NTNU – Trondheim
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Total Equipment Monitoring

Ship equipment operation, performance and
cost monitoring for VLGCs and LGCs

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ABSTRACT

In this thesis a model of establishing operation and operation costs of all ship equipment powered by electricity produced by the generators has been proposed. The model is based on the running hours for the equipment, the power ratings of the equipment and the specific fuel consumption of the generators. The work has been carried out for nine vessels; six Very Large Gas Carriers (VLGC) and three Large Gas Carriers (LGC), whereas all ship equipment where running hours are registered have been included. A test validating the accuracy of the model proposed has been performed.

The results have been used to review the operational performance of selected equipment to determine whether savings can be made if measures are carried out and awareness is increased for both shipowner and crew. The equipment selected was the main engine lube oil pumps, the steering gear pumps and the cargo seawater cooling pumps.

Based on the findings and the data available, an equipment performance report intended used by both crew and onshore employees to evaluate, validate and compare operation and operation costs of ship equipment have been established. The report can be used as a complement to the *Ship Energy Efficiency Management Plan* (SEEMP).

In addition, the use of Kongsberg Ship@Web to establish and automatize the model and the equipment performance report has been reviewed.

All vessels in this report are anonymous, due to extensive use and description of internal company data. The report requires a thorough technical and operational understanding of ship equipment.

PREFACE

This report is the results of the Master thesis work by Alexander Grødeland at the Norwegian University of Science and Technology (NTNU), in the spring of 2013. The work has been carried out in cooperation with Solvang ASA and *Energy Management In Practice 2* (EMIP-2).

The project during a summer internship at Solvang ASA, where the task was to review the operation and operation costs of the ship equipment on a Solvang Liquefied Petroleum Gas (LPG) carrier. What started as a project to map the operation and operation costs of one vessel, eventually became a task of creating a tool to review the operational performance of ship equipment for the majority of the fleet, as well as a feedback tool for the crew.

To review the operation and operation cost of the equipment requires a substantial amount of data. Running hours for all equipment for nine vessels have been registered for every month, spanning 2009 to 2012. In addition, the operational profile, fuel consumption, main machinery operation and fuel type had to be included, as these parameters influence the operation of the equipment. All data had to be interconnected to produce accurate results. The most challenging task has been to familiarize with the operation and specifications of the ship equipment. The author previously had little in-depth knowledge or experience of ship equipment in practice. The project included all equipment of nine vessels, thus a steep learning curve was required.

With great help challenges were overcome, producing possibly the first tool to review the operation of ship equipment on a component level. First of all I would like to thank my supervisor, Prof. Ingrid Bouwer Utne for great feedback and valuable lessons. I am also in great debt to the ship crew, who gave me valuable insights, great feedback and 3 weeks at sea which I will remember fondly. In addition I would like to thank Naval Architect Jone Ask for answering numerous questions, as well as Dr. Ing Tor Øyvind Ask for great insights on how the results can be used to the full extent. I would also like to thank the vessel managers, Roy Trydal and Trygve Knutsen for their input. Finally, I would like to thank Ine Haugen.

Trondheim, 8th of June, 2013

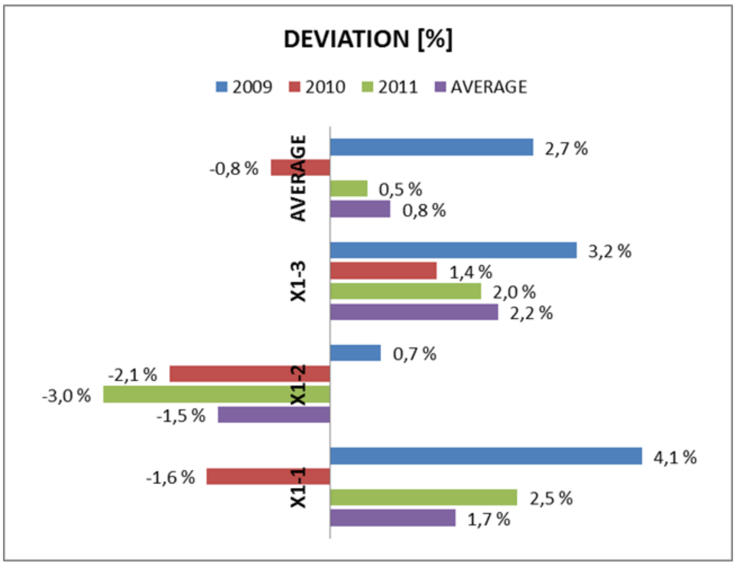
Alexander Grødeland

EXECUTIVE SUMMARY

This thesis has been carried out in cooperation with Solvang ASA, as a part of Energy Management in Practice *2* (EMIP-2). EMIP's vision is to enable a robust knowledge and innovation platform related to energy efficiency on ships, with rational utilization of limited resources and a strong focus on verification of practical energy efficiency measures, contributing to increasing Norwegian shipping's competitive edge and environmental performance.

This study focuses on the operation and operation costs of the ship equipment powered by electricity generated by the generators. Solvang operates 16 LPG carriers, where the fuel consumption of the generators, powering the ship equipment, often represents more than 15% of the total fuel consumption for the vessels. In this thesis a model to establish and review the operation and operation costs have been proposed. The model is based on the running hours for the equipment (currently only used for maintenance planning), the power ratings and specifications of the equipment and the specific fuel consumption of the generators.

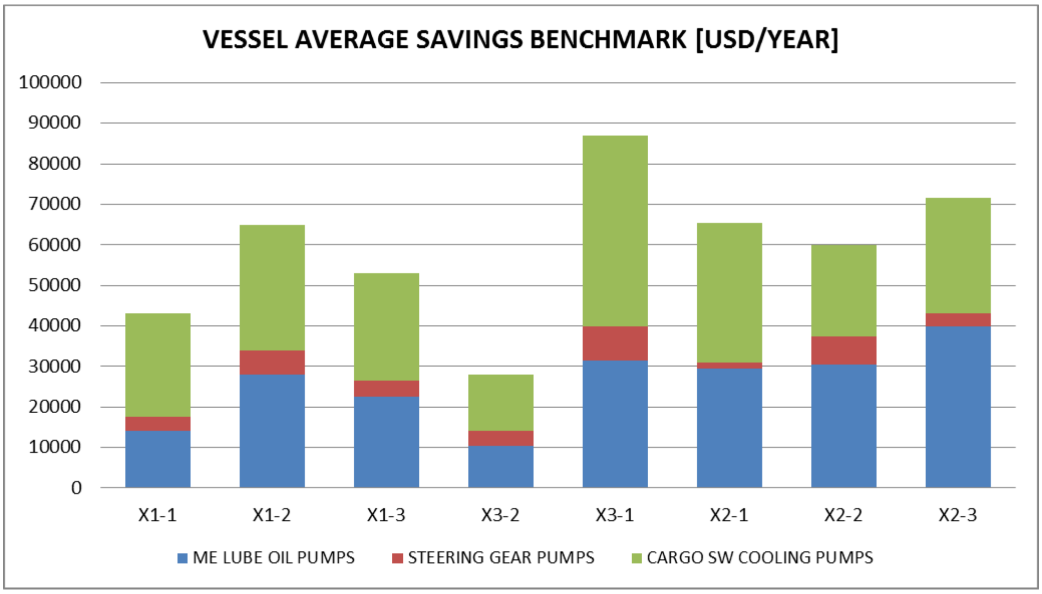
DEVIATION, REGISTERED/ESTIMATED GENERATOR FUEL CONSUMPTION



Comparing the registered fuel consumption of the generators to the estimated theoretical fuel consumption of all ship equipment, an average accuracy of 99.2%, ranging from an average deviation of -0.8% to 2.7%, was found for the vessels using the model proposed in the report.

The data gathered was used to further analyze three types of equipment being heavy consumers and showing potential for improvement. Potential savings ranging from 20,000 USD to excess of 80,000 USD per year per vessel were found. The total minimum savings for the nine vessels for the equipment investigated were estimated to 473,000 USD on average, ranging from a minimum of 291,000 USD to nearly 700,000 USD maximum per year.

POSSIBLE OPERATIONAL SAVINGS [USD/YEAR]



On the 1st of January 2013 the Ship Energy Efficiency Management Plan (SEEMP) for vessels over 400 gross ton (GT) was enforced by the International Maritime Organization (IMO). The SEEMP is a regulation intended to improve the energy efficiency of a ship in a cost-effective manner, where every vessel is required to have a document or manual containing operational measures to improve efficiency. The model proposed to determine operation and operation costs is highly relevant in the work to establish a high quality SEEMP, as the following parameters are provided:

- Data of the operation and operation costs for the equipment
- A platform to identify equipment that is run efficient or inefficient
- A tool to monitor the measures implemented in the SEEMP.

The data gathered for the ship equipment on the nine vessels in this report are used to establish a Ship Equipment Cost Overview and Performance Report (SECOPR). The SECOPR is intended to be used by onshore employees for evaluation, validation and comparison of ship equipment operation. In addition, the report is intended to be issued to the crew for feedback, making them able to track their operational performance.

In addition, the SECOPR is intended to complement the SEEMP and to be used as a monitoring tool. For owners that do not have software or systems that can monitor SEEMP measures, IMO has proposed using the Energy Efficiency Operational Indicator (EEOI). The EEOI quantifies the energy efficiency in terms of actual CO_2 emissions per unit of transport work as it is influenced by the operational features of the ship. The EEOI is useful to determine the overall operational efficiency of the vessel, but is not best suited for monitoring specific measures carried out on ship equipment.

The model proposed and the SECOPR requires an extensive amount of data and the possibility of automatizing this process by use of Kongsberg's Ship@Web system has been reviewed.

All the nine vessels analyzed in this report are anonymous.

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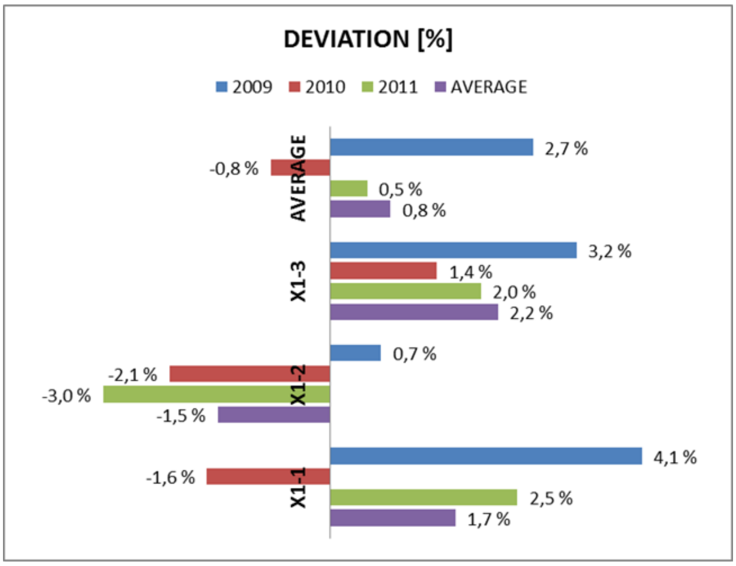
SAMMENDRAG

Denne oppgaven er utført i samarbeid med Solvang ASA, som en del av Energy Managment in Practice 2 (EMIP-2). EMIPs visjon er å etablere et godt fundament for kunnskap og innovasjon knyttet til energieffektivitet på skip, med rasjonell utnyttelse av begrensede ressurser og et sterkt fokus på verifikasjon av praktiske energireduksjonstiltak som vil bidra til å øke konkurransekraft og miljøinnsats i norsk skipsfart.

Oppgaven fokuserer på drift og driftskostnader for skipsutstyr, drevet av elektrisitet produsert av generatorene. Solvang drifter 16 LPG-skip, hvor drivstofforbruket til generatorene ofte utgjør mer enn 15% av det totale drivstoffbruket. I denne rapporten belyses muligheten for å bruke driftstimer for utstyret, det spesifikke drivstofforbruket for generatorene og spesifikasjonene på skipsutstyret til å estimere driftskostnader for skipsutstyret basert på teoretisk drivstofforbruk.

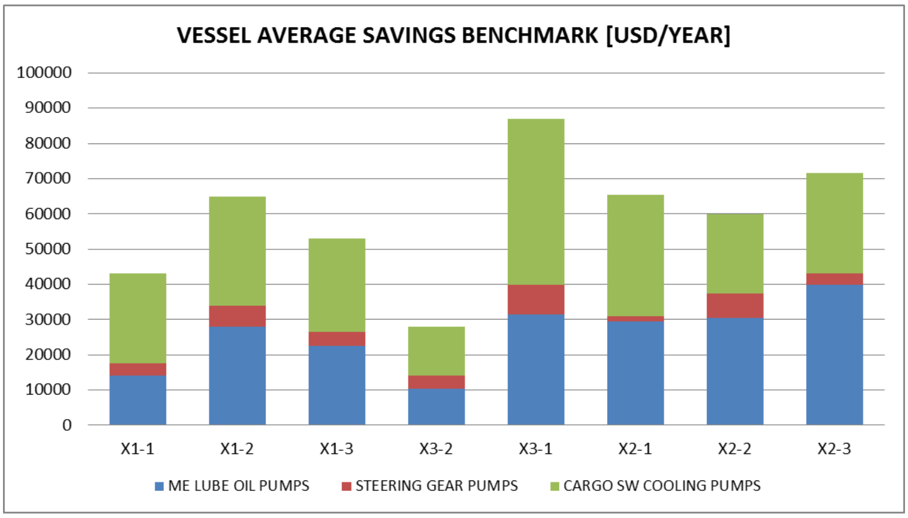
AVVIK, REGISTRERT/ESTIMERT DRIVSTOFFORBRUK GENERATORER



Sammenlignet med det registrerte drivstofforbruket på generatorene og det teoretisk beregnede drivstofforbruket for skipsutstyret, ble en gjennomsnittlig nøyaktighet på 99,2%, med et gjennomsnittlig avvik fra -0,8% til 2,7%, funnet ved bruk av metoden foreslått i rapporten.

Resultatene ble brukt til å analysere tre typer komponenter med høyt energikonsum som antas å ha potensial for forbedring. Innsparingspotensialet som ble funnet gikk fra 20.000 USD til overkant av 80.000 USD per år per skip for dette utstyret. De totale besparelsene på de ni skipene for utstyret som er analysert ble anslått til 473,000 USD i gjennomsnitt, fra et minimum på 291,000 USD til et maksimum på 700,000 USD per år.

MULIGE DRFITSMESSIGE BESPARELSER [USD/ÅR]



The International Maritime Organization (IMO) innførte den første januar 2012 tiltaket Ship Energy Efficiency Management Plan (SEEMP) for fartøy over 400GT. Tiltaket er ment å forbedre energieffektiviteten for skip på en kostnadseffektiv måte. Gjennom SEEMP er hvert fartøy pålagt å ha et dokument eller en manual som inneholder operasjonelle tiltak for å bedre effektiviteten. Imidlertid har det vært en debatt i skipsfarten om SEEMP bare er ekstra arbeidsbelastning for både ansatte på land og mannskaper. Andre ser på SEEMP som et godt tiltak for å hjelpe eiere og operatører med å redusere kostnader, samt utslipp.

Å utarbeide en god SEEMP krever nøye arbeid dersom resultatene skal bli gode. Modellen som er foreslått i denne rapporten er svært relevant for å etablere en god SEEMP, da den gir:
• Data om drift og driftskostnader for utstyret.
• Verktøy for å identifisere utstyr som driftes effektivt eller ineffektivt.
• Ett verktøy for å overvåke tiltakene i SEEMP.

Dataene og funnene som er gjort er brukt til å fastsette en rapport som oppsummerer drift, driftskostnader og energieffektivitet for skipsutstyret (Ship Equipment Cost Overview and Performance Report, SECOPR). SECOPR er ment brukt av ansatte på land til evaluering, validering og sammenligning av driften av skipsutstyret. Den er også ment utstedt til mannskapet, som en tilbakemelding på driften på komponentnivå.

I tillegg er SECOPR ment å utfylle SEEMP som et overvåkingsverktøy for tiltakene. For eiere som ikke har programvare eller systemer som registrerer driften av skipsutstyr, har IMO foreslått å bruke Energy Efficiency Operational Indicator (EEOI). EEOI kvantifiserer energieffektivitet i form av faktiske CO_2-utslipp per enhet transportarbeid som er påvirket av den operasjonelle driften av skipet. EEOI er nyttig for å angi den totale energieffektiviteten på driften av fartøyet, men er ikke best egnet til overvåkning av spesifikke tiltak som utføres på skipsutstyr.

Metoden foreslått, samt SECOPR, krever en omfattende data og muligheten for å automatisere denne prosessen ved bruk av Kongsbergs Ship@Web system har blitt vurdert.

Alle de ni fartøyene som er analysert i denne rapporten er anonyme, grunnet sensitive data. Rapporten krever enn inngående teknisk og operasjonell forståelse av skipsutstyr.

CONTENT

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF FORMULAS

NOMENCLATURE

SEEMP	Ship Energy Efficiency Management Plan
EEOI	Energy Efficiency Operational Indicator
EEDI	Energy Efficiency Design Index
ELA	Electric Load Analysis
LGC	Large Gas Carrier
VLGC	Very Large Gas Carrier
IMO	International Maritime Organization
LPG	Liquefied Petroleum Gas
HFO	Heavy Fuel Oil
LSHFO	Low Sulphur Heavy Fuel Oil
MDO	Marine Diesel Oil
NCV	Net Calorific Value [MJ/kg]
SFC	Specific Fuel Consumption [g/kWh, kg/h]
NSA	Norwegian Shipowners' Association
BOG	Boil Off Gas

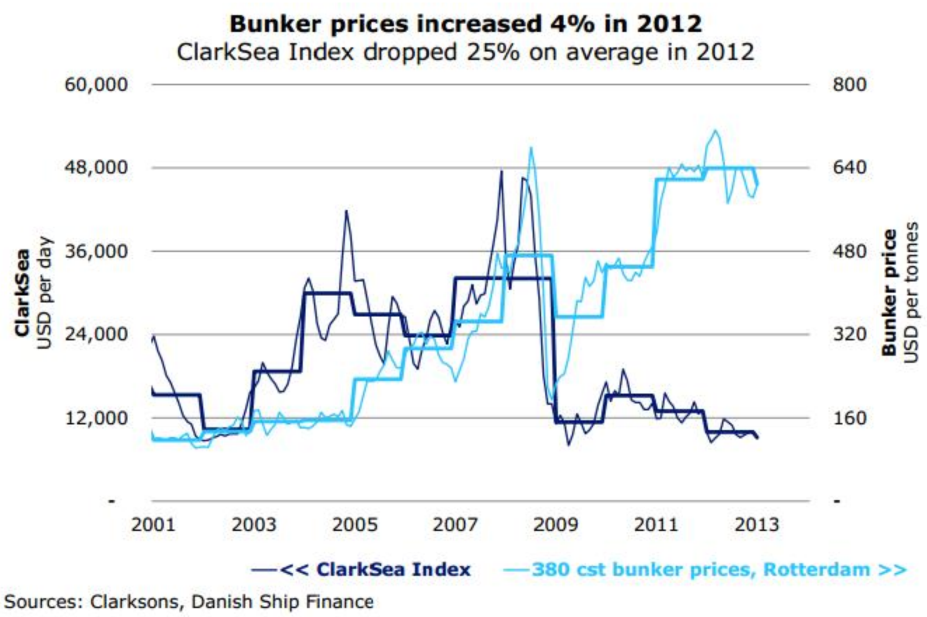
1. INTRODUCTION

1.1 BACKGROUND

Since the financial crisis started in 2008, the shipping industry has been facing a downturn in which it still has not recovered (2013). Shipping, characterized by market cycles and high volatility, creates a potential for great profit, but also great losses. When the downturn hit, the orderbooks for the shipyards throughout the world were brimming, resulting in new tonnage flooding the already depressed market.

The downturn has forced several shipping companies out of business or into serious economic distress, where the tank, bulk and container market were hit especially hard.

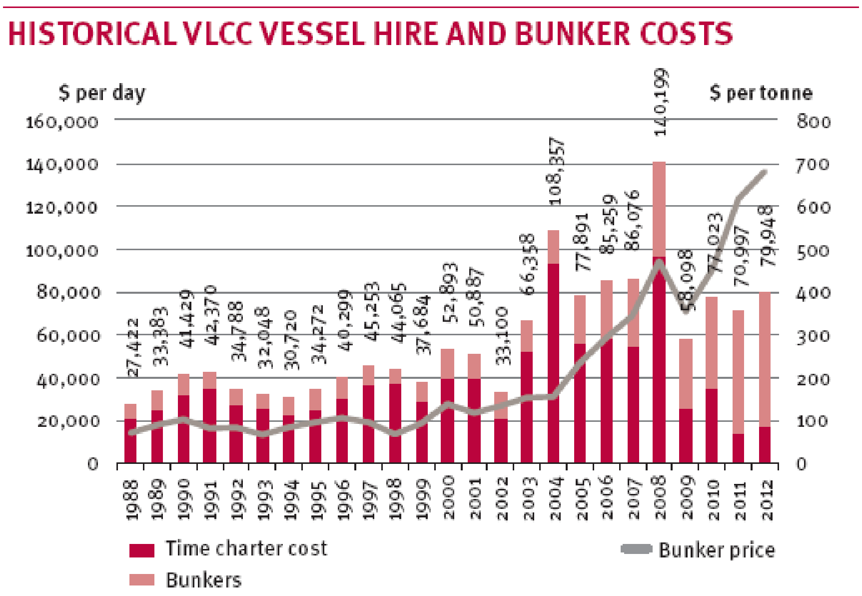
FIGURE 1: HISTORICAL BUNKER PRICES [1]



Secondly, in addition to the current depressed market, the fuel prices have been soaring, making the situation for the shipping companies worse. As can be seen in figure 1, the price of 380[cst] bunker in Rotterdam have quadrupled in less than 10 years. A 265,000 ton VLCC may be burning up to 100,000 USD of bunker fuel per day, which may constitute more than 75% of operating costs, illustrated in figure 2 [2]. In order to weather a downturn, as well as maximizing profits regardless of market cycle, there is great potential in reducing fuel consumption. The new generation of ships, so called eco-ships, have recently been stealing the headlines, in which many sees these ships as the solution to consolidating the market and getting rid of inefficient tonnage.

Much effort and money has been invested to reduce fuel consumption in the shipping industry. In a market where the losses are high and the current access to capital is scarce, or at least proving more difficult than in the past, many shipowners will be forced to carry out operational measures, or retrofits, in order to cut the total fuel bill. Mainly, the focus has been on cutting consumption for the main engine by measures like hull, trim and engine optimizations. Arguably, there has been less focus on cutting fuel consumption of the auxiliary engines generating electricity, hereby called *generators*, powering the electrical equipment of the ship, as well measures enhancing the operational performance of ship equipment.

FIGURE 2: HISTORICAL VLCC HIRE/BUNKER COSTS [2]



The Norwegian shipowner Solvang ASA operates 16 LPG carriers; 7 semi-refrigerated LPG/ethylene carriers, 6 LGCs and 3 VLGCs (2 newbuilds will be delivered shortly). The cargo equipment of LPG carriers requires a substantial amount of power produced by the auxiliary engines generating power. As opposed to other types of vessels, like bulk and tank, the fuel consumed by the generators will be higher on LPG carriers. In table 1, the fuel consumption and costs of the generators in comparison to the main engine is given. As can be seen, the fuel consumption of the generators ranges from 14.7% to 25.1%, with an average of 18.6% in the total fuel bill. The data is average yearly consumption, as registered in the vessel performance report in 2010-2012 and includes all fuel types.

TABLE 1: AVERAGE FUEL CONSUMPTION AND RATIO, MAIN ENGINE (ME)/GENERATORS (AUX) [14]

AVG. 2010/12	FUEL CONS. [TON/YEAR]		COSTS [650 USD/TON]		
VESSEL	**ME**	**AUX**	**ME**	**AUX**	**RATIO**
X1-1	8331	1667	5 414 927	1 083 580	**16,7 %**
X1-2	8634	1537	5 611 965	999 177	**15,1 %**
X1-3	8476	1464	5 509 387	951 292	**14,7 %**
X2-1	6817	1806	4 431 180	1 173 922	**20,9 %**
X2-2	6492	1728	4 219 622	1 123 070	**21,0 %**
X2-3	6475	1786	4 208 837	1 161 052	**21,6 %**
X3-1	8472	1665	5 507 038	1 082 354	**16,4 %**
X3-2	5210	1746	3 386 808	1 134 922	**25,1 %**
X4-1	9474	1790	6 158 230	1 163 624	**15,9 %**
AVERAGE	**7598**	**1688**	**4938666**	**1096999**	**18,6 %**

The fuel bill for the generators indicates that savings can be made if improvements are possible. Reducing the fuel consumption of the generators can either be done by carrying out engine or load optimizations, or by reducing the power consumed by the electrical equipment. However, an ocean-going vessel is a complex machinery system, consisting of several systems and numerous components. If the fuel consumption of the generators is to be reduced by reducing the power consumption of the electrical equipment, the operation of the ship equipment and the resulting operating costs must be established.

Knowing the fuel consumption of the generators, consequently the ship equipment, play an important part of the total fuel bill, Solvang has increased the focus on ship equipment as a part of their work to increase performance, decrease fuel consumption and to operate an environmentally sound and efficient fleet.

1.2 SHIP EFFICIENCY REGULATIONS

Shipping is the most efficient and most environmentally sound mode of transportation, carrying about 90% of all transport and emitting far less than all other means of transportation in terms of emissions per transport unit [3]. Regardless, there is increased focus on emissions in the shipping industry. Key environmental regulations coming into force address emissions such as sulphur oxides (SOx), nitrous oxides (NOx), particulate matter (PM), carbon dioxide (CO_2) and ballast water treatment.

Generally, the aim is to produce the same amount of useful energy, while using less energy and emitting less pollution into the sea or the atmosphere, thus being energy efficient. Energy efficiency can be achieved by various means, whereas the following parameters can be used [4]:

- Thermodynamic efficiency – Relating to the first and second law of thermodynamics, the thermodynamic efficiency is measures in terms of “state-functions”.
- Energy conservation – Energy conservation means saving energy relative to a baseline, which can be achieved by operating efficiently and not use excess energy beyond what is needed.
- Environmental efficiency – The amount of emissions emitted as a consequence of the work conducted. If the work performed is assumed constant, the environmental efficiency could be enhanced by after-treating of emissions, by using sources of energy that emit less pollution or increase the efficiency of the machinery generating useful work.

The increased focus on emissions in the shipping industry has resulted in regulations being enforced to secure a more efficient and sustainable world shipping fleet. In the context of reducing fuel consumption of the generators, the current regulations which apply to the shipping industry are summarized in table 2.

TABLE 2: IMO REGULATIONS [16]

IMO REGULATIONS	
YEAR	REGULATION
2010	1% ECA sulphur limit
2011	NOx Tier II for newbuilds
2012	3,5% global sulphur limit
	0,1% sulphur limit in California
	North American ECA
2013	Efficiency Design Index (EEDI)
	Ship Efficiency Management Plan (SEEMP)
2015	0,1% ECA sulphur limit
2016	NOx Tier III for newbuilds

Table 2 shows a summary of the regulations that the International Maritime Organization (IMO) has and plans to enforce. Fuel sulfur limits are enforced to reduce SO_x emissions and Tier II/III is being enforced to reduce NO_x emissions. In the context of operational efficiency of the generators, the Energy Efficiency Design Index (EEDI), Ship Energy Efficiency Management Plan (SEEMP) and the Energy Efficiency Operational Indicator (EEOI) are the most relevant regulations that have and are planned to be enforced.

The EEDI, SEEMP and EEOI are further reviewed in the coming section.

1.2.1 ENERGY EFFICIENCY DESIGN INDEX (EEDI)

The Energy Efficiency Design Index (EEDI) stipulates an energy efficiency level for new ships. The objective of the EEDI is to stimulate the continued technical development of all the components influencing the fuel efficiency of a ship by separating the technical and design-based measures from the operational and commercial ones. It is already being used to enable a comparison to be made of the energy efficiency of individual ships with similar ships of the same size that could have undertaken the same transport work.

The simplified version of the EEDI is given by formula 1 [5]

FORMULA 1: ENERGY EFFICIENCY DESIGN INDEX (EEDI)

$$EEDI = \frac{CO_2\ emission}{transport\ work}$$

The EEDI is calculated on the background technical- and design-based parameters that can achieve noteworthy reductions in fuel consumption and resulting CO_2 emissions on a capacity basis. This means that operational parameters are not included, other than large scale operational measures, such as lower speed and voyage optimization. In other words, two sister vessels will have the same EEDI if the speed and voyage is the same, regardless of the operational efficiency between the vessels.

The EEDI can be considered a CO_2 efficiency indicator, demonstrating the amount of CO_2 produced from the transport work by the vessel, or theoretical emissions of CO_2 per ton-mile. The attained ship EEDI is a measure of ships energy efficiency and calculated by the formula 2 [5]

FORMULA 2: EEOI COMPLETE [18]

$$\frac{\overbrace{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME} \cdot SFC_{ME}\right)}^{\text{Main engine(s)}} + \overbrace{\left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}\right)}^{\text{Auxiliary engine(s)}} + \overbrace{\left(\left(\prod_{j=1}^{M} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right)}^{\text{Energy saving technologies (auxiliary power)}} - \overbrace{\left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}\right)}^{\text{Energy saving technologies (main power)}}}{f_i \cdot \underbrace{f_c \cdot Capacity \cdot f_w}_{\text{Transport work}} \cdot V_{ref}}$$

The parameters of formula 2 will not be elaborated, but consists of four main terms:

- Main engine parameters
- Auxiliary engines
- Energy saving technologies (Auxiliary power)
- Energy saving technologies (Main engine)

For generators, the EEDI formula has the following parameters:
SFC_{AE} = Specific fuel consumption for the generators at 50% load [g/kWh]
P_{AE} = Power output of the auxiliary engines [kW]
Cf_{AE} = Conversion factor between fuel consumption and CO_2 emission

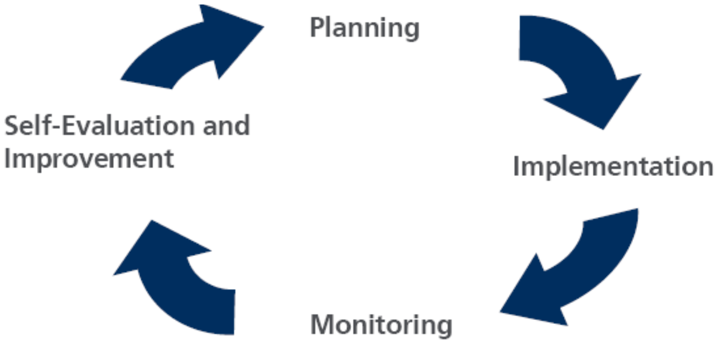
The EEDI formula is relevant in the effort to reduce the consumption of the generators, but as the parameters of the formula are fixed with regards to design specifications it is not relevant with respects to determine the operational performance of ship equipment. It can be used as a benchmark of describing the overall efficiency of vessels, thus giving an indication why there would be differences in the fuel consumption of the generators for vessels that are not sister vessels, even if the overall operation equipment operation is similar. Energy saving technologies, such as waste heat recovery can be installed to achieve a more efficient EEDI.

The EEDI is useful to determine the efficiency of design parameters, but is not relevant in the work to increase the operational performance of ship equipment. With this, the EEDI is not further elaborated in this report.

1.2.2 SHIP ENERGY EFFICIENCY MANAGEMENT PLAN (SEEMP)

As of 1st of January 2013, all ships over 400GT are enforced to have a Ship Energy Efficiency Management Plan (SEEMP) onboard [7]. The SEEMP is an operational measure that establishes a mechanism to improve the energy efficiency of a ship in a cost-effective manner.

FIGURE 3: SEEMP KEY IMPLEMENTATION PROCESSES [6]



The SEEMP is a document or manual, containing energy improvement measures identified by the owner and the vessel crew, specific for each ship. The document should be reviewed regularly to establish the relevance and impact of each measure on the ship and fleet operations. There are four key processes, illustrated in figure 3 [6].

In phase 1, planning, the owner is to review current practices and energy usage for each ship with a view to determine any shortfalls or areas for improvement of energy efficiency. This is a crucial first step to developing an effective management plan and should identify various aspects that are either ship or company specific, as well as assessing human resources development and goal setting. A selection of measures, grouped into systems, is given in figure 4 [6].

FIGURE 4: EXAMPLES OF SEEMP MEASURES [6]

SEEMP measures	
1. Fuel efficient operations	**4. Machinery and equipment optimisation**
1.1. Improved voyage planning	4.1. Main and auxiliary engine optimisation
1.2. Weather routeing	4.2. Equipment and systems
1.3. Just-in-time	4.3. Heat recovery
1.4. Speed optimisation	
1.5. Optimised shaft power	
2. Optimised ship handling	**5. Cargo handling optimisation**
2.1. Optimum trim	5.1. Cargo heating and insulation
2.2. Optimum ballast	5.2. Other measures for cargo handling optimisation
2.3. Optimum propeller and propeller inflow considerations	
2.4. Optimum use of rudder and autopilot	
3. Hull and propeller optimisation	**6. Energy conservation and awareness**
3.1. Hull resistance optimisation	6.1. Accommodation energy optimisation
3.2. Propeller management	6.2. Use of renewable energy
	6.3. Use of shore-based power sources when at port (cold ironing)
	6.4. Energy conservation investigation projects
	6.5. Training and awareness

After the planning stage, a system of how each energy improvement measure is to be implemented must be established. The development of the system can be considered under the planning stage and should set out the tasks required to achieve each measure along with who is assigned to them. When the measures have been implemented, phase 3 of SEEMP suggest that the measure is monitored. In the SEEMP guidance, it is recommended that the EEOI is used for monitoring, or by using established methods, preferably of an international standard [7].

The SEEMP is established by the owner and thus the format, quality and the extensiveness of the SEEMP may vary. Even though there are several suggestions available from the IMO and other organizations, the quality of the SEEMP requires a high level of consideration, as well as experience and know-how available in the company. There is a debate within the shipping industry, suggesting the development of two ‘tiers’ in the industry’s approach to the SEEMP. The opinion is split, with one camp believing SEEMP to be a time-consuming exercise in paper-pushing for officers onboard and their shore-based colleagues that will have little impact on the efficiency of daily operation. Others take the SEEMP legislation in the spirit it was intended; to help owners and operators reduce costs, as well as emissions.

In the context of reducing the fuel consumption of the generators, consequently the ship equipment, the SEEMP is highly relevant with regards to operational measures carried out for ship equipment. Especially relevant are the measures aimed to improve operation of ship equipment, measure 4.2 (Equipment and Systems) and all measures in group 6 (Energy conservation and awareness). The benefits of the SEEMP can be documented by monitoring the measures and validating the savings as a result of the measures. As mentioned, the recommended method of monitoring the measures of the SEEMP is the EEOI, which will be addressed in the coming section.

1.2.3 ENERGY EFFICIENCY OPERATIONAL INDICATOR (EEOI)

As was the case for the EEDI, the Energy Efficiency Operational Indicator (EEOI) calculates the CO_2 per unit of transport work. However, the EEOI quantifies the energy efficiency in terms of actual CO_2 emissions per unit of transport work as it is influenced by the operational features of the ship, not the design features as for the EEDI.

The EEOI is calculated by formula 3 [8]

FORMULA 3: ENERGY EFFICIENCY OPERATIONAL INDICATOR [EEOI]

$$\mathrm{EEOI} = \frac{\sum_j FC_j \cdot C_{Fj}}{m_{cargo} \cdot D}$$

Where:
FC_J = The mass of fuel consumed of type *j* [ton]
C_{FJ} = The fuel mass to CO_2 conversion factor for fuel *j* [g/ton]
m_{CARGO} = The cargo carried or work done [tons/TEU/PAX]
D = Distance corresponding to cargo carried [nm]

Where average of the indicator for a period (i), or for a number of voyages, is calculated by formula 4 [8]

FORMULA 4: ENERGI EFFICIENCY OPERATIONAL INDICATOR, AVERAGE

$$\text{Average EEOI} = \frac{\sum_i \sum_j (FC_{ij} \cdot C_{Fj})}{\sum_i (m_{cargo,i} \cdot D_i)}$$

It is recommended in the SEEMP guidelines that the rolling average of the EEOI can be used to monitor the impact of the measures implemented in the SEEMP. It is probable that some of the SEEMP measures mentioned in figure 4, like optimized ship handling, hull and propeller optimizations and fuel efficient operations will have an effect and impact on the EEOI that is measurable. However, it is unlikely that improved operation of ship equipment powered by the generators will be easily measured by using the rolling average of the EEOI. Improved operation on several components powered by the generators may be measured by the EEOI, but the individual impact and effect would be impossible to discern. In addition, it would be vain to use the EEOI in order to validate and identify inefficient or efficient operation of ship equipment.

1.3 OBJECTIVES

Norwegian Shipowners' Association (NSA) ambitious environmental vision is that Norwegian shipping and the offshore contracting industry shall not release environmentally harmful emissions into the sea or the air. In line with this vision, the main goal of the EMIP project is enabling a robust knowledge and innovation platform related to energy efficiency on ships, with rational utilization of limited resources and a strong focus on verification of practical energy efficiency measures, contributing to increasing Norwegian shipping's competitive edge and the environmental performance.

The fuel consumption of the generators, consequently the ship equipment, accounts for a significant part of the total fuel bill for the LPG carriers of Solvang ASA. Optimizing the operation of the ship equipment will benefit in the work to reduce the fuel consumption, increase the competitive edge and environmental performance.

In accordance with their mission statement and their effort to increase the operational performance of ship equipment and to establish a proper SEEMP, Solvang ASA has set the following objectives:

- Establish an overview of the operation and operation costs for all ship equipment – Establishing the operation and the resulting operation costs for ship equipment is to provide a foundation for selecting equipment for further investigated with regards to performance.
- Carry out an analysis of ship equipment which by is operated with varying degrees of efficiency. Equipment that is found to be operated inefficient can then be implemented in the SEEMP.
- Establish a basic report in which the crew and onshore employees can validate the performance of ship equipment operation.
- Review the use of Kongsberg Ship@Web to automate the process of monitoring ship equipment and establish an equipment operation and performance report.

The aim of this thesis is to map the operation and operation costs of ship equipment. The results are to be used as a platform to identify efficient and inefficient operation of ship equipment and provide the background for a performance analysis for selected equipment.

The results of the performance analysis are to include potential savings. In addition, an equipment performance report which can be used to monitor and provide data for both crew and onshore employees, is to be established. The report is to include the overall operational parameters of the vessel related to operation of the equipment, which can be used to discuss the results of the findings.

1.4 SCOPE OF WORK

The work carried out in this thesis includes nine LPG carriers operated by Solvang ASA, compromising six LGCs and three VLCGs. Among the nine vessels there are four different designs, whereas sister vessels are marked by color in table 3.

TABLE 3: MAIN SPECIFICATIONS

VESSEL	L.O.A [m]	MAIN ENG. [kW]	AUX. ENG. [kW]
X1-1	205	10150	3600
X1-2	205	10150	3600
X1-3	205	10150	3600
X2-1	205	11275	3990
X2-2	205	11275	3990
X2-3	205	11275	3990
X3-1	227	12270	3600
X3-2	227	12270	3600
X4	225	13350	5400

For instance, vessel X1-3 indicates that the vessel is the third vessel of vessel group 1. Vessel X4 is unique and will be referred to as the X4-vessel or vessel X4-1. Due to the fact that the vessels are anonymous, detailed specifications of the vessels will not be given in the report. Vessel names are found in the appendix, which is restricted and will only be available upon request and confirmation.

All ship equipment powered by electricity generated by the generators of the vessels is to be included, looking at the period of 2009-2012, with the following conditions:

- Data are available (Running hours and equipment specifications)
- The equipment is solely powered by electricity generated by the generators and not external energy sources. Ship equipment like incinerator and boiler will thus not be studied as the main source of energy is fuel.

Ship equipment with no operational data or specifications is not to be included as the operation and operation costs would have to be entirely assumed. The data used in order to solve the objectives will be taken from the database of Solvang ASA.

All the results are to be the property of Solvang ASA. Due to confidentiality, all results and vessels described in this thesis are anonymous, except for the results given in the appendix. The appendix is only available upon request and confirmation from the author and/or Solvang ASA.

2. TOTAL EQUIPMENT MONITORING

The first part of this study aims to map the operation and operation costs of the ship equipment powered by the generators. This includes all ship equipment on the nine vessels in the scope of this study using electricity generated by the generators, hereafter called *components*, such as fans, compressors, pumps and electronic equipment. Boilers and incinerators are therefore not included, even though this equipment in its own respects is common ship equipment.

Establishing operation for all components on nine modern and advanced LPG carriers for 2009-2012, requires a substantial amount of data. In order to provide an easy overview of how the analysis is carried out, the data gathering and the parameters included are done stepwise, as discussed below:

1. **Vessel operation** – The operational performance of the components will differ by several parameters with regards to the overall operation of the vessel, such as operation profile, sea conditions and type of cargo. To provide a complete overview, these factors must be accounted for in order to review the data properly.
2. **Establishing components** – The components included must be established and relevant specifications included.
3. **Establishing operation of components** – Having data on the running hours of the components and the possibility of comparison, especially between sister vessels, is essential. Currently, the only data available for Solvang ASA and the crew is the total running hours for the equipment fitted with hour-meters (counters), throughout the lifetime of the vessel.
4. **Generator operation**– The components are powered by electricity generated by the generators. As the engine specifications and the specific fuel consumption of the generators differ, the generators must be reviewed.
5. **Model for calculating operation cost of components** – Knowing the running hours makes for easy overview and comparison, but as some components consume far more power than others, the running hours alone provides limited information. For small consumers, 50 hours of operation is negligible when looking at operation costs, but for heavy consumers like cargo compressors, a difference of 50 hours is not negligible. Expressed in costs, the operation is easier understood and communicated.
6. **Accuracy validation test** – A validation of the calculated operation cost should be carried out in order to determine whether the results can be viewed as accurate.
7. **Discussion of model –** Discussion of the main sources of error using the model is reviewed.

Vessel operation, components and generators have been reviewed before establishing the model for estimating operation cost in order to determine which data is available. Having set the model, an accuracy validation test is performed.

All data for the vessels have been gathered from Solvang ASA and the data and the model proposed in this chapter, will form the foundation for the rest of the work carried out in this report.

2.1 VESSEL OPERATION

The operation of the components is dependent on the operation of the vessel as a whole. A direct comparison of components on vessels shipping ammonia, as opposed to ethylene, is vain as ethylene requires more cooling due to the properties of the products. Moreover, a vessel that has spent the major time idle or off-hire would likely be less efficient overall than a vessel trading continuously. The overall operation parameters affecting the operation of the components must thus be included to properly validate and discuss the results.

The main parameters to be included in order to compare overall operation are:

- **Operation profile-** [Loaded, Ballast, Maneuvering and Port]
- **Cargoes carried and which type –** The cargoes which can be shipped by the LPG carriers of Solvang ASA are as follows: Ethylene, Ethane, Butene/-diene, Propane, Propylene, Crude C4, n-Butane, ISO-Butane, Ammonia and Propane+Butane [9]. None of the vessels in the scope of this report can carry ethylene or ethane.
- **Fuel consumption and which type –** The type and amount of fuel consumed by the generators must be included, as the different fuels have variations in Net Calorific Value (NCV) [MJ/kg]. Solvang uses a variation of Heavy Fuel Oil (HFO), Low Sulphur Heavy Fuel Oil (LSHFO) and Marine Diesel Oil (MDO) in compliance with regulations.

As discussed above, both operation profile and type of cargo must be included to provide an overview of the vessels' overall operation. In addition, the registered fuel consumption of the generators must be included, as the task is to determine where this fuel has been used and by which component. Ideally, the following could also be included;

- **Seawater temperature**– Seawater temperature has an impact on both the cooling system for the main machinery and the cargo system. A higher seawater temperature will result in more operation of the cooling pumps.
- **Environmental conditions –** Sea and wind conditions will affect the overall operation of the vessels. Air temperature also will affect the operation of the cooling fans, such as the supply fans for the engine room.
- **Sailed distance** – The sailed distance and at which speed heavily affects the operation of the main engine and the components in the main engine support systems.

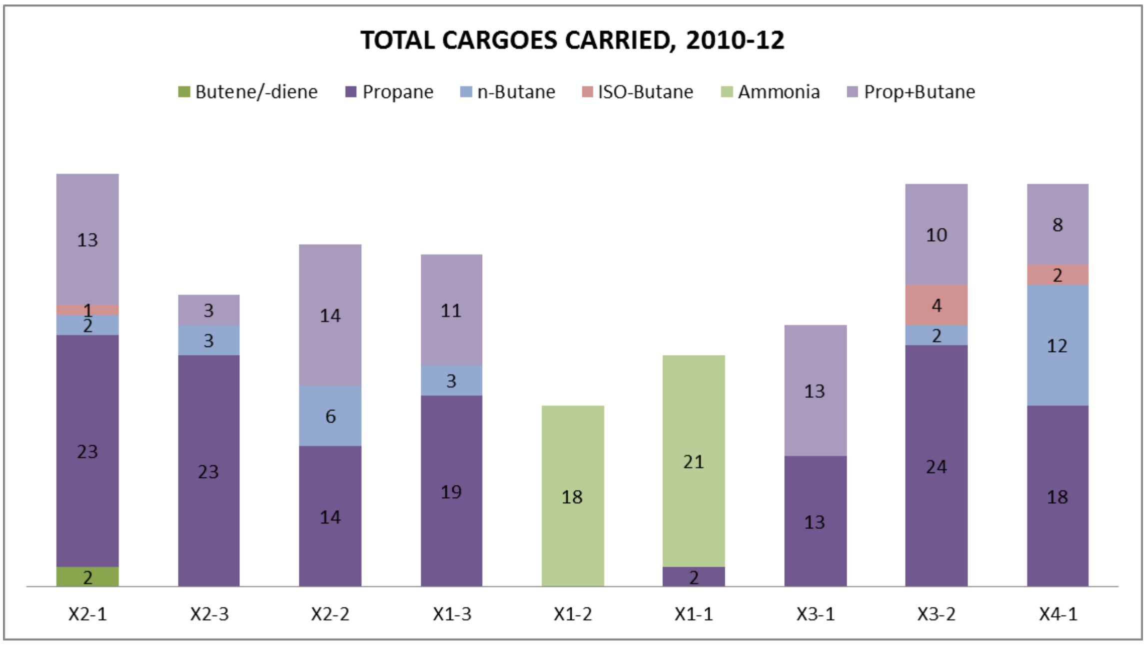
The above parameters have been omitted in this study. Seawater temperature will have an impact that is not to be looked upon as negligible, but this data is not available. Estimations could be made, but would have required that operation of the cooling pumps to be compared with the areas where and when they were used, likely producing inaccurate results. Environmental condition is registered by Solvang, but is assumed to have no major effect for the components. Sailed distance could be used when referring to the operation and performance of the main engine and the main engine support systems, but as the trade routes differ, looking at the running hours of the main engine would be more accurate when looking at performance of these components. With this, the overall parameters to describe the overall vessel operation are:

- Cargoes carried and type
- Operating profile

- Fuel consumption and type

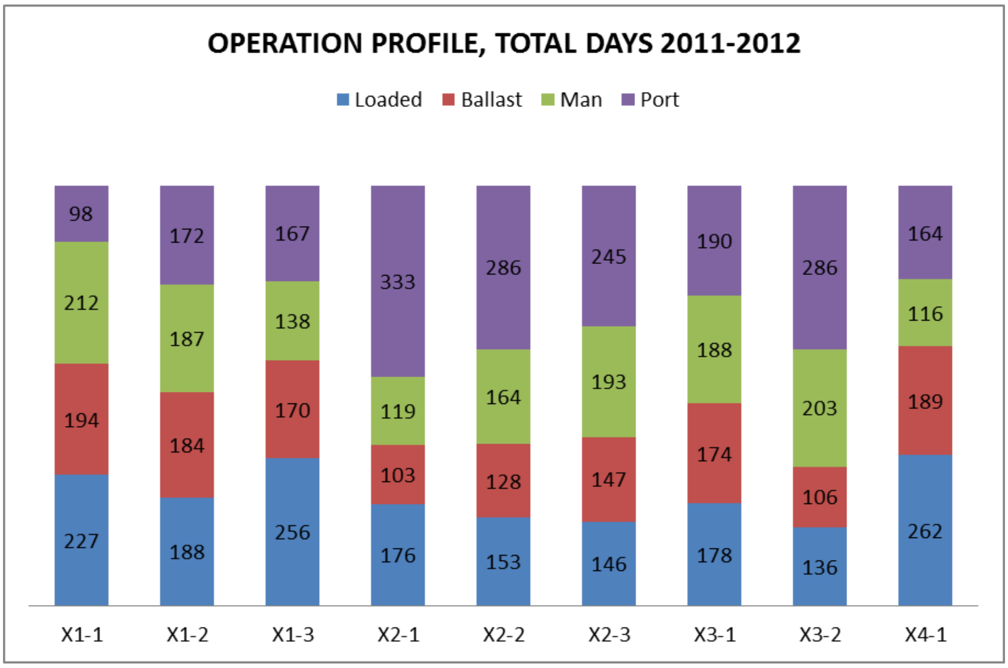
This data should be used as a reference and a source of discussion for the results of the component operation and operation costs.

FIGURE 5: CARGOES CARRIED, 2010-2012 [14]



The cargoes and of which type shipped in total for 2010-2012, are illustrated in figure 5. Vessel X1-2 and X1-1 are shipping mainly ammonia and the other vessels are shipping mainly propane and butane. The cargoes shipped for each year respectively, can be found in appendix 2.

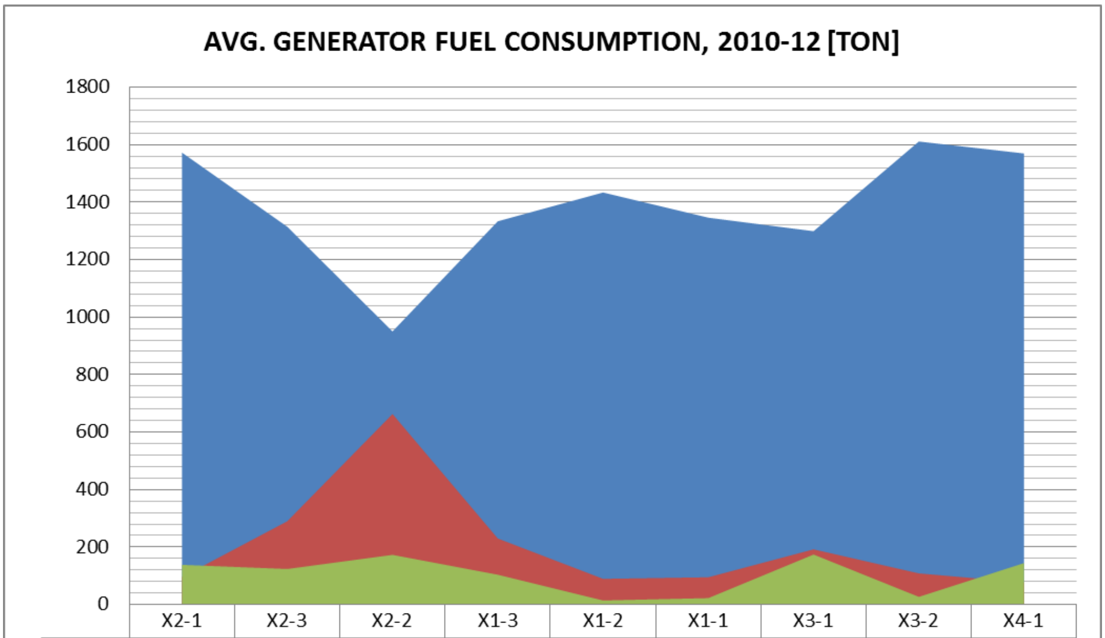
FIGURE 6: OPERATION PROFILE, 2011-2012[14]



The operation profile for the vessels in total days, 2011-2012, is given in figure 6. 2010 was omitted from the figure, as days spent in maneuvering were not registered before 2011, as well as vessel X4-1 coming under technical management in 2010. The operation profile on a yearly basis can be found in appendix 3.

In figure 7, the average consumption in 2010-2012 of the generators for the different fuels is given. In the context of generators, the amount of MDO used is important, as MDO has a higher NCV than LSHFO and HFO. HFO and LSHFO are estimated as having a NCV of 40 [MJ/kg] and MDO 42 [MJ/kg] [10]. Vessel X3-1 and X2-2 are the heaviest consumers of MDO, which is a result of their trade route and regulations in these areas.

FIGURE 7: AVERAGE GENERATOR FUEL TYPE CONSUMPTION, 2010-2012 [14]

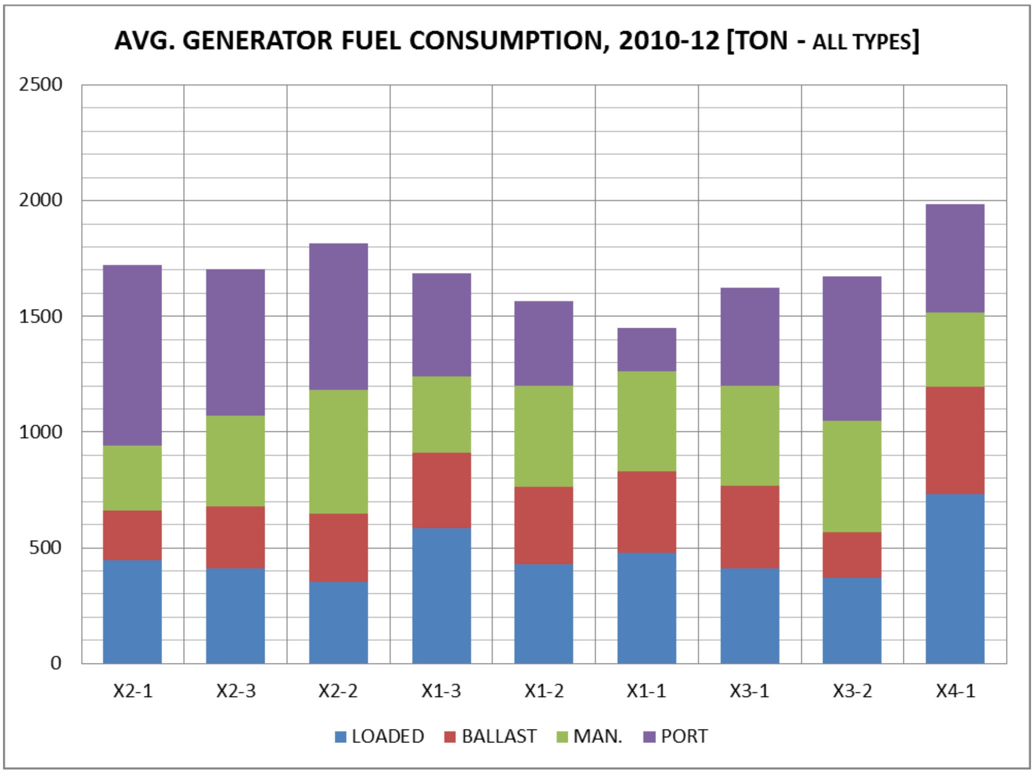


	X2-1	X2-3	X2-2	X1-3	X1-2	X1-1	X3-1	X3-2	X4-1
HFO	1572	1314	950	1333	1434	1346	1299	1611	1569
LSHFO	96	290	663	230	90	95	192	108	77
MDO	138	124	173	104	14	22	174	27	144

In addition to the consumption of the different fuels, Solvang also registers the consumption of fuel in different operation profiles. This can be of interest when looking at the estimated fuel consumption of some of the components which are used in specific modes, like the main cargo pumps used for offloading in port. The average consumption of fuel with regards to operation profile can be found in figure 8.

The yearly data on types of fuels used each year, 2010-2012, can be found in appendix 4 and the consumption with regards to the operation profile can be found in appendix 5. Having set all the parameters describing the overall vessel operation, the components can now be addressed.

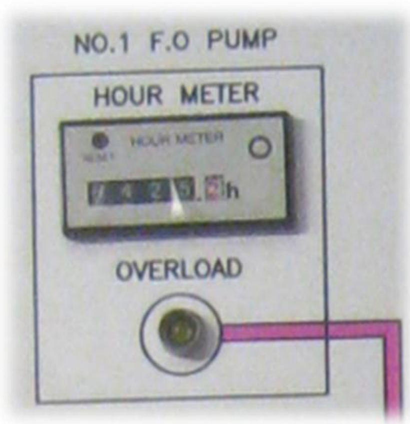
FIGURE 8: AVERAGE GENERATOR FUEL CONSUMPTION, PROFILE 2010-2012 [14]



2.2 ESTABLISHING COMPONENTS

The components where operation data is available are the components which are fitted hour-meters, hereafter referred to as *counters*. The counters measure the total running hours of the components, which are registered in the maintenance software in order to plan maintenance.

FIGURE 9: HOUR METER/COUNTER



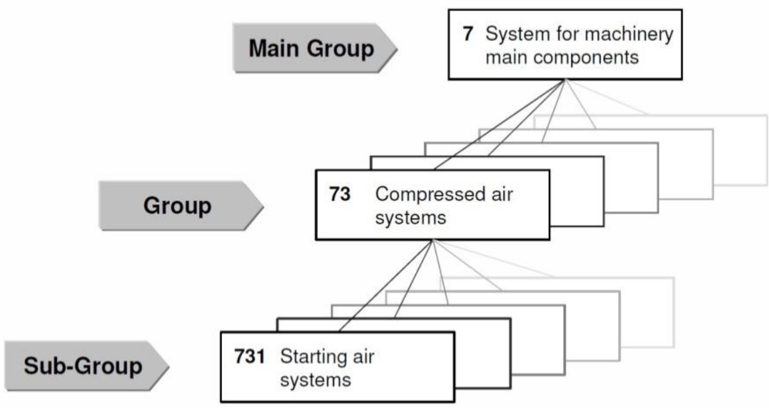
In figure 9, the counter of the fuel oil pumps of vessel X1-1 is shown. The extent of equipment fitted with counters will vary greatly between vessels of different types, build and age. Solvang's vessels, which are both technically advanced and modern, have counters fitted for the majority of the equipment. For vessel X1-1, there are 119 components of 164 fitted with counters, giving 73%. Counters are usually fitted for the heaviest consumers and components with a power output rated at more than 400 [W].

The operation of components not fitted with counters has to be estimated entirely and thus only the components fitted with counters are included in this study. However, in the accuracy test carried out for the X1-vessels, the components not fitted with counters will be estimated in chapter 2.6.1.With only components fitted with counters to be included, the complete list of equipment registered in the maintenance software, which is Star IPS, was pulled for all the vessels. The maintenance software provided the following information on each component:

- **Description –** Short description of the component.
- **Technical account number** – SFI code for component
- **Unique code –** A unique code for each component is provided. This code is essential for linking the correct component to the corresponding registered running hours registered in the database.

A total of 1046 components for the nine vessels were pulled from the Star IPS maintenance system. The technical account number is based upon the SFI grouping system, which can be used to group the components into standardized system and subsystems in which the components belong to. This will prove valuable when looking at operation and operation costs for systems and subsystems.

FIGURE 10: SFI GROUPING SYSTEM [15]



The SFI grouping system is illustrated in figure 10. The first number relates to the main group, whereas the two and three first numbers give the group and subgroup, respectively. The sub-group has been omitted, as it covers more than 200 different subgroups. The SFI-grouping system can be found in attachment C4. SFI *main group* and *group* will hereby be referred to as *system* and *subsystem*.

Table 4 shows the setup for code, IPS (technical account number) and description for some components of vessel X1-2. As can be seen in the figure, redundant and/or multiple components have been grouped under one name in the group description. This is done due to the fact that the crew alternates between using similar components and thus the total operation of a component group must be summed.

TABLE 4: SELECTED COMPONENTS

CODE	VESSEL	IPS	DESCRIPTION	GROUPED DESCRIPTION
1990104584	X1-2	351.01	CARGO MAIN PUMP 1 S	CARGO MAIN PUMP
1990104585	X1-2	351.02	CARGO MAIN PUMP 1 P	CARGO MAIN PUMP
1990104586	X1-2	351.03	CARGO MAIN PUMP 2 S	CARGO MAIN PUMP
1990104587	X1-2	351.04	CARGO MAIN PUMP 2 P	CARGO MAIN PUMP
1990104588	X1-2	351.05	CARGO MAIN PUMP 3 S	CARGO MAIN PUMP

The database with the overview for the components can be found in attachment C4.

When the components of the vessels have been established, the power ratings of the components were added [19]. This data was found in the Electric Load Analysis (ELA) in the technical documentation of the vessels, or in the technical folder for the specific equipment. The ELA is an overview of the power consumers and is used to determine the load of the generators in different operation profiles. The ELA provided the following data on the components:

- Rated/Nameplate power [kW]
- Efficiency [%]
- Load factor [%]

The rated power output, sometimes labeled the nameplate power, is the maximum output power of a component. This represents the rated output when the motor is loaded to rated torque at rated speed. Efficiency is defined as the ratio of the power output divided by the power input. Machine losses are in the form of heat, and include stator winding loss, rotor loss, core loss (hysteresis and eddy current), friction and stray load loss [19]. The power output and efficiency of the components have been obtained by shop test of the equipment and can thus be deemed accurate.

Dividing rated power by the efficiency gives the mean input of the electrical motor powering the component. Mean input gives the average power consumed by the electrical motor when operating on full load in optimal conditions. However, as the components are not always running at full load under optimal conditions, this has to be corrected for when looking at the mean input over a period.

In the ELA, load factor is given for the components. Load factor is defined as the ratio between the average load demand and the maximum demand during a certain period. Thus the load factor will always be lower than 1, given by formula 5.

FORMULA 5: LOAD FACTOR

$$f_{load\ factor} = \frac{Average\ load\ [kW]}{Maximum\ load\ [kW]}$$

Where:
Average load [kW] - The average load measured in the given testing period
Maximum load [kW] - The maximum load measured in the given testing period

Whereas electrical engineering usually operates with power factor, defined as the real power/usable power divided by the apparent power, the yards and/or manufacturers have used load factor to describe the load of the components. The benefit of using a load factor is that the average load over the testing period is given, which likely reflects the operation better than a fixed load. However, there is no information given about the length of the testing period.

The load factor for the components has been estimated either shop tests or initial vessel tests, which may not reflect actual operating conditions. The load factor for the components has been discussed with both crew and vessel managers of Solvang, but will nonetheless prove a source of error. Knowing the load factor as a source of error, the load factors proposed in the load analysis will be used in order to estimate the mean input of the components. Exceptions to this are discussed in the coming subchapters.

A selection of equipment and power ratings is given in table 5 [19].

TABLE 5: SELECTED POWER RATINGS

			POWER RATINGS		
CODE	VESSEL	DESCRIPTION	P [kW]	EFF. [%]	LF [%]
1990104584	X1-2	CARGO MAIN PUMP 1 S	330	96 %	82 %
1990104585	X1-2	CARGO MAIN PUMP 1 P	330	96 %	82 %
1990104590	X1-2	CARGO MAIN PUMP 4 S	330	96 %	82 %
1990104594	X1-2	CARGO COMPRESSOR S (O)	270	94 %	82 %
1990104595	X1-2	CARGO COMPRESSOR S (I)	270	94 %	82 %

For components that have a definitive source of error, the load factor proposed has been changed, based on input from crew and vessel managers at Solvang. The components that have been changed are marked with yellow. The complete list of components with power ratings can be found in attachment C4.

2.2.1 SERVICE AND CONTROL AIR COMPRESSORS

The service and control air compressors are listed with a 78% load factor originally. This load factor applies when the compressor is in use. However, the service and control air compressors are usually running in idle mode. The running hours registered for these compressors include idle-mode, thus the load factor must reflect this. The load factor has been altered to 20% based on input from the crew.

2.2.2 STEERING GEAR PUMPS

The steering gear pumps are listed with a load factor ranging between 25-50% [19]. As the vessels in this study have deep-sea trade routes, with little time spent maneuvering overall, the load factor of the steering gear pumps have been set to 30%. Exceptions have been made for the vessels fitted with three steering gear pumps of lesser power. The load factor for the vessels with three steering gear pumps have been set to 60%, as given in the ELA. The steering gear pumps are further analyzed in chapter 3.2.

2.3 ESTABLISHING OPERATION

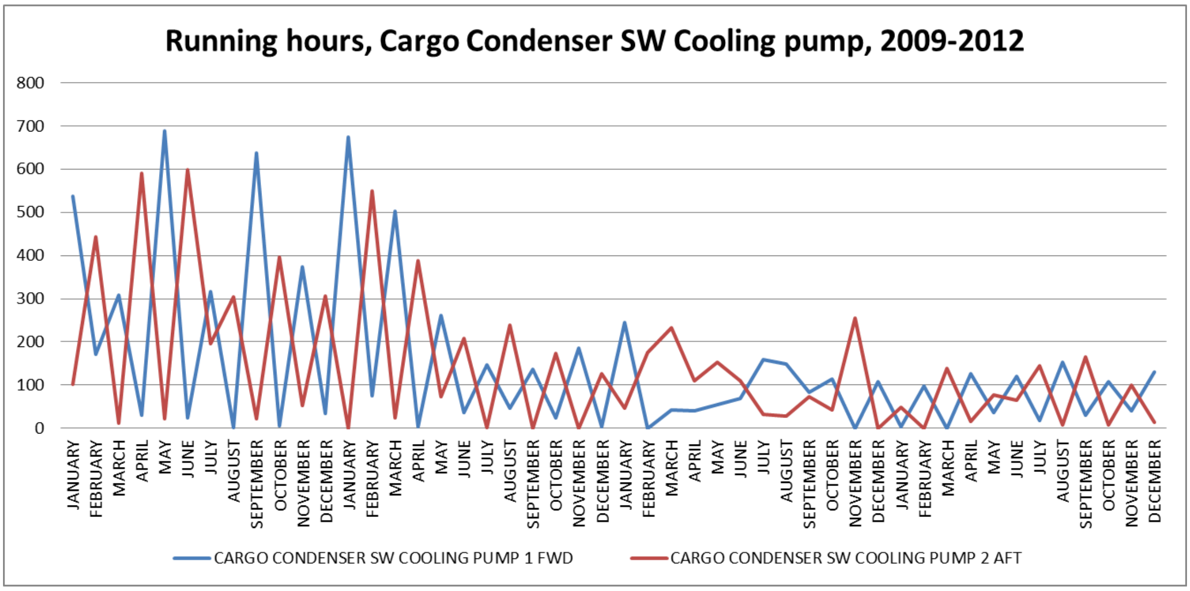
Having established the components, the operation and the registered running hours of the components can be found in the Star IPS maintenance system. The running hours for the component are registered every month by the vessels electrician.

The Star IPS database does not allow sorting, so the entire database of running hours for all equipment on Solvang's vessels had to be pulled from the database. The data was then sorted on the nine vessels for the years 2009-2012, based on the unique code and registration date. The running hours are not always registered at the end of the month as specified, or at all, which can prove an issue for the accuracy of comparing equipment. The following method was used to extract the monthly running hours and link them up with the corresponding component, to provide the best results:

- A script linking the components with the running hours for the corresponding component for every month, 2009-2012, was made. The components were linked on the basis of the unique component code.
- In order to deal with the issue of components not registered at the end of each month, a sensitivity of 3 days was put into the script. In effect, if the component was registered within three days of the specified end date of each month, it was registered. If not, that value for that month was left blank.
- The counters are sometimes reset. Negative values were blanked.

Having linked up with the correct component, the operation of all components fitted with counters can now be addressed and compared. The database of running hours can be found in attachment A2. In figure 11, an example of running hours of the cargo condenser seawater cooling pumps of vessel X1-1 is given.

FIGURE 11: RUNNING HOURS, CARGO CONDENSER PUMP



As can be seen in the figure, the crew alternates between using redundant and/or multiple components, so that one component is not run significantly more than the other. This is due to maintenance planning. As mentioned in the previous chapter, this is the reason that multiple components were grouped together under a grouped description.

2.4 GENERATOR SPECIFICATIONS

An important parameter when calculating the operation costs of the components are the generators, as they are powering the components and thus are the source of the fuel costs. To provide an estimate of the power consumption and consequently the fuel consumed by a component, the generator producing the power for the component is crucial. In order to link power consumption with fuel consumption, the Specific Fuel

Consumption (SFC) of the generators is needed. The manufacturer, model and power output on the installed generators installed are depicted in table 6.

TABLE 6: GENERATOR OVERVIEW

VESSEL	MANUFACTURER	MODEL	GENSETS
X1-1	Hyundai-B&W	8H21/32	3x1200kW
X1-2	Hyundai-B&W	8H21/32	3x1200kW
X1-3	Hyundai-B&W	8H21/32	3x1200kW
X2-1	MAN B&W	8l23/30h + 5l23/30	2x1470kW+1x1050kW
X2-2	MAN B&W	8l23/30h + 5l23/31	2x1470kW+1x1050kW
X2-3	MAN B&W	8l23/30h + 5l23/32	2x1470kW+1x1050kW
X3-1	Hyundai-B&W	8H21/32	3x1200kW
X3-2	Hyundai-B&W	8H21/32	3x1200kW
X4-1	MAN B&W	6L28/32H	4x1260kW

All the vessels have three generators, except the X4-vessel, which has four. The X2-vessels are fitted with a smaller generator, which is practical is it makes it possible for the crew to use this generator at a higher load if not the full load of the other generators are needed. This can benefit in having more efficient generator operation with respects to a more efficient SFC [g/kWh].

However, with the data available it is not possible to discern from which generator the components are powered and thus the SFC X2-vessels will be simplified to the SFC of the larger generators.

2.4.1 SPECIFIC FUEL CONSUMPTION

Among the nine vessels, the generators are delivered by two different suppliers and there are three different models. With specifications being unique for each model, the SFC of the different models must be calculated in order to provide accurate results.

Engine manufacturers are required to test generators to provide an estimate of NOx emissions in g/kWh [10]. The input found the shop test can be used in order to calculate the specific fuel consumption of the generators. The shop tests include the following:

- **Specific fuel consumption** – The shop tests of the generators specify the kg/h and g/kWh of fuel used at 100%, 75%, 50% and 25% load.
- **Generator efficiency –** Calculated on the basis of shaft power and produced power
- **Specific energy of fuel** – The Net Calorific Value (NCV) is relevant as it varies for the different fuels. The fuel used in the shop test is usually MDO.

In the shop test the final specific fuel consumption [g/kWh] has been adjusted to ISO-conditions, which reflects parameters such as temperature, pressure, humidity for scavenging air and fuel, but has not been included in this study as the ISO-conditions are only given for 100% load [19]

The specific fuel consumption, measured by shaft power, is given in the shop test, as is the generator efficiency. By dividing the specific fuel consumption for shaft power with generator efficiency, the specific fuel consumption for the generator of the power produced is obtained.

Formula 6 is used to calculate the specific fuel consumption for the generators for produced power. In other words, the fuel needed to produce an corresponding amount of power.

FORMULA 6: SPECIFIC FUEL CONSUMPTION, PRODUCED POWER

$$SFC_P = \frac{SFC_S}{\eta_G} \cdot \frac{NCV_{ST}}{NCV_O}$$

Where:
SFC_P = Specific fuel consumption, produced power [g/kWh]
SFC_S = Specific fuel consumption, shaft [g/kWh]
η_G = Generator efficiency [%]
NCV_{ST} = Net calorific value of fuel used at shop test [MJ/kg]
NCV_O = Net calorific value of fuel used in operation [MJ/kg]

The vessels are laden with three kinds of fuel, used according to regulations enforced in areas where the vessels trade; HFO, LSHFO and MDO. Specific amount of fuel used for each year, 2010-2012, can be found in appendix 4. The fuel used in the shop test is usually MDO with a NCV of around 42 [MJ/kg]. Solvang's vessels use HFO/LSHFO, commonly rated at 40 [MJ/kg], as well as MDO rated at 42 [MJ/kg] [10]. The relationship in produced power using the different fuels has been estimated as linear [10]. With this, all data needed to use formula 6 to calculate the specific fuel consumption for the generators have been obtained. The full data used can be found in appendix 6.

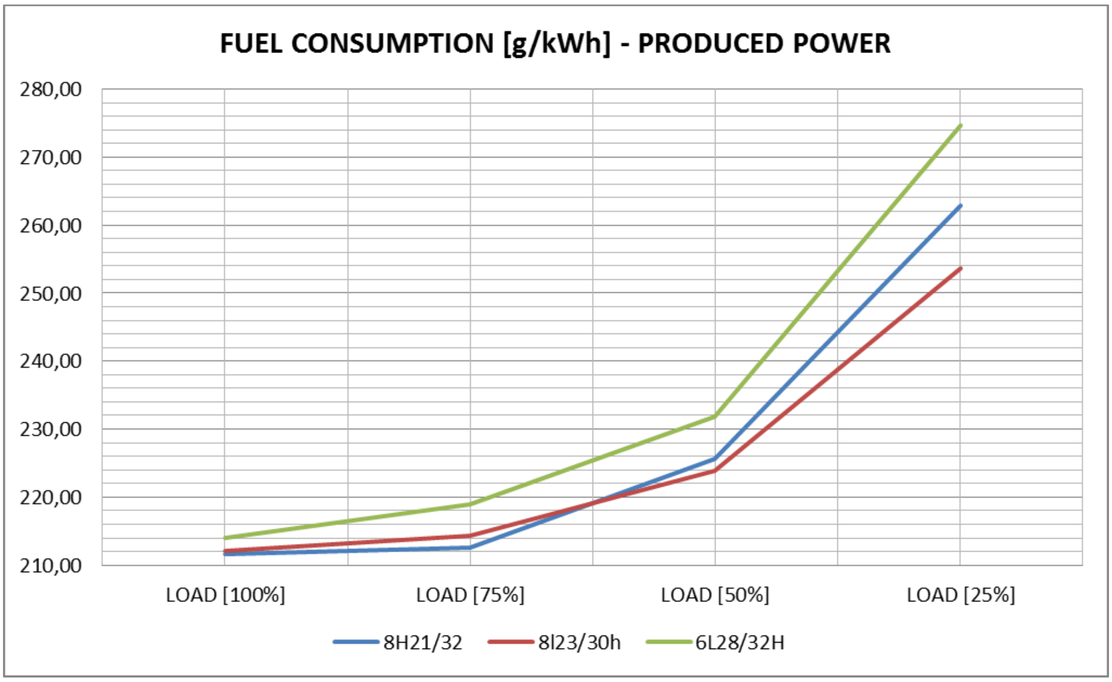
The necessary input found in the shop tests for solving the formula and obtaining an estimate of the fuel consumption with regards to produced power, is found in table 7.

TABLE 7: GENERATOR SPECIFICATIONS

	HIMSEN 8H21/32			9L28/32H			6L28/32H		
TEST BED	**100 %**	**75 %**	**50 %**	**100 %**	**75 %**	**50 %**	**100 %**	**75 %**	**50 %**
Shaft power [kW]	1280	960	640	2079	1559	1040	1050	787,5	525
Generator power [kW]	1233	927	617	2000	1497	991	1008	758	508
Efficiency [%]	0,96	0,97	0,96	0,96	0,96	0,95	0,96	0,96	0,97
Shaft, fuel cons. [g/kWh]	194,2	195,6	207,2	192,4	194	201,1	193,8	198,7	211,4
NCV fuel [MJ/kg]	42,0	42,0	42,0	42,4	42,4	42,4	42,4	42,4	42,4
OPERATION - PRODUCED	**100 %**	**75 %**	**50 %**	**100 %**	**75 %**	**50 %**	**100 %**	**75 %**	**50 %**
HFO, 40 MJ/kg, [g/kWh]	211,7	212,6	225,7	212,1	214,4	223,8	214,1	219,0	231,8
MDO, 42 MJ/kg, [g/kWh]	201,6	202,5	214,9	202,0	204,2	213,2	203,9	208,5	220,7

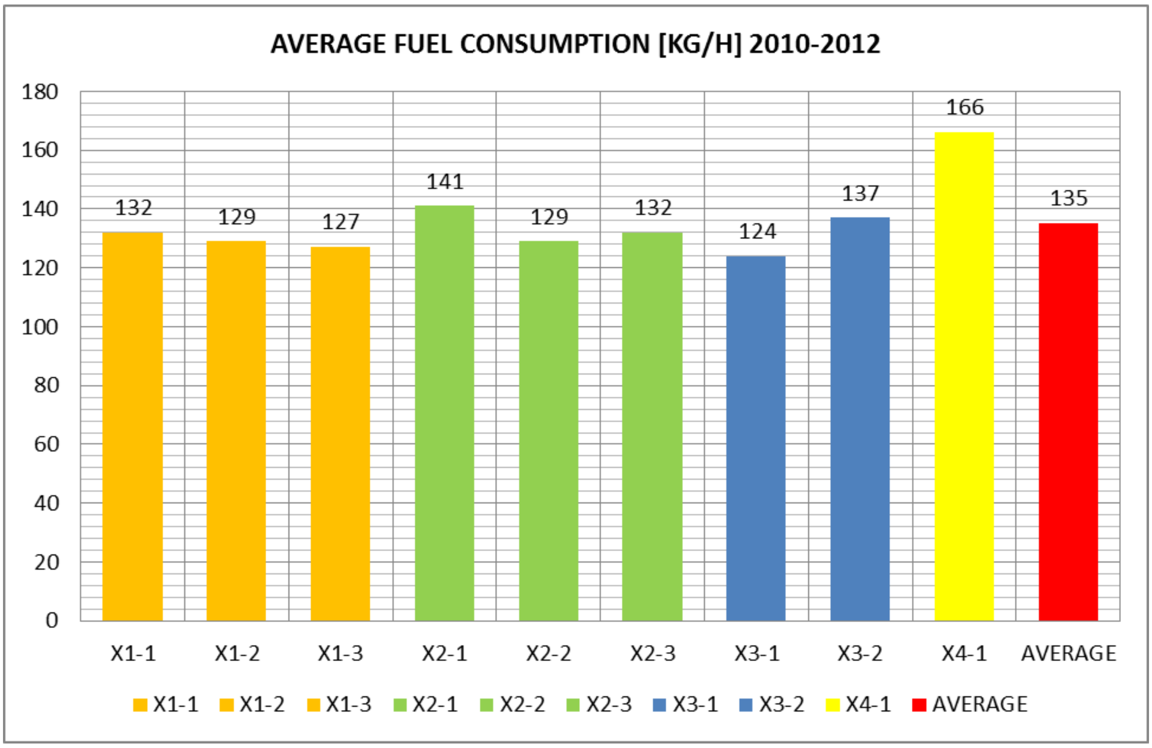
Figure 12 shows the specific fuel consumption of the different generator types found in the vessels part of this study. It should be noted that the results are for *produced power*, thus giving the fuel used to produce one kilowatt-hour.

FIGURE 12: FUEL CONSUMPTION, PRODUCED POWER



In figure 12, the SFC of the generators at different loads is illustrated. The optimal load can be found in 75-100% load condition. In order to estimate the average load of the generators, historical data on running hours and fuel consumption of the generators must be studied. Using the total registered fuel consumption and running hours for the generators in 2010-2012, yields the results found in figure 13 [14].

FIGURE 13: AVERAGE FUEL CONSUMPTION, GENERATORS [14]



From figure 13, the average fuel consumption of the vessels is 135 kg/h. By comparing these results with the fuel consumption measured by load in the shop tests for the generators, this translates to an average generator load of 50%. Using the model proposed in this report, the operation costs is calculated based on the power consumption [kWh] and the fuel consumption of the generators to produce the corresponding amount of power. Thus, in order to estimate the operation costs for the equipment, the specific fuel consumption of the generators will have to be set at 50% load.

Table 8 shows the results for the vessels, where the nearest load have been marked with yellow. Vessel X4-1 performs close to 75% average load, but as this vessel came under technical management by Solvang in 2010, there are fewer years with data on this vessel.

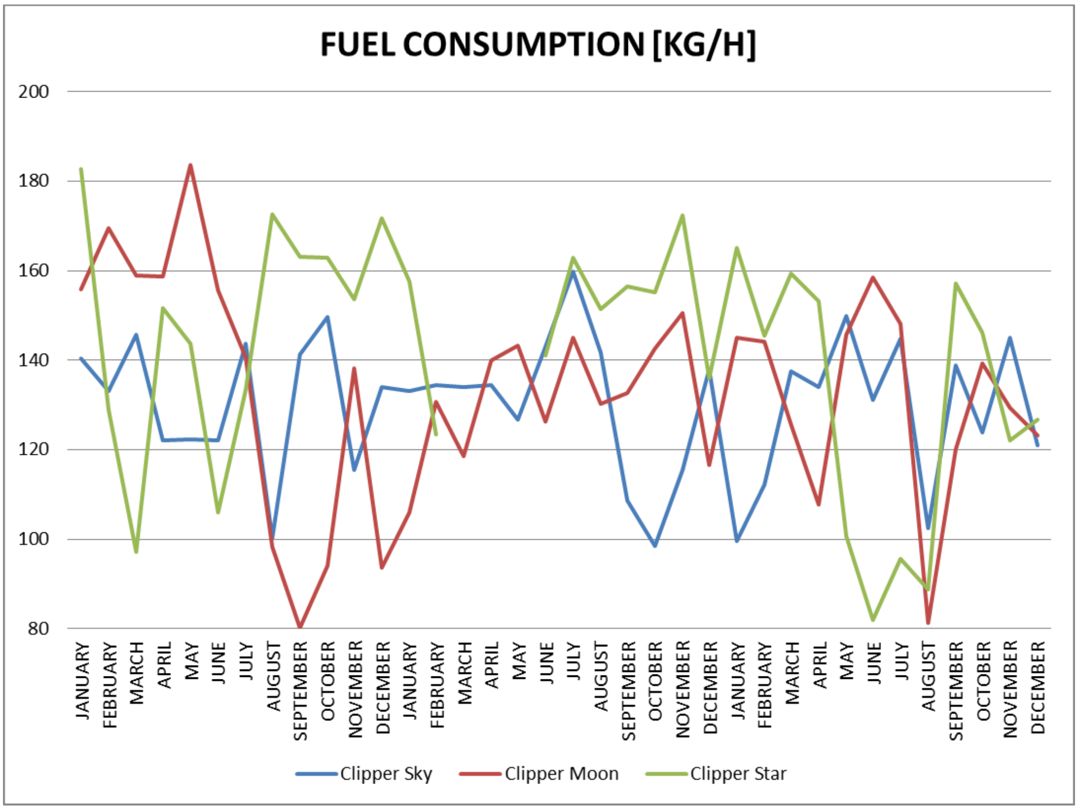
TABLE 8: FUEL CONSUMPTION IN OPERATION/THEORETICAL

	8H21/32	8H21/32	8I23/30h	6L28/32H
VESSEL GROUP	**X1**	**X3**	**X2**	**X4**
AVG. 2010-2012 [KG/H]	**129,8**	**130**	**134**	**166**
Fuel consumption [kg/h] - 100%	233,06	233,06	282,76	244,2
Fuel consumption [kg/h] - 75%	176,06	176,06	213,85	187,8
Fuel consumption [kg/h] - 50%	124,31	124,31	147,78	133,2
Fuel consumption [kg/h] - 25%	71,06	71,06	81,20	77,52

However, even though the generators have a load factor that on a yearly basis is similar, there are large fluctuations on a month to month basis. This is a natural result of operating conditions, where the load of the generators will be high when much power is needed and lower otherwise, such as the vessel operating in loaded or in ballast condition. An example of the fluctuations in load of the generators is given in figure 14, where the load for the X2-vessels is given monthly for 2010-2012.

The volatility of the load on a monthly basis indicates that it would not be accurate to use generator consumption as a basis for cost estimations on short periods, as well as explain variations in load for generators in a short period of time.

FIGURE 14: GENERATOR LOAD VOLATILITY



When calculating the EEDI index the engine specific fuel consumption is that recorded on the test report included in a NOx technical file at the engine(s) 50% of MCR power or torque rating [5]. In compliance with the EEDI-index calculations and the observed load of generators measured in kg/h, the specific fuel consumption for produced power for the components for the generators will be set at 50% load.

However, using a fixed SFC will result in source of error for the heaviest consumers. The compressors, being the heaviest consumers on the vessels, will consume the lion's share of the power produced when they are running. The problem by measuring the average generator load in kg/h is that the amount of produced power is not taken into account.

In order to get the correct estimation of fuel consumption for components, the specific fuel consumption of the generators for when the components was used, is needed. With the data available, this is not possible. Taking into account that the heaviest consumers will put a higher load on the generators, resulting in a more efficient SFC, the following component are calculated with a 75% SFC [10]

1. Cargo compressors (Heaviest consumer)
2. Cargo seawater cooling pump (Used together with the compressors)
3. Deepwell pumps (The deepwell pumps are used when offloading cargo, producing peak loads)
4. Bow thruster (The bow thruster, rated above 1000kW for all vessels, will produce peak load)

TABLE 9: FUEL CONSUMPTION FOR ESTIMATIONS, PRODUCED POWER

		HFO/LSHFO [40 MJ/kg]		MDO [42 MJ/kg]	
VESSEL	TYPE	HC	LC	HC	LC
X1-1	8H21/32	212,6	225,7	195,6	207,2
X1-2	8H21/32	212,6	225,7	195,6	207,2
X1-3	8H21/32	212,6	225,7	195,6	207,2
X2-1	9L28/32H	214,4	223,8	196,0	203,2
X2-2	9L28/32H	214,4	223,8	196,0	203,2
X2-3	9L28/32H	214,4	223,8	196,0	203,2
X3-1	8H21/32	212,6	225,7	195,6	207,2
X3-2	8H21/32	212,6	225,7	195,6	207,2
X4-1	6L28/32H	219,0	231,8	200,6	213,4

For these components, hereby referred to as HC (Heavy consumers), the SFC used to calculate their costs will be set to 75% generator load, measured in g/kWh. The consumers other than the high consumers have been labeled Low Consumers (LC) where a 50% generator load is used to calculate the operation costs. With this, the fixed specific fuel consumption for the produced power of the vessels is depicted in table 9. These results have been calculated on the basis of formula 6.

Thus, when the power consumption of a component has been calculated on the basis of running hours and power ratings, the specific fuel consumption of the generators for produced power calculated above, will be used to estimate the theoretical fuel consumed.

2.5 CALCULATING OPERATION COSTS FOR COMPONENTS

Having gathered the running hours and power ratings for the components, the power consumption [kWh] of the components can be estimated by multiplying the running hours with the mean input of the component. When the power consumption of the component has been established, the specific fuel consumption [g/kWh] for produced power on the generators can be used to calculate the amount of fuel needed to produce the corresponding amount of power.

The method and formulas used to calculate the operation costs of the components, are summarized in this chapter.

Initially, the power ratings found for the components in the ELA, found in vessel documentation, were:

- Power output [kW]
- Efficiency [%]
- Load factor [%]

Using the power output [kW], efficiency [%], load factor [%] and running hours [h], the power consumption of the components is calculated with formula 7.

FORMULA 7: POWER CONSUMPTION, COMPONENTS

$$P(t) = \frac{P_c \cdot f \cdot t}{\eta_e}$$

Where:
P(t) = Power consumption [kWh]
Pc = Rated power [kW]
η_E = Efficiency of component [%]
f = Load factor of component [%]
t = Running hours [h]

By using this formula to calculate the power consumption of the components when turned on, the following assumptions are made:

- The load factor for the components reflects the load in operation.
- The mean input reflects the power consumed when the equipment is turned on, thereby giving an estimate of the power consumption when multiplied with running hours.

The assumptions are assumed correct as this is the way the electric load has been estimated in the Electric Load Analysis of the vessels. When the mean input of the components has been established, the isolated fuel consumption by the components can be estimated by looking at the fuel consumption of the generators to produce the corresponding amount of power.

Formula 8 is used to estimate the fuel consumed [ton] by the generator to deliver the power needed by the component. Knowing the fuel consumed, this can multiplied by the market price of the used fuel, to find the operation costs of the component.

FORMULA 8: ESTIMATED FUEL CONSUMPTION, COMPONENTS

$$F(t) = \frac{P(t) \cdot SFC}{10^6}$$

Where:
F(t) = Fuel consumed [Ton]
P(t) = Power consumption [kWh]
SFC = Specific fuel consumption of generator for produced power [g/kWh]

The operation cost of the component can then be estimated by formula 9.

FORMULA 9: OPERATION COSTS, COMPONENTS

$$C(t) = F(t) \cdot K_{fuel}$$

Where:
C(t) = Operating costs [USD]
F(t) = Fuel consumed [ton]
Kfuel = Market price, fuel used [USD/ton]

The total fuel consumption for all components is thus:

FORMULA 10: TOTAL FUEL CONSUMPTION, COMPONENTS

$$F(t) = \sum_{0}^{n} \frac{P_{HC}(\mathrm{n}, t) \cdot SFC_{P75\%}}{10^6} + \frac{P_{LC}(\mathrm{n}, t) \cdot SFC_{L50\%}}{10^6}$$

Where:
$F(t)$ = Fuel consumption [ton – all types]
t = Running hours for component
n = Components
P_{HC} = Power consumption of heavy consumers [kWh]
$SFC_{P75\%}$ = Specific fuel consumption, generators, for produced power at 75% load [g/kWh]
P_{LC} = Power consumption of low consumers [kWh]
$SFC_{P50\%}$ = Specific fuel consumption, generators, for produced power at 50% load

In the next chapter formula 10 is utilized to estimate the fuel consumption of the components and the accuracy is validated by comparing the results to the registered fuel consumption of the generators. The main sources of errors are also discussed.

2.6 VALIDATON OF MODEL

To determine the accuracy of using the proposed model, the estimated fuel consumption of the components is compared to the validated and registered fuel consumption of the generators. The validation is conducted on a yearly basis for the X1-vessels. The test is carried out for 2009-2011, as running hours for several heavy consumers at the end of 2012 is not available. To provide a complete overview of the operation in the tested period, the operation profile and the operation for the main machinery have been included.

Vessel X1-3 was shipping mainly propane and butane in the period, as opposed to X1-1 and X1-2 shipping mainly ammonia. The variation in cargo will provide a valuable test as to checking accuracy of the model with different cargoes.

2.6.1 COMPONENTS WITHOUT COUNTERS

For the components not fitted with counters, the operation and running hours have been estimated based on the author's experiences while onboard vessel X1-1 on a voyage from Algeciras (Spain) to Yuzhny (Ukraine), as well as input from crew and vessel managers. The power ratings for the components have been found in the ELA and the running hours for a year have been estimated on the basis of average use per day and can thus not be viewed as particularly accurate. The estimations of the components not fitted with counters were estimated to a total of 212.9 ton fuel per year and the detailed estimations can be found in appendix 7.

2.6.2 COMPONENTS WITH COUNTERS

For the three vessels there are 116 components fitted with counters. Being sister vessels, the components are similar for all vessels. Using the model of described in the previous chapter, the fuel consumption has been calculated for the components.

When all, or some components, are missing from one of the component groups, the following estimations were made:

- If the operation hours of all components in an equipment group have not been registered, the missing component(s) were estimated linearly based on the registered components. If only one out of two similar components are registered, the component missing is estimated to have run as much as the other component.

This should produce accurate estimations, as the crew alternates the use of the components, so the total running hours is similar for the components.

- If a component group has not been registered at all, the average fuel consumption of the corresponding component(s) for the other vessels have been estimated, with the exception of cargo equipment

2.6.3 VALIDATION RESULTS

The results for 2011 will be given as an immediate example for the accuracy test. In figure 15, the overview of the results is given. The sum of the estimated fuel consumption is given as:

- **Equipment w/counters** – Components that are properly registered at the specified period
- **Equipment w/counters, estimated** – For components where one or more of in the components group is missing. As discussed above, the fuel consumption has been estimated as linear. For components missing entirely, it has been estimated as the average of the other vessels.
- **Equipment w/o counters** – Components not fitted with counters, estimated in chapter 2.6.2.

FIGURE 15: ACCURACY, OVERVIEW

2011	1

(green)	REGISTERED
(yellow)	CALCULATED

	OVERVIEW		
	X1-1	X1-2	X1-3
EQUIPMENT W/COUNTERS, SUM [TON]	1137	1106	1483
EQUIPMENT W/COUNTERS, ESTIMATED [TON]	84	115	9
EQUIPMENT W/O COUNTERS	212,9	212,9	212,9
SUM ESTIMATED [TON]	1433	1434	1706
REGISTERED CONSUMPTION [TON]	1381	1464	1650
DEVIATION [TON]	-52	30	-56
DEVIATION [%]	3,8 %	-2,1 %	3,4 %

	FUEL TYPE [TON]		
	X1-1	X1-2	X1-3
HFO	1340	1367	1328
LSHFO	15	57	139
MDO	26	41	183
TOTAL	**1381**	**1464**	**1650**
SFC HC	212,3	212,2	210,8
SFC LC	225,4	225,2	223,0

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3
LOADED	104	82	132	418	345	596	4,0	4,2	4,5
BALLAST	95	84	88	335	304	339	3,5	3,6	3,8
MAN	116	87	55	433	383	259	3,7	4,4	4,7
PORT	50	112	90	195	432	456	3,9	3,9	5,1
SUM/AVERAGE	**365**	**365**	**365**	**1381**	**1464**	**1650**	**3,8**	**4,0**	**4,5**

	RUNNING HOURS [H]			REG. [TON]			SFC [KG/H]		
MACHINERY	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3
MAIN DIESEL ENGINE	6443	5267	5996	8511	7955	9009	1321,0	1510,5	1502,4
AUX. DIESEL GENERATOR	10943	11223	12202	1381	1464	1650	126,2	130,5	135,2

The total sum of the estimations is thereafter compared to the registered fuel consumption of the vessel in the corresponding year, whereas the deviation is given in ton and percent. In addition the following are given:

- Fuel consumption and type (MDO, LSHFO and HFO). The amount of these fuels affects the SFC of the generators, according to formula 6. In addition, the fuel consumed in the different operation profiles is included, whereas an estimate of the fuel used per day in the operation profiles is given. This can give valuable information of the overall operation of the vessel.
- The running hours for the main machinery, compared to the registered amount of fuel used. This is especially relevant for the generators, as it can give an indication of the overall load in the period. For instance, vessel X1-3 has the

highest SFC for 2011, which can translate to a higher overall load of the generators as this is measured in [kg/h]

In figure 16, the results are shown for all components fitted with counters, whereas the components which are marked by green has registered running hours for all components correctly, yellow marks where one or more components are missing and red where all components of the component group are missing. The columns marked *N* defines the number of components of that type and the under the column *RUNNING HOURS*, the *N* defines the number of components that have been registered.

To the right the estimated fuel consumption based on the specifications on the equipment and specific fuel consumption of the generators are given. The columns marked *REG* defines the consumption based on the running hours registered and *TOT* the total estimated fuel consumption, including the estimations done for missing components. With this, the total estimated fuel consumption can be summed, as summarized in figure 15.

The deviations in fuel consumed by the components will not be elaborated in this chapter, even though there are components that clearly are not operated efficiently for one or more vessels. For instance, consider the following:

- The cargo compressor room exhaust fan of vessel X1-2 have been consuming more fuel compared to vessel X1-3, even though the last mentioned vessel has shipped far more cargo.
- The main engine lube oil pumps have similar consumption, but when looking at the operation of the main engine there are major differences. The main engine lube oil pumps should be turned off 15 minutes after the main engine has been shut down.

Deviations and a tool to identify poor operation and performance are further elaborated in chapter 3 and 5.

FIGURE 16: ACCURACY CHECK, COMPONENT LIST

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

		RUNNING HOURS [H]						ESTIMATED CONSUMPTION [TON]					
		X1-1		X1-2		X1-3		X1-1		X1-2		X1-3	
MACHINERY	N	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	1387	8	878	8	1446	8	83,0	83,0	52,5	52,5	85,9	85,9
CARGO BOOSTER PUMP	2	3	2	0	2	132	2	0,1	0,1	0,0	0,0	4,5	4,5
CARGO COMPRESSOR	4	4166	4	4194	4	8775	4	209,5	209,5	210,7	210,7	437,9	437,9
CARGO TANK GAS-FREEING FAN	4	145	4	83	4	5	4	1,6	1,6	0,9	0,9	0,1	0,1
IGG COOLING SW (SCRUBBER) PUMP	1	158	1	64	1	200	1	3,1	3,1	1,3	1,3	3,9	3,9
NITROGEN GENERATOR	1	1439	1	0	0	164	1	1,6	1,6		0,9	0,2	0,2
CARGO HOSE CRANE	1	61	1	0	0	55	1	0,5	0,5		0,5	0,4	0,4
CARGO CONDENSER SW COOLING PUMP	2	2318	2	3590	2	4744	2	49,4	49,4	76,5	76,5	100,1	100,1
GLYCOL COOLING SYSTEM PUMP	2	8718	2	8664	2	8723	2	23,8	23,8	23,6	23,6	23,6	23,6
GLYCOL COOLING SYSTEM PUMP (VAPORISER)	1	0	1	0	1	79	1	0,0	0,0	0,0	0,0	0,2	0,2
STEERING GEAR HYDR OIL PUMP	2	9301	2	9334	2	8666	2	25,8	25,8	25,9	25,9	23,8	23,8
BOW THRUSTER	1	70	1	102	1	128	1	15,9	15,9	23,3	23,3	29,0	29,0
HYDRAULIC OIL PUMP BOW THRUSTER	1	77	1	0	0	128	1	0,1	0,1		0,1	0,1	0,1
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	447	2	300	2	208	1	11,2	11,2	7,5	7,5	5,1	10,3
MOORING WINCH HYDR. OIL PUMP	2	570	2	525	2	391	2	11,5	11,5	10,6	10,6	7,8	7,8
INCINERATOR	1	2285	1	0	0	1639	1	4,6	4,6		3,9	3,2	3,2
PROVISION COOLING COMPRESSOR	2	4416	2	4303	2	4101	2	8,3	8,3	8,0	8,0	7,6	7,6
AIR-CONDITION COOLING COMPRESSOR	2	0	0	0	0	6701	2		83,9		83,9	83,9	83,9
SUPPLY FAN, ENGINE ROOM	4	30988	4	32935	4	31729	4	89,8	89,8	95,4	95,4	91,0	91,0
EXHAUST FAN, PURIFIER AREA	1	7154	1	8199	1	8193	1	3,0	3,0	3,4	3,4	3,4	3,4
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	7252	1	8738	1	8719	1	17,1	17,1	20,6	20,6	20,4	20,4
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	8754	1	8769	1	8732	1	1,6	1,6	1,6	1,6	1,6	1,6
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	8757	1	8779	1	8744	1	9,0	9,0	9,0	9,0	8,9	8,9
SUPPLY FAN, BOW THRUSTER & BOSUN STORE	1	82	1	171	1	207	1	0,1	0,1	0,2	0,2	0,2	0,2
POTABLE WATER HYDROPHORE PUMP	2	915	2	0	0	1491	2	0,9	0,9		1,2	1,5	1,5
ME COMBUSTION AIR BLOWER	2	730	2	1121	2	676	2	6,4	6,4	9,9	9,9	5,9	5,9
ME TURNING GEAR	1	2	1	0	0	0	1	0,0	0,0		0,0	0,0	0,0
AE LO PRIMING PUMP	3	14693	3	14542	3	13717	3	2,9	2,9	2,9	2,9	2,7	2,7
HFO TRANSFER PUMP	3	434	3	525	3	480	3	1,3	1,3	1,5	1,5	1,4	1,4
MDO TRANSFER PUMP	1	10	1	10	1	29	1	0,0	0,0	0,0	0,0	0,0	0,0
HFO PURIFIER	2	8706	2	7336	2	7591	2	29,9	29,9	25,2	25,2	25,8	25,8
SLUDGE OIL PUMP	1	47	1	117	1	75	1	0,0	0,0	0,1	0,1	0,1	0,1
ME FO SUPPLY PUMP	2	8759	2	8798	2	3138	1	2,7	2,7	2,7	2,7	1,0	1,9
ME FO CIRCULATING PUMP	2	8779	2	8798	2	1044	1	6,6	6,6	6,6	6,6	0,8	1,6
AE FO SUPPLY PUMP	2	8759	2	8804	2	3726	1	1,3	1,3	1,3	1,3	0,6	1,1
AE FO BOOSTER PUMP	2	8759	2	8798	2	2748	1	6,6	6,6	6,6	6,6	2,1	4,1
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR	1	1	1	3	1	0	1	0,0	0,0	0,0	0,0	0,0	0,0
AUX. BOILER FO PUMP	2	8727	2	8774	2	8448	2	0,9	0,9	0,9	0,9	0,8	0,8
LO TRANSFER PUMP	1	28	1	1	1	0	1	0,0	0,0	0,0	0,0	0,0	0,0
AE LO PURIFIER	2	11065	2	11744	2	9801	2	11,7	11,7	12,5	12,5	10,3	10,3
ME LO PURIFIER	2	8649	2	15148	2	13233	2	9,2	9,2	16,1	16,1	13,9	13,9
AE LO PURIFIER SUPPLY PUMP	2	11065	2	0	0	16943	2	1,0	1,0		1,3	1,6	1,6
ME LO PURIFIER SUPPLY PUMP	2	8581	2	0	0	0	2	2,7	2,7		1,3	0,0	0,0
ME LO PUMP	2	8732	2	8731	2	8577	2	126,7	126,7	126,6	126,6	123,2	123,2
STERN TUBE LO PUMP	2	9029	2	8798	2	8754	2	1,7	1,7	1,6	1,6	1,6	1,6
ME COOLING SW PUMP	3	14647	3	13476	3	16018	3	107,5	107,5	98,9	98,9	116,4	116,4
ME JACKET COOLING FW PUMP	2	8760	2	8782	2	8754	2	25,6	25,6	25,7	25,7	25,3	25,3
CENTRAL COOLING FW PUMP	3	17519	3	17597	3	15706	3	133,4	133,4	133,9	133,9	118,3	118,3
MAIN STARTING AIR COMPRESSOR	2	734	2	366	2	1175	2	5,9	5,9	2,9	2,9	9,4	9,4
SERVICE AIR COMPRESSOR	1	5377	1	3997	1	5068	1	6,8	6,8	5,1	5,1	6,4	6,4
CONTROL AIR COMPRESSOR	1	8405	1	8342	1	8372	1	16,1	16,1	15,9	15,9	15,8	15,8
AUX. BOILER FEED WATER PUMP	2	8743	2	8788	2	8733	2	13,3	13,3	13,4	13,4	13,2	13,2
AUX. BOILER CIRCULATING PUMP	2	8209	2	8785	2	8501	2	6,8	6,8	7,2	7,2	6,9	6,9
FW GENERATOR SW PUMP	1	5402	1	0	0	5629	1	20,5	20,5		20,8	21,1	21,1
FW GENERATOR DISTILLATE PUMP	1	5867	1	0	0	0	1	1,6	1,6		0,8	0,0	0,0
BALLAST PUMP	2	418	2	432	2	398	2	9,4	9,4	9,7	9,7	8,8	8,8
BILGE TRANSFER PUMP	1	131	1	214	1	209	1	0,1	0,1	0,1	0,1	0,1	0,1
BILGE/MAIN FIRE/GS PUMP	2	285	2	387	2	258	2	5,8	5,8	7,9	7,9	5,2	5,2
DECK WATERSPRAY PUMP	1	4	1	2	1	1	1	0,1	0,1	0,0	0,0	0,0	0,0
EMERGENCY FIRE PUMP	1	99	1	4	1	11	1	0,1	0,1	0,0	0,0	0,0	0,0
CARGO REMOTE VALVE HYDR. OIL PUMP	2	177	2	346	2	858	2	0,1	0,1	0,1	0,1	0,3	0,3
BALLAST REMOTE VALVE HYDR. OIL PUMP	2	1269	2	255	2	308	2	0,5	0,5	0,1	0,1	0,1	0,1

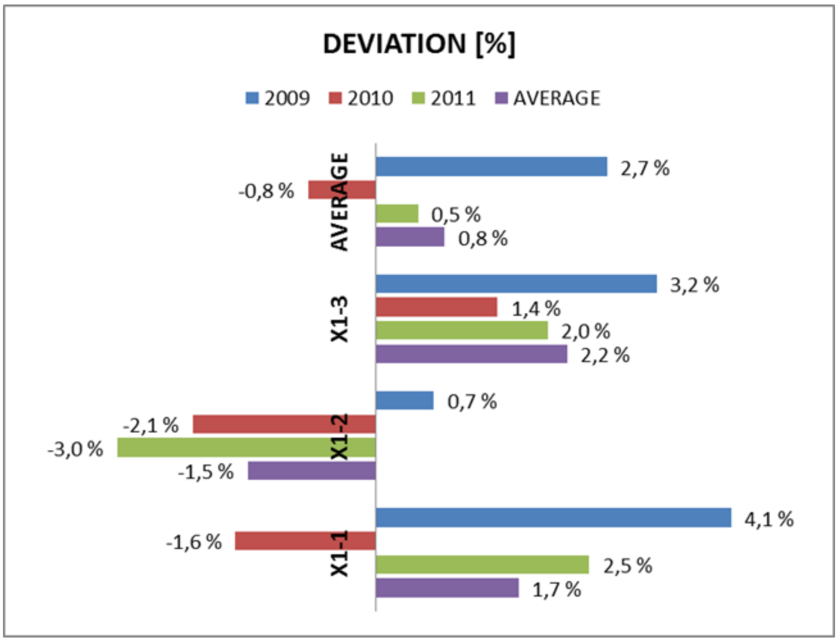
The results for the X1-vessels, year by year, can be found in appendix 8. The overview of the results for each year is given in table 10.

TABLE 10: ACCURACY CHECK, 2009-2011

	2009			2009			2011			
DESCRIPTION	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3	AVG
EQUIPMENT W/COUNTERS, SUM [TON]	1399	1220	1221	1271	1138	1453	1137	1106	1483	1270
EQUIPMENT W/COUNTERS, ESTIMATED [TON]	0	147	15	0	115	6	84	115	9	55
EQUIPMENT W/O COUNTERS	213	213	213	213	213	213	213	213	213	213
SUM ESTIMATED [TON]	1612	1580	1450	1466	1446	1652	1415	1420	1683	1525
REGISTERED CONSUMPTION [TON]	1548	1570	1404	1490	1477	1629	1381	1464	1650	1512
DEVIATION [TON]	64	11	46	-24	-31	23	34	-44	33	12
DEVIATION [%]	4,1 %	0,7 %	3,2 %	-1,6 %	-2,1 %	1,4 %	2,5 %	-3,0 %	2,0 %	0,8 %

As can be seen, the deviation ranges from a -3.0% to 4.1%, with an average deviation for all vessels in the tested period of 0.8%. Knowing that the fuel estimations are only to be used as a tool to indicate operation costs for the components, the results are arguably very satisfying.

FIGURE 17: ACCURACY/DEVIATION, 2009-2011



The deviation and spread are illustrated in figure 17. The spread for vessel X1-2 and vessel X1-3 is low, where the estimations on vessel X1-3 are slightly above the actual fuel used and vessel X1-2 slightly lower. This may be the result of different operation of the components not fitted with counters.

For vessel X1-1 the estimations are higher than actual fuel used, but otherwise for 2010. There are no explanations than can readily explain this from the operation of the components, but it can be down to operation of the components not fitted with counters or that the reported fuel consumption is not entirely correct.

Overall, the result imply that the model used and the estimates on both fuel and operation costs should reflect the actual consumption and costs. Even though there are several sources of error, the results seem to even out when looking on a yearly basis.

2.6.4 DISCUSSION OF MODEL

In this chapter the model of establishing all components and their operation and operation costs have been reviewed. As there are no textbook method for the task of estimating the operation cost for ship equipment available, the model which is proposed in the study have been done so on the data recorded by Solvang and in the maintenance system. In addition, no reports on similar projects have been found. Even though available literature could have provided input on the model, it could also prove fruitless as there are major differences between different vessel types, build and the vessel documentation provided. The model developed for the vessels part of this study, was done so on the basis of the data available, which summarized, were:

- Power ratings for components [Vessel documentation]
- Running hours [Maintenance software]
- Specific fuel consumption of generators [NOx report/Vessel documentation]

When assessing uncertainties and sources of error, the following are factors are proposed [12]:

- Uncertainty to system model
- Uncertainty related to data
- Uncertainty related to calculation approaches

2.6.4.1 UNCERTAINTIES TO SYSTEM MODEL

The model used has been established entirely based on the system data available and developed by the author. The main parameters of the model are the running hours, component specifications and specific fuel consumption of the generators. In addition, the operation profile, fuel consumption and type of cargo shipped are used for validation. Some of the uncertainties linked to the accuracy of the model are the following:

- The main uncertainty to the system model is whether the theoretical power input of the components, as calculated by the power output, efficiency and load factor, describes the power input of the component in operation. The power consumption is calculated by multiplying the power input of the component with the running hours and thus the power input used in the calculations must reflect the power input in operation. The model used is the same as is done in the ELA in the vessel documentation and can therefore be added some credibility, even though the methods used is highly simplified compared to what is used in electrical engineering.
- The specific fuel consumption of the generators. It has been found that the load of the generators vary depending on operation profile. With the available data however, it is not possible to discern the load of the generator when the component is used. The average load was set to 50%, based the average load measured in 2009-2012.

2.6.4.2 UNCERTAINTIES RELATED TO DATA

To map the operation and the operation costs for all equipment on nine vessels requires a great amount of data and with it uncertainties. The relevance, amount and quality of the data are important. The accuracy of the following can be questioned when looking at the data:

- The power ratings of the equipment has been found in the vessel documentation provided by shop test carried out by the yard or manufacturer. The accuracy of the power output and efficiency of the component of the components can be viewed as accurate, but the load factor cannot be deemed as accurate. The accuracy of this data is dependent on how meticulous the testing has been carried out and even so the load factor may not reflect actual operating conditions. The power ratings (power output, efficiency, load factor) of the components have been used to determine the load of the generators under different conditions upon delivery of the vessel, but the total accuracy can none the less be questioned.

- Accuracy of the running hours. The running hours used in the model are the running hours registered in the maintenance system which has been registered by the vessel's electrician. If the running hours have not been registered correctly, this will affect the overall accuracy. In addition, the running hours are sometimes reset.
- The registered and validated fuel consumption used to compare the results may not be entirely correct. It has been an issue in the shipping industry that flow-meters and manual measuring are not accurate, making the registered fuel consumption incorrect. Even when buying bunkers, it is a problem that the fuel received is not the always the same as the fuel paid for [10].

2.6.4.3 UNCERTAINTIES TO CALCULATION APPROACHES

The model used requires several calculations to estimate the fuel consumption of the components. The calculation is based on simple and basic approaches used to estimate the power consumption, whereas the power consumption is used to calculate fuel and operation costs. For instance formulas using ampere, frequency and voltage as parameters could be used to calculate the power consumption, but these data are not readily available for all components.

2.6.4.4 CLOSING REMAKRS ON MODEL

The main benefit of calculating the power and fuel consumption for the components is due to the fact that operation of components can be much more easily understood in terms of fuel used and related costs, both for the owner and the crew. In addition, the impact of differences in operation is more easily illustrated by costs rather than by hours of operation. Knowing the running hours makes for easy overview and comparison, but as some components consume far more power than others, only knowing the running gives limited information. For small consumers, 50 hours of operation is negligible when looking at operation costs, but for heavy consumers like cargo compressors, this is not the case.

With this in mind, the calculations made for fuel consumption and related costs do not have to be entirely accurate. The results may be viewed as a tool in order to easily detect the costs and consequences of deviations, as well as a cost estimate of operating the various components. Even though there are several sources of error, the results proved in the accuracy test showed that the results were more accurate than anticipated. Knowing that the overall accuracy is satisfying, the results can be used to give estimations on the operation costs, as well as savings if measures are carried out.

The operation in terms of running hours is by its own accounts enough to establish the operation and comparison between vessels, but having an estimate of the operation costs make these tasks far more versatile and easier to communicate.

3. OPERATIONAL PERFORMANCE

Having mapped the operation and operation costs for all the components included for the nine vessels and knowing the results can be deemed accurate, the operational performance of components can be addressed. Addressing the operational performance of all components would far exceed the scope of this report, so the components included are limited to the components which are heavy consumers and believed to have potential for improvement.

By improving performance and reducing running hours of the components, the following benefits will apply:

- Reduced fuel consumption
- Reduced maintenance
- Reduced need for spare parts

Both owner and the crew will have benefits of improving operational performance of the components as both fuel costs and workload due to maintenance will be reduced. On the background of the operational data retrieved and input from vessel managers at Solvang, the following components are heavy consumers that may have potential for operational improvement:

- Main engine lube oil pumps
- Steering gear pumps
- Cargo seawater cooling pumps

Doubtless, there are several other components which can have possibilities for improvement, but the performance analysis in this study is limited to the above.

The operation of the components mentioned above will in this chapter be analyzed between sister vessels. The operational performance, as well as the potential savings pitched against a benchmark will be investigated. The operation of the components must be normalized, as the components are dependent on the operation of other components and the operation of the vessel itself. The performance of the components mentioned above will be illustrated by a performance factor. The performance factor is used to highlight the operation of the component(s) normalized to the main component determining the use.

The method used is summarized in formula 11.

FORMULA 11: PERFORMANCE FACTOR

$$PF = \frac{\sum_1^n O_c}{\left(\frac{\sum_1^n O_N}{n_N}\right)}$$

Where:
PF = Performance factor [#]
O_c = Total running hours for component type [h] - [Total running hours for all components of the specified type
O_N = Total running hours for machinery/equipment the specified components is normalized to [Main engine, compressors]

n_N = Number of components for the main machinery/equipment of dependency

Normalizing the components is necessary, as many components are used only when main machinery or equipment, like main engine, auxiliary engines or compressors are running and should be turned off or used less otherwise. A direct comparison would be pointless, as the operation of the main machinery and the cargo equipment is used differently according to trade route and shipped cargo. Using a normalized performance factor can highlight the problem of components that are not turned off when they should be, either by the crew forgetting it, not knowing that it could be turned off or that the component is simply not operated in the most efficient manner.

Having set a method in which the performance factor is calculated, the method in which the potential savings are estimated must be set. For example, the main engine lube oil pumps should only be running when the main engine is running. Summing the total running hours for the two main engine lube oil pumps and dividing by the running hours of the main engine should in theory equal 1, as only pump should be running when the main engine is in operation. A performance factor of 1 is thus the theoretical benchmark when looking at the lube pumps, but as the pumps run a while after and before the engine is stopped or started, the operational benchmark used to determine the efficiency operation should be set higher.

Using the method above for normalizing the operation and setting a performance factor, the possible savings can be calculated when comparing the recorded performance to a benchmark performance. The overview of the potential savings pitched against a benchmark includes:

- Average potential savings for the average performance factor recorded, 2009-2012
- Potential savings for the best performance factor recorded, 2009-2012
- Potential savings for the least efficient performance factor recorded, 2009-2012

In order to calculate the costs, the specific fuel consumption of the generators is an important parameter. As the vessels have different specifications on the generators, the SFC for produced power has been assumed fixed and set to 225 [g/kWh]. The cost of one ton fuel has been set to 650 USD/ton, regardless of fuel type used by the vessels.

After calculating the performance factors as explained below and taking the results from the cost estimations as done in the previous chapter, but with fixed SFC, the savings can be estimated by comparing the registered performance factor to a benchmark performance factor.

The average savings has been calculated on basis of the average performance factor for 2009-2012. The formula in which the average savings are calculated is given below:

FORMULA 12: AVERAGE BENCHMARK SAVINGS

$$S_{AVERAGE} = C_{AVERAGE} - C_{AVERAGE}\frac{PF_{BECNHMARK}}{PF_{AVERAGE}}$$

Where:

$S_{AVERAGE}$ = The average savings per year recorded if the benchmark was achieved [USD]
$C_{AVERAGE}$= The average cost of the component in the years recorded, 2009-2012
$PF_{BENCHMARK}$ = The set benchmark performance factor with efficient operation
$PF_{AVERAGE}$ = The average performance factor recorded, 2009-2012

The savings are thus estimated linearly, based upon the relationship of the performance factors. However, it is important to note that the average savings are based on the average savings which could have been achieved for every year in 2009-2012 if the benchmark was achieved. If the results are stable and would continue, this would apply for the coming years.

The savings for the most and least efficient operational performance recorded, is calculated by formula 13.

FORMULA 13: MINIMUM/MAXIMUM BENCHMARK SAVINGS

$$S_{MIN/MAX} = C_{AVERAGE}\frac{(PF_{MIN/MAX} - PF_{BENCHMARK})}{PF_{AVERAGE}}$$

Where:
S_{MIN} = The potential savings for the best performance factor recorded, as compared with the benchmark [USD]
S_{MAX} = The savings for the least efficient performance factor recorded, as compared with the benchmark [USD]
$C_{AVERAGE}$= The average cost of the component in the years recorded, 2009-2012
$PF_{BENCHMARK}$ = The set benchmark performance factor with efficient operation
$PF_{AVERAGE}$ = The average performance factor recorded, 2009-2012
PF_{MIN} = The best performance factor recorded, 2009-2012
PF_{MAX} = The least efficient performance factor recorded, 2009-2012

For vessels that have improved in 2009-2012, the possible savings from the best performance factor recorded would be more interesting than knowing the average savings possible. In addition, the spread in savings between the most and least efficient operation recorded would indicate the savings which have already been made by improving operation, given a positive trend.

In the next section, the components picked for further investigation, will be analyzed according to the method discussed in above. The results for the savings will be rounded to the nearest 500 USD.

3.1 MAIN ENGINE LUBE OIL PUMPS PERFORMANCE

The main engine lube oil pumps are among the highest consumers of the components on the vessels and are of crucial importance. If both pumps have broken down, the main engine cannot be run and the vessel is forced to a halt. The lubricating oil for a marine diesel engine achieves the following [11];

- Lubricate and reduce friction of cylinders, crankshaft, crosshead, piston heads, bearings and moving parts. Overall, reduce wear and performance loss of the main engine.
- Cooling of main engine
- Limit corrosion and filter particles.

Figure 18 shows the main engine lube oil pumps on vessel X1-1, placed next to the main engine.

FIGURE 18: MAIN ENGINE LUBE OIL PUMPS, VESSEL X1-1

When the main engine is running, one pump is needed to provide the functions mentioned above. The crew alternates between using the two pumps to ensure that one pump has not been running more than the other, which could lead to a breakdown. The main engine lube oil pumps can be turned off 15 minutes after the main engine is turned off [11]. When in standby or in between short stops, one pump should be running to ensure the engine is lubricated and cooled.

To normalize the operation of the lube oil pumps the running hours must thus be compared to the main engine. As one pump is needed when the main engine is running, the theoretical lowest operation factor for the lube oil pumps is 1. Lower than 1 means either an error in the data or that the main engine has been run in a non-reliable state. As the pumps are operated when on call, between short stops and 15 minutes after the engine has been stopped, the operational benchmark has been set to 1.25, adding 25% to the theoretical performance factor. The power ratings, operational benchmark and average operation costs for 2009-2012 for the lube oil pumps for the vessels are given in table 11.

TABLE 11: MAIN ENGINE LUBE OIL PUMPS PARAMETERS

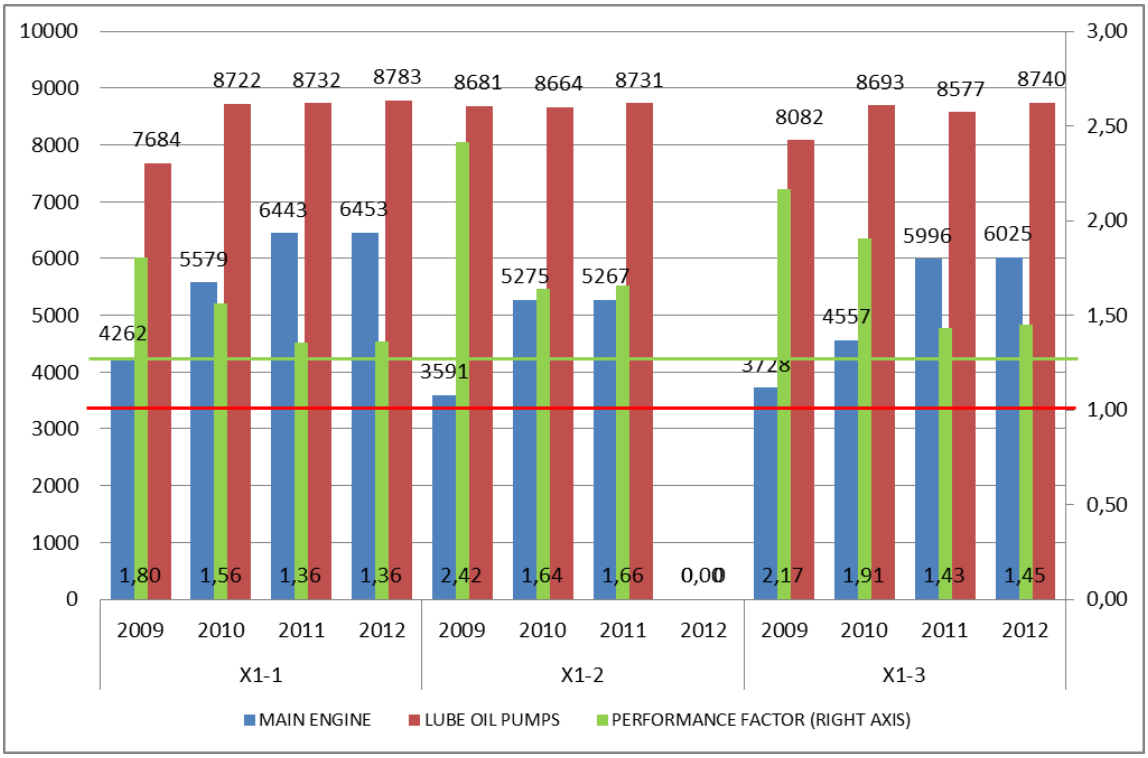
			POWER RATINGS			BENCHMARK		OP. COSTS [USD]
VESSEL GROUP	DESCRIPTION	NR	P [kW]	EFF. [%]	LF [%]	THEOR.	OPER.	AVG, 2009-2012
X1	ME LO PUMP	2	75	92 %	79 %	1,0	1,25	80671
X3	ME LO PUMP	2	75	92 %	87 %	1,0	1,25	75094
X2	ME LO PUMP	2	75	92 %	86 %	1,0	1,25	87374

The average operation cost recorded 2009-2012 for the main engine lube oil pumps exceed 80,000 USD per year on average for vessel group X1 and X2. The X3-vessels has an average operation cost of 75,000 USD, as a result of efficient performance of the main engine lube oil pumps on vessel X3-2, as will be shown in the next section

3.1.1 MAIN ENGINE LUBE OIL PERFORMANCE, X1-VESSELS

The running hours for the main engine and lube oil pumps, in addition to the performance factor, are illustrated in figure 19. The running hours indicate that the lube oil pumps are run continuously throughout the year, without any regards to the operation of the main engine. Based on the calculation of the performance factor, the vessels with the highest running hours for the main engine will end up having the most preferable performance factor, even though this may not be due to operational awareness. If this is the case, this means that significant savings can be made if this trend is broken.

FIGURE 19: LUBE OIL PUMPS OPERATION, X1-VESSELS



As can be seen from the figure above, the best performing is vessel X1-1, which in 2011 and 2012 had a performance factor of 1.36. These results are however not to be outright credited, as it is may be a results of increased running hours for the main engine, rather than awareness, which can be observed in the figure above.

Using an operational benchmark of 1.25, the benchmark savings for the vessels calculated by formula 12 and 13 yields the results in figure 20. The figure gives the following data:

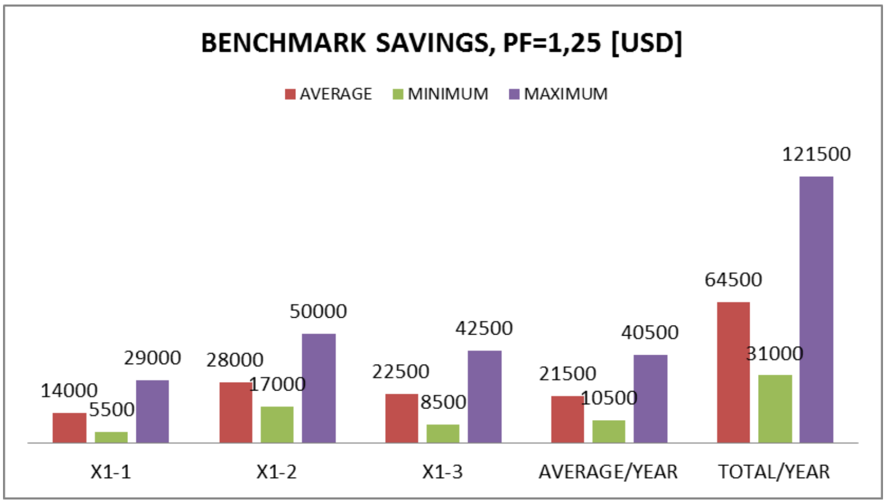
- Average savings for each vessel based on the average performance factor recorded for 2009-2012, using formula 12.

- Minimum and maximum savings for each vessel based on the on the most efficient and least efficient performance factor recorded in 2009-2012, using formula 13.
- Total savings, adding up the average, minimum and maximum savings recorded for the vessels.
- Average savings for the vessel group, calculated by taking the average of the minimum, maximum and average savings for the vessels in the vessel group.

As illustrated in figure 20, the least efficient performance recorded is vessel X1-2, where even for the best recorded performance, 17,000 USD could be saved compared to the benchmark. Vessel X1-1 has the best performance, with an average of 14,000 USD in potential savings.

That average savings for the vessel group if measures are carried out, are 21,500 USD per year per vessel. An average total of 64,500 USD can be saved for the three vessels per year, ranging from a minimum of 31,000 USD to a staggering 121,500 USD.

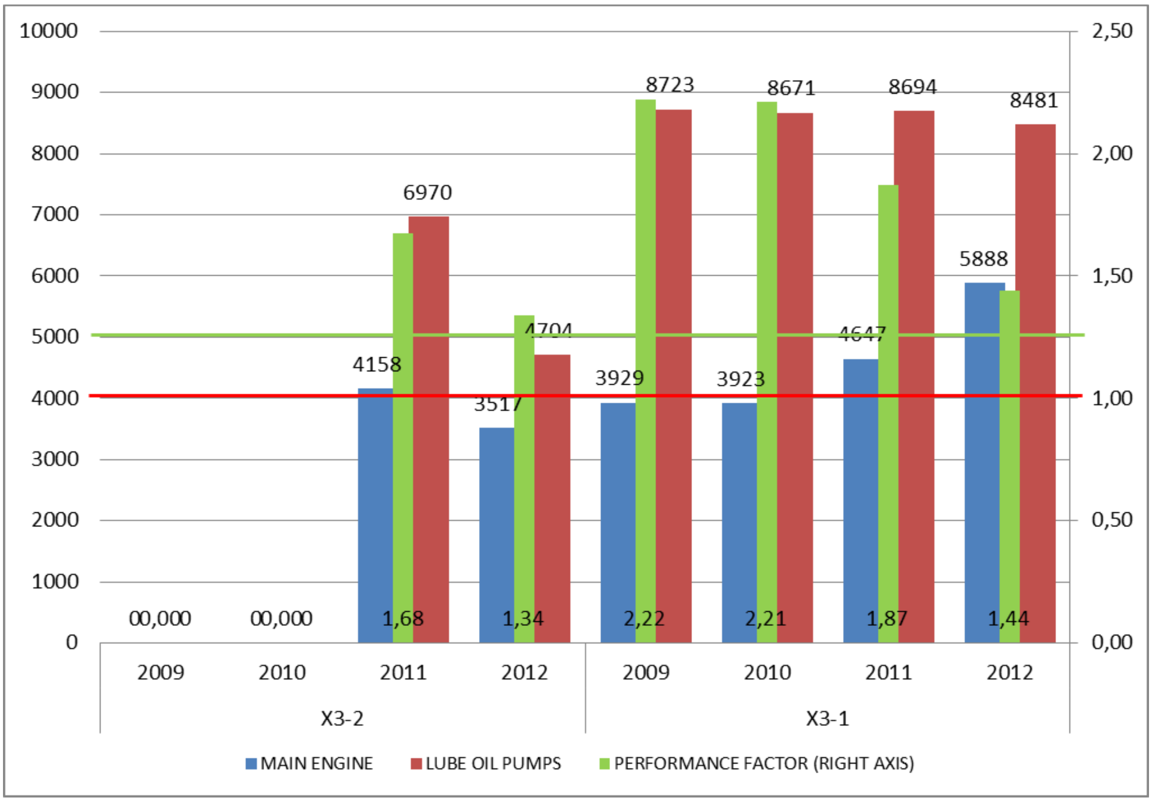
FIGURE 20: BENCHMARK SAVINGS, LUBE OIL PUMPS, X1-VESSELS



3.1.2 MAIN ENGINE LUBE OIL PERFORMANCE, X3-VESSELS

Running hours for main engine, lube oil pumps and the performance factor for the X3-vessels are given in figure 21. Vessel X3-2 has been running the lube oil pumps considerably less than 8000 hours, which indicates that the vessel turns off the lube oil pumps when the main engine is not in use.

FIGURE 21: LUBE OIL OPERATION, X3-VESSELS



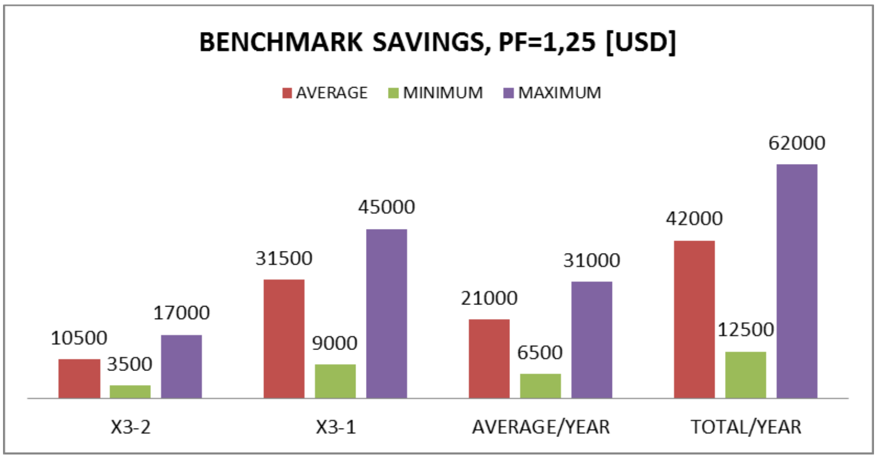
The overall performance of vessel X3-2 is superior to that of the other. However, vessel X3-2 only has available data for 2009 and 2010, which gives a limited overall view.

In figure 22, the benchmark savings for vessel X3-1 range from 9,000 USD to the far maximum of 45,000 USD, with an average of 31,500 USD. Vessel X3-2 has benchmark savings ranging from only 3,500 USD for the best recorded result in 2012, to a maximum of 17,000 USD in 2011, with an average of 10,500 USD. If the trend of 2012 continues, the result for vessel X3-2 is satisfying and can only slightly improve.

The fact that vessel X3-2 turns off the main engine lube oil pumps have saved Solvang for a fuel bill of 21,000 USD per year compared to that of vessel X3-1. If both vessels improved and met the criteria of only using one main engine lube oil pump when the main engine was running, the average savings would equal 21,000 USD per vessel year, totaling 42,000 USD per year. The minimum savings on average would be 12,500 USD per year for both vessels.

The operation on vessel X3-2 should be investigated and be implemented as best-practice. As the coming section will show, the results for vessel group X2 is the same as the X1 vessels, making vessel X3-2 the only vessel which looks to be turning off the main engine lube oil pumps when the main engine is not running.

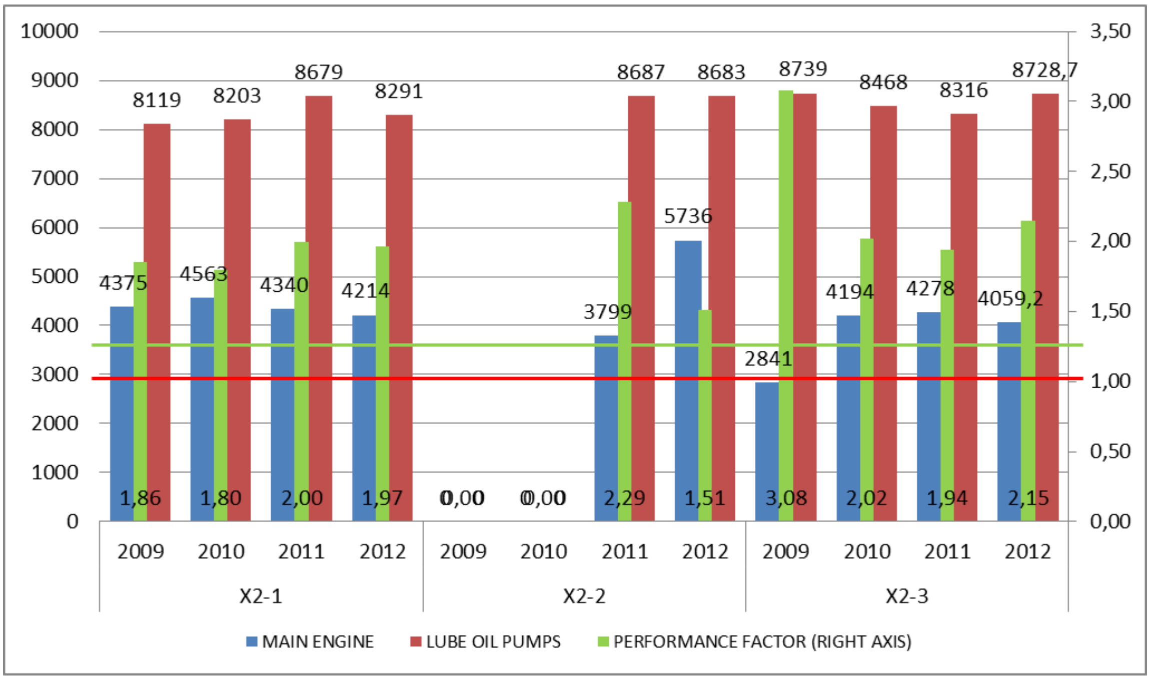
FIGURE 22: BENCHMARK SAVINGS, LUBE OIL PUMPS, X3-VESSELS



3.1.3 MAIN ENGINE LUBE OIL PERFORMANCE, X2-VESSELS

The performance data for the lube oil pumps is given in figure 23. Data on 2009 and 2010 is missing for vessel X2-2. As was the case for the X1-vessels, the running hours of the lube oil pumps are not showing correlation to that of the main engine. For instance vessel X2-3 had the main engine in operation in 2841 hours in 2009, but the main engine lube oil pumps were running throughout the year.

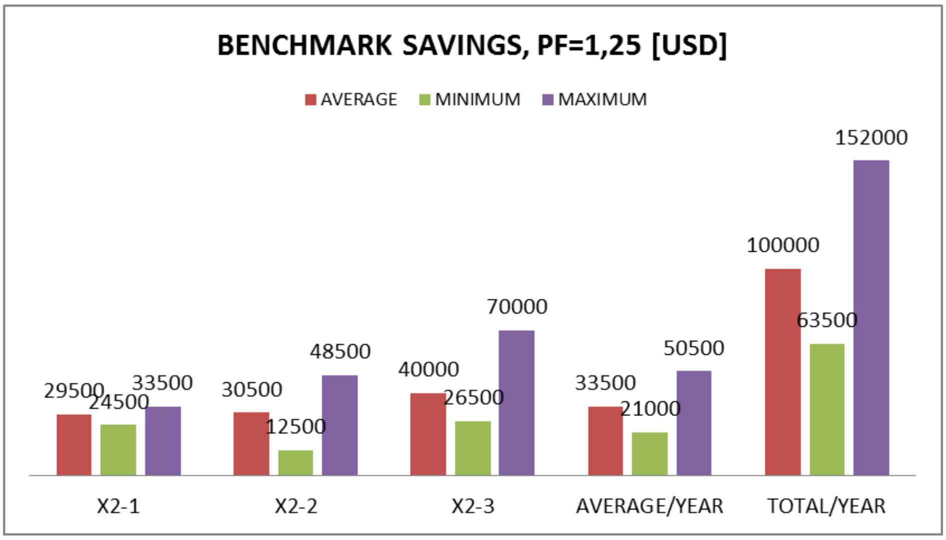
FIGURE 23: LUBE OIL OPERATION, X2-VESSELS



Data on vessel X2-2 is limited, but in 2012 vessel X2-2 had the best performance recorded for all the vessels. Vessel X2-3 have poor results overall, with the least efficient performance recorded in 2009. The three sister vessels have significant room for improvement. As compared to the other vessels, these vessels have the least efficient average performance factor.

The benchmark savings if a performance factor of 1.25 is achieved are given in figure 24. On average, over 33,500 USD can be saved per vessel if the operation of the lube oil pumps is improved. In total, an average of 100,000 USD can be saved each year for the three vessels in total, whereas the worst case estimates a staggering 152,000 USD.

FIGURE 24: BENCHMARK SAVINGS, LUBE OIL PUMPS, X2-VESSELS



The operation of the main engine lube oil pumps as a whole uncovers an alarming trend, where the pumps are running with no regards to the main engine. The main engine operation manual states that the pumps can be turned off without damaging the engine or other components.

3.2 STEERING GEAR PUMPS PERFORMANCE

The steering gear pumps powers the hydraulics used for rudder motion. The number of steering gear pumps varies from 2-3. For the vessel fitted with two pumps, only one is needed, as shown in the Remote Operator Station (ROS) in figure 25 for vessel X1-1. For vessels with three pumps, one or two is needed. When a more responsive rudder is preferred, the Master may opt for two or more pumps in operation.

FIGURE 25: STEERING GEAR PUMPS IN ROS

There has been a debate in Solvang that the autopilot modes results in excessive use of the steering gear pumps. When some modes of the autopilot is used, the vessel will move by the coordinates set by the autopilot which can result in excessive use of the steering gear to keep the course set with little or no deviation. If the sea conditions are rough, the rudder will be used excessively to keep within the bounds of the set course.

As mentioned earlier, the load factor of the pumps is given as between 25-50% by the shipyard, dependent of how much the rudder is in use. The load factor was set to 30%, as most of the vessels trade on deep sea trade routes, as opposed to coastal routes, requiring more maneuvering and thus more operation of the rudder. For the vessels equipped with three steering gear pumps rated at 15 [kW], as opposed to 37 [kW] or 45 [kW] for the vessels with two pumps, the load factor is 60% as given in the ELA. The power ratings, benchmark and average yearly operation costs as recorded 2009-2012 for the steering gear pumps of the vessels are given in table 12.

TABLE 12: STEERING GEAR PUMPS PARAMETERS

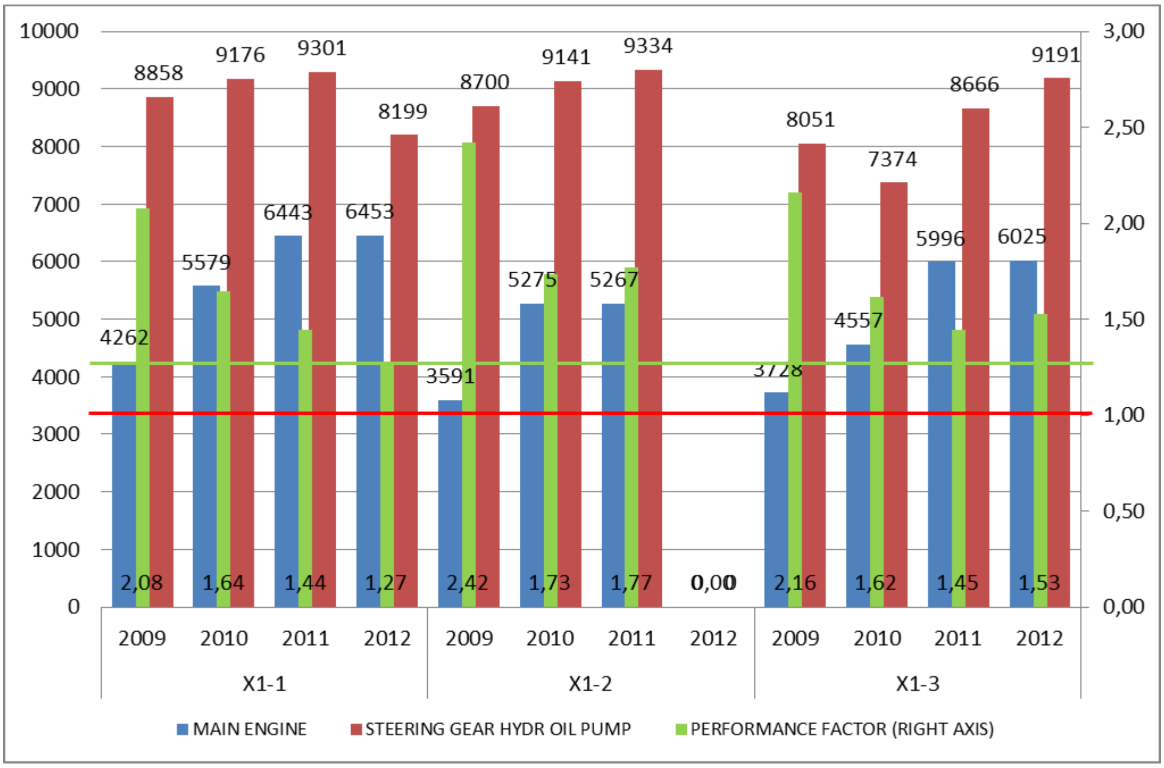
			POWER RATINGS			BENCHMARK		OP. COSTS [USD]
VESSEL GROUP	DESCRIPTION	NR	P [kW)	EFF. [%]	LF [%]	THEOR.	OPER.	AVG, 2009-2012
X1	STEERING GEAR	2	37	90 %	30 %	1,0	1,25	15790
X3	STEERING GEAR	2	45	91 %	30 %	1,0	1,25	17374
X2	STEERING GEAR	3	15	91 %	60 %	1,5	1,875	15370

Knowing the power ratings, the performance factor will be determined by the relation of running hours for the steering gear pumps in total as compared to the running hours of the main engine, as for the example with the lube oil pumps. The theoretical performance factor is 1, meaning that one pump is to be running when the main engine is running. For the vessels fitted with three pumps, the theoretical performance factor is set to 1.5. The steering gear pumps may be running when the vessel is on call and even when drifting, so the operational performance factor will be set to 1.25 for the vessels with two pumps and 1.875 for the vessels with three steering gear pumps.

3.2.1 STEERING GEAR PUMPS PERFORMANCE, X1-VESSELS

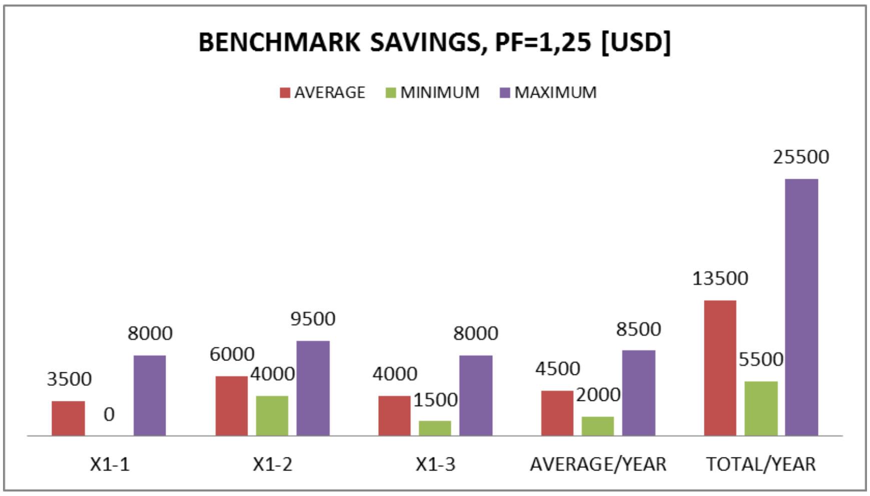
The running hours of the main engine and the steering gear pumps, as well as performance factor, for the X1-vessels are given in figure 26. Data is missing for vessel X1-2 in 2012.

FIGURE 26: STEERING GEAR PUMPS OPERATION, X1-VESSELS



Vessel X1-1 has overall the best performance factors, but looking at the running hours it seems that the yearly reduction is only a result of increased operation if the main engine, as was the case for the lube oil pumps. The only result indicating that the steering gear pumps have indeed been turned off is vessel X1-3 in 2010.Seeing that the steering gear pumps are continuously running, even when the main engine is not, the awareness of these pumps should be increased by giving feedback to the crew. In figure 27, the savings when compared a performance factor benchmark of 1.25 are illustrated. A minimum of 2,000 USD, a maximum of 8,500 USD, with an average of 4,500 USD could be saved per year per vessel with the performance data recorded in 2009-2012. In total, this equals an average saving 13,500 USD per year for the three vessels.

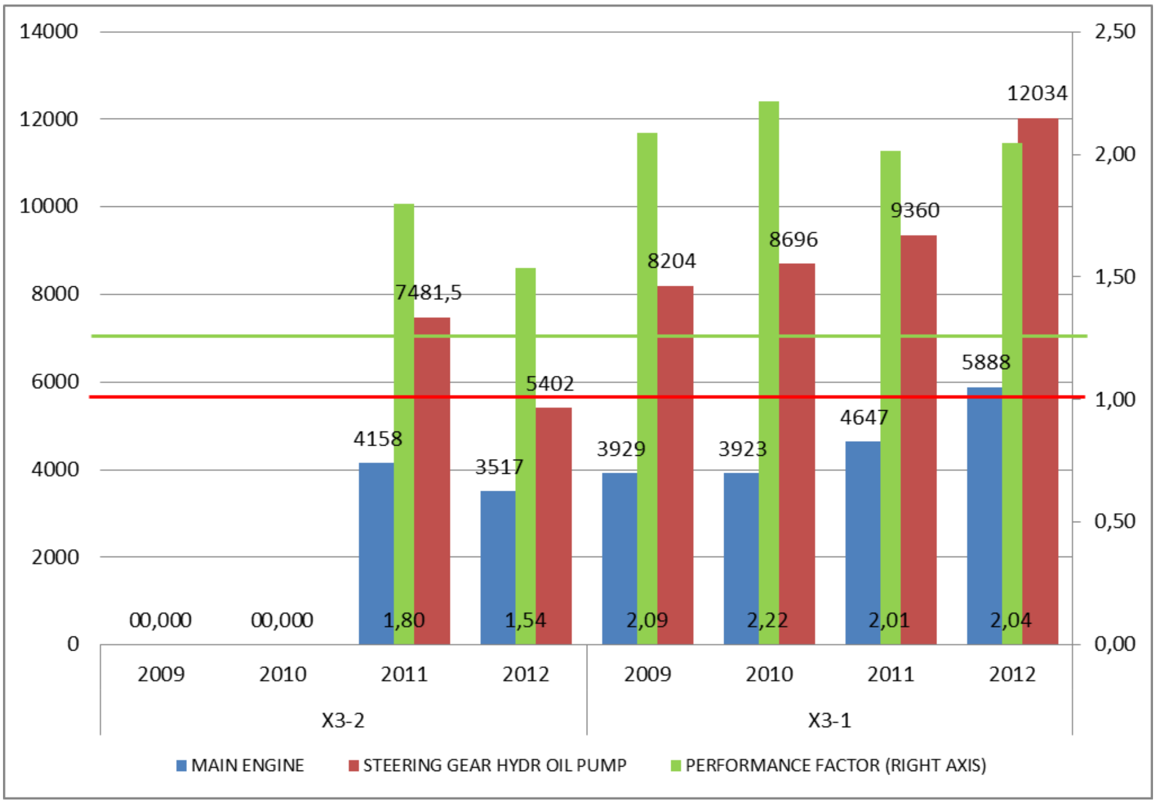
FIGURE 27: BENCHMARK SAVINGS, STEERING GEAR, X1-VESSELS



3.2.2 STEERING GEAR PUMPS PERFORMANCE, X3-VESSELS

The running hours of the main engine and the steering gear pumps, as well as performance factor, for the X3-vessels are given in figure 28. Data is missing for vessel X3-2 in 2009 and 2010.

FIGURE 28: STEERING GEAR OPERATION, X3-VESSELS

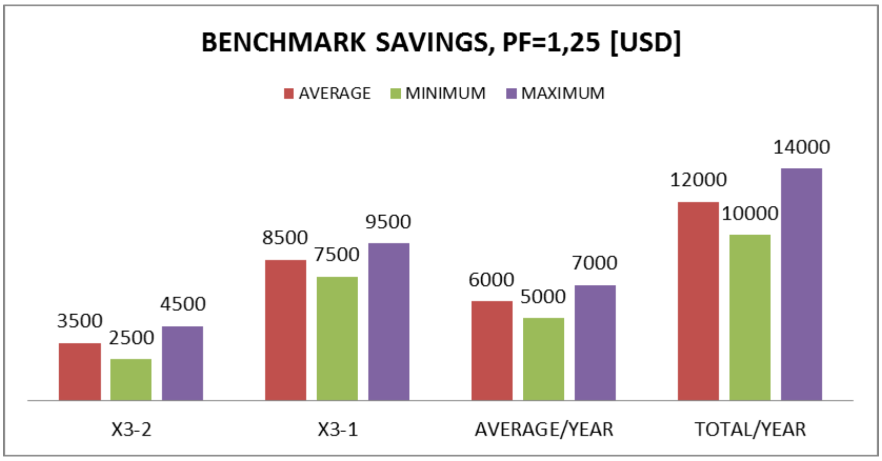


Vessel X3-2 is the better achiever of the two vessels, showing an improving trend for the years recorded. In addition, the results indicate that the steering gear pumps are turned off when the main engine is not running.

For vessel X3-1 the running hours for the steering gear pumps have little or no correlation to the operation of the main engine. The results are stable, but the performance is overall not satisfying and is showing no improving trend. For 2012, the results of vessel X3-1 can be further questioned when looking at the operation profile. Vessel X3-1 spent more time in loaded condition and ballast compared to vessel X3-2, which should normally result in the steering gear pumps needed less than more time spent maneuvering.

The operation of the steering gear pumps for vessel X3-1 increased in 2012 for no apparent reason when looking at the operation profile. This can either be due to the autopilot issue discussed previously or that the awareness and operational performance was especially calloused in 2012.

FIGURE 29: BENCHMARK SAVINGS, STEERING GEAR, X3-VESSELS

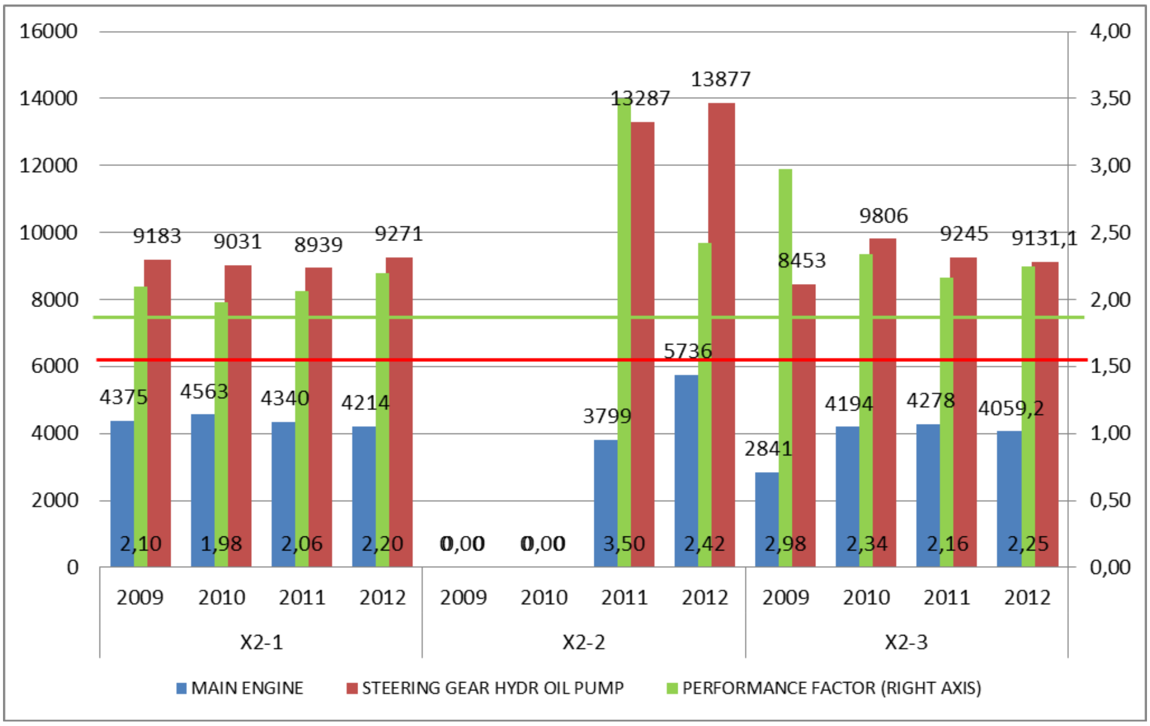


In figure 29, the savings if the benchmark is achieved is on average 5,000 USD in the best case scenario and 7,000 USD if the current operation reflects the worst case performance. Even though the possible yearly savings are far less than in the case of other equipment, an average of 6,000 USD may be saved each year per vessel if the operational performance of the steering gear pumps is enhanced. In total this equal savings of 12,000 USD on average, ranging from a minimum of 10,000 USD to a 14,000 USD maximum.

3.2.3 STEERING GEAR PUMPS PERFORMANCE, X2-VESSELS

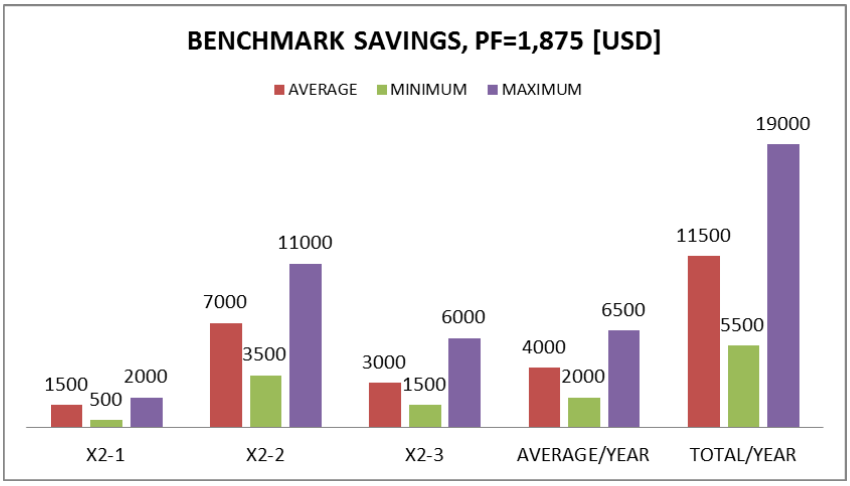
The X2-vessels are fitted with three steering gear pumps and the theoretical and operational benchmark has been set to 1.5 and 1.875, respectively. The running hours for the steering gear pumps and the main engine of the three vessels, as well as the performance factor, are depicted in figure 30.

FIGURE 30: STEERING GEAR OPERATION, X2-VESSELS



Vessel X2-1 and X2-3 are achieving stable and fairly satisfying results. Vessel X2-2 however, is running the steering gear pumps more than the other two vessels. This vessel should be further checked to see if the autopilot system has anything to do with the increased number of running hours for the steering gear pumps.

FIGURE 31: BENCHMARK SAVINGS, STEERING GEAR, X2-VESSELS



The benchmark savings are given in figure 31. For vessel X2-2, 7,000 USD can be saved if the benchmark is achieved, ranging from 3,500 USD to 11,000 USD. In total for all vessels, 11,500 USD can be saved on average, ranging from a minimum of 5,500 USD to a maximum of 19,000 USD.

3.3 CARGO EQUIPMENT PERFORMANCE

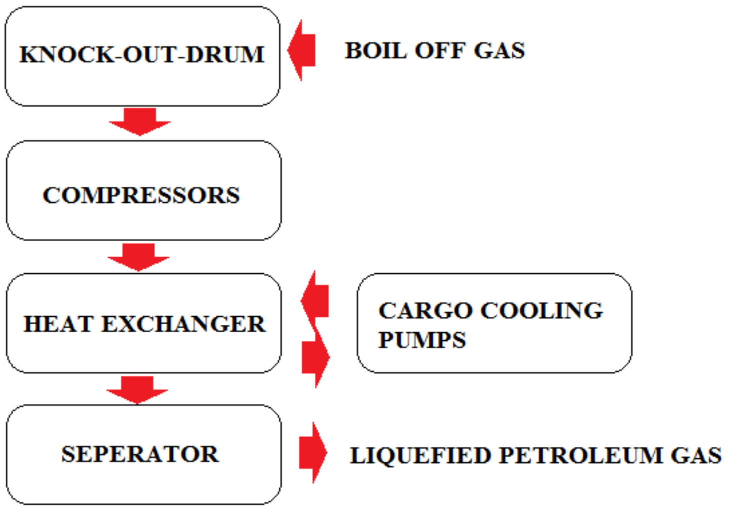
The components of cargo equipment are in total the most costly to operate, whereas the cargo compressors are the heaviest consumers. The operation of the cargo equipment depends heavily on the type of cargo shipped and thus the normalization of the components is complex.

The cargo equipment test is limited to the cargo seawater cooling pumps.

The cargo seawater cooling pumps are part of the LPG re-liquefaction system. The LPG re-liquefaction system re-liquefies the boil of gas (BOG) and returns it to the cargo tanks. The BOG from the cargo tanks first gets to the Knock-Out-Drum (KOD) to be separated from the LPG. Then, the BOG stream goes through gas compressors to be pre-cooled down. Next, the BOG stream gets further cooled down at the heat exchanger and gets re-liquefied by expanders. Finally, LPG goes back to the cargo tanks.

The re-liquefaction system is illustrated in figure 32.

FIGURE 32: CARGO RE-LIQUEFACTION SYSTEM



The cargo seawater cooling pumps should only be operating when the cargo compressors are in use. There are two or three cargo seawater condenser cooling pumps, whereas one or two is needed when the cargo compressors are operating. There are four compressors on all nine vessels. Depending on cargo and cooling needed, the number of compressors running may vary, but usually the most efficient way of cooling down the cargo is by running the four compressors simultaneously, as opposed to three or less.

Given that four compressors are running simultaneously, it can be derived that the total running hours of the seawater cooling pumps divided by the average running hours of the four compressors should be about 1. Therefore, the theoretical performance factor is set to 1.The operational performance factor is set to 1.25, adding 25% to the theoretical performance. For the vessels fitted with 3 cargo seawater cooling pumps, the operational benchmark has been set to 1,875.

Even though the most efficient way of running the compressors four at a time usually is the most effective, this is not always possible in operation. Therefore the results should be viewed as an indication of possible savings.

In table 13, the power ratings and benchmark are summarized for the vessels.

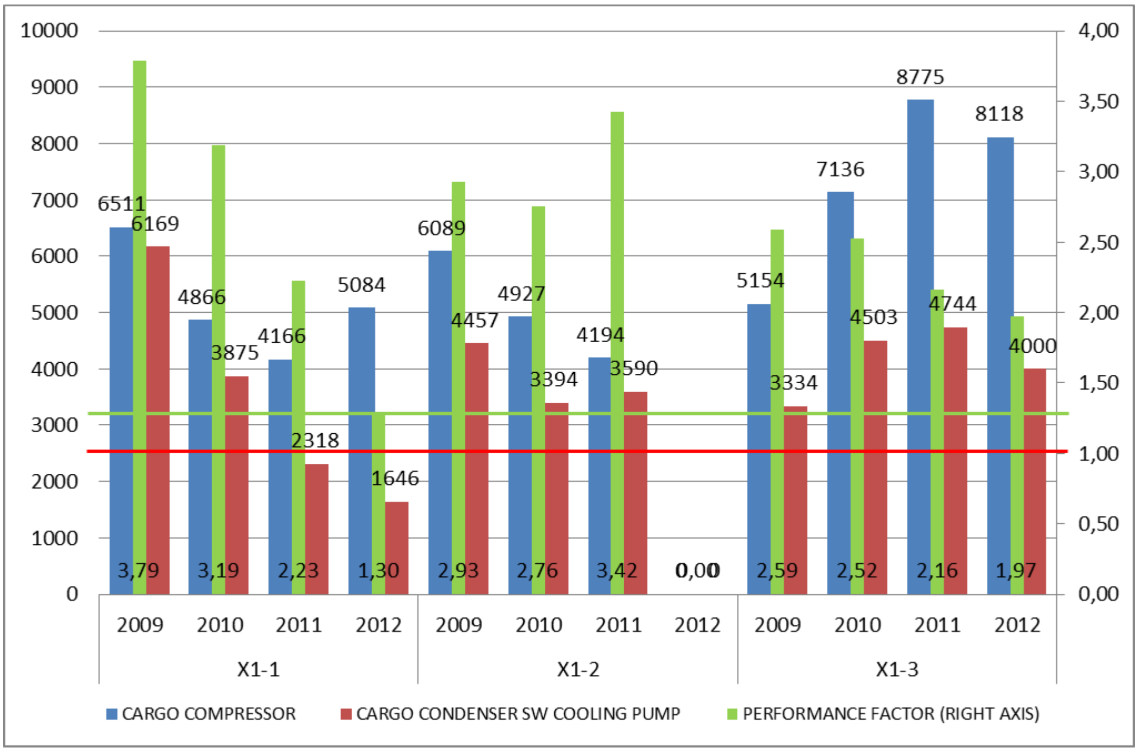
TABLE 13: CARGO CONDENSER PUMP PARAMETERS

			POWER RATINGS			BENCHMARK		OP. COSTS [USD]
VESSEL GROUP	DESCRIPTION	NR	P [kW]	EFF. [%]	LF [%]	THEOR.	OPER.	AVG, 2009-2012
X1	CARGO SW PUMP	2	110	93 %	80 %	1	1,25	52867
X3	CARGO SW PUMP	3	75	92 %	80 %	1,5	1,875	72738
X2	CARGO SW PUMP	2	110	93 %	80 %	1	1,25	59073

3.3.1 CARGO COOLING PUMPS PERFORMANCE, X1-VESSELS

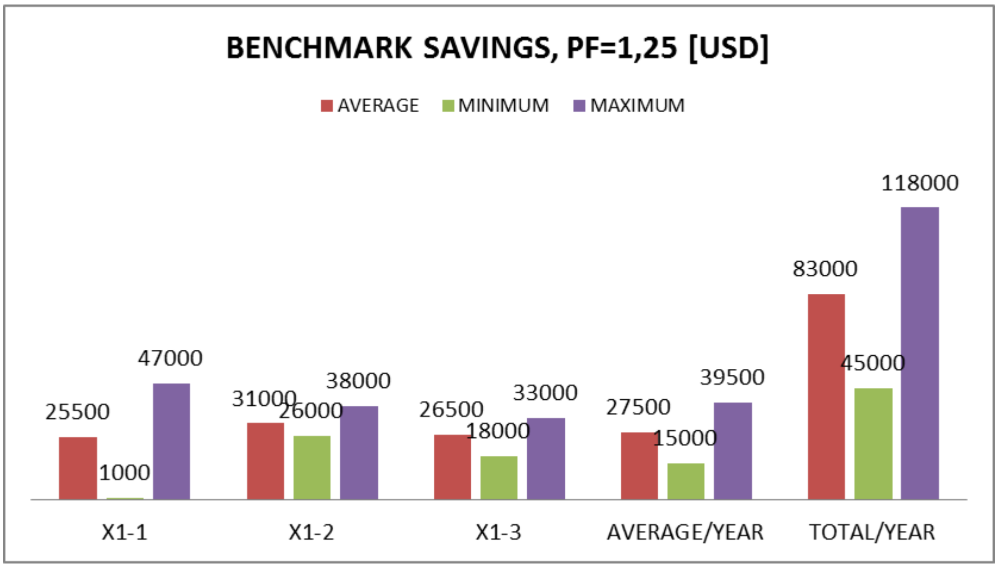
The total running hours of the cargo seawater cooling pumps (CSWCP) and the cargo compressors (CC) and the resulting performance factor is given in figure 33. In 2012, the results of vessel X1-1 are close to the operational performance set. In addition, vessel X1-1 has decreased the running hours of the CSWCP even though the operation of the compressors has increased in the recent year.

FIGURE 33: CARGO COOLING PUMPS PERFORMANCE, X1-VESSELS



Vessel X1-2 on the other hand, has decreased operation of the compressors, but with only a marginal decrease in the operation of the CSWCP. Vessel X1-2 had the worst recorded performance in 2012, whereas the CSWCP have been run nearly as much as the compressors. This indicates that the pumps have been running when the compressors have not or that only one of the compressors running at a time. However, the cargo carried and trade route for vessel X1-1 and vessel X1-2 was similar for 2010 and 2011, further questioning the operation. Vessel X1-3, shipping mainly propane and butane, has operated the cargo compressors more than X1-1 and X1-2 and achieves a fair performance with a slight positive trend.

FIGURE 34: BENCHMARK SAVINGS, CARGO COOLING PUMPS, X1-VESSELS



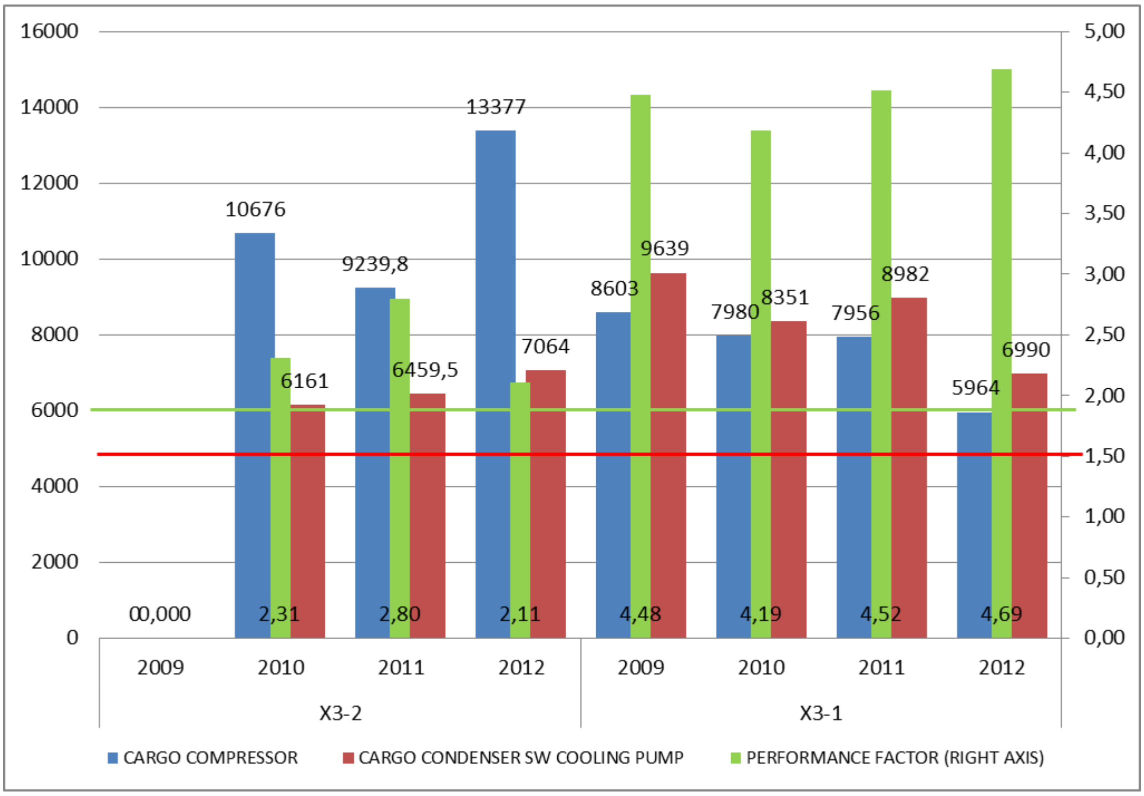
Looking at figure 35, an average saving of 27,500 USD per vessel per year can be expected should the performance be enhanced to match the performance benchmark of 1.25.

The best performing vessel, vessel X1-1, have minimum savings of 1,000 USD per year, an average of 25,500 USD and a maximum of 47,000 USD. The trend for this vessel suggests that the minimum savings is the most realistic for the years to come. The minimum savings for the least efficient performance, vessel X1-2, could save a minimum of 26,000 USD per year if measures are carried out and the benchmark is achieved, given that four compressors are running simultaneously. In total an average of 83,000 USD, with a minimum of 45,000 USD and a maximum of 118,000 USD could be saved per year for the three vessels.

3.3.2 CARGO COOLING PUMPS PERFORMANCE, X3-VESSELS

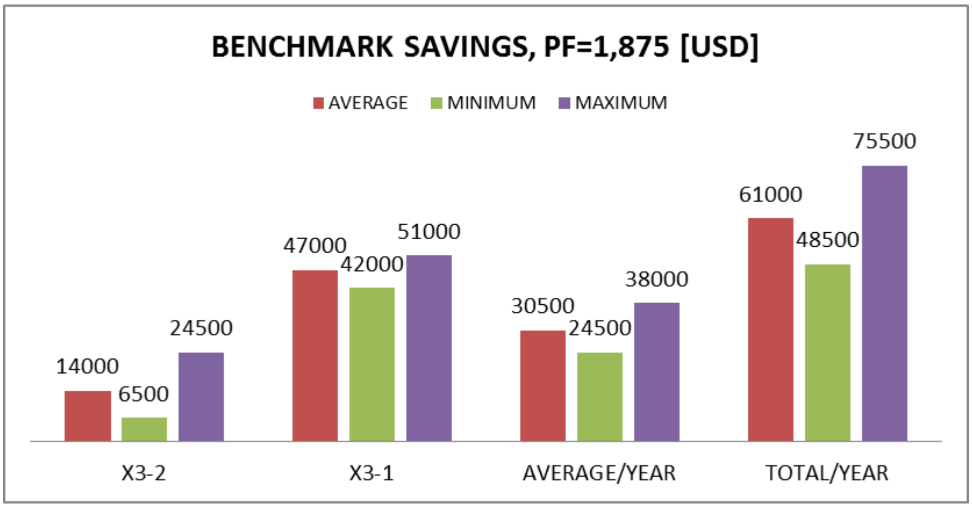
The total running hours of the cargo seawater cooling pumps (CSWCP) and the cargo compressors (CC) and the resulting performance factors for the X3-vessels are given in figure 36.

FIGURE 35: CARGO COOLING PUMPS PERFORMANCE, X3-VESSELS



The results for vessel X3-1 are exceptionally poor when compared to vessel X3-2. Vessel X3-1 has a total compressor operation of 13,377 hours in 2012, where the CSWCP were running for 7,064 hours. On the other hand, vessel X3-1 with a total compressor operation of 5,964 hours, nearly three times less than that of the other vessel, operated the CSWCP 6,990 hours. The results either show an alarming trend for vessel X3-1 for the operational awareness of the CSWCP, or that the operation of the compressors is entirely different. Even if the compressors on vessel X3-1 are not operated simultaneously, the cargoes shipped by the vessels are similar, making this questionable. If the results are because of inefficient operation of the CSWCP, the savings are a staggering 47,000 USD per year on average if the benchmark is achieved. By benchmark standard and compared to vessel X3-1, this equals an operation that has cost Solvang 33,000 USD extra on average per year.

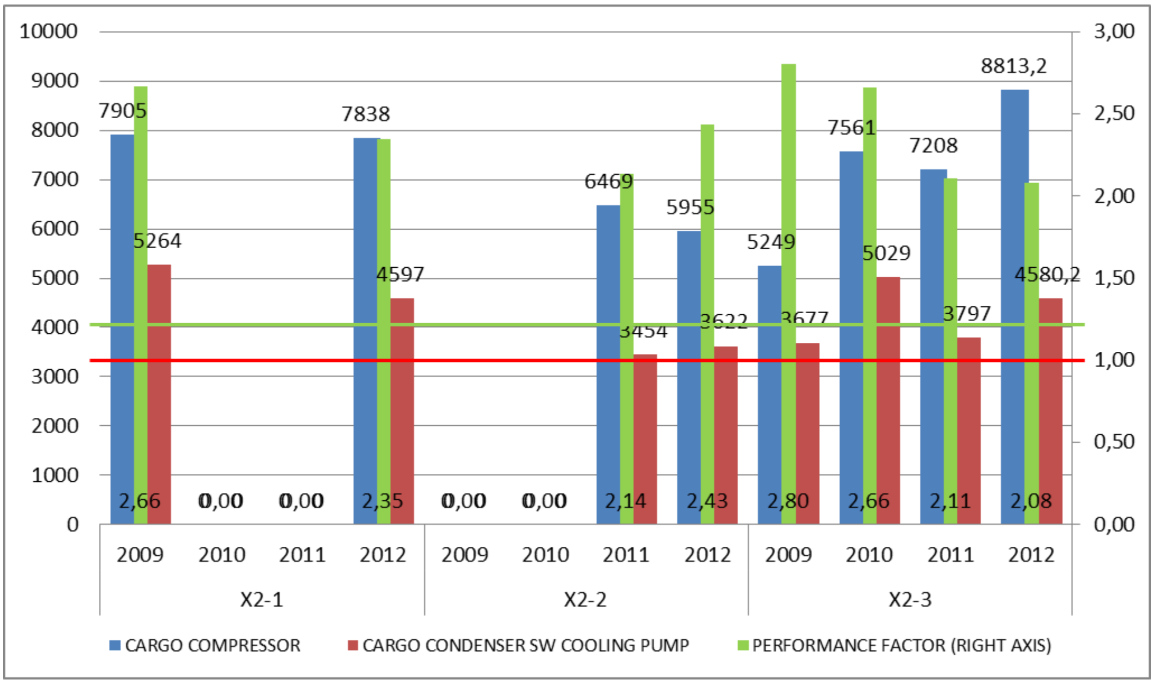
FIGURE 36: BENCHMARK SAVINGS, CARGO COOLING PUMPS, X3-VESSELS



A total of 30,500 USD can be saved on average per vessel per year, totaling 61,000 USD for both vessels a year. The operation of the CSWCP should be further investigated for vessel X3-1.

3.3.3 CARGO COOLING PUMPS PERFORMANCE, X2-VESSELS

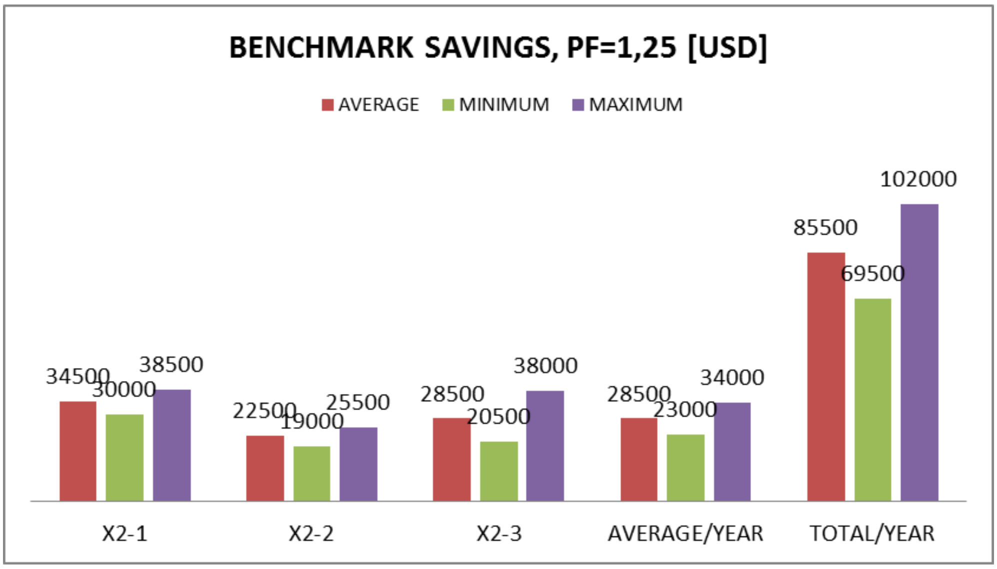
FIGURE 37: CARGO COOLING PUMPS PERFORMANCE, X2-VESSELS



The running hours for cargo compressor and the cargo seawater cooling pumps, in addition to the resulting performance factor is given in figure 37. Unfortunately, the data on vessel X2-1 and X2-2 are limited, as data has been lost due to resetting and incorrect registration of running hours.

The results are comparable to that of the other vessels, with exception of vessel X3-2, indicating that major improvements which can be made if the results are due to poor awareness, rather than operation of the compressors. The correlation between the running hours for the compressors and the CSWCP are either way non-existent. The best result recorded is vessel X2-3 in 2012, with a performance factor of 2.08.

FIGURE 38: BENCHMARK SAVINGS, CARGO COOLING PUMPS, X2-VESSELS



The savings, if the vessels are usually running four compressors simultaneously, are on average 28,500 USD per year per vessel. In total this translates to 85,500 USD on average, with a minimum 69,500 USD and a maximum of 102,000 USD per year for the three vessels.

As shown earlier, vessel X3-2 recorded excellent results for the CSWCP. The cargoes shipped by the X2-vessels are similar to what has been shipped vessel X3-2, thus not implying that the compressors have been operated entirely different. If it is not the case that the vessels are running the CSWCP simultaneously, a cost analysis of the way the cargo cooling system is operated should be investigated further, as the results show significant savings when looking at the CSWCP.

3.4 OPERATIONAL PERFORMANCE REVIEW

The performance of the main engine lube oil pumps, the steering gear pumps and the cargo seawater cooling pumps have been analyzed in this chapter. The findings indicate that significant savings can be made if measures to enhance the operation of these components are carried out. These components should be added to the SEEMP and monitored by the means proposed in this report, normalized against the main equipment of dependency, like the main engine or the cargo compressors.

The uncertainties in the estimated savings include:

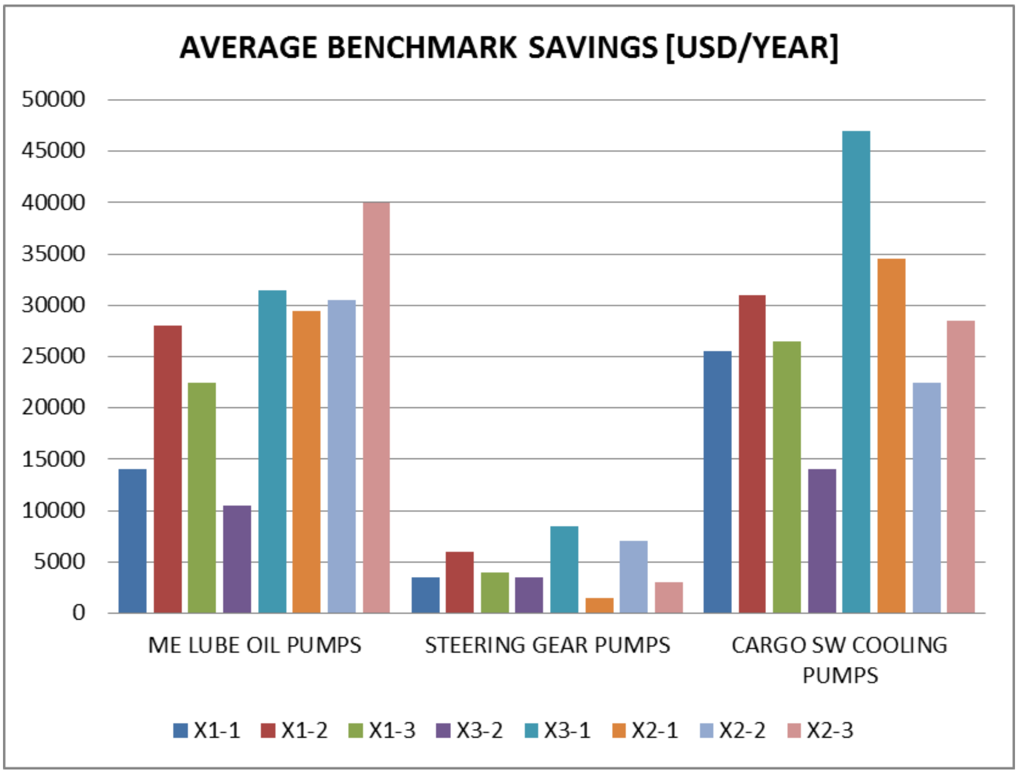
- Uncertainties to the model of calculating operation costs, as reviewed in chapter 2.6.4

- The set operational benchmarks, especially for the CSWCP being normalized to the compressors.

There are no additional uncertainties posed by the method used to calculate savings, as this is based on the linear relations in the running hours registered for the components and their main dependency. For the equipment normalized with regards to the main engine, the main engine lube oil pumps and the steering gear pumps, the results can be viewed as accurate. For the equipment normalized with regards to the cargo compressors however, there may be deviations in the savings that are estimated and the savings which can be made in everyday operation. This is mainly due to the fact that it has been assumed that all four compressors are running simultaneously. Running four compressors simultaneously are the most efficient, but may not always be possible due to cargo specifications, pressure in the tanks, need for cooling and different specifications on the cargo system. A proper normalization of this equipment will require the average number of compressors running simultaneously.

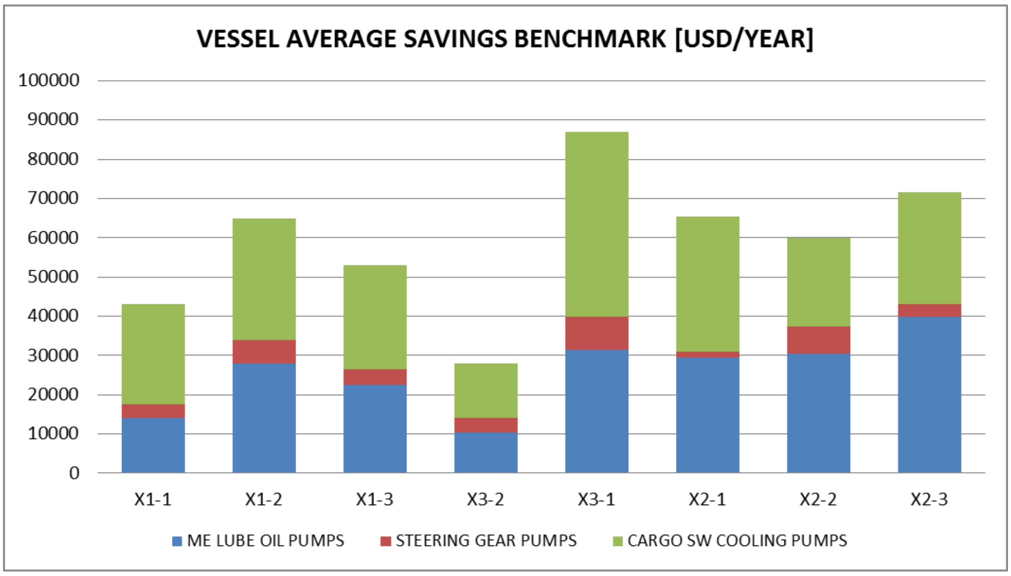
The average estimated savings if the set benchmarks are achieved, sorted for the components, is given in figure 39. As discussed above, the savings estimated for the main engine lube oil pumps and steering gear pumps can be deemed accurate. In addition, this operational performance of the lube oil and steering gear pumps is also applicable to other vessels types, as this is common ship equipment found on any vessel.

FIGURE 39: BECNHMARK SAVINGS



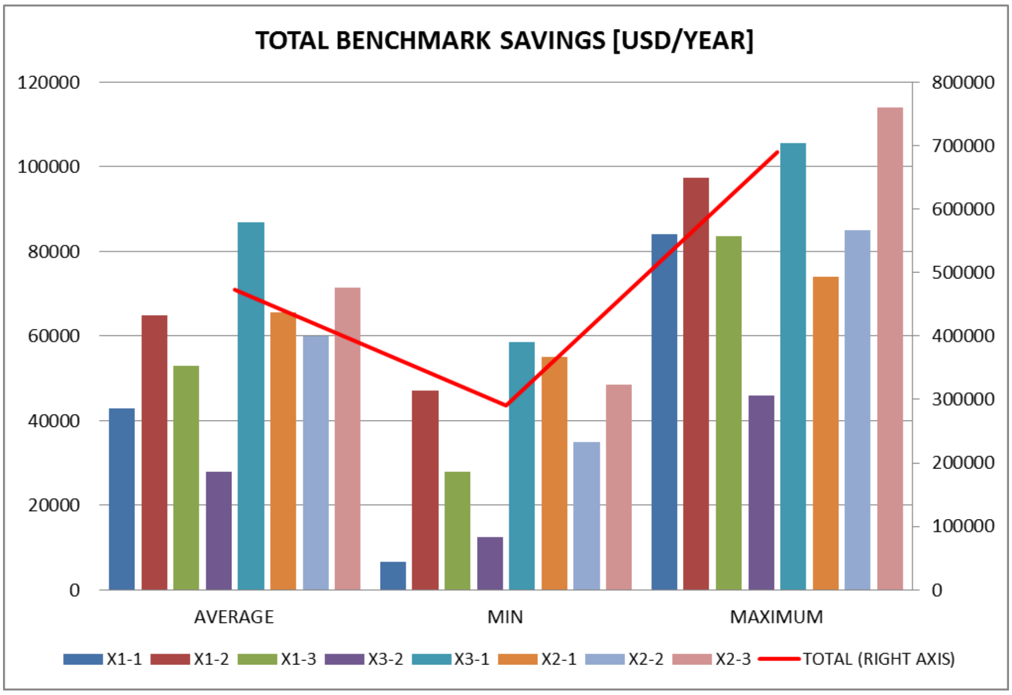
The average savings sorted for vessel is given in figure 40. The vessel with the best performance recorded for the components analyzed is vessel X3-1, which on average can save 28,000 USD for the measures analyzed. The worst performing vessel, vessel X3-1, which interestingly is vessel X3-2's sister vessel, has an estimated average benchmark savings of 87,000 USD, more than 3 times as much as vessel X3-1. Furthermore, the vessels carry similar cargo.

FIGURE 40: VESSEL AVERAGE BENCHMARK SAVINGS



The X1-vessels have spread in results, but the main difference can be seen between vessel X1-1 (best results) and X1-2 (least efficient results). These vessels have carried similar cargo, ammonia, in similar trade route and thus the difference in the results is odd. Vessel X1-3 has carried mainly propane and butane and achieves results in between the others. The X2-vessels have similar performance, whereas the main difference in performance can be found for the cargo seawater cooling pumps.

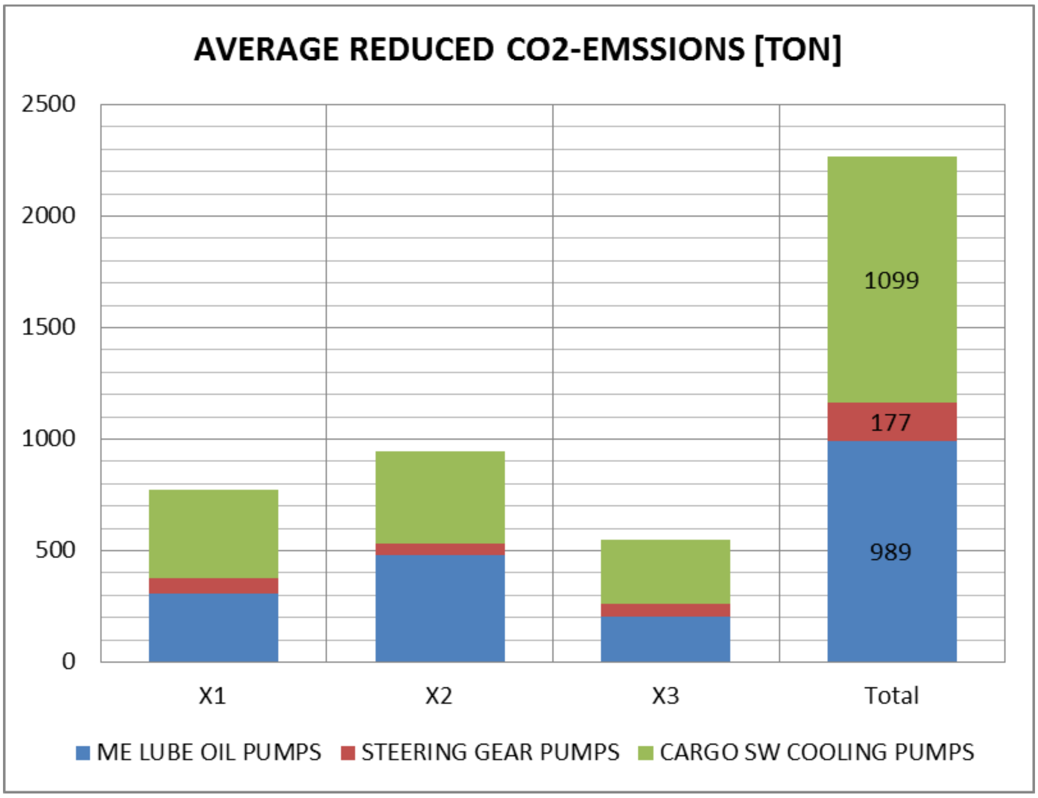
FIGURE 41: TOTAL BENCHMARK SAVINGS



In figure 41, the total average, minimum and maximum savings are given. The total minimum savings is estimated to 473,000 USD on average, 291,000 USD minimum and nearly 700,000 USD maximum. Even the minimum savings are substantial and indicate that if equipment is properly monitored and measures are carried out as a result of the findings, significant savings can be made.

In terms of reduced CO_2-emissions, using a CO_2 conversion factor of 3,114 [ton CO_2/ton HFO] yields the results in figure 42 [5]. A total of 2,265 ton of CO_2-emssions can be reduced using the average benchmark savings found.

FIGURE 42: REDUCED CO_2 EMISSIONS [TON]



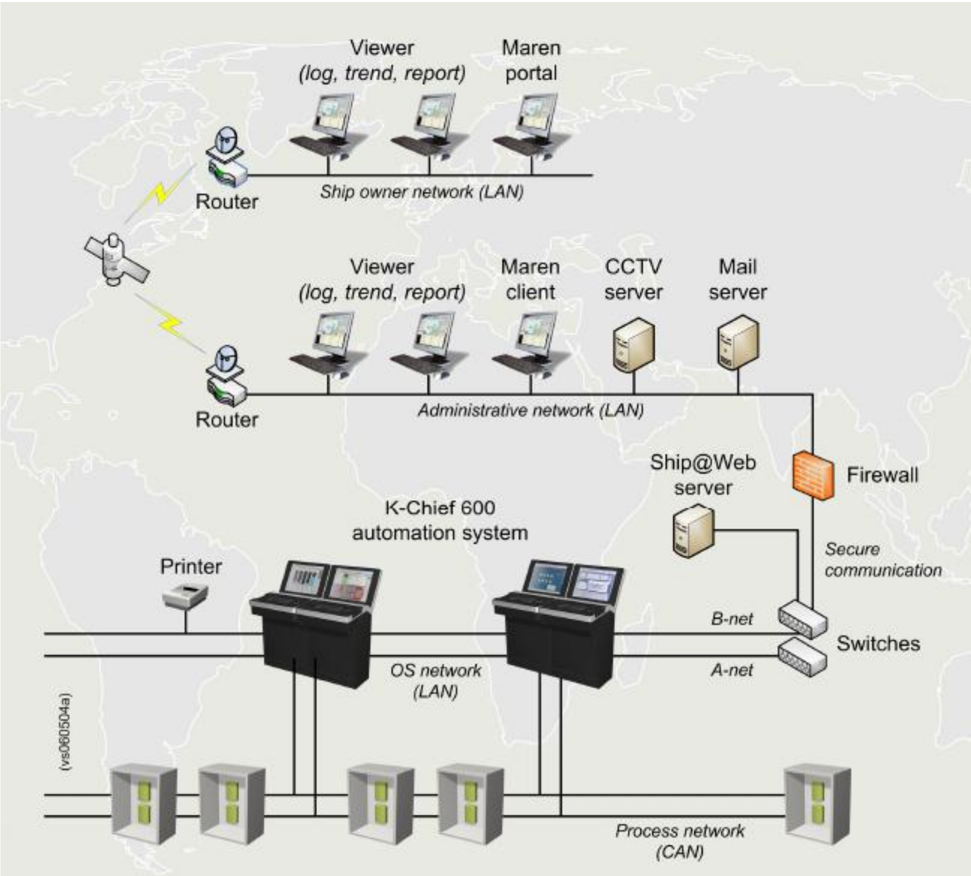
4. KONGSBERG SHIP@WEB SOFTWARE

The model and results discussed in the previous chapter requires a substantial amount of data. The work has been carried out using Microsoft Excel, which is an excellent and widely used tool, but none the less has limitations in layout, ease of use and readability, especially for large amounts of data. In addition, the data has to be manually added to the database after extraction from the maintenance system database. This chapter will review use of Kongsberg's Ship@Web software to automatize the gathering of data and establishing a cost overview and performance report for ship equipment.

The Kongsberg Ship@Web system is designed to enable continuous access to primary vessel data both onboard the vessel and from ashore. The Ship@Web system can display data from the K-Chief 600 marine automation system, making all the logged data for sensors onboard the vessel, available on a continuous basis, even from ashore.

A vessel if fitted with numerous sensors of different types, for example temperature sensors, alarms, flow-meters, hour-meter/counters and pressure gauges. The full list of available sensors for vessel X3-1 can be found in attachment C6. In addition to the data logged for the sensors, manual data can be recorded and put into the Ship@Web database account for the vessel.

FIGURE 43: SHIP@WEB SYSTEM ARCHITECTURE



The Ship@Web system architecture is a K-Chief 600 automation system with a server/firewall solution installed, prohibiting active intervention of operation from ashore. The main role of the server is to be the connection point with external networks, making information from the K-Chief 600 system available. The information from the server onboard can be synchronized to the onshore server as frequently as desired. The Ship@Web system architecture is illustrated in figure 43.

The key features of Ship@Web, as listed by Kongsberg, are: [13]

- Access to automation data
- Organization and storage of data
- Presentation and decision support
- Automatic and manual ship reporting
- Presentation in a web browser
- Navigation structure identical with the K-Chief 600 system
- All sub-systems can be displayed (for example engine monitoring, power
- Management, fire or tank systems)
- Presentation of lists, alarm views and process views
- Presentation of counters, event logs, Exhaust Gas

The data and the features available through the Ship@Web system can be used for a wide variety of purposes and functions. The main functions, as listed by Kongsberg, are [13]:

- **Viewer** - displays online data generated by the K-Chief 600 automation system. Process information can be made available anywhere on-board a vessel through the ship's administrative network or in an office ashore using a standard personal computer. Data is presented using a mimic user interface similar to that used by the Kongsberg K-Chief 600 system.
- **Trend** - Records and presents vessel process data generated by the K-Chief 600 automation system. The Trend application provides an effective tool for displaying and trending data in the K-Chief 600 automation system. This gives the user an effective tool for visualization of logged data without using an operator station. The Trend application may be used for trending information such as fuel consumption, compressor recycle time, power production and other key parameters in the automation system. The Trend can be utilized in a number of ways. Typical uses of the application include recording specific sensors to observe the changes in a selected value over time, aid in tuning controllers and monitor the condition of vessel components such as the main engine, compressors, pumps and auxiliary engines.
- **Report** - Provides reports based on online information generated by the K-Chief 600 automation system. Report data may be printed or stored as electronic PDF documents. The application includes a predefined range of report templates. Through the Report Designer, the user may also create reports with self-defined data.
- **Data Log** - provides online information from the K-Chief 600 automation system to third party recipients in the administrative network. Typical data recipients are Planned Maintenance Systems and Loading Computers. The Data Log also provides an extended logging period for K-Chief 600 process data.

Ship@Web enables direct insight into the operation, the K-Chief 600, where onshore employees can in real-time view mimic of the user interface onboard the vessel. The data logged from the numerous sensors onboard can be used to trend operation of different applications, as well as be used in self-defined reports.

In the coming section, the use of Ship@Web to monitor, validate and review performance of ship equipment according to the model proposed in the previous chapter is reviewed.

4.1 SHIP@WEB REPORT DESIGNER

All values registered by the sensors are available in Ship@Web as *tags*, representing the value registered by the sensors. The values will be registered as frequent as every 2-3 seconds and logged in the servers onboard the vessels. The Ship@Web can gather all data found in the tag-list, which compromises near all sensors connected to the K-Chief. In addition manual tags can be added, which are registered by the crew and put into the same database.

With the Kongsberg Ship@Web system, self-defined reports can be made with the Report Designer software. The report designer can import all the data found in the tag-list and the values can be the report designer supports the following formats:

- Images
- Formulas with the following operators: Add (+), Subtract (–), Multiply (*), Divide (/), Brackets (), Decimal point (.), (SUM), Average (AVG), Minimum (MIN), Maximum (MAX) and Square root (SQRT)
- Text
- Import mimic images of components or systems.

The functionality has all the formats needed to establish the Ship Equipment Cost Overview and Performance Report proposed and elaborated in the next chapter.

4.1.1 INPUT DATA USING SHIP@WEB

The model proposed in this report is based on the following parameters:

- Running hours for the components
- Power ratings for the components
- Vessel operation parameters [Fuel consumption, fuel type, operation profile and cargoes carried]

The running hours for the components are logged in the K-Chief and are thus available in Ship@Web. In the overview of sensors available for vessel X3-1, all components were accounted for and fitted with a sensor measuring running hours. The benefit of using Ship@Web as opposed to pulling the running hours for the components out of the maintenance database is that the running hours are registered continuously in Ship@Web, whereas in the maintenance database the running hours are registered at the end of each month. The frequency of which the data are extracted can be determined by the user.

The fact that the running hours for the components are available at the desired frequency adds several interesting additions to the ship equipment performance report. For instance, if the running hours are logged every day, the running hours could also be linked to the corresponding operation profile. This may not be interesting for all equipment, but for some equipment the running hours grouped into the operation profile would give valuable knowledge on the operation. Furthermore, the running hours for the cargo equipment could also be sorted by type of cargo shipped, which could be used to determine measures or suggest best practice for the different kinds of cargoes.

To calculate the operation costs, the power ratings can be added to the report template in the Report Designer, using the formula function to calculate the operation costs.

The vessel operational parameters are not available through the K-Chief, but can be added by adding manual tags which the crew will have to register. Currently, the parameters are registered in an excel workbook which is sent to Solvang. By using Ship@Web these parameters will be registered in the database and can be extracted upon need.

4.1.2 GENERATOR DATA USING SHIP@WEB

As discussed in chapter 3, one of the main sources of error when calculating the operation cost for the components, is the specific fuel consumption for the generators. However, this source of error can be greatly reduced by using Ship@Web as load, fuel consumption and produced power of the generators is recorded by the K-Chief 600. Knowing the fuel consumption and the produced power can be used to calculate the specific fuel consumption accurately, especially if this is recorded daily.

For instance, by measuring the average power produced in 24 hours, this will indicate the kilowatt-hours produced for that specific day. By dividing this with the amount of fuel consumption registered for the same period would therefore give an average of the specific fuel consumption [g/kWh] for produced power, used to calculate the operation cost of the components. Furthermore, this would make the specifications for the generators obsolete.

The enhanced data for the generators could in addition be used to monitor the operation of the generators on a far more detailed level, looking at average load and operation pattern and trends.

4.1.3 SHIP@WEB EQUIPMENT PERFORMANCE REPORT

Ship@Web is very suited for automatizing the model for assessing ship equipment operation as proposed in this report and will both improve the accuracy and the work needed to establish it. The software has additional features that will be useful in order to enhance performance of ship equipment and the overall vessel operation. Furthermore, Ship@Web is tailored to monitor SEEMP measures, as the operation of the components is available in detail. In addition to the performance factors used to normalize the operation, the trend and operation pattern for the measures can be easily reviewed using Ship@Web.

Solvang and Kongsberg, as a part of the EMIP-2 project, have installed Ship@Web for vessel X3-1 in order to test the functionality. Unfortunately, the software was installed to late in order to further elaborate the functionality and possibilities of the system in this thesis.

Using Ship@Web as a tool to establish operational performance for the ship equipment and overall operation of the vessel as a whole should be reviewed in further work.

5. RESULTS

By monitoring operation of ship equipment and estimating the costs, inefficient and efficient operation can be reviewed and measures can be carried out. By estimating the operation costs in addition to the operation, the operational performance and implemented measures are easier to validate and to communicate. In chapter 3 components were further analyzed and the results showed that there are indeed differences in operation leading to increased costs, some of which cannot be readily explained. With component monitoring, the vessel operation and performance can be assessed in detail. This could complement the SEEMP, where components showing deviations could be investigated further and where the best practice can be used as the norm.

In this chapter, the findings and results of the earlier chapter are utilized to establish a basic Ship Equipment Cost Overview Report (SECOPR), including the overall operation of the vessel, main machinery, as well as operation cost for all equipment. The report is to be used to issue a feedback report to onshore employees and ship crew.

In addition to the onshore employees being able to monitor the ship components, the crew of the vessel can benefit from having feedback on their operation. Currently, the only available data for the crew is the total running hours for the components throughout the lifespan of the vessel. Furthermore, the awareness of the operation cost could be increased by the crew knowing the actual operation costs of the components. On the Officer’s Conference of Solvang, the full majority of the chief engineers and Masters answered that feedback which would enable them to monitor their operation, compare against similar vessels and track the performance would be beneficial to operate the equipment in a more efficient manner.

Such a tool can also be used as a complement to the SEEMP. As the measures proposed in the SEEMP are to be monitored, the SECOPR would be a powerful tool in which the SEEMP measures can be easily monitored and validated, as well as normalized against the main components of dependency. As was the case for the component analysis, grouping sister vessels makes it easier for to direct comparison. Even though sister vessels trade with different cargo and trade routes, the equipment will be identical, except whereas changes have been made after delivery.

Based on findings in this report, the following are included in the Ship Equipment Cost Overview Report (SECOPR):

- Main machinery overview – Including the registered fuel used by the main machinery, as well as the running hours. This can be used to estimate the load, giving an indication of the performance of the main machinery.
- Vessel operation parameters, including operation profile, cargoes carried and registered fuel consumption of each type and in each operation profile.
- SEEMP measures. An overview of the SEEMP measures with total running hours, as well as normalization if possible. The components added to the SEEMP-monitoring in the proposed report, is the same as given in chapter 3.
- SFI-grouping. To see overall trends of several components, the main group and group, as used in the SFI grouping, can be useful for detecting the overall trend for equipment in the same systems.

Based upon the criteria given above, the SECOPR tool has been designed. The layout, design and parameters have similarities to the accuracy test used in the previous chapter. Having established the model, the running hours and the power ratings for all components, as well as having established the accuracy, the operation costs for all components has been calculated based on the model proposed in chapter 2. Using the model to establish the estimated fuel consumption of the components, the result can be multiplied by the market price of the fuel, giving the estimated operation cost of the component. For the operation costs calculated, an average price of 650 USD/ton have been used.

The proposed report is elaborated in the coming section, as well as the main results for the vessels.

5.1 SECOPR OVERVIEW

In the overview of the SECOPR, the total operation costs of the components, systems and operational parameters are given; similar to what was given in the accuracy test.

The overview is mostly for the onshore based employees in order to quickly identify operational parameters that will affect the results, such as type of cargo shipped, operation profile and running hours for the main machinery. This can be relevant data to the crew as well, as they are to compare to operation to sister vessels, where the operational parameters may be different.

The overview includes the following:

- **Registered fuel consumption and type of fuel used –** Due to the different NCV, the fuels used are of importance
- **Operation profile and related fuel consumption –** Different trading patterns and the fuel used in the conditions are valuable as an overview and can be used to calculate the fuel consumption per day in the operation profiles. Major deviations among sister vessels can indicate inefficient operation and that the equipment list should be further reviewed.
- **Main machinery and fuel consumption –** The operation of the main machinery and the registered fuel consumption for the main machinery can uncover poor operation leading to increased fuel consumption, even though the operation of the ship equipment is satisfying.
- **SEEMP measures –** The SEEMP measures for components, in addition to normalization if possible, is given in the overview.
- **Shipped cargo –** To be able to establish the performance of the cargo system, the type of cargo is important.

As was the case for the accuracy test, the overview includes the sum of the estimated equipment. Equipment fitted with counters that are partly or wholly missing, is estimated linearly or based on the operation of the other vessels and is listed under *Equipment w/counters, missing [Average ton],* as shown in figure 43 in the SECOPR for 2010 for the X1-vessels.

When summing up the estimated fuel consumption of the equipment and subtracting this from the registered and validated fuel consumption, the result is the fuel consumption of the components not fitted with counters. However, this also includes the inaccuracies of the model. The model was shown to be satisfyingly accurate and thus this value can be used to determine the operation of the equipment not fitted with counters. Even though this includes errors, the value should be monitored over time, to establish the average. If the average estimated fuel consumption of the components not fitted with counters have a large spread among sister vessels, this can indicate that the equipment not fitted with counters have been operated inefficient.

The overview of the SECOPR for the X1-vessels for 2010 is given in figure 44.

FIGURE 44: SHIP EQUIPMENT COST OVERVIEW AND PERFORMANCE REPORT, OVERVIEW

2010	1	
		REGISTERED
		CALCULATED

	OVERVIEW		
	X1-1	**X1-2**	**X1-3**
EQUIPMENT W/COUNTERS, SUM [TON]	1271	1138	1453
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	0	115	6
SUM ESTIMATED [TON]	1271	1253	1459
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1490	1477	1629
OTHER EQUIPMENT	219	224	170

	FUEL TYPE [TON]		
	X1-1	**X1-2**	**X1-3**
HFO	1306	1475	1175
LSHFO	144	0	369
MDO	39	2	85
TOTAL	**1490**	**1477**	**1629**
SFC HC	212,2	212,6	211,7
SFC LC	225,2	225,7	224,7

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3
LOADED	123	110	82	530	475	414	4,3	4,3	5,1
BALLAST	101	103	105	383	409	395	3,8	4,0	3,8
MAN	0	0	0	0	0	0			
PORT	141	152	178	577	593	820	4,1	3,9	4,6
SUM/AVERAGE	**365**	**365**	**365**	**1490**	**1477**	**1629**	**4,1**	**4,1**	**4,5**

	RUNNING HOURS [H]			REG. FUEL [TON]			SFC [KG/H]		
MACHINERY	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3
MAIN DIESEL ENGINE	5579	5275	4557	8454	7445	6725	1515,2	1411,4	1475,7
AUX. DIESEL GENERATOR	11228	11250	12369	1490	1477	1629	132,7	131,3	131,7
CARGO COMPRESSOR	4866	4927	7136						

	RUNNING HOURS [H]			P. FACTOR [#]			
SEEMP/MONITORED EQUIPMENT	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3	DEPENDENCY
ME LO PUMP	8722	8664	8693	1,56	1,64	1,91	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	9176	9141	7374	1,64	1,73	1,62	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	3875	3394	4503	3,19	2,76	2,52	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	7850	8489	7520	6,45	6,89	4,22	/(COMPRESSORS/4)

	CARGOES [NR]		
TYPE OF CARGO	X1-1	X1-2	X1-3
Ethylene	0	0	0
Ethane	0	0	0
Butene/-diene	0	0	0
Propane	1	0	7
Propylene	0	0	0
Crude C4	0	0	0
n-Butane	0	0	1
ISO-Butane	0	0	0
Ammonia	7	5	0
Prop+Butane	0	0	3
TOTAL	**8**	**5**	**11**

5.1.1 SECOPR OVERVIEW RESULTS

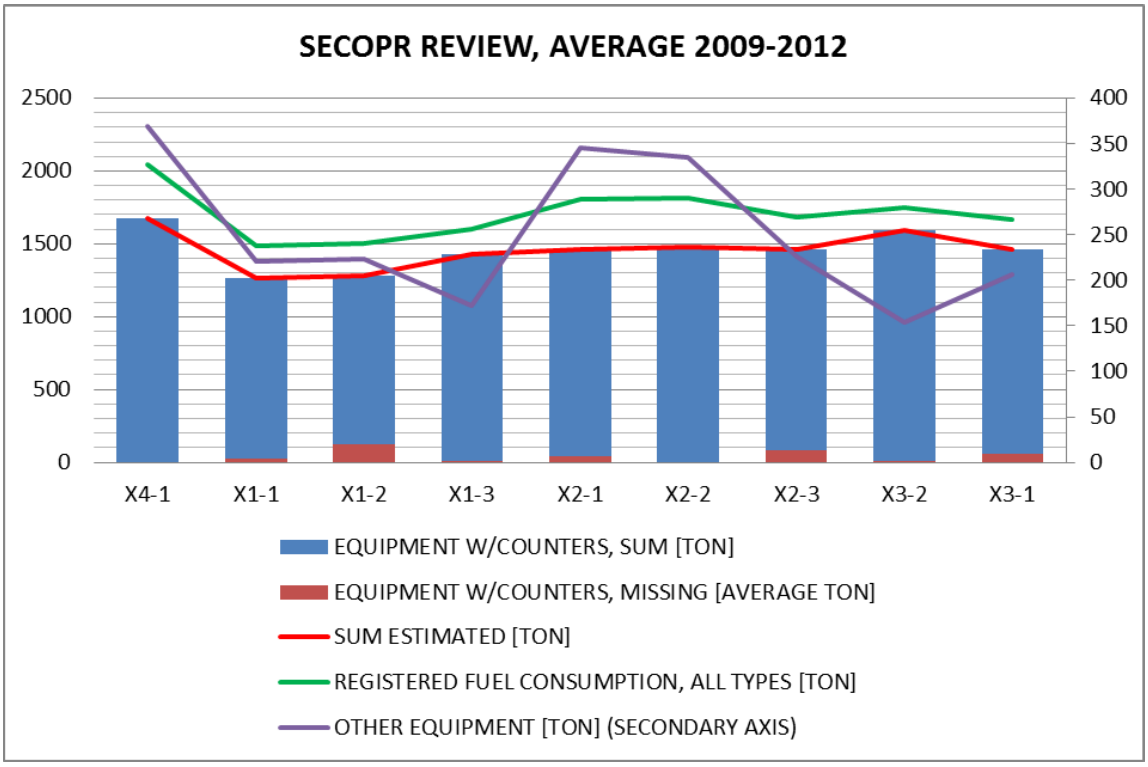
The operation profile, SEEMP measures, type of cargo and fuel consumption with regards type and operation profile have already been established earlier in this report. The full results for the estimations, however, have not been reviewed. In figure 45, the average results for 2009-2012 for the following parameters are given:

- The total estimated fuel consumption, consisting of components that have been registered correctly and the components whereas one or more are missing. These results are indicated in the bars, whereas the fuel consumption calculated on the registered running hours for the components is illustrated by the blue part of the bars. Estimations of the components missing registered running hours are illustrated by the red part of the bar.

- The registered fuel consumption [ton] (all types) – Green line
- The difference in registered and estimated fuel consumption, labeled as *Other equipment* (Purple line)

The correlation between the estimated fuel consumption and the registered fuel consumption is deemed satisfactory for all vessels, observing satisfactory correlation for the red and green line. The correlation is highest for the X1 and X3-vessels. For the X2-vessels, vessel X2-1 and X2-2 have the highest difference in estimated fuel consumption and registered fuel consumption. Either this is due to error in the calculations, ratio of components fitted with counters or that the components not fitted with counters are operated less efficient. Their sister vessel, X2-3 achieves far better results in this respect. Vessel X4-1 has the highest difference, but only has data for 2012.

FIGURE 45: ESTIMATED FUEL CONSUMPTION, COMPARED



5.2 SECOPR SYSTEM OVERVIEW

The SFI code can be used to group the components into systems and subsystems and thus the SECOPR can also be used to summarize the results looking on a system level. For instance, this can be useful when looking at an isolated system, or preferring to exclude the cargo system as this will vary with type and volume of cargo shipped.

In the coming section the results for the operation and operation costs for the systems and subsystems are given, as well as a brief discussion on the heaviest consumers of the systems, dependencies and the possibility of normalizing the operation of the systems.

The system and subsystem for the individual components can be found in attachment C4.

In figure 46, the proposed systems overview of the SECOPR is given for the X-1 vessels. The main system is listed, whereas the subsystems of the main system are listed below.

For instance, *Equipment for Cargo* SFI-system consists of the following subsystems:

- Loading/discharging systems for liquid cargo (Deepwell pumps and cargo booster pumps)
- Freezing, refrigerating & heating systems for cargo (Cargo compressors)
- Gas/ventilation systems for cargo holds/tanks (Gas freeing fans)
- Auxiliary systems & equipment for cargo (Glycol pumps, cargo seawater cooling pumps)

Note that the sum for the systems equals the sum for the subsystems.

FIGURE 46: SHIP EQUIPMENT COST OVERVIEW AND PERFORMANCE REPORT, SYSTEMS

	RUNNING HOURS [H]			EST. FUEL [TON]		
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	X1-1	X1-2	X1-3	X1-1	X1-2	X1-3
EQUIPMENT FOR CARGO	20230	15846	22590	439	418	588
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	1240	796	1848	72	51	105
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	5157	5070	7296	259	255	366
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	1535	184	464	9	5	5
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	12299	9796	12983	99	106	112
SHIP EQUIPMENT	12192	10991	11806	69	77	82
MANOEUVRING MACHINERY & EQUIPMENT	9053	9264	8624	42	55	55
ANCHORING, MOORING & TOWING EQUIPMENT	1026	688	958	23	17	22
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	2113	1039	2224	4	5	4
EQUIPMENT FOR CREW	71913	71975	76400	200	220	222
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	4660	4222	4353	9	8	8
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	66514	67753	70803	190	212	213
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	739	0	1245	1	1	1
MACHINERY MAIN COMPONENTS	15266	13827	14517	9	14	9
DIESEL ENGINES FOR PROPULSION	665	1302	661	6	11	6
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	14600	12525	13856	3	3	3
SYSTEMS FOR MAIN MACHINERY	179894	171242	165710	530	528	515
FUEL SYSTEMS	46742	50464	38670	46	44	37
LUBE OIL SYSTEMS	51403	50808	53186	146	161	149
COOLING SYSTEMS	41591	40233	40414	270	262	261
COMPRESSED AIR SYSTEMS	14051	10510	12064	27	20	28
STEAM, CONDENSATE & FEED WATER SYSTEMS	16724	17519	16255	20	21	19
DISTILLED & MAKE-UP WATER SYST	9382	1708	5123	21	20	19
SHIP COMMON SYSTEMS	1971	1657	2337	18	24	14
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	654	610	547	11	10	8
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	534	506	273	7	14	5
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	784	541	1517	0	0	1
SUM	301466	285538	293362	1264	1280	1429

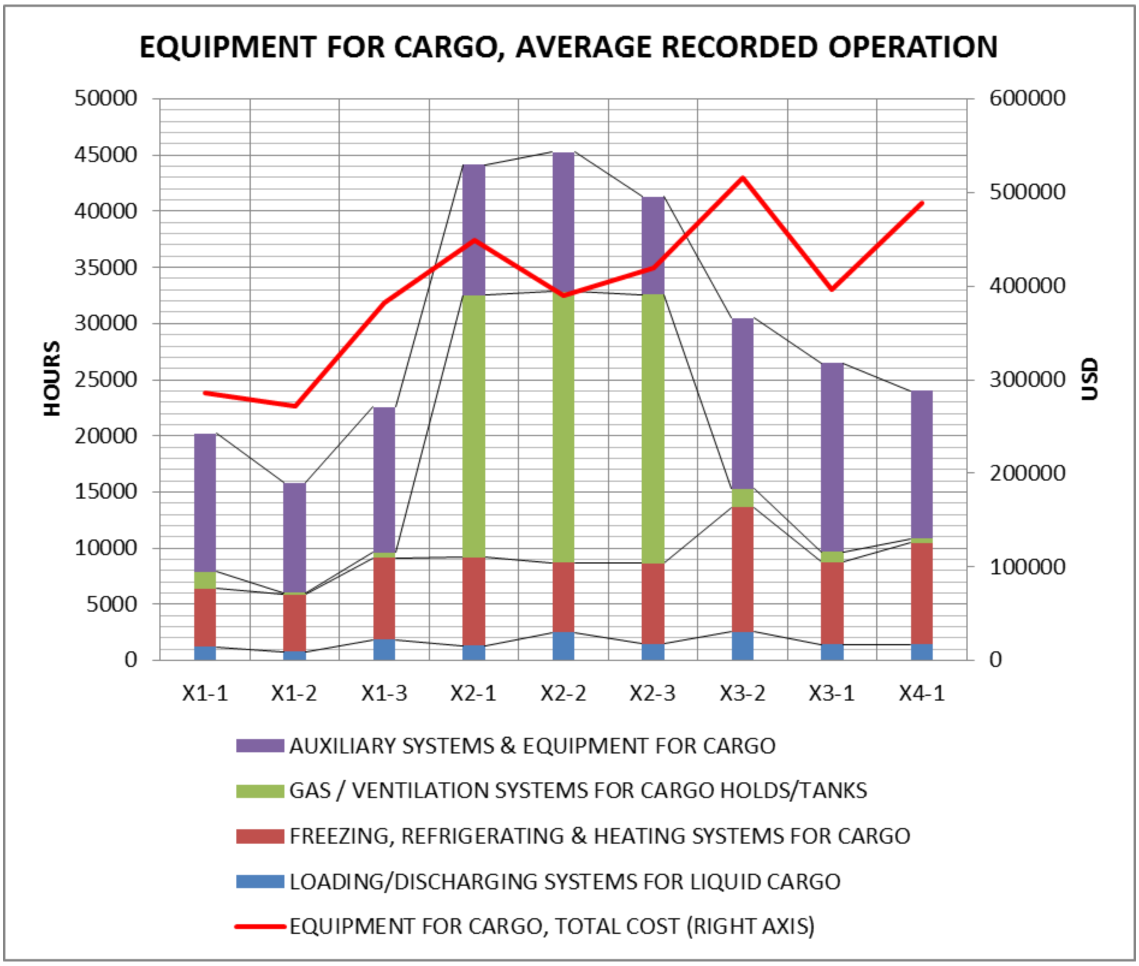
In the coming section the following systems will be reviewed: Equipment for cargo, Ship equipment, Equipment for crew and Systems for main machinery. The *Ship Common Systems* and *Machinery Main Components* systems have not been reviewed due to the lower amount of operation and operation costs compared to the other systems.

Even though the systems are SFI standardized, the number of components with registered running hours varies among the vessels. Thus, estimated operation and operation costs may not reflect the real-time system operation and operation costs. Moreover, this can result in differences for vessels that are not sister vessels.

5.2.1 EQUIPMENT FOR CARGO, OPERATION AND COSTS

In figure 47, the average recorded operation of the cargo equipment is given for the nine vessels, as well as the total cost for the system. The equipment for cargo is the most costly system and the most expensive in terms of operation/cost ratio.

FIGURE 47: EQUIPMENT FOR CARGO, OPERATION AND COSTS



There are differences between the vessels which are normal due to variation in total cargo shipped and of which type. It can be observed from the figure that the operation of the *Gas/Ventilation Systems For Cargo Holds/Tanks* has far more operation for the X2-vessels as compared to the others. This is due to the fact that the exhaust fan of the cargo compressor room and the air-lock fan are listed in this system, whereas these components have been listed otherwise for the other vessels.

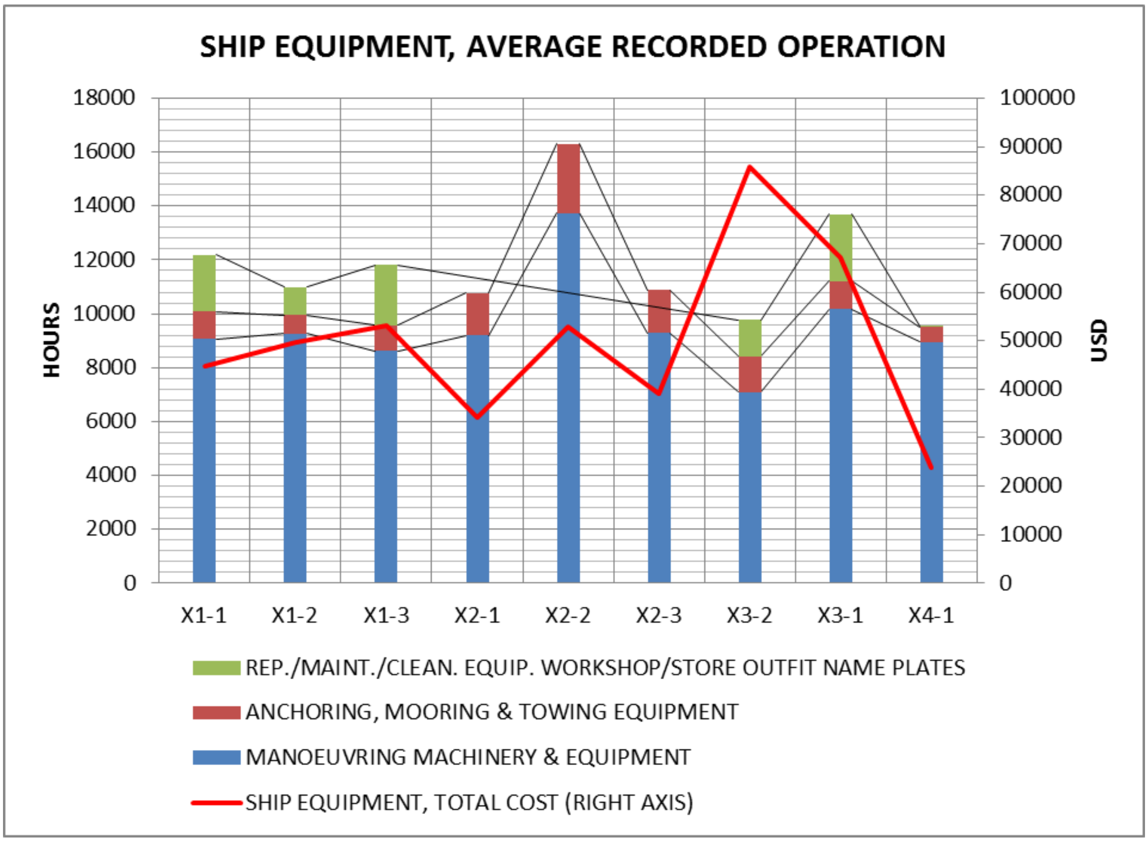
The highest consumers of the system are cargo compressors, cargo main pumps and cargo seawater cooling pumps.

The specific operation costs of the components are found in the next chapter. Direct comparison of the cargo equipment is pointless if the results have not been normalized with regards to cargo and type of cargo shipped, which are the main dependencies of this system. This has not been performed in this thesis, but could have been of great benefit when comparing the performance of cargo operations. The cargo equipment system is by far the most expensive system in operation costs, where vessel X3-2 has an average operation cost exceeding 500,000 USD per year. Even minor inefficiencies can result in significant losses and a method enabling for accurate performance monitoring and comparison between vessels in order to establish should be reviewed in further work.

5.2.2 SHIP EQUIPMENT SYSTEM, OPERATION AND COSTS

In figure 48, the operation and operation costs for the Ship Equipment System, is given. The subsystems of ship equipment include various workshop equipment, anchoring/mooring and towing equipment, as well as maneuvering machinery equipment.

FIGURE 48: SHIP EQUIPMENT, OPERATION AND COSTS



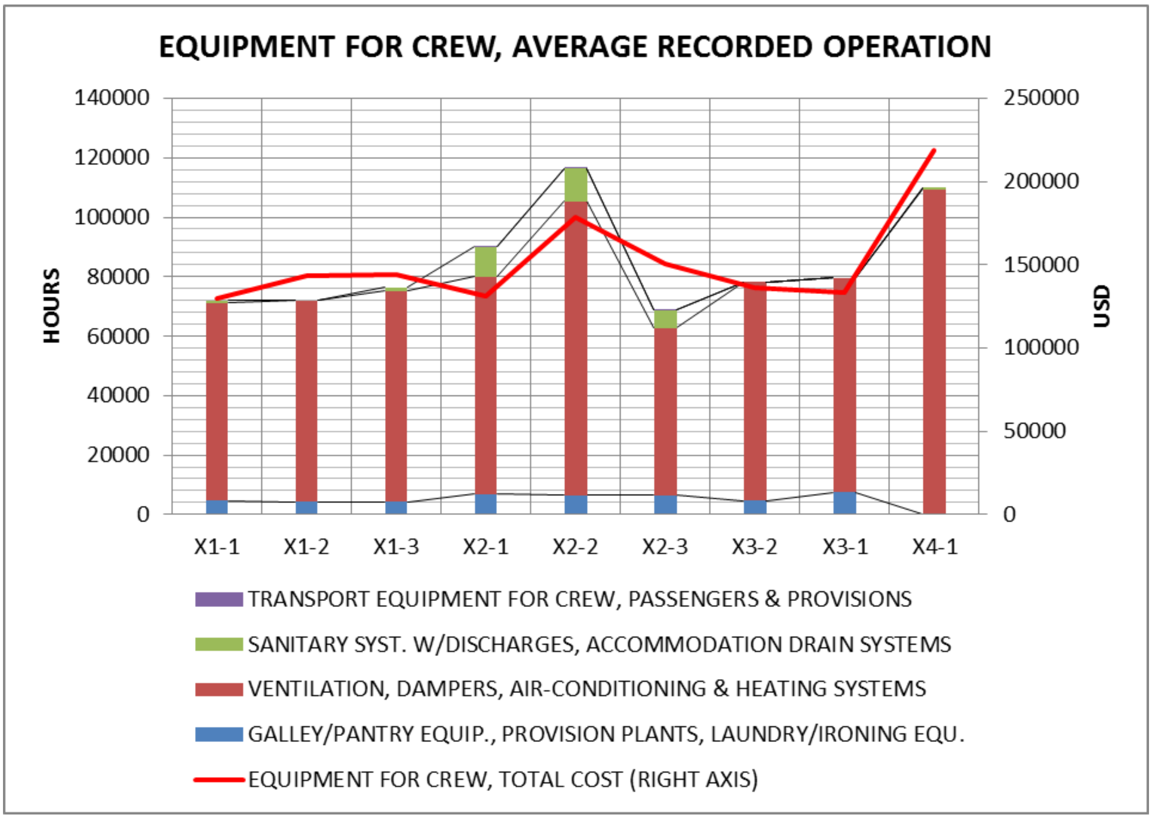
The highest consumers of this system are steering gear hydraulic oil pumps, bow thruster and windlass/mooring equipment.

The main dependency of this system is the amount of time spent maneuvering, mainly due to the bow thruster. Vessels spending more time at sea should experience lower consumption of the components part of the ship equipment system and its subgroups. The highest average recorded operation cost for the ship equipment system, is vessel X3-2. This is mainly due to use of the bow thrusters, which can be attributed to the high number of cargoes shipped by this vessel in this period.

5.2.3 EQUIPMENT FOR CREW, OPERATION AND COSTS

The operation and operation costs for the vessels for the *equipment for crew* system is given in figure 49.

FIGURE 49: EQUIPMENT FOR CREW, OPERATION AND COSTS



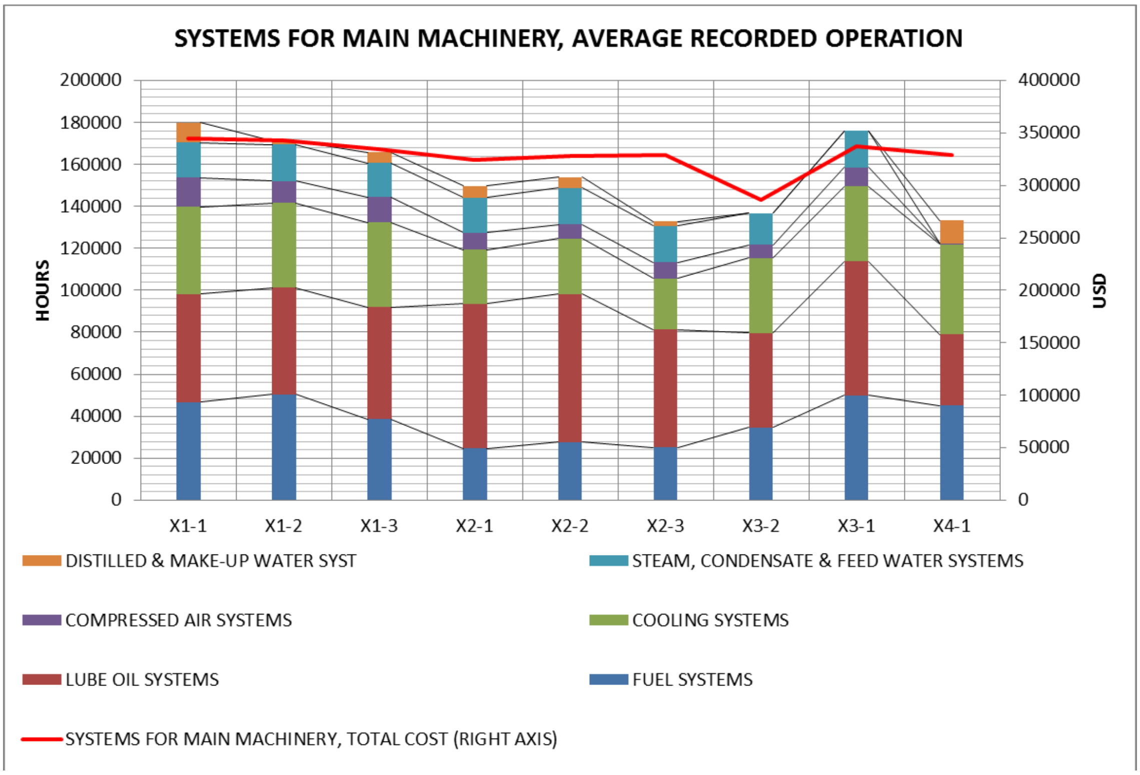
The main operation costs of this system are mainly from the subgroup *ventilation, dampers, air-conditioning &heating systems*. The equipment in this subgroup has 60,000-100,000 running hours in total. The main consumers in this system are air condition cooling compressors/fans, supply fans in the engine room and the cargo compressor exhaust fan.

For specific operation costs of these components, refer to the next chapter. The *Equipment for crew* system is mostly dependent on temperature where the highest consumers are the air-condition compressors and engine room supply fans. Thus, in order to normalize this system, temperature in the trade route would be the most effective. However, many of the components in this system is based on the welfare of the crew and should therefore be thought thoroughly through before measured are enforced. None the less, experiences imply that both the air condition compressors and the supply fans are not necessarily operated with the highest grade of efficiency.

5.2.4 SYSTEMS FOR MAIN MACHINERY, OPERATION AND COSTS

The systems for main machinery are the second most costly system, after the cargo equipment. The average recorded operation and operation costs for this system is illustrated in figure 50.

FIGURE 50: SYSTEMS FOR MAIN MACHINERY, OPERATION AND COSTS



There are 6 main subgroups of this, as given in the figure 50. The main consumers of this system are the main engine lube oil pumps, central cooling pumps and air compressors.

It was shown in chapter 3 that the equipment in this system is not always operated as efficiently as possible, where the lube oil pumps was proved to be operated with little correlation to the main engine. The main dependency of this system is the main engine and the amount of fuel used, but for this system, the subsystems are of higher interest. The lube oil system and the fuel oil systems can be normalized with regards to amount of fuel or lube oil used and of which kind, as well as the main engine. The cooling systems can be normalized looking at the main engine and the trade route with regards to seawater temperature.

5.3 SECOPR COMPONENT OVERVIEW

The average operation costs for the components fitted with counters for 2009-2012 will be given for the vessels in the scope of this report. The operation costs have been found using the model given in chapter 2. The price of fuel has been set to 650 USD/ton, regardless of fuel used.

The SECOPR component overview can be used to:

- Establish a database for equipment operation and operation costs
- The model proposed in this thesis utilizes the power ratings (power output, efficiency and load factor) and running hours to establish the operation costs. This data can be used to calculate the savings if operational measures are carried out, as reviewed out in chapter 3. In addition, the data can be used to calculate

the cost-benefit when investing in new equipment with improved specifications, simply be altering the parameters that are different. The estimated savings when installing new equipment can be compared to the cost of the new equipment to calculate the payback time.

- Data on the operation and operation cost can be used as a foundation when establishing equipment for newbuilds. If adding the manufacturer and model, the solutions can be compared and the best solution can be selected.
- Establish the needed power output of components. For instance, the four engine room supply fans of vessel X4-1 are rated at 30 [kW] compared to the four engine room fans for the other vessels, rated at 15 [kW]. Data shows that the running hours for the engine room supply fans on vessel X4-1 are running just as much as that of the other vessels. This may indicate that the engine room supply fans are over dimensioned.
- Comparison of different system setups. For instance, some vessels are fitted with two steering gear pumps while others are fitted with three. By comparing the setups, the best solution in terms of operation and operation costs can be compared.

The results for the components will not be discussed or elaborated, but the average operation costs recorded for 2009-2012 are given in figure 51-54. These results have been added due to the appendix of the report being restricted.

As was the case the in the accuracy test, the *N*-column under *RUNNING HOURS* indicate the average number of registered components. The total components of the group are given next to the machinery and mean power input, also under column *N*. If the average components are lower than the total components, cost estimations has been made linearly or based on the other vessels. This is not the case for the running hours. The running hours given are based on what is registered. For the components where not all components have been registered, the running hours must be scaled according to the average number of components registered, which has not been carried out in the figures.

FIGURE 51: AVERAGE COMPONENT OPERATION AND COSTS, X1-VESSELS

			RUNNING HOURS [H]						OP COSTS [USD/YEAR]		
			X1-1		X1-2		X1-3		X1-1	X1-2	X1-3
MACHINERY	N	kW	RH	N	RH	N	RH	N	TOT	TOT	TOT
CARGO MAIN PUMP	8	281,9	1140	8,0	796	8,0	1547	7,8	44348	30973	61277
CARGO BOOSTER PUMP	2	162,2	100	2,0	0	1,0	301	2,0	2244	2111	6726
CARGO COMPRESSOR	4	236,8	5157	4,0	5070	4,0	7296	4,0	168613	165755	237713
CARGO TANK GAS-FREEING FAN	4	48,1	414	3,8	57	2,7	12	4,0	3155	1334	82
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	174	1,0	127	1,0	185	0,8	2200	1604	3232
NITROGEN GENERATOR	1	4,8	946	1,0	0	0,0	267	1,0	668	463	188
CARGO HOSE CRANE	1	36,6	63	1,0	24	0,3	56	1,0	335	348	298
CARGO CONDENSER SW COOLING PUMP	2	94,6	3502	2,0	3814	2,0	4145	2,0	48468	52880	57162
GLYCOL COOLING SYSTEM PUMP	2	12,8	8690	2,0	5949	1,3	8711	2,0	15400	15966	15389
GLYCOL COOLING SYSTEM PUMP (VAPORISER)	1	12,8	44	1,0	10	1,0	71	1,0	83	18	132
STEERING GEAR HYDR OIL PUMP	2	12,3	8883	2,0	9058	2,0	8321	2,0	15995	16371	14958
BOW THRUSTER	1	1073,7	76	1,0	128	1,0	140	1,0	11244	19011	20637
HYDRAULIC OIL PUMP BOW THRUSTER	1	4,9	94	1,0	77	0,3	164	1,0	67	113	118
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	452	2,0	302	2,0	385	1,8	7313	4898	7063
MOORING WINCH HYDR. OIL PUMP	2	89,5	575	2,0	386	1,7	573	2,0	7510	6358	7479
INCINERATOR	1	8,9	2113	1,0	1039	0,3	2224	1,0	2723	3003	2869
PROVISION COOLING COMPRESSOR	2	8,3	4660	2,0	4222	2,0	4353	2,0	5648	5135	5267
AIR-CONDITION COOLING COMPRESSOR	2	56,1	4112	1,5	0	0,0	7519	2,0	47269	52268	61503
SUPPLY FAN, ENGINE ROOM	4	12,9	30599	4,0	33365	4,0	30304	4,0	57417	62862	56789
EXHAUST FAN, PURIFIER AREA	1	1,8	7734	1,0	7925	1,0	8181	1,0	2085	2145	2203
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,5	6584	1,0	8650	1,0	7074	1,0	10091	13278	10799
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,8	8614	1,0	8754	1,0	8736	1,0	1045	1066	1059
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	4,6	8747	1,0	8758	1,0	8740	1,0	5813	5844	5802
SUPPLY FAN, BOW THRUSTER & BOSUN STORE R	1	4,7	124	1,0	302	1,0	250	1,0	85	208	171
POTABLE WATER HYDROPHORE PUMP	2	4,5	739	2,0	0	0,0	1245	2,0	479	501	806
ME COMBUSTION AIR BLOWER	2	39,1	662	2,0	1302	2,0	661	2,0	3781	7469	3772
ME TURNING GEAR	1	3,4	4	0,8	0	0,0	0	0,8	2	1	0
AE LO PRIMING PUMP	3	0,9	14600	3,0	12525	2,7	13856	3,0	1882	1810	1784
HFO TRANSFER PUMP	3	13,0	404	3,0	418	2,3	436	3,0	764	1184	823
MDO TRANSFER PUMP	1	4,9	5	1,0	3	0,3	15	1,0	4	6	10
HFO PURIFIER	2	15,3	8260	2,0	6119	1,7	6647	2,0	18378	15733	14769
SLUDGE OIL PUMP	1	3,3	38	1,0	103	1,0	61	1,0	19	50	30
ME FO SUPPLY PUMP	2	1,4	7651	1,8	8765	2,0	7358	1,8	1761	1769	1636
ME FO CIRCULATING PUMP	2	3,3	6578	1,5	8766	2,0	3717	1,3	3322	4300	2566
AE FO SUPPLY PUMP	2	0,7	7664	1,8	8767	2,0	7502	1,8	864	868	831
AE FO BOOSTER PUMP	2	3,3	7649	1,8	8766	2,0	4406	1,5	4266	4300	2984
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR D	1	2,1	1	1,0	13	0,7	30	0,8	0	4	9
AUX. BOILER FO PUMP	2	0,4	8492	2,0	8744	2,0	8498	2,0	547	566	547
LO TRANSFER PUMP	1	3,3	19	1,0	0	0,7	0	0,8	9	0	0
AE LO PURIFIER	2	4,7	8825	2,0	14455	2,0	9874	2,0	6057	9974	6773
ME LO PURIFIER	2	4,7	8234	2,0	11451	1,7	11695	2,0	5657	9458	8019
AE LO PURIFIER SUPPLY PUMP	2	0,4	8842	2,0	5400	0,7	14334	2,0	533	837	864
ME LO PURIFIER SUPPLY PUMP	2	1,4	8234	2,0	2043	0,3	0	1,5	1655	1401	332
ME LO PUMP	2	64,4	8480	2,0	8692	2,0	8523	2,0	79694	82028	80017
STERN TUBE LO PUMP	2	0,8	8769	2,0	8766	2,0	8760	2,0	1059	1063	1057
ME COOLING SW PUMP	3	32,6	15544	3,0	13942	3,0	15766	3,0	73932	66553	74882
ME JACKET COOLING FW PUMP	2	13,0	8760	2,0	8760	2,0	8762	2,0	16591	16659	16577
CENTRAL COOLING FW PUMP	3	33,8	17287	3,0	17531	3,0	15887	3,0	85240	86788	78251
MAIN STARTING AIR COMPRESSOR	2	35,7	660	2,0	391	2,0	1408	2,0	3446	2045	7339
SERVICE AIR COMPRESSOR	1	5,7	5265	1,0	3278	1,0	4964	1,0	4339	2715	4089
CONTROL AIR COMPRESSOR	1	8,5	8127	1,0	6841	1,0	5692	1,0	10055	8499	7024
AUX. BOILER FEED WATER PUMP	2	6,8	8765	2,0	8763	2,0	8755	2,0	8662	8695	8643
AUX. BOILER CIRCULATING PUMP	2	3,7	7960	2,0	8756	2,0	7500	2,0	4247	4692	3996
FW GENERATOR SW PUMP	1	16,8	5119	1,0	1708	0,3	5123	1,0	12575	12554	12571
FW GENERATOR DISTILLATE PUMP	1	1,2	4264	0,8	0	0,0	0	0,8	762	334	0
BALLAST PUMP	2	99,4	468	2,0	431	2,0	361	2,0	6781	6268	5223
BILGE TRANSFER PUMP	1	2,1	186	1,0	179	1,0	186	1,0	56	54	56
BILGE/MAIN FIRE/GS PUMP	2	90,3	313	2,0	475	1,7	258	2,0	4125	8569	3393
DECK WATERSPRAY PUMP	1	121,9	4	1,0	15	1,0	2	1,0	69	266	31
EMERGENCY FIRE PUMP	1	6,3	217	1,0	16	1,0	14	1,0	196	15	12
CARGO REMOTE VALVE HYDR. OIL PUMP	2	1,8	173	2,0	304	1,7	1134	2,0	44	105	290
BALLAST REMOTE VALVE HYDR. OIL PUMP	2	1,8	611	2,0	237	2,0	383	2,0	157	61	98

FIGURE 52: AVERAGE COMPONENT OPERATION AND COSTS, X2-VESSELS

		RUNNING HOURS [H]						OP COSTS [USD/YEAR]		
		X2-1		X2-2		X2-3		X2-1	X2-2	X2-3
MACHINERY	N	RH	N	RH	N	RH	N	TOT	TOT	TOT
BOILER FEED WATER PUMP	2	8423	2,0	8736	2,0	8742	2,0	8018	8384	8451
BOILER WATER CIRCULATION PUMP	2	8221	2,0	8724	2,0	8736	2,0	4927	5272	5317
ME JACKET COOLING FW PUMP	2	8451	2,0	8759	2,0	6750	1,5	15360	16052	16697
ME LO PUMP	2	8323	2,0	8685	2,0	8563	2,0	81617	85866	85281
BALLAST PUMP	2	307	2,0	480	2,0	262	1,5	3626	5710	4452
GLYCOL PUMP	2	8535	2,0	8837	2,0	4446	1,0	9172	9573	9499
CARGO COMPRESSOR	4	7868	4,0	6212	4,0	7208	4,0	321236	252578	294361
CARGO CONDENSER SW COOLING PUMP	2	3041	1,5	3538	2,0	4271	2,0	47677	46455	56330
CARGO DEEPWELL PUMP	8	1172	6,0	1967	8,0	1216	7,5	45793	55411	36813
CARGO BOOSTER PUMP	2	138	1,0	517	2,0	250	2,0	8355	11520	5572
WORKING AIR COMPRESSOR	1	2539	1,0	3209	1,0	2670	1,0	5019	6400	5358
CONTROL AIR COMPRESSOR	1	4170	1,0	3311	1,0	4178	1,0	3366	2690	3421
STARTING AIR COMPRESSOR	2	1575	2,0	313	2,0	643	2,0	10085	2024	4188
HFO TRANSFER PUMP	3	131	3,0	120	3,0	148	3,0	284	262	324
PRE-LUB PUMP	3	13728	3,0	13249	3,0	13787	3,0	1229	1196	1254
ME COMBUSTION AIR BLOWER	2	1370	2,0	1222	2,0	1119	2,0	7514	6742	6217
CENTRAL COOLING FW PUMP	2	8448	2,0	8759	2,0	8754	2,0	82838	86598	87174
ME EXH VALVE ACTUATOR OIL PUMP	2	8315	2,0	8681	2,0	8479	2,0	1675	1763	1735
STERN TUBE LUB OIL PUMP	2	8436	2,0	8760	2,0	8755	2,0	850	890	896
ME FO SUPPLY PUMP	2	8427	2,0	8738	2,0	8750	2,0	1698	1775	1790
ME FO CIRC. PUMP	2	5783	1,5	8744	2,0	8814	2,0	5283	6216	6312
AUX. ENGINE DO SUPPLY PUMP	1	423	1,0	666	1,0	392	1,0	77	124	73
BILGE TRANSFER PUMP	1	66	1,0	67	1,0	95	1,0	30	31	45
ME COOLING SW PUMP	2	8466	2,0	8760	2,0	8769	2,0	71429	74521	75136
DECK WATERSPRAY PUMP	1	2	0,5	2	1,0	2	1,0	41	28	40
IGG SW PUMP	1	356	1,0	55	1,0	84	1,0	2956	465	710
HFO DAILY TRANSFER PUMP	1	1552	1,0	1442	1,0	1278	1,0	452	423	378
HYD PUMP FOR REMOTE CONTR. VALVES	2	1554	2,0	3326	2,0	2655	2,0	274	591	475
SIDE THRUSTER (BOW THRUSTER)	1	97	1,0	149	1,0	126	1,0	15034	22986	19545
E-MOTOR ROOM SUPPLY FAN	2	7515	1,5	9020	2,0	7209	1,8	5789	4886	4490
EXHAUST FAN, CARGO COMPRESSOR ROOI	1	7288	1,0	6389	1,0	8103	1,0	9954	8802	11242
AIR LOCK SP SUPPLY FAN	1	8458	1,0	8733	1,0	8555	1,0	663	690	681
SUPPLY FAN, ENGINE ROOM	4	29250	4,0	32829	4,0	19653	2,5	50644	57304	53250
BOSN STR & THR COMP SUPPLY FAN	1	404	1,0	354	1,0	356	1,0	112	98	100
DRY POWDER EXH FAN	1	3573	1,0	8521	1,0	0	1,0	271	654	0
HFO SEPARATOR	2	8283	2,0	7902	2,0	5651	1,5	10132	9747	8955
ME LUB OIL SEPARATOR	1	7620	1,0	8183	1,0	3910	0,5	5526	5984	5705
AE LUB OIL SEPARATOR	3	22462	3,0	22948	3,0	12678	2,0	3108	3201	2797
HOT WATER CIRC PUMP	1	5915	1,0	6837	1,0	3179	0,5	289	338	330
HYDROPHORE PUMP	2	4115	2,0	4167	2,0	2822	1,5	1727	1769	1482
STEERING GEAR HYDR OIL PUMP	3	9106	3,0	13582	3,0	9159	3,0	12612	18966	12882
PROVISION REF. COMPRESSOR	2	6851	2,0	6458	2,0	6407	2,0	12663	12024	12017
AIR-CONDITION COOLING COMPRESSOR	2	6111	2,0	9184	2,0	7169	2,0	28034	42442	33382
SUPPLY VENT FAN FOR ACCOMONDATION	2	10250	2,0	17483	2,0	10058	1,5	23297	40050	31084
SLUDGE OIL PUMP	1	63	1,0	83	1,0	89	1,0	17	23	25
FWG EJECTOR PUMP	1	5486	1,0	5109	1,0	2161	0,5	8404	7890	7367
HYDR. UNIT WINDLASS & MOORING W.	3	705	3,0	936	3,0	851	3,0	2974	3980	3636
HYDR. UNIT MOORING W. AFT	3	864	3,0	1644	3,0	735	3,0	3636	6991	3143
EXH FAN FOR ACCOMODATION	2	10242	2,0	17487	2,0	10058	1,5	13990	24074	18680

FIGURE 53: AVERAGE COMPONENT OPERATION AND COSTS, X3-VESSELS

		RUNNING HOURS [H]				OP COSTS [USD/YEAR]	
		X3-2		X3-1		X3-2	X3-1
MACHINERY	N	RH	N	RH	N	TOT	TOT
CARGO MAIN PUMP	8	2254	8,0	1205	4,7	69131	60375
CARGO BOOSTER PUMP	2	280	2,0	238	1,3	6940	8319
CARGO COMPRESSOR	4	11098	4,0	7300	4,0	362809	237011
CARGO TANK GAS-FREEING FAN	2	47	2,0	46	1,3	315	419
INERT GAS PLANT W/ GAS GENERATOR	1	38	1,0	72	1,0	1307	2476
IGG COOLING SW (SCRUBBER) PUMP	1	166	1,0	16	0,3	2088	1397
NITROGEN GENERATOR	1	1401	1,0	809	1,0	984	564
CARGO CONDENSER SW COOLING PUMP	3	6561	3,0	8108	3,0	59070	72489
GLYCOL COOLING SYSTEM PUMP	2	8670	2,0	8697	2,0	13555	13508
STEERING GEAR HYDR OIL PUMP	2	6827	2,0	10030	2,0	14717	21486
BOW THRUSTER	1	258	1,0	141	1,0	50428	27433
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	603	2,0	472	2,0	9223	7173
MOORING WINCH HYDR. OIL PUMP	2	737	2,0	576	2,0	9603	7448
INCINERATOR	1	1358	1,0	2474	1,0	1922	3488
PROVISION COOLING COMPRESSOR	2	4575	2,0	7506	2,0	5522	9001
AIR-CONDITION COOLING COMPRESSOR	2	6193	2,0	5756	2,0	53062	48944
SUPPLY FAN, ENGINE ROOM	4	32640	4,0	32020	4,0	56014	54592
EXHAUST FAN, PURIFIER AREA	1	8596	1,0	8024	1,0	2072	1920
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	8410	1,0	8558	1,0	12232	12368
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	8759	1,0	8753	1,0	247	246
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	8754	1,0	8677	1,0	6756	6653
SUPPLY FAN, BOW THRUSTER ROOM	1	374	1,0	327	1,0	283	246
ME COMBUSTION AIR BLOWER	2	629	2,0	944	2,0	4382	6530
AE LO PRIMING PUMP	3	13202	3,0	11117	2,3	1695	1863
HFO TRANSFER PUMP FWD	2	72	2,0	101	2,0	137	189
HFO TRANSFER PUMP AFT	1	246	1,0	407	1,0	341	562
MDO TRANSFER PUMP	1	85	1,0	34	1,0	61	24
HFO PURIFIER	2	5548	2,0	8285	2,0	12301	18264
HFO PURIFIER SUPPLY PUMP	2	5548	2,0	5902	1,3	1111	1681
SLUDGE OIL PUMP	1	55	1,0	72	1,0	27	35
ME FO SUPPLY PUMP	2	6047	1,7	8727	2,0	1249	1737
ME FO CIRCULATING PUMP	2	5557	1,3	8727	2,0	6103	6275
AE FO SUPPLY PUMP	2	6102	1,7	8715	2,0	634	867
AE FO BOOSTER PUMP	2	5361	1,3	8698	2,0	4003	4208
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVE	1	13	1,0	280	1,0	4	82
LO TRANSFER PUMP	1	0	1,0	2	1,0	0	1
AE LO PURIFIER	2	8865	2,0	15373	2,0	6080	10457
ME LO PURIFIER	2	5869	2,0	8308	2,0	7415	10443
AE LO PURIFIER SUPPLY PUMP	2	8865	2,0	14268	2,0	534	853
ME LO PURIFIER SUPPLY PUMP	2	5869	2,0	8516	2,0	1174	1695
ME LO PUMP	2	6801	2,0	8615	2,0	70108	88306
STERN TUBE LO PUMP	2	8764	2,0	8766	2,0	1055	1048
ME COOLING SW PUMP	3	13268	3,0	13672	3,0	62842	64359
ME JACKET COOLING FW PUMP	2	8381	2,0	6234	1,3	19249	21810
CENTRAL COOLING FW PUMP	3	14074	3,0	15866	3,0	66644	74713
MAIN STARTING AIR COMPRESSOR	2	520	2,0	615	2,0	2646	3104
SERVICE AIR COMPRESSOR	1	2574	1,0	1503	1,0	2114	1228
CONTROL AIR COMPRESSOR	1	3130	1,0	6949	1,0	3856	8511
AUX. BOILER FEED WATER PUMP	2	8758	2,0	8688	2,0	12811	12626
AUX. BOILER CIRCULATING PUMP	2	6476	2,0	8746	2,0	3196	4291
BALLAST PUMP	2	484	2,0	423	2,0	50	43
BILGE/MAIN FIRE/GS PUMP	2	333	2,0	315	2,0	4820	4531
DECK WATERSPRAY PUMP	1	2	1,0	0	0,3	19	21
EMERGENCY FIRE PUMP	1	4	1,0	19	1,0	40	208
ENGINE ROOM LOCAL WATERSPRAY SYSTEM	1	2	1,0	1	1,0	27	11

FIGURE 54: AVERAGE COMPONENT OPERATION AND COSTS, X4-VESSEL

			RH [H]		OP COSTS [USD/YEAR]
			X4-1		X4-1
MACHINERY	N	kW	RH	N	TOT
ME LO PURIFIER	2	5,1	7728	2,0	5889
MAIN STARTING AIR COMPRESSOR	2	32,2	562	2,0	2724
CARGO TANK GAS-FREEING FAN	2	45,7	2	2,0	12
GLYCOL COOLING PUMP	2	14,6	8616	2,0	18916
ME COOLING SW PUMP	3	39,1	16450	3,0	96986
ME JACKET COOLING FW PUMP	2	15,2	9154	2,0	20929
CENTRAL COOLING FW PUMP	3	39,1	17349	3,0	102286
ME FO SUPPLY PUMP	2	2,1	8787	2,0	2842
ME FO CIRCULATING PUMP	2	5,1	8829	2,0	6806
AE FO SUPPLY PUMP	2	1,3	8789	2,0	1738
AE FO BOOSTER PUMP	2	1,9	8886	2,0	2514
ME LO PUMP	2	69,3	8706	2,0	90895
STERN TUBE LO PUMP	2	0,9	8771	2,0	1128
CARGO CONDENSER SW COOLING PUMP	3	77,4	4504	3,0	52538
STEERING GEAR HYDR OIL PUMP	2	14,7	8946	2,0	19779
IGG COOLING SW PUMP	1	110,2	348	1,0	5779
BALLAST PUMP	2	107,5	695	2,0	11260
FIRE, BILGE & GS PUMP	2	113,5	1054	2,0	18032
FW GENERATOR SW EJECTOR PUMP	1	21,4	5360	1,0	17265
FW GENERATOR DISTILLATE PUMP	1	1,6	5627	1,0	1375
HFO TRANSFER PUMP	1	9,7	496	1,0	723
AE MDO FLUSHING PUMP	1	3,6	20	1,0	11
SLUDGE PUMP	1	1,3	98	1,0	20
POTABLE WATER HYDROPHORE PUMP	2	2,5	590	2,0	225
MOORING WINCH HYDR. OIL PUMP	2	85,2	258	2,0	3310
SUPPLY FAN, ENGINE ROOM	4	26,7	32527	4,0	130689
AE PRELUBRICATING OIL (PRIMING) PUMP	4	0,8	21289	4,0	2666
ME TURNING GEAR	1	3,4	15	1,0	8
HFO PURIFIER SUPPLY PUMP	2	1,3	9199	2,0	1819
ME LO PURIFIER SUPPLY PUMP	2	1,1	8542	2,0	1448
AUX. BOILER FEED WATER PUMP	2	8,8	2354	2,0	3103
EXHAUST GAS ECONOMISER FEED WATER PUMP	2	6,0	6989	2,0	6282
CARGO HOSE CRANE	1	26,1	57	1,0	224
EXHAUST FAN, PURIFIER ROOM	1	1,8	8612	1,0	2324
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	13,6	8700	1,0	17875
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR ROOM)	1	0,8	8715	1,0	994
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	8,0	8715	1,0	10505
EXHAUST FAN, PIPE DUCT	1	3,6	153	1,0	83
SUPPLY FAN, BOSUN STORE FWD	1	3,4	69	1,0	35
EXHAUST FAN, SANITARY SPACE	1	2,3	8727	1,0	2967
EXHAUST FAN, GALLEY AREA	1	0,6	5080	1,0	477
EXHAUST FAN, PAINT STORE	1	0,6	4277	1,0	402
PROVISION CRANE	2	19,3	59	2,0	172
PROVISION REF COMPRESSOR	2	5,4	8052	2,0	6514
AIR-CONDITION COOLING COMPRESSOR	2	41,8	7452	2,0	46904
ME AIR COOLER CHEMICAL CLEANING PUMP	1	1,5	5	1,0	1
SUPPLY FAN, STEERING GEAR ROOM	1	1,4	7529	1,0	1547
VENT. FAN, AIR COND. ACCOMMODATION	1	20,8	8729	1,0	27327
CARGO MAIN PUMP	8	200,9	1406	8,0	40218
CARGO BOOSTER PUMP	2	189,5	30	2,0	845
DRINKING WATER HYDROPHORE PUMP	2	2,5	117	2,0	45
CARGO CIRCUIT COMPRESSOR	4	319,4	9060	4,0	411895
COMB WINDLASS/MOORING HYDR. OIL PUMP	2	85,2	309	2,0	3965
MDO TRANSFER PUMP	1	5,1	6	1,0	4
LO TRANSFER PUMP	1	3,3	0	1,0	0

5.4 FINALIZED REPORT AND DISCUSSION

Based on the findings and results in this thesis, the proposed Ship Equipment Cost Overview and Performance Report consists of the main overview reviewed in chapter 5.1, the systems overview in chapter 5.2 and the component overview in chapter 5.3 In figure 54, the finalized report for the X3-vessels for 2010 are illustrated. The report for all vessels, year by year, can be found in appendix 9, where the operation costs have been given as fuel consumption to make the results more versatile due to fluctuating fuel prices.

The report is basic, but it enables the crew to review their operation of the components on a specific level, on a system level and on a total level, as well as compare the said results with sister vessels. Even though the results are basic, the report covers a need whereas there currently is no solution. The SECOPR report is proposed issued every quarter, as the monthly operation will vary greatly due to operation profile. Comparing a vessel spending a month laden with cargo compared to another vessel in ballast, would be pointless.

The finalized report is to be viewed as a possible solution in the task of increasing knowledge and awareness of ship equipment operation and operation costs, both for crew and onshore employees. There are several features which could be added, such as Key Performance Indicators (KPI). Based on the proposed report and the results, the following should be reviewed in further work:

- KPIs with relation to the systems and measured data. For example, the total running hours and estimated operation costs of the main engine support system in relation to the operation hours for the main engine. The main consumers and dependencies of the systems have been discussed in the previous chapters.
- KPIs measuring the total running hours and operation costs of equipment not in the cargo system, in relation the registered fuel consumption in profiles other than *loaded* and *port*.
- KPIs for the main consumers.

No KPI’s have been added in the SECOPR report, mainly as it is intended for both onshore and offshore employees. By splitting the report up, whereas one is intended for onshore employees and the other for crew, this could be an option. The addition of KPI’s should be reviewed in further work.

In figure 55, the finalized report for the X3-vessels in 2010. The report is given as an example and the results are not discussed. The report enables both crew and onshore employees to validate the fuel consumption, which fuels are used and in which condition, as well as the main machinery operation. Estimated fuel consumption for main system and subsystem are given, as well as detailed in the component list.

FIGURE 55: SHIP EQUIPMENT COST OVERVIEW AND PERFORMANCE REPORT

2010	3	REGISTERED
		CALCULATED

	OVERVIEW	
	X3-2	X3-1
EQUIPMENT W/COUNTERS, SUM [TON]	1687	1515
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	0	0
SUM ESTIMATED [TON]	1687	1515
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1894	1745
OTHER EQUIPMENT	207	230

	FUEL TYPE [TON]	
	X3-2	X3-1
HFO	1850	1535
LSHFO	38	88
MDO	7	122
TOTAL	**1894**	**1745**
SFC HC	212,6	211,5
SFC LC	224,3	223,5

	PROFILE [DAYS]		REG. FUEL [TON]		FUEL [TON/DAY]	
CONDITION	X3-2	X3-1	X3-2	X3-1	X3-2	X3-1
LOADED	45	98	275	498	6,1	5,1
BALLAST	39	66	158	291	4,1	4,4
MAN	0	0	0	0		
PORT	281	201	1461	956	5,2	4,8
SUM/AVERAGE	**365**	**365**	**1894**	**1745**	**5,1**	**4,7**

	RH [H]		REG. FUEL [TON]		SFC [KG/H]	
MACHINERY	X3-2	X3-1	X3-2	X3-1	X3-2	X3-1
MAIN DIESEL ENGINE	2261	3923	3570	6762	1579,0	1723,7
AUX. DIESEL GENERATOR	13687	12773	1894	1745	138,4	136,6
CARGO COMPRESSOR	10676	7980				

	RH[H]		P. FACTOR [#]		
SEEMP/MONITORED EQUIPMENT	X3-2	X3-1	X3-2	X3-1	DEPENDENCY
ME LO PUMP	8730	8671	3,86	2,21	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	7596	8696	3,36	2,22	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	6161	8351	2,31	4,19	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	8731	8711	3,27	4,37	/(COMPRESSORS/4)

	RH [H]		EST. FUEL [TON]		
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	X3-2	X3-1	X3-2	X3-1	COMMENT
EQUIPMENT FOR CARGO	**29727**	**28600**	**800**	**653**	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	3235	2474	148	113	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	10676	7980	537	400	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	919	1124	8	5	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	14897	17022	106	136	
SHIP EQUIPMENT	**10726**	**12570**	**147**	**101**	
MANOEUVRING MACHINERY & EQUIPMENT	7866	8841	107	72	
ANCHORING, MOORING & TOWING EQUIPMENT	1769	1058	38	23	
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	1091	2671	2	6	
EQUIPMENT FOR CREW	**79034**	**79162**	**201**	**205**	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	4811	7317	9	14	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	74223	71845	192	192	
MACHINERY MAIN COMPONENTS	**12924**	**13499**	**11**	**14**	
DIESEL ENGINES FOR PROPULSION	792	1033	8	11	
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	12132	12466	2	2	
SYSTEMS FOR MAIN MACHINERY	**163830**	**184458**	**524**	**534**	
FUEL SYSTEMS	50216	54810	49	56	
LUBE OIL SYSTEMS	50033	63733	169	176	
COOLING SYSTEMS	41418	39671	270	256	
COMPRESSED AIR SYSTEMS	4642	8762	11	19	
STEAM, CONDENSATE & FEED WATER SYSTEMS	17520	17482	26	26	
SHIP COMMON SYSTEMS	**586**	**775**	**4**	**8**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	408	410	0	0	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	178	365	4	8	
SUM	**296827**	**319064**	**1687**	**1515**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

		RUNNING HOURS				CONS[TON]&COSTS[USD]					
		X3-2		X3-1		X3-2			X3-1		
						REG	TOT	COST	REG	TOT	COST
MACHINERY	N	RH [H]	N	RH [H]	N	[TON]	[TON]	[USD]	[TON]	[TON]	[USD]
CARGO MAIN PUMP	8	2733	8	2060	8	129	129,1	83914	96,8	96,8	62906
CARGO BOOSTER PUMP	2	502	2	414	2	19,2	19,2	12451	15,7	15,7	10221
CARGO COMPRESSOR	4	10676	4	7980	4	537,4	537,4	349294	399,6	399,6	259719
CARGO TANK GAS-FREEING FAN	2	2	2	89	2	0,0	0,0	12	0,9	0,9	597
INERT GAS PLANT W/ GAS GENERATOR	1	56	1	39	1	3,0	3,0	1932	2,1	2,1	1341
IGG COOLING SW (SCRUBBER) PUMP	1	212	1	47	1	4,1	4,1	2664	0,9	0,9	591
NITROGEN GENERATOR	1	650	1	949	1	0,7	0,7	458	1,0	1,0	666
CARGO CONDENSER SW COOLING PUMP	3	6161	3	8351	3	85,4	85,4	55514	115,2	115,2	74857
GLYCOL COOLING SYSTEM PUMP	2	8736	2	8671	2	21,1	21,1	13690	20,8	20,8	13539
STEERING GEAR HYDR OIL PUMP	2	7596	2	8696	2	25,3	25,3	16429	28,8	28,8	18740
BOW THRUSTER	1	270	1	146	1	81,3	81,3	52830	43,6	43,6	28368
COMB. WINDLASS/MOORING HYDR. OIL P	2	721	2	469	2	17,0	17,0	11039	11,0	11,0	7142
MOORING WINCH HYDR. OIL PUMP	2	1048	2	589	2	21,0	21,0	13682	11,8	11,8	7659
INCINERATOR	1	1091	1	2671	1	2,4	2,4	1551	5,8	5,8	3783
PROVISION COOLING COMPRESSOR	2	4811	2	7317	2	9,0	9,0	5822	13,6	13,6	8822
AIR-CONDITION COOLING COMPRESSOR	2	5258	2	5462	2	69,4	69,4	45114	71,8	71,8	46697
SUPPLY FAN, ENGINE ROOM	4	33565	4	32880	4	88,8	88,8	57731	86,7	86,7	56351
EXHAUST FAN, PURIFIER AREA	1	8758	1	6880	1	3,3	3,3	2115	2,5	2,5	1656
EXHAUST FAN, CARGO COMPRESSOR ROO	1	8731	1	8711	1	19,6	19,6	12729	19,5	19,5	12654
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR	1	8752	1	8738	1	0,4	0,4	248	0,4	0,4	246
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	8750	1	8712	1	10,4	10,4	6769	10,3	10,3	6715
SUPPLY FAN, BOW THRUSTER ROOM	1	409	1	462	1	0,5	0,5	311	0,5	0,5	349
ME COMBUSTION AIR BLOWER	2	792	2	1033	2	8,5	8,5	5519	11,0	11,0	7179
AE LO PRIMING PUMP	3	12132	3	12466	3	2,4	2,4	1562	2,5	2,5	1599
HFO TRANSFER PUMP FWD	2	66	2	81	2	0,2	0,2	124	0,2	0,2	152
HFO TRANSFER PUMP AFT	1	198	1	383	1	0,4	0,4	276	0,8	0,8	532
MDO TRANSFER PUMP	1	1	1	18	1	0,0	0,0	0	0,0	0,0	13
HFO PURIFIER	2	7392	2	9267	2	25,3	25,3	16435	31,6	31,6	20531
HFO PURIFIER SUPPLY PUMP	2	7392	2	10083	2	2,3	2,3	1484	3,1	3,1	2017
SLUDGE OIL PUMP	1	58	1	54	1	0,0	0,0	29	0,0	0,0	26
ME FO SUPPLY PUMP	2	8761	2	8742	2	2,7	2,7	1759	2,7	2,7	1749
ME FO CIRCULATING PUMP	2	8761	2	8743	2	9,8	9,8	6356	9,7	9,7	6320
AE FO SUPPLY PUMP	2	8790	2	8543	2	1,4	1,4	883	1,3	1,3	855
AE FO BOOSTER PUMP	2	8760	2	8541	2	6,6	6,6	4275	6,4	6,4	4154
AE MDO FLUSHING PUMP P (ELECTRIC MO	1	38	1	355	1	0,0	0,0	11	0,2	0,2	104
LO TRANSFER PUMP	1	0	1	0	1	0,0	0,0	0	0,0	0,0	0
AE LO PURIFIER	2	7762	2	15339	2	8,2	8,2	5328	16,1	16,1	10491
ME LO PURIFIER	2	8511	2	8562	2	16,6	16,6	10793	16,6	16,6	10819
AE LO PURIFIER SUPPLY PUMP	2	7762	2	13334	2	0,7	0,7	468	1,2	1,2	802
ME LO PURIFIER SUPPLY PUMP	2	8511	2	9086	2	2,6	2,6	1709	2,8	2,8	1818
ME LO PUMP	2	8730	2	8671	2	138,9	138,9	90265	137,4	137,4	89334
STERN TUBE LO PUMP	2	8759	2	8741	2	1,6	1,6	1057	1,6	1,6	1051
ME COOLING SW PUMP	3	15562	3	13821	3	113,7	113,7	73910	100,6	100,6	65405
ME JACKET COOLING FW PUMP	2	8760	2	8742	2	31,0	31,0	20175	30,9	30,9	20061
CENTRAL COOLING FW PUMP	3	17096	3	17108	3	124,9	124,9	81194	124,6	124,6	80960
MAIN STARTING AIR COMPRESSOR	2	483	2	587	2	3,8	3,8	2460	4,6	4,6	2978
SERVICE AIR COMPRESSOR	1	1560	1	1285	1	2,0	2,0	1285	1,6	1,6	1055
CONTROL AIR COMPRESSOR	1	2600	1	6891	1	4,9	4,9	3213	13,1	13,1	8487
AUX. BOILER FEED WATER PUMP	2	8761	2	8742	2	19,8	19,8	12845	19,6	19,6	12772
AUX. BOILER CIRCULATING PUMP	2	8759	2	8741	2	6,7	6,7	4336	6,6	6,6	4311
BALLAST PUMP	2	408	2	410	2	0,1	0,1	42	0,1	0,1	42
BILGE/MAIN FIRE/GS PUMP	2	173	2	345	2	3,9	3,9	2512	7,7	7,7	4982
DECK WATERSPRAY PUMP	1	1	1	1	1	0,0	0,0	9	0,0	0,0	15
EMERGENCY FIRE PUMP	1	3	1	18	1	0,0	0,0	29	0,3	0,3	206
ENGINE ROOM LOCAL WATERSPRAY SYSTE	1	1	1	0	1	0,0	0,0	18	0,0	0,0	0

6. CONCLUSION

In the effort to reduce fuel consumption and reduce emissions, increasing the operational performance of ship equipment can be an important factor along with other measures, especially for vessel types where the cargo equipment is the main consumer.

The model proposed in this report enables detailed monitoring of ship equipment and as far as the author is aware, few or none shipping companies currently have this possibility. The main benefit is that the operation can be reviewed on a component level, whereas the crew can have accurate feedback. The Chief Engineer can be instructed to increase the operational performance on specific equipment, as opposed to overall inefficiencies.

Relevant regulations to the work carried out are the Ship Efficiency Management Plan (SEEMP), the Energy Efficiency Design Index (EEDI) and the Energy Efficiency Operational Indicator (EEOI), which can be useful when validating and establishing energy efficiency of vessels.

In the context of operational efficiency for ship equipment, the SEEMP and EEOI are the most relevant regulations, whereas the EEOI is proposed to be used to monitor the effect of the measures carried out in the SEEMP. Some argue that the SEEMP just induces additional paper-work both onshore and on the vessel, while others look upon the SEEMP as a powerful tool for reducing fuel consumption and enhancing operation.

Using the model reviewed in this this report can greatly increase the quality of the SEEMP. Establishing a quality SEEMP requires extensive know-how of operation and operation costs, the ability to identify and detect inefficient operation and being able to follow up the measures. This data will be provided by monitoring the operation and operation costs by the model proposed in this report. Furthermore, the model is far more suited than the EEOI to monitor measures carried out on component level than the EEOI. While the EEOI provides interesting data, it is unlikely that the impact of measures on a component level would be quantifiable using the EEOI for monitoring.

The Ship Equipment Cost and Performance Overview Report (SECOPR) proposed in this report has several sources of error and can be time consuming to establish, but has great potential in the task of assessing the impact of measures, as well as validating the operation of ship equipment. By comparing vessels, sister-vessels or otherwise, as well as including important operational parameters such as operation profile, shipped cargo and fuel used, this comparison can uncover inefficient or efficient operation of ship equipment. By uncovering efficient or inefficient operation, the best-practice can be implemented as a standard in the SEEMP. As was uncovered, the main engine lube oil pumps were generally run all the time for all vessels, regardless of the operation of the main engine.

The results can not only be used to monitor, validate and compare operation and operation costs of ship equipment. As the specifications of the ship equipment and the running hours are the basis for the cost estimations, the results can be used to estimate the impact when carrying out operational measures or when investing in new and improved equipment, simply by altering the parameters. Furthermore, the performance of the components for different suppliers and systems setups can be reviewed and the best solution identified. This can be useful data for the suppliers, as well as the owner when choosing equipment for newbuilds. Moreover, as all power ratings of the equipment are given, this can be used to identify the optimal power output of components. For instance, all vessels analyzed in this thesis has four engine room supply fans, but the power output ranges from 15-30kW, whereas the operation is similar. This may be due to different engine room settings, but could also indicate that the supply fans are over dimensioned.

While the accuracy of the model to estimate calculation has been proved accurate, it should be noted that the main reason to do these calculations is to translate the operation of ship equipment into a language everyone can understand; costs in USD. This makes the operation, the differences and the impact of efficient or inefficient operation more versatile and easier to communicate. Even though the accuracy of the operation costs is not entirely correct, the registered running hours are.

Kongsberg’s Ship@Web system, enabling the owner to access all operational data recorded by the K-Chief 600, can be used to automatize the process and increase the accuracy of the model and the equipment performance report. In addition, Ship@Web offers a wide variety of functions which can benefit in the work to increase the overall energy efficiency of vessels.

6.1 CLOSING REMARKS

The main effort of writing this thesis has been to establish the tools which can be found in the attachments. However, this data is confidential and are thus not publicly available. A lot of effort has been put into getting the main findings and experiences into the report, without compromising confidentiality.

The main impression of the author is that significant savings can be made if measures ensure that ship equipment is run as efficient as possible. The SEEMP can be an important tool in order to achieve this, but in order to utilize the SEEMP a solid foundation on how the measures are to be singled out, monitored and reviewed are needed. Most importantly, the crew needs to be given specific feedback on their operation of the vessel and its equipment, as opposed to being told: “Be efficient”.

To invest in software providing this functionality can have great advantages. Ship@Web is tailored for the task of monitoring ship equipment as it utilizes the extensive amount of data which are already available, without installing additional sensors or equipment other than servers.

The importance of having an experienced and skilled crew has been emphasized by the work carried out in this thesis. An experienced and skilled crew should be looked upon as the most important factor for efficient operation of ship equipment.

6.2 FURTHER WORK

Further work should focus on establishing key performance indicators for the components, normalized against the main machinery or equipment of dependency. This would make the effort to easily identify the level of performance without familiarizing with all aspects of the vessels operation. The key performance indicators can be implemented on a component or systems basis.

A natural waypoint for further work is to establish tools to automate the process of gathering the data of the equipment and doing so on a continuous basis. Kongsberg's Ship@Web system has been reviewed, but should be further analyzed for the task of creating and equipment performance report.

In terms of accuracy, there are several aspects which should be further investigated:

- The specific fuel consumption of the generators. The main challenge is the fluctuating load of the generators. As the load changes continuously, the specific fuel consumption will also do so. In order to accurately determine the operation costs, the operation of the components must be linked to the specific fuel consumption to when they are operated.
- The power ratings and especially the load factor is a definitive source of error. A more accurate way of determining the power consumption of the components should be investigated, or the possibility of installing power-meters for the components.

The equipment where the greatest potential savings can be made, both operational and otherwise, is the cargo equipment. Establishing the best practice operation of the cargo equipment and identifying the best setup and specifications for this equipment can result in significant savings for vessels such as LPG carriers.

The equipment performance report should be further reviewed in terms of:

- Design, layout and description. This is especially important for the feedback report issued to the crew, where the report must be easy to understand.
- The parameters included in the equipment report. Choosing the important and relevant parameters is important, where decisions on what information is necessary, what is interesting and what is not needed must be addressed.

7. REFERENCES

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ATTACHMENTS

The following attachments are available at CD/disk:

A – INPUT
- A1 – Data (Equipment operational data sorted by year)
- A2 – Feedsheet (Equipment operational data sorted for extraction)

B – GENERATORS
- B1 – Gensets data
- B2 – Historical load

C – TOTAL EQUIPMENT MONITORING
- C1 – Vessels (Vessel specifications)
- C2 – Profile (Complete operational data for vessels)
- C3 – Cargo (Shipped cargoes and type)
- C4 – Mastersheet (Equipment list, power ratings and measure analysis)
- C5 – Accuracy test (Accuracy validation test for X1-vessels 2009-2011)
- C6 – Tag list, vessel X3-1

D – SHIP EQUIPMENT COST OVERVIEW AND PERFORMANCE REPORT
- D1 – SECOPR, X1-vessels
- D2 – SECOPR, X2-vessels
- D3 – SECOPR, X3-vessels
- D4 – SECOPR, X4-vessel
- D5 – Systems overview

APPENDIX (RESTRICTED)

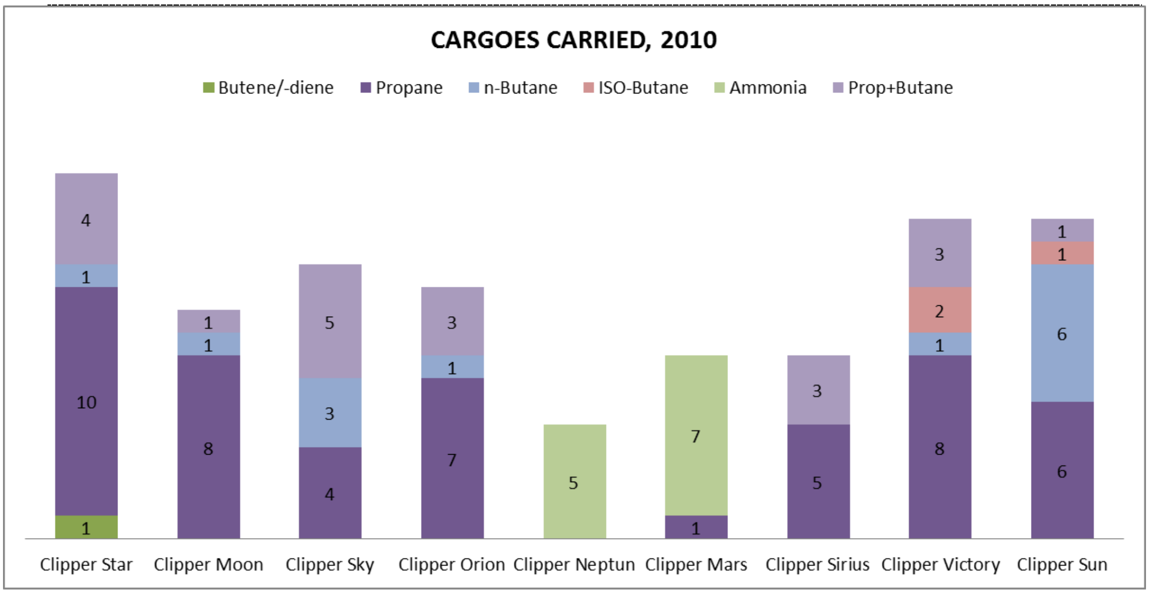
1. VESSELS

1.1 VESSELS UNVEILED

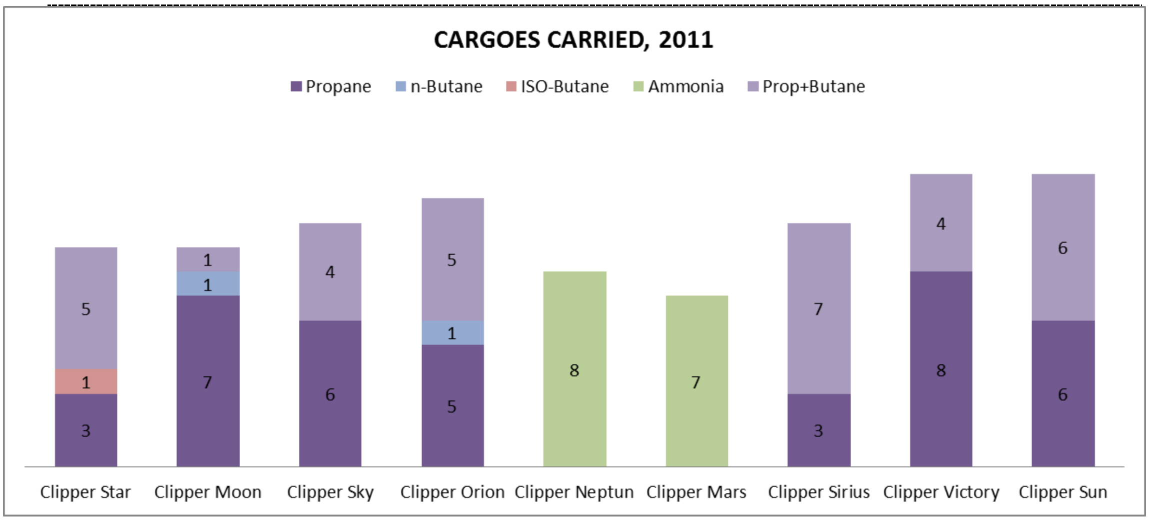
VESSEL	ANONYMOUS	L.O.A [m]	BUILT	YARD	MAIN ENG. [kW]	AUX. ENG. [kW]
Clipper Mars	X1-1	204,98	2008	Hyundai HI	10150	3600
Clipper Orion	X1-2	204,98	2008	Hyundai HI	10150	3600
Clipper Neptun	X1-3	204,98	2008	Hyundai HI	10150	3600
Clipper Star	X2-1	204,85	2003	Kawasaki HI	11275	3990
Clipper Sky	X2-2	204,92	2004	Kawasaki HI	11275	3990
Clipper Moon	X2-3	204,92	2003	Kawasaki HI	11275	3990
Clipper Sirius	X3-1	227,21	2008	Hyundai HI	12270	3600
Clipper Victory	X3-2	227,21	2009	Hyundai HI	12270	3600
Clipper Sun	X4	225,27	2008	Hyundai HI	13350	5400

2. CARGOES CARRIED

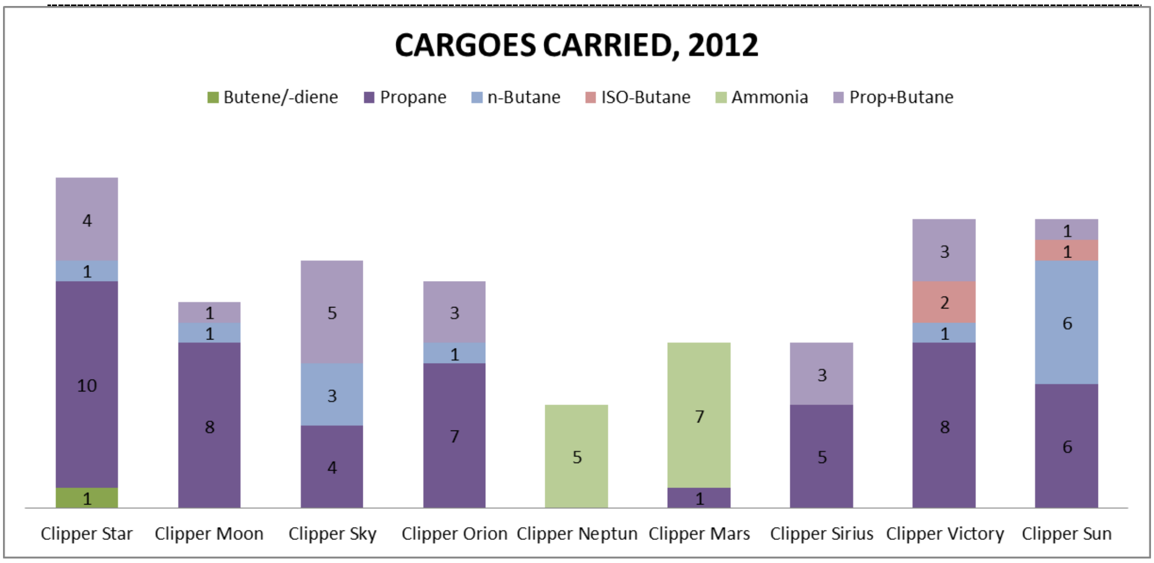
2.1 CARGOES CARRIED 2010



2.2 CARGOES CARRIED 2011

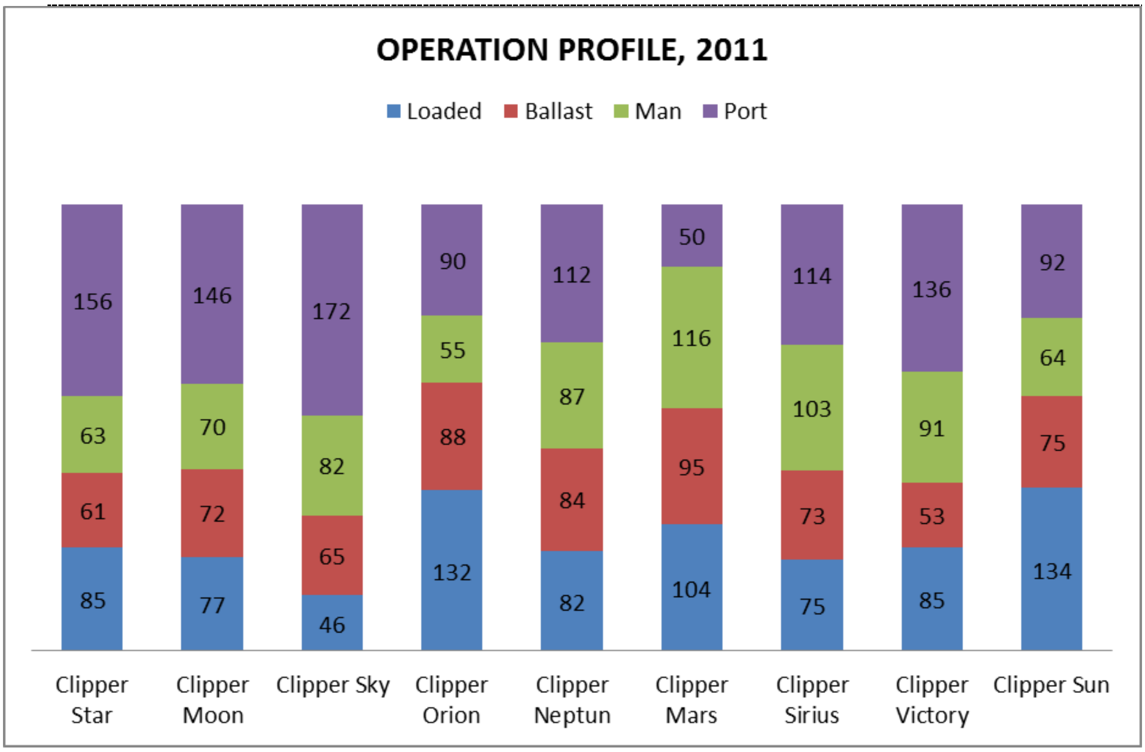


2.3 CARGOES CARRIED 2012

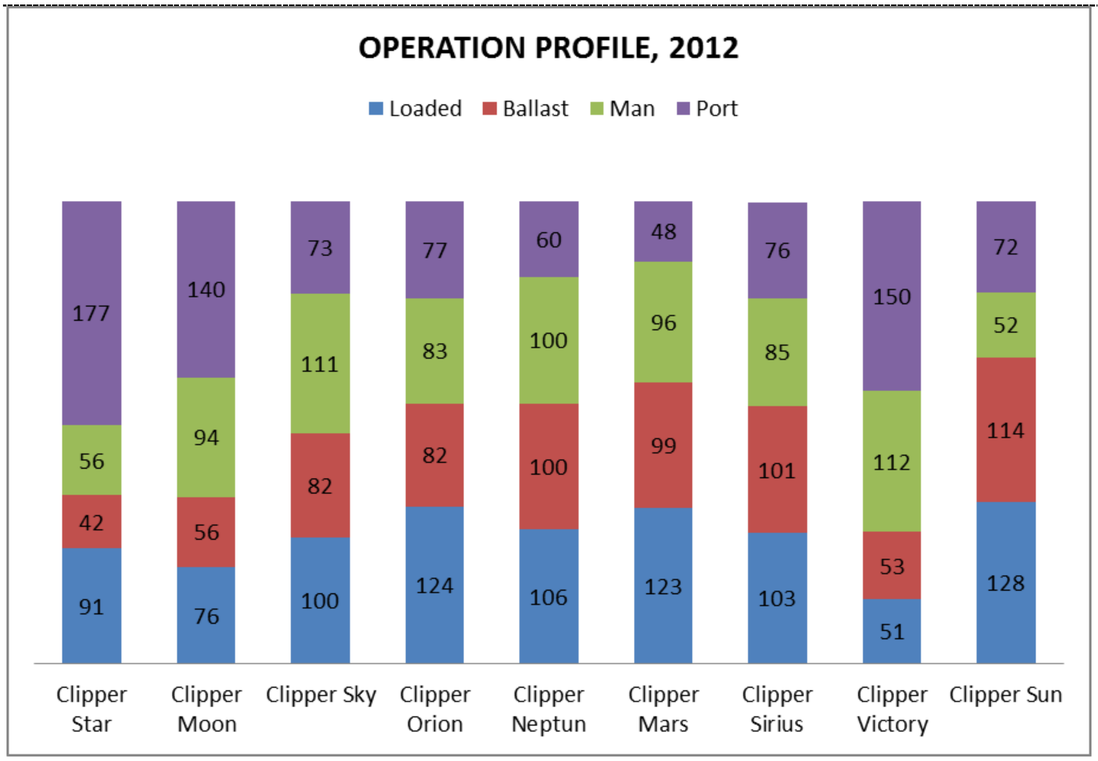


3. OPERATION PROFILE

3.1 OPERATION PROFILE 2011

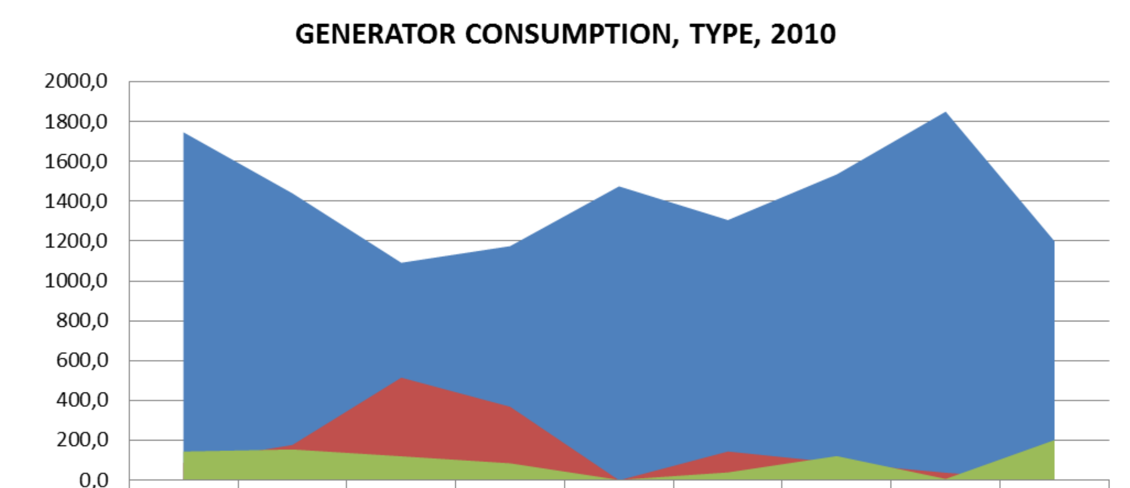


3.2 OPERATION PROFILE 2012



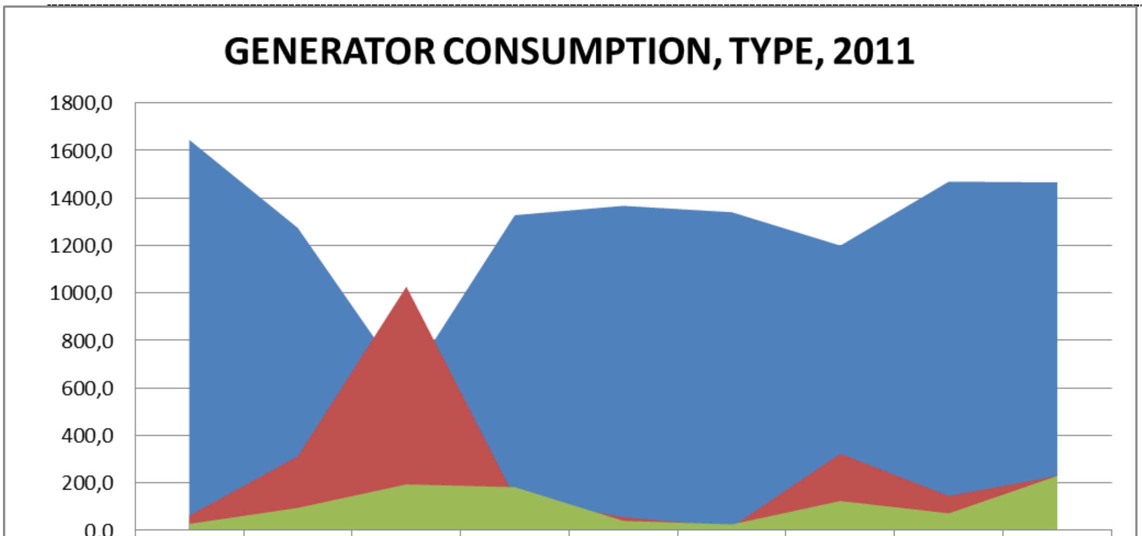
4. GENERATOR FUEL TYPE CONSUMPTION

4.1 GENERATOR FUEL TYPE CONSUMPTION, 2010



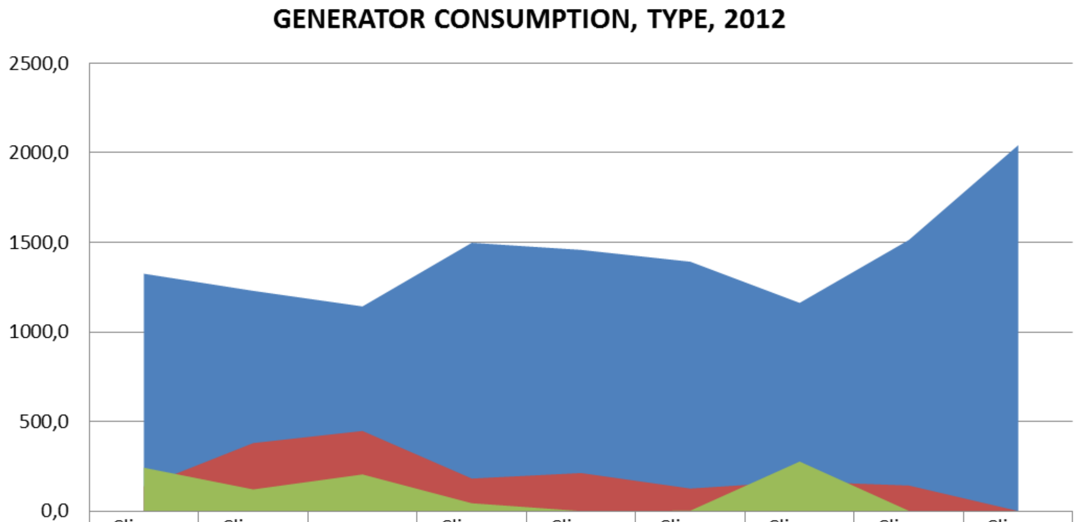
	Clipper Star	Clipper Moon	Clipper Sky	Clipper Orion	Clipper Neptun	Clipper Mars	Clipper Sirius	Clipper Victory	Clipper Sun
HFO	1746,4	1440,1	1091,7	1174,8	1475,2	1305,9	1534,8	1849,7	1199,5
LSHFO	86,7	177,2	514,8	368,9	0,0	144,4	88,2	37,8	0,0
MDO	144,3	154,5	120,4	85,0	1,9	39,4	121,5	6,8	201,9

4.2 GENERATOR FUEL TYPE CONSUMPTION, 2011



	Clipper Star	Clipper Moon	Clipper Sky	Clipper Orion	Clipper Neptun	Clipper Mars	Clipper Sirius	Clipper Victory	Clipper Sun
HFO	1644,9	1273,6	616,6	1327,8	1367,1	1340,1	1199,8	1469,1	1465,5
LSHFO	62,8	312,5	1026,9	139,1	56,5	15,3	323,4	145,1	230,1
MDO	28,0	95,6	194,3	182,9	40,5	25,7	124,3	72,3	230,0

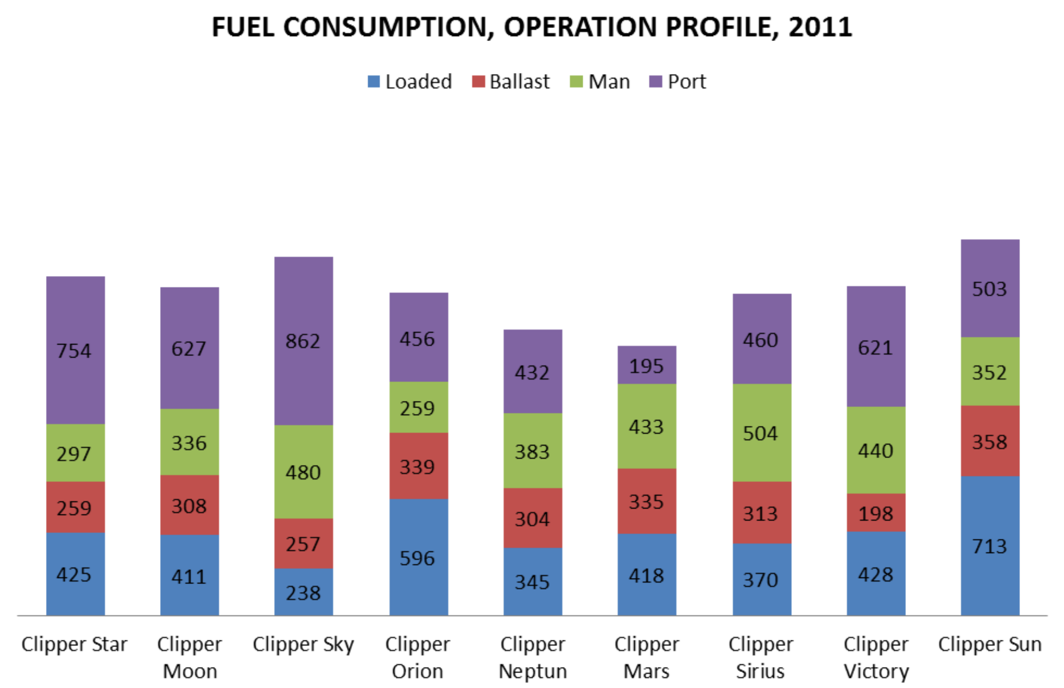
4.3 GENERATOR FUEL TYPE CONSUMPTION, 2012



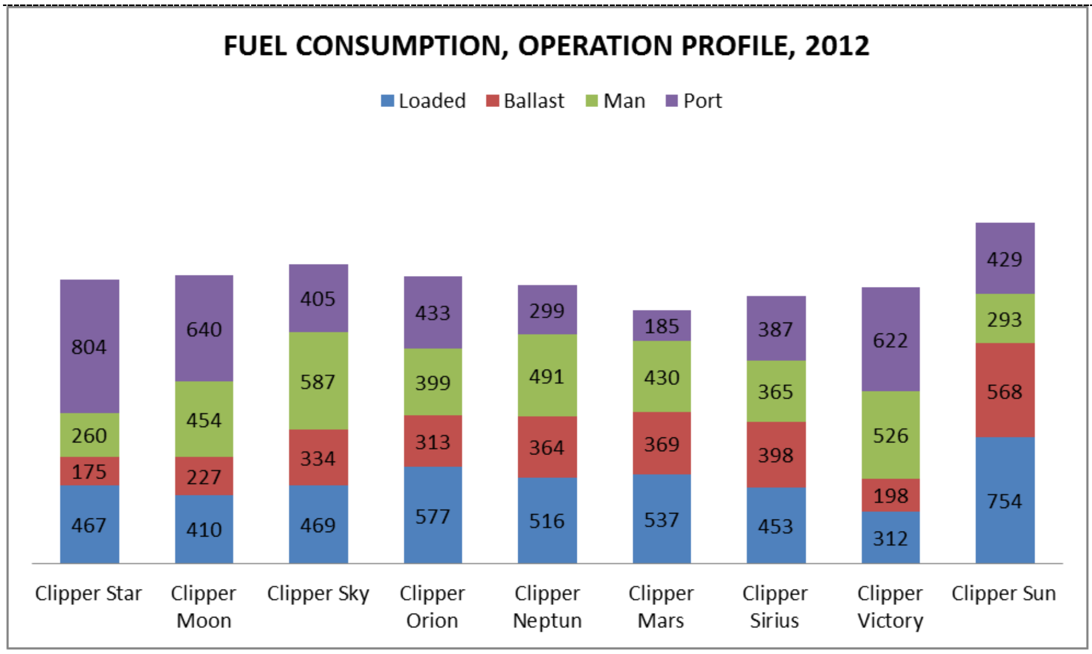
	Clipper Star	Clipper Moon	Clipper Sky	Clipper Orion	Clipper Neptun	Clipper Mars	Clipper Sirius	Clipper Victory	Clipper Sun
HFO	1325,1	1229,6	1142,6	1497,7	1458,3	1392,2	1162,1	1513,9	2042,8
LSHFO	137,7	379,5	447,1	181,5	212,1	125,4	165,0	142,2	0,0
MDO	242,2	120,8	204,3	43,5	0,0	2,2	276,3	1,2	0,8

5. GENERATOR FUEL CONSUMPTION, PROFILE

5.1 GENERATOR FUEL CONSUMPTION, PROFILE 2011



5.2 GENERATOR FUEL CONSUMPTION, PROFILE, 2012



6. GENERATOR SPECIFICATIONS

MANUFACTURER	Hyundai-B&W	MAN B&W	Hyundai-B&W
TYPE	Himsen 8H21/32	8l23/30h	6L28/32H
OUTPUT [kW]	1200	1470	1260
FUEL AT TEST	ISO 8217	MDO	ISO 8217
NCV, test [MJ/kg]	42,00	42,44	42,4
NCV, HFO [MJ/kg]	40	40	40
NCV, MDO [MJ/kg]	42	42	42
LOAD [100%]	1200	1470	1260
LOAD [75%]	900	1102,5	945
LOAD [50%]	600	735	630
LOAD [25%]	300	367,5	315
Shaft power at test [100%]	1280	2079	1050
Shaft power at test [75%]	960	1559	787,5
Shaft power at test [50%]	640	1040	525
Shaft power at test [25%]	320	520	262,5
Efficiency [%]- 100%	96,3 %	96,2 %	95,97 %
Efficiency [%]- 75%	96,6 %	96,0 %	96,20 %
Efficiency [%]- 50%	96,4 %	95,3 %	96,70 %
Efficiency [%]- 25%	94,6 %	92,4 %	95,00 %
Fuel consumption [kg/h] - 100%	248,60	399,90	203,50
Fuel consumption [kg/h] - 75%	187,80	302,40	156,50
Fuel consumption [kg/h] - 50%	132,60	209,10	111,00
Fuel consumption [kg/h] - 25%	75,80	114,90	64,60
Uncorr. fuel cons, shaft - 100% [g/kWh]	194,22	192,35	193,81
Uncorr. fuel cons, shaft - 75% [g/kWh]	195,63	193,97	198,73
Uncorr. fuel cons, shaft - 50% [g/kWh]	207,19	201,06	211,43
Uncorr. fuel cons, shaft - 25% [g/kWh]	236,88	220,96	246,10
Fuel consumption, gen [g/kWh] - 100%	201,60	199,95	201,95
Fuel consumption, gen [g/kWh] - 75%	202,51	202,05	206,58
Fuel consumption, gen [g/kWh] - 50%	214,95	210,97	218,64
Fuel consumption, gen [g/kWh] - 25%	250,40	239,14	259,05
NOX [g/kWh]	11,10	10,7	11,5
Fuel consumption, HFO [g/kWh] - 100%	211,68	212,15	214,06
Fuel consumption, HFO [g/kWh] - 75%	212,64	214,38	218,98
Fuel consumption, HFO [g/kWh] - 50%	225,69	223,84	231,76
Fuel consumption, HFO [g/kWh] - 25%	262,92	253,72	274,59
Fuel consumption, MDO [g/kWh] - 100%	194,2	194,4	195,7
Fuel consumption, MDO [g/kWh] - 75%	195,6	196,0	200,6
Fuel consumption, MDO [g/kWh] - 50%	207,2	203,2	213,4
Fuel consumption, MDO [g/kWh] - 25%	236,9	223,3	248,4

7. COMPONENTS NOT FITTED WITH COUNTERS

7.1 CONSUMPTION AND POWER RATINGS

		POWER RATINGS			CONSUMPTION	
NR	DESCRIPTION	P [kW]	EFF. [%]	LF [%]	P [kWh]	FUEL [TON]
1	STEERING GEAR ROOM SUPPLY FAN	3,7	83 %	77 %	10023	2,3
1	WELDING SPACE EXHAUST FAN	0,43	69 %	70 %	1274	0,3
1	DRY POWDER ROOM FAN	0,4	67 %	70 %	3661	0,8
1	AIR-CONDITION CENTRAL UNIT FAN	30	90 %	60 %	175200	39,4
1	FAN COIL UNIT IN GALLEY	0,6	60 %	70 %	2044	0,5
1	GALLEY SUPPLY FAN	0,4	67 %	70 %	1220	0,3
1	GALLEY EXHAUST FAN	0,43	67 %	70 %	1312	0,3
1	SANITARY EXHAUST FAN	3,7	83 %	74 %	28897	6,5
1	PAINT STORE EXHAUST FAN	0,37	70 %	70 %	3241	0,7
1	CO2 ROOM EXHAUST FAN	0,4	67 %	70 %	3661	0,8
1	PIPE DUCT EXH. FAN	5,5	93 %	62 %	174	0,0
1	ACCOMODATION LIGHTS	35	100 %	100 %	51100	11,5
1	ENGINE ROOM LIGHTS	20	100 %	100 %	175200	39,4
1	DECK FLOOD LIGHTS	22	100 %	100 %	8030	1,8
1	RADIO AND LOW POWER EQIP.	12	100 %	100 %	105120	23,7
1	CONTROL AND INSTRUMENTS	5	100 %	100 %	43800	9,9
1	I.C.C.P	6	100 %	100 %	10950	2,5
1	GALLEY AND LAUNDRY EQUIPMENT	113	100 %	50 %	82490	18,6
1	WORKSHOP EQUIPMENT	6,7	88 %	80 %	8893	2,0
1	ELEC./TIG WELDER	24	100 %	100 %	8760	2,0
3	GLYCOL HEATER	6	100 %	100 %	26280	5,9
1	CALORIFIER	15	100 %	100 %	274	0,1
1	WHEELHOUSE UNIT COOLER	7	80 %	70 %	53655	12,1
1	ENGINE CONTROL ROOM UNIT COOLER	6	80 %	78 %	51246	11,5
1	CARGO SWBD RM UNIT COOLER	7	80 %	70 %	2236	0,5
1	CONTROL AIR DRYERS	0,5	74 %	80 %	4735	1,1
1	E/R CRANE	3,7	76 %	80 %	355	0,1
2	PROVISION CRANE	24	88 %	83 %	6382	1,4
1	LIFE BOAT WINCH	3,7	83 %	56 %	0	0,0
1	LIFE/RESCUE BOAT WINCH	18	80 %	72 %	0	0,0
1	SEWAGE PLANT	5,5	74 %	70 %	37980	8,5
1	HOT WATER CIRC. PUMP	0,4	68 %	60 %	3092	0,7
1	M/E AIR COOLER CHEMICAL CLEANING PUMP	1,5	78 %	73 %	17	0,0
1	SWBD ROOM UNIT COOLER F.W BOOSTER PUMP	2,2	83 %	73 %	13199	3,0
2	HFO PURIFIER SUPPLY PUMP	1,5	80 %	73 %	6033	1,4
2	BOOSTER UNIT FOR ALPHA LUBRICATOR	2,2	82 %	73 %	8578	1,9
1	OILY BILGE PUMP	2,2	82 %	77 %	113	0,0
2	A/E JACKET PRE-HEATING PUMP	1,5	74 %	80 %	7103	1,6

7.2 COMMENTS AND OPERATION TIME ESTIMATIONS

	ESTIMATED RUNNING HOURS WITH COMMENTS		
DESCRIPTION	AV/DAY	AV/YEAR	COMMENT
STEERING GEAR ROOM SUPPLY FAN	8	2920	On in work hours
WELDING SPACE EXHAUST FAN	8	2920	On in work hours
DRY POWDER ROOM FAN	24	8760	On all the time
AIR-CONDITION CENTRAL UNIT FAN	24	8760	On all the time. Verified by counters.
FAN COIL UNIT IN GALLEY	8	2920	On while cooking
GALLEY SUPPLY FAN	8	2920	On while cooking
GALLEY EXHAUST FAN	8	2920	On while cooking
SANITARY EXHAUST FAN	24	8760	On all the time
PAINT STORE EXHAUST FAN	24	8760	On all the time
CO2 ROOM EXHAUST FAN	24	8760	On all the time
PIPE DUCT EXH. FAN	0,13	47	Only when inspected
ACCOMODATION LIGHTS	4	1460	Crew estimate
ENGINE ROOM LIGHTS	24	8760	On all the time
DECK FLOOD LIGHTS	1	365	Cargo operations in dark
RADIO AND LOW POWER EQIP.	24	8760	On all the time
CONTROL AND INSTRUMENTS	24	8760	On all the time
I.C.C.P	5	1825	Only in transit at sea, not freshwater
GALLEY AND LAUNDRY EQUIPMENT	4	1460	Estimated 50% use in free hours
WORKSHOP EQUIPMENT	4	1460	Estimated 50% use in work hours
ELEC./TIG WELDER	1	365	Crew estimate 1 hours use daily
GLYCOL HEATER	12	4380	Crew estimate 360 hours/month
CALORIFIER	0,05	18	Only when boiler is not in use
WHEELHOUSE UNIT COOLER	24	8760	On all the time
ENGINE CONTROL ROOM UNIT COOLER	24	8760	On all the time
CARGO SWBD RM UNIT COOLER	1	365	Air-Con usually enough.
CONTROL AIR DRYERS	24	8760	On all the time
E/R CRANE	0,25	91	Seldom used
PROVISION CRANE	0,77	280	On board counters, 1302 days
LIFE BOAT WINCH	0	0	Emergency, only for testing
LIFE/RESCUE BOAT WINCH	0	0	Emergency, only for testing
SEWAGE PLANT	20	7300	On board counters, 1302 days
HOT WATER CIRC. PUMP	24,0	8760	On board counters, 1302 days
M/E AIR COOLER CHEMICAL CLEANING PUMP	0,03	12	On board counters, 1302 days
SWBD ROOM UNIT COOLER F.W BOOSTER PUMP	18,6	6780	On board counters, 1302 days
HFO PURIFIER SUPPLY PUMP	12	4380	One pump running all the time
BOOSTER UNIT FOR ALPHA LUBRICATOR	12	4380	When engines are running
OILY BILGE PUMP	0,15	55	Estimated
A/E JACKET PRE-HEATING PUMP	12	4380	One pump running all the time

8. ACCYRACY TESTS

8.1 ACCURACY TEST, 2009

2009	1		
CLIPPER MARS		(green)	REGISTERED
CLIPPER NEPTUN		(orange)	CALCULATED
CLIPPER ORION			

	OVERVIEW		
	MARS	NEPTUN	ORION
EQUIPMENT W/COUNTERS, SUM [TON]	1399	1220	1221
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	0	147	15
EQUIPMENT W/O COUNTERS	194	194	194
SUM ESTIMATED [TON]	1593	1561	1431
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1548	1570	1404
DEVIATION [TON]	-45	8	-27
DEVIATION [USD]	2,9 %	-0,5 %	1,9 %

	FUEL TYPE [TON]		
	MARS	NEPTUN	ORION
HFO	1543	1551	1386
LSHFO	0	0	0
MDO	5	18	18
TOTAL	**1548**	**1570**	**1404**
SFC [g/kWh]-HC	212,6	212,4	212,4
SFC [g/kWh]-LC	225,6	225,5	225,5

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
LOADED	98	83	95	439	371	392	4,5	4,5	4,1
BALLAST	64	66	89	264	275	319	4,1	4,2	3,6
MAN	0	0	0	0	0	0			
PORT	203	216	181	846	923	693	4,2	4,3	3,8
SUM/AVERAGE	**365**	**365**	**365**	**1548**	**1570**	**1404**	**4,3**	**4,3**	**3,8**

	RUNNING HOURS [H]			REG. [TON]			SFC [KG/H]		
MACHINERY	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
MAIN DIESEL ENGINE	4262	3591	3728	6340	5179	5240	1487,6	1442,1	1405,7
AUX. DIESEL GENERATOR	11937	12317	10980	1548	1570	1404	129,7	127,4	127,9

	RUNNING HOURS [H]			EST. FUEL [TON]		
MAIN SYSTEM	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
EQUIPMENT FOR CARGO	25361	16163	18955	580	487	429
SHIP EQUIPMENT	11396	12867	10923	65	91	76
EQUIPMENT FOR CREW	78854	71402	71305	218	219	201
MACHINERY MAIN COMPONENTS	14749	9752	15386	8	11	7
SYSTEMS FOR MAIN MACHINERY	168003	180460	158455	511	527	512
SHIP COMMON SYSTEMS	1533	1782	1617	17	32	12
SUM	**299897**	**292425**	**276641**	**1399**	**1367**	**1237**

	RUNNING HOURS [H]			EST. FUEL [TON]		
SUBSYSTEM	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	1511	664	1078	80	50	68
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	6511	6089	5154	328	306	259
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	2256	265	613	15	10	7
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	15084	9144	12110	156	121	95
MANOEUVRING MACHINERY & EQUIPMENT	9060	9105	8299	45	64	51
ANCHORING, MOORING & TOWING EQUIPMENT	748	644	1005	17	21	22
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	1588	3118	1619	3	6	3
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	5404	4128	4068	10	8	8
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	73071	67273	66825	208	211	193
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	379	0	412	0	0	0
DIESEL ENGINES FOR PROPULSION	593	991	486	5	9	4
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	14157	8760	14900	3	3	3
FUEL SYSTEMS	51409	46830	48841	44	40	38
LUBE OIL SYSTEMS	41581	62323	38449	129	164	136
COOLING SYSTEMS	41967	41040	42217	275	268	276
COMPRESSED AIR SYSTEMS	12512	7659	9070	25	16	25
STEAM, CONDENSATE & FEED WATER SYSTEMS	15568	17485	15098	19	21	19
DISTILLED & MAKE-UP WATER SYST	4967	5123	4780	19	19	18
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	605	631	414	9	9	7
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	453	579	202	8	22	4
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	475	572	1001	0	0	0
SUM	**299897**	**292425**	**276641**	**1399**	**1367**	**1237**

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED CONSUMPTION [TON]					
			MARS		NEPTUN		ORION		MARS		NEPTUN		ORION	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	281,9	1116	8	664	8	907	7	66,9	66,9	39,8	39,8	54,3	62,1
CARGO BOOSTER PUMP	2	162,2	394	2	0	0	171	2	13,6	13,6		9,7	5,9	5,9
CARGO COMPRESSOR	4	236,8	6511	4	6089	4	5154	4	327,7	327,7	306,3	306,3	259,2	259,2
CARGO TANK GAS-FREEING FAN	4	48,1	755	4	0	0	38	4	8,2	8,2		4,3	0,4	0,4
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	306	1	265	1	0	0	6,0	6,0	5,2	5,2		5,6
NITROGEN GENERATOR	1	4,8	1195	1	0	0	575	1	1,3	1,3		1,0	0,6	0,6
CARGO HOSE CRANE	1	36,6	73	1	71	1	50	1	0,6	0,6	0,6	0,6	0,4	0,4
CARGO CONDENSER SW COOLING PUMP	2	94,6	6169	2	4457	2	3334	2	131,7	131,7	95,1	95,1	71,1	71,1
GLYCOL COOLING SYSTEM PUMP	2	12,8	8714	2	4587	1	8726	2	23,8	23,8	12,5	25,0	23,8	23,8
GLYCOL COOLING SYSTEM PUMP (VAPORISER)	1	12,8	130	1	29	1	0	1	0,4	0,4	0,1	0,1	0,0	0,0
STEERING GEAR HYDR OIL PUMP	2	12,3	8858	2	8700	2	8051	2	24,6	24,6	24,2	24,2	22,4	22,4
BOW THRUSTER	1	1073,7	88	1	173	1	124	1	20,1	20,1	39,5	39,5	28,3	28,3
HYDRAULIC OIL PUMP BOW THRUSTER	1	4,9	114	1	231	1	124	1	0,1	0,1	0,3	0,3	0,1	0,1
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	366	2	349	2	354	2	9,1	9,1	8,7	8,7	8,8	8,8
MOORING WINCH HYDR. OIL PUMP	2	89,5	382	2	295	1	651	2	7,7	7,7	6,0	11,9	13,1	13,1
INCINERATOR	1	8,9	1588	1	3118	1	1619	1	3,2	3,2	6,2	6,2	3,2	3,2
PROVISION COOLING COMPRESSOR	2	8,3	5404	2	4128	2	4068	2	10,1	10,1	7,7	7,7	7,6	7,6
AIR-CONDITION COOLING COMPRESSOR	2	56,1	6365	2	0	0	6491	2	80,6	80,6		81,4	82,1	82,1
SUPPLY FAN, ENGINE ROOM	4	12,9	31788	4	32642	4	28801	4	92,2	92,2	94,6	94,6	83,5	83,5
EXHAUST FAN, PURIFIER AREA	1	1,8	8653	1	8045	1	8437	1	3,6	3,6	3,4	3,4	3,5	3,5
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,5	8698	1	8722	1	5424	1	20,6	20,6	20,6	20,6	12,8	12,8
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,8	8705	1	8739	1	8676	1	1,6	1,6	1,6	1,6	1,6	1,6
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	4,6	8704	1	8740	1	8751	1	8,9	8,9	9,0	9,0	9,0	9,0
SUPPLY FAN, BOW THRUSTER & BOSUN STORE ROOM	1	4,7	158	1	385	1	245	1	0,2	0,2	0,4	0,4	0,3	0,3
POTABLE WATER HYDROPHORE PUMP	2	4,5	379	2	0	0	412	2	0,4	0,4		0,4	0,4	0,4
ME COMBUSTION AIR BLOWER	2	39,1	593	2	991	2	486	2	5,2	5,2	8,7	8,7	4,3	4,3
ME TURNING GEAR	1	3,4	0	0	0	0	0	0		0,0		0,0		0,0
AE LO PRIMING PUMP	3	0,9	14157	3	8760	2	14900	3	2,8	2,8	1,7	2,6	3,0	3,0
HFO TRANSFER PUMP	3	13,0	317	3	308	1	362	3	0,9	0,9	0,9	2,7	1,1	1,1
MDO TRANSFER PUMP	1	4,9	6	1	0	0	8	1	0,0	0,0		0,0	0,0	0,0
HFO PURIFIER	2	15,3	7327	2	2764	1	5334	2	25,2	25,2	9,5	19,0	18,3	18,3
SLUDGE OIL PUMP	1	3,3	25	1	78	1	52	1	0,0	0,0	0,1	0,1	0,0	0,0
ME FO SUPPLY PUMP	2	1,4	8657	2	8740	2	8752	2	2,7	2,7	2,7	2,7	2,7	2,7
ME FO CIRCULATING PUMP	2	3,3	8774	2	8742	2	8752	2	6,6	6,6	6,6	6,6	6,6	6,6
AE FO SUPPLY PUMP	2	0,7	8775	2	8742	2	8753	2	1,3	1,3	1,3	1,3	1,3	1,3
AE FO BOOSTER PUMP	2	3,3	8764	2	8743	2	8752	2	6,6	6,6	6,6	6,6	6,6	6,6
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVEN	1	2,1	0	1	0	0	0	0	0,0	0,0		0,0		0,0
AUX. BOILER FO PUMP	2	0,4	8765	2	8712	2	8076	2	0,9	0,9	0,9	0,9	0,8	0,8
LO TRANSFER PUMP	1	3,3	0	1	0	0	0	0	0,0	0,0		0,0		0,0
AE LO PURIFIER	2	4,7	5543	2	15795	2	7943	2	5,9	5,9	16,8	16,8	8,4	8,4
ME LO PURIFIER	2	4,7	7019	2	6774	1	5470	2	7,5	7,5	7,2	14,4	5,8	5,8
AE LO PURIFIER SUPPLY PUMP	2	0,4	5543	2	16200	2	8203	2	0,5	0,5	1,5	1,5	0,8	0,8
ME LO PURIFIER SUPPLY PUMP	2	1,4	7019	2	6130	1	0	0	2,2	2,2	1,9	3,8		2,0
ME LO PUMP	2	64,4	7684	2	8681	2	8082	2	111,7	111,7	126,1	126,1	117,3	117,3
STERN TUBE LO PUMP	2	0,8	8772	2	8743	2	8751	2	1,6	1,6	1,6	1,6	1,6	1,6
ME COOLING SW PUMP	3	32,6	16114	3	14813	3	16741	3	118,4	118,4	108,8	108,8	123,0	123,0
ME JACKET COOLING FW PUMP	2	13,0	8735	2	8742	2	8752	2	25,6	25,6	25,6	25,6	25,6	25,6
CENTRAL COOLING FW PUMP	3	33,8	17119	3	17485	3	16724	3	130,5	130,5	133,2	133,2	127,4	127,4
MAIN STARTING AIR COMPRESSOR	2	35,7	498	2	422	2	1801	2	4,0	4,0	3,4	3,4	14,5	14,5
SERVICE AIR COMPRESSOR	1	5,7	3791	1	2506	1	4627	1	4,8	4,8	3,2	3,2	5,9	5,9
CONTROL AIR COMPRESSOR	1	8,5	8223	1	4731	1	2642	1	15,7	15,7	9,0	9,0	5,1	5,1
AUX. BOILER FEED WATER PUMP	2	6,8	8773	2	8743	2	8751	2	13,4	13,4	13,3	13,3	13,4	13,4
AUX. BOILER CIRCULATING PUMP	2	3,7	6795	2	8742	2	6347	2	5,6	5,6	7,2	7,2	5,2	5,2
FW GENERATOR SW PUMP	1	16,8	4967	1	5123	1	4780	1	18,9	18,9	19,4	19,4	18,1	18,1
FW GENERATOR DISTILLATE PUMP	1	1,2	0	0	0	0	0	0		0,0		0,0		0,0
BALLAST PUMP	2	99,4	389	2	419	2	325	2	8,7	8,7	9,4	9,4	7,3	7,3
BILGE TRANSFER PUMP	1	2,1	216	1	213	1	89	1	0,1	0,1	0,1	0,1	0,0	0,0
BILGE/MAIN FIRE/GS PUMP	2	90,3	392	2	517	1	196	2	8,0	8,0	10,5	21,0	4,0	4,0
DECK WATERSPRAY PUMP	1	121,9	3	1	28	1	2	1	0,1	0,1	0,8	0,8	0,1	0,1
EMERGENCY FIRE PUMP	1	6,3	58	1	34	1	4	1	0,1	0,1	0,0	0,0	0,0	0,0
CARGO REMOTE VALVE HYDR. OIL PUMP	2	1,8	121	2	319	1	583	2	0,0	0,0	0,1	0,3	0,2	0,2
BALLAST REMOTE VALVE HYDR. OIL PUMP	2	1,8	354	2	253	2	418	2	0,1	0,1	0,1	0,1	0,2	0,2

8.2 ACCURACY TEST, 2010

2010	1	
CLIPPER MARS		REGISTERED (green)
CLIPPER NEPTUN		CALCULATED (orange)
CLIPPER ORION		

	OVERVIEW		
	MARS	NEPTUN	ORION
EQUIPMENT W/COUNTERS, SUM [TON]	1271	1138	1453
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	0	115	6
EQUIPMENT W/O COUNTERS	194	194	194
SUM ESTIMATED [TON]	1465	1447	1653
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1490	1477	1629
DEVIATION [TON]	25	30	-24
DEVIATION [USD]	-1,7 %	-2,1 %	1,5 %

	FUEL TYPE [TON]		
	MARS	NEPTUN	ORION
HFO	1306	1475	1175
LSHFO	144	0	369
MDO	39	2	85
TOTAL	**1490**	**1477**	**1629**
SFC [g/kWh]-HC	212,2	212,6	211,7
SFC [g/kWh]-LC	225,2	225,7	224,7

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
LOADED	123	110	82	530	475	414	4,3	4,3	5,1
BALLAST	101	103	105	383	409	395	3,8	4,0	3,8
MAN	0	0	0	0	0	0			
PORT	141	152	178	577	593	820	4,1	3,9	4,6
SUM/AVERAGE	**365**	**365**	**365**	**1490**	**1477**	**1629**	**4,1**	**4,1**	**4,5**

	RUNNING HOURS [H]			REG. [TON]			SFC [KG/H]		
MACHINERY	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
MAIN DIESEL ENGINE	5579	5275	4557	8454	7445	6725	1515,2	1411,4	1475,7
AUX. DIESEL GENERATOR	11228	11250	12369	1490	1477	1629	132,7	131,3	131,7

	RUNNING HOURS [H]			EST. FUEL [TON]		
MAIN SYSTEM	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
EQUIPMENT FOR CARGO	19689	13902	23502	431	399	635
SHIP EQUIPMENT	12192	9845	11163	80	68	86
EQUIPMENT FOR CREW	70810	72632	71999	181	219	212
MACHINERY MAIN COMPONENTS	15457	16067	14079	10	19	8
SYSTEMS FOR MAIN MACHINERY	185310	166750	159622	550	527	505
SHIP COMMON SYSTEMS	1554	1549	1341	19	21	13
SUM	**305013**	**280744**	**281706**	**1271**	**1253**	**1459**

	RUNNING HOURS [H]			EST. FUEL [TON]		
SUBSYSTEM	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	1220	846	2825	73	51	156
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	4866	4927	7136	244	248	358
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	928	139	149	6	2	1
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	12676	7990	13392	107	98	120
MANOEUVRING MACHINERY & EQUIPMENT	9374	9250	7696	46	51	57
ANCHORING, MOORING & TOWING EQUIPMENT	1442	595	1082	32	13	24
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	1376	0	2385	3	4	5
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	4692	4235	4170	9	8	8
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	65645	68396	66867	172	210	203
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	473	0	962	0	1	1
DIESEL ENGINES FOR PROPULSION	800	1795	637	7	16	6
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	14657	14272	13442	3	3	3
FUEL SYSTEMS	51894	52599	40185	47	48	36
LUBE OIL SYSTEMS	48736	45681	50171	148	160	147
COOLING SYSTEMS	43747	39805	39940	287	259	258
COMPRESSED AIR SYSTEMS	13710	11166	9523	29	22	27
STEAM, CONDENSATE & FEED WATER SYSTEMS	17265	17499	15128	20	21	19
DISTILLED & MAKE-UP WATER SYST	9958	0	4675	19	18	18
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	803	552	456	13	10	7
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	293	548	309	6	11	6
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	458	449	576	0	0	0
SUM	**305013**	**280744**	**281706**	**1271**	**1253**	**1459**

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED CONSUMPTION [TON]					
			MARS		NEPTUN		ORION		MARS		NEPTUN		ORION	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	281,9	1220	8	846	8	2318	8	72,9	72,9	50,7	50,7	138,4	138,4
CARGO BOOSTER PUMP	2	162,2	0	2	0	1	507	2	0,0	0,0	0,0	0,0	17,4	17,4
CARGO COMPRESSOR	4	236,8	4866	4	4927	4	7136	4	244,5	244,5	248,0	248,0	357,8	357,8
CARGO TANK GAS-FREEING FAN	4	48,1	329	4	89	4	3	4	3,6	3,6	1,0	1,0	0,0	0,0
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	124	1	51	1	67	1	2,4	2,4	1,0	1,0	1,3	1,3
NITROGEN GENERATOR	1	4,8	476	1	0	0	79	1	0,5	0,5		0,3	0,1	0,1
CARGO HOSE CRANE	1	36,6	78	1	0	0	54	1	0,6	0,6		0,5	0,4	0,4
CARGO CONDENSER SW COOLING PUMP	2	94,6	3875	2	3394	2	4503	2	82,6	82,6	72,5	72,5	95,8	95,8
GLYCOL COOLING SYSTEM PUMP	2	12,8	8677	2	4597	1	8688	2	23,6	23,6	12,5	25,1	23,6	23,6
GLYCOL COOLING SYSTEM PUMP (VAPORISER)	1	12,8	46	1	0	1	147	1	0,1	0,1	0,0	0,0	0,4	0,4
STEERING GEAR HYDR OIL PUMP	2	12,3	9176	2	9141	2	7374	2	25,5	25,5	25,4	25,4	20,4	20,4
BOW THRUSTER	1	1073,7	88	1	109	1	161	1	20,0	20,0	25,0	25,0	36,6	36,6
HYDRAULIC OIL PUMP BOW THRUSTER	1	4,9	110	1	0	0	161	1	0,1	0,1		0,2	0,2	0,2
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	585	2	256	2	500	2	14,6	14,6	6,4	6,4	12,5	12,5
MOORING WINCH HYDR. OIL PUMP	2	89,5	857	2	339	2	582	2	17,3	17,3	6,8	6,8	11,7	11,7
INCINERATOR	1	8,9	1376	1	0	0	2385	1	2,7	2,7		3,7	4,7	4,7
PROVISION COOLING COMPRESSOR	2	8,3	4692	2	4235	2	4170	2	8,8	8,8	7,9	7,9	7,8	7,8
AIR-CONDITION COOLING COMPRESSOR	2	56,1	4544	2	0	0	7502	2	57,4	57,4		76,0	94,6	94,6
SUPPLY FAN, ENGINE ROOM	4	12,9	28536	4	34517	4	26482	4	82,6	82,6	100,2	100,2	76,5	76,5
EXHAUST FAN, PURIFIER AREA	1	1,8	7087	1	7531	1	7637	1	2,9	2,9	3,1	3,1	3,2	3,2
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,5	7850	1	8489	1	7520	1	18,5	18,5	20,1	20,1	17,7	17,7
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,8	8747	1	8755	1	8752	1	1,6	1,6	1,6	1,6	1,6	1,6
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	4,6	8746	1	8754	1	8751	1	9,0	9,0	9,0	9,0	9,0	9,0
SUPPLY FAN, BOW THRUSTER & BOSUN STORE ROOM	1	4,7	135	1	351	1	223	1	0,1	0,1	0,4	0,4	0,2	0,2
POTABLE WATER HYDROPHORE PUMP	2	4,5	473	2	0	0	962	2	0,5	0,5		0,7	1,0	1,0
ME COMBUSTION AIR BLOWER	2	39,1	795	2	1795	2	637	2	7,0	7,0	15,8	15,8	5,6	5,6
ME TURNING GEAR	1	3,4	6	1	0	0	0	1	0,0	0,0		0,0	0,0	0,0
AE LO PRIMING PUMP	3	0,9	14657	3	14272	3	13442	3	2,9	2,9	2,8	2,8	2,7	2,7
HFO TRANSFER PUMP	3	13,0	458	3	422	3	378	3	1,3	1,3	1,2	1,2	1,1	1,1
MDO TRANSFER PUMP	1	4,9	4	1	0	0	12	1	0,0	0,0		0,0	0,0	0,0
HFO PURIFIER	2	15,3	7943	2	8256	2	5161	2	27,3	27,3	28,4	28,4	17,7	17,7
SLUDGE OIL PUMP	1	3,3	39	1	113	1	80	1	0,0	0,0	0,1	0,1	0,1	0,1
ME FO SUPPLY PUMP	2	1,4	8758	2	8756	2	8758	2	2,7	2,7	2,7	2,7	2,7	2,7
ME FO CIRCULATING PUMP	2	3,3	8759	2	8756	2	4283	1	6,6	6,6	6,6	6,6	3,2	6,4
AE FO SUPPLY PUMP	2	0,7	8758	2	8756	2	8747	2	1,3	1,3	1,3	1,3	1,3	1,3
AE FO BOOSTER PUMP	2	3,3	8748	2	8756	2	4060	1	6,6	6,6	6,6	6,6	3,1	6,1
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVEN	1	2,1	0	1	37	1	0	1	0,0	0,0	0,0	0,0	0,0	0,0
AUX. BOILER FO PUMP	2	0,4	8427	2	8747	2	8706	2	0,8	0,8	0,9	0,9	0,9	0,9
LO TRANSFER PUMP	1	3,3	0	1	0	1	0	1	0,0	0,0	0,0	0,0	0,0	0,0
AE LO PURIFIER	2	4,7	7218	2	15827	2	5892	2	7,7	7,7	16,8	16,8	6,2	6,2
ME LO PURIFIER	2	4,7	8545	2	12433	2	11407	2	9,1	9,1	13,2	13,2	12,1	12,1
AE LO PURIFIER SUPPLY PUMP	2	0,4	7218	2	0	0	15428	2	0,7	0,7		1,1	1,4	1,4
ME LO PURIFIER SUPPLY PUMP	2	1,4	8545	2	0	0	0	2	2,7	2,7		1,3	0,0	0,0
ME LO PUMP	2	64,4	8722	2	8664	2	8693	2	126,5	126,5	125,9	125,9	125,8	125,8
STERN TUBE LO PUMP	2	0,8	8488	2	8756	2	8751	2	1,6	1,6	1,6	1,6	1,6	1,6
ME COOLING SW PUMP	3	32,6	17473	3	13536	3	15549	3	128,2	128,2	99,5	99,5	113,8	113,8
ME JACKET COOLING FW PUMP	2	13,0	8758	2	8756	2	8754	2	25,6	25,6	25,6	25,6	25,5	25,5
CENTRAL COOLING FW PUMP	3	33,8	17517	3	17512	3	15637	3	133,3	133,3	133,5	133,5	118,7	118,7
MAIN STARTING AIR COMPRESSOR	2	35,7	938	2	384	2	1821	2	7,5	7,5	3,1	3,1	14,6	14,6
SERVICE AIR COMPRESSOR	1	5,7	5366	1	3330	1	3761	1	6,8	6,8	4,2	4,2	4,8	4,8
CONTROL AIR COMPRESSOR	1	8,5	7406	1	7452	1	3941	1	14,1	14,1	14,3	14,3	7,5	7,5
AUX. BOILER FEED WATER PUMP	2	6,8	8758	2	8757	2	8752	2	13,4	13,4	13,4	13,4	13,3	13,3
AUX. BOILER CIRCULATING PUMP	2	3,7	8507	2	8742	2	6376	2	7,0	7,0	7,2	7,2	5,2	5,2
FW GENERATOR SW PUMP	1	16,8	4658	1	0	0	4675	1	17,7	17,7		17,7	17,7	17,7
FW GENERATOR DISTILLATE PUMP	1	1,2	5300	1	0	0	0	1	1,5	1,5		0,7	0,0	0,0
BALLAST PUMP	2	99,4	566	2	441	2	317	2	12,7	12,7	9,9	9,9	7,1	7,1
BILGE TRANSFER PUMP	1	2,1	237	1	111	1	139	1	0,1	0,1	0,1	0,1	0,1	0,1
BILGE/MAIN FIRE/GS PUMP	2	90,3	266	2	522	2	284	2	5,4	5,4	10,6	10,6	5,8	5,8
DECK WATERSPRAY PUMP	1	121,9	5	1	15	1	1	1	0,1	0,1	0,4	0,4	0,0	0,0
EMERGENCY FIRE PUMP	1	6,3	22	1	10	1	24	1	0,0	0,0	0,0	0,0	0,0	0,0
CARGO REMOTE VALVE HYDR. OIL PUMP	2	1,8	110	2	247	2	347	2	0,0	0,0	0,1	0,1	0,1	0,1
BALLAST REMOTE VALVE HYDR. OIL PUMP	2	1,8	348	2	203	2	229	2	0,1	0,1	0,1	0,1	0,1	0,1

8.3 ACCURACY TEST, 2011

2011	1		REGISTERED
CLIPPER MARS			CALCULATED
CLIPPER NEPTUN			
CLIPPER ORION			

	OVERVIEW		
	MARS	NEPTUN	ORION
EQUIPMENT W/COUNTERS, SUM [TON]	1137	1106	1483
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	84	115	9
EQUIPMENT W/O COUNTERS	194	194	194
SUM ESTIMATED [TON]	1415	1415	1687
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1381	1464	1650
DEVIATION [TON]	-33	49	-37
DEVIATION [USD]	2,4 %	-3,3 %	2,3 %

	FUEL TYPE [TON]		
	MARS	NEPTUN	ORION
HFO	1340	1367	1328
LSHFO	15	57	139
MDO	26	41	183
TOTAL	**1381**	**1464**	**1650**
SFC [g/kWh]-HC	212,3	212,2	210,8
SFC [g/kWh]-LC	225,4	225,2	223,0

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
LOADED	104	82	132	418	345	596	4,0	4,2	4,5
BALLAST	95	84	88	335	304	339	3,5	3,6	3,8
MAN	116	87	55	433	383	259	3,7	4,4	4,7
PORT	50	112	90	195	432	456	3,9	3,9	5,1
SUM/AVERAGE	**365**	**365**	**365**	**1381**	**1464**	**1650**	**3,8**	**4,0**	**4,5**

	RUNNING HOURS [H]			REG. [TON]			SFC [KG/H]		
MACHINERY	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
MAIN DIESEL ENGINE	6443	5267	5996	8511	7955	9009	1321,0	1510,5	1502,4
AUX. DIESEL GENERATOR	10943	11223	12202	1381	1464	1650	126,2	130,5	135,2

	RUNNING HOURS [H]			EST. FUEL [TON]		
MAIN SYSTEM	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
EQUIPMENT FOR CARGO	18396	17473	24323	373	367	657
SHIP EQUIPMENT	12750	10261	11160	69	71	74
EQUIPMENT FOR CREW	68317	71893	78617	214	223	218
MACHINERY MAIN COMPONENTS	15426	15663	14393	9	13	9
SYSTEMS FOR MAIN MACHINERY	193792	166517	162540	540	529	520
SHIP COMMON SYSTEMS	2383	1640	2043	16	18	15
SUM	**311063**	**283447**	**293077**	**1221**	**1221**	**1493**

	RUNNING HOURS [H]			EST. FUEL [TON]		
SUBSYSTEM	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	1391	878	1578	83	52	90
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	4166	4194	8775	209	211	438
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	1742	147	370	6	3	4
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	11097	12254	13601	74	101	124
MANOEUVRING MACHINERY & EQUIPMENT	9448	9436	8922	42	49	53
ANCHORING, MOORING & TOWING EQUIPMENT	1017	825	599	23	18	18
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	2285	0	1639	5	4	3
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	4416	4303	4101	8	8	8
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	62986	67590	73025	204	214	209
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	915	0	1491	1	1	1
DIESEL ENGINES FOR PROPULSION	733	1121	676	6	10	6
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	14693	14542	13717	3	3	3
FUEL SYSTEMS	52982	51963	27277	49	45	37
LUBE OIL SYSTEMS	57148	44422	57308	153	159	151
COOLING SYSTEMS	40926	39855	40477	267	258	260
COMPRESSED AIR SYSTEMS	14516	12705	14614	29	24	32
STEAM, CONDENSATE & FEED WATER SYSTEMS	16952	17573	17235	20	21	20
DISTILLED & MAKE-UP WATER SYST	11269	0	5629	22	22	21
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	549	646	607	9	10	9
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	388	393	270	6	8	5
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	1446	601	1166	1	0	0
SUM	**311063**	**283447**	**293077**	**1221**	**1221**	**1493**

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED CONSUMPTION [TON]					
			MARS		NEPTUN		ORION		MARS		NEPTUN		ORION	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	281,9	1387	8	878	8	1446	8	83,0	83,0	52,5	52,5	85,9	85,9
CARGO BOOSTER PUMP	2	162,2	3	2	0	2	132	2	0,1	0,1	0,0	0,0	4,5	4,5
CARGO COMPRESSOR	4	236,8	4166	4	4194	4	8775	4	209,5	209,5	210,7	210,7	437,9	437,9
CARGO TANK GAS-FREEING FAN	4	48,1	145	4	83	4	5	4	1,6	1,6	0,9	0,9	0,1	0,1
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	158	1	64	1	200	1	3,1	3,1	1,3	1,3	3,9	3,9
NITROGEN GENERATOR	1	4,8	1439	1	0	0	164	1	1,6	1,6		0,9	0,2	0,2
CARGO HOSE CRANE	1	36,6	61	1	0	0	55	1	0,5	0,5		0,5	0,4	0,4
CARGO CONDENSER SW COOLING PUMP	2	94,6	2318	2	3590	2	4744	2	49,4	49,4	76,5	76,5	100,1	100,1
GLYCOL COOLING SYSTEM PUMP	2	12,8	8718	2	8664	2	8723	2	23,8	23,8	23,6	23,6	23,6	23,6
GLYCOL COOLING SYSTEM PUMP (VAPORISER)	1	12,8	0	1	0	1	79	1	0,0	0,0	0,0	0,0	0,2	0,2
STEERING GEAR HYDR OIL PUMP	2	12,3	9301	2	9334	2	8666	2	25,8	25,8	25,9	25,9	23,8	23,8
BOW THRUSTER	1	1073,7	70	1	102	1	128	1	15,9	15,9	23,3	23,3	29,0	29,0
HYDRAULIC OIL PUMP BOW THRUSTER	1	4,9	77	1	0	0	128	1	0,1	0,1		0,1	0,1	0,1
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	447	2	300	2	208	1	11,2	11,2	7,5	7,5	5,1	10,3
MOORING WINCH HYDR. OIL PUMP	2	89,5	570	2	525	2	391	2	11,5	11,5	10,6	10,6	7,8	7,8
INCINERATOR	1	8,9	2285	1	0	0	1639	1	4,6	4,6		3,9	3,2	3,2
PROVISION COOLING COMPRESSOR	2	8,3	4416	2	4303	2	4101	2	8,3	8,3	8,0	8,0	7,6	7,6
AIR-CONDITION COOLING COMPRESSOR	2	56,1	0	0	0	0	6701	2		83,9		83,9	83,9	83,9
SUPPLY FAN, ENGINE ROOM	4	12,9	30988	4	32935	4	31729	4	89,8	89,8	95,4	95,4	91,0	91,0
EXHAUST FAN, PURIFIER AREA	1	1,8	7154	1	8199	1	8193	1	3,0	3,0	3,4	3,4	3,4	3,4
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,5	7252	1	8738	1	8719	1	17,1	17,1	20,6	20,6	20,4	20,4
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,8	8754	1	8769	1	8732	1	1,6	1,6	1,6	1,6	1,6	1,6
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	4,6	8757	1	8779	1	8744	1	9,0	9,0	9,0	9,0	8,9	8,9
SUPPLY FAN, BOW THRUSTER & BOSUN STORE ROOM	1	4,7	82	1	171	1	207	1	0,1	0,1	0,2	0,2	0,2	0,2
POTABLE WATER HYDROPHORE PUMP	2	4,5	915	2	0	0	1491	2	0,9	0,9		1,2	1,5	1,5
ME COMBUSTION AIR BLOWER	2	39,1	730	2	1121	2	676	2	6,4	6,4	9,9	9,9	5,9	5,9
ME TURNING GEAR	1	3,4	2	1	0	0	0	1	0,0	0,0		0,0	0,0	0,0
AE LO PRIMING PUMP	3	0,9	14693	3	14542	3	13717	3	2,9	2,9	2,9	2,9	2,7	2,7
HFO TRANSFER PUMP	3	13,0	434	3	525	3	480	3	1,3	1,3	1,5	1,5	1,4	1,4
MDO TRANSFER PUMP	1	4,9	10	1	10	1	29	1	0,0	0,0	0,0	0,0	0,0	0,0
HFO PURIFIER	2	15,3	8706	2	7336	2	7591	2	29,9	29,9	25,2	25,2	25,8	25,8
SLUDGE OIL PUMP	1	3,3	47	1	117	1	75	1	0,0	0,0	0,1	0,1	0,1	0,1
ME FO SUPPLY PUMP	2	1,4	8759	2	8798	2	3138	1	2,7	2,7	2,7	2,7	1,0	1,9
ME FO CIRCULATING PUMP	2	3,3	8779	2	8798	2	1044	1	6,6	6,6	6,6	6,6	0,8	1,6
AE FO SUPPLY PUMP	2	0,7	8759	2	8804	2	3726	1	1,3	1,3	1,3	1,3	0,6	1,1
AE FO BOOSTER PUMP	2	3,3	8759	2	8798	2	2748	1	6,6	6,6	6,6	6,6	2,1	4,1
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVEN	1	2,1	1	1	3	1	0	1	0,0	0,0	0,0	0,0	0,0	0,0
AUX. BOILER FO PUMP	2	0,4	8727	2	8774	2	8448	2	0,9	0,9	0,9	0,9	0,8	0,8
LO TRANSFER PUMP	1	3,3	28	1	1	1	0	1	0,0	0,0	0,0	0,0	0,0	0,0
AE LO PURIFIER	2	4,7	11065	2	11744	2	9801	2	11,7	11,7	12,5	12,5	10,3	10,3
ME LO PURIFIER	2	4,7	8649	2	15148	2	13233	2	9,2	9,2	16,1	16,1	13,9	13,9
AE LO PURIFIER SUPPLY PUMP	2	0,4	11065	2	0	0	16943	2	1,0	1,0		1,3	1,6	1,6
ME LO PURIFIER SUPPLY PUMP	2	1,4	8581	2	0	0	0	2	2,7	2,7		1,3	0,0	0,0
ME LO PUMP	2	64,4	8732	2	8731	2	8577	2	126,7	126,7	126,6	126,6	123,2	123,2
STERN TUBE LO PUMP	2	0,8	9029	2	8798	2	8754	2	1,7	1,7	1,6	1,6	1,6	1,6
ME COOLING SW PUMP	3	32,6	14647	3	13476	3	16018	3	107,5	107,5	98,9	98,9	116,4	116,4
ME JACKET COOLING FW PUMP	2	13,0	8760	2	8782	2	8754	2	25,6	25,6	25,7	25,7	25,3	25,3
CENTRAL COOLING FW PUMP	3	33,8	17519	3	17597	3	15706	3	133,4	133,4	133,9	133,9	118,3	118,3
MAIN STARTING AIR COMPRESSOR	2	35,7	734	2	366	2	1175	2	5,9	5,9	2,9	2,9	9,4	9,4
SERVICE AIR COMPRESSOR	1	5,7	5377	1	3997	1	5068	1	6,8	6,8	5,1	5,1	6,4	6,4
CONTROL AIR COMPRESSOR	1	8,5	8405	1	8342	1	8372	1	16,1	16,1	15,9	15,9	15,8	15,8
AUX. BOILER FEED WATER PUMP	2	6,8	8743	2	8788	2	8733	2	13,3	13,3	13,4	13,4	13,2	13,2
AUX. BOILER CIRCULATING PUMP	2	3,7	8209	2	8785	2	8501	2	6,8	6,8	7,2	7,2	6,9	6,9
FW GENERATOR SW PUMP	1	16,8	5402	1	0	0	5629	1	20,5	20,5		20,8	21,1	21,1
FW GENERATOR DISTILLATE PUMP	1	1,2	5867	1	0	0	0	1	1,6	1,6		0,8	0,0	0,0
BALLAST PUMP	2	99,4	418	2	432	2	398	2	9,4	9,4	9,7	9,7	8,8	8,8
BILGE TRANSFER PUMP	1	2,1	131	1	214	1	209	1	0,1	0,1	0,1	0,1	0,1	0,1
BILGE/MAIN FIRE/GS PUMP	2	90,3	285	2	387	2	258	2	5,8	5,8	7,9	7,9	5,2	5,2
DECK WATERSPRAY PUMP	1	121,9	4	1	2	1	1	1	0,1	0,1	0,0	0,0	0,0	0,0
EMERGENCY FIRE PUMP	1	6,3	99	1	4	1	11	1	0,1	0,1	0,0	0,0	0,0	0,0
CARGO REMOTE VALVE HYDR. OIL PUMP	2	1,8	177	2	346	2	858	2	0,1	0,1	0,1	0,1	0,3	0,3
BALLAST REMOTE VALVE HYDR. OIL PUMP	2	1,8	1269	2	255	2	308	2	0,5	0,5	0,1	0,1	0,1	0,1

9. OPERATION COSTS

9.1 X1 VESSELS 2009

2009	1		REGISTERED
CLIPPER MARS			CALCULATED
CLIPPER NEPTUN			
CLIPPER ORION			

	OVERVIEW		
	MARS	NEPTUN	ORION
EQUIPMENT W/COUNTERS, SUM [TON]	1399	1220	1221
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	0	147	15
SUM ESTIMATED [TON]	1399	1367	1237
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1548	1570	1404
OTHER EQUIPMENT	149	202	167

	FUEL TYPE [TON]		
	MARS	NEPTUN	ORION
HFO	1543	1551	1386
LSHFO	0	0	0
MDO	5	18	18
TOTAL	**1548**	**1570**	**1404**
SFC [g/kWh]-HC	212,6	212,4	212,4
SFC [g/kWh]-LC	225,6	225,5	225,5

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
LOADED	98	83	95	439	371	392	4,5	4,5	4,1
BALLAST	64	66	89	264	275	319	4,1	4,2	3,6
MAN	0	0	0	0	0	0			
PORT	203	216	181	846	923	693	4,2	4,3	3,8
SUM/AVERAGE	**365**	**365**	**365**	**1548**	**1570**	**1404**	**4,3**	**4,3**	**3,8**

	RUNNING HOURS [H]			REG. FUEL [TON]			SFC [KG/H]		
MACHINERY	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
MAIN DIESEL ENGINE	4262	3591	3728	6340	5179	5240	1487,6	1442,1	1405,7
AUX. DIESEL GENERATOR	11937	12317	10980	1548	1570	1404	129,7	127,4	127,9
CARGO COMPRESSOR	6511	6089	5154						

	RUNNING HOURS [H]			P. FACTOR [#]			
SEEMP/MONITORED EQUIPMENT	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	DEPENDENCY
ME LO PUMP	7684	8681	8082	1,80	2,42	2,17	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	8858	8700	8051	2,08	2,42	2,16	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	6169	4457	3334	3,79	2,93	2,59	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	8698	8722	5424	5,34	5,73	4,21	/(COMPRESSORS/4)

	RUNNING HOURS [H]			EST. COSTS [USD]			
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	COMMENT
EQUIPMENT FOR CARGO	**25361**	**16163**	**18955**	**580**	**487**	**429**	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	1511	664	1078	80	50	68	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	6511	6089	5154	328	306	259	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	2256	265	613	15	10	7	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	15084	9144	12110	156	121	95	
SHIP EQUIPMENT	**11396**	**12867**	**10923**	**65**	**91**	**76**	
MANOEUVRING MACHINERY & EQUIPMENT	9060	9105	8299	45	64	51	
ANCHORING, MOORING & TOWING EQUIPMENT	748	644	1005	17	21	22	
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	1588	3118	1619	3	6	3	
EQUIPMENT FOR CREW	**78854**	**71402**	**71305**	**218**	**219**	**201**	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	5404	4128	4068	10	8	8	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	73071	67273	66825	208	211	193	
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	379	0	412	0	0	0	
MACHINERY MAIN COMPONENTS	**14749**	**9752**	**15386**	**8**	**11**	**7**	
DIESEL ENGINES FOR PROPULSION	593	991	486	5	9	4	
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	14157	8760	14900	3	3	3	
SYSTEMS FOR MAIN MACHINERY	**168003**	**180460**	**158455**	**511**	**527**	**512**	
FUEL SYSTEMS	51409	46830	48841	44	40	38	
LUBE OIL SYSTEMS	41581	62323	38449	129	164	136	
COOLING SYSTEMS	41967	41040	42217	275	268	276	
COMPRESSED AIR SYSTEMS	12512	7659	9070	25	16	25	
STEAM, CONDENSATE & FEED WATER SYSTEMS	15568	17485	15098	19	21	19	
DISTILLED & MAKE-UP WATER SYST	4967	5123	4780	19	19	18	
SHIP COMMON SYSTEMS	**1533**	**1782**	**1617**	**17**	**32**	**12**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	605	631	414	9	9	7	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	453	579	202	8	22	4	
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	475	572	1001	0	0	0	
SUM	**299897**	**292425**	**276641**	**1399**	**1367**	**1237**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED OPERATION COSTS [USD]					
			MARS		NEPTUN		ORION		MARS		NEPTUN		ORION	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	281,9	1116	8	664	8	907	7	67	66,9	39,8	39,8	54,3	62,1
CARGO BOOSTER PUMP	2	162,2	394	2	0	0	171	2	13,6	13,6		9,7	5,9	5,9
CARGO COMPRESSOR	4	236,8	6511	4	6089	4	5154	4	327,7	327,7	306,3	306,3	259,2	259,2
CARGO TANK GAS-FREEING FAN	4	48,1	755	4	0	0	38	4	8,2	8,2		4,3	0,4	0,4
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	306	1	265	1	0	0	6,0	6,0	5,2	5,2		5,6
NITROGEN GENERATOR	1	4,8	1195	1	0	0	575	1	1,3	1,3		1,0	0,6	0,6
CARGO HOSE CRANE	1	36,6	73	1	71	1	50	1	0,6	0,6	0,6	0,6	0,4	0,4
CARGO CONDENSER SW COOLING PUMP	2	94,6	6169	2	4457	2	3334	2	131,7	131,7	95,1	95,1	71,1	71,1
GLYCOL COOLING SYSTEM PUMP	2	12,8	8714	2	4587	1	8726	2	23,8	23,8	12,5	25,0	23,8	23,8
GLYCOL COOLING SYSTEM PUMP (VAPORISER)	1	12,8	130	1	29	1	0	1	0,4	0,4	0,1	0,1	0,0	0,0
STEERING GEAR HYDR OIL PUMP	2	12,3	8858	2	8700	2	8051	2	24,6	24,6	24,2	24,2	22,4	22,4
BOW THRUSTER	1	1073,7	88	1	173	1	124	1	20,1	20,1	39,5	39,5	28,3	28,3
HYDRAULIC OIL PUMP BOW THRUSTER	1	4,9	114	1	231	1	124	1	0,1	0,1	0,3	0,3	0,1	0,1
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	366	2	349	2	354	2	9,1	9,1	8,7	8,7	8,8	8,8
MOORING WINCH HYDR. OIL PUMP	2	89,5	382	2	295	1	651	2	7,7	7,7	6,0	11,9	13,1	13,1
INCINERATOR	1	8,9	1588	1	3118	1	1619	1	3,2	3,2	6,2	6,2	3,2	3,2
PROVISION COOLING COMPRESSOR	2	8,3	5404	2	4128	2	4068	2	10,1	10,1	7,7	7,7	7,6	7,6
AIR-CONDITION COOLING COMPRESSOR	2	56,1	6365	2	0	0	6491	2	80,6	80,6		81,4	82,1	82,1
SUPPLY FAN, ENGINE ROOM	4	12,9	31788	4	32642	4	28801	4	92,2	92,2	94,6	94,6	83,5	83,5
EXHAUST FAN, PURIFIER AREA	1	1,8	8653	1	8045	1	8437	1	3,6	3,6	3,4	3,4	3,5	3,5
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,5	8698	1	8722	1	5424	1	20,6	20,6	20,6	20,6	12,8	12,8
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,8	8705	1	8739	1	8676	1	1,6	1,6	1,6	1,6	1,6	1,6
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	4,6	8704	1	8740	1	8751	1	8,9	8,9	9,0	9,0	9,0	9,0
SUPPLY FAN, BOW THRUSTER & BOSUN STORE ROOM	1	4,7	158	1	385	1	245	1	0,2	0,2	0,4	0,4	0,3	0,3
POTABLE WATER HYDROPHORE PUMP	2	4,5	379	2	0	0	412	2	0,4	0,4		0,4	0,4	0,4
ME COMBUSTION AIR BLOWER	2	39,1	593	2	991	2	486	2	5,2	5,2	8,7	8,7	4,3	4,3
ME TURNING GEAR	1	3,4	0	0	0	0	0	0		0,0		0,0		0,0
AE LO PRIMING PUMP	3	0,9	14157	3	8760	2	14900	3	2,8	2,8	1,7	2,6	3,0	3,0
HFO TRANSFER PUMP	3	13,0	317	3	308	1	362	3	0,9	0,9	0,9	2,7	1,1	1,1
MDO TRANSFER PUMP	1	4,9	6	1	0	0	8	1	0,0	0,0		0,0	0,0	0,0
HFO PURIFIER	2	15,3	7327	2	2764	1	5334	2	25,2	25,2	9,5	19,0	18,3	18,3
SLUDGE OIL PUMP	1	3,3	25	1	78	1	52	1	0,0	0,0	0,1	0,1	0,0	0,0
ME FO SUPPLY PUMP	2	1,4	8657	2	8740	2	8752	2	2,7	2,7	2,7	2,7	2,7	2,7
ME FO CIRCULATING PUMP	2	3,3	8774	2	8742	2	8752	2	6,6	6,6	6,6	6,6	6,6	6,6
AE FO SUPPLY PUMP	2	0,7	8775	2	8742	2	8753	2	1,3	1,3	1,3	1,3	1,3	1,3
AE FO BOOSTER PUMP	2	3,3	8764	2	8743	2	8752	2	6,6	6,6	6,6	6,6	6,6	6,6
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVEN)	1	2,1	0	1	0	0	0	0	0,0	0,0		0,0		0,0
AUX. BOILER FO PUMP	2	0,4	8765	2	8712	2	8076	2	0,9	0,9	0,9	0,9	0,8	0,8
LO TRANSFER PUMP	1	3,3	0	1	0	0	0	0	0,0	0,0		0,0		0,0
AE LO PURIFIER	2	4,7	5543	2	15795	2	7943	2	5,9	5,9	16,8	16,8	8,4	8,4
ME LO PURIFIER	2	4,7	7019	2	6774	1	5470	2	7,5	7,5	7,2	14,4	5,8	5,8
AE LO PURIFIER SUPPLY PUMP	2	0,4	5543	2	16200	2	8203	2	0,5	0,5	1,5	1,5	0,8	0,8
ME LO PURIFIER SUPPLY PUMP	2	1,4	7019	2	6130	1	0	0	2,2	2,2	1,9	3,8		2,0
ME LO PUMP	2	64,4	7684	2	8681	2	8082	2	111,7	111,7	126,1	126,1	117,3	117,3
STERN TUBE LO PUMP	2	0,8	8772	2	8743	2	8751	2	1,6	1,6	1,6	1,6	1,6	1,6
ME COOLING SW PUMP	3	32,6	16114	3	14813	3	16741	3	118,4	118,4	108,8	108,8	123,0	123,0
ME JACKET COOLING FW PUMP	2	13,0	8735	2	8742	2	8752	2	25,6	25,6	25,6	25,6	25,6	25,6
CENTRAL COOLING FW PUMP	3	33,8	17119	3	17485	3	16724	3	130,5	130,5	133,2	133,2	127,4	127,4
MAIN STARTING AIR COMPRESSOR	2	35,7	498	2	422	2	1801	2	4,0	4,0	3,4	3,4	14,5	14,5
SERVICE AIR COMPRESSOR	1	5,7	3791	1	2506	1	4627	1	4,8	4,8	3,2	3,2	5,9	5,9
CONTROL AIR COMPRESSOR	1	8,5	8223	1	4731	1	2642	1	15,7	15,7	9,0	9,0	5,1	5,1
AUX. BOILER FEED WATER PUMP	2	6,8	8773	2	8743	2	8751	2	13,4	13,4	13,3	13,3	13,4	13,4
AUX. BOILER CIRCULATING PUMP	2	3,7	6795	2	8742	2	6347	2	5,6	5,6	7,2	7,2	5,2	5,2
FW GENERATOR SW PUMP	1	16,8	4967	1	5123	1	4780	1	18,9	18,9	19,4	19,4	18,1	18,1
FW GENERATOR DISTILLATE PUMP	1	1,2	0	0	0	0	0	0		0,0		0,0		0,0
BALLAST PUMP	2	99,4	389	2	419	2	325	2	8,7	8,7	9,4	9,4	7,3	7,3
BILGE TRANSFER PUMP	1	2,1	216	1	213	1	89	1	0,1	0,1	0,1	0,1	0,0	0,0
BILGE/MAIN FIRE/GS PUMP	2	90,3	392	2	517	1	196	2	8,0	8,0	10,5	21,0	4,0	4,0
DECK WATERSPRAY PUMP	1	121,9	3	1	28	1	2	1	0,1	0,1	0,8	0,8	0,1	0,1
EMERGENCY FIRE PUMP	1	6,3	58	1	34	1	4	1	0,1	0,1	0,0	0,0	0,0	0,0
CARGO REMOTE VALVE HYDR. OIL PUMP	2	1,8	121	2	319	1	583	2	0,0	0,0	0,1	0,3	0,2	0,2
BALLAST REMOTE VALVE HYDR. OIL PUMP	2	1,8	354	2	253	2	418	2	0,1	0,1	0,1	0,1	0,2	0,2

9.2 X1-VESSELS 2010

2010	1		
CLIPPER MARS			
CLIPPER NEPTUN			
CLIPPER ORION			

(green)	REGISTERED
(orange)	CALCULATED

	OVERVIEW		
	MARS	NEPTUN	ORION
EQUIPMENT W/COUNTERS, SUM [TON]	1271	1138	1453
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	0	115	6
SUM ESTIMATED [TON]	1271	1253	1459
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1490	1477	1629
OTHER EQUIPMENT	219	224	170

	FUEL TYPE [TON]		
	MARS	NEPTUN	ORION
HFO	1306	1475	1175
LSHFO	144	0	369
MDO	39	2	85
TOTAL	**1490**	**1477**	**1629**
SFC [g/kWh]-HC	212,2	212,6	211,7
SFC [g/kWh]-LC	225,2	225,7	224,7

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	**MARS**	**NEPTUN**	**ORION**	**MARS**	**NEPTUN**	**ORION**	**MARS**	**NEPTUN**	**ORION**
LOADED	123	110	82	530	475	414	4,3	4,3	5,1
BALLAST	101	103	105	383	409	395	3,8	4,0	3,8
MAN	0	0	0	0	0	0			
PORT	141	152	178	577	593	820	4,1	3,9	4,6
SUM/AVERAGE	**365**	**365**	**365**	**1490**	**1477**	**1629**	**4,1**	**4,1**	**4,5**

	RUNNING HOURS [H]			REG. FUEL [TON]			SFC [KG/H]		
MACHINERY	**MARS**	**NEPTUN**	**ORION**	**MARS**	**NEPTUN**	**ORION**	**MARS**	**NEPTUN**	**ORION**
MAIN DIESEL ENGINE	5579	5275	4557	8454	7445	6725	1515,2	1411,4	1475,7
AUX. DIESEL GENERATOR	11228	11250	12369	1490	1477	1629	132,7	131,3	131,7
CARGO COMPRESSOR	4866	4927	7136						

	RUNNING HOURS [H]			P. FACTOR [#]			
SEEMP/MONITORED EQUIPMENT	**MARS**	**NEPTUN**	**ORION**	**MARS**	**NEPTUN**	**ORION**	**DEPENDENCY**
ME LO PUMP	8722	8664	8693	1,56	1,64	1,91	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	9176	9141	7374	1,64	1,73	1,62	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	3875	3394	4503	3,19	2,76	2,52	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	7850	8489	7520	6,45	6,89	4,22	/(COMPRESSORS/4)

	RUNNING HOURS [H]			EST. COSTS [USD]			
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	**MARS**	**NEPTUN**	**ORION**	**MARS**	**NEPTUN**	**ORION**	**COMMENT**
EQUIPMENT FOR CARGO	**19689**	**13902**	**23502**	**431**	**399**	**635**	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	1220	846	2825	73	51	156	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	4866	4927	7136	244	248	358	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	928	139	149	6	2	1	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	12676	7990	13392	107	98	120	
SHIP EQUIPMENT	**12192**	**9845**	**11163**	**80**	**68**	**86**	
MANOEUVRING MACHINERY & EQUIPMENT	9374	9250	7696	46	51	57	
ANCHORING, MOORING & TOWING EQUIPMENT	1442	595	1082	32	13	24	
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	1376	0	2385	3	4	5	
EQUIPMENT FOR CREW	**70810**	**72632**	**71999**	**181**	**219**	**212**	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	4692	4235	4170	9	8	8	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	65645	68396	66867	172	210	203	
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	473	0	962	0	1	1	
MACHINERY MAIN COMPONENTS	**15457**	**16067**	**14079**	**10**	**19**	**8**	
DIESEL ENGINES FOR PROPULSION	800	1795	637	7	16	6	
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	14657	14272	13442	3	3	3	
SYSTEMS FOR MAIN MACHINERY	**185310**	**166750**	**159622**	**550**	**527**	**505**	
FUEL SYSTEMS	51894	52599	40185	47	48	36	
LUBE OIL SYSTEMS	48736	45681	50171	148	160	147	
COOLING SYSTEMS	43747	39805	39940	287	259	258	
COMPRESSED AIR SYSTEMS	13710	11166	9523	29	22	27	
STEAM, CONDENSATE & FEED WATER SYSTEMS	17265	17499	15128	20	21	19	
DISTILLED & MAKE-UP WATER SYST	9958	0	4675	19	18	18	
SHIP COMMON SYSTEMS	**1554**	**1549**	**1341**	**19**	**21**	**13**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	803	552	456	13	10	7	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	293	548	309	6	11	6	
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	458	449	576	0	0	0	
SUM	**305013**	**280744**	**281706**	**1271**	**1253**	**1459**	

Alexander Grødeland
Total Equipment Monitoring

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED OPERATION COSTS [USD]					
			MARS		NEPTUN		ORION		MARS		NEPTUN		ORION	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	281,9	1220	8	846	8	2318	8	73	72,9	50,7	50,7	138,4	138,4
CARGO BOOSTER PUMP	2	162,2	0	2	0	1	507	2	0,0	0,0	0,0	0,0	17,4	17,4
CARGO COMPRESSOR	4	236,8	4866	4	4927	4	7136	4	244,5	244,5	248,0	248,0	357,8	357,8
CARGO TANK GAS-FREEING FAN	4	48,1	329	4	89	4	3	4	3,6	3,6	1,0	1,0	0,0	0,0
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	124	1	51	1	67	1	2,4	2,4	1,0	1,0	1,3	1,3
NITROGEN GENERATOR	1	4,8	476	1	0	0	79	1	0,5	0,5		0,3	0,1	0,1
CARGO HOSE CRANE	1	36,6	78	1	0	0	54	1	0,6	0,6		0,5	0,4	0,4
CARGO CONDENSER SW COOLING PUMP	2	94,6	3875	2	3394	2	4503	2	82,6	82,6	72,5	72,5	95,8	95,8
GLYCOL COOLING SYSTEM PUMP	2	12,8	8677	2	4597	1	8688	2	23,6	23,6	12,5	25,1	23,6	23,6
GLYCOL COOLING SYSTEM PUMP (VAPORISER)	1	12,8	46	1	0	1	147	1	0,1	0,1	0,0	0,0	0,4	0,4
STEERING GEAR HYDR OIL PUMP	2	12,3	9176	2	9141	2	7374	2	25,5	25,5	25,4	25,4	20,4	20,4
BOW THRUSTER	1	1073,7	88	1	109	1	161	1	20,0	20,0	25,0	25,0	36,6	36,6
HYDRAULIC OIL PUMP BOW THRUSTER	1	4,9	110	1	0	0	161	1	0,1	0,1		0,2	0,2	0,2
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	585	2	256	2	500	2	14,6	14,6	6,4	6,4	12,5	12,5
MOORING WINCH HYDR. OIL PUMP	2	89,5	857	2	339	2	582	2	17,3	17,3	6,8	6,8	11,7	11,7
INCINERATOR	1	8,9	1376	1	0	0	2385	1	2,7	2,7		3,7	4,7	4,7
PROVISION COOLING COMPRESSOR	2	8,3	4692	2	4235	2	4170	2	8,8	8,8	7,9	7,9	7,8	7,8
AIR-CONDITION COOLING COMPRESSOR	2	56,1	4544	2	0	0	7502	2	57,4	57,4		76,0	94,6	94,6
SUPPLY FAN, ENGINE ROOM	4	12,9	28536	4	34517	4	26482	4	82,6	82,6	100,2	100,2	76,5	76,5
EXHAUST FAN, PURIFIER AREA	1	1,8	7087	1	7531	1	7637	1	2,9	2,9	3,1	3,1	3,2	3,2
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,5	7850	1	8489	1	7520	1	18,5	18,5	20,1	20,1	17,7	17,7
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,8	8747	1	8755	1	8752	1	1,6	1,6	1,6	1,6	1,6	1,6
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	4,6	8746	1	8754	1	8751	1	9,0	9,0	9,0	9,0	9,0	9,0
SUPPLY FAN, BOW THRUSTER & BOSUN STORE ROOM	1	4,7	135	1	351	1	223	1	0,1	0,1	0,4	0,4	0,2	0,2
POTABLE WATER HYDROPHORE PUMP	2	4,5	473	2	0	0	962	2	0,5	0,5		0,7	1,0	1,0
ME COMBUSTION AIR BLOWER	2	39,1	795	2	1795	2	637	2	7,0	7,0	15,8	15,8	5,6	5,6
ME TURNING GEAR	1	3,4	6	1	0	0	0	1	0,0	0,0		0,0	0,0	0,0
AE LO PRIMING PUMP	3	0,9	14657	3	14272	3	13442	3	2,9	2,9	2,8	2,8	2,7	2,7
HFO TRANSFER PUMP	3	13,0	458	3	422	3	378	3	1,3	1,3	1,2	1,2	1,1	1,1
MDO TRANSFER PUMP	1	4,9	4	1	0	0	12	1	0,0	0,0		0,0	0,0	0,0
HFO PURIFIER	2	15,3	7943	2	8256	2	5161	2	27,3	27,3	28,4	28,4	17,7	17,7
SLUDGE OIL PUMP	1	3,3	39	1	113	1	80	1	0,0	0,0	0,1	0,1	0,1	0,1
ME FO SUPPLY PUMP	2	1,4	8758	2	8756	2	8758	2	2,7	2,7	2,7	2,7	2,7	2,7
ME FO CIRCULATING PUMP	2	3,3	8759	2	8756	2	4283	1	6,6	6,6	6,6	6,6	3,2	6,4
AE FO SUPPLY PUMP	2	0,7	8758	2	8756	2	8747	2	1,3	1,3	1,3	1,3	1,3	1,3
AE FO BOOSTER PUMP	2	3,3	8748	2	8756	2	4060	1	6,6	6,6	6,6	6,6	3,1	6,1
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVEN)	1	2,1	0	1	37	1	0	1	0,0	0,0	0,0	0,0	0,0	0,0
AUX. BOILER FO PUMP	2	0,4	8427	2	8747	2	8706	2	0,8	0,8	0,9	0,9	0,9	0,9
LO TRANSFER PUMP	1	3,3	0	1	0	1	0	1	0,0	0,0	0,0	0,0	0,0	0,0
AE LO PURIFIER	2	4,7	7218	2	15827	2	5892	2	7,7	7,7	16,8	16,8	6,2	6,2
ME LO PURIFIER	2	4,7	8545	2	12433	2	11407	2	9,1	9,1	13,2	13,2	12,1	12,1
AE LO PURIFIER SUPPLY PUMP	2	0,4	7218	2	0	0	15428	2	0,7	0,7		1,1	1,4	1,4
ME LO PURIFIER SUPPLY PUMP	2	1,4	8545	2	0	0	0	2	2,7	2,7		1,3	0,0	0,0
ME LO PUMP	2	64,4	8722	2	8664	2	8693	2	126,5	126,5	125,9	125,9	125,8	125,8
STERN TUBE LO PUMP	2	0,8	8488	2	8756	2	8751	2	1,6	1,6	1,6	1,6	1,6	1,6
ME COOLING SW PUMP	3	32,6	17473	3	13536	3	15549	3	128,2	128,2	99,5	99,5	113,8	113,8
ME JACKET COOLING FW PUMP	2	13,0	8758	2	8756	2	8754	2	25,6	25,6	25,6	25,6	25,5	25,5
CENTRAL COOLING FW PUMP	3	33,8	17517	3	17512	3	15637	3	133,3	133,3	133,5	133,5	118,7	118,7
MAIN STARTING AIR COMPRESSOR	2	35,7	938	2	384	2	1821	2	7,5	7,5	3,1	3,1	14,6	14,6
SERVICE AIR COMPRESSOR	1	5,7	5366	1	3330	1	3761	1	6,8	6,8	4,2	4,2	4,8	4,8
CONTROL AIR COMPRESSOR	1	8,5	7406	1	7452	1	3941	1	14,1	14,1	14,3	14,3	7,5	7,5
AUX. BOILER FEED WATER PUMP	2	6,8	8758	2	8757	2	8752	2	13,4	13,4	13,4	13,4	13,3	13,3
AUX. BOILER CIRCULATING PUMP	2	3,7	8507	2	8742	2	6376	2	7,0	7,0	7,2	7,2	5,2	5,2
FW GENERATOR SW PUMP	1	16,8	4658	1	0	0	4675	1	17,7	17,7		17,7	17,7	17,7
FW GENERATOR DISTILLATE PUMP	1	1,2	5300	1	0	0	0	1	1,5	1,5		0,7	0,0	0,0
BALLAST PUMP	2	99,4	566	2	441	2	317	2	12,7	12,7	9,9	9,9	7,1	7,1
BILGE TRANSFER PUMP	1	2,1	237	1	111	1	139	1	0,1	0,1	0,1	0,1	0,1	0,1
BILGE/MAIN FIRE/GS PUMP	2	90,3	266	2	522	2	284	2	5,4	5,4	10,6	10,6	5,8	5,8
DECK WATERSPRAY PUMP	1	121,9	5	1	15	1	1	1	0,1	0,1	0,4	0,4	0,0	0,0
EMERGENCY FIRE PUMP	1	6,3	22	1	10	1	24	1	0,0	0,0	0,0	0,0	0,0	0,0
CARGO REMOTE VALVE HYDR. OIL PUMP	2	1,8	110	2	247	2	347	2	0,0	0,0	0,1	0,1	0,1	0,1
BALLAST REMOTE VALVE HYDR. OIL PUMP	2	1,8	348	2	203	2	229	2	0,1	0,1	0,1	0,1	0,1	0,1

9.3 X1-VESSELS 2011

2011	1		
		(green)	REGISTERED
		(orange)	CALCULATED

CLIPPER MARS
CLIPPER NEPTUN
CLIPPER ORION

	OVERVIEW		
	MARS	NEPTUN	ORION
EQUIPMENT W/COUNTERS, SUM [TON]	1137	1106	1483
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	84	115	9
SUM ESTIMATED [TON]	1221	1221	1493
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1381	1464	1650
OTHER EQUIPMENT	161	243	157

	FUEL TYPE [TON]		
	MARS	NEPTUN	ORION
HFO	1340	1367	1328
LSHFO	15	57	139
MDO	26	41	183
TOTAL	**1381**	**1464**	**1650**
SFC [g/kWh]-HC	212,3	212,2	210,8
SFC [g/kWh]-LC	225,4	225,2	223,0

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
LOADED	104	82	132	418	345	596	4,0	4,2	4,5
BALLAST	95	84	88	335	304	339	3,5	3,6	3,8
MAN	116	87	55	433	383	259	3,7	4,4	4,7
PORT	50	112	90	195	432	456	3,9	3,9	5,1
SUM/AVERAGE	**365**	**365**	**365**	**1381**	**1464**	**1650**	**3,8**	**4,0**	**4,5**

	RUNNING HOURS [H]			REG. FUEL [TON]			SFC [KG/H]		
MACHINERY	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
MAIN DIESEL ENGINE	6443	5267	5996	8511	7955	9009	1321,0	1510,5	1502,4
AUX. DIESEL GENERATOR	10943	11223	12202	1381	1464	1650	126,2	130,5	135,2
CARGO COMPRESSOR	4166	4194	8775						

	RUNNING HOURS [H]			P. FACTOR [#]			
SEEMP/MONITORED EQUIPMENT	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	DEPENDENCY
ME LO PUMP	8732	8731	8577	1,36	1,66	1,43	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	9301	9334	8666	1,44	1,77	1,45	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	2318	3590	4744	2,23	3,42	2,16	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	7252	8738	8719	6,96	8,33	3,97	/(COMPRESSORS/4)

	RUNNING HOURS [H]			EST. COSTS [USD]			
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	COMMENT
EQUIPMENT FOR CARGO	**18396**	**17473**	**24323**	**373**	**367**	**657**	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	1391	878	1578	83	52	90	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	4166	4194	8775	209	211	438	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	1742	147	370	6	3	4	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	11097	12254	13601	74	101	124	
SHIP EQUIPMENT	**12750**	**10261**	**11160**	**69**	**71**	**74**	
MANOEUVRING MACHINERY & EQUIPMENT	9448	9436	8922	42	49	53	
ANCHORING, MOORING & TOWING EQUIPMENT	1017	825	599	23	18	18	
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	2285	0	1639	5	4	3	
EQUIPMENT FOR CREW	**68317**	**71893**	**78617**	**214**	**223**	**218**	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	4416	4303	4101	8	8	8	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	62986	67590	73025	204	214	209	
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	915	0	1491	1	1	1	
MACHINERY MAIN COMPONENTS	**15426**	**15663**	**14393**	**9**	**13**	**9**	
DIESEL ENGINES FOR PROPULSION	733	1121	676	6	10	6	
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	14693	14542	13717	3	3	3	
SYSTEMS FOR MAIN MACHINERY	**193792**	**166517**	**162540**	**540**	**529**	**520**	
FUEL SYSTEMS	52982	51963	27277	49	45	37	
LUBE OIL SYSTEMS	57148	44422	57308	153	159	151	
COOLING SYSTEMS	40926	39855	40477	267	258	260	
COMPRESSED AIR SYSTEMS	14516	12705	14614	29	24	32	
STEAM, CONDENSATE & FEED WATER SYSTEMS	16952	17573	17235	20	21	20	
DISTILLED & MAKE-UP WATER SYST	11269	0	5629	22	22	21	
SHIP COMMON SYSTEMS	**2383**	**1640**	**2043**	**16**	**18**	**15**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	549	646	607	9	10	9	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	388	393	270	6	8	5	
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	1446	601	1166	1	0	0	
SUM	**311063**	**283447**	**293077**	**1221**	**1221**	**1493**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED OPERATION COSTS [USD]					
			MARS		NEPTUN		ORION		MARS		NEPTUN		ORION	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	281,9	1387	8	878	8	1446	8	83	83,0	52,5	52,5	85,9	85,9
CARGO BOOSTER PUMP	2	162,2	3	2	0	2	132	2	0,1	0,1	0,0	0,0	4,5	4,5
CARGO COMPRESSOR	4	236,8	4166	4	4194	4	8775	4	209,5	209,5	210,7	210,7	437,9	437,9
CARGO TANK GAS-FREEING FAN	4	48,1	145	4	83	4	5	4	1,6	1,6	0,9	0,9	0,1	0,1
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	158	1	64	1	200	1	3,1	3,1	1,3	1,3	3,9	3,9
NITROGEN GENERATOR	1	4,8	1439	1	0	0	164	1	1,6	1,6		0,9	0,2	0,2
CARGO HOSE CRANE	1	36,6	61	1	0	0	55	1	0,5	0,5		0,5	0,4	0,4
CARGO CONDENSER SW COOLING PUMP	2	94,6	2318	2	3590	2	4744	2	49,4	49,4	76,5	76,5	100,1	100,1
GLYCOL COOLING SYSTEM PUMP	2	12,8	8718	2	8664	2	8723	2	23,8	23,8	23,6	23,6	23,6	23,6
GLYCOL COOLING SYSTEM PUMP (VAPORISER)	1	12,8	0	1	0	1	79	1	0,0	0,0	0,0	0,0	0,2	0,2
STEERING GEAR HYDR OIL PUMP	2	12,3	9301	2	9334	2	8666	2	25,8	25,8	25,9	25,9	23,8	23,8
BOW THRUSTER	1	1073,7	70	1	102	1	128	1	15,9	15,9	23,3	23,3	29,0	29,0
HYDRAULIC OIL PUMP BOW THRUSTER	1	4,9	77	1	0	0	128	1	0,1	0,1		0,1	0,1	0,1
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	447	2	300	2	208	1	11,2	11,2	7,5	7,5	5,1	10,3
MOORING WINCH HYDR. OIL PUMP	2	89,5	570	2	525	2	391	2	11,5	11,5	10,6	10,6	7,8	7,8
INCINERATOR	1	8,9	2285	1	0	0	1639	1	4,6	4,6		3,9	3,2	3,2
PROVISION COOLING COMPRESSOR	2	8,3	4416	2	4303	2	4101	2	8,3	8,3	8,0	8,0	7,6	7,6
AIR-CONDITION COOLING COMPRESSOR	2	56,1	0	0	0	0	6701	2		83,9		83,9	83,9	83,9
SUPPLY FAN, ENGINE ROOM	4	12,9	30988	4	32935	4	31729	4	89,8	89,8	95,4	95,4	91,0	91,0
EXHAUST FAN, PURIFIER AREA	1	1,8	7154	1	8199	1	8193	1	3,0	3,0	3,4	3,4	3,4	3,4
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,5	7252	1	8738	1	8719	1	17,1	17,1	20,6	20,6	20,4	20,4
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,8	8754	1	8769	1	8732	1	1,6	1,6	1,6	1,6	1,6	1,6
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	4,6	8757	1	8779	1	8744	1	9,0	9,0	9,0	9,0	8,9	8,9
SUPPLY FAN, BOW THRUSTER & BOSUN STORE ROOM	1	4,7	82	1	171	1	207	1	0,1	0,1	0,2	0,2	0,2	0,2
POTABLE WATER HYDROPHORE PUMP	2	4,5	915	2	0	0	1491	2	0,9	0,9		1,2	1,5	1,5
ME COMBUSTION AIR BLOWER	2	39,1	730	2	1121	2	676	2	6,4	6,4	9,9	9,9	5,9	5,9
ME TURNING GEAR	1	3,4	2	1	0	0	0	1	0,0	0,0		0,0	0,0	0,0
AE LO PRIMING PUMP	3	0,9	14693	3	14542	3	13717	3	2,9	2,9	2,9	2,9	2,7	2,7
HFO TRANSFER PUMP	3	13,0	434	3	525	3	480	3	1,3	1,3	1,5	1,5	1,4	1,4
MDO TRANSFER PUMP	1	4,9	10	1	10	1	29	1	0,0	0,0	0,0	0,0	0,0	0,0
HFO PURIFIER	2	15,3	8706	2	7336	2	7591	2	29,9	29,9	25,2	25,2	25,8	25,8
SLUDGE OIL PUMP	1	3,3	47	1	117	1	75	1	0,0	0,0	0,1	0,1	0,1	0,1
ME FO SUPPLY PUMP	2	1,4	8759	2	8798	2	3138	1	2,7	2,7	2,7	2,7	1,0	1,9
ME FO CIRCULATING PUMP	2	3,3	8779	2	8798	2	1044	1	6,6	6,6	6,6	6,6	0,8	1,6
AE FO SUPPLY PUMP	2	0,7	8759	2	8804	2	3726	1	1,3	1,3	1,3	1,3	0,6	1,1
AE FO BOOSTER PUMP	2	3,3	8759	2	8798	2	2748	1	6,6	6,6	6,6	6,6	2,1	4,1
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVEN)	1	2,1	1	1	3	1	0	1	0,0	0,0	0,0	0,0	0,0	0,0
AUX. BOILER FO PUMP	2	0,4	8727	2	8774	2	8448	2	0,9	0,9	0,9	0,9	0,8	0,8
LO TRANSFER PUMP	1	3,3	28	1	1	1	0	1	0,0	0,0	0,0	0,0	0,0	0,0
AE LO PURIFIER	2	4,7	11065	2	11744	2	9801	2	11,7	11,7	12,5	12,5	10,3	10,3
ME LO PURIFIER	2	4,7	8649	2	15148	2	13233	2	9,2	9,2	16,1	16,1	13,9	13,9
AE LO PURIFIER SUPPLY PUMP	2	0,4	11065	2	0	0	16943	2	1,0	1,0		1,3	1,6	1,6
ME LO PURIFIER SUPPLY PUMP	2	1,4	8581	2	0	0	0	2	2,7	2,7		1,3	0,0	0,0
ME LO PUMP	2	64,4	8732	2	8731	2	8577	2	126,7	126,7	126,6	126,6	123,2	123,2
STERN TUBE LO PUMP	2	0,8	9029	2	8798	2	8754	2	1,7	1,7	1,6	1,6	1,6	1,6
ME COOLING SW PUMP	3	32,6	14647	3	13476	3	16018	3	107,5	107,5	98,9	98,9	116,4	116,4
ME JACKET COOLING FW PUMP	2	13,0	8760	2	8782	2	8754	2	25,6	25,6	25,7	25,7	25,3	25,3
CENTRAL COOLING FW PUMP	3	33,8	17519	3	17597	3	15706	3	133,4	133,4	133,9	133,9	118,3	118,3
MAIN STARTING AIR COMPRESSOR	2	35,7	734	2	366	2	1175	2	5,9	5,9	2,9	2,9	9,4	9,4
SERVICE AIR COMPRESSOR	1	5,7	5377	1	3997	1	5068	1	6,8	6,8	5,1	5,1	6,4	6,4
CONTROL AIR COMPRESSOR	1	8,5	8405	1	8342	1	8372	1	16,1	16,1	15,9	15,9	15,8	15,8
AUX. BOILER FEED WATER PUMP	2	6,8	8743	2	8788	2	8733	2	13,3	13,3	13,4	13,4	13,2	13,2
AUX. BOILER CIRCULATING PUMP	2	3,7	8209	2	8785	2	8501	2	6,8	6,8	7,2	7,2	6,9	6,9
FW GENERATOR SW PUMP	1	16,8	5402	1	0	0	5629	1	20,5	20,5		20,8	21,1	21,1
FW GENERATOR DISTILLATE PUMP	1	1,2	5867	1	0	0	0	1	1,6	1,6		0,8	0,0	0,0
BALLAST PUMP	2	99,4	418	2	432	2	398	2	9,4	9,4	9,7	9,7	8,8	8,8
BILGE TRANSFER PUMP	1	2,1	131	1	214	1	209	1	0,1	0,1	0,1	0,1	0,1	0,1
BILGE/MAIN FIRE/GS PUMP	2	90,3	285	2	387	2	258	2	5,8	5,8	7,9	7,9	5,2	5,2
DECK WATERSPRAY PUMP	1	121,9	4	1	2	1	1	1	0,1	0,1	0,0	0,0	0,0	0,0
EMERGENCY FIRE PUMP	1	6,3	99	1	4	1	11	1	0,1	0,1	0,0	0,0	0,0	0,0
CARGO REMOTE VALVE HYDR. OIL PUMP	2	1,8	177	2	346	2	858	2	0,1	0,1	0,1	0,1	0,3	0,3
BALLAST REMOTE VALVE HYDR. OIL PUMP	2	1,8	1269	2	255	2	308	2	0,5	0,5	0,1	0,1	0,1	0,1

9.4 X1-VESSELS 2012

2012	1	
CLIPPER MARS		REGISTERED
CLIPPER NEPTUN		CALCULATED
CLIPPER ORION		

	OVERVIEW		
	MARS	NEPTUN	ORION
EQUIPMENT W/COUNTERS, SUM [TON]	1159		1528
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	7		1
SUM ESTIMATED [TON]	1167		1528
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1520		1723
OTHER EQUIPMENT	353		194

	FUEL TYPE [TON]		
	MARS	NEPTUN	ORION
HFO	1392		1498
LSHFO	125		182
MDO	2		43
TOTAL	**1520**		**1723**
SFC [g/kWh]-HC	212,6	#DIV/0!	212,2
SFC [g/kWh]-LC	222,0	#DIV/0!	223,9

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
LOADED	123		124	537		577	4,4		4,7
BALLAST	99		82	369		313	3,7		3,8
MAN	96		83	430		399	4,5		4,8
PORT	48		77	185		433	3,8		5,6
SUM/AVERAGE	**366**		**366**	**1520**		**1723**	**4,1**		**4,7**

	RUNNING HOURS [H]			REG. FUEL [TON]			SFC [KG/H]		
MACHINERY	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION
MAIN DIESEL ENGINE	6453		6025	8464	10501	9259	1311,6		1536,8
AUX. DIESEL GENERATOR	10226		12468	1520	1670	1723	148,6		138,2
CARGO COMPRESSOR	5084		8118						

	RUNNING HOURS [H]			P. FACTOR [#]			
SEEMP/MONITORED EQUIPMENT	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	DEPENDENCY
ME LO PUMP	8783		8740	1,36		1,45	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	8199		9191	1,27		1,53	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	1646		4000	1,30		1,97	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	2536		6634	2,00		3,27	/(COMPRESSORS/4)

	RUNNING HOURS [H]			EST. COSTS [USD]			
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	MARS	NEPTUN	ORION	MARS	NEPTUN	ORION	COMMENT
EQUIPMENT FOR CARGO	**17473**		**23581**	**374**		**631**	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	838		1912	50		104	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	5084		8118	256		408	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	1214		725	9		9	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	10338		12827	59		109	
SHIP EQUIPMENT	**12429**		**13979**	**62**		**90**	
MANOEUVRING MACHINERY & EQUIPMENT	8329		9581	36		59	
ANCHORING, MOORING & TOWING EQUIPMENT	899		1145	20		25	
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	3201		3254	6		6	
EQUIPMENT FOR CREW	**69671**		**83680**	**186**		**258**	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	4127		5072	8		9	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	64354		76495	177		246	
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	1190		2113	1		2	
MACHINERY MAIN COMPONENTS	**15431**		**14212**	**8**		**10**	
DIESEL ENGINES FOR PROPULSION	536		847	5		7	
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	14895		13365	3		3	
SYSTEMS FOR MAIN MACHINERY	**172472**		**182225**	**519**		**523**	
FUEL SYSTEMS	30685		38378	44		38	
LUBE OIL SYSTEMS	58149		66815	152		164	
COOLING SYSTEMS	39722		39021	254		250	
COMPRESSED AIR SYSTEMS	15468		15048	28		30	
STEAM, CONDENSATE & FEED WATER SYSTEMS	17113		17558	20		21	
DISTILLED & MAKE-UP WATER SYST	11335		5406	22		20	
SHIP COMMON SYSTEMS	**2416**		**4348**	**19**		**16**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	658		711	11		9	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	1002		312	7		6	
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	757		3325	0		1	
SUM	**289893**		**322025**	**1167**		**1528**	

Legend
ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED OPERATION COSTS [USD]					
			MARS		NEPTUN		ORION		MARS		NEPTUN		ORION	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	281,9	835	8			1518	8	50	50,0			90,8	90,8
CARGO BOOSTER PUMP	2	162,2	3	2			394	2	0,1	0,1			13,6	13,6
CARGO COMPRESSOR	4	236,8	5084	4			8118	4	256,0	256,0			407,9	407,9
CARGO TANK GAS-FREEING FAN	4	48,1	428	3			0	4	4,6	6,1			0,0	0,0
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	110	1			475	1	2,1	2,1			9,2	9,2
NITROGEN GENERATOR	1	4,8	676	1			250	1	0,7	0,7			0,3	0,3
CARGO HOSE CRANE	1	36,6	39	1			64	1	0,3	0,3			0,5	0,5
CARGO CONDENSER SW COOLING PUMP	2	94,6	1646	2			4000	2	34,6	34,6			84,8	84,8
GLYCOL COOLING SYSTEM PUMP	2	12,8	8652	2			8706	2	23,6	23,6			23,7	23,7
GLYCOL COOLING SYSTEM PUMP (VAPORISER)	1	12,8	1	1			58	1	0,0	0,0			0,2	0,2
STEERING GEAR HYDR OIL PUMP	2	12,3	8199	2			9191	2	22,4	22,4			25,4	25,4
BOW THRUSTER	1	1073,7	58	1			146	1	13,2	13,2			33,2	33,2
HYDRAULIC OIL PUMP BOW THRUSTER	1	4,9	72	1			244	1	0,1	0,1			0,3	0,3
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	410	2			479	2	10,1	10,1			11,9	11,9
MOORING WINCH HYDR. OIL PUMP	2	89,5	489	2			666	2	9,7	9,7			13,4	13,4
INCINERATOR	1	8,9	3201	1			3254	1	6,3	6,3			6,4	6,4
PROVISION COOLING COMPRESSOR	2	8,3	4127	2			5072	2	7,6	7,6			9,4	9,4
AIR-CONDITION COOLING COMPRESSOR	2	56,1	5540	2			9381	2	69,0	69,0			117,9	117,9
SUPPLY FAN, ENGINE ROOM	4	12,9	31085	4			34203	4	88,7	88,7			98,5	98,5
EXHAUST FAN, PURIFIER AREA	1	1,8	8043	1			8458	1	3,3	3,3			3,5	3,5
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,5	2536	1			6634	1	5,9	5,9			15,6	15,6
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,8	8249	1			8783	1	1,5	1,5			1,6	1,6
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	4,6	8779	1			8712	1	8,9	8,9			8,9	8,9
SUPPLY FAN, BOW THRUSTER & BOSUN STORE ROOM	1	4,7	121	1			325	1	0,1	0,1			0,3	0,3
POTABLE WATER HYDROPHORE PUMP	2	4,5	1190	2			2113	2	1,2	1,2			2,1	2,1
ME COMBUSTION AIR BLOWER	2	39,1	529	2			847	2	4,6	4,6			7,4	7,4
ME TURNING GEAR	1	3,4	7	1			0	1	0,0	0,0			0,0	0,0
AE LO PRIMING PUMP	3	0,9	14895	3			13365	3	2,9	2,9			2,6	2,6
HFO TRANSFER PUMP	3	13,0	407	3			524	3	1,2	1,2			1,5	1,5
MDO TRANSFER PUMP	1	4,9	0	1			10	1	0,0	0,0			0,0	0,0
HFO PURIFIER	2	15,3	9065	2			8502	2	30,7	30,7			29,0	29,0
SLUDGE OIL PUMP	1	3,3	41	1			37	1	0,0	0,0			0,0	0,0
ME FO SUPPLY PUMP	2	1,4	4431	1			8786	2	1,4	2,7			2,7	2,7
ME FO CIRCULATING PUMP	2	3,3	0	0			789	1		0,6			0,6	1,2
AE FO SUPPLY PUMP	2	0,7	4364	1			8784	2	0,7	1,3			1,3	1,3
AE FO BOOSTER PUMP	2	3,3	4327	1			2064	2	3,2	6,4			1,5	1,5
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVEN)	1	2,1	1	1			120	1	0,0	0,0			0,1	0,1
AUX. BOILER FO PUMP	2	0,4	8049	2			8762	2	0,8	0,8			0,9	0,9
LO TRANSFER PUMP	1	3,3	49	1			0	1	0,0	0,0			0,0	0,0
AE LO PURIFIER	2	4,7	11475	2			15859	2	12,0	12,0			16,7	16,7
ME LO PURIFIER	2	4,7	8724	2			16669	2	9,1	9,1			17,6	17,6
AE LO PURIFIER SUPPLY PUMP	2	0,4	11543	2			16761	2	1,1	1,1			1,6	1,6
ME LO PURIFIER SUPPLY PUMP	2	1,4	8791	2			0	2	2,7	2,7			0,0	0,0
ME LO PUMP	2	64,4	8783	2			8740	2	125,6	125,6			126,1	126,1
STERN TUBE LO PUMP	2	0,8	8785	2			8786	2	1,6	1,6			1,6	1,6
ME COOLING SW PUMP	3	32,6	13943	3			14756	3	100,8	100,8			107,6	107,6
ME JACKET COOLING FW PUMP	2	13,0	8785	2			8786	2	25,3	25,3			25,5	25,5
CENTRAL COOLING FW PUMP	3	33,8	16995	3			15479	3	127,4	127,4			117,1	117,1
MAIN STARTING AIR COMPRESSOR	2	35,7	471	2			835	2	3,7	3,7			6,7	6,7
SERVICE AIR COMPRESSOR	1	5,7	6524	1			6399	1	8,2	8,2			8,1	8,1
CONTROL AIR COMPRESSOR	1	8,5	8473	1			7814	1	15,9	15,9			14,8	14,8
AUX. BOILER FEED WATER PUMP	2	6,8	8785	2			8784	2	13,2	13,2			13,3	13,3
AUX. BOILER CIRCULATING PUMP	2	3,7	8328	2			8774	2	6,8	6,8			7,2	7,2
FW GENERATOR SW PUMP	1	16,8	5447	1			5406	1	20,4	20,4			20,4	20,4
FW GENERATOR DISTILLATE PUMP	1	1,2	5888	1			0	1	1,6	1,6			0,0	0,0
BALLAST PUMP	2	99,4	498	2			403	2	11,0	11,0			9,0	9,0
BILGE TRANSFER PUMP	1	2,1	159	1			308	1	0,1	0,1			0,1	0,1
BILGE/MAIN FIRE/GS PUMP	2	90,3	309	2			294	2	6,2	6,2			5,9	5,9
DECK WATERSPRAY PUMP	1	121,9	4	1			3	1	0,1	0,1			0,1	0,1
EMERGENCY FIRE PUMP	1	6,3	689	1			15	1	1,0	1,0			0,0	0,0
CARGO REMOTE VALVE HYDR. OIL PUMP	2	1,8	283	2			2749	2	0,1	0,1			1,1	1,1
BALLAST REMOTE VALVE HYDR. OIL PUMP	2	1,8	473	2			577	2	0,2	0,2			0,2	0,2

9.5 X2-VESSELS 2009

2009	2	
CLIPPER STAR		REGISTERED (green)
CLIPPER SKY		CALCULATED (orange)
CLIPPER MOON		

OVERVIEW	STAR	SKY	MOON
EQUIPMENT W/COUNTERS, SUM [TON]	1480		1230
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	0		3
SUM ESTIMATED [TON]	1480		1233
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1806		1561
OTHER EQUIPMENT	326		328

FUEL TYPE [TON]	STAR	SKY	MOON
HFO	1783	1830	1561
LSHFO	0	0	0
MDO	23	23	0
TOTAL	**1806**	**1853**	**1561**
SFC [g/kWh]-HC	214,1	214,1	214,4
SFC [g/kWh]-LC	216,9	213,0	218,2

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**
LOADED	90	54	69	535	337	338	5,9	6,2	4,9
BALLAST	77	95	34	347	452	137	4,5	4,8	4,0
MAN	0	0	0	0	0	0			
PORT	198	216	262	924	1063	1086	4,7	4,9	4,1
SUM/AVERAGE	**365**	**365**	**365**	**1806**	**1853**	**1561**	**5,0**	**5,3**	**4,4**

	RUNNING HOURS [H]			REG. FUEL [TON]			SFC [KG/H]		
MACHINERY	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**
MAIN DIESEL ENGINE	4375	3780	2841	6528	4783	3725	1492,2	1265,4	1311,0
AUX. DIESEL GENERATOR	12028	11549	10576	1806	1853	1561	150,1	160,4	147,6
CARGO COMPRESSOR	7905	0	5249						

	RUNNING HOURS [H]			P. FACTOR [#]			
SEEMP/MONITORED EQUIPMENT	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**DEPENDENCY**
ME LO PUMP	8119	0	8739	1,86	0,00	3,08	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	9183	0	8453	2,10	0,00	2,98	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	5264	0	3677	2,66		2,80	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	7516	0	8410	3,80		6,41	/(COMPRESSORS/4)

	RUNNING HOURS [H]			EST. COSTS [USD]			
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**COMMENT**
EQUIPMENT FOR CARGO	**47447**	**0**	**39365**	**725**	**605**	**488**	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	13671	0	12633	121	106	90	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	7905	0	5249	499	415	331	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	1945	0	951	81	61	40	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	23926	0	20532	24	23	26	
SHIP EQUIPMENT	**9267**	**0**	**8548**	**40**	**40**	**41**	
MANOEUVRING MACHINERY & EQUIPMENT	9267	0	8548	40	40	41	
	0	0	0	0	0	0	
EQUIPMENT FOR CREW	**68523**	**0**	**63516**	**191**	**185**	**178**	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	50138	0	47150	165	160	155	
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	10274	0	9458	3	3	3	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	8085	0	6882	23	21	20	
TRANSPORT EQUIPMENT FOR CREW, PASSENGERS & PROVISIONS	26	0	26	0	0	0	
MACHINERY MAIN COMPONENTS	**2288**	**0**	**1663**	**19**	**17**	**14**	
DIESEL ENGINES FOR PROPULSION	2288	0	1663	19	17	14	
SYSTEMS FOR MAIN MACHINERY	**148038**	**0**	**144190**	**497**	**501**	**506**	
STEAM, CONDENSATE & FEED WATER SYSTEMS	16407	0	17504	20	20	21	
COOLING SYSTEMS	24784	0	26617	257	266	276	
LUBE OIL SYSTEMS	66995	0	59107	142	146	150	
FUEL SYSTEMS	25791	0	27724	27	29	31	
COMPRESSED AIR SYSTEMS	7665	0	8766	36	27	18	
DISTILLED & MAKE-UP WATER SYST	6396	0	4472	15	13	11	
SHIP COMMON SYSTEMS	**1583**	**0**	**3002**	**8**	**7**	**6**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	448	0	397	7	6	5	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	290	0	450	0	0	0	
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	845	0	2155	0	0	1	
SUM	**277146**	**0**	**260284**	**1480**	**1355**	**1233**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED OPERATION COSTS [USD]					
			STAR		SKY		MOON		STAR		SKY		MOON	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
BOILER FEED WATER PUMP	2	6,8	8199	2			8749	2	12	12,1		12,5	13,0	13,0
BOILER WATER CIRCULATION PUMP	2	4,3	8208	2			8755	2	7,6	7,6		7,9	8,2	8,2
ME JACKET COOLING FW PUMP	2	13,0	8216	2			9041	2	23,2	23,2		24,4	25,6	25,6
ME LO PUMP	2	70,1	8119	2			8739	2	123,5	123,5		128,5	133,6	133,6
BALLAST PUMP	2	84,4	389	2			266	2	7,1	7,1		6,0	4,9	4,9
DO TRANSFER PUMP	1	0,0	12	1			24	1	0,0	0,0		0,0	0,0	0,0
GLYCOL PUMP	2	7,7	8407	2			8956	2	14,0	14,0		14,5	15,0	15,0
CARGO COMPRESSOR	4	294,6	7905	4			5249	4	498,6	498,6		415,0	331,5	331,5
CARGO CONDENSER SW COOLING PUMP	2	95,1	5264	2			3677	2	107,2	107,2		91,1	75,0	75,0
CARGO DEEPWELL PUMP	8	204,1	1568	8			826	8	68,5	68,5		52,3	36,1	36,1
CARGO BOOSTER PUMP	2	158,0	377	2			125	2	12,9	12,9		8,6	4,3	4,3
WORKING AIR COMPRESSOR	1	14,1	2661	1			2513	1	8,2	8,2		8,0	7,8	7,8
CONTROL AIR COMPRESSOR	1	5,8	2561	1			5995	1	3,2	3,2		5,4	7,5	7,5
STARTING AIR COMPRESSOR	2	45,8	2443	2			258	2	24,3	24,3		13,4	2,6	2,6
HFO TRANSFER PUMP	3	15,4	127	3			156	3	0,4	0,4		0,5	0,5	0,5
PRE-LUB PUMP	3	0,6	13696	3			14502	3	1,9	1,9		2,0	2,0	2,0
ME COMBUSTION AIR BLOWER	2	39,1	2288	2			1663	2	19,4	19,4		16,8	14,2	14,2
CENTRAL COOLING FW PUMP	2	70,1	8215	2			8749	2	124,9	124,9		129,3	133,8	133,8
ME EXH VALVE ACTUATOR OIL PUMP	2	1,4	8116	2			8743	2	2,5	2,5		2,6	2,7	2,7
STERN TUBE LUB OIL PUMP	2	0,7	8215	2			8748	2	1,3	1,3		1,3	1,4	1,4
ME FO SUPPLY PUMP	2	1,4	8189	2			8750	2	2,6	2,6		2,7	2,7	2,7
ME FO CIRC. PUMP	2	5,0	8189	2			8750	2	9,0	9,0		9,3	9,6	9,6
AUX. ENGINE DO SUPPLY PUMP	1	1,3	45	1			2	1	0,0	0,0		0,0	0,0	0,0
BILGE TRANSFER PUMP	1	3,3	59	1			131	1	0,0	0,0		0,1	0,1	0,1
FIRE, BILGE AND BALLST PUMP	1	0,0	184	1			187	1	0,0	0,0		0,0	0,0	0,0
FIRE & G.S. PUMP	1	0,0	60	1			242	1	0,0	0,0		0,0	0,0	0,0
ME COOLING SW PUMP	2	60,3	8218	2			8773	2	107,5	107,5		111,5	115,4	115,4
DECK WATERSPRAY PUMP	1	121,9	4	1			3	1	0,1	0,1		0,1	0,1	0,1
IGG SW PUMP	1	59,5	135	1			54	1	1,7	1,7		1,2	0,7	0,7
HFO DAILY TRANSFER PUMP	1	2,1	1544	1			1003	1	0,7	0,7		0,6	0,5	0,5
HYD PUMP FOR REMOTE CONTR. VALVES	2	1,3	845	2			2155	2	0,2	0,2		0,4	0,6	0,6
SIDE THRUSTER (BOW THRUSTER)	1	1118,0	84	1			95	1	20,1	20,1		21,4	22,8	22,8
E-MOTOR ROOM SUPPLY FAN	2	3,8	8202	2			4069	1	6,8	6,8		5,1	3,4	6,8
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	9,8	7516	1			8410	1	15,9	15,9		16,9	17,9	17,9
AIR LOCK SP SUPPLY FAN	1	0,6	8208	1			8053	1	1,0	1,0		1,0	1,0	1,0
SUPPLY FAN, ENGINE ROOM	4	12,4	28443	4			32938	4	76,4	76,4		82,6	88,9	88,9
BOSN STR & THR COMP SUPPLY FAN	1	2,0	351	1			335	1	0,2	0,2		0,1	0,1	0,1
DRY POWDER EXH FAN	1	0,5	3425	1			0	1	0,4	0,4		0,2	0,0	0,0
HFO SEPARATOR	2	8,7	7685	2			9039	2	14,6	14,6		15,9	17,2	17,2
ME LUB OIL SEPARATOR	1	5,2	6832	1			7118	1	7,7	7,7		7,9	8,0	8,0
AE LUB OIL SEPARATOR	3	1,0	21953	3			11194	3	4,7	4,7		3,6	2,4	2,4
HOT WATER CIRC PUMP	1	0,4	6326	1			4754	1	0,5	0,5		0,4	0,4	0,4
HYDROPHORE PUMP	2	3,0	3948	2			4704	2	2,6	2,6		2,8	3,1	3,1
STEERING GEAR HYDR OIL PUMP	3	9,9	9183	3			8453	3	19,7	19,7		19,0	18,3	18,3
EMERGENCY FIRE PUMP	1	0,0	42	1			18	1	0,0	0,0		0,0	0,0	0,0
PROVISION REF. COMPRESSOR	2	13,2	8085	2			6882	2	23,2	23,2		21,5	19,8	19,8
AIR-CONDITION COOLING COMPRESSOR	2	32,8	7019	2			4706	2	49,9	49,9		41,8	33,6	33,6
SUPPLY VENT FAN FOR ACCOMONDATION	2	16,2	10900	2			9171	2	38,4	38,4		35,4	32,5	32,5
STORE HANDLING CRANE	2	0,0	26	2			26	2	0,0	0,0		0,0	0,0	0,0
SLUDGE OIL PUMP	1	2,0	64	1			63	1	0,0	0,0		0,0	0,0	0,0
FWG EJECTOR PUMP	1	10,9	6396	1			4472	1	15,2	15,2		12,9	10,7	10,7

9.6 X2-VESSELS 2010

2010	2		
		(green)	REGISTERED
		(orange)	CALCULATED

CLIPPER STAR
CLIPPER SKY
CLIPPER MOON

	OVERVIEW		
	STAR	**SKY**	**MOON**
EQUIPMENT W/COUNTERS, SUM [TON]	1356		1363
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	98		148
SUM ESTIMATED [TON]	1454		1511
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1977		1772
OTHER EQUIPMENT	523		261

	FUEL TYPE [TON]		
	STAR	**SKY**	**MOON**
HFO	1746	1092	1440
LSHFO	87	515	177
MDO	144	120	155
TOTAL	**1977**	**1727**	**1772**
SFC [g/kWh]-HC	213,0	213,1	212,8
SFC [g/kWh]-LC	212,4	219,3	216,7

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**
LOADED	122	78	100	754	417	524	6,2	5,3	5,2
BALLAST	71	82	75	312	358	328	4,4	4,4	4,4
MAN	0	0	0	0	0	0			
PORT	172	205	190	912	952	920	5,3	4,6	4,8
SUM/AVERAGE	**365**	**365**	**365**	**1977**	**1727**	**1772**	**5,3**	**4,8**	**4,8**

	RUNNING HOURS [H]			REG. FUEL [TON]			SFC [KG/H]		
MACHINERY	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**
MAIN DIESEL ENGINE	4563	4038	4194	7083	5876	6457	1552,2	1455,0	1539,4
AUX. DIESEL GENERATOR	12456	12274	12072	1977	1727	1772	158,8	140,7	146,8
CARGO COMPRESSOR	8359	0	7561						

	RUNNING HOURS [H]			P. FACTOR [#]			
SEEMP/MONITORED EQUIPMENT	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**DEPENDENCY**
ME LO PUMP	8203	0	8468	1,80	0,00	2,02	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	9031	0	9806	1,98	0,00	2,34	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	1316	0	5029	0,63		2,66	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	8179	0	8708	3,91		4,61	/(COMPRESSORS/4)

	RUNNING HOURS [H]			EST. COSTS [USD]			
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**COMMENT**
EQUIPMENT FOR CARGO	**43446**	**0**	**40252**	**729**	**685**	**717**	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	9619	0	5029	67	78	115	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	8359	0	7561	525	499	474	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	960	0	2481	106	83	102	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	24508	0	25181	31	25	26	
SHIP EQUIPMENT	**9138**	**0**	**9965**	**44**	**52**	**59**	
MANOEUVRING MACHINERY & EQUIPMENT	9138	0	9965	44	52	59	
	0	0	0	0	0	0	
EQUIPMENT FOR CREW	**74369**	**0**	**30267**	**174**	**147**	**206**	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	53083	0	22512	154	127	185	
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	15847	0	1671	5	4	3	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	5419	0	6050	15	16	17	
TRANSPORT EQUIPMENT FOR CREW, PASSENGERS & PROVISIONS	20	0	34	0	0	0	
MACHINERY MAIN COMPONENTS	**1006**	**0**	**936**	**8**	**8**	**8**	
DIESEL ENGINES FOR PROPULSION	1006	0	936	8	8	8	
SYSTEMS FOR MAIN MACHINERY	**148756**	**0**	**117484**	**491**	**491**	**513**	
STEAM, CONDENSATE & FEED WATER SYSTEMS	16549	0	18175	19	21	22	
COOLING SYSTEMS	25421	0	23094	259	266	286	
LUBE OIL SYSTEMS	66330	0	45898	140	142	147	
FUEL SYSTEMS	27242	0	23597	28	24	25	
COMPRESSED AIR SYSTEMS	7534	0	6721	30	25	20	
DISTILLED & MAKE-UP WATER SYST	5680	0	0	13	13	13	
SHIP COMMON SYSTEMS	**2258**	**0**	**3050**	**7**	**6**	**9**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	424	0	302	6	5	8	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	550	0	133	0	0	0	
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	1284	0	2615	0	1	1	
SUM	**278973**	**0**	**201954**	**1454**	**1389**	**1511**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED OPERATION COSTS [USD]					
			STAR		SKY		MOON		STAR		SKY		MOON	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
BOILER FEED WATER PUMP	2	6,8	8262	2			9087	2	12	11,9		12,7	13,4	13,4
BOILER WATER CIRCULATION PUMP	2	4,3	8287	2			9088	2	7,5	7,5		8,0	8,4	8,4
ME JACKET COOLING FW PUMP	2	13,0	8335	2			4767	1	23,0	23,0		18,2	13,4	26,8
ME LO PUMP	2	70,1	8203	2			8468	2	122,1	122,1		125,4	128,6	128,6
BALLAST PUMP	2	84,4	356	2			217	1	6,4	6,4		5,2	4,0	7,9
DO TRANSFER PUMP	1	0,0	0	0			66	1		0,0		0,0	0,0	0,0
GLYCOL PUMP	2	7,7	8303	2			0	0	13,5	13,5		13,5		13,5
CARGO COMPRESSOR	4	294,6	8359	4			7561	4	524,5	524,5		499,2	473,9	473,9
CARGO CONDENSER SW COOLING PUMP	2	95,1	1316	1			5029	2	26,7	53,3		64,2	101,8	101,8
CARGO DEEPWELL PUMP	8	204,1	960	4			1819	8	41,7	83,5		60,4	79,0	79,0
CARGO BOOSTER PUMP	2	158,0	0	0			662	2		22,7		22,7	22,7	22,7
WORKING AIR COMPRESSOR	1	14,1	2714	1			3588	1	8,2	8,2		9,6	11,0	11,0
CONTROL AIR COMPRESSOR	1	5,8	2891	1			2531	1	3,5	3,5		3,3	3,2	3,2
STARTING AIR COMPRESSOR	2	45,8	1929	2			602	2	18,8	18,8		12,4	6,0	6,0
HFO TRANSFER PUMP	3	15,4	131	3			156	3	0,4	0,4		0,5	0,5	0,5
PRE-LUB PUMP	3	0,6	12804	3			13827	3	1,7	1,7		1,8	1,9	1,9
ME COMBUSTION AIR BLOWER	2	39,1	1006	2			936	2	8,4	8,4		8,1	7,9	7,9
CENTRAL COOLING FW PUMP	2	70,1	8335	2			9087	2	124,1	124,1		131,1	138,0	138,0
ME EXH VALVE ACTUATOR OIL PUMP	2	1,4	8178	2			8138	2	2,5	2,5		2,5	2,5	2,5
STERN TUBE LUB OIL PUMP	2	0,7	8280	2			9087	2	1,3	1,3		1,3	1,4	1,4
ME FO SUPPLY PUMP	2	1,4	8270	2			9077	2	2,5	2,5		2,7	2,8	2,8
ME FO CIRC. PUMP	2	5,0	8096	2			9052	2	8,7	8,7		9,3	9,9	9,9
AUX. ENGINE DO SUPPLY PUMP	1	1,3	660	1			667	1	0,2	0,2		0,2	0,2	0,2
BILGE TRANSFER PUMP	1	3,3	68	1			86	1	0,0	0,0		0,1	0,1	0,1
FIRE, BILGE AND BALLST PUMP	1	0,0	301	1			97	1	0,0	0,0		0,0	0,0	0,0
FIRE & G.S. PUMP	1	0,0	244	1			0	0	0,0	0,0		0,0		0,0
ME COOLING SW PUMP	2	60,3	8391	2			9107	2	107,5	107,5		113,3	119,0	119,0
DECK WATERSPRAY PUMP	1	121,9	0	0			2	1		0,0		0,0	0,0	0,0
IGG SW PUMP	1	59,5	360	1			133	1	4,5	4,5		3,1	1,7	1,7
HFO DAILY TRANSFER PUMP	1	2,1	1553	1			1643	1	0,7	0,7		0,7	0,7	0,7
HYD PUMP FOR REMOTE CONTR. VALVES	2	1,3	1284	2			2615	2	0,3	0,3		0,5	0,7	0,7
SIDE THRUSTER (BOW THRUSTER)	1	1118,0	107	1			159	1	25,5	25,5		31,6	37,8	37,8
E-MOTOR ROOM SUPPLY FAN	2	3,8	8176	1			7835	2	6,7	13,3		6,6	6,5	6,5
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	9,8	8179	1			8708	1	17,0	17,0		17,7	18,4	18,4
AIR LOCK SP SUPPLY FAN	1	0,6	8153	1			8638	1	1,0	1,0		1,0	1,0	1,0
SUPPLY FAN, ENGINE ROOM	4	12,4	28907	4			7857	1	76,0	76,0		48,5	21,1	84,3
BOSN STR & THR COMP SUPPLY FAN	1	2,0	465	1			375	1	0,2	0,2		0,2	0,2	0,2
DRY POWDER EXH FAN	1	0,5	7605	1			0	1	0,9	0,9		0,4	0,0	0,0
HFO SEPARATOR	2	8,7	8532	2			2936	1	15,9	15,9		10,7	5,6	11,1
ME LUB OIL SEPARATOR	1	5,2	7592	1			0	0	8,4	8,4		8,4		8,4
AE LUB OIL SEPARATOR	3	1,0	21226	3			6294	1	4,5	4,5		2,9	1,3	4,0
HOT WATER CIRC PUMP	1	0,4	8321	1			0	0	0,6	0,6		0,6		0,6
HYDROPHORE PUMP	2	3,0	7526	2			1671	1	4,8	4,8		3,0	1,1	2,2
STEERING GEAR HYDR OIL PUMP	3	9,9	9031	3			9806	3	19,0	19,0		20,0	21,0	21,0
EMERGENCY FIRE PUMP	1	0,0	5	1			35	1	0,0	0,0		0,0	0,0	0,0
PROVISION REF. COMPRESSOR	2	13,2	5419	2			6050	2	15,2	15,2		16,2	17,3	17,3
AIR-CONDITION COOLING COMPRESSOR	2	32,8	5987	2			7904	2	41,7	41,7		48,9	56,1	56,1
SUPPLY VENT FAN FOR ACCOMONDATION	2	16,2	10119	2			6377	1	34,9	34,9		28,7	22,4	44,9
STORE HANDLING CRANE	2	0,0	20	2			34	2	0,0	0,0		0,0	0,0	0,0
SLUDGE OIL PUMP	1	2,0	47	1			83	1	0,0	0,0		0,0	0,0	0,0
FWG EJECTOR PUMP	1	10,9	5680	1			0	0	13,2	13,2		13,2		13,2

9.7 X2-VESSELS 2011

2011	2		
CLIPPER STAR		(green)	REGISTERED
CLIPPER SKY		(orange)	CALCULATED
CLIPPER MOON			

	OVERVIEW		
	STAR	SKY	MOON
EQUIPMENT W/COUNTERS, SUM [TON]	1323	1419	1238
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	74	0	136
SUM ESTIMATED [TON]	1396	1419	1374
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1736	1838	1682
OTHER EQUIPMENT	339	418	308

	FUEL TYPE [TON]		
	STAR	SKY	MOON
HFO	1645	617	1274
LSHFO	63	1027	313
MDO	28	194	96
TOTAL	**1736**	**1838**	**1682**
SFC [g/kWh]-HC	214,1	212,4	213,3
SFC [g/kWh]-LC	216,6	217,1	219,8

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**
LOADED	85	46	77	425	238	411	5,0	5,2	5,3
BALLAST	61	65	72	259	257	308	4,2	4,0	4,3
MAN	63	82	70	297	480	336	4,7	5,9	4,8
PORT	156	172	146	754	862	627	4,8	5,0	4,3
SUM/AVERAGE	**365**	**365**	**365**	**1736**	**1838**	**1682**	**4,7**	**5,0**	**4,7**

	RUNNING HOURS [H]			REG. FUEL [TON]			SFC [KG/H]		
MACHINERY	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**
MAIN DIESEL ENGINE	4340	3799	4278	6372	5181	6877	1468,1	1363,7	1607,5
AUX. DIESEL GENERATOR	11500	12696	12003	1736	1838	1682	150,9	144,7	140,1
CARGO COMPRESSOR	7370	6469	7208						

	RUNNING HOURS [H]			P. FACTOR [#]			
SEEMP/MONITORED EQUIPMENT	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**DEPENDENCY**
ME LO PUMP	8679	8687	8316	2,00	2,29	1,94	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	8939	13287	9245	2,06	3,50	2,16	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	988	3454	3797	0,54	2,14	2,11	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	6915	7012	7660	3,75	4,34	4,25	/(COMPRESSORS/4)

	RUNNING HOURS [H]			EST. COSTS [USD]			
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**COMMENT**
EQUIPMENT FOR CARGO	**38804**	**45473**	**36891**	**626**	**599**	**625**	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	9991	12473	3797	55	85	92	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	7370	6469	7208	465	405	453	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	825	2083	1311	82	86	56	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	20618	24449	24576	24	23	24	
SHIP EQUIPMENT	**9046**	**13416**	**9369**	**45**	**59**	**50**	
MANOEUVRING MACHINERY & EQUIPMENT	9046	13416	9369	45	59	50	
	0	0	0	0	0	0	
EQUIPMENT FOR CREW	**68124**	**85215**	**28441**	**199**	**243**	**192**	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	52552	68759	20875	178	220	171	
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	8875	9721	913	2	4	2	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	6634	6690	6631	19	19	19	
TRANSPORT EQUIPMENT FOR CREW, PASSENGERS & PROVISIONS	63	45	22	0	0	0	
MACHINERY MAIN COMPONENTS	**1441**	**1184**	**947**	**12**	**10**	**8**	
DIESEL ENGINES FOR PROPULSION	1441	1184	947	12	10	8	
SYSTEMS FOR MAIN MACHINERY	**153410**	**151156**	**113746**	**509**	**499**	**492**	
STEAM, CONDENSATE & FEED WATER SYSTEMS	17150	17428	16729	21	21	20	
COOLING SYSTEMS	26387	26277	21320	273	273	267	
LUBE OIL SYSTEMS	71898	69393	46560	152	152	148	
FUEL SYSTEMS	22322	26541	21949	27	27	26	
COMPRESSED AIR SYSTEMS	10392	7168	7188	23	16	18	
DISTILLED & MAKE-UP WATER SYST	5261	4350	0	12	10	11	
SHIP COMMON SYSTEMS	**3978**	**5528**	**3068**	**6**	**10**	**7**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	337	522	405	5	9	6	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	425	1168	248	0	0	0	
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	3216	3837	2414	1	1	1	
SUM	**274803**	**301971**	**192462**	**1396**	**1419**	**1374**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED OPERATION COSTS [USD]					
			STAR		SKY		MOON		STAR		SKY		MOON	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
BOILER FEED WATER PUMP	2	6,8	8734	2	8725	2	8366	2	13	12,9	12,9	12,9	12,5	12,5
BOILER WATER CIRCULATION PUMP	2	4,3	8416	2	8703	2	8362	2	7,8	7,8	8,1	8,1	7,9	7,9
ME JACKET COOLING FW PUMP	2	13,0	8757	2	8744	2	4417	1	24,6	24,6	24,7	24,7	12,6	25,2
ME LO PUMP	2	70,1	8679	2	8687	2	8316	2	131,7	131,7	132,2	132,2	128,1	128,1
BALLAST PUMP	2	84,4	266	2	467	2	346	2	4,9	4,9	8,6	8,6	6,4	6,4
DO TRANSFER PUMP	1	0,0	0	0	75	1	42	1		0,0	0,0	0,0	0,0	0,0
GLYCOL PUMP	2	7,7	9003	2	9019	2	0	0	15,0	15,0	15,0	15,0		15,0
CARGO COMPRESSOR	4	294,6	7370	4	6469	4	7208	4	464,7	464,7	404,8	404,8	452,9	452,9
CARGO CONDENSER SW COOLING PUMP	2	95,1	988	1	3454	2	3797	2	20,1	40,2	69,8	69,8	77,0	77,0
CARGO DEEPWELL PUMP	8	204,1	825	4	1619	8	1200	8	36,0	72,1	70,2	70,2	52,2	52,2
CARGO BOOSTER PUMP	2	158,0	0	0	464	2	111	2		9,9	15,9	15,9	3,9	3,9
WORKING AIR COMPRESSOR	1	14,1	1666	1	2635	1	1765	1	5,1	5,1	8,1	8,1	5,5	5,5
CONTROL AIR COMPRESSOR	1	5,8	7902	1	4246	1	4741	1	9,9	9,9	5,3	5,3	6,0	6,0
STARTING AIR COMPRESSOR	2	45,8	824	2	286	2	682	2	8,2	8,2	2,8	2,8	6,9	6,9
HFO TRANSFER PUMP	3	15,4	162	3	97	3	155	3	0,5	0,5	0,3	0,3	0,5	0,5
PRE-LUB PUMP	3	0,6	14532	3	13423	3	13303	3	2,0	2,0	1,9	1,9	1,9	1,9
ME COMBUSTION AIR BLOWER	2	39,1	1441	2	1184	2	947	2	12,2	12,2	10,1	10,1	8,1	8,1
CENTRAL COOLING FW PUMP	2	70,1	8757	2	8744	2	8405	2	132,9	132,9	133,0	133,0	129,5	129,5
ME EXH VALVE ACTUATOR OIL PUMP	2	1,4	8640	2	8680	2	8310	2	2,7	2,7	2,7	2,7	2,6	2,6
STERN TUBE LUB OIL PUMP	2	0,7	8757	2	8743	2	8410	2	1,4	1,4	1,4	1,4	1,3	1,3
ME FO SUPPLY PUMP	2	1,4	8751	2	8732	2	8401	2	2,7	2,7	2,7	2,7	2,7	2,7
ME FO CIRC. PUMP	2	5,0	3208	1	8743	2	8380	2	3,5	7,0	9,6	9,6	9,3	9,3
AUX. ENGINE DO SUPPLY PUMP	1	1,3	81	1	616	1	445	1	0,0	0,0	0,2	0,2	0,1	0,1
BILGE TRANSFER PUMP	1	3,3	71	1	55	1	59	1	0,1	0,1	0,0	0,0	0,0	0,0
FIRE, BILGE AND BALLST PUMP	1	0,0	234	1	306	1	215	1	0,0	0,0	0,0	0,0	0,0	0,0
FIRE & G.S. PUMP	1	0,0	187	1	843	1	0	0	0,0	0,0	0,0	0,0		0,0
ME COOLING SW PUMP	2	60,3	8758	2	8745	2	8416	2	114,4	114,4	114,5	114,5	111,6	111,6
DECK WATERSPRAY PUMP	1	121,9	0	0	1	1	2	1		0,0	0,0	0,0	0,1	0,1
IGG SW PUMP	1	59,5	115	1	44	1	82	1	1,5	1,5	0,6	0,6	1,1	1,1
HFO DAILY TRANSFER PUMP	1	2,1	1597	1	1158	1	1246	1	0,7	0,7	0,5	0,5	0,6	0,6
HYD PUMP FOR REMOTE CONTR. VALVES	2	1,3	3216	2	3837	2	2414	2	0,9	0,9	1,0	1,0	0,7	0,7
SIDE THRUSTER (BOW THRUSTER)	1	1118,0	107	1	129	1	124	1	25,6	25,6	30,5	30,5	29,6	29,6
E-MOTOR ROOM SUPPLY FAN	2	3,8	4961	1	8739	2	8160	2	4,1	8,3	7,3	7,3	6,9	6,9
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	9,8	6915	1	7012	1	7660	1	14,6	14,6	14,9	14,9	16,4	16,4
AIR LOCK SP SUPPLY FAN	1	0,6	8742	1	8697	1	8756	1	1,1	1,1	1,1	1,1	1,1	1,1
SUPPLY FAN, ENGINE ROOM	4	12,4	31331	4	32350	4	6329	1	84,0	84,0	86,9	86,9	17,2	68,9
BOSN STR & THR COMP SUPPLY FAN	1	2,0	501	1	307	1	300	1	0,2	0,2	0,1	0,1	0,1	0,1
DRY POWDER EXH FAN	1	0,5	1751	1	8738	1	0	1	0,2	0,2	1,0	1,0	0,0	0,0
HFO SEPARATOR	2	8,7	8523	2	7119	2	3280	1	16,1	16,1	13,5	13,5	6,3	12,6
ME LUB OIL SEPARATOR	1	5,2	8138	1	7860	1	0	0	9,1	9,1	8,8	8,8		9,0
AE LUB OIL SEPARATOR	3	1,0	23062	3	21895	3	8123	1	4,9	4,9	4,7	4,7	1,8	5,3
HOT WATER CIRC PUMP	1	0,4	6588	1	4916	1	0	0	0,5	0,5	0,4	0,4		0,4
HYDROPHORE PUMP	2	3,0	2287	2	4805	2	913	1	1,5	1,5	3,1	3,1	0,6	1,2
STEERING GEAR HYDR OIL PUMP	3	9,9	8939	3	13287	3	9245	3	19,2	19,2	28,6	28,6	20,1	20,1
EMERGENCY FIRE PUMP	1	0,0	4	1	18	1	32	1	0,0	0,0	0,0	0,0	0,0	0,0
PROVISION REF. COMPRESSOR	2	13,2	6634	2	6690	2	6631	2	19,0	19,0	19,2	19,2	19,2	19,2
AIR-CONDITION COOLING COMPRESSOR	2	32,8	7478	2	9913	2	7013	2	53,1	53,1	70,5	70,5	50,5	50,5
SUPPLY VENT FAN FOR ACCOMONDATION	2	16,2	11491	2	17451	2	7233	1	40,4	40,4	61,5	61,5	25,8	51,6
STORE HANDLING CRANE	2	0,0	63	2	45	2	22	2	0,0	0,0	0,0	0,0	0,0	0,0
SLUDGE OIL PUMP	1	2,0	90	1	105	1	98	1	0,0	0,0	0,0	0,0	0,0	0,0
FWG EJECTOR PUMP	1	10,9	5261	1	4350	1	0	0	12,5	12,5	10,3	10,3		11,4

9.8 X2-VESSELS 2012

2012	2	
CLIPPER STAR		REGISTERED (green)
CLIPPER SKY		CALCULATED (orange)
CLIPPER MOON		

	OVERVIEW		
	STAR	SKY	MOON
EQUIPMENT W/COUNTERS, SUM [TON]	1384	1434	1547
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	4	0	19
SUM ESTIMATED [TON]	1388	1434	1566
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1705	1794	1730
OTHER EQUIPMENT	317	360	164

	FUEL TYPE [TON]		
	STAR	SKY	MOON
HFO	1325	1143	1230
LSHFO	138	447	380
MDO	242	204	121
TOTAL	**1705**	**1794**	**1730**
SFC [g/kWh]-HC	211,8	212,3	213,1
SFC [g/kWh]-LC	215,0	217,0	219,8

	PROFILE [DAYS]			REG. FUEL [TON]			FUEL [TON/DAY]		
CONDITION	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**
LOADED	91	100	76	467	469	410	5,1	4,7	5,4
BALLAST	42	82	56	175	334	227	4,2	4,1	4,1
MAN	56	111	94	260	587	454	4,6	5,3	4,8
PORT	177	73	140	804	405	640	4,5	5,5	4,6
SUM/AVERAGE	**366**	**366**	**366**	**1705**	**1794**	**1730**	**4,6**	**4,9**	**4,7**

	RUNNING HOURS [H]			REG. FUEL [TON]			SFC [KG/H]		
MACHINERY	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**
MAIN DIESEL ENGINE	4214	5736	4059	6998	8369	6142	1660,5	1459,0	1513,1
AUX. DIESEL GENERATOR	11500	12411	12394	1705	1794	1730	148,3	144,6	139,6
CARGO COMPRESSOR	7838	5955	8813						

	RUNNING HOURS [H]			P. FACTOR [#]			
SEEMP/MONITORED EQUIPMENT	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**DEPENDENCY**
ME LO PUMP	8291	8683	8729	1,97	1,51	2,15	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	9271	13877	9131	2,20	2,42	2,25	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	4597	3622	4580	2,35	2,43	2,08	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	6540	5765	7635	3,34	3,87	3,47	/(COMPRESSORS/4)

	RUNNING HOURS [H]			EST. COSTS [USD]			
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	**STAR**	**SKY**	**MOON**	**STAR**	**SKY**	**MOON**	**COMMENT**
EQUIPMENT FOR CARGO	**46364**	**44952**	**48523**	**681**	**601**	**748**	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	13025	12278	13407	107	88	108	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	7838	5955	8813	489	372	553	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	1510	2885	1120	64	120	63	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	23991	23835	25183	22	21	25	
SHIP EQUIPMENT	**9361**	**14046**	**9258**	**41**	**70**	**50**	
MANOEUVRING MACHINERY & EQUIPMENT	9361	14046	9258	41	70	50	
	0	0	0	0	0	0	
EQUIPMENT FOR CREW	**55008**	**86529**	**76505**	**156**	**233**	**234**	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	42579	67982	58405	133	212	213	
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	5124	12287	11962	2	3	3	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	7264	6226	6065	21	18	18	
TRANSPORT EQUIPMENT FOR CREW, PASSENGERS & PROVISIONS	40	35	73	0	0	0	
MACHINERY MAIN COMPONENTS	**744**	**1260**	**929**	**6**	**11**	**8**	
DIESEL ENGINES FOR PROPULSION	744	1260	929	6	11	8	
SYSTEMS FOR MAIN MACHINERY	**148613**	**156864**	**155888**	**499**	**510**	**516**	
STEAM, CONDENSATE & FEED WATER SYSTEMS	16470	17493	17504	20	21	21	
COOLING SYSTEMS	26288	26391	26400	272	274	277	
LUBE OIL SYSTEMS	70566	71785	73485	145	153	156	
FUEL SYSTEMS	23140	28828	27040	28	30	28	
COMPRESSED AIR SYSTEMS	7544	6499	7286	24	18	23	
DISTILLED & MAKE-UP WATER SYST	4605	5869	4173	11	14	10	
SHIP COMMON SYSTEMS	**1313**	**4635**	**4207**	**4**	**10**	**9**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	281	571	325	4	9	8	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	161	1250	448	0	0	0	
SPECIAL COMMON HYDRAULIC OIL SYSTEMS	870	2814	3434	0	1	1	
SUM	**261402**	**308287**	**295310**	**1388**	**1434**	**1566**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]						ESTIMATED OPERATION COSTS [USD]					
			STAR		SKY		MOON		STAR		SKY		MOON	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT	REG	TOT
BOILER FEED WATER PUMP	2	6,8	8495	2	8747	2	8767	2	12	12,4	12,9	12,9	13,1	13,1
BOILER WATER CIRCULATION PUMP	2	4,3	7974	2	8746	2	8737	2	7,3	7,3	8,1	8,1	8,2	8,2
ME JACKET COOLING FW PUMP	2	13,0	8494	2	8775	2	8776	2	23,7	23,7	24,7	24,7	25,1	25,1
ME LO PUMP	2	70,1	8291	2	8683	2	8729	2	124,9	124,9	132,0	132,0	134,4	134,4
BALLAST PUMP	2	84,4	217	2	492	2	220	1	3,9	3,9	9,0	9,0	4,1	8,2
DO TRANSFER PUMP	1	0,0	83	1	69	1	47	1	0,0	0,0	0,0	0,0	0,0	0,0
GLYCOL PUMP	2	7,7	8428	2	8655	2	8827	2	13,9	13,9	14,4	14,4	14,9	14,9
CARGO COMPRESSOR	4	294,6	7838	4	5955	4	8813	4	488,9	488,9	372,4	372,4	553,2	553,2
CARGO CONDENSER SW COOLING PUMP	2	95,1	4597	2	3622	2	4580	2	92,6	92,6	73,1	73,1	92,8	92,8
CARGO DEEPWELL PUMP	8	204,1	1335	8	2314	8	1020	6	57,7	57,7	100,3	100,3	44,4	59,2
CARGO BOOSTER PUMP	2	158,0	176	2	570	2	100	2	6,0	6,0	19,5	19,5	3,5	3,5
WORKING AIR COMPRESSOR	1	14,1	3115	1	3783	1	2812	1	9,5	9,5	11,6	11,6	8,7	8,7
CONTROL AIR COMPRESSOR	1	5,8	3326	1	2376	1	3445	1	4,1	4,1	3,0	3,0	4,4	4,4
STARTING AIR COMPRESSOR	2	45,8	1104	2	340	2	1029	2	10,9	10,9	3,4	3,4	10,4	10,4
HFO TRANSFER PUMP	3	15,4	106	3	143	3	124	3	0,4	0,4	0,5	0,5	0,4	0,4
PRE-LUB PUMP	3	0,6	13878	3	13075	3	13515	3	1,9	1,9	1,8	1,8	1,9	1,9
ME COMBUSTION AIR BLOWER	2	39,1	744	2	1260	2	929	2	6,3	6,3	10,7	10,7	8,0	8,0
CENTRAL COOLING FW PUMP	2	70,1	8484	2	8774	2	8776	2	127,8	127,8	133,4	133,4	135,2	135,2
ME EXH VALVE ACTUATOR OIL PUMP	2	1,4	8328	2	8682	2	8727	2	2,6	2,6	2,7	2,7	2,8	2,8
STERN TUBE LUB OIL PUMP	2	0,7	8494	2	8776	2	8776	2	1,3	1,3	1,4	1,4	1,4	1,4
ME FO SUPPLY PUMP	2	1,4	8498	2	8744	2	8771	2	2,6	2,6	2,7	2,7	2,8	2,8
ME FO CIRC. PUMP	2	5,0	3639	1	8745	2	9075	2	3,9	7,9	9,6	9,6	10,1	10,1
AUX. ENGINE DO SUPPLY PUMP	1	1,3	907	1	717	1	453	1	0,3	0,3	0,2	0,2	0,1	0,1
BILGE TRANSFER PUMP	1	3,3	64	1	79	1	105	1	0,0	0,0	0,1	0,1	0,1	0,1
FIRE, BILGE AND BALLST PUMP	1	0,0	94	1	716	1	69	1	0,0	0,0	0,0	0,0	0,0	0,0
FIRE & G.S. PUMP	1	0,0	57	1	521	1	351	1	0,0	0,0	0,0	0,0	0,0	0,0
ME COOLING SW PUMP	2	60,3	8496	2	8775	2	8781	2	110,1	110,1	114,8	114,8	116,4	116,4
DECK WATERSPRAY PUMP	1	121,9	2	1	2	1	3	1	0,1	0,1	0,0	0,0	0,1	0,1
IGG SW PUMP	1	59,5	814	1	67	1	68	1	10,4	10,4	0,9	0,9	0,9	0,9
HFO DAILY TRANSFER PUMP	1	2,1	1515	1	1725	1	1222	1	0,7	0,7	0,8	0,8	0,6	0,6
HYD PUMP FOR REMOTE CONTR. VALVES	2	1,3	870	2	2814	2	3434	2	0,2	0,2	0,8	0,8	1,0	1,0
SIDE THRUSTER (BOW THRUSTER)	1	1118,0	90	1	169	1	127	1	21,3	21,3	40,2	40,2	30,2	30,2
E-MOTOR ROOM SUPPLY FAN	2	3,8	8722	2	9300	2	8774	2	7,2	7,2	7,7	7,7	7,4	7,4
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	9,8	6540	1	5765	1	7635	1	13,7	13,7	12,2	12,2	16,4	16,4
AIR LOCK SP SUPPLY FAN	1	0,6	8729	1	8769	1	8774	1	1,1	1,1	1,1	1,1	1,1	1,1
SUPPLY FAN, ENGINE ROOM	4	12,4	28319	4	33307	4	31489	4	75,3	75,3	89,4	89,4	85,6	85,6
BOSN STR & THR COMP SUPPLY FAN	1	2,0	300	1	400	1	413	1	0,1	0,1	0,2	0,2	0,2	0,2
DRY POWDER EXH FAN	1	0,5	1509	1	8304	1	0	1	0,2	0,2	1,0	1,0	0,0	0,0
HFO SEPARATOR	2	8,7	8393	2	8685	2	7350	2	15,8	15,8	16,5	16,5	14,1	14,1
ME LUB OIL SEPARATOR	1	5,2	7918	1	8507	1	8522	1	8,8	8,8	9,6	9,6	9,7	9,7
AE LUB OIL SEPARATOR	3	1,0	23605	3	24002	3	25103	3	5,0	5,0	5,2	5,2	5,5	5,5
HOT WATER CIRC PUMP	1	0,4	2424	1	8758	1	7963	1	0,2	0,2	0,7	0,7	0,6	0,6
HYDROPHORE PUMP	2	3,0	2700	2	3529	2	4000	2	1,7	1,7	2,3	2,3	2,6	2,6
STEERING GEAR HYDR OIL PUMP	3	9,9	9271	3	13877	3	9131	3	19,7	19,7	29,8	29,8	19,9	19,9
EMERGENCY FIRE PUMP	1	0,0	8	1	12	1	26	1	0,0	0,0	0,0	0,0	0,0	0,0
PROVISION REF. COMPRESSOR	2	13,2	7264	2	6226	2	6065	2	20,6	20,6	17,8	17,8	17,6	17,6
AIR-CONDITION COOLING COMPRESSOR	2	32,8	3961	2	8455	2	9053	2	27,9	27,9	60,1	60,1	65,2	65,2
SUPPLY VENT FAN FOR ACCOMONDATION	2	16,2	8491	2	17516	2	17451	2	29,6	29,6	61,7	61,7	62,3	62,3
STORE HANDLING CRANE	2	0,0	40	2	35	2	73	2	0,0	0,0	0,0	0,0	0,0	0,0
SLUDGE OIL PUMP	1	2,0	51	1	62	1	114	1	0,0	0,0	0,0	0,0	0,0	0,0
FWG EJECTOR PUMP	1	10,9	4605	1	5869	1	4173	1	10,8	10,8	13,9	13,9	10,0	10,0

9.9 X3-VESSELS 2010

2010	3	REGISTERED
CLIPPER VICTORY		CALCULATED
CLIPPER SIRIUS		

	OVERVIEW	
	VICTORY	SIRIUS
EQUIPMENT W/COUNTERS, SUM [TON]	1687	1515
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	0	0
SUM ESTIMATED [TON]	1687	1515
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1894	1745
OTHER EQUIPMENT	207	230

	FUEL TYPE [TON]	
	VICTORY	SIRIUS
HFO	1850	1535
LSHFO	38	88
MDO	7	122
TOTAL	**1894**	**1745**
SFC HC	212,6	211,5
SFC LC	224,3	223,5

	PROFILE [DAYS]		REG. FUEL [TON]		FUEL [TON/DAY]	
CONDITION	VICTORY	SIRIUS	VICTORY	SIRIUS	VICTORY	SIRIUS
LOADED	45	98	275	498	6,1	5,1
BALLAST	39	66	158	291	4,1	4,4
MAN	0	0	0	0		
PORT	281	201	1461	956	5,2	4,8
SUM/AVERAGE	**365**	**365**	**1894**	**1745**	**5,1**	**4,7**

	RUNNING HOURS [H]		REG. FUEL [TON]		SFC [KG/H]	
MACHINERY	VICTORY	SIRIUS	VICTORY	SIRIUS	VICTORY	SIRIUS
MAIN DIESEL ENGINE	2261	3923	3570	6762	1579,0	1723,7
AUX. DIESEL GENERATOR	13687	12773	1894	1745	138,4	136,6
CARGO COMPRESSOR	10676	7980				

	RUNNING HOURS [H]		P. FACTOR [#]		
SEEMP/MONITORED EQUIPMENT	VICTORY	SIRIUS	VICTORY	SIRIUS	DEPENDENCY
ME LO PUMP	8730	8671	3,86	2,21	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	7596	8696	3,36	2,22	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	6161	8351	2,31	4,19	/(COMPRESSORS/4
EXHAUST FAN, CARGO COMPRESSOR ROOM	8731	8711	3,27	4,37	/(COMPRESSORS/4

	RUNNING HOURS [H]		EST. COSTS [USD]		
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	VICTORY	SIRIUS	VICTORY	SIRIUS	COMMENT
EQUIPMENT FOR CARGO	**29727**	**28600**	**800**	**653**	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	3235	2474	148,3	112,5	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	10676	7980	537,4	399,6	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	919	1124	7,8	4,9	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	14897	17022	106,5	136,0	
SHIP EQUIPMENT	**10726**	**12570**	**147,0**	**101,1**	
MANOEUVRING MACHINERY & EQUIPMENT	7866	8841	106,6	72,5	
ANCHORING, MOORING & TOWING EQUIPMENT	1769	1058	38,0	22,8	
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	1091	2671	2,4	5,8	
EQUIPMENT FOR CREW	**79034**	**79162**	**201,3**	**205,4**	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	4811	7317	9,0	13,6	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	74223	71845	192,3	191,8	
MACHINERY MAIN COMPONENTS	**12924**	**13499**	**10,9**	**13,5**	
DIESEL ENGINES FOR PROPULSION	792	1033	8,5	11,0	
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	12132	12466	2,4	2,5	
SYSTEMS FOR MAIN MACHINERY	**163830**	**184458**	**524,1**	**533,5**	
FUEL SYSTEMS	50216	54810	48,7	56,1	
LUBE OIL SYSTEMS	50033	63733	168,6	175,9	
COOLING SYSTEMS	41418	39671	269,7	256,0	
COMPRESSED AIR SYSTEMS	4642	8762	10,7	19,3	
STEAM, CONDENSATE & FEED WATER SYSTEMS	17520	17482	26,4	26,3	
SHIP COMMON SYSTEMS	**586**	**775**	**4,0**	**8,1**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	408	410	0,1	0,1	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	178	365	4,0	8,0	
SUM	**296827**	**319064**	**1687**	**1515**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]				FUEL CONS. [TON]			
			VICTORY		SIRIUS		VICTORY		SIRIUS	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	222,2	2733	8	2060	8	129	129,1	96,8	96,8
CARGO BOOSTER PUMP	2	179,5	502	2	414	2	19,2	19,2	15,7	15,7
CARGO COMPRESSOR	4	236,8	10676	4	7980	4	537,4	537,4	399,6	399,6
CARGO TANK GAS-FREEING FAN	2	46,5	2	2	89	2	0,0	0,0	0,9	0,9
INERT GAS PLANT W/ GAS GENERATOR	1	236,7	56	1	39	1	3,0	3,0	2,1	2,1
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	212	1	47	1	4,1	4,1	0,9	0,9
NITROGEN GENERATOR	1	4,8	650	1	949	1	0,7	0,7	1,0	1,0
CARGO CONDENSER SW COOLING PUMP	3	65,2	6161	3	8351	3	85,4	85,4	115,2	115,2
GLYCOL COOLING SYSTEM PUMP	2	10,7	8736	2	8671	2	21,1	21,1	20,8	20,8
STEERING GEAR HYDR OIL PUMP	2	14,8	7596	2	8696	2	25,3	25,3	28,8	28,8
BOW THRUSTER	1	1342,1	270	1	146	1	81,3	81,3	43,6	43,6
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	721	2	469	2	17,0	17,0	11,0	11,0
MOORING WINCH HYDR. OIL PUMP	2	89,5	1048	2	589	2	21,0	21,0	11,8	11,8
INCINERATOR	1	9,8	1091	1	2671	1	2,4	2,4	5,8	5,8
PROVISION COOLING COMPRESSOR	2	8,3	4811	2	7317	2	9,0	9,0	13,6	13,6
AIR-CONDITION COOLING COMPRESSOR	2	58,9	5258	2	5462	2	69,4	69,4	71,8	71,8
SUPPLY FAN, ENGINE ROOM	4	11,8	33565	4	32880	4	88,8	88,8	86,7	86,7
EXHAUST FAN, PURIFIER AREA	1	1,7	8758	1	6880	1	3,3	3,3	2,5	2,5
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,0	8731	1	8711	1	19,6	19,6	19,5	19,5
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,2	8752	1	8738	1	0,4	0,4	0,4	0,4
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	5,3	8750	1	8712	1	10,4	10,4	10,3	10,3
SUPPLY FAN, BOW THRUSTER ROOM	1	5,2	409	1	462	1	0,5	0,5	0,5	0,5
ME COMBUSTION AIR BLOWER	2	47,8	792	2	1033	2	8,5	8,5	11,0	11,0
AE LO PRIMING PUMP	3	0,9	12132	3	12466	3	2,4	2,4	2,5	2,5
HFO TRANSFER PUMP FWD	2	13,0	66	2	81	2	0,2	0,2	0,2	0,2
HFO TRANSFER PUMP AFT	1	9,6	198	1	383	1	0,4	0,4	0,8	0,8
MDO TRANSFER PUMP	1	4,9	1	1	18	1	0,0	0,0	0,0	0,0
HFO PURIFIER	2	15,3	7392	2	9267	2	25,3	25,3	31,6	31,6
HFO PURIFIER SUPPLY PUMP	2	1,4	7392	2	10083	2	2,3	2,3	3,1	3,1
SLUDGE OIL PUMP	1	3,3	58	1	54	1	0,0	0,0	0,0	0,0
ME FO SUPPLY PUMP	2	1,4	8761	2	8742	2	2,7	2,7	2,7	2,7
ME FO CIRCULATING PUMP	2	5,0	8761	2	8743	2	9,8	9,8	9,7	9,7
AE FO SUPPLY PUMP	2	0,7	8790	2	8543	2	1,4	1,4	1,3	1,3
AE FO BOOSTER PUMP	2	3,3	8760	2	8541	2	6,6	6,6	6,4	6,4
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVEN)	1	2,0	38	1	355	1	0,0	0,0	0,2	0,2
LO TRANSFER PUMP	1	3,3	0	1	0	1	0,0	0,0	0,0	0,0
AE LO PURIFIER	2	4,7	7762	2	15339	2	8,2	8,2	16,1	16,1
ME LO PURIFIER	2	8,7	8511	2	8562	2	16,6	16,6	16,6	16,6
AE LO PURIFIER SUPPLY PUMP	2	0,4	7762	2	13334	2	0,7	0,7	1,2	1,2
ME LO PURIFIER SUPPLY PUMP	2	1,4	8511	2	9086	2	2,6	2,6	2,8	2,8
ME LO PUMP	2	70,9	8730	2	8671	2	138,9	138,9	137,4	137,4
STERN TUBE LO PUMP	2	0,8	8759	2	8741	2	1,6	1,6	1,6	1,6
ME COOLING SW PUMP	3	32,6	15562	3	13821	3	113,7	113,7	100,6	100,6
ME JACKET COOLING FW PUMP	2	15,8	8760	2	8742	2	31,0	31,0	30,9	30,9
CENTRAL COOLING FW PUMP	3	32,6	17096	3	17108	3	124,9	124,9	124,6	124,6
MAIN STARTING AIR COMPRESSOR	2	34,9	483	2	587	2	3,8	3,8	4,6	4,6
SERVICE AIR COMPRESSOR	1	5,7	1560	1	1285	1	2,0	2,0	1,6	1,6
CONTROL AIR COMPRESSOR	1	8,5	2600	1	6891	1	4,9	4,9	13,1	13,1
AUX. BOILER FEED WATER PUMP	2	10,1	8761	2	8742	2	19,8	19,8	19,6	19,6
AUX. BOILER CIRCULATING PUMP	2	3,4	8759	2	8741	2	6,7	6,7	6,6	6,6
BALLAST PUMP	2	0,7	408	2	410	2	0,1	0,1	0,1	0,1
BILGE/MAIN FIRE/GS PUMP	2	99,4	173	2	345	2	3,9	3,9	7,7	7,7
DECK WATERSPRAY PUMP	1	77,7	1	1	1	1	0,0	0,0	0,0	0,0
EMERGENCY FIRE PUMP	1	77,7	3	1	18	1	0,0	0,0	0,3	0,3
ENGINE ROOM LOCAL WATERSPRAY SYSTEM	1	121,9	1	1	0	1	0,0	0,0	0,0	0,0

9.10 X3-VESSELS 2011

2011	3	
		REGISTERED
		CALCULATED

CLIPPER VICTORY
CLIPPER SIRIUS

	OVERVIEW	
	VICTORY	SIRIUS
EQUIPMENT W/COUNTERS, SUM [TON]	1456	1389
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	0	78
SUM ESTIMATED [TON]	1456	1468
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1687	1648
OTHER EQUIPMENT	230	180

	FUEL TYPE [TON]	
	VICTORY	SIRIUS
HFO	1469	1200
LSHFO	145	323
MDO	72	124
TOTAL	**1687**	**1648**
SFC HC	211,9	211,4
SFC LC	221,3	222,8

	PROFILE [DAYS]		REG. FUEL [TON]		FUEL [TON/DAY]	
CONDITION	VICTORY	SIRIUS	VICTORY	SIRIUS	VICTORY	SIRIUS
LOADED	85	75	428	370	5,0	4,9
BALLAST	53	73	198	313	3,7	4,3
MAN	91	103	440	504	4,8	4,9
PORT	136	114	621	460	4,6	4,0
SUM/AVERAGE	**365**	**365**	**1687**	**1648**	**4,5**	**4,5**

	RUNNING HOURS [H		REG. FUEL [TON]		SFC [KG/H]	
MACHINERY	VICTORY	SIRIUS	VICTORY	SIRIUS	VICTORY	SIRIUS
MAIN DIESEL ENGINE	4158	4647	6522	8337	1568,6	1794,1
AUX. DIESEL GENERATOR	11386	11825	1687	1648	148,1	139,3
CARGO COMPRESSOR	9240	7956				

	RUNNING HOURS [H		P. FACTOR [#]		
SEEMP/MONITORED EQUIPMENT	VICTORY	SIRIUS	VICTORY	SIRIUS	DEPENDENCY
ME LO PUMP	6970	8694	1,68	1,87	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	7482	9360	1,80	2,01	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	6460	8982	2,80	4,52	/(COMPRESSORS/4
EXHAUST FAN, CARGO COMPRESSOR ROOM	8401	8441	3,64	4,24	/(COMPRESSORS/4

	RUNNING HOURS [H		EST. COSTS [USD]		
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	VICTORY	SIRIUS	VICTORY	SIRIUS	COMMENT
EQUIPMENT FOR CARGO	**28801**	**26656**	**689**	**629**	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	2353	422	109	76	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	9240	7956	464	398	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	2096	634	7	11	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	15112	17643	110	145	
SHIP EQUIPMENT	**10697**	**13145**	**114**	**101**	
MANOEUVRING MACHINERY & EQUIPMENT	7679	9499	83	72	
ANCHORING, MOORING & TOWING EQUIPMENT	1229	1089	27	23	
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	1788	2558	4	6	
EQUIPMENT FOR CREW	**76562**	**78481**	**198**	**203**	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	4590	7065	8	13	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	71972	71416	189	190	
MACHINERY MAIN COMPONENTS	**14737**	**12425**	**7**	**15**	
DIESEL ENGINES FOR PROPULSION	436	1070	5	11	
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	14301	11355	3	3	
SYSTEMS FOR MAIN MACHINERY	**145699**	**166110**	**440**	**511**	
FUEL SYSTEMS	43978	46806	39	50	
LUBE OIL SYSTEMS	42655	59748	133	172	
COOLING SYSTEMS	36375	33969	230	245	
COMPRESSED AIR SYSTEMS	7469	8370	14	18	
STEAM, CONDENSATE & FEED WATER SYSTEMS	15223	17217	24	26	
SHIP COMMON SYSTEMS	**745**	**788**	**8**	**9**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	396	391	0	0	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	349	398	8	9	
SUM	**277240**	**297604**	**1456**	**1468**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]				FUEL CONS. [TON]			
			VICTORY		SIRIUS		VICTORY		SIRIUS	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	222,2	2147	8	389	2	101	101,1	18,3	73,1
CARGO BOOSTER PUMP	2	179,5	205	2	33	1	7,8	7,8	1,2	2,5
CARGO COMPRESSOR	4	236,8	9240	4	7956	4	463,6	463,6	398,2	398,2
CARGO TANK GAS-FREEING FAN	2	46,5	121	2	48	1	1,2	1,2	0,5	1,0
INERT GAS PLANT W/ GAS GENERATOR	1	236,7	36	1	143	1	1,9	1,9	7,5	7,5
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	86	1	0	0	1,6	1,6		1,6
NITROGEN GENERATOR	1	4,8	1853	1	443	1	2,0	2,0	0,5	0,5
CARGO CONDENSER SW COOLING PUMP	3	65,2	6460	3	8982	3	89,3	89,3	123,8	123,8
GLYCOL COOLING SYSTEM PUMP	2	10,7	8653	2	8661	2	20,6	20,6	20,7	20,7
STEERING GEAR HYDR OIL PUMP	2	14,8	7482	2	9360	2	24,6	24,6	30,9	30,9
BOW THRUSTER	1	1342,1	198	1	139	1	58,8	58,8	41,5	41,5
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	637	2	493	2	15,0	15,0	11,5	11,5
MOORING WINCH HYDR. OIL PUMP	2	89,5	592	2	596	2	11,7	11,7	11,9	11,9
INCINERATOR	1	9,8	1788	1	2558	1	3,9	3,9	5,6	5,6
PROVISION COOLING COMPRESSOR	2	8,3	4590	2	7065	2	8,4	8,4	13,1	13,1
AIR-CONDITION COOLING COMPRESSOR	2	58,9	5631	2	5797	2	73,3	73,3	76,0	76,0
SUPPLY FAN, ENGINE ROOM	4	11,8	31848	4	30883	4	83,2	83,2	81,2	81,2
EXHAUST FAN, PURIFIER AREA	1	1,7	8276	1	8750	1	3,0	3,0	3,2	3,2
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,0	8401	1	8441	1	18,6	18,6	18,8	18,8
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,2	8757	1	8719	1	0,4	0,4	0,4	0,4
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	5,3	8755	1	8541	1	10,3	10,3	10,1	10,1
SUPPLY FAN, BOW THRUSTER ROOM	1	5,2	305	1	285	1	0,4	0,4	0,3	0,3
ME COMBUSTION AIR BLOWER	2	47,8	436	2	1070	2	4,6	4,6	11,4	11,4
AE LO PRIMING PUMP	3	0,9	14301	3	11355	2	2,8	2,8	2,2	3,4
HFO TRANSFER PUMP FWD	2	13,0	62	2	112	2	0,2	0,2	0,3	0,3
HFO TRANSFER PUMP AFT	1	9,6	296	1	398	1	0,6	0,6	0,8	0,8
MDO TRANSFER PUMP	1	4,9	16	1	20	1	0,0	0,0	0,0	0,0
HFO PURIFIER	2	15,3	5405	2	7735	2	18,2	18,2	26,3	26,3
HFO PURIFIER SUPPLY PUMP	2	1,4	5405	2	3076	1	1,6	1,6	0,9	1,9
SLUDGE OIL PUMP	1	3,3	39	1	63	1	0,0	0,0	0,0	0,0
ME FO SUPPLY PUMP	2	1,4	8756	2	8899	2	2,7	2,7	2,7	2,7
ME FO CIRCULATING PUMP	2	5,0	7910	2	8628	2	8,7	8,7	9,6	9,6
AE FO SUPPLY PUMP	2	0,7	8765	2	8796	2	1,3	1,3	1,3	1,3
AE FO BOOSTER PUMP	2	3,3	7323	2	8795	2	5,4	5,4	6,6	6,6
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVEN)	1	2,0	0	1	284	1	0,0	0,0	0,1	0,1
LO TRANSFER PUMP	1	3,3	0	1	6	1	0,0	0,0	0,0	0,0
AE LO PURIFIER	2	4,7	7196	2	13915	2	7,5	7,5	14,6	14,6
ME LO PURIFIER	2	8,7	6267	2	7792	2	12,1	12,1	15,1	15,1
AE LO PURIFIER SUPPLY PUMP	2	0,4	7196	2	12710	2	0,7	0,7	1,2	1,2
ME LO PURIFIER SUPPLY PUMP	2	1,4	6267	2	7878	2	1,9	1,9	2,4	2,4
ME LO PUMP	2	70,9	6970	2	8694	2	109,4	109,4	137,4	137,4
STERN TUBE LO PUMP	2	0,8	8759	2	8752	2	1,6	1,6	1,6	1,6
ME COOLING SW PUMP	3	32,6	13253	3	13236	3	95,6	95,6	96,0	96,0
ME JACKET COOLING FW PUMP	2	15,8	8757	2	5130	1	30,6	30,6	18,1	36,1
CENTRAL COOLING FW PUMP	3	32,6	14366	3	15604	3	103,6	103,6	113,2	113,2
MAIN STARTING AIR COMPRESSOR	2	34,9	411	2	503	2	3,2	3,2	3,9	3,9
SERVICE AIR COMPRESSOR	1	5,7	3298	1	1672	1	4,1	4,1	2,1	2,1
CONTROL AIR COMPRESSOR	1	8,5	3760	1	6196	1	7,1	7,1	11,7	11,7
AUX. BOILER FEED WATER PUMP	2	10,1	8751	2	8521	2	19,5	19,5	19,1	19,1
AUX. BOILER CIRCULATING PUMP	2	3,4	6472	2	8696	2	4,9	4,9	6,6	6,6
BALLAST PUMP	2	0,7	396	2	391	2	0,1	0,1	0,1	0,1
BILGE/MAIN FIRE/GS PUMP	2	99,4	340	2	384	2	7,5	7,5	8,5	8,5
DECK WATERSPRAY PUMP	1	77,7	2	1	0	0	0,0	0,0		0,0
EMERGENCY FIRE PUMP	1	77,7	4	1	13	1	0,1	0,1	0,2	0,2
ENGINE ROOM LOCAL WATERSPRAY SYSTEM	1	121,9	3	1	0	1	0,1	0,1	0,0	0,0

9.11 X3-VESSELS 2012

2012	3	
CLIPPER VICTORY		REGISTERED
CLIPPER SIRIUS		CALCULATED

	OVERVIEW	
	VICTORY	SIRIUS
EQUIPMENT W/COUNTERS, SUM [TON]	1617	1306
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	16	88
SUM ESTIMATED [TON]	1634	1394
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	1657	1603
OTHER EQUIPMENT	24	210

	FUEL TYPE [TON]	
	VICTORY	SIRIUS
HFO	1514	1162
LSHFO	142	165
MDO	1	276
TOTAL	**1657**	**1603**
SFC HC	212,6	209,7
SFC LC	225,7	220,7

	PROFILE [DAYS]		REG. FUEL [TON]		FUEL [TON/DAY]	
CONDITION	**VICTORY**	**SIRIUS**	**VICTORY**	**SIRIUS**	**VICTORY**	**SIRIUS**
LOADED	51	103	312	453	6,1	4,4
BALLAST	53	101	198	398	3,7	3,9
MAN	112	85	526	365	4,7	4,3
PORT	150	76	622	387	4,1	5,1
SUM/AVERAGE	**366**	**365**	**1657**	**1603**	**4,7**	**4,4**

	RUNNING HOURS [H		REG. FUEL [TON]		SFC [KG/H]	
MACHINERY	**VICTORY**	**SIRIUS**	**VICTORY**	**SIRIUS**	**VICTORY**	**SIRIUS**
MAIN DIESEL ENGINE	3517	5888	5539	10318	1574,9	1752,3
AUX. DIESEL GENERATOR	12639	11429	1657	1603	131,1	140,3
CARGO COMPRESSOR	13377	5964				

	RUNNING HOURS [H		P. FACTOR [#]		
SEEMP/MONITORED EQUIPMENT	**VICTORY**	**SIRIUS**	**VICTORY**	**SIRIUS**	**DEPENDENCY**
ME LO PUMP	4704	8481	1,34	1,44	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	5402	12034	1,54	2,04	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	7064	6990	2,11	4,69	/(COMPRESSORS/4
EXHAUST FAN, CARGO COMPRESSOR ROOM	8099	8523	2,42	5,72	/(COMPRESSORS/4

	RUNNING HOURS [H		EST. COSTS [USD]		
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	**VICTORY**	**SIRIUS**	**VICTORY**	**SIRIUS**	**COMMENT**
EQUIPMENT FOR CARGO	**33017**	**24216**	**893**	**548**	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	2014	1435	94	129	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	13377	5964	673	296	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	1941	1070	7	7	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	15685	15748	119	116	
SHIP EQUIPMENT	**7924**	**15365**	**136**	**107**	
MANOEUVRING MACHINERY & EQUIPMENT	5708	12174	111	81	
ANCHORING, MOORING & TOWING EQUIPMENT	1022	997	22	21	
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	1194	2194	3	5	
EQUIPMENT FOR CREW	**79307**	**81220**	**230**	**210**	
GALLEY/PANTRY EQUIP., PROVISION PLANTS, LAUNDRY/IRONING EQU.	4324	8137	8	15	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	74983	73083	222	195	
MACHINERY MAIN COMPONENTS	**13833**	**10258**	**10**	**10**	
DIESEL ENGINES FOR PROPULSION	660	729	7	8	
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	13173	9529	3	3	
SYSTEMS FOR MAIN MACHINERY	**101008**	**177641**	**354**	**513**	
FUEL SYSTEMS	9710	48226	32	51	
LUBE OIL SYSTEMS	42408	68065	97	173	
COOLING SYSTEMS	29372	33678	187	241	
COMPRESSED AIR SYSTEMS	6561	10069	15	22	
STEAM, CONDENSATE & FEED WATER SYSTEMS	12957	17604	23	26	
SHIP COMMON SYSTEMS	**1141**	**711**	**11**	**5**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	648	469	0	0	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	493	242	11	5	
SUM	**236230**	**309411**	**1634**	**1394**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

			RUNNING HOURS [H]				FUEL CONS. [TON]			
			VICTORY		SIRIUS		VICTORY		SIRIUS	
MACHINERY	N	POWER	RH [H]	N	RH [H]	N	REG	TOT	REG	TOT
CARGO MAIN PUMP	8	222,2	1881	8	1167	4	89	88,9	54,4	108,7
CARGO BOOSTER PUMP	2	179,5	133	2	268	1	5,1	5,1	10,1	20,2
CARGO COMPRESSOR	4	236,8	13377	4	5964	4	673,5	673,5	296,1	296,1
CARGO TANK GAS-FREEING FAN	2	46,5	18	2	1	1	0,2	0,2	0,0	0,0
INERT GAS PLANT W/ GAS GENERATOR	1	236,7	22	1	35	1	1,2	1,2	1,8	1,8
IGG COOLING SW (SCRUBBER) PUMP	1	86,3	200	1	0	0	3,9	3,9		3,9
NITROGEN GENERATOR	1	4,8	1701	1	1034	1	1,9	1,9	1,1	1,1
CARGO CONDENSER SW COOLING PUMP	3	65,2	7064	3	6990	3	98,0	98,0	95,6	95,6
GLYCOL COOLING SYSTEM PUMP	2	10,7	8621	2	8758	2	20,9	20,9	20,8	20,8
STEERING GEAR HYDR OIL PUMP	2	14,8	5402	2	12034	2	18,1	18,1	39,4	39,4
BOW THRUSTER	1	1342,1	306	1	140	1	92,7	92,7	41,5	41,5
COMB. WINDLASS/MOORING HYDR. OIL PUMP	2	110,8	451	2	455	2	10,6	10,6	10,6	10,6
MOORING WINCH HYDR. OIL PUMP	2	89,5	571	2	542	2	11,5	11,5	10,7	10,7
INCINERATOR	1	9,8	1194	1	2194	1	2,6	2,6	4,7	4,7
PROVISION COOLING COMPRESSOR	2	8,3	4324	2	8137	2	8,1	8,1	14,9	14,9
AIR-CONDITION COOLING COMPRESSOR	2	58,9	7691	2	6009	2	102,1	102,1	78,1	78,1
SUPPLY FAN, ENGINE ROOM	4	11,8	32506	4	32299	4	86,5	86,5	84,1	84,1
EXHAUST FAN, PURIFIER AREA	1	1,7	8754	1	8440	1	3,3	3,3	3,1	3,1
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	10,0	8099	1	8523	1	18,3	18,3	18,8	18,8
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR RM.)	1	0,2	8769	1	8801	1	0,4	0,4	0,4	0,4
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	5,3	8757	1	8777	1	10,5	10,5	10,3	10,3
SUPPLY FAN, BOW THRUSTER ROOM	1	5,2	407	1	234	1	0,5	0,5	0,3	0,3
ME COMBUSTION AIR BLOWER	2	47,8	660	2	729	2	7,1	7,1	7,7	7,7
AE LO PRIMING PUMP	3	0,9	13173	3	9529	2	2,6	2,6	1,9	2,8
HFO TRANSFER PUMP FWD	2	13,0	89	2	110	2	0,3	0,3	0,3	0,3
HFO TRANSFER PUMP AFT	1	9,6	242	1	439	1	0,5	0,5	0,9	0,9
MDO TRANSFER PUMP	1	4,9	239	1	64	1	0,3	0,3	0,1	0,1
HFO PURIFIER	2	15,3	3848	2	7852	2	13,2	13,2	26,4	26,4
HFO PURIFIER SUPPLY PUMP	2	1,4	3848	2	4548	1	1,2	1,2	1,4	2,8
SLUDGE OIL PUMP	1	3,3	68	1	99	1	0,1	0,1	0,1	0,1
ME FO SUPPLY PUMP	2	1,4	624	1	8540	2	0,2	0,4	2,6	2,6
ME FO CIRCULATING PUMP	2	5,0	0	0	8809	2		9,7	9,7	9,7
AE FO SUPPLY PUMP	2	0,7	752	1	8805	2	0,1	0,2	1,3	1,3
AE FO BOOSTER PUMP	2	3,3	0	0	8759	2		6,5	6,5	6,5
AE MDO FLUSHING PUMP P (ELECTRIC MOTOR DRIVEN)	1	2,0	0	1	200	1	0,0	0,0	0,1	0,1
LO TRANSFER PUMP	1	3,3	0	1	0	1	0,0	0,0	0,0	0,0
AE LO PURIFIER	2	4,7	11637	2	16866	2	12,4	12,4	17,5	17,5
ME LO PURIFIER	2	8,7	2829	2	8569	2	5,6	5,6	16,5	16,5
AE LO PURIFIER SUPPLY PUMP	2	0,4	11637	2	16761	2	1,1	1,1	1,5	1,5
ME LO PURIFIER SUPPLY PUMP	2	1,4	2829	2	8583	2	0,9	0,9	2,6	2,6
ME LO PUMP	2	70,9	4704	2	8481	2	75,3	75,3	132,8	132,8
STERN TUBE LO PUMP	2	0,8	8772	2	8805	2	1,6	1,6	1,6	1,6
ME COOLING SW PUMP	3	32,6	10988	3	13959	3	80,8	80,8	100,4	100,4
ME JACKET COOLING FW PUMP	2	15,8	7625	2	4831	1	27,2	27,2	16,8	33,7
CENTRAL COOLING FW PUMP	3	32,6	10759	3	14887	3	79,1	79,1	107,1	107,1
MAIN STARTING AIR COMPRESSOR	2	34,9	666	2	756	2	5,3	5,3	5,8	5,8
SERVICE AIR COMPRESSOR	1	5,7	2865	1	1553	1	3,7	3,7	1,9	1,9
CONTROL AIR COMPRESSOR	1	8,5	3030	1	7760	1	5,8	5,8	14,5	14,5
AUX. BOILER FEED WATER PUMP	2	10,1	8761	2	8801	2	19,9	19,9	19,5	19,5
AUX. BOILER CIRCULATING PUMP	2	3,4	4196	2	8803	2	3,2	3,2	6,6	6,6
BALLAST PUMP	2	0,7	648	2	469	2	0,1	0,1	0,1	0,1
BILGE/MAIN FIRE/GS PUMP	2	99,4	486	2	216	2	10,9	10,9	4,7	4,7
DECK WATERSPRAY PUMP	1	77,7	2	1	0	0	0,0	0,0		0,0
EMERGENCY FIRE PUMP	1	77,7	4	1	25	1	0,1	0,1	0,4	0,4
ENGINE ROOM LOCAL WATERSPRAY SYSTEM	1	121,9	1	1	2	1	0,0	0,0	0,0	0,0

9.12 X4-VESSEL 2012

2012	4		REGISTERED
CLIPPER SUN			CALCULATED

	OVERVIEW
	SUN
EQUIPMENT W/COUNTERS, SUM [TON]	1854
EQUIPMENT W/COUNTERS, MISSING [AVERAGE TON]	0
SUM ESTIMATED [TON]	1854
REGISTERED FUEL CONSUMPTION, ALL TYPES [TON]	2044
OTHER EQUIPMENT	189

	FUEL TYPE [TON]
	SUN
HFO	2043
LSHFO	0
MDO	1
TOTAL	**2044**
SFC HC	219,0
SFC LC	231,8

	PROFILE [DAYS]	REG. FUEL [TON]	FUEL [TON/DAY]
CONDITION	**SUN**	**SUN**	**SUN**
LOADED	128	754	5,9
BALLAST	114	568	5,0
MAN	52	293	5,6
PORT	72	429	6,0
SUM/AVERAGE	**366**	**2044**	**5,6**

	RUNNING HOURS [H]	REG. FUEL [TON]	SFC [KG/H]
MACHINERY	**SUN**	**SUN**	**SUN**
MAIN DIESEL ENGINE	6717	12415	1848,2
AUX. DIESEL GENERATOR	12311	2044	166,0
CARGO COMPRESSOR	8052		

	RUNNING HOURS [H]	P. FACTOR [#]	
SEEMP/MONITORED EQUIPMENT	**SUN**	**SUN**	**DEPENDENCY**
ME LO PUMP	8706	1,30	/MAIN ENGINE
STEERING GEAR HYDR OIL PUMP	8946	1,33	/MAIN ENGINE
CARGO CONDENSER SW COOLING PUMP	4504	2,24	/(COMPRESSORS/4)
EXHAUST FAN, CARGO COMPRESSOR ROOM	8700	4,32	/(COMPRESSORS/4)

	RUNNING HOURS [H]	EST. FUEL [TON]	
SHIP EQUIPMENT MAIN SYSTEM/SYSTEM	**SUN**	**SUN**	**COMMENT**
EQUIPMENT FOR CARGO	**24022**	**816**	
GAS / VENTILATION SYSTEMS FOR CARGO HOLDS/TANKS	350	9	
AUXILIARY SYSTEMS & EQUIPMENT FOR CARGO	13177	110	
LOADING/DISCHARGING SYSTEMS FOR LIQUID CARGO	1436	63	
FREEZING, REFRIGERATING & HEATING SYSTEMS FOR CARGO	9060	634	
SHIP EQUIPMENT	**9518**	**42**	
MANOEUVRING MACHINERY & EQUIPMENT	8946	30	
ANCHORING, MOORING & TOWING EQUIPMENT	567	11	
REP./MAINT./CLEAN. EQUIP. WORKSHOP/STORE OUTFIT NAME PLATES	5	0	
EQUIPMENT FOR CREW	**118103**	**383**	
SANITARY SYST. W/DISCHARGES, ACCOMMODATION DRAIN SYSTEMS	707	0	
VENTILATION, DAMPERS, AIR-CONDITIONING & HEATING SYSTEMS	109285	373	
MACHINERY MAIN COMPONENTS	**21304**	**4**	
MOTOR AGGREGATES FOR MAIN ELECTRIC POWER PRODUCTION	21289	4	
DIESEL ENGINES FOR PROPULSION	15	0	
SYSTEMS FOR MAIN MACHINERY	**142702**	**564**	
LUBE OIL SYSTEMS	33747	153	
COMPRESSED AIR SYSTEMS	562	4	
COOLING SYSTEMS	42953	339	
FUEL SYSTEMS	45110	25	
DISTILLED & MAKE-UP WATER SYST	10987	29	
SHIP COMMON SYSTEMS	**1749**	**45**	
BALLAST & BILGE SYSTEMS, GUTTER PIPES OUTSIDE ACCOMMOD.	695	17	
FIRE & LIFEBOAT ALARM, FIRE FIGHTING & WASH DOWN SYSTEMS	1054	28	
SUM	**317398**	**1854**	

ALL COMPONENTS ACCOUNTED FOR
COMPONENTS MISSING
NOT REGISTERED

		RUNNING HOURS [H]		FUEL CONS. [TON]	
		SUN		SUN	
MACHINERY	N	RH [H]	N	REG	TOT
ME LO PURIFIER	2	7728	2	9	9,1
MAIN STARTING AIR COMPRESSOR	2	562	2	4,2	4,2
CARGO TANK GAS-FREEING FAN	2	2	2	0,0	0,0
GLYCOL COOLING PUMP	2	8616	2	29,1	29,1
ME COOLING SW PUMP	3	16450	3	149,2	149,2
ME JACKET COOLING FW PUMP	2	9154	2	32,2	32,2
CENTRAL COOLING FW PUMP	3	17349	3	157,4	157,4
ME FO SUPPLY PUMP	2	8787	2	4,4	4,4
ME FO CIRCULATING PUMP	2	8829	2	10,5	10,5
AE FO SUPPLY PUMP	2	8789	2	2,7	2,7
AE FO BOOSTER PUMP	2	8886	2	3,9	3,9
ME LO PUMP	2	8706	2	139,8	139,8
STERN TUBE LO PUMP	2	8771	2	1,7	1,7
CARGO CONDENSER SW COOLING PUMP	3	4504	3	80,8	80,8
STEERING GEAR HYDR OIL PUMP	2	8946	2	30,4	30,4
IGG COOLING SW PUMP	1	348	1	8,9	8,9
BALLAST PUMP	2	695	2	17,3	17,3
FIRE, BILGE & GS PUMP	2	1054	2	27,7	27,7
FW GENERATOR SW EJECTOR PUMP	1	5360	1	26,6	26,6
FW GENERATOR DISTILLATE PUMP	1	5627	1	2,1	2,1
HFO TRANSFER PUMP	1	496	1	1,1	1,1
AE MDO FLUSHING PUMP	1	20	1	0,0	0,0
SLUDGE PUMP	1	98	1	0,0	0,0
POTABLE WATER HYDROPHORE PUMP	2	590	2	0,3	0,3
MOORING WINCH HYDR. OIL PUMP	2	258	2	5,1	5,1
SUPPLY FAN, ENGINE ROOM	4	32527	4	201,1	201,1
AE PRELUBRICATING OIL (PRIMING) PUMP	4	21289	4	4,1	4,1
ME TURNING GEAR	1	15	1	0,0	0,0
HFO PURIFIER SUPPLY PUMP	2	9199	2	2,8	2,8
ME LO PURIFIER SUPPLY PUMP	2	8542	2	2,2	2,2
AUX. BOILER FEED WATER PUMP	2	2354	2	4,8	4,8
EXHAUST GAS ECONOMISER FEED WATER PUMP	2	6989	2	9,7	9,7
CARGO HOSE CRANE	1	57	1	0,3	0,3
EXHAUST FAN, PURIFIER ROOM	1	8612	1	3,6	3,6
EXHAUST FAN, CARGO COMPRESSOR ROOM	1	8700	1	27,5	27,5
SUPPLY FAN, AIR LOCK (ELECTRIC MOTOR ROOM)	1	8715	1	1,5	1,5
SUPPLY FAN, ELECTRIC MOTOR ROOM	1	8715	1	16,2	16,2
EXHAUST FAN, PIPE DUCT	1	153	1	0,1	0,1
SUPPLY FAN, BOSUN STORE FWD	1	69	1	0,1	0,1
EXHAUST FAN, SANITARY SPACE	1	8727	1	4,6	4,6
EXHAUST FAN, GALLEY AREA	1	5080	1	0,7	0,7
EXHAUST FAN, PAINT STORE	1	4277	1	0,6	0,6
PROVISION CRANE	2	59	2	0,3	0,3
PROVISION REF COMPRESSOR	2	8052	2	10,0	10,0
AIR-CONDITION COOLING COMPRESSOR	2	7452	2	72,2	72,2
ME AIR COOLER CHEMICAL CLEANING PUMP	1	5	1	0,0	0,0
SUPPLY FAN, STEERING GEAR ROOM	1	7529	1	2,4	2,4
VENT. FAN, AIR COND. ACCOMMODATION	1	8729	1	42,0	42,0
CARGO MAIN PUMP	8	1406	8	61,9	61,9
CARGO BOOSTER PUMP	2	30	2	1,3	1,3
DRINKING WATER HYDROPHORE PUMP	2	117	2	0,1	0,1
CARGO CIRCUIT COMPRESSOR	4	9060	4	633,7	633,7
COMB WINDLASS/MOORING HYDR. OIL PUMP	2	309	2	6,1	6,1
MDO TRANSFER PUMP	1	6	1	0,0	0,0
LO TRANSFER PUMP	1	0	1	0,0	0,0