



## **ESTIMATION OF FUEL CONSUMPTION**

FOR

**LMG 35-CRV**

Doc. no.: 369011-RE-101-Y-LMG-00001

Client Doc. no.:

Revision: 01

**Bergen 09.12.2016**



**Client** : HAVFORSKNINGSINSTITUTTET  
**Key person** : PER W. NIEUWEJAAR  
**Document title** : ESTIMATION OF FUEL CONSUMPTION  
**Project name** : LMG 35-CRV  
**Project number** : 369011  
**Internal document number** : 369011-RE-101-Y-LMG-00001  
**Client Document Number** :  
**External distribution** : ACC. TO ORDER NO. 50484  
**Classification** : CONFIDENTIAL

THE AUTHOR OF THIS DOCUMENT IS LMG MARIN AS. THE DOCUMENT OWNERSHIP AND RIGHTS OF USE IS ACCORDING TO IMR ORDER NO. 50484

01	09.12.2016	PEMA	MAGO	PEMA	First issue
<b>Revision</b>	<b>Date</b>	<b>By</b>	<b>Checked</b>	<b>Approved</b>	<b>Comments</b>



## CONTENTS

<b>1. EXECUTIVE SUMMARY</b> .....	<b>2</b>
<b>2. RESISTANCE ESTIMATION</b> .....	<b>3</b>
<b>3. ENGINE CONFIGURATION</b> .....	<b>4</b>
<b>4. CALCULATION OF ELECTRICAL LOSSES</b> .....	<b>4</b>
<b>5. CONSUMPTION IN DIFFERENT OPERATIONAL MODES</b> .....	<b>4</b>
5.1 TRANSIT AT 10 KNOTS .....	4
5.2 TRANSIT AT 4 KNOTS .....	5
5.3 DP OPERATION .....	5
5.4 AT SHORE .....	5



---

## **DOCUMENT REVISION LIST**

### **Rev. 01 updates**

Initial issue

## 1. EXECUTIVE SUMMARY

The fuel consumption at different modes for the LMG 35-CRV coastal research vessel has been calculated. The different modes and corresponding fuel consumptions are shown in the table below.

Summary of fuel consumption				
Mode	Speed [knots]	Total engine power [kW]	Consumption [t/day]	Ammont of time [%]
Transit at 10 knots	10.0	564.7	2.76	16.67 %
Transit at 4 knots	4.0	125.1	0.60	16.67 %
DP Mode	-	338.4	1.60	16.67 %
At shore	-	62.8	0.31	50.00 %
<b>Average consumption</b>		<b>202.8</b>	<b>0.98</b>	<b>100.00 %</b>

All numbers are given without any sea margin.

## 2. RESISTANCE ESTIMATION

The resistance has been estimated by Hollenbach’s empirical method, which is the most recent empirical prediction method available. Propulsive efficiencies are assumed based on experience.

The calm water resistance curve is given in Figure 2-1.

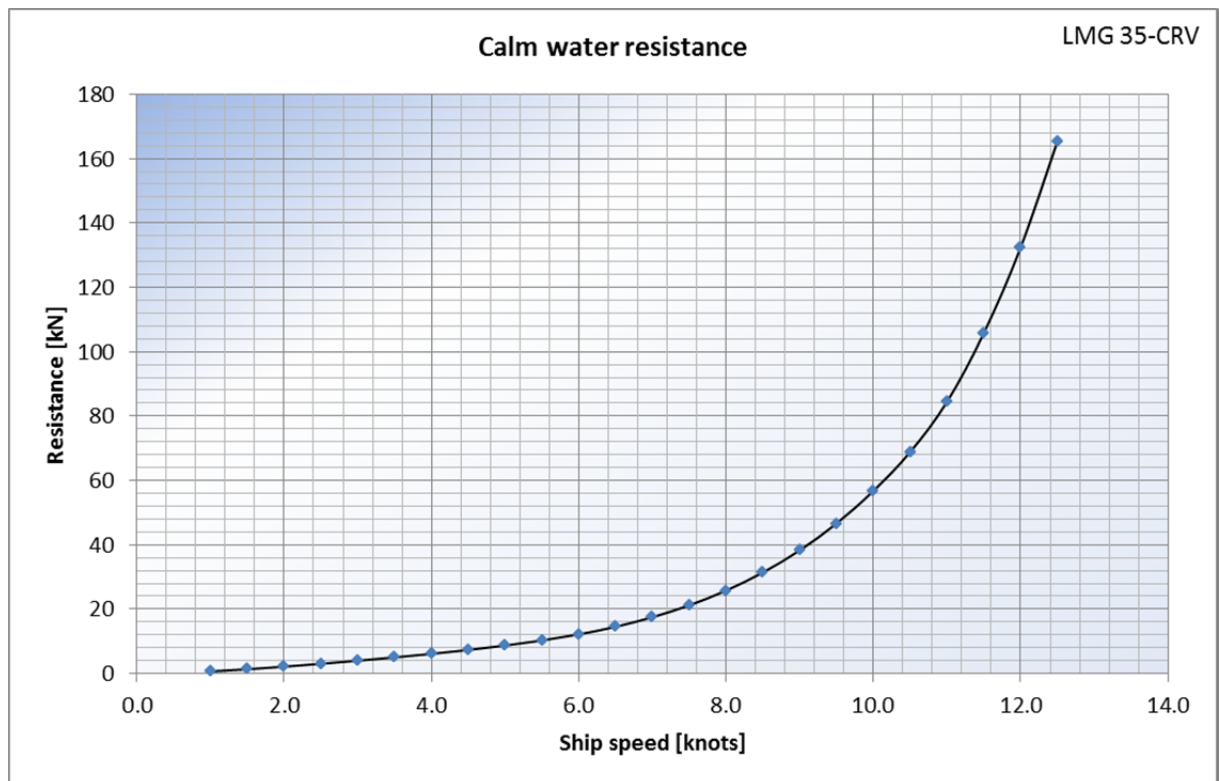


Figure 2-1 Calm water resistance curve

The loading condition applied for this resistance calculation is shown in Table 2-1.

Table 2-1 Loading condition used in resistance calculation

Item	Symbol	Unit	Value
Displacement	$\Delta$	tonne	660
Mean draught	T	m	3.48

### 3. ENGINE CONFIGURATION

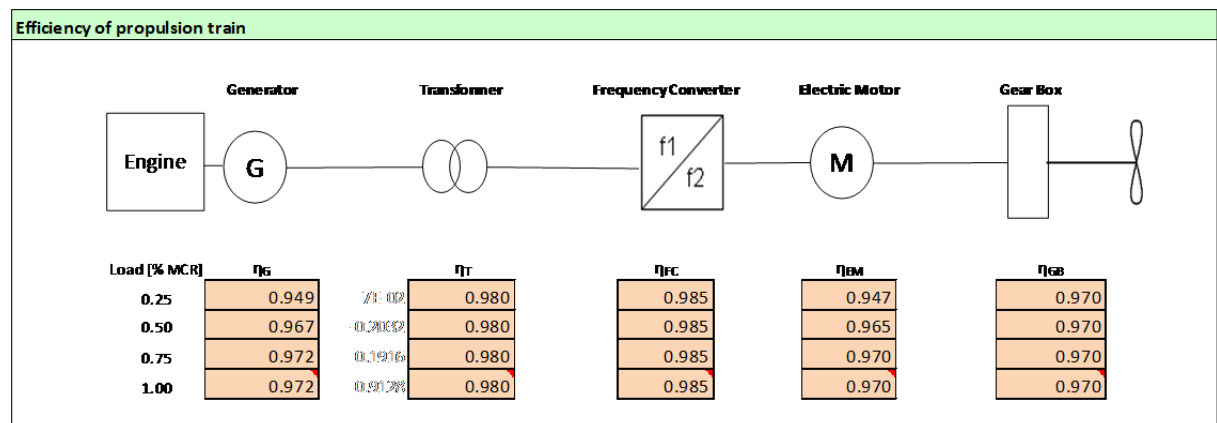
The vessel has a diesel-mechanic hybrid propulsion system, consisting of one main engine connected to a reduction gear, two auxiliary engines and one PTO/PTI connected to the reduction gear. With this configuration the vessel is able to run in pure diesel-electric mode at the lowest speeds in order to eliminate the zero-pitch loss. This configuration allows for running purely diesel-electric up to about 8 knots. The engine configuration is listed in Table 3-1.

**Table 3-1 Engine configuration**

Type	Power [kW]	No of [-]
Main engine	1 400	1
Auxiliary engine	200	2
PTI (Electric propulsion motor)	400	1

### 4. CALCULATION OF ELECTRICAL LOSSES

The electrical losses are calculated by estimating a loss for each component in the electric part of the propulsion train as function of loading. The transmission loss in the gearbox comes in addition. The propulsion train with corresponding efficiencies are shown in Figure 4-1. In case of pure mechanic propulsion, it is only the gearbox that contributes to the transmission losses.



**Figure 4-1 Efficiency of propulsion train**

### 5. CONSUMPTION IN DIFFERENT OPERATIONAL MODES

The fuel consumption at different operational modes is calculated in this chapter, and a summary is shown in Table 5-1. Details of the calculations are shown in Figure 5-1 at the end of the chapter. All numbers are given without sea margin. For all modes at sea the hotel load is assumed to be 100 kW, while at shore the hotel load is assumed to be 60 kW.

#### 5.1 TRANSIT AT 10 KNOTS

At 10 knots the vessel runs with diesel-mechanic propulsion. The propulsion power is abt. 440 kW, and the total fuel consumption is 2.76 t/day.



## 5.2 TRANSIT AT 4 KNOTS

It is assumed that the vessel runs with diesel-electric propulsion at 4 knots. The propulsion power is abt. 19 kW, and the total fuel consumption is 0.6 t/day.

## 5.3 DP OPERATION

The DP operation is calculated for the following environmental conditions:

- Wind speed: 15.0 m/s
- Current speed: 0.5 knot

The worst heading is taken into account, giving a required thruster power of 205 kW. It is assumed that the vessel runs in diesel-electric mode on DP, giving a consumption of 1.6 t/day.

## 5.4 AT SHORE

At shore hotel load is the only power consumer, and this is assumed to be 60 kW. This gives a consumption of 0.31 t/day.

In average, accounting for a preliminary operational profile, the consumption is 0.98 t/day.

**Table 5-1 Summary of fuel consumption**

Summary of fuel consumption				
Mode	Speed [knots]	Total engine power [kW]	Consumption [t/day]	Ammont of time [%]
Transit at 10 knots	10.0	564.7	2.76	16.67 %
Transit at 4 knots	4.0	125.1	0.60	16.67 %
DP Mode	-	338.4	1.60	16.67 %
At shore	-	62.8	0.31	50.00 %
<b>Average consumption</b>		<b>202.8</b>	<b>0.98</b>	<b>100.00 %</b>





		Engine Configuration		Power [kW]		No. of [-]	
		- Propulsion el-motor		300		1	
		- Genset		200		2	
		- Main engine		1400		1	
		Total installed power		1800		1	

		Performance in transit																							
V [knots]	Total resistance [kN]	Open water efficiency [-]	Hull efficiency [-]	Relative rotaceff. [-]	Propulsive efficiency [-]	El-motor efficiency [-]	Drives efficiency [-]	Trafo efficiency [-]	Generator efficiency [-]	Tot.electric efficiency [-]	Mechanical efficiency [-]	Effective power [kW]	Propeller power [kW]	Propulsion motor load [-]	Propulsion motor power [kW/motor]	Hotel load [kW]	Tot.generator output power [kW]	Tot.engine power [kW]	No. on line [-]	No. on line [-]	Genset load [% of MCR]	Engine load [% of MCR]	SFC Genset [g/kWh]	SFC main engine [g/kWh]	Fuel consumption [t/day]
1.00	0.65	0.65	1.05	1.00	0.68	0.91	0.99	0.98	0.97	0.85	0.97	2.2	3.2	0.01	3.32	100.0	103.8	107.2	1	1	53.6	-	201.0	-	0.52
2.00	2.13	0.65	1.05	1.00	0.68	0.91	0.99	0.98	0.97	0.85	0.97	6.2	9.0	0.03	9.33	100.0	110.5	114.1	1	1	57.0	-	201.0	-	0.55
3.00	4.00	0.65	1.05	1.00	0.68	0.92	0.99	0.98	0.97	0.86	0.97	12.6	18.5	0.06	19.05	100.0	121.4	125.1	1	1	62.5	-	200.7	-	0.60
4.00	6.13	0.65	1.05	1.00	0.68	0.92	0.99	0.98	0.97	0.86	0.97	22.4	32.8	0.11	33.77	100.0	137.6	141.6	1	1	70.8	-	199.2	-	0.68
5.00	8.69	0.65	1.05	1.00	0.68	0.93	0.99	0.98	0.97	0.87	0.97	37.6	55.1	0.19	56.76	100.0	162.5	167.2	1	1	83.6	-	196.7	-	0.79
6.00	12.17	0.65	1.05	1.00	0.68	0.94	0.99	0.98	0.97	0.88	0.97	63.1	92.4	0.32	95.25	100.0	203.5	210.3	2	2	52.6	-	201.0	-	1.01
7.00	17.51	0.65	1.05	1.00	0.68	0.95	0.99	0.98	0.97	0.91	0.97	106.0	155.4	0.53	160.17	100.0	271.8	279.7	2	2	69.9	-	199.4	-	1.34
8.00	25.77	0.65	1.05	1.00	0.68	0.97	0.99	0.98	0.97	0.91	0.97	177.2	259.7	0.79	267.72	100.0	367.7	387.9	1	1	60.1	19.1	201.0	205.0	1.90
9.00	38.28	0.65	1.05	1.00	0.68	1.00	1.00	1.00	0.96	0.96	0.97	291.9	427.8	1.19	440.98	100.0	541.0	564.7	1	1	61.9	31.5	200.9	204.6	2.76
10.00	56.75	0.65	1.05	1.00	0.68	1.00	1.00	1.00	0.97	0.97	0.97	477.7	699.9	1.52	721.59	100.0	821.6	848.9	1	1	63.7	51.5	200.5	201.0	4.09
11.00	84.42	0.65	1.05	1.00	0.68	1.00	1.00	1.00	0.97	0.97	0.97	817.6	1197.9	2.24	1234.97	100.0	1335.0	1373.3	1	1	69.2	88.2	199.5	197.6	6.52
12.00	132.44	0.65	1.05	1.00	0.68	1.00	1.00	1.00	0.97	0.97	0.97														

		Performance in DP															
Zero-speed modes [-]	Ashore	Total thruster power [kW]	El-motor efficiency [-]	Drives efficiency [-]	Trafo efficiency [-]	Generator efficiency [-]	Total electric efficiency [-]	Mechanica efficiency [-]	Propulsion motor load [-]	Hotel load [kW]	Total generator output power [kW]	Total engine power [kW]	No. on line [-]	No. on line [-]	Engine load [% of MCR]	SFC consumption [g/kWh]	Fuel consumption [t/day]
DP		205.0	0.96	0.99	0.98	0.97	0.98	0.97	0.97	100.0	328.95	338.4	2	2	84.6	197.0	1.60
Ashore			0.91	0.99	0.98	0.95	0.84	0.97	-	60.0	60.00	62.8	1	1	31.4	204.6	0.31

Figure 5-1 Details of calculations