEED COEFS		ITTC-78 COEFS						
SPEED [kt]	FN	FV	RN	CF	[CTLT/CF]	CR	dCF	CA	CT
10,00	**0,112**	**0,248**	**9,25e8**	**0,001546**	**1,179**	**0,000741**	**0,000000**	**0,000176**	**0,002739**
10,50	**0,118**	**0,260**	**9,71e8**	**0,001536**	**1,179**	**0,000737**	**0,000000**	**0,000176**	**0,002725**
11,00	**0,124**	**0,272**	**1,02e9**	**0,001527**	**1,179**	**0,000737**	**0,000000**	**0,000176**	**0,002714**
11,50	**0,129**	**0,285**	**1,06e9**	**0,001519**	**1,179**	**0,000742**	**0,000000**	**0,000176**	**0,002709**
12,00	**0,135**	**0,297**	**1,11e9**	**0,001511**	**1,179**	**0,000753**	**0,000000**	**0,000176**	**0,002711**
12,50	**0,140**	**0,310**	**1,16e9**	**0,001503**	**1,179**	**0,000772**	**0,000000**	**0,000176**	**0,002720**
13,00	**0,146**	**0,322**	**1,20e9**	**0,001496**	**1,179**	**0,000798**	**0,000000**	**0,000176**	**0,002739**
13,50	**0,152**	**0,334**	**1,25e9**	**0,001489**	**1,179**	**0,000835**	**0,000000**	**0,000176**	**0,002767**
14,00	**0,157**	**0,347**	**1,29e9**	**0,001483**	**1,179**	**0,000883**	**0,000000**	**0,000176**	**0,002807**
+ 14,50 +	**0,163**	**0,359**	**1,34e9**	**0,001476**	**1,179**	**0,000944**	**0,000000**	**0,000176**	**0,002860**

	RESISTANCE							
SPEED [kt]	RBARE [kN]	RAPP [kN]	RWIND [kN]	RSEAS [kN]	RCHAN [kN]	RTOWED [kN]	RMARGIN [kN]	RTOTAL [kN]
10,00	**424,20**	**21,21**	**0,00**	**0,00**	**0,00**	**63,63**	**63,63**	**509,04**
10,50	**465,14**	**23,26**	**0,00**	**0,00**	**0,00**	**69,77**	**69,77**	**558,16**
11,00	**508,54**	**25,43**	**0,00**	**0,00**	**0,00**	**76,28**	**76,28**	**610,24**
11,50	**554,80**	**27,74**	**0,00**	**0,00**	**0,00**	**83,22**	**83,22**	**665,76**
12,00	**604,45**	**30,22**	**0,00**	**0,00**	**0,00**	**90,67**	**90,67**	**725,34**
12,50	**658,14**	**32,91**	**0,00**	**0,00**	**0,00**	**98,72**	**98,72**	**789,77**
13,00	**716,65**	**35,83**	**0,00**	**0,00**	**0,00**	**107,50**	**107,50**	**859,98**
13,50	**780,92**	**39,05**	**0,00**	**0,00**	**0,00**	**117,14**	**117,14**	**937,10**
14,00	**852,02**	**42,60**	**0,00**	**0,00**	**0,00**	**127,80**	**127,80**	**1022,43**
+ 14,50 +	**931,19**	**46,56**	**0,00**	**0,00**	**0,00**	**139,68**	**139,68**	**1117,43**

	EFFECTIVE POWER		OTHER		
SPEED [kt]	PEBARE [kW]	PETOTAL [kW]	CTLR	CTLT	RBARE/W
10,00	**2182,3**	**2618,7**	**0,01060**	**0,03916**	**0,00049**
10,50	**2512,5**	**3015,0**	**0,01054**	**0,03895**	**0,00054**
11,00	**2877,7**	**3453,3**	**0,01054**	**0,03880**	**0,00059**
11,50	**3282,3**	**3938,7**	**0,01061**	**0,03873**	**0,00065**
12,00	**3731,5**	**4477,8**	**0,01077**	**0,03875**	**0,00070**
12,50	**4232,2**	**5078,6**	**0,01103**	**0,03889**	**0,00077**
13,00	**4792,8**	**5751,4**	**0,01141**	**0,03915**	**0,00084**
13,50	**5423,5**	**6508,2**	**0,01194**	**0,03956**	**0,00091**
14,00	**6136,5**	**7363,8**	**0,01263**	**0,04013**	**0,00099**
+ 14,50 +	**6946,1**	**8335,4**	**0,01349**	**0,04089**	**0,00109**

Report ID20160509-1116 HydroComp NavCad 2014 14.02.0029.S1002.539

Resistance

9 may 2016 11:16
HydroComp NavCad 2014

Project ID
Description
File name **datos 1.hcnc**

Hull data

General		
Configuration:		**Monohull**
Chine type:		**Round/multiple**
Length on WL:		**213,790 m**
Max beam on WL:	[LWL/BWL 6,629]	**32,250 m**
Max molded draft:	[BWL/T 2,212]	**14,580 m**
Displacement:	[CB 0,848]	**87500,00 t**
Wetted surface:	[CS 2,671]	**11405,4 m2**
ITTC-78 (CT)		
LCB fwd TR:	[XCB/LWL 0,483]	**103,190 m**
LCF fwd TR:	[XCF/LWL 0,483]	**103,190 m**
Max section area:	[CX 0,999]	**469,6 m2**
Waterplane area:	[CWP 0,918]	**6326,1 m2**
Bulb section area:		**22,9 m2**
Bulb ctr below WL:		**12,120 m**
Bulb nose fwd TR:		**216,000 m**
Imm transom area:	[ATR/AX 0,026]	**12,1 m2**
Transom beam WL:	[BTR/BWL 0,624]	**20,110 m**
Transom immersion:	[TTR/T 0,000]	**0,000 m**
Half entrance angle:		**46,08 deg**
Bow shape factor:	[AVG flow]	**0,0**
Stern shape factor:	[AVG flow]	**0,0**

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***
Deadrise:		***0,00 deg***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Fwd station (fwd TR):		***0,000 m***
Deadrise:		***0,00 deg***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Propulsor type:		***Propeller***
Max prop diameter:		***8500,0 mm***
Shaft angle to WL:		***0,00 deg***
Position fwd TR:		***0,000 m***
Position below WL:		***0,000 m***
Transom lift device:		***Flap***
Device count:		***0***
Span:		***0,000 m***
Chord length:		***0,000 m***
Deflection angle:		***0,00 deg***
Tow point fwd TR:		***0,000 m***
Tow point below WL:		***0,000 m***

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Resistance

9 may 2016 11:16
HydroComp NavCad 2014

Project ID
Description
File name **datos 1.hcnc**

Appendage data

General	
Definition:	**Percentage**
Percent of hull drag:	**5,00 %**
Planing influence	
LCE fwd TR:	**0,000 m**
VCE below WL:	**0,000 m**
Shafting	
Count:	**1**
Max prop diameter:	**8500,0 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
9 may 2016 11:16
HydroComp NavCad 2014

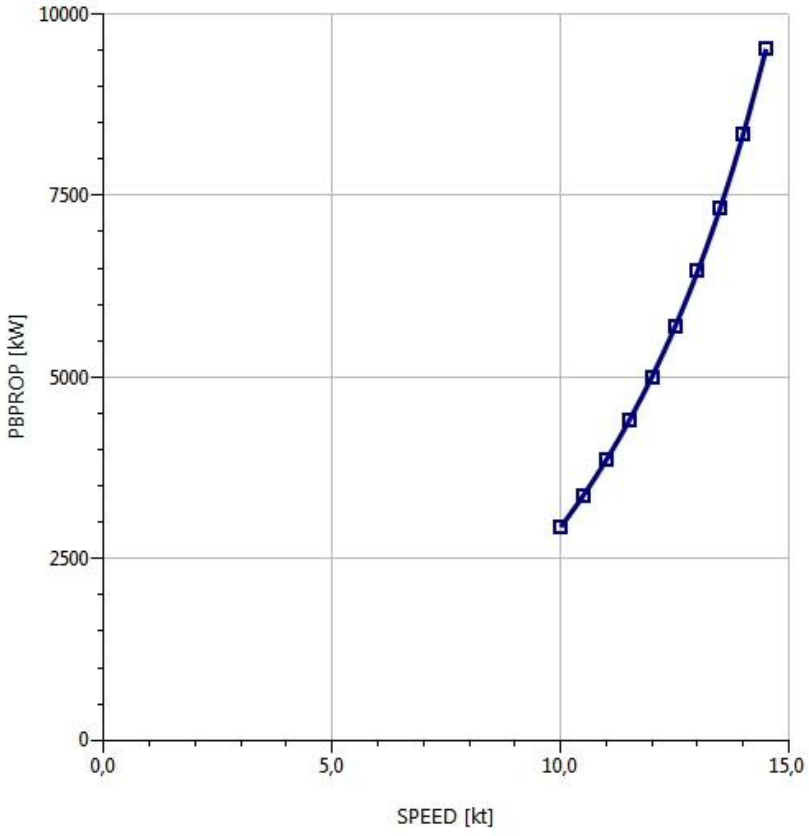
Project ID
Description
File name **datos 1.hcnc**

Symbols and values

SPEED =	Vessel speed
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
RTOWED =	Additional towed object resistance
RMARGIN =	Resistance margin
RTOTAL =	Total vessel resistance
PEBARE =	Bare-hull effective power
PETOTAL =	Total effective power
CTLR =	Telfer residuary resistance coefficient
CTLT =	Telfer total bare-hull resistance coefficient
RBARE/W =	Bare-hull resistance to weight ratio
+ =	Design speed indicator
* =	Exceeds parameter limit

Report ID20160509-1116 HydroComp NavCad 2014 14.02.0029.S1002.539

Gráfica da potencia ao freo en función da velocidade.



Datos do cálculo da potencia.

Propulsion

9 may 2016 11:20
HydroComp NavCad 2014

Project ID
Description
File name **datos 1.hcnc**

Analysis parameters

Hull-propulsor interaction		**System analysis**	
Technique:	[Calc] Prediction	Cavitation criteria:	**Keller eqn**
Prediction:	**Holtrop**	Analysis type:	**Free run**
Reference ship:		CPP method:	
Max prop diam:	**8500,0 mm**	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	[Off]	RPM constraint:	
Rudder location:		Limit [RPM/s]:	
Friction line:		**Water properties**	
Hull form factor:		Water type:	**Salt**
Corr allowance:		Density:	**1026,00 kg/m3**
Roughness [mm]:		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	**0,16**	**0,85**	**6,63**	**2,21**
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 [%]
10,00	**2618,7**	**0,6768**	**0,1922**	**1,0271**	**71**	**2935,1**	**---**	**0,0**
10,50	**3015,0**	**0,6763**	**0,1922**	**1,0271**	**74**	**3373,8**	**---**	**0,0**
11,00	**3453,3**	**0,6758**	**0,1922**	**1,0271**	**78**	**3860,3**	**---**	**0,0**
11,50	**3938,7**	**0,6753**	**0,1922**	**1,0271**	**81**	**4401,6**	**---**	**0,0**
12,00	**4477,8**	**0,6749**	**0,1922**	**1,0271**	**85**	**5006,9**	**---**	**0,0**
12,50	**5078,6**	**0,6745**	**0,1922**	**1,0271**	**89**	**5687,8**	**---**	**0,0**
13,00	**5751,4**	**0,6741**	**0,1922**	**1,0271**	**92**	**6459,3**	**---**	**0,0**
13,50	**6508,2**	**0,6737**	**0,1922**	**1,0271**	**96**	**7339,6**	**---**	**0,0**
14,00	**7363,8**	**0,6733**	**0,1922**	**1,0271**	**101**	**8351,3**	**---**	**0,0**
+ 14,50 +	**8335,4**	**0,6730**	**0,1922**	**1,0271**	**105**	**9521,3**	**---**	**0,0**

	POWER DELIVERY							
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	QENG [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP
10,00	**43**	**644,18**	**393,28**	**2847,0**	**2935,1**	**2935,1**	**2935,1**	**---**
10,50	**45**	**706,57**	**431,37**	**3272,6**	**3373,8**	**3373,8**	**3373,8**	**---**
11,00	**48**	**772,69**	**471,74**	**3744,5**	**3860,3**	**3860,3**	**3860,3**	**---**
11,50	**50**	**843,14**	**514,75**	**4269,5**	**4401,6**	**4401,6**	**4401,6**	**---**
12,00	**52**	**918,67**	**560,87**	**4856,6**	**5006,9**	**5006,9**	**5006,9**	**---**
12,50	**54**	**1000,23**	**610,66**	**5517,2**	**5687,8**	**5687,8**	**5687,8**	**970,1**
13,00	**56**	**1088,98**	**664,84**	**6265,5**	**6459,3**	**6459,3**	**6459,3**	**888,4**
13,50	**59**	**1186,27**	**724,24**	**7119,4**	**7339,6**	**7339,6**	**7339,6**	**812,0**
14,00	**61**	**1293,70**	**789,83**	**8100,7**	**8351,3**	**8351,3**	**8351,3**	**740,0**
+ 14,50 +	**64**	**1413,02**	**862,67**	**9235,7**	**9521,3**	**9521,3**	**9521,3**	**672,3**

	EFFICIENCY				THRUST	
SPEED [kt]	EFFO	EFFG	EFFOA	MERIT	THRPROP [kN]	DELTHR [kN]
10,00	**0,3584**	**1,0000**	**0,8922**	**0,70906**	**630,19**	**509,04**
10,50	**0,3595**	**1,0000**	**0,8937**	**0,70826**	**691,00**	**558,16**
11,00	**0,3604**	**1,0000**	**0,8946**	**0,70763**	**755,47**	**610,24**
11,50	**0,3610**	**1,0000**	**0,8948**	**0,70719**	**824,20**	**665,76**
12,00	**0,3613**	**1,0000**	**0,8943**	**0,707**	**897,96**	**725,34**
12,50	**0,3612**	**1,0000**	**0,8929**	**0,70708**	**977,72**	**789,77**
13,00	**0,3606**	**1,0000**	**0,8904**	**0,70748**	**1064,64**	**859,98**
13,50	**0,3595**	**1,0000**	**0,8867**	**0,70823**	**1160,11**	**937,10**
14,00	**0,3579**	**1,0000**	**0,8818**	**0,70936**	**1265,75**	**1022,43**
+ 14,50 +	**0,3557**	**1,0000**	**0,8754**	**0,71088**	**1383,34**	**1117,42**

Propulsion

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Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	
10,00	0,2708	0,2255	0,02711	3,0748	1,3656	7,8298	21,273	3,82e7	
10,50	0,2717	0,2251	0,02708	3,0482	1,3494	7,7623	21,022	4,01e7	
11,00	0,2725	0,2248	0,02705	3,0274	1,3369	7,7093	20,826	4,19e7	
11,50	0,2730	0,2246	0,02703	3,0133	1,3283	7,6734	20,693	4,38e7	
12,00	0,2732	0,2245	0,02702	3,007	1,3245	7,6574	20,634	4,57e7	
12,50	0,2731	0,2246	0,02703	3,0098	1,3262	7,6643	20,66	4,77e7	
13,00	0,2727	0,2247	0,02704	3,0228	1,334	7,6975	20,782	4,98e7	
13,50	0,2718	0,2251	0,02708	3,0474	1,3489	7,7601	21,014	5,19e7	
14,00	0,2704	0,2256	0,02713	3,0849	1,3717	7,8555	21,369	5,41e7	
+ 14,50 +	0,2686	0,2263	0,02719	3,1364	1,4032	7,9868	21,86	5,65e7	

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
10,00	70,32	5,16	1,05	19,29	0,419	16,33	2,0	2,0	4570,5
10,50	63,58	4,69	0,96	20,22	0,440	17,91	2,0	2,0	4573,5
11,00	57,76	4,29	0,87	21,15	0,462	19,58	2,0	2,0	4575,9
11,50	52,69	3,93	0,80	22,10	0,486	21,36	2,0	2,0	4577,5
12,00	48,26	3,60	0,73	23,08	0,512	23,27	2,3	2,3	4578,3
12,50	44,37	3,31	0,67	24,08	0,539	25,34	2,6	2,6	4577,9
13,00	40,92	3,04	0,62	25,11	0,569	27,59	3,0	3,0	4576,4
13,50	37,86	2,80	0,57	26,20	0,602	30,07	3,5	3,5	4573,6
14,00	35,13	2,57	0,52	27,33	0,639	32,81	4,1	4,1	4569,4
+ 14,50 +	32,68	2,36	0,48	28,53	0,680	35,85	4,8	4,8	4563,6

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Propulsion

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Description
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Hull data

General			Planing		
Configuration:		**Monohull**	*Proj chine length:*		***0,000 m***
Chine type:		**Round/multiple**	*Proj bottom area:*		***0,0 m2***
Length on WL:		**213,790 m**	*LCG fwd TR:*	*[XCG/LP 0,000]*	***0,000 m***
Max beam on WL:	[LWL/BWL 6,629]	**32,250 m**	*VCG below WL:*		***0,000 m***
Max molded draft:	[BWL/T 2,212]	**14,580 m**	*Aft station (fwd TR):*		***0,000 m***
Displacement:	[CB 0,848]	**87500,00 t**	*Deadrise:*		***0,00 deg***
Wetted surface:	[CS 2,671]	**11405,4 m2**	*Chine beam:*		***0,000 m***
ITTC-78 (CT)			*Chine ht below WL:*		***0,000 m***
LCB fwd TR:	[XCB/LWL 0,483]	**103,190 m**	*Fwd station (fwd TR):*		***0,000 m***
LCF fwd TR:	[XCF/LWL 0,483]	**103,190 m**	*Deadrise:*		***0,00 deg***
Max section area:	[CX 0,999]	**469,6 m2**	*Chine beam:*		***0,000 m***
Waterplane area:	[CWP 0,918]	**6326,1 m2**	*Chine ht below WL:*		***0,000 m***
Bulb section area:		**22,9 m2**	*Propulsor type:*		***Propeller***
Bulb ctr below WL:		**12,120 m**	*Max prop diameter:*		***8500,0 mm***
Bulb nose fwd TR:		**216,000 m**	*Shaft angle to WL:*		***0,00 deg***
Imm transom area:	[ATR/AX 0,026]	**12,1 m2**	*Position fwd TR:*		***0,000 m***
Transom beam WL:	[BTR/BWL 0,624]	**20,110 m**	*Position below WL:*		***0,000 m***
Transom immersion:	[TTR/T 0,000]	**0,000 m**	*Transom lift device:*		***Flap***
Half entrance angle:		**46,08 deg**	*Device count:*		***0***
Bow shape factor:	[AVG flow]	**0,0**	*Span:*		***0,000 m***
Stern shape factor:	[AVG flow]	**0,0**	*Chord length:*		***0,000 m***
			Deflection angle:		***0,00 deg***
			Tow point fwd TR:		***0,000 m***
			Tow point below WL:		***0,000 m***

Propulsor data

Propulsor				Propeller options	
Count:		**1**		Oblique angle corr:	**Off**
Propulsor type:		**Propeller series**		Shaft angle to WL:	**0,00 deg**
Propeller type:		**FPP**		Added rise of run:	**0,00 deg**
Propeller series:		**B Series**		Propeller cup:	**0,0 mm**
Propeller sizing:		**By thrust**		KTKQ corrections:	**Custom**
Reference prop:				Scale correction:	**None**
Blade count:		**4**		KT multiplier:	**1,000**
Expanded area ratio:		**0,6799**	**[Size]**	KQ multiplier:	**1,000**
Propeller diameter:		**8500,0 mm**	**[Size]**	Blade T/C [0.7R]:	**0,00**
Propeller mean pitch:	[P/D 0,7248]	**6161,1 mm**	**[Size]**	Roughness:	**0,00 mm**
Hub immersion:		**11,1 mm**		Cav breakdown:	**Off**
Engine/gear				**Design condition**	
Engine data:				Max prop diam:	**8500,0 mm**
Rated RPM:		**0 RPM**		Design speed:	**14,50 kt**
Rated power:		**0,0 kW**		Reference power:	**0,0 kW**
Gear efficiency:		**1,000**		Design point:	**0,000**
Load correction:		**Off**		Reference RPM:	**100,0**
Gear ratio:		**1,638**	**[Size]**	Design point:	**1,050**
Shaft efficiency:		**0,970**			

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Symbols and values

SPEED =	Vessel speed
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
FUEL =	Fuel rate per engine
LOADENG =	Percentage of engine max available power at given RPM
RPMPROP =	Propulsor RPM
QPROP =	Propulsor open water torque
QENG =	Engine torque
PDPROP =	Delivered power per propulsor
PSPROP =	Shaft power per propulsor
PSTOTAL =	Total vessel shaft power
PBTOTAL =	Total vessel brake power
TRANSP =	Transport factor
EFFO =	Propulsor open-water efficiency
EFFG =	Gear efficiency (load corrected)
EFFOA =	Overall propulsion efficiency [=PETOTAL/PSTOTAL]
MERIT =	Propulsor merit coefficient
THRPROP =	Open-water thrust per propulsor
DELTHR =	Total vessel delivered thrust
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
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

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ANEXO II

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Engine Configuration PRELIMINARY

Engine Data

CMCR Power Rx:	11920	kW = 100.0% R1	MCR Power R1:	11920	kW
CMCR Speed Rx:	105.0	rpm = 100.0% R1	MCR Speed R1:	105.0	rpm
CSR Power:	10132	kW = 85.0% CMCR			
CSR Speed:	99.5	rpm			
Turbocharger (ABB):	2 x A165-L		Bore:	520	mm
Scavenge air cooler:	2 x SAC-A52-SD		Stroke:	2315	mm

Tuning:
Options:
NOx emission compliance: IMO Tier II / III compliant
Type of propeller: Fixed pitch

Ancillary System

Cooling system:	FW cooled / Single-Stage SAC / Sep. HT circuit
Cylinder cooling water inlet temperature:	75 °C
Cylinder cooling water outlet temperature:	90 °C
Lubricating oil system:	integrated TC lubrication
Oil temperature before engine:	45 °C
Oil pressure before engine:	4.5 bar
Viscosity:	84.3 mm²/s

Brake specific fuel consumption ISO 3046-1:2002

Air temp. before compressor: 25.0 °C
Cooler temp. before SAC: 25.0 °C
Relative humidity: 30.0 %

Tolerances + 5 % 100-85 % Power
+ 6 % 84-65 % Power
+ 7 % 64-50 % Power

Tier II

Power [%]	110.0	100.0	95.0	90.0	85.0	80.0	75.0	70.0	60.0	50.0	40.0	30.0	25.0
BSFC [g/kWh]	182.9	181.9	178.9	176.2	174.8	174.0	173.6	173.6	174.3	176.0	178.9	180.0	181.1

Tier III

Power [%]	110.0	100.0	95.0	90.0	85.0	80.0	75.0	70.0	60.0	50.0	40.0	30.0	25.0
BSEC [kJ/kWh]	-	7200	7171	7158	7153	7149	7149	7149	7171	7235	7350	7508	7580

BSFC: Total fuel consumption including pilot oil (diesel mode) LHV MDO 42707 kJ/kg
BSEC: Total energy consumption (gas mode), BSEC = BSGC × LHV Gas + BSPC × LHV MDO LHV Gas 50000 kJ/kg

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
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Summary PRELIMINARY

General information

Bore	520 mm
Stroke	2315 mm
MEP	17.32 bar
Piston speed	8.1 m/s

Engine dimensions

Length	8730 mm
Net engine mass	323 t
Weight water/oil	3.2 t
Lift vertical (standard)	10250 mm
Minimum crane capacity	3.5 t

Oil consumption

System oil consumption per cylinder and per day	6.0 kg
Cylinder oil consumption, guide feed rate (pulse lubricating system)	PLS 0.6 g/kWh

Guide feed rate 0.6 g/kWh for low sulphur content only.

Other components

Aux. blower: min. installed electric motor power (shaft)	-
Turning gear capacity	-

Pumps

	Minimum capacities	Delivery head *1)
Fuel oil booster	5.4 m³/h	6.5 bar
Fuel oil feed	3.0 m³/h	5.0 bar
High temperature water circuit	110 m³/h	4.0 bar
Low temperature water circuit	454 m³/h	2.2 bar
Lubricating oil *2)	198 m³/h	6.6 bar
Crosshead lubricating oil	19 m³/h	8.5 bar
Sea water	503 m³/h	2.0 bar
Pilot oil feed	0.35 m³/h	8.5 bar

*1) Pressure difference across pump (final delivery head) must be according to the actual piping layout. The capacities do not account for other components than the engine itself.
*2) Lubricating oil flow excluding oil flow for damper. System pressure loss 2.1 bar assumed.

Cooling system

Central cooler, heat dissipation	10460 kW
SAC, heat dissipation	7477 kW
Cylinder cooler, heat dissipation	1907 kW
Lub. oil cooler, heat dissipation	1076 kW

Design conditions, maximum heat dissipation

Exhaust gas and air flow

Exhaust gas, mass flow	100.7 t/h
Exhaust gas, temperature	275 °C
Exhaust gas density	0.654 kg/m³
Scavenge air, mass flow	98.6 t/h

Design conditions

Starting air system

Number of starts	12
Propeller pitch control	FPP
Rel. shaft inertia specified (J-tot / J-Eng)	2.00
Engine inertia (J-Eng)	45200 kgm²
Air compressor (30 bar)	2 x 150 m³/h
Air receiver (30 bar)	2 x 5.0 m³

The capacities are for the engine only and without PTO.
Engine inertia is given for engine without damper and front disc on crankshaft but including smallest flywheel.

Tank system

Main lub. oil drain tank	16.0 m³
Fresh water expansion tank	-
HFO separator	2600 l/h
LO separator	1633 l/h
FO endheater	107 kW

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Engine Performance Data (Diesel mode, Tier II) PRELIMINARY

Conditions	ISO	Design	Specified
Air temperature before compressor	25 °C	45 °C	20 °C
Coolant temperature before SAC	29 °C	36 °C	25 °C
Relative humidity	30 %	60 %	30 %
Exhaust gas back pressure	300 mm WC	300 mm WC	300 mm WC

Performance				ISO				Design			
Power [%]	Power [kW]	Speed [rpm]	BMEP [bar]	BSPC [g/kWh]	BSFC [g/kWh]	BSEF [kg/kWh]	tEaTm [°C]	BSPC [g/kWh]	BSFC [g/kWh]	BSEF [kg/kWh]	tEaTm [°C]
110.0	13112	108.4	18.45	1.4	183.3	8.30	279	1.4	184.6	7.83	304
100.0	11920	105.0	17.32	1.5	182.3	8.96	252	1.5	183.6	8.45	275
95.0	11324	103.2	16.74	1.6	179.3	9.19	240	1.6	181.2	8.65	267
90.0	10728	101.4	16.14	1.6	176.6	9.42	229	1.6	179.0	8.82	260
85.0	10132	99.5	15.54	1.7	175.0	9.66	217	1.7	178.0	8.96	254
80.0	9536	97.5	14.92	1.7	174.2	9.99	209	1.7	177.2	9.24	247
75.0	8940	95.4	14.30	1.8	173.8	10.32	201	1.8	176.8	9.53	239
70.0	8344	93.2	13.65	1.9	173.8	10.62	197	1.9	176.8	9.77	235
60.0	7152	88.6	12.32	2.1	174.5	11.19	191	2.1	177.5	10.25	231
50.0	5960	83.3	10.91	2.4	176.2	11.76	189	2.4	179.2	10.74	229
40.0	4768	77.4	9.40	2.8	179.1	12.23	195	2.8	182.1	11.15	235
30.0	3576	70.3	7.76	3.3	180.2	12.54	211	3.3	183.2	11.41	252
25.0	2980	66.1	6.87	3.8	181.3	14.13	191	3.8	184.3	12.99	225

Performance				Specified			
Power [%]	Power [kW]	Speed [rpm]	BMEP [bar]	BSPC [g/kWh]	BSFC [g/kWh]	BSEF [kg/kWh]	tEaTm [°C]
110.0	13112	108.4	18.45	1.4	182.6	8.39	273
100.0	11920	105.0	17.32	1.5	181.7	9.05	246
95.0	11324	103.2	16.74	1.6	178.5	9.29	233
90.0	10728	101.4	16.14	1.6	175.8	9.53	221
85.0	10132	99.5	15.54	1.7	174.2	9.77	210
80.0	9536	97.5	14.92	1.7	173.4	10.11	202
75.0	8940	95.4	14.30	1.8	173.0	10.45	194
70.0	8344	93.2	13.65	1.9	173.0	10.76	189
60.0	7152	88.6	12.32	2.1	173.7	11.35	183
50.0	5960	83.3	10.91	2.4	175.4	11.92	181
40.0	4768	77.4	9.40	2.8	178.3	12.41	187
30.0	3576	70.3	7.76	3.3	179.4	12.73	203
25.0	2980	66.1	6.87	3.8	180.5	14.34	183

Tolerances

BSFC	+ 5 %	100-85 % Power
	+ 6 %	84-65 % Power
	+ 7 %	64-50 % Power
BSEF	± 8 %	
tEaT	± 23 °C	

Tolerances apply from and above 50% power. In general, an increase of BSEF by 8% corresponds to a decrease of tEaT by 23°C.

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Engine Performance Data (Gas mode, Tier III) PRELIMINARY

Conditions	ISO	Design	Specified
Air temperature before compressor	25 °C	45 °C	20 °C
Coolant temperature before SAC	29 °C	36 °C	25 °C
Relative humidity	30 %	60 %	30 %
Exhaust gas back pressure	300 mm WC	300 mm WC	300 mm WC

Performance				ISO					Design				
Power [%]	Power [kW]	Speed [rpm]	BMEP [bar]	BSPC [g/kWh]	BSGC [g/kWh]	BSEC [kJ/kWh]	BSEF [kg/kWh]	tEaTm [°C]	BSPC [g/kWh]	BSGC [g/kWh]	BSEC [kJ/kWh]	BSEF [kg/kWh]	tEaTm [°C]
110.0	13112	108.4	18.45	-	-	-	-	-	-	-	-	-	-
100.0	11920	105.0	17.32	1.5	142.7	7200	7.96	225	1.5	142.7	7200	7.28	264
95.0	11324	103.2	16.74	1.6	142.0	7171	8.09	226	1.6	142.0	7171	7.46	260
90.0	10728	101.4	16.14	1.6	141.8	7158	8.23	228	1.6	141.8	7158	7.67	254
85.0	10132	99.5	15.54	1.7	141.6	7153	8.37	229	1.7	141.6	7153	7.89	248
80.0	9536	97.5	14.92	1.7	141.5	7149	8.50	231	1.7	141.5	7149	8.02	250
75.0	8940	95.4	14.30	1.8	141.4	7149	8.64	233	1.8	141.4	7149	8.15	253
70.0	8344	93.2	13.65	1.9	141.4	7149	8.71	239	1.9	141.4	7149	8.22	259
60.0	7152	88.6	12.32	2.1	141.6	7171	8.91	247	2.1	141.6	7171	8.43	268
50.0	5960	83.3	10.91	2.4	142.6	7235	9.19	253	2.4	142.6	7235	8.70	273
40.0	4768	77.4	9.40	2.8	144.6	7350	9.67	256	2.8	144.6	7350	9.18	276
30.0	3576	70.3	7.76	3.3	147.3	7508	10.33	256	3.3	147.3	7508	9.83	276
25.0	2980	66.1	6.87	3.8	148.4	7580	11.25	250	3.8	148.4	7580	10.74	268

Performance				Specified				
Power [%]	Power [kW]	Speed [rpm]	BMEP [bar]	BSPC [g/kWh]	BSGC [g/kWh]	BSEC [kJ/kWh]	BSEF [kg/kWh]	tEaTm [°C]
110.0	13112	108.4	18.45	-	-	-	-	-
100.0	11920	105.0	17.32	1.5	142.7	7200	8.08	218
95.0	11324	103.2	16.74	1.6	142.0	7171	8.22	219
90.0	10728	101.4	16.14	1.6	141.8	7158	8.36	220
85.0	10132	99.5	15.54	1.7	141.6	7153	8.51	221
80.0	9536	97.5	14.92	1.7	141.5	7149	8.65	223
75.0	8940	95.4	14.30	1.8	141.4	7149	8.79	225
70.0	8344	93.2	13.65	1.9	141.4	7149	8.86	230
60.0	7152	88.6	12.32	2.1	141.6	7171	9.08	238
50.0	5960	83.3	10.91	2.4	142.6	7235	9.37	244
40.0	4768	77.4	9.40	2.8	144.6	7350	9.87	246
30.0	3576	70.3	7.76	3.3	147.3	7508	10.54	247
25.0	2980	66.1	6.87	3.8	148.4	7580	11.45	241

Tolerances

BSEC	+ 5 %	100-85 % Power
	+ 6 %	84-65 % Power
	+ 7 %	64-50 % Power
BSEF	± 8 %	
tEaT	± 23 °C	

Maximum CMCR-power

	ISO	Design	Specified
	100.0 %	100.0 %	100.0 %
Gas fuel reference	Min. lower heating value		28.0 MJ/Nm3
	Methane number		80 -
	Gas feed pressure		16.0 bar g

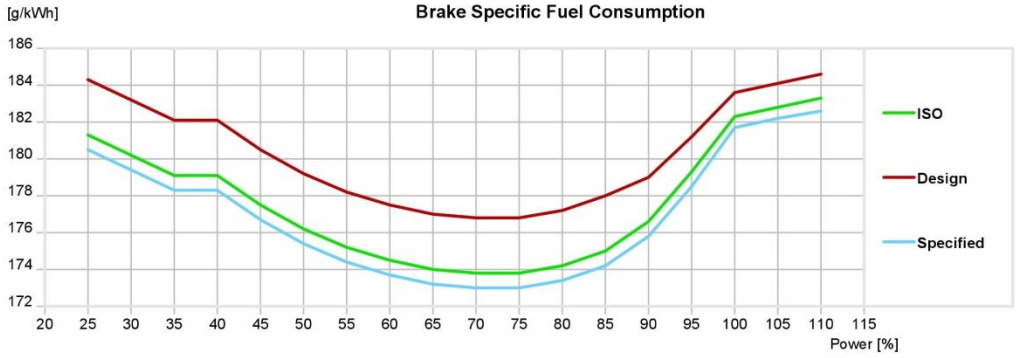
Tolerances apply from and above 50% power. In general, an increase of BSEF by 8% corresponds to a decrease of tEaT by 23°C.

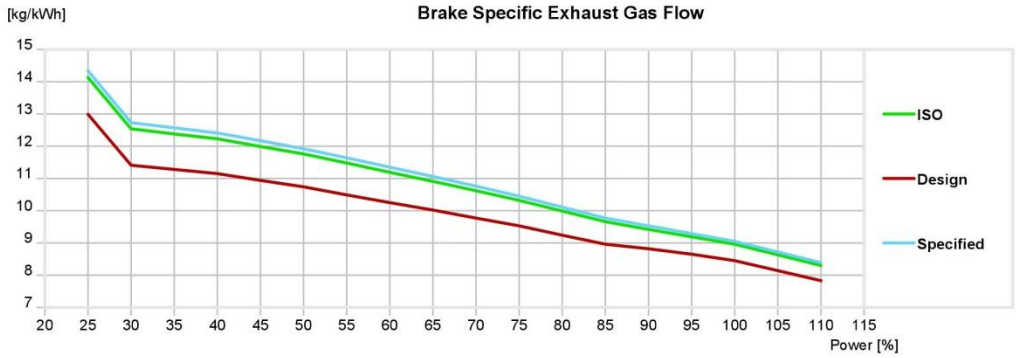
W8X52DF
IMO Tier II / III compliant

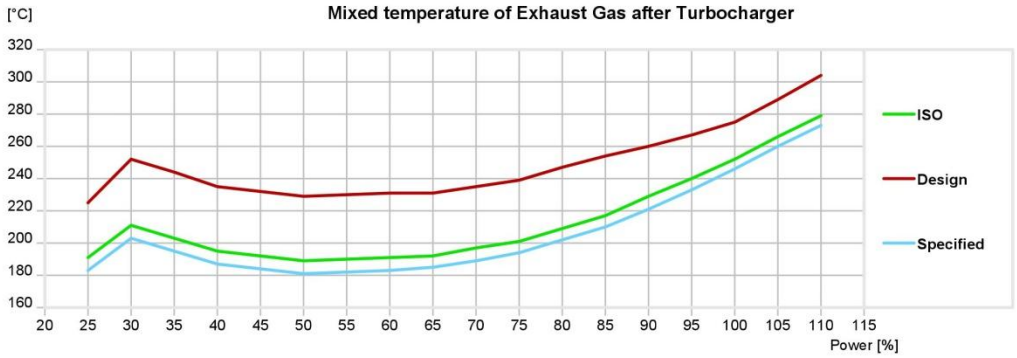
11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Engine Performance Data (Diesel mode, Tier II) PRELIMINARY







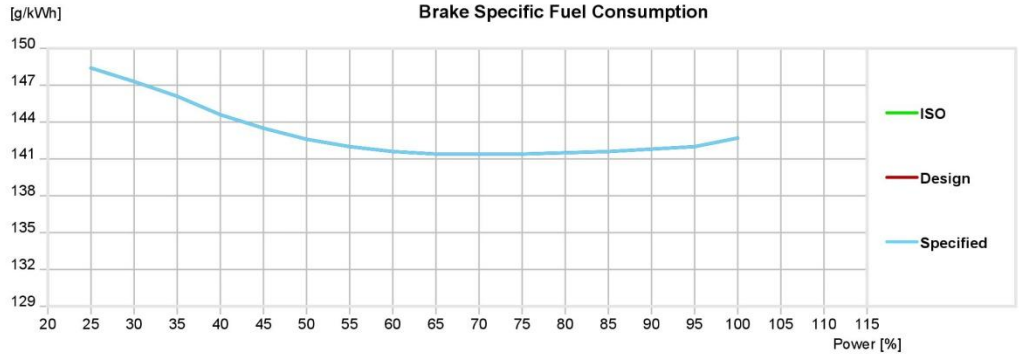
Effective values and shape of curves up to 40% power will depend on final settings of auxiliary blower.

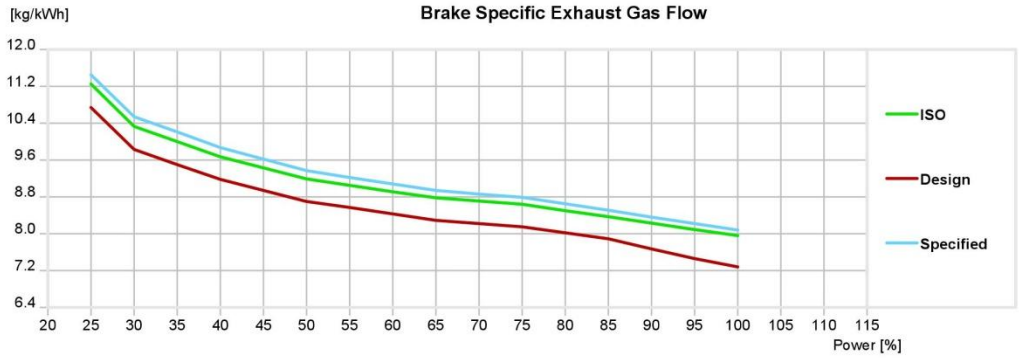
W8X52DF
IMO Tier II / III compliant

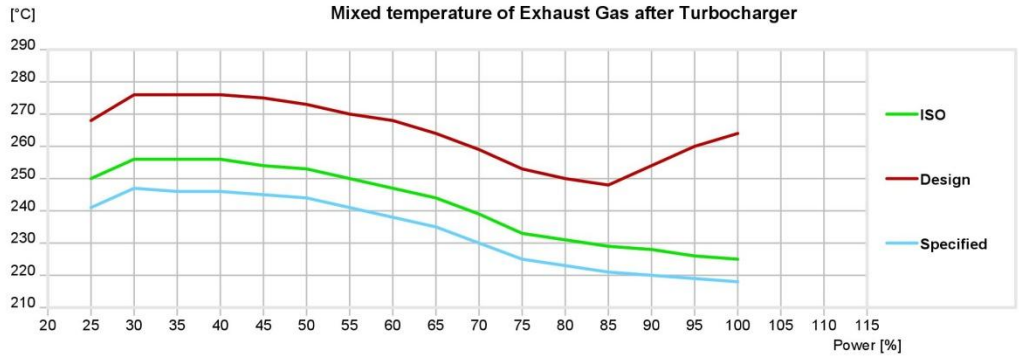
11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Engine Performance Data (Gas mode, Tier III) PRELIMINARY







Effective values and shape of curves up to 40% power will depend on final settings of auxiliary blower.

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Heat Dissipation (Diesel mode, Tier II) PRELIMINARY

ISO Conditions

tAbC = 25°C, tCbS = 29°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	SAC LT [kW]	Cylinder [kW]	Lub. Oil [kW]	Radiation [kW]	SPP [kW]
110.0	13112	108.4	5817	1951	1096	261	3338
100.0	11920	105.0	5754	1739	994	261	2373
95.0	11324	103.2	5473	1619	945	261	1933
90.0	10728	101.4	5181	1520	904	261	1514
85.0	10132	99.5	4880	1443	866	261	1117
80.0	9536	97.5	4601	1341	815	261	853
75.0	8940	95.4	4312	1253	777	261	598
70.0	8344	93.2	3961	1171	741	261	451
60.0	7152	88.6	3233	1026	680	261	272
50.0	5960	83.3	2504	881	625	261	195
40.0	4768	77.4	1708	746	574	261	270
30.0	3576	70.3	969	611	525	261	429
25.0	2980	66.1	759	507	468	261	143

Design Conditions

tAbC = 45°C, tCbS = 36°C, RH = 60%

Power [%]	Power [kW]	Speed [rpm]	SAC LT [kW]	Cylinder [kW]	Lub. Oil [kW]	Radiation [kW]	SPP [kW]
110.0	13112	108.4	7571	2131	1182	158	3928
100.0	11920	105.0	7477	1907	1076	158	2954
95.0	11324	103.2	7059	1815	1042	158	2633
90.0	10728	101.4	6609	1741	1015	158	2344
85.0	10132	99.5	6136	1684	989	158	2085
80.0	9536	97.5	5784	1573	934	158	1823
75.0	8940	95.4	5421	1475	893	158	1559
70.0	8344	93.2	4988	1382	854	158	1396
60.0	7152	88.6	4090	1215	786	158	1151
50.0	5960	83.3	3188	1047	725	158	970
40.0	4768	77.4	2206	889	669	158	908
30.0	3576	70.3	1277	733	616	158	908
25.0	2980	66.1	1038	617	555	158	541

Specified Conditions

tAbC = 20°C, tCbS = 25°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	SAC LT [kW]	Cylinder [kW]	Lub. Oil [kW]	Radiation [kW]	SPP [kW]
110.0	13112	108.4	5743	1951	1095	202	3151
100.0	11920	105.0	5676	1746	997	202	2204
95.0	11324	103.2	5427	1615	943	202	1719
90.0	10728	101.4	5140	1518	903	202	1302
85.0	10132	99.5	4843	1443	866	202	908
80.0	9536	97.5	4569	1344	816	202	647
75.0	8940	95.4	4284	1258	780	202	396
70.0	8344	93.2	3937	1179	745	202	253
60.0	7152	88.6	3216	1039	687	202	87
50.0	5960	83.3	2493	898	635	202	29
40.0	4768	77.4	1701	767	588	202	129
30.0	3576	70.3	966	636	543	202	319
25.0	2980	66.1	754	533	489	202	46

SPP: Steam production power (± 7%) for a constant temperature after economizer of 180°C.
Tolerances: SPP ±7%, cylinder heat dissipation +0%/-15%.

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Heat Dissipation (Gas mode, Tier III) PRELIMINARY

ISO Conditions

tAbC = 25°C, tCbS = 29°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	SAC LT [kW]	Cylinder [kW]	Lub. Oil [kW]	Radiation [kW]	SPP [kW]
110.0	13112	108.4	-	-	-	-	-
100.0	11920	105.0	4767	1540	897	261	1317
95.0	11324	103.2	4410	1476	874	261	1313
90.0	10728	101.4	4062	1414	850	261	1300
85.0	10132	99.5	3725	1356	822	261	1278
80.0	9536	97.5	3396	1297	792	261	1275
75.0	8940	95.4	3077	1233	766	261	1262
70.0	8344	93.2	2710	1175	743	261	1316
60.0	7152	88.6	2063	1054	695	261	1323
50.0	5960	83.3	1506	915	645	261	1236
40.0	4768	77.4	1024	774	593	261	1081
30.0	3576	70.3	607	626	536	261	870
25.0	2980	66.1	388	537	492	261	720

Design Conditions

tAbC = 45°C, tCbS = 36°C, RH = 60%

Power [%]	Power [kW]	Speed [rpm]	SAC LT [kW]	Cylinder [kW]	Lub. Oil [kW]	Radiation [kW]	SPP [kW]
110.0	13112	108.4	-	-	-	-	-
100.0	11920	105.0	5849	1621	936	158	2254
95.0	11324	103.2	5560	1556	914	158	2082
90.0	10728	101.4	5288	1493	890	158	1878
85.0	10132	99.5	5007	1435	862	158	1680
80.0	9536	97.5	4598	1376	833	158	1662
75.0	8940	95.4	4196	1311	808	158	1633
70.0	8344	93.2	3736	1253	785	158	1663
60.0	7152	88.6	2902	1130	738	158	1630
50.0	5960	83.3	2166	990	691	158	1496
40.0	4768	77.4	1521	846	641	158	1297
30.0	3576	70.3	945	695	587	158	1036
25.0	2980	66.1	647	604	545	158	864

Specified Conditions

tAbC = 20°C, tCbS = 25°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	SAC LT [kW]	Cylinder [kW]	Lub. Oil [kW]	Radiation [kW]	SPP [kW]
110.0	13112	108.4	-	-	-	-	-
100.0	11920	105.0	4759	1587	920	202	1124
95.0	11324	103.2	4406	1523	897	202	1117
90.0	10728	101.4	4063	1460	873	202	1106
85.0	10132	99.5	3728	1402	845	202	1086
80.0	9536	97.5	3401	1343	816	202	1087
75.0	8940	95.4	3083	1278	790	202	1081
70.0	8344	93.2	2718	1220	767	202	1142
60.0	7152	88.6	2072	1098	720	202	1167
50.0	5960	83.3	1515	958	671	202	1098
40.0	4768	77.4	1032	816	620	202	963
30.0	3576	70.3	612	666	565	202	776
25.0	2980	66.1	387	575	522	202	646

SPP: Steam production power (± 7%) for a constant temperature after economizer of 180°C.
Tolerances: SPP ±7%, cylinder heat dissipation +0%/-15%.

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Scavenge Air (Diesel mode, Tier II) PRELIMINARY

ISO Conditions

tAbC = 25°C, tCbS = 29°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	tAaC [°C]	tScav [°C]	mScav [kg/h]	pScav [bar]	Cond. water [kg/h]
110.0	13112	108.4	228	33.2	106469	5.00	0
100.0	11920	105.0	229	33.1	104658	5.01	0
95.0	11324	103.2	224	32.8	102067	4.86	0
90.0	10728	101.4	219	32.5	99198	4.72	0
85.0	10132	99.5	214	32.2	96051	4.57	0
80.0	9536	97.5	208	32.0	93596	4.40	0
75.0	8940	95.4	201	31.7	90741	4.23	0
70.0	8344	93.2	194	31.4	87153	4.02	0
60.0	7152	88.6	177	30.8	78815	3.58	0
50.0	5960	83.3	160	30.2	69017	3.11	0
40.0	4768	77.4	136	29.7	57454	2.59	0
30.0	3576	70.3	108	29.3	44199	2.04	0
25.0	2980	66.1	94	29.2	41571	1.89	0

Design Conditions

tAbC = 45°C, tCbS = 36°C, RH = 60%

Power [%]	Power [kW]	Speed [rpm]	tAaC [°C]	tScav [°C]	mScav [kg/h]	pScav [bar]	Cond. water [kg/h]
110.0	13112	108.4	262	46.5	100304	5.00	2512
100.0	11920	105.0	263	46.4	98554	5.00	2479
95.0	11324	103.2	255	46.0	95870	4.80	2395
90.0	10728	101.4	247	45.6	92665	4.59	2293
85.0	10132	99.5	239	45.2	89008	4.38	2175
80.0	9536	97.5	232	44.9	86449	4.21	2076
75.0	8940	95.4	225	44.5	83592	4.04	1968
70.0	8344	93.2	217	44.1	80049	3.83	1841
60.0	7152	88.6	199	43.3	72054	3.39	1561
50.0	5960	83.3	181	42.3	62933	2.94	1249
40.0	4768	77.4	155	41.2	52301	2.44	898
30.0	3576	70.3	125	39.8	40144	1.92	530
25.0	2980	66.1	112	39.3	38156	1.80	428

Specified Conditions

tAbC = 20°C, tCbS = 25°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	tAaC [°C]	tScav [°C]	mScav [kg/h]	pScav [bar]	Cond. water [kg/h]
110.0	13112	108.4	220	29.3	107578	5.00	0
100.0	11920	105.0	221	29.2	105742	5.00	0
95.0	11324	103.2	217	28.9	103207	4.88	0
90.0	10728	101.4	212	28.6	100346	4.73	0
85.0	10132	99.5	206	28.3	97202	4.59	0
80.0	9536	97.5	200	28.1	94749	4.42	0
75.0	8940	95.4	194	27.8	91892	4.25	0
70.0	8344	93.2	187	27.5	88298	4.04	0
60.0	7152	88.6	171	26.9	79910	3.60	0
50.0	5960	83.3	153	26.3	70018	3.13	0
40.0	4768	77.4	130	25.7	58325	2.60	0
30.0	3576	70.3	102	25.3	44895	2.05	0
25.0	2980	66.1	89	25.2	42181	1.90	0

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Scavenge Air (Gas mode, Tier III) PRELIMINARY

ISO Conditions

tAbC = 25°C, tCbS = 29°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	tAaC [°C]	tScav [°C]	mScav [kg/h]	pScav [bar]	Cond. water [kg/h]
110.0	13112	108.4	-	-	-	-	-
100.0	11920	105.0	215	32.0	92857	4.45	0
95.0	11324	103.2	207	31.7	89762	4.23	0
90.0	10728	101.4	199	31.4	86503	4.01	0
85.0	10132	99.5	191	31.1	83082	3.80	0
80.0	9536	97.5	183	30.9	79483	3.60	0
75.0	8940	95.4	176	30.6	75722	3.40	0
70.0	8344	93.2	166	30.3	71258	3.17	0
60.0	7152	88.6	148	29.9	62556	2.75	0
50.0	5960	83.3	130	29.5	53759	2.37	0
40.0	4768	77.4	110	29.3	45296	2.03	0
30.0	3576	70.3	89	29.1	36296	1.70	0
25.0	2980	66.1	71	29.1	32989	1.54	0

Design Conditions

tAbC = 45°C, tCbS = 36°C, RH = 60%

Power [%]	Power [kW]	Speed [rpm]	tAaC [°C]	tScav [°C]	mScav [kg/h]	pScav [bar]	Cond. water [kg/h]
110.0	13112	108.4	-	-	-	-	-
100.0	11920	105.0	238	45.0	84778	4.20	2082
95.0	11324	103.2	233	44.7	82568	4.07	2000
90.0	10728	101.4	228	44.4	80467	3.94	1917
85.0	10132	99.5	222	44.1	78234	3.79	1826
80.0	9536	97.5	214	43.8	74874	3.59	1704
75.0	8940	95.4	206	43.4	71367	3.40	1577
70.0	8344	93.2	196	42.9	67214	3.17	1430
60.0	7152	88.6	176	42.0	59079	2.75	1145
50.0	5960	83.3	156	41.1	50869	2.37	871
40.0	4768	77.4	136	40.2	42942	2.03	625
30.0	3576	70.3	113	39.2	34510	1.70	387
25.0	2980	66.1	94	38.4	31463	1.53	262

Specified Conditions

tAbC = 20°C, tCbS = 25°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	tAaC [°C]	tScav [°C]	mScav [kg/h]	pScav [bar]	Cond. water [kg/h]
110.0	13112	108.4	-	-	-	-	-
100.0	11920	105.0	208	28.2	94247	4.49	0
95.0	11324	103.2	200	27.9	91180	4.27	0
90.0	10728	101.4	193	27.6	87933	4.05	0
85.0	10132	99.5	185	27.3	84490	3.83	0
80.0	9536	97.5	177	27.0	80877	3.63	0
75.0	8940	95.4	170	26.7	77068	3.43	0
70.0	8344	93.2	160	26.4	72552	3.20	0
60.0	7152	88.6	142	25.9	63737	2.78	0
50.0	5960	83.3	124	25.6	54814	2.40	0
40.0	4768	77.4	105	25.3	46222	2.06	0
30.0	3576	70.3	84	25.1	37080	1.72	0
25.0	2980	66.1	66	25.1	33588	1.55	0

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Exhaust Gas (Diesel mode, Tier II) PRELIMINARY

ISO Conditions

tAbC = 25°C, tCbS = 29°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	Bypass [%]	tEbT [°C]	tEaT [°C]	tEbE *1) [°C]	pExh [bar]	Steam *2) [kg/h]
110.0	13112	108.4	6.7	465	266	277	4.87	4850
100.0	11920	105.0	3.1	439	246	250	4.88	3420
95.0	11324	103.2	2.1	423	236	238	4.74	2770
90.0	10728	101.4	1.0	406	227	227	4.59	2150
85.0	10132	99.5	0.0	390	217	215	4.45	1570
80.0	9536	97.5	0.0	377	209	207	4.28	1180
75.0	8940	95.4	0.0	363	201	199	4.11	800
70.0	8344	93.2	0.0	352	197	195	3.90	590
60.0	7152	88.6	0.0	331	191	189	3.47	330
50.0	5960	83.3	0.0	313	189	187	3.00	220
40.0	4768	77.4	0.0	297	195	193	2.49	350
30.0	3576	70.3	0.0	287	211	209	1.95	600
25.0	2980	66.1	0.0	255	191	189	1.80	170

Design Conditions

tAbC = 45°C, tCbS = 36°C, RH = 60%

Power [%]	Power [kW]	Speed [rpm]	Bypass [%]	tEbT [°C]	tEaT [°C]	tEbE *1) [°C]	pExh [bar]	Steam *2) [kg/h]
110.0	13112	108.4	3.7	506	296	302	4.88	5730
100.0	11920	105.0	0.0	479	275	273	4.88	4290
95.0	11324	103.2	0.0	464	267	265	4.68	3820
90.0	10728	101.4	0.0	450	260	258	4.48	3390
85.0	10132	99.5	0.0	436	254	252	4.27	3010
80.0	9536	97.5	0.0	422	247	245	4.10	2620
75.0	8940	95.4	0.0	409	239	237	3.92	2230
70.0	8344	93.2	0.0	397	235	233	3.72	2000
60.0	7152	88.6	0.0	376	231	229	3.29	1640
50.0	5960	83.3	0.0	356	229	227	2.84	1380
40.0	4768	77.4	0.0	338	235	233	2.35	1300
30.0	3576	70.3	0.0	327	252	250	1.84	1310
25.0	2980	66.1	0.0	288	225	223	1.72	770

Specified Conditions

tAbC = 20°C, tCbS = 25°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	Bypass [%]	tEbT [°C]	tEaT [°C]	tEbE *1) [°C]	pExh [bar]	Steam *2) [kg/h]
110.0	13112	108.4	7.0	456	259	271	4.88	4570
100.0	11920	105.0	3.5	430	239	244	4.88	3170
95.0	11324	103.2	2.1	413	229	231	4.75	2450
90.0	10728	101.4	1.0	397	219	219	4.61	1840
85.0	10132	99.5	0.0	381	210	208	4.47	1260
80.0	9536	97.5	0.0	367	202	200	4.30	870
75.0	8940	95.4	0.0	354	194	192	4.13	500
70.0	8344	93.2	0.0	342	189	187	3.92	290
60.0	7152	88.6	0.0	322	183	181	3.49	60
50.0	5960	83.3	0.0	304	181	179	3.02	0
40.0	4768	77.4	0.0	288	187	185	2.51	140
30.0	3576	70.3	0.0	278	203	201	1.97	430
25.0	2980	66.1	0.0	247	183	181	1.81	30

Since the exhaust waste gate is controlled by the scavenge air pressure, the indicated load is an approximation only. The opening/closing hysteresis is not shown.

*1) Exhaust gas temperature drop of 2°C from mixed temperature after turbine to economizer inlet.

*2) Guiding steam production capacity at 7bar / 165°C, boiler efficiency 100%, pinch point temperature difference 15°C, feed water temperature 80°C.

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
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Exhaust Gas (Gas mode, Tier III) PRELIMINARY

ISO Conditions

tAbC = 25°C, tCbS = 29°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	Bypass [%]	tEbT [°C]	tEaT [°C]	tEbE *1) [°C]	pExh [bar]	Steam *2) [kg/h]
110.0	13112	108.4	-	-	-	-	-	-
100.0	11920	105.0	0.0	399	225	223	4.34	1870
95.0	11324	103.2	1.2	393	224	224	4.12	1860
90.0	10728	101.4	2.5	387	224	226	3.90	1850
85.0	10132	99.5	3.7	381	223	227	3.69	1820
80.0	9536	97.5	4.3	376	225	229	3.49	1820
75.0	8940	95.4	4.8	371	226	231	3.29	1800
70.0	8344	93.2	5.6	368	231	237	3.07	1890
60.0	7152	88.6	6.6	360	239	245	2.66	1900
50.0	5960	83.3	6.9	349	246	251	2.29	1780
40.0	4768	77.4	6.0	334	251	254	1.96	1560
30.0	3576	70.3	3.9	315	254	254	1.65	1260
25.0	2980	66.1	7.9	292	246	248	1.48	1040

Design Conditions

tAbC = 45°C, tCbS = 36°C, RH = 60%

Power [%]	Power [kW]	Speed [rpm]	Bypass [%]	tEbT [°C]	tEaT [°C]	tEbE *1) [°C]	pExh [bar]	Steam *2) [kg/h]
110.0	13112	108.4	-	-	-	-	-	-
100.0	11920	105.0	0.0	445	264	262	4.10	3270
95.0	11324	103.2	0.0	435	260	258	3.97	3010
90.0	10728	101.4	0.0	425	254	252	3.83	2710
85.0	10132	99.5	0.2	414	248	246	3.69	2420
80.0	9536	97.5	0.8	408	249	248	3.50	2400
75.0	8940	95.4	1.4	403	251	251	3.30	2360
70.0	8344	93.2	2.2	399	255	257	3.08	2400
60.0	7152	88.6	3.3	390	263	266	2.67	2360
50.0	5960	83.3	3.7	377	269	271	2.29	2170
40.0	4768	77.4	2.9	360	274	274	1.97	1880
30.0	3576	70.3	0.8	339	275	274	1.65	1500
25.0	2980	66.1	5.0	313	265	266	1.48	1250

Specified Conditions

tAbC = 20°C, tCbS = 25°C, RH = 30%

Power [%]	Power [kW]	Speed [rpm]	Bypass [%]	tEbT [°C]	tEaT [°C]	tEbE *1) [°C]	pExh [bar]	Steam *2) [kg/h]
110.0	13112	108.4	-	-	-	-	-	-
100.0	11920	105.0	0.0	390	218	216	4.37	1580
95.0	11324	103.2	1.2	384	217	217	4.16	1570
90.0	10728	101.4	2.5	378	216	218	3.94	1560
85.0	10132	99.5	3.7	372	215	219	3.72	1530
80.0	9536	97.5	4.3	367	216	221	3.53	1540
75.0	8940	95.4	4.8	362	218	223	3.33	1530
70.0	8344	93.2	5.6	359	222	228	3.10	1630
60.0	7152	88.6	6.6	350	230	236	2.69	1670
50.0	5960	83.3	6.9	339	237	242	2.31	1580
40.0	4768	77.4	6.0	324	241	244	1.99	1390
30.0	3576	70.3	3.9	305	244	245	1.66	1120
25.0	2980	66.1	7.9	284	238	239	1.49	930

Since the exhaust waste gate is controlled by the scavenge air pressure, the indicated load is an approximation only. The opening/closing hysteresis is not shown.

*1) Exhaust gas temperature drop of 2°C from mixed temperature after turbine to economizer inlet.

*2) Guiding steam production capacity at 7bar / 165°C, boiler efficiency 100%, pinch point temperature difference 15°C, feed water temperature 80°C.

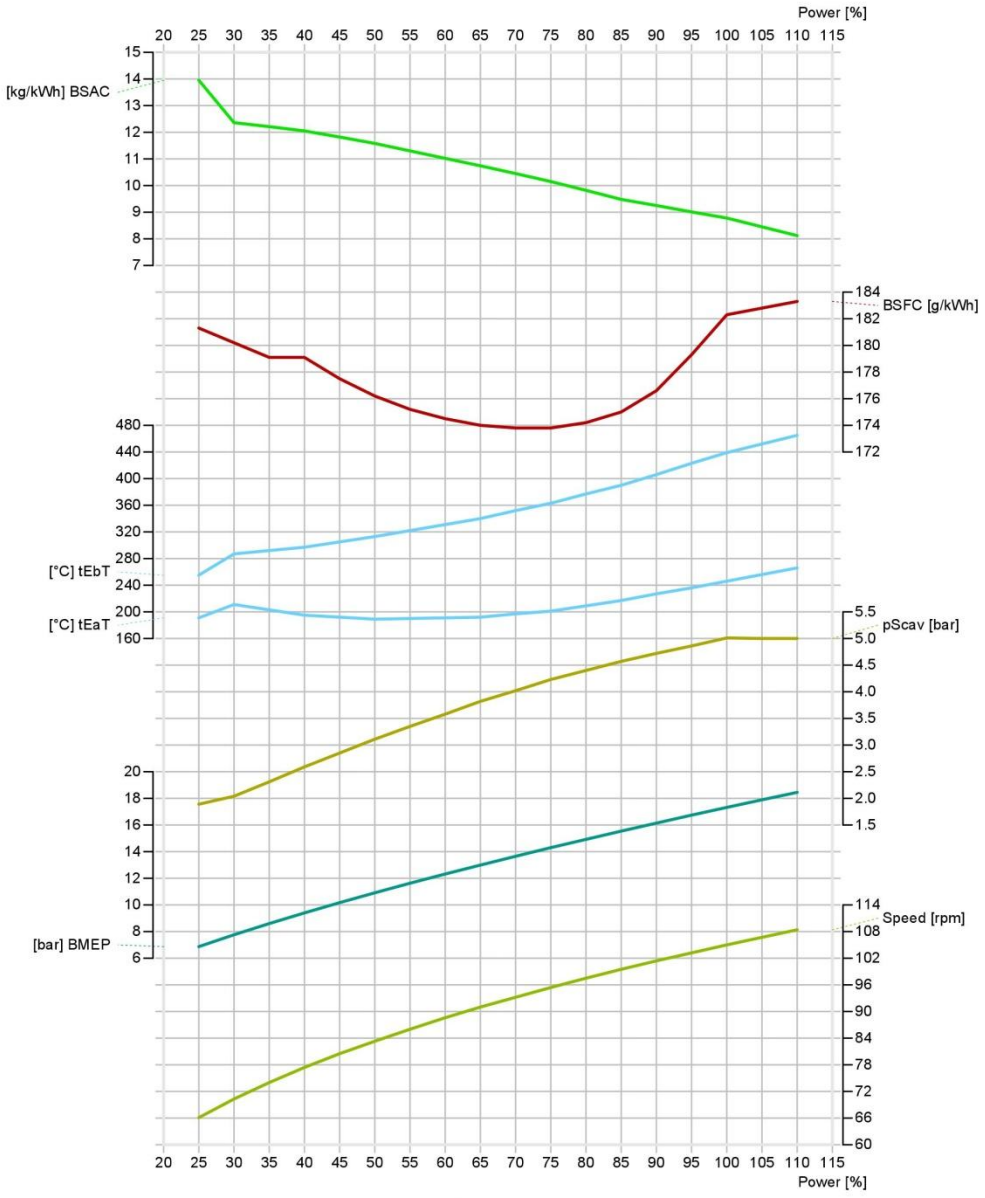
W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Performance Summary (Diesel mode, Tier II) PRELIMINARY

ISO Conditions



Effective values and shape of curves up to 40% power will depend on final settings of auxiliary blower.

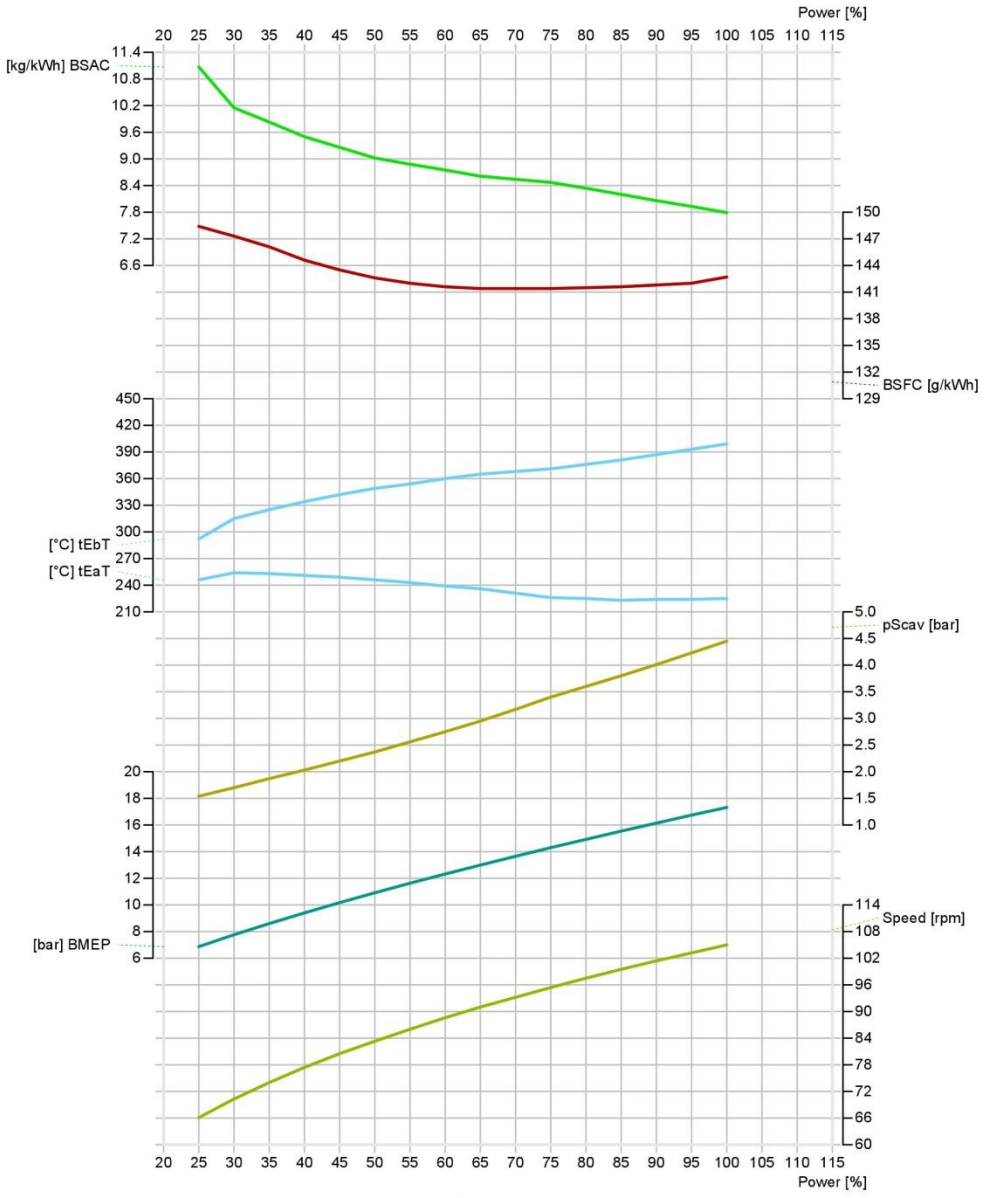
W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Performance Summary (Gas mode, Tier III) PRELIMINARY

ISO Conditions



Effective values and shape of curves up to 40% power will depend on final settings of auxiliary blower.

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

Turbocharging Data (Diesel mode, Tier II) PRELIMINARY

Turbocharger: **2 x A165-L**

ISO Conditions

Air temperature before compressor:	25 °C
Coolant temperature before SAC:	29 °C
Relative humidity:	30 %
Back pressure after turbine:	300 mm WC
SAC differential pressure (max.):	300 mm WC

Performance			Scavenge air side				Exhaust gas side					
Power	Power	Speed	pScav	tAaC	tScav	Com Flow	pExh	tEbT	tEaT	Tur Flow	Bypass	EtaTC
[%]	[kW]	[rpm]	[bar]	[°C]	[°C]	[kg/s]	[bar]	[°C]	[°C]	[kg/s]	[%]	[%]
110.0	13112	108.4	5.00	228	33.2	29.6	4.87	465	266	28.2	6.7	66.1
100.0	11920	105.0	5.01	229	33.1	29.1	4.88	439	246	28.8	3.1	66.1
95.0	11324	103.2	4.86	224	32.8	28.4	4.74	423	236	28.3	2.1	67.1
90.0	10728	101.4	4.72	219	32.5	27.6	4.59	406	227	27.8	1.0	67.9
85.0	10132	99.5	4.57	214	32.2	26.7	4.45	390	217	27.2	0.0	68.5
80.0	9536	97.5	4.40	208	32.0	26.0	4.28	377	209	26.5	0.0	69.1
75.0	8940	95.4	4.23	201	31.7	25.2	4.11	363	201	25.6	0.0	69.6
70.0	8344	93.2	4.02	194	31.4	24.2	3.90	352	197	24.6	0.0	69.9
60.0	7152	88.6	3.58	177	30.8	21.9	3.47	331	191	22.2	0.0	70.0
50.0	5960	83.3	3.11	160	30.2	19.2	3.00	313	189	19.5	0.0	69.6
40.0	4768	77.4	2.59	136	29.7	16.0	2.49	297	195	16.2	0.0	68.6

Bypass: Percentage of total exhaust gas mass flow.

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
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Turbocharging Data (Gas mode, Tier III) PRELIMINARY

Turbocharger: **2 x A165-L**

ISO Conditions

Air temperature before compressor:	25 °C
Coolant temperature before SAC:	29 °C
Relative humidity:	30 %
Back pressure after turbine:	300 mm WC
SAC differential pressure (max.):	300 mm WC

Performance			Scavenge air side				Exhaust gas side					
Power	Power	Speed	pScav	tAaC	tScav	Com Flow	pExh	tEbT	tEaT	Tur Flow	Bypass	EtaTC
[%]	[kW]	[rpm]	[bar]	[°C]	[°C]	[kg/s]	[bar]	[°C]	[°C]	[kg/s]	[%]	[%]
110.0	13112	108.4	-	-	-	-	-	-	-	-	-	-
100.0	11920	105.0	4.45	215	32.0	25.8	4.34	399	225	26.4	0.0	69.0
95.0	11324	103.2	4.23	207	31.7	24.9	4.12	393	224	25.1	1.2	69.5
90.0	10728	101.4	4.01	199	31.4	24.0	3.90	387	224	23.9	2.5	69.9
85.0	10132	99.5	3.80	191	31.1	23.1	3.69	381	223	22.7	3.7	70.0
80.0	9536	97.5	3.60	183	30.9	22.1	3.49	376	225	21.6	4.3	70.0
75.0	8940	95.4	3.40	176	30.6	21.0	3.29	371	226	20.4	4.8	69.9
70.0	8344	93.2	3.17	166	30.3	19.8	3.07	368	231	19.1	5.6	69.7
60.0	7152	88.6	2.75	148	29.9	17.4	2.66	360	239	16.5	6.6	69.0
50.0	5960	83.3	2.37	130	29.5	14.9	2.29	349	246	14.2	6.9	68.0
40.0	4768	77.4	2.03	110	29.3	12.6	1.96	334	251	12.0	6.0	66.8

Bypass: Percentage of total exhaust gas mass flow.

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11920 kW 100.0% R1
105.0 rpm 100.0% R1

System data at 100.0% Rx (11920kW)

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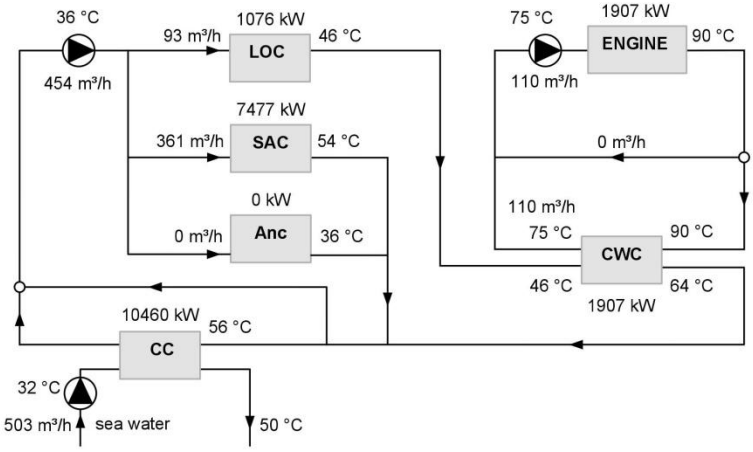
Cooling System PRELIMINARY

FW cooled / Single-Stage SAC / Sep. HT circuit

Design Conditions

Air temperature before compressor:	45 °C
Coolant temperature before SAC:	36 °C
Relative humidity:	60 %



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11920 kW 100.0% R1
105.0 rpm 100.0% R1

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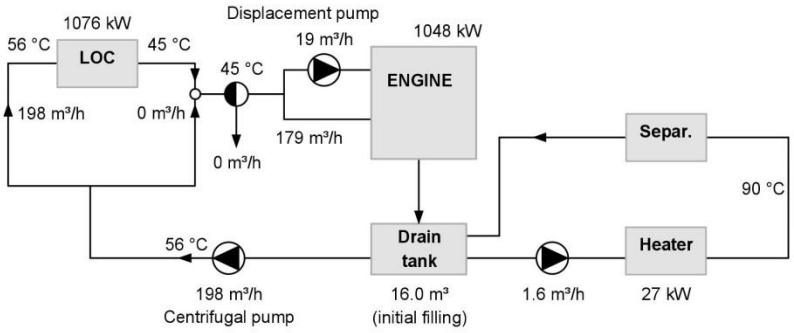
Lubricating Oil System PRELIMINARY

Main lubrication oil system (integrated TC lubrication)

Design Conditions

Air temperature before compressor:	45 °C
Coolant temperature before SAC:	36 °C
Relative humidity:	60 %



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11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
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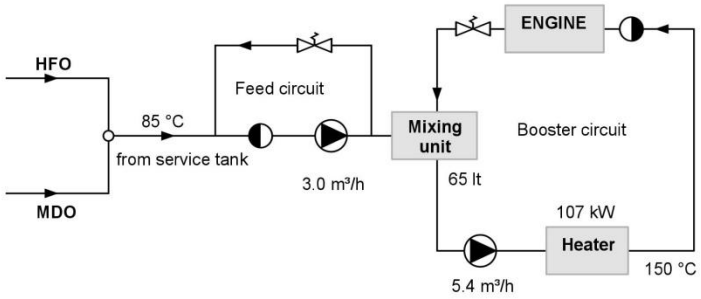
Fuel Oil System PRELIMINARY

Tank System Data and HFO Treatment

Feed circuit	HFO setting tank	19	m³	8 h operation at CMCR
	HFO service tank	19	m³	8 h operation at CMCR
	MDO service tank	19	m³	8 h operation at CMCR
	Feed pump	3.0	m³/h	
Booster circuit	Booster pump	5.4	m³/h	
	HFO end heater	107	kW	
	Mixing unit	65	lt	
	Temperature after heater	150	°C	
Treatment	Separator throughput	2.6	m³/h	
	HFO preheater	44	kW	

Pressurized Fuel Oil System



W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
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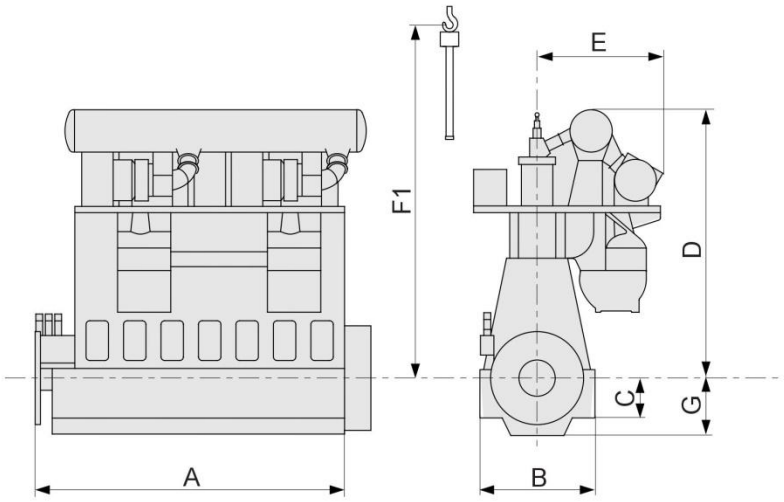
Installation Data PRELIMINARY



Dimensions

In mm with a tolerance of approx. ± 10mm

A	8730	mm
B	3514	mm
C	1205	mm
D	8444	mm
E	3445	mm
F1	10250	mm
G	1910	mm

Weight masses

Net engine mass	323	t
Weight water/oil	3.2	t
Minimum crane capacity	3.5	t

Engine mass is calculated according to nominal dimensions of drawings, incl. turbochargers and scavenge air coolers (specified for R1), piping and platforms but without oil / water. The dimensions are in mm across R1-rated engines without Efficiency-Booster System with a tolerance of approx. ± 10mm.

The standard piston dismantling height as shown in the sketch can be reduced by using special tools and / or tilted lift of the piston.

The data on this page is for guiding in an early project stage only and is not binding.

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
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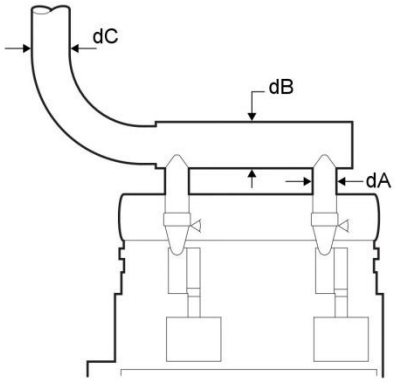
Exhaust Gas System PRELIMINARY

Design Conditions

2 x A165-L



Exhaust gas

Mass flow	100742 kg/h
Temperature after TC	275 °C
Density	0.654 kg/m³
Back pressure	300 mm WC

Exhaust gas pipes	Gas velocity	Volume flow	Diameter
Pipe A	40.0 m/s	77033 m³/h	dA 900 mm
Pipe B	25.0 m/s	154067 m³/h	dB 1500 mm
Pipe C	35.0 m/s	154067 m³/h	dC 1300 mm

W8X52DF
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11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
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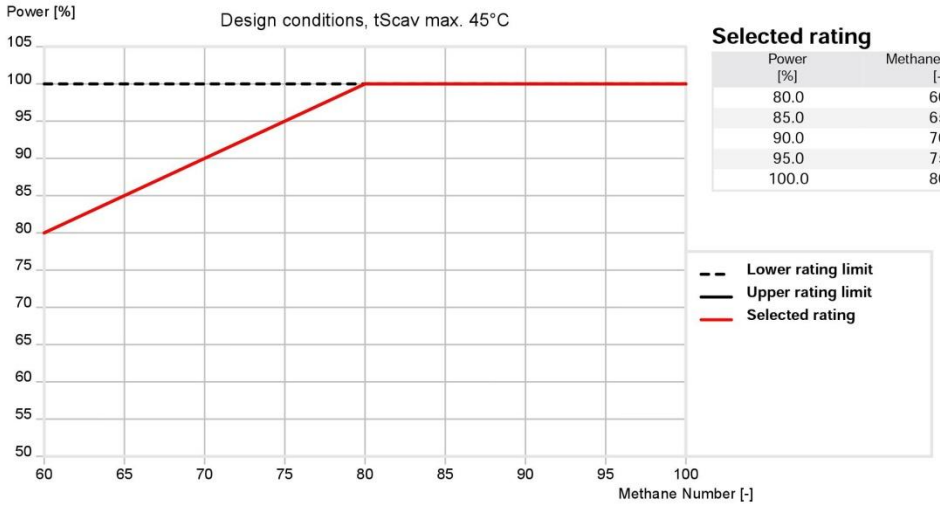
Output Limitations in Gas Mode PRELIMINARY

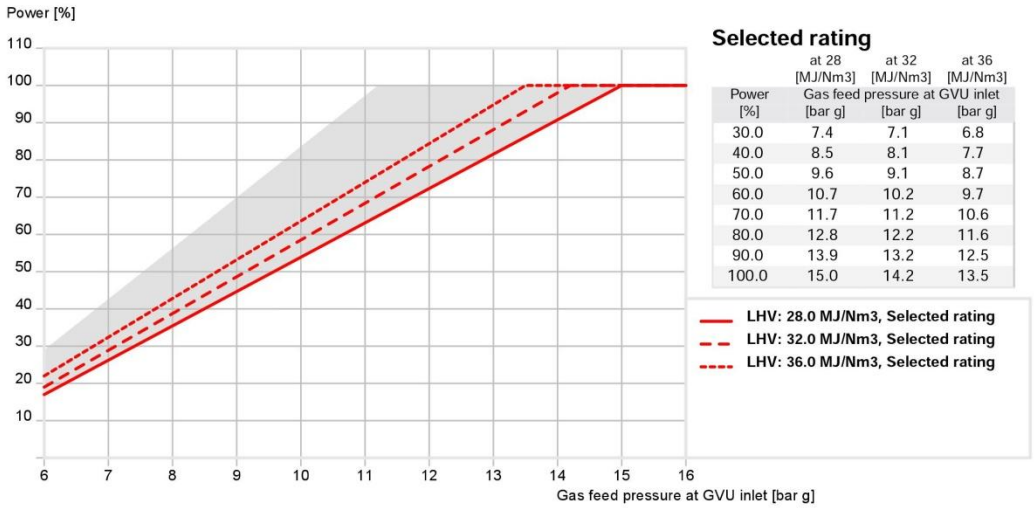
Methane number requirement



Selected rating

Power [%]	Methane number [-]
80.0	60
85.0	65
90.0	70
95.0	75
100.0	80

Gas supply pressure requirement



Selected rating

Power [%]	at 28 [MJ/Nm3] Gas feed pressure at GVU inlet [bar g]	at 32 [MJ/Nm3] [bar g]	at 36 [MJ/Nm3] [bar g]
30.0	7.4	7.1	6.8
40.0	8.5	8.1	7.7
50.0	9.6	9.1	8.7
60.0	10.7	10.2	9.7
70.0	11.7	11.2	10.6
80.0	12.8	12.2	11.6
90.0	13.9	13.2	12.5
100.0	15.0	14.2	13.5

W8X52DF
IMO Tier II / III compliant

11920 kW 100.0% R1
105.0 rpm 100.0% R1

Project:
Yard / Plant:
Owner:
Created: 25.05.2016 / Pedro

References PRELIMINARY

Conditions	ISO (3046-3:2006)	Design	Specified
Air temperature before compressor	25 °C	45 °C	20 °C
Engine room ambient air temp.	25 °C	45 °C	35 °C
Coolant temperature before SAC *1)	29 °C	36 °C	25 °C
Barometric pressure	1000 mbar	1000 mbar	1000 mbar
Cylinder water outlet temperature	90 °C	90 °C	90 °C
Oil temperature before engine	45 °C	45 °C	45 °C
Exhaust gas back pressure	300 mm WC	300 mm WC	300 mm WC
Relative humidity	30 %	60 %	30 %

*1) The seawater temperature will be 4°C lower than the specified coolant temperatures.

Abbreviations

BMEP	Brake mean effective pressure
BSAC	Brake specific air consumption
BSEC	Brake specific energy consumption
BSEF	Brake specific exhaust gas flow
BSFC	Brake specific fuel oil consumption
BSGC	Brake specific gas consumption
BSPC	Brake specific pilot oil consumption
CMCR	Contract max. continuous rating (Rx)
CPP	Controllable pitch propeller
CSR	Continuous service rating
etaTC	Turbocharger overall efficiency
FPP	Fixed pitch propeller
HFO	Heavy fuel oil
HP	High pressure
HT	High temperature
LHV	Lower heating value
LP	Low pressure
LT	Low temperature

MCR	Maximum continuous rating (R1/R1+)
MDO	Marine diesel oil
mScav	Scavenge air mass flow
pExh	Exhaust gas pressure before turbine
pScav	Scavenge air pressure
PTO	Power take-off
RH	Air relative humidity before compressor
SAC	Scavenge air cooler
SCR	Selective catalytic reduction
SPC	Steam production control
SPP	Steam production power
tAaC	Air temperature after compressor
tAbC	Air temperature before compressor
tCbS	Coolant temperature before SAC
tEaT	Exhaust temperature after turbine
tEaTm	Exhaust temperature after turbine, mixed
tEbE	Exhaust temperature before economizer
tEbT	Exhaust temperature before turbine
tScav	Scavenge air temperature

Values for EEDI calculation

Engine type	W8X52DF
CMCR Power	11920 kW
CMCR Speed	105.0 rpm
Ambient condition	ISO
Gas fuel data	
Fuel LHV, Reference	50000 kJ/kg
BSGC (CMCR)	142.7 g/kWh
BSGC (75% Load)	141.4 g/kWh
BSGC (75% Load) + 6% Tolerance	149.9 g/kWh
Pilot fuel data	
Fuel LHV, Reference	42707 kJ/kg
BSPC (CMCR)	1.5 g/kWh
BSPC (75% Load)	1.8 g/kWh