Bachelor Thesis – ME 141502

Container Arrangement Software Development as Tool to Obtain Optimum Trim in Respect to Fuel Consumption in Container Carrier

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Double Degree Program of

Marine Engineering Department

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Institut Teknologi Sepuluh Nopember, Surabaya

2018

Skripsi – ME 141502

Pembuatan Perangkat Lunak Pengatur Kontainer Sebagai Alat untuk Mencapai Kondisi Trim Optimal Sehubungan dengan Konsumsi Bahan Bakar pada Kapal Kontainer

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APPROVAL FORM

Container Arrangement Software Development as Tool to Obtain Optimum Trim in Respect to Fuel Consumption in Container Carrier

Bachelor Thesis

Proposed to Fulfill One of the Requirements for Obtaining a Bachelor Engineering Degree

on

Reliability, Availability, Management and Safety (RAMS) Laboratory

Study Program Bachelor Double Degree of Marine Engineering Department

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ABSTRACT

Currently fuel is the largest operating cost in a ship. Fuel cost represent approximately 60% of total ship operating cost, depends on type of ship and the service speed. These force shipping companies to evaluate and implement fuel saving options. Such options as anti-fouling system, higher machinery efficiency, bulbous bow, etc. applied to reduce the fuel consumption. Trim optimization is a cheap option which promise energy saving with easy application, without equipment extension, nor design change. Trim optimization able to save fuel due to reduction of the resistance on related condition. In this research, study focused on a 100 TEUS ship owned by Kementrian Perhubungan Republik Indonesia. At this research required to find out the resistance of ship in different trim condition, that having the same displacement. In this research MAXSURF software is used to model the ship, calculate the resistance and analyze the stability. The result showed that the variation of trim in trim by stern condition created less resistance, thereby required less fuel consumption in the same speed and displacement. Achieving the result from MAXSURF software, the data collected and created a new software to arrange the container to achieve the least resistance condition applicable in the ship using Microsoft Visual Studio software that used C# as language program. Thereby, by using the software created, it can easily use by the owner of the ship to achieve optimum trim condition and reduce the fuel consumption. In this research shown that in the optimum trim condition, it is able to reduce the power required up to 6%.

Keywords: Trim Optimization, Fuel Consumption, Container Arrangement

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Pembuatan Perangkat Lunak Pengatur Kontainer Sebagai Alat untuk Mencapai Kondisi Trim Optimal Sehubungan dengan Konsumsi Bahan Bakar pada Kapal Kontainer

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ABSTRAK

Saat ini biaya bahan bakar pada kapal adalah faktor utama dalam biaya operasional kapal. Bahan bakar membutuhkan sekitar 60% dari total biaya operasional suatu kapal, tergantung pada jenis kapal dan kecepatan servis kapal itu sendiri. Hal ini mendorong perusahaan pelayaran untuk mengevaluasi dan mengimplementasikan langkah-langkah untuk mengurangi penggunaan bahan bakar. Opsi itu antara lain seperti *anti fouling system*, permesinan dengan tingkat efisiensi yang lebih tinggi, pengaplikasian bulbuous bow pada kapal dan lainnya yang diterapkan untuk mengurangi konsumsi bahan bakar. Optimasi trim adalah salah satu opsi yang bisa diterapkan untuk mengurangi konsumsi bahan bakar, dimana optimasi trim adalah opsi yang murah, menawarkan penghematan energi dengan penerapan yang relative mudah, tanpa penambahan peralatan baru, ataupun perubahan dari desain kapal. Optimasi trim dapat menghemat bahan bakar dengan cara mengurangi tahanan kapal dalam kondisi tertentu. Dalam penelitian ini, fokus penelitian diterapkan pada Kapal Kontainer 100 TEUS milik Kementrian Perhubungan Republik Indonesia. Pada penelitian ini dilakukan simulasi untuk mendapatkan tahanan kapal pada kondisi trim yang berbeda, dengan kapasitas displasemen kapal yang sama. Pada penelitian ini, perangkat lunak MAXSURF digunakan untuk melakukan pemodelan pada kapal, menghitung tahanan yang dihadapi kapal dan menganalisa aspek stabilitas kapal. Hasil penelitian menunjukan bahwa variasi trim pada kondisi trim pada buritan menghasilkan tahanan yang lebih kecil dibandingkan kondisi lainnya, sehingga menghasilkan kebutuhan bahan bakar yang lebih kecil dengan kecepatan servis yang sama, serta kapasitas muat yang sama. Setelah mendapatkan hasil analisa dari perangkat lunak MAXSURF, data yang dikumpulkan dan dilakukan pembuatan perangkat lunak baru untuk melakukan penataletakan container yang memungkinkan kapal untuk mendapatkan tahanan terkecil menggunakan perangkat lunak Microsoft Visual Studio yang menggunakan Bahasa pemrograman C#. Dengan menggunakan software ciptaan baru ini, maka pemilik kapal dapat dengan mudah mengatur tata letak container dengan kondisi tahanan terkecil, sehingga dapat menghemat penggunaan bahan bakar. Pada penelitian ini didapat bahwa dengan penerapan kondisi trim optimal, maka dapat mengurangi daya yang dibutuhkan kapal sampai dengan 6%.

Keywords: Trim Optimization, Fuel Consumption, Container Arrangement

PREFACE

Grateful to God because of His grace and blessing, author can finish this bachelor thesis with title "CONTAINER ARRANGEMENT SOFTWARE DEVELOPMENT AS TOOL TO OBTAIN OPTIMUM TRIM IN RESPECT TO FUEL CONSUMPTION IN CONTAINER CARRIER" in order to fulfill the requirement of obtaining a Bachelor Engineering Degree on Department of Marine Engineering, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember, Surabaya.

Along the process of this bachelor thesis, author want to give thank you to all who helped and support, among others:

1. Father, Mother and Sister who always giving support, pray and love.
2. Uncle Pudjiono, uncle Pudjianto and family who financially supported my study.
3. Uncle Margono, aunt Mariana and family who provided shelter during my study.
4. Mr. Dr. Eng. Badrus Zaman, ST., MT. as Head of Department of Marine Engineering, Faculty of Marine Technology, ITS.
5. Mr. Dr-Ing. Wolfgang Busse as Representative of Hochschule Wismar
6. Mr. Dr. I Made Ariana, ST., MT. and Ms. Fadilla Indrayuni P., ST., MSc. as bachelor thesis advisor whom give a lot of times to guide and teach the author during the process.
7. Mr. Indra Ranu Kusuma, ST., M.Sc as university advisor.
8. Prof. I Ketut Buda Artana, ST., MSc. , Mr. A.A. Bagus Dinariyana Dwi P., ST., MES., PHd. , and Dr. Dhimas Widhi Handani, ST., MSc. for the advice and guidance in the laboratory.
9. All civitas academic of Department of Marine Engineering, Faculty of Marine Technology, ITS who giving a lot of knowledge to the author.
10. All of friends in Department of Marine Engineering, especially batch 2014 and Double Degree Marine Engineering Class 2014 for the memories, experiences and knowledges.
11. All friends and committee in Bina Antarbudaya Surabaya for being the second home in Surabaya, especially Anggi Mopri, Krisna,Meriana, Robby, Tegar, Faris, Ricky, Dewa, Alodia, Iga, Nisita and Dindi.

12. All friends in Purna Caraka Muda Indonesia Jawa Timur for supporting me and trust me, especially Angger, Riski, Mutafawwiqin, Adit, Billy, Bethari, Virga, Hilda, Joko and Yusril.
13. Mr. Wahyu of ITS International Office for giving me the opportunities and trust.
14. Naufal of PT. Daya Radar Utama, Jakarta for provide the required data in this research.
15. Giovani and Imannuel from Sekolah Tinggi Teknik Surabaya, who passionately guide me during Software Development.
16. Reko, Arika and Sarah for the experiences, memories and support during our study in King Mongkut University of Technology, Thonburi, Bangkok.
17. All member of RAMS Laboratory for the great time and support.

Author hopes that this research can be used for further research, even more applied in a real ship condition to reduce the fuel oil consumption of a ship. If there any comments or critics from the reader, author is open for it.

Surabaya, July 2018

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CHAPTER I: INTRODUCTION

1.1. BACKGROUND

Shipping in this modern era played important role in global economy and emission, where a data from International Chamber of Shipping shown that around 90% of nowadays world trade is carried by ship. Whereas in number, total of ship in the world itself exceed 52.000. Imagine how many fuels used and emission produced by the merchant ship worldwide.

Currently, fuel is the largest operating cost for a ship. Where fuel cost represents around 50-60% of total ship operating cost, depends on type of ship and the service speed[1]. Whereas research shown by Drewry Shipping Consultant Ltd. shown that fuel is the most cost of ship's operational cost, where in this case the size of ship used is Panamax, Post-Panamax and Post-Panamax Plus.

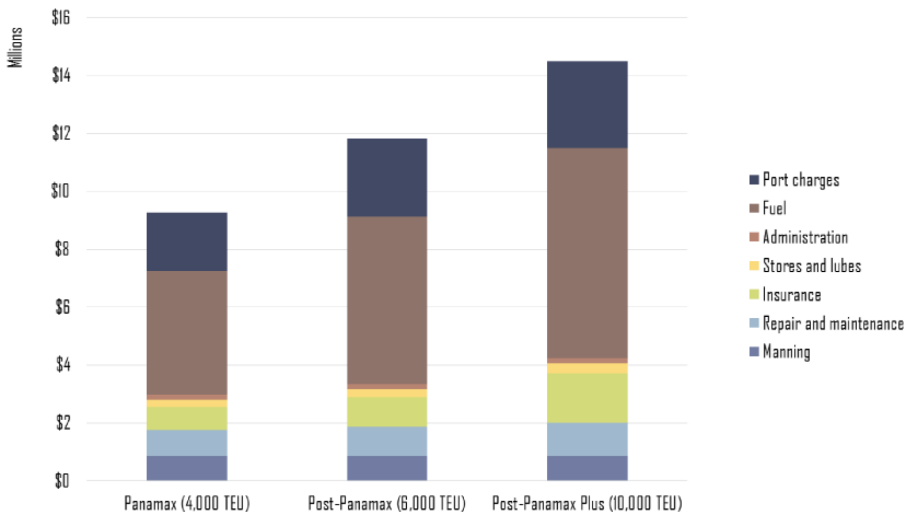


Figure 1.1 *Fuel Percentage in a Ship Operational Cost*

Besides the economical factor, in the past years shipping industry has been highlighted regarding the environmental pollution. Environmental pollution related with fuel consumption, where compound such as sulfur and nitrogen released to environment as the side effect from the combustion process. Sulfur caused damage to the atmosphere and contribute to global warming that lead to changes of climate. It is also dangerous for human health, as well as the acid rain that can damaged the environment.

[1] World Shipping Council, "Record Fuel Prices Place Stress On Ocean Shipping " , 2008.

Therefore, International Maritime Organization (IMO) had initiated Marine Environmental Protection Committee (MEPC) and introduced the International Convention for the Prevention of Pollution from Ships (MARPOL) to overcome the modern environmental challenges.

A new chapter to promoted strict regulation toward sulfur pollutant and nitrous oxides (NOx) is Marpol Annex VI that adopted by IMO in 2011. The sulfur oxide control measures are introduced with respect to the sulfur content of the fuel. Where the nitrous oxide (NOx) control measures are introduced with respect to the operational condition of the ship. Further, the SOx and NOx emission control limits are introduced globally and the limits are tightened even more in the future. Whereas in the future, it is possible that more and more area will be designated as Emission Control Area (ECA).

Also, in 2011 the Marine Environmental Protection Committee of the UN International Maritime Organization added a new chapter on energy efficiency regulation for ships. The chapter introduce the Energy Efficiency Design Index (EEDI) mandatory for new ships and the Ship Energy Efficiency Management Plan (SEEMP) mandatory for all ships (IMO,2011). EEDI itself provides a figure expressed in grams of CO2 per ton mile that measures the attainable energy efficiency of a ship. It forced the owner of ship and the designer to achieve creative way with the ship design and equipment to achieve the specified efficiency given by the IMO.

These factors force shipping companies of all vessel types to evaluate and implement fuel saving options. There are many options to optimizing the ship performance, such as anti-fouling system, better hull design, higher machinery efficiency, apply bulbous bow, etc. This option may require change of equipment, plan from design phase or even cost a lot of money. Thus, an efficient consumption of fuel is reducing the CO2, NOx and SOx emission. Bring less operational cost for the company and will be considered as environmental friendly.

While there are a lot of options to ensure the energy saving, there is a cheap option which promise energy saving with easy application, without equipment extension, nor design change. The option is trim optimization, where it is enable to save fuel due to reduction of the resistance on related condition. A research shown that trim optimization calculation applied in MV. MERATUS TANGGUH 2 for 24-hour sailing time from Surabaya to Makassar, with the right trim condition, can save the fuel up to 2% (Nur Salim, 2013).

While trim optimization calculation already quite well known in some company, there still be problem for the container arrangement to achieve the optimum trim condition. In this final project it will underline the importance of trim optimization related with resistance, container arrangement to fulfill the optimum trim condition and fuel consumption difference before and after trim optimization on a 100 TEU's container ship owned by Kementerian Perhubungan Republik Indonesia.

1.2. PROBLEMS

According to the overview above, the main problems in this final project are:

1. How many degree trim is the optimum trim?
2. Is the optimum trim condition applicable?
3. Is the fuel consumption affected by trim condition?
4. How to simplify the calculation of container arrangement to achieve optimum trim condition in 100 TEU's container ship owned by Kementerian Perhubungan Republik Indonesia?
5. How to simplify the container arrangement to achieve optimum trim condition in 100 TEU's container ship owned by Kementerian Perhubungan Republik Indonesia?

1.3. LIMITATIONS

The limitations of this final project are:

1. The case used only for 100 TEU's container ship owned by Kementerian Perhubungan Republik Indonesia.
2. The limitation of displacement is from 60%,65%70%,75%80%,85% 90%, 95% and 100% of displacement.
3. The speed is limited from 8-12 knot and assumed in stable condition.
4. All container shall be assumed in homogeneously condition.

1.4. OBJECTIVE

The objectives of this final projects are:

1. To determine the optimum trim condition.
2. To determine if the optimum trim condition applicable.
3. To measure the fuel consumption after the trim optimization.
4. To make a database about the trim and the relation with resistance on 100 TEU's container ship owned by Kementerian Perhubungan Republik Indonesia.
5. To make a software to find the optimum trim condition and container arrangement on 100 TEU's container ship owned by Kementerian Perhubungan Republik Indonesia.

1.5. TOOLS

The tools used in this final project is:

1. Maxsurf Modeller Advanced 64-bit.
2. Maxsurf Stability Advanced 64-bit.
3. Maxsurf Resistance Advanced 64-bit.
4. Microsoft Visual Studio

1.6. BENEFITS

The benefits from this final project are:

1. This final project can be applied into 100 TEU's container ship owned by Kementerian Perhubungan Republik Indonesia to reduce the fuel consumption.
2. This final project might reduce the operational cost with cheap applicable trim optimization.
3. This final project might reduce the NOx and SOx emission produced by 100 TEU's container ship owned by Kementerian Perhubungan Republik Indonesia.
4. This final project can recommend the container arrangement and the optimum trim using the software created.

CHAPTER II: LITERATURE STUDY

2.1. SHIP ENERGY EFFICIENCY

In July 2011, IMO adopted measures to reduce ship's emission of greenhouse gases (GHG), where the Energy Efficiency Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP) are introduced. EEDI become mandatory for new ships built after 2011, and SEEMP applied for both new and existing ships through the amendments of MARPOL Annex VI (resolution MEPC.203(62)). The adoption of these mandatory for new built ship after 2011 (EEDI) and all operated ship (SEEMP) from 2013 onwards, according to the IMO, will lead to significant emission reduction. The emission reduction will also result in significant fuel cost reduction for the shipping companies, although these savings might require higher investments in more efficient ship and more advanced technologies than today (Cazzulo,2013).

2.1.1. ENERGY EFFICIENCY DESIGN INDEX

The EEDI is a complex formula that applied in the design phase of a ship. But the concept itself is quite simple, where the minimum energy efficiency level is expressed in grams of carbon dioxide (CO2) per capacity-mile of the ship. A smaller EEDI value show that a ship design having more energy efficiency. The EEDI calculation based on technical design parameters for various ship types and sizes, assumption of fuel consumption (g/kWh) compared to power installed on ship. Where the EEDI represent the design efficiency of a ship, but in the reality two sister ships may have different emission and fuel consumption, based on payload, sea condition, operation and management plan.

EEDI is a requirement for a new built ship after 2013. The technical details of EEDI contain with the information about ship hull and main propulsion system. Where the details is mainly about deadweight (DWT) or gross tonnage (GT), maximum continuous rating (MCR) from the main engine, as well as from auxiliary engine, service speed (Vs) and the electrical specification.

EEDI must not exceed the required EEDI. Required EEDI itself can be calculated using this formula:

$$\text{Required EEDI} = \left(1 - \frac{x}{100}\right) \text{RLV}$$

Where :

X = Reduction factor (%); for container ship more than 15000 DWT at January 2015 until 31 December 2019 the x value is 10%.

RLV = Reference Line Value

$$\text{RLV} = 174{,}2 \;.\; b^{-0.201}$$

Where:

b = Ship's DWT.

To calculate the EEDI, we can use this formula:

$$\text{EEDI} = \frac{P\ x\ sfc\ x\ Cf}{C\ x\ V}$$

Where:

EEDI	= Energy Efficiency Design Index	(gr CO2/ton.nmil)
P	= Ship Power	(kW)
Sfc	= Specific Fuel Consumption	(gr/kWh)
Cf	= CO2 conversion	
C	= Ship capacity	(DWT or GT)
V	= Speed	(knot)

IMO through MARPOL Annex VI Regulation for the prevention of Air Pollution from Ship; Chapter 3.13. regulate about the NOx emission, where the maximum emission allowed are classified into these:

I. Tier I

For ship using diesel engine and being built from 1 January 2000 to 1 January 2011, the NOx emissions are not allowed to be more than:

a. 17 g/kWh for RPM less than 130
b. 45 x $RPM^{(-0,2)}$ g/kWh for RPM greater than 130 and less than 2000
c. 9,8 g/kWh for RPM 2000 or more

II. Tier II

For ship using diesel engine and being built from 1 January 2011 to 1 January 2016, the NOx emissions are not allowed to be more than:

a. 14,4 g/kWh for RPM less than 130
b. 44 x $RPM^{(-0,2)}$ g/kWh for RPM greater than 130 and less than 2000
c. 7,7 g/kWh for RPM 2000 or more

III. Tier III

For ship using diesel engine and being built from 1 January 2016 and after, the NOx emissions are not allowed to be more than:

d. 3,4 g/kWh for RPM less than 130
e. 9 x $RPM^{(-0,2)}$ g/kWh for RPM greater than 130 and less than 2000
f. 2 g/kWh for RPM 2000 or more

2.1.2. SHIP ENERGY EFFICIENCY MANAGEMENT PLAN

SEEMP is an operational measure for improve the energy efficiency of new ship and existing ship. SEEMP provides an approach for shipping companies to manage their fleet by using non-mandatory Energy Efficiency Operational Indicator (EEOI), or any other kind of index to provide required information according to operational efficiency that focused on ship's fuel consumption and payload. In this kind of approach, CO2 emissions are directly proportional to fuel consumption, using the carbon conversion factors that established by IMO for various type of fuel. The ship's actual energy efficiency explained here does not depend on fuel consumption factor, but also consider the amount of transport work undertaken and the level and intensity of activities.

The purpose of SEEMP is to establish a mechanism for a company to improve their ships energy efficiency operation. SEEMP process in general including four key processes: Planning, Implementation, Monitoring, Evaluation and Improvement.

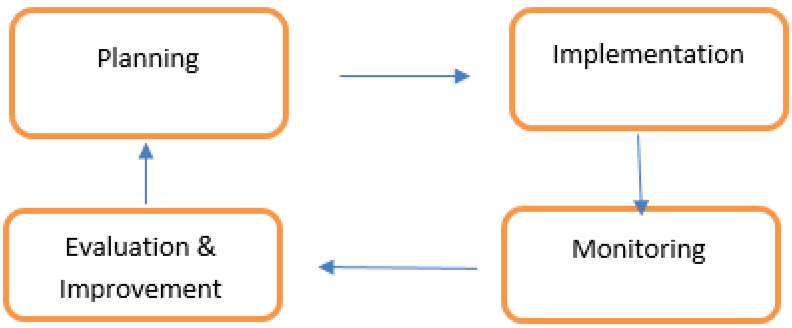


Figure 2.1 *SEEMP Process*

2.1.3. ENERGY EFFICIENCY OPERATION INDEX

Energy Efficiency Operation Index (EEOI) is a voluntary monitoring tool for managing ship and fleet efficiency performance over time recommended by IMO, where in 1997 IMO adopted a resolution on CO2 emissions from ships. EEOI is an operational measure tool for assessing the ship energy efficiency and CO2 emission to the environment per transport work. It represents the actual transport efficiency of a ship in operation.

EEOI provides an accurate figure for each voyage. The unit of EEOI depends on the measurement of payload carried or the transport work done. The EEOI is calculated using this formula, where a smaller EEOI means a more energy efficiency of a ship:

$$\text{EEOI} = \frac{CO2\ emission}{performed\ transport\ work}$$

Where basic expression for EEOI for a voyage is defined as:

$$\text{EEOI} = \frac{\sum_j\ FCj\ x\ CFj}{m\ cargo\ x\ D}$$

As for the average indicator for a period or for a number of voyages is obtained, the Indicator is calculated as:

$$\text{Average EEOI} = \frac{\sum_i \sum_j (FCij\ x\ CFj)}{\sum_i (m\ cargoi\ x\ Di)}$$

Where:

- j is the fuel type
- i is the voyage number
- FCi j is the mass of consumed fuel j at voyage i
- CFj is the fuel mass to CO2 mass conversion factor for fuel j
- mcargo is cargo carried (tonnes) or work done (number of TEU or passengers) or gross tonnes for passenger ships
- D is the distance in nautical miles corresponding to the cargo carried or work done.

CFj itself is a non-dimensional conversion factor between fuel consumption measured in g and CO_2 emission also measured in g based on carbon content. According to IMO, the value of CF is as follows:

Table 2.1 Fuel to Mass Conversion Factor According to IMO

Type of Fuel	Reference	Carbon Content	CF (t-CO2/t-Fuel)
1. Diesel/Gas Oil	ISO 8217 Grades DMX through DMC	0.875	3.206000
2. Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.86	3.151040
3. Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.85	3.114400
4. Liquified Petroleum Gas (LPG)	Propane Butane	0.819 0.827	3.000000 3.030000
5. Liquified Natural Gas (LNG)		0.75	2.750000

2.2. TRIM CONDITION

Draught difference between bow and stern part of ship is described in quantity is called as trim. Whereas the displacement of a vessel is equal to the mass of water displaced by the ship. These two are in particular part of operation condition of ship that normally can be controlled by the relocation or charge-discharge of the ship's ballast water system.

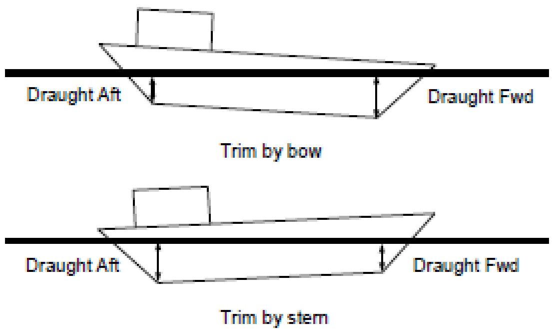


Figure 2.2 *Different Trim Condition of a Ship*

Source: *Pétursson, 2009*

The trim difference is shown as bellow:

$$Trim = T_{aft} - T_{fwd} \qquad [m]$$

Trim can be positive, negative or zero. In the trim condition, negative value is equivalent to the largest draught at the bow, where positive trim is equivalent to the largest draught at the stern and zero is the even keel condition of a ship.

Trim in special case are affected by the sea condition, such as strong waves, bad weather, etc. This condition will change dynamically and continuously.

2.2.1. EFFECT OF TRIM

Trim affects some ship's parameters. These are the parameters that affect by the trim condition of a ship:

- Wetted Surface Area (WSA)
- Water Line Length (LWL)
- Residual Resistance Coefficient (CR)
- Thrust Deduction
- Wake Fraction
- Propeller Efficiency

A study by Larsen (2014) about trim optimization shown that trim condition may variate in some variables, such as the wetted surface area. The variation in wetted surface due to trim relates in most cases to large flat stern area and is relatively small. It can up to 5% differences of even keel wetted surface and thereby varies the total resistance in the same variable.

Water line length in most cases also vary up to 5% differences from the even keel condition, the inverse proportionality may result in increase/decrease the propulsive power of 0.5% differences.

Residual coefficient (CR) is often claimed to be the parameter that affected by trim, where from previous analysis the residual resistance coefficient at trimmed condition may vary up to 150% from even keel condition, which can change to power requirement around 20%.

Thrust deduction and wake fraction is factors that affects hull efficiency. Where the value of thrust deduction factor will change with different trim condition. This may lead up to 3% power difference.

2.2.2. THEORY OF TRIM OPTIMIZATION

The hydrodynamic efficiency of a vessel can be manipulated by the trim of a ship. The difference in trim condition will affect the vessel performance, where in the correct trim condition it can improve the operational efficiency and reducing the fuel consumption of a ship, thereby reducing the emission (Sun, 2016). A study by Sun in 2016, applied in 4250-TEU container ship using Computational Fluid Dynamics (CFD) in conjunction with towing tank tests and real ship application. With the application of trim optimization in all-year-round operation mode in 4250-TEU container ship from Nansha Port, Guangzhou to Tianjin Port, the adoption of the optimal trim has helped the ship to achieve 5-8% of energy saving for its operation during the whole year with average of fuel consumption around 3.2 ton/day. CO2 emission using trim optimization also reduced by 9.96 ton/day. For economic analysis, if the ship operates for 200 days within the whole year, around 640 t fuel can be saved and the operational cost from fuel can be optimized up to 482.000 USD with assumption of fuel cost 750 USD per ton.

Another study done by Nur Salim (2014) and Margono (2016) using Holtrop Method, in a container ship, showing that by applying optimal trim condition in a ship can optimized the power used by engine and reduced the fuel oil consumption up to 2%

In the common way, vessels are optimized for a single condition, with parameter normally such as the contract speed at design draft. At the other speed and draft combinations, adjusting trim to the correct condition can often be used to reduce the hull resistance.

2.2.3. TRIM LIMIT

The trim limit of a ship is tolerated if the difference value between longitudinal center of buoyancy (LCB) and longitudinal center of gravity (LCG) are not exceed 1% of ship's longitudinal between perpendicular (LPP) (Andrianto,2013).

2.2.4. TRIM LIMIT FOR MAIN ENGINE AND AUXILIARY ENGINE

As the trim condition of the ship will impact on the main engine itself, thus there are some regulations regulate about the limit for main engine. According to Biro Klasifikasi Indonesia (BKI) Rules Volume III section 1.C.1.1. , the trim for main engine and auxiliary engine for static condition is 5 degree (where for ship with length more than 100m, the maximum trim is 500/L degree) and dynamic condition is 7.5 degree. 100 TEU's container ship is a ship with L=70, thus the trim allowed is 5 degrees.

2.3. SHIP RESISTANCE

The motion of the ship through water requires energy to overcome the resistance, where the total resistance itself consist of:

$$R\text{total} = R\text{hull} + R\text{wave} + R\text{wind}$$

The propulsive power (PD) is the one that able to move the ship through the incoming resistance, where the power itself affected by factor such as hull resistance (RT), speed (V) and propulsive efficiency (ηD). Here is the formula as shown below:

$$P\text{D} = \frac{RT\,.\,\text{V}}{\eta\text{D}}$$

The speed of the ship itself is kept constant at the service speed to fulfill the schedule, thus to reduce the propulsive power, the option is to reduce the resistance and/or increase the total efficiency of the ship.

Below is the illustration of the proportion of each resistance factor to the total factor:

Table 2.2 *Proportion of Each Factor to Total Resistance (Pétursson, 2009)*

Resistance	% of Total Resistance
Hull	45 – 90
Wind	5 – 45
Wave	2 – 10

2.3.1. RESISTANCE REDUCTION

According to ITTC (International Towing Tank Conference) standards, still water ship resistance described by this formula:

$$\text{Rhull} = {}^{1}/_{2} \cdot \rho \cdot V^2 \cdot S \cdot CT$$

In 1982, a journal named "An Approximate Power Prediction Method" made by J. Holtrop and G.G.J. Mennen, which the method is still widely used until today, explained about the total resistance factor of the ship using this formula:

$$RT = {}^{1}/_{2} \cdot \rho \cdot V^2 \cdot STot \cdot [CF\,(1+k) + CA\,) + \frac{Rw}{W}\,W$$

$$RT = RF\,(1+k) + RAPP + RW + RB + RTR + RA$$

Where:

RF = Frictional Resistance according ITTC 1957

1+k = Form Factor of Hull

RAPP = Appendage Resistance

RW = Wave Resistance

RB = Additional Pressure Resistance of Bulbous Bow near the water surface

RTR = Additional Pressure Resistance due to transom immersion

RA = Model-Ship correlation resistance

In the real sailing condition of a ship, the density of the sea water will remain constant. Therefore, to reduce the hull resistance of the ship, the possibilities are reduced the wetted surface area (S) and/or the total resistance coefficient (CT). The service speed of the ship itself must remain constant in order to fulfill the shipping schedule.

The total resistance coefficients are based on the formula bellow:

$$CT = CR + (1+k).CF0 + CA$$

Allowance coefficient (CA) normally remain at constant condition. Exception for ship with great variation of trim, such as VLCC ship at the loading-unloading condition.

The frictional resistance coefficient (CF0) varies according to the ITTC standards, with the Reynolds number (Re) flow along the hull:

$$CF0 = \frac{0.075}{(log10(Re)-2)^2}$$

Reynold number itself defined by:

$$Re = \frac{V.Lwl}{v}$$

From the formula above, it can be derived that the frictional resistance coefficient is a function of the water line length (Lwl). Where the viscosity (v) of the sea water will stay at the constant value in the same temperature condition.

The residual resistance coefficient (CR) is often claimed to be the parameter most affected by the trim, where the (1+k) normally assumed in constant condition.

2.4. PROPULSIVE EFFICIENCY

Ship propulsion efficiency is a function related with propeller open-water efficiency (ηD), hull efficiency (ηH), relative rotative efficiency (ηrr), shaft efficiency (ηS) and reduction gear efficiency (ηG).

2.4.1. HULL EFFICIENCY

Hull efficiency is a function of thrust deduction (t) and wake fraction (w). The formula of hull efficiency can be seen bellow:

$$\eta H = \frac{1-t}{1-w}$$

To gain more from the optimum trim, we can reduce the thrust deduction or/and increase the wake fraction.

Thrust deduction is a function of propeller thrust (T) and hull resistance.

$$t = \frac{T-Rt}{T}$$

While wake fraction is a function of ship speed and the speed of current through propeller.

$$w = \frac{V-V_A}{V}$$

2.4.2. PROPELLER EFFICIENCY

Propeller efficiency can be determined through open water curve. Open water curve plotted as the function of advance ratio, where (n) is the rotation of propeller and (D) is the diameter of propeller.

$$J = \frac{V_A}{n\,.D}$$

2.4.3. RELATIVE ROTATIVE EFFICIENCY

Relative rotative efficiency is a ratio between the moment of propeller at open water condition (Qow) and behind the ship condition (Qship).

$$\eta rr = \frac{Qow}{Qship}$$

2.4.4. SHAFT EFFICIENCY

As if the engine room located at the stern part of the ship, there will be losses as much as 2%. As if the engine room located at the midship, there will be losses as much as 3% (Principal of Naval Architecture Vol.2.). Since the engine room of 100 TEU's container ship owned by Kementerian Perhubungan Republik Indonesia located at the stern side of ship, thus the loss is 2%.

2.5. PROPULSIVE POWER AT SHIP

The propulsive power (*P*D) is the one that able to move the ship through the incoming resistance. The power delivered from propulsive power (*P*D) come from shaft horse power (*P*S). Where the main source is come from break horse power (*P*B) of main engine.

2.5.1. EFFECTIVE HORSE POWER (EHP)

Effective horse power is the required power to overcome the incoming resistance with the designed service speed.

$$EHP = RT \cdot Vs$$

Where:

RT	= Total resistance of ship	(N)
Vs	= Service speed	(knot)

2.5.2. THRUST POWER (PT)

Thrust power is the power produced by the propeller.

$$PT = T \cdot Va$$

Where:

PT	= Thrust Power	(kW)
T	= Thrust Force	(kN)
Va	= Advanced Fluid Current Speed in Stern	(m/s)

2.5.3. DELIVERED HORSE POWER (DHP)

Delivered horse power is the power delivered by propeller to the water.

$$DHP = EHP / \eta D$$

Where:

ηD = Propeller Efficiency

2.5.4. SHAFT HORSE POWER (SHP)

$$SHP = DHP / \eta S$$

Where:

ηS = Shaft Efficiency

2.5.5. BRAKE HORSE POWER (BHP)

Brake Horse Power is the power produced by the main engine to move the ship in her service speed.

$$BHP = DHP / \eta t$$

ηt = Reduction Gear Efficiency

2.6. FUEL OIL CONSUMPTION

Specific fuel oil consumption depends on the torque produced by the main engine for each of fuel injected to the combustion process. For each different load, the fuel oil consumption shall be different as well.

$$Whfo = P \,.\, SFOC \,.\, t \,.\, C \,.\, 10^{-6}$$

Where:

P	= Main Engine Power	(kW)
SFOC	= Specific Fuel Oil Consumption	(g/kWh)
T	= Voyage Duration	(hour)
C	= Constant Addition of Fuel	(1.3 – 1.5)

2.7. SHIP STABILITY

Stability is an important factor to keep the safety and reliability of a ship, where a bad stability of a ship might lead to an accident. Stability is the ability of ship to return to the start point after received external force that make the ship in a tilt condition. The external force can come from wind, wave, etc.

Factors that influence ship stability is center of gravity (G), center of buoyancy (B) and metacenter (M). Ship stability itself can be divided into stable equilibrium, neutral equilibrium and unstable equilibrium.

2.7.1. BUOYANCY

A buoyancy force applied on a floating object, where an upward force by fluid opposes the weight of immersed object. The force of an object downward caused by the gravity (g) and the mass of the object (M). This force is called as Mg, where if the object floating, thus there is an equilibrium force that work upward as much as Mg. The force that work upward is called as buoyancy. The formula to calculate the buoyancy is as follow:

$$B = \rho.V.g$$

Where:

B	= Buoyant Force	(N)
ρ	= Density	(kg/m3)
V	= Displaced body of object	(kg/m3)
g	= 9,806	m/s^2

2.7.2. CENTER OF GRAVITY

Center of gravity in ship (G) can be imagined as a point, where the whole weight of the object may be regarded as acting. If the object is suspended from center of gravity, then it will remain balanced and will not tilt. The location of center of gravity itself can be found through observe the distribution of weight on ship. The location of center of gravity at an empty ship can be found through experiment. Thereby, as long as there is not any object movement in ship, location of center of gravity will not change in a shaky condition.

The following figures describe the movement of center of gravity of vessel:

The center of gravity moves towards an added weight. See figure 2.3.

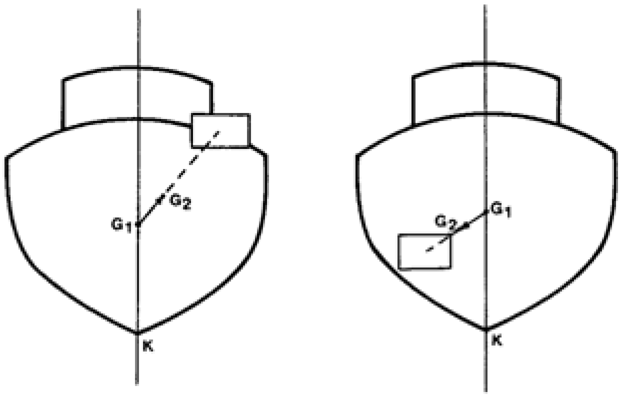


Figure 2.3 *Weight Added to Ship*

Source: www.splashmaritime.au

The center of gravity moves away from a discharged weight. See figure 2.4.

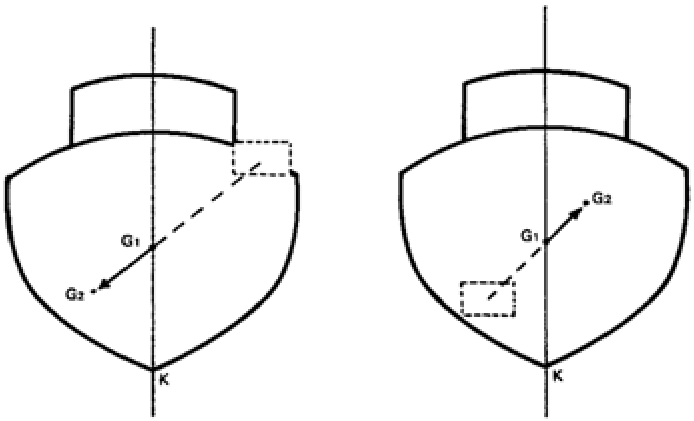


Figure 2.4 *Weight Removed from Ship*

Source: www.splashmaritime.au

The center of gravity moves parallel to the movement of a weight that already on board. See figure 2.5.

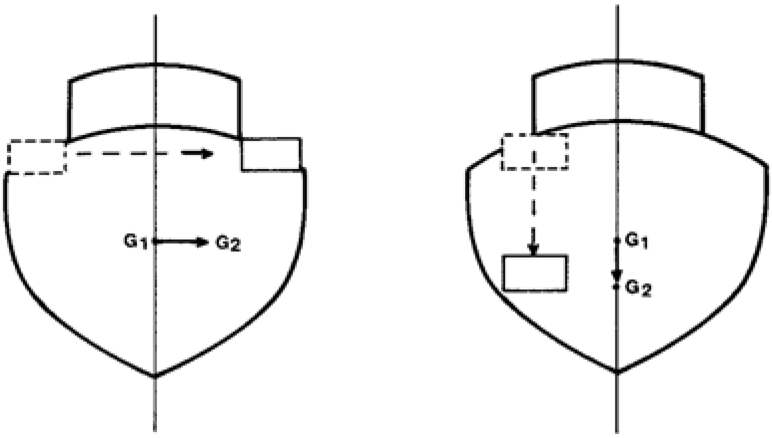


Figure 2.5 *Shifting Weights*

Source: www.splashmaritime.au

The movement of center of gravity is depend upon:

1. Size of weight moved
2. Distance between center of gravity of ship and center of gravity of object
3. Displacement of ship

2.7.3. METACENTER (M)

Buoyancy acts vertically upwards through the center of buoyancy as shown and cuts the center line of the vessel at a point called the metacenter (M). The initial position of metacenter is determined by the shape of the underwater portion of hull. It is a theoretical point at which an imaginary vertical line passing the center of buoyancy and the center of gravity intersects the imaginary vertical line through a new center of buoyancy created when the body is displaced or tipped in the water. The distance from G to M is called the metacentric height (GM).

2.8. EQUILIBRIUM

The ship stability depends on three main factors, which is center of gravity (G), buoyancy (B) and metacenter height (GM). Equilibrium itself used to describe a vessel that is a float, where the weight and buoyancy are equal and balance – that the B and G are in the same vertical line and the ship is not being aced on by an external force.

2.8.1. STABLE EQUILIBRIUM

A vessel which tend to return to the start condition after being heeled by an external force. The G is located under M, where at this condition MG is positive and the ship is in a stable condition. In the figure 2.6. we can see a stable condition where G is located under M.

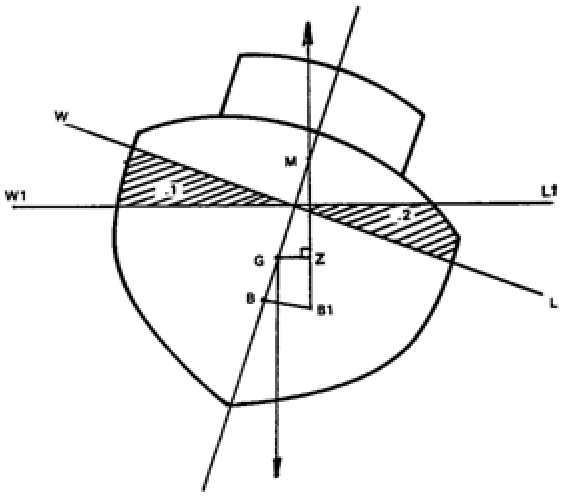


Figure 2.6 *Stable Equilibrium*

Source: www.splashmaritime.au

2.8.2. UNSTABLE EQUILIBRIUM

In this condition, M is located under the G, as we can see in figure 2.7. If this happened, thus the ship is said to be in unstable equilibrium. It will not remain upright. As there is external force hit the ship, it will not able to return to the start position, since the ship don't have the required returning moment.

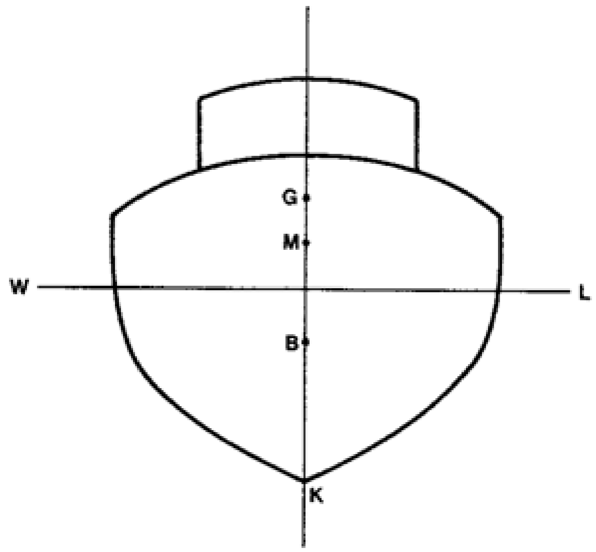


Figure 2.7 *Unstable Equilibrium*

Source: www.splashmaritime.au

2.8.3. NEUTRAL EQUILIBRIUM

If G and M coincide, as shown in figure 2.8. then, theoretically the ship will have no reason to remain upright. As there is external force hit the ship, it will have no tendency to hell further or return to the upright. The unsafe state is called as loll.

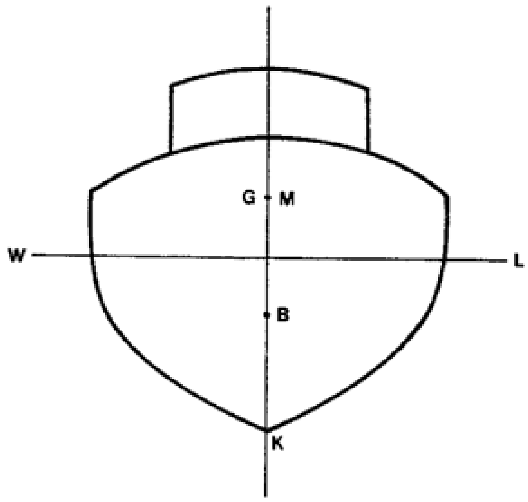


Figure 2.8 *Neutral Equilibrium*

Source: www.splashmaritime.au

2.8.4. CALCULATING LOADING AND UNLOADING OF WEIGHTS

The amount that center of gravity of vessel is shifted by loading of a weight can be calculated by this formula:

$$\frac{Distance\ from\ VCG\ x\ weight\ added}{Weight\ of\ vessel + weight\ added} = \text{Change in meters of vertical center of gravity}$$

The amount that center of gravity of vessel is shifted by unloading of a weight can be calculated by this formula:

$$\frac{Distance\ from\ VCG\ x\ weight\ added}{Weight\ of\ vessel - weight\ added} = \text{Change in meters of vertical center of gravity}$$

2.9. LONGITUDINAL STABILITY

Parameters such as center of gravity and center of buoyancy have been used in describing transverse stability, while they can be used to describe longitudinal stability.

2.9.1. LCB AND LCG

LCB is the longitudinal center of buoyancy. This is the longitudinal center of underwater volume and is the point which all buoyancy can be said to act vertical upwards.

LCG is the longitudinal center of gravity. This is the point which all weight of the ship act vertically downwards.

If the position of LCG and LCB are as shown in figure 2.9. then the actions of buoyancy and weight will cause the ship to rotate as shown by the arrow. The stern will sink deeper and the bow will rise higher. It will cause trim by stern. LCB is the longitudinal center of all underwater volume. As the vessel rotates, the shape of the underwater volume will change and LCB will move to the new point.

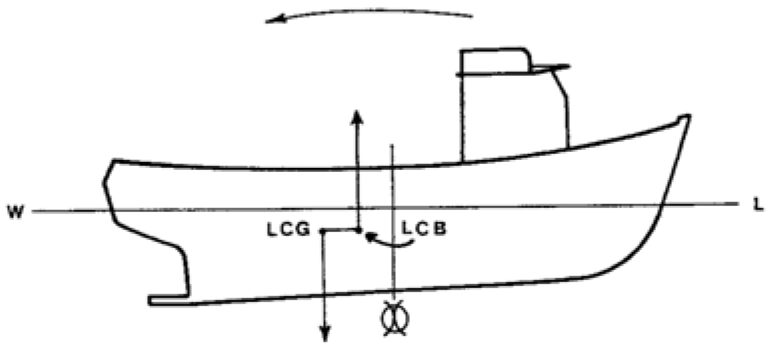


Figure 2.9 *Trim by Stern – LCB Forward of LCG*

Source: www.splashmaritime.au

When the LCG and LCB in the same vertical line, the rotation will stop and the vessel will be in a no trimming moment condition, such as shown in figure 2.10.

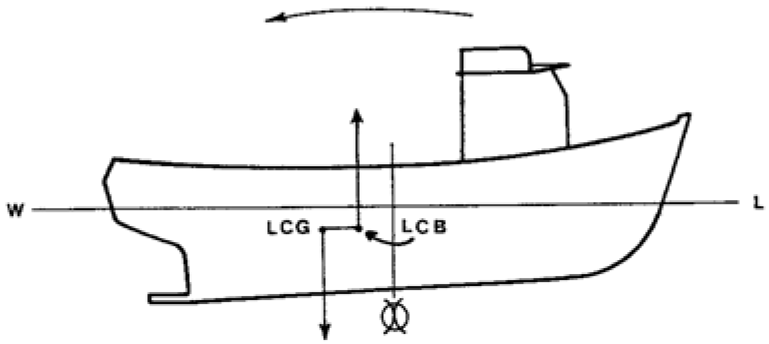


Figure 2.10 *No Trimming Moment – LCB in Same Vertical Line as LCG*

Source: www.splashmaritime.au

Where the vessel had started with LCB aft of LCG as shown in figure 2.11. then the rotation would cause a trim by bow.

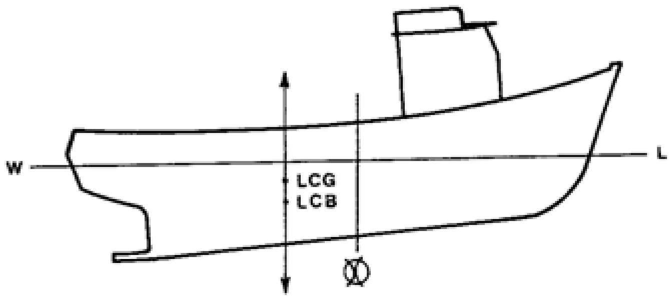


Figure 2.11 *Trim by Bow – LCB aft of LCG*

Source: www.splashmaritime.au

2.10. ALGORITHM

Algorithm is a detailed series or steps to solve problems or carrying out an operation, where it having the ability to perform calculation, data processing and automated reasoning task. The instruction designed to perform such as specific task, which can be a simple process or complex situation. Algorithm can be used to manipulate data in various ways, such as inserting new data item, searching for a particular item or sorting an item.

Algorithm design is a method or mathematical process for problem solving. The design itself also called as algorithm design patterns, template method pattern and decorator pattern. In the developments of algorithm, there are several typical steps:

a. Problem Definition
b. Development of Model
c. Specification o Algorithm
d. Designing Algorithm
e. Checking Correctness of Algorithm
f. Analysis of Algorithm
g. Implementation of Algorithm
h. Program Testing
i. Documentation Preparation

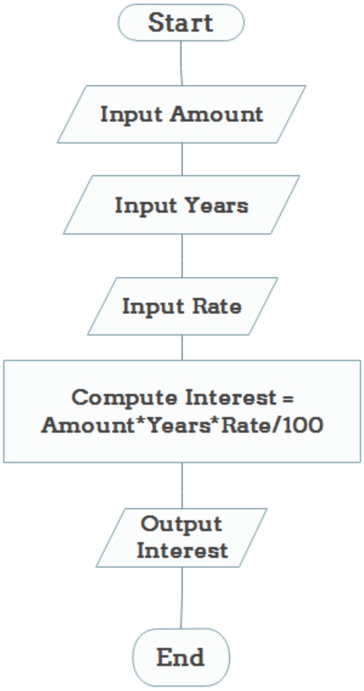


Figure 2.12 *Example of Simple Algorithm*

Source: https://www.edrawsoft.com/algorithm-flowchart-examples.php

2.10.1. C# LANGUAGE

C# is a modern object-oriented programming language developed in 2000 as a rival to Java language. C# has grown quickly since it was first created and become one of the most popular programming languages with the support from Microsoft. C# can be used to create Windows desktop applications and games. C# can be used to develop web applications and become increasingly popular for mobile development.

C# improved and updated many C and C++ language features. C# has a huge standard library that well-implemented and easy to use. It is also supporting an easier GUI creation in C#.

2.10.2. LOOPS IN C#

Looping is an essential technique when writing a software code. Loops is the ability to repeat a block of code or command for several times until the required situation achieved. In C# there are 4 variants of loops that can be applied.

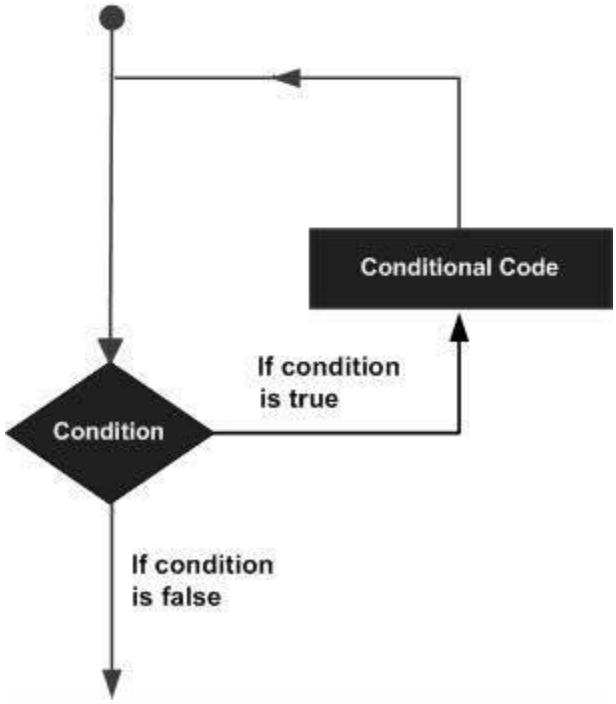


Figure 2.13 *Flow Diagram using Looping Code*

Source: https://www.tutorialspoint.com/csharp/csharp_loops.htm

The loop type itself are:

- While Loop
- For Loop
- Do...While Loop
- Nested Loop

2.10.3. WHILE LOOP

The while loop is the simplest one that will execute a block of code as long as the condition given is true. It repeats a statement or group statements while a given condition is true. It tests the condition before executing the loop body.

```
using System;

namespace ConsoleApplication1
{
    class Program
    {
        static void Main(string[] args)
        {
            int number = 0;

            while(number < 5)
            {
                Console.WriteLine(number);
                number = number + 1;
            }

            Console.ReadLine();
        }
    }
}
```

Figure 2.14 *Example of While Loop Code*

In this example the loops work for listing number from 0 to 4. The number is defined as 0 and each time the code in the loop executed, it is incremented by one.

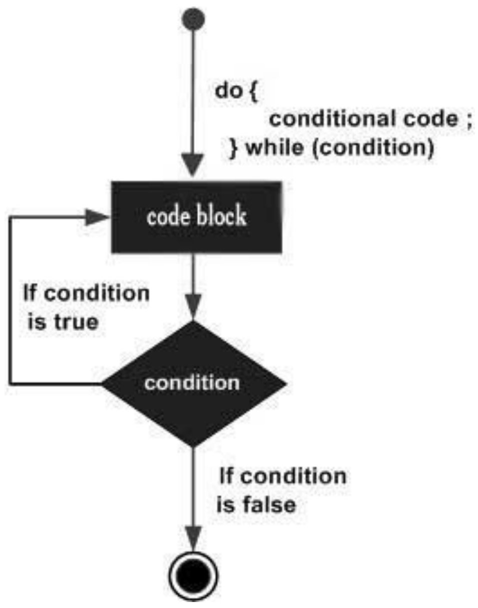


Figure 2.15 *Flow Diagram of While Loop Code*

Source: https://www.tutorialspoint.com/csharp/csharp_loops.htm

2.10.4. DO LOOP

The do loop works like the while loop in other aspects through. It is evaluating the condition after the loop has executed.

```
do
{
    Console.WriteLine(number);
    number = number + 1;
} while(number < 5);
```

Figure 2.16 *Example of Do Loop Code*

The for loop executes a sequence of statements multiple times and abbreviates the code that manages the loop variable.

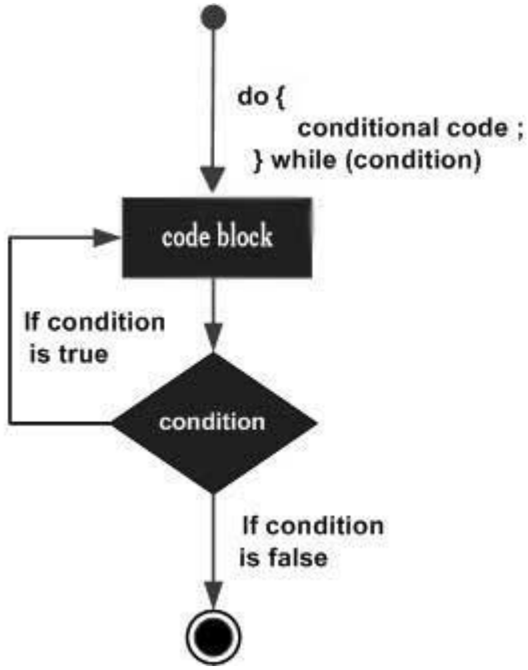


Figure 2.17 *Flow Diagram using Do Loop Code*

Source: https://www.tutorialspoint.com/csharp/csharp_loops.htm

2.10.5. FOR LOOP

For Loop is a repetition control structure that allows to efficiently write a loop that needs to execute a specific number of times. The initial step is executed first and only once to declare and initialize any loop control variables. Next the condition is evaluated, if true, then the loop is executed, where if its is false, the loop does not execute and jumps to the next statement just after the loop.After the body loop executes, the flow of control jumps back to increment state, where this state allow update any loop control variables. The condition is now evaluated again.

```
using System;

namespace ConsoleApplication1
{
    class Program
    {
        static void Main(string[] args)
        {
            int number = 5;

            for(int i = 0; i < number; i++)
                Console.WriteLine(i);

            Console.ReadLine();
        }
    }
}
```

Figure 2.18 *Example of For Loop Code*

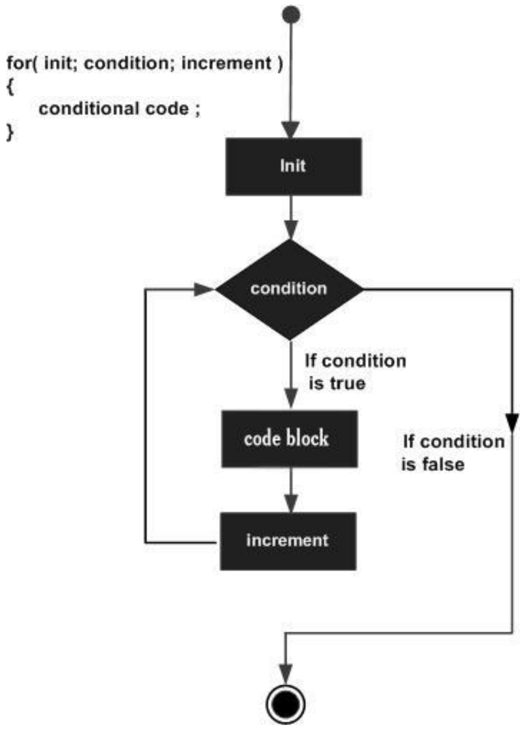


Figure 2.19 *Flow Diagram using For Loop Code*

Source: https://www.tutorialspoint.com/csharp/csharp_loops.htm

The process produces the same output as the previous loop, but the loop is more compact. It consists of 3 parts, which is variable counting, conditional statement and increment counter.

2.10.6. NESTED LOOP

C# allows to use one loop inside another loop. In the nested loop, it is allowed to use nested for loop, nested while loop and nested do… while loop. A final note on loop nesting is that any type of loop can be placed inside of any other type of loop. For example, a for loop can be inside a while loop or vice versa.

2.11. EXCEL READER C#

In the C# there is a feature to read excel format to the Microsoft Visual Studio software. This feature allows the user to find the named ranges in excel and get the range of used area in excel sheet.

```
Excel.Application xlApp = new
Excel.Workbook xlWorkBook ;
Excel.Worksheet xlWorksheet ;
Excel. Range range ;

xlApp = new Excel.Application();
xlWorkBook = xlApp.Workbooks.Open(@”e:”\TA_Titus_Trim-
Excel.xls”,0,true,
xlWorkSheet = (Excel.Worksheet)xlWorkBook.Worksheets.get_Item(1);
```

Figure 2.20 *Initialize Excel to C#*

CHAPTER III: METHODOLOGY

Methodology represents of the basic framework from stages to finish the final project. The methodology of this final project cover all of the activity that supports the completion of this final project. The stages of this methodology are as follows:

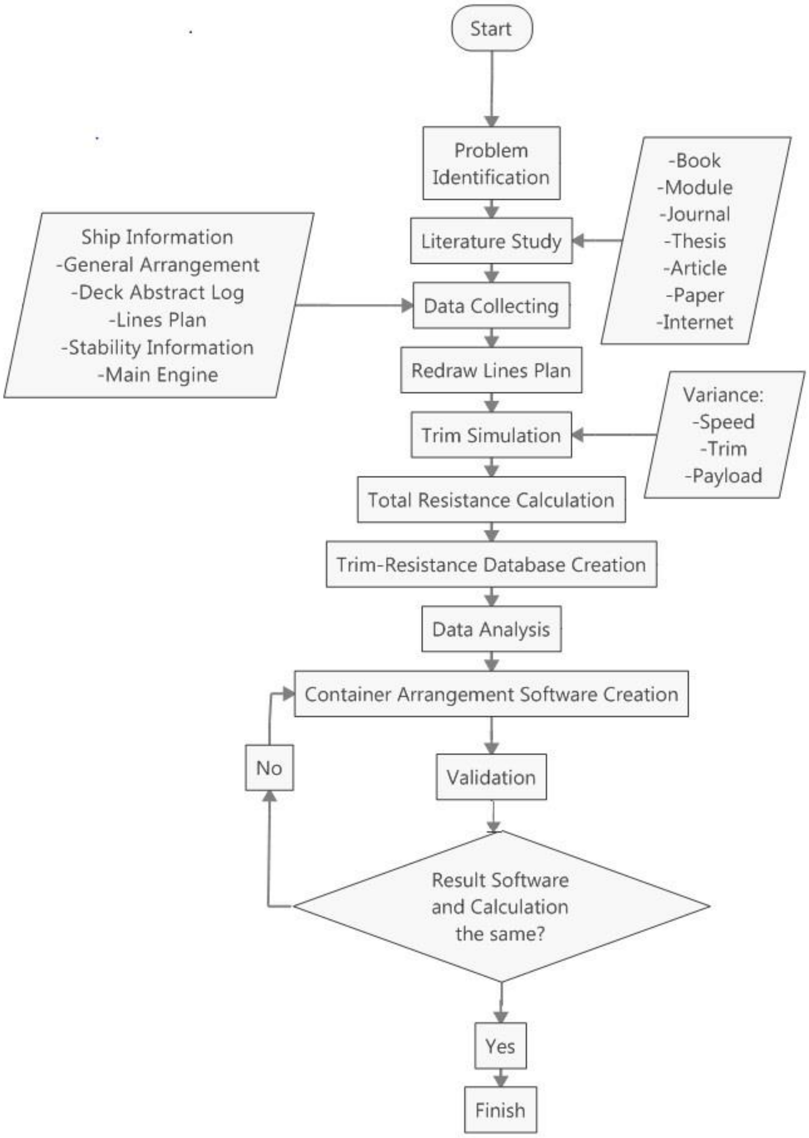


Figure 3.1 *Methodology Chart*

3.1. PROBLEM IDENTIFICATION

The first step in this final project is to determine the existing problem. Whereas after the problem found, thereby the object of the research can be specified. The object research taken on this final project is a container ship. Resistance is the most important factor that connected with the power of the main engine, where the power required by the main engine itself will affect the requirement of the fuel oil usage. Thereby trim optimization become the focus in this research, where an optimum trim optimization can reduce the resistance, which shall take effect on less fuel oil consumption.

While after find out the optimum trim condition, there come another problem. How to arrange the cargo to obtain the optimum trim still become a problem for the crew of the ship, where it require calculation to achieve such as a condition. Recognizing this problem, in this opportunity the writer tries to create a software that can show where the optimum trim condition is, as well as the container arrangement recommendation on 100 TEU's container ship owned by Kementerian Perhubungan Republik Indonesia to achieve such as condition.

3.2. LITERATURE STUDY

In the literature study phase, the writer collected and study more about theories from reference that focused about trim, effect of trim, ship resistance, fuel oil consumption and ship stability. The reference itself came from many medias, such as:

- Book
- Learning Module
- Journal
- E-Book
- Research Paper
- Final Projects
- Article
- Internet

Where in this phase, the writer focused on:

- Studying how to calculate the ship resistance using Holtrop-Mennen method.
- Studying about trim on ship and the effect on resistance.
- Studying about fuel oil consumption calculation.
- Studying about the ship stability.
- Studying about software that related on ship resistance and stability.
- Studying from research that focused on trim and the effect on ship's resistance.

3.3. DATA COLLECTING

The data in this research play important role, where the required data shall relevant and includes all aspect according to the trim optimization. The required data in this final project such as:

- Lines Plan
- General Arrangement
- Deck Abstract Log
- Stability Information for Master and Loading Manual
- Main Engine Specification
- Payload and LWT
- Route

3.4. REDRAW LINES PLAN

After received the required data about lines plan, the next phase to redraw the lines plan can proceed. The redraw of lines plan in this phase shall use software Autocad. The finished redraw from autocad later on can be exported in some software related with ship resistance and stability.

3.5. TRIM SIMULATION AND RESISTANCE CALCULATION

Using the redraw lines plan from Autocad, we can apply it to Maxsurf Modeller software. Where in this final project the scale used is 1:1, which mean it is the same as the real ship's condition. Model used is the whole hull of the ship up to main deck. In this step, trim simulations shall be done using variance such as speed, degree of trim and the payload in accordance with ship's resistance, where we can also connect it with the required power to move the ship.

3.6. TRIM-RESISTANCE DATA BASE CREATION AND DATA ANALYSIS

The result from the previous trim simulations using various variance and condition shall be recorded. After the data base finished, it shall be used as the basic data for Software Development, thus the analysis shall be done in order to achieve the required formula to create the software.

3.7. SOFTWARE DEVELOPMENT

Using the created data base and analyzed formula, the software shall be created using XY method. The software itself shall contain the information about recommended optimum trim condition and ship container arrangement to achieve such as condition. As the input data itself using variance such as ship speed and payload. The software shall also show the fuel consumption and resistance difference before and after the trim optimization condition.

3.8. VALIDATION

In this phase, the software shall be tested and validate it using the created database. As there still difference, thus further repair in the software must be done. The result from the software must show the same result as shown in the database of trim-resistance created using simulation in Maxsurf Modeller software.

CHAPTER IV: ANALYZE

4.1. SHIP PRINCIPAL DIMENSION

The ship analyzed in this bachelor thesis is a currently built ship owned by Kementerian Perhubungan Republik Indonesia. This ship is a 100 TEU's container ship with data such as:

Table 4.1 *Ship Principal Dimension*

Compulsory Information		
Builders	:	PT. Daya Radar Utama
LoA	:	74.3 m
Lpp	:	70 m
Breadth	:	17.2 m
Depth	:	5.6 m
Draft	:	3.5 m
Displacement	:	3109 ton
WL	:	71.8 m
Wetted Area	:	1353.855 m2
Waterplan Area	:	1082 m2
Tpc	:	11.099 tonne/cm
Lwt	:	1018 ton
Class	:	BKI

4.2. SHIP MODELLING

From the data collected, the next step is to create the model of the ship. The purpose of create the model is to analyze the effect of the speed, payload and degree of trim to the resistance of ship. To analyze the resistance of the ship, the software used in this bachelor degree thesis is Maxsurf Modeller, Maxsurf Resistance and Maxsurf Stability. The first step is to remodel the design of ship from Autocad 2017 to 3D design in Maxsurf Modeller.

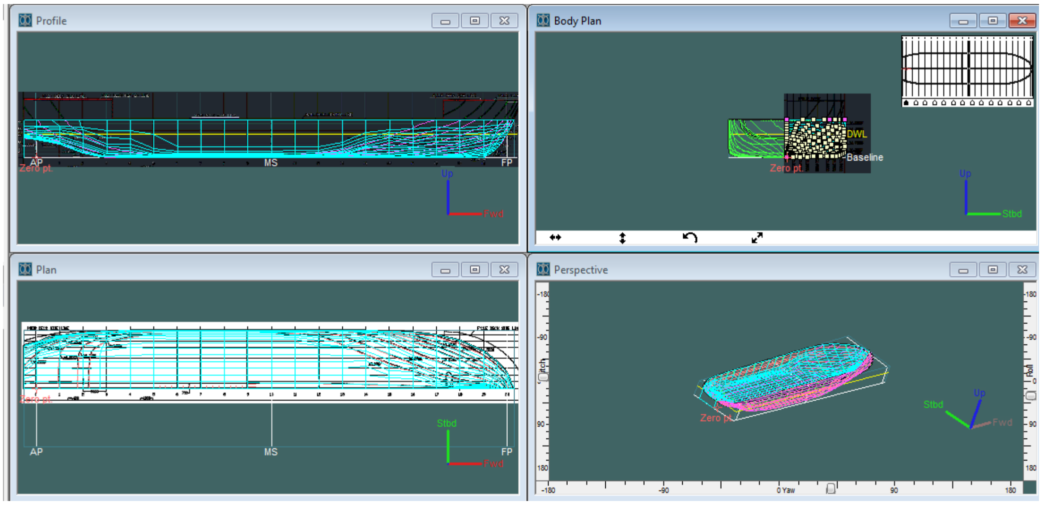


Figure 4.1 *Ship Redrawing Process in Maxsurf Modeller*

From the Autocad 2017 redrawing, we can see the 3 D version of the ship in Maxurf Modeller.

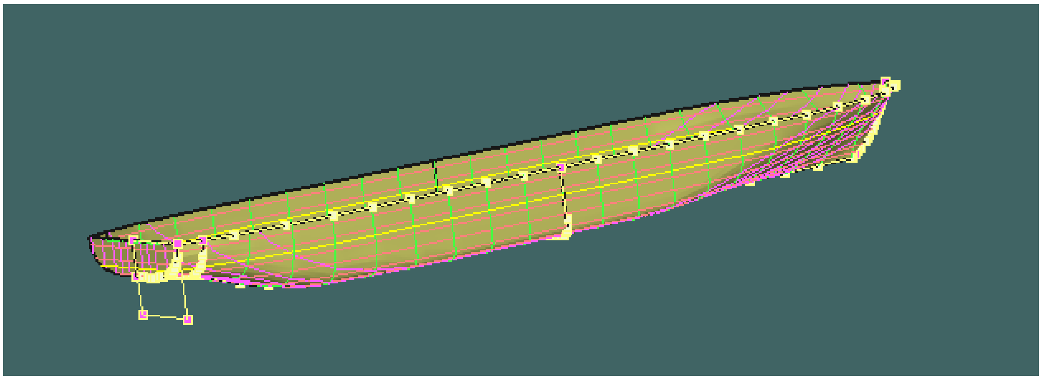


Figure 4.2 *Ship 3-D Model in Maxsurf Modeller*

From the model in Maxsurf Modeller, further analysis can be done in Maxsurf Resistance and Maxsurf Stability to analyze the resistance and stability of ship. In this modelling the real condition of tank location also applicated, thus a simulation of the ship can be as close as possible as the real ship condition.

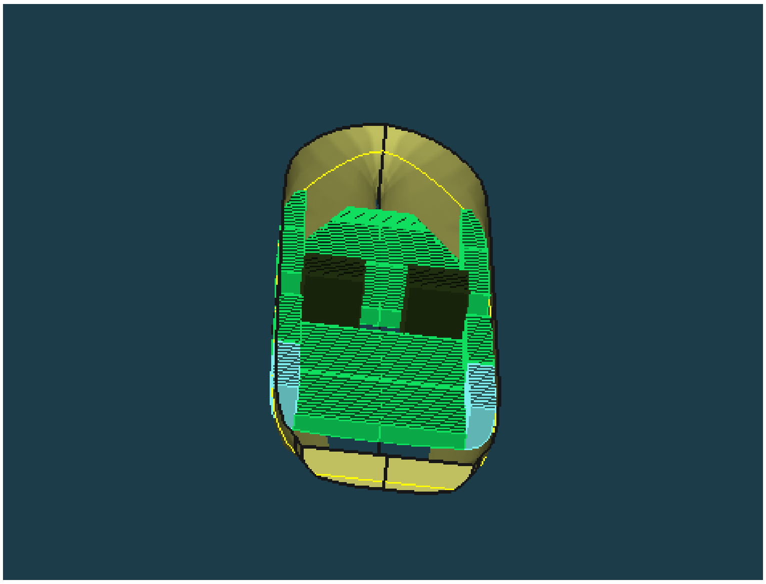
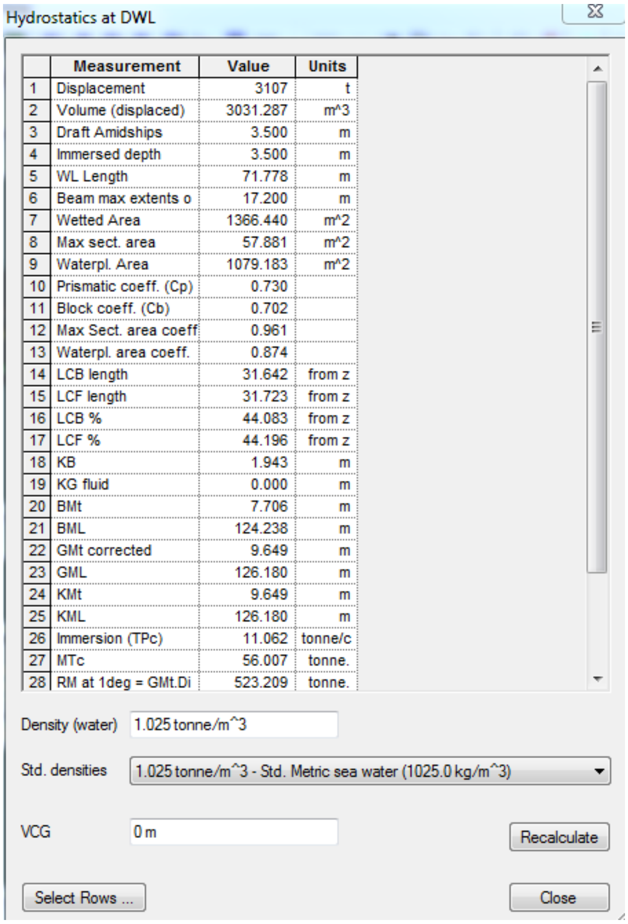


Figure 4.3 *Ship 3-D Tanks Location in Maxsurf Stability*

With the modelling of the ship, the next step is to check the hidrostatic data of the ship itself. This step can be done using Maxsurf Modeller. Maxsurf Modeller feature allow us to obtain the hydrostatics data of ship, such as displacement, draft of the ship, water plan area, TPC, beam,etc.



	Measurement	Value	Units
1	Displacement	3107	t
2	Volume (displaced)	3031.287	m^3
3	Draft Amidships	3.500	m
4	Immersed depth	3.500	m
5	WL Length	71.778	m
6	Beam max extents o	17.200	m
7	Wetted Area	1366.440	m^2
8	Max sect. area	57.881	m^2
9	Waterpl. Area	1079.183	m^2
10	Prismatic coeff. (Cp)	0.730	
11	Block coeff. (Cb)	0.702	
12	Max Sect. area coeff	0.961	
13	Waterpl. area coeff.	0.874	
14	LCB length	31.642	from z
15	LCF length	31.723	from z
16	LCB %	44.083	from z
17	LCF %	44.196	from z
18	KB	1.943	m
19	KG fluid	0.000	m
20	BMt	7.706	m
21	BML	124.238	m
22	GMt corrected	9.649	m
23	GML	126.180	m
24	KMt	9.649	m
25	KML	126.180	m
26	Immersion (TPc)	11.062	tonne/c
27	MTc	56.007	tonne.
28	RM at 1deg = GMt.Di	523.209	tonne.

Figure 4.4 *Hydrostatics Data Analysis in Maxsurf Modeller*

Knowing the ship principal dimension and the dimension on the model, thereby a comparation between these two data can be done. The percentage of difference between the model and the real ship dimension can be seen bellow:

Table 4.2 *Comparison of Design from Shipyard and Maxsurf Redraw*

Compulsory Information			Redraw	Margin
Builders	:	PT. Daya Radar Utama		
LoA	:	74.3	74.3	0 %
Lpp	:	70	70	0 %
Breadth	:	17.2	17.2	0 %
Depth	:	5.6	5.6	0 %
Draft	:	3.5	3.5	0 %
Displacement	:	3109	3107	0.06432937 %
WL	:	71.8	71.778	0.03064067 %
Wetted Area	:	1353.855	1366	-0.897068 %
Waterplan Area	:	1082	1079	0.27726433 %
Tpc	:	11.099	11.062	0.33336337 %

4.3. TRIM VARIATIONS

In this bachelor thesis proposal, the research focused on the effect of different trim condition to ship resistance. After knowing the optimum trim condition, then the arrangement of container shall be analyzed to achieve such as condition.

In this phase, the trim variations limited into 17 conditions, where 8 trims by bow conditions, 8 trims by stern conditions and even keel condition.

Trim variation created using Maxsurf Stability software, with 12 different displacement conditions, which are: 3107 ton (100% Δ), 2951 ton (95% Δ), 2796 ton (90% Δ), 2640 ton (85% Δ), 2485 ton (80% Δ), 2330 ton (75% Δ), 2174 ton (70% Δ), 2019 ton (65% Δ) and 1864 ton (60% Δ).

Table 4.3 *Trim Variation at 100% Displacement*

	100% Displacement (3107 ton)																
	Trim by Stern								E.K.	Trim by Bow							
Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trim(degree)	1.3	1.14	0.98	0.81	0.65	0.49	0.32	0.16	0	-0.16	-0.32	-0.49	-0.65	-0.81	-0.98	-1.14	-1.3
Trim (m)	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Ta (m)	4.2	4.12	4.03	3.944	3.86	3.77	3.675	3.585	3.5	3.4	3.313	3.221	3.129	3.037	2.944	2.85	2.755
Tf (m)	2.6	2.72	2.83	2.944	3.06	3.17	3.275	3.385	3.5	3.6	3.713	3.821	3.929	4.037	4.144	4.25	4.355
T midship (m)	3.4	3.42	3.43	3.444	3.46	3.47	3.475	3.485	3.5	3.5	3.513	3.521	3.529	3.537	3.544	3.55	3.555
Displacement	3107																

Table 4.4 *Trim Variation at 95% Displacement*

	95% Displacement (2951 ton)																
	Trim by Stern								E.K.	Trim by Bow							
Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trim(degree)	1.3	1.14	0.98	0.81	0.65	0.49	0.32	0.16	0	-0.16	-0.32	-0.49	-0.65	-0.81	-0.98	-1.14	-1.3
Trim (m)	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Ta (m)	4.064	3.976	3.89	3.8	3.71	3.62	3.533	3.443	3.353	3.263	3.172	3.08	2.989	2.896	2.803	2.708	2.613
Tf (m)	2.464	2.576	2.69	2.8	2.91	3.02	3.133	3.243	3.353	3.463	3.572	3.68	3.789	3.896	4.003	4.108	4.213
T midship (m)	3.264	3.276	3.29	3.3	3.31	3.32	3.333	3.343	3.353	3.363	3.372	3.38	3.389	3.396	3.403	3.408	3.413
Displacement	2951																

Table 4.5 *Trim Variation at 90% Displacement*

	90% Displacement (2796 ton)																
	Trim by Stern								E.K.	Trim by Bow							
Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trim(degree)	1.3	1.14	0.98	0.81	0.65	0.49	0.32	0.16	0	-0.16	-0.32	-0.49	-0.65	-0.81	-0.98	-1.14	-1.3
Trim (m)	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Ta (m)	3.919	3.832	3.75	3.657	3.57	3.48	3.391	3.302	3.212	3.121	3.031	2.939	2.847	2.754	2.66	2.565	2.47
Tf (m)	2.319	2.432	2.55	2.657	2.77	2.88	2.991	3.102	3.212	3.321	3.431	3.539	3.647	3.754	3.86	3.965	4.07
T midship (m)	3.119	3.132	3.15	3.157	3.17	3.18	3.191	3.202	3.212	3.221	3.231	3.239	3.247	3.254	3.26	3.265	3.27
Displacement	2796																

Table 4.6 *Trim Variation at 85% Displacement*

	85% Displacement (2640 ton)																
	Trim by Stern								E.K.	Trim by Bow							
Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trim(degree)	1.3	1.14	0.98	0.81	0.65	0.49	0.32	0.16	0	-0.16	-0.32	-0.49	-0.65	-0.81	-0.98	-1.14	-1.3
Trim (m)	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Ta (m)	3.773	3.686	3.6	3.511	3.42	3.34	3.247	3.157	3.068	2.978	2.887	2.795	2.702	2.609	2.515	2.42	2.324
Tf (m)	2.173	2.286	2.4	2.511	2.62	2.74	2.847	2.957	3.068	3.178	3.287	3.395	3.502	3.609	3.715	3.82	3.924
T midship (m)	2.973	2.986	3	3.011	3.02	3.04	3.047	3.057	3.068	3.078	3.087	3.095	3.102	3.109	3.115	3.12	3.124
Displacement	2640																

Table 4.7 *Trim Variation at 80% Displacement*

	80% Displacement (2485 ton)																
	Trim by Stern								E.K.	Trim by Bow							
Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trim(degree)	1.3	1.14	0.98	0.81	0.65	0.49	0.32	0.16	0	-0.16	-0.32	-0.49	-0.65	-0.81	-0.98	-1.14	-1.3
Trim (m)	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Ta (m)	3.625	3.539	3.45	3.366	3.28	3.19	3.102	3.013	2.92	2.833	2.742	2.649	2.556	2.463	2.368		
Tf (m)	2.025	2.139	2.25	2.366	2.48	2.59	2.702	2.813	2.92	3.033	3.142	3.249	3.356	3.463	3.568		
T midship (m)	2.825	2.839	2.85	2.866	2.88	2.89	2.902	2.913	2.92	2.933	2.942	2.949	2.956	2.963	2.968		
Displacement	2485																

Table 4.8 *Trim Variation at 75% Displacement*

	75% Displacement (2330 ton)																
	Trim by Stern								E.K.	Trim by Bow							
Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trim(degree)	1.3	1.14	0.98	0.81	0.65	0.49	0.32	0.16	0	-0.16	-0.32	-0.49	-0.65	-0.81	-0.98	-1.14	-1.3
Trim (m)	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Ta (m)	3.447	3.391	3.31	3.218	3.13	3.04	2.956	2.867	2.77	2.666	2.594	2.501	2.408	2.314			
Tf (m)	1.847	1.991	2.11	2.218	2.33	2.44	2.556	2.667	2.77	2.866	2.994	3.101	3.208	3.314			
T midship (m)	2.647	2.691	2.71	2.718	2.73	2.74	2.756	2.767	2.77	2.766	2.794	2.801	2.808	2.814			
Displacement	2330																

Table 4.9 *Trim Variation at 70% Displacement*

	70% Displacement (2174 ton)																
	Trim by Stern								E.K.		Trim by Bow						
Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trim(degree)	1.3	1.14	0.98	0.81	0.65	0.49	0.32	0.16	0	-0.16	-0.32	-0.49	-0.65	-0.81	-0.98	-1.14	-1.3
Trim (m)	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Ta (m)	3.326	3.241	3.16	3.069	2.98	2.89	2.806	2.717	2.62	2.535	2.443	2.305					
Tf (m)	1.726	1.841	1.96	2.069	2.18	2.29	2.406	2.517	2.62	2.735	2.843	2.905					
T midship (m)	2.526	2.541	2.56	2.569	2.58	2.59	2.606	2.617	2.62	2.635	2.643	2.605					
Displacement	2174																

Table 4.10 *Trim Variation at 65% Displacement*

	65% Displacement (2019 ton)																
	Trim by Stern								E.K.		Trim by Bow						
Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trim(degree)	1.3	1.14	0.98	0.81	0.65	0.49	0.32	0.16	0	-0.16	-0.32	-0.49	-0.65	-0.81	-0.98	-1.14	-1.3
Trim (m)	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Ta (m)	3.174	3.089	3	2.918	2.83	2.74	2.654	2.564	2.474	2.382	2.29						
Tf (m)	1.574	1.689	1.8	1.918	2.03	2.14	2.254	2.364	2.474	2.582	2.69						
T midship (m)	2.374	2.389	2.4	2.418	2.43	2.44	2.454	2.464	2.474	2.482	2.49						
Displacement	2019																

Table 4.11 *Trim Variation at 60% Displacement*

	60% Displacement (1864 ton)																
	Trim by Stern								E.K.	Trim by Bow							
Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trim(degree)	1.3	1.14	0.98	0.81	0.65	0.49	0.32	0.16	0	-0.16	-0.32	-0.49	-0.65	-0.81	-0.98	-1.14	-1.3
Trim (m)	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
Ta (m)	3.021	2.936	2.85	2.765	2.68	2.59	2.5	2.41	2.319								
Tf (m)	1.421	1.536	1.65	1.765	1.88	1.99	2.1	2.21	2.319								
T midship (m)	2.221	2.236	2.25	2.265	2.28	2.29	2.3	2.31	2.319								
Displacement	1864																

The limit of trim optimization in this research is in 60% displacement, since the propeller will immerse 103% at 2.2 m. At some displacement condition in trim by bow variation, the propeller is not immersed. This may cause cavitation and hamming that caused damaged to the propeller itself.

4.4. ANALYSIS OF SHIP RESISTANCE METHOD

In this research, the analysis of ship resistance is done using Maxsurf Resistance Advance. In Maxsurf Resistance Advance itself there are five available methods to use. The method itself are Holtrop, Van Ootmerssen, Series 60, Compton and Fung. From the dimension of ship as we can see in Table 4.1., the method that can be used in this research is Holtrop method.

Holtrop method applicable for ship with type such as: tankers, general cargo, fishing vessels, tugs and container ship. Compton method itself specialized in patrol boat and powerboat recreational with transom design. Series 60 method applicable for general cargo with one propeller.

Table 4.12 *Method in Maxsurf Resistance and Requirements*

Method	Dimension Requirement				
Holtrop	0.55	<	Cp	<	0.85
	3.9	<	L/B	<	15
	2.1	<	B/T	<	4
Van Ootmerssen	8	<	L	<	80
	3	<	L/B	<	6.2
	0.5	<	CP	<	0.73
	-7%	<	LCG/L	<	2.80%
	5	<	V	<	3000
	1.9	<	B/T	<	4
	0.7	<	Cm	<	0.97
	10	<	Ie	<	46
Series 60	0.6	<	Cb	<	0.8
	5.5	<	L/B	<	8.5
	2.5	<	B/T	<	3.5
	-2.48%	<	LCB	<	3.51%
Compton	-0.13	<	LCG/L	<	-0.02
	4	<	L/B	<	5.2
	0.00368	<	V/L3	<	0.00525
Fung	0.00057	<	V/L3	<	0.01257
	1.696	<	B/T	<	10.204
	0.526	<	Cp	<	0.774
	0.662	<	Cwp	<	0.841

4.5. ANALYSIS OF SHIP RESISTANCE DUE TO TRIM

Using the data resulted from trim variation and the holtrop method, further analysis about the relation between trim and resistance can be done. The software used in this step is Maxsurf Resistance Advanced.

The analysis in this step is using variances between speed, displacement and trim condition. The result can be seen as follow:

Table 4.13 *Ship Resistance in Various Trim Condition at 12 Knot and 100% Displacement*

	100% Displacement at 12 Knot				
	Condition	Trim (m)	Trim (°)	Holtrop (kN)	EHP (kW)
Trim by Stern	1	1.6	1.3	93.8	579.337
	2	1.4	1.14	94.7	584.32
	3	1.2	0.98	95.3	588.605
	4	1	0.81	96.1	593.103
	5	0.8	0.65	97	598.759
	6	0.6	0.49	97.8	603.486
	7	0.4	0.32	98.4	607.676
	8	0.2	0.16	99.3	612.916
	EK	0	0	100.5	620.543
Trim by Bow	9	0.2	0.16	101	623.59
	10	0.4	0.32	101.3	625.125
	11	0.6	0.49	100.5	620.695
	12	0.8	0.65	98	605.051
	13	1	0.81	96.7	596.921
	14	1.2	0.98	95.3	588.183
	15	1.4	1.14	94.9	585.922
	16	1.6	1.3	95	586.456

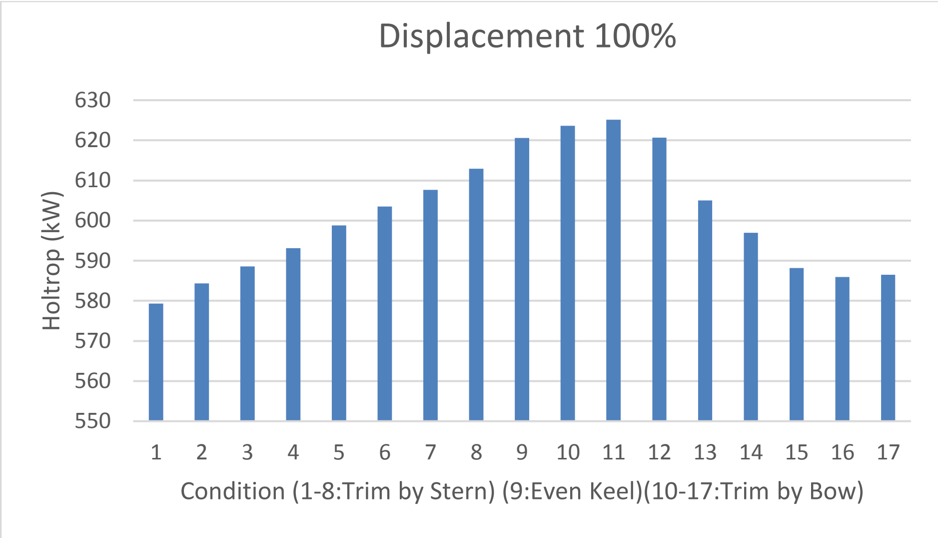


Figure 4.5 *Ship Resistance in Various Trim Condition at 12 Knot and 100% Displacement*

Table 4.14 *Ship Resistance in Various Trim Condition at 12 Knot and 95% Displacement*

	95% Displacement at 12 Knot				
	Condition	Trim(m)	Trim(°)	Holtrop(kN)	EHP(kW)
Trim by Stern	1	1.6	1.3	91.3	563.383
	2	1.4	1.14	91.9	567.435
	3	1.2	0.98	92.7	572.005
	4	1	0.81	93.4	576.638
	5	0.8	0.65	94.1	581.047
	6	0.6	0.49	94.9	585.713
	7	0.4	0.32	95.7	590.583
	8	0.2	0.16	96.3	594.324
	EK	0	0	96.9	598.263
Trim by Bow	9	0.2	0.16	97.6	602.483
	10	0.4	0.32	97.8	603.628
	11	0.6	0.49	97.8	603.69
	12	0.8	0.65	97.1	599.416
	13	1	0.81	95	586.356
	14	1.2	0.98	95.2	587.996
	15	1.4	1.14	95.3	588.482
	16	1.6	1.3	94.8	585.394

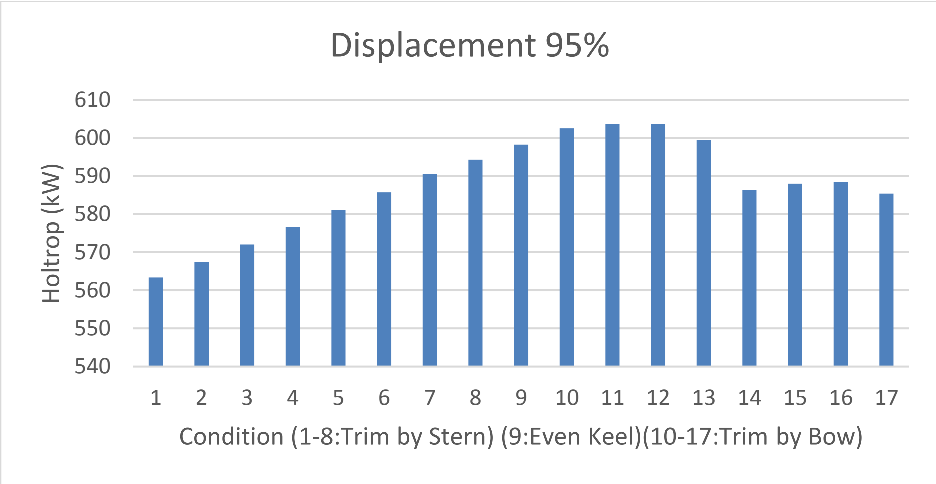


Figure 4.6 *Ship Resistance in Various Trim Condition at 12 Knot and 95% Displacement*

Table 4.15 *Ship Resistance in Various Trim Condition at 12 Knot and 90% Displacement*

	90% Displacement at 12 Knot				
	Condition	Trim(m)	Trim(°)	Holtrop(kN)	EHP(kW)
Trim by Stern	1	1.6	1.3	88.5	546.38
	2	1.4	1.14	89.2	550.533
	3	1.2	0.98	90	555.528
	4	1	0.81	90.7	559.723
	5	0.8	0.65	91.4	564.52
	6	0.6	0.49	92.2	569.274
	7	0.4	0.32	93	574.227
	8	0.2	0.16	93.6	577.792
	EK	0	0	94.2	581.698
Trim by Bow	9	0.2	0.16	94.1	581.024
	10	0.4	0.32	93.8	579.259
	11	0.6	0.49	93.9	579.75
	12	0.8	0.65	94.4	582.594
	13	1	0.81	95.7	590.734
	14	1.2	0.98	94.6	584.14
	15	1.4	1.14	93.5	577.215
	16	1.6	1.3	92.9	573.701

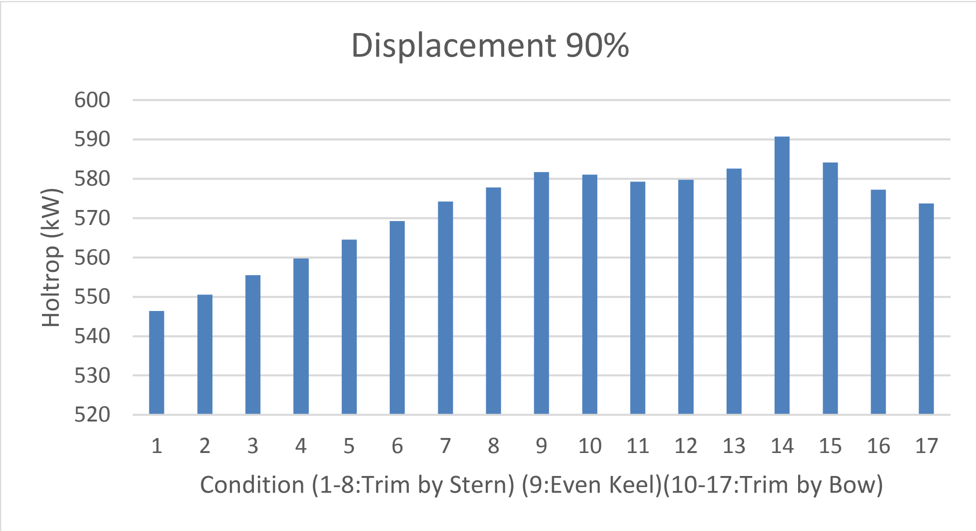


Figure 4.7 *Ship Resistance in Various Trim Condition at 12 Knot and 90% Displacement*

Table 4.16 *Ship Resistance in Various Trim Condition at 12 Knot and 85% Displacement*

	85% Displacement at 12 Knot				
	Condition	Trim(m)	Trim(°)	Holtrop(kN)	EHP(kW)
Trim by Stern	1	1.6	1.3	85.8	529.447
	2	1.4	1.14	86.4	533.469
	3	1.2	0.98	87.1	537.7691
	4	1	0.81	87.9	542.625
	5	0.8	0.65	88.6	546.907
	6	0.6	0.49	89.5	552.594
	7	0.4	0.32	90.2	557.143
	8	0.2	0.16	90.8	560.758
	EK	0	0	91.4	564.461
Trim by Bow	9	0.2	0.16	91.3	563.661
	10	0.4	0.32	90.7	559.703
	11	0.6	0.49	91.5	564.936
	12	0.8	0.65	92.9	573.593
	13	1	0.81	93.8	579.136
	14	1.2	0.98	94	580.233
	15	1.4	1.14	93.7	578.675
	16	1.6	1.3	91.3	563.503

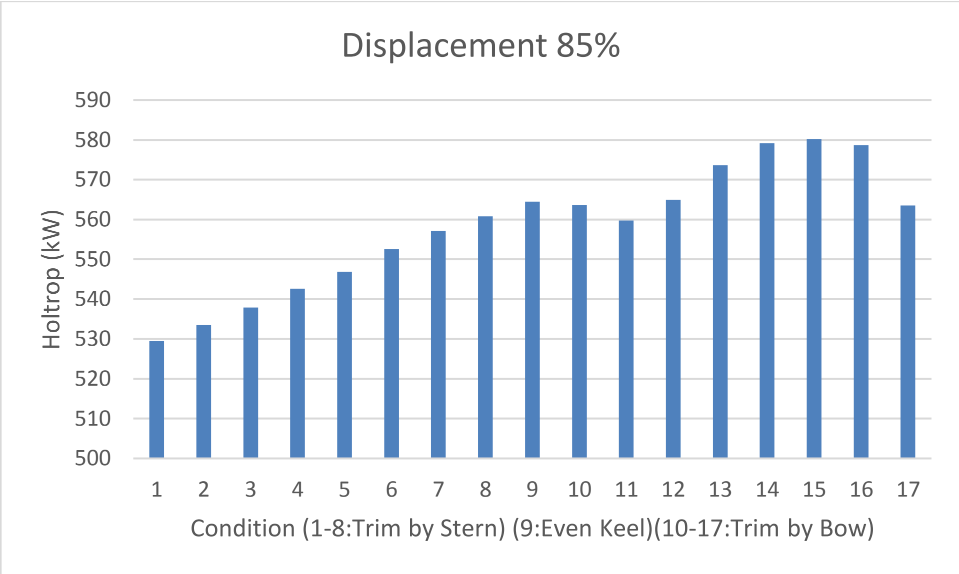


Figure 4.8 *Ship Resistance in Various Trim Condition at 12 Knot and 85% Displacement*

Table 4.17 *Ship Resistance in Various Trim Condition at 12 Knot and 80% Displacement*

	80% Displacement at 12 Knot				
	Condition	Trim(m)	Trim(°)	Holtrop(kN)	EHP(kW)
Trim by Stern	1	1.6	1.3	83.1	512.888
	2	1.4	1.14	85.2	525.816
	3	1.2	0.98	84.3	520.447
	4	1	0.81	85.1	525.59
	5	0.8	0.65	85.9	530.366
	6	0.6	0.49	86.6	534.915
	7	0.4	0.32	87.4	539.825
	8	0.2	0.16	88.2	544.236
	EK	0	0	88.5	546.414
Trim by Bow	9	0.2	0.16	89.1	550.203
	10	0.4	0.32	89.9	555.218
	11	0.6	0.49	90.4	558.138
	12	0.8	0.65	90.5	558.425
	13	1	0.81	91.1	562.154
	14	1.2	0.98	91.6	565.569
	15	1.4	1.14	0	0
	16	1.6	1.3	0	0

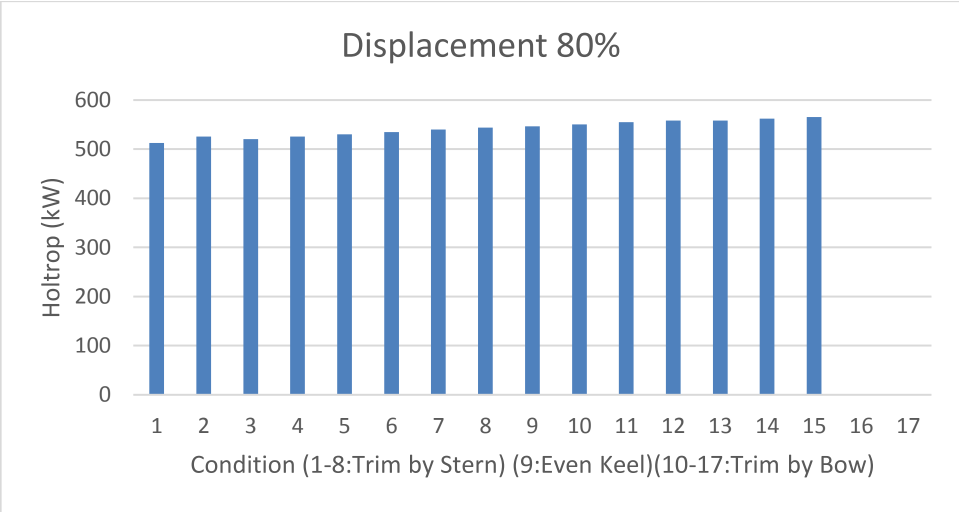


Figure 4.9 *Ship Resistance in Various Trim Condition at 12 Knot and 80% Displacement*

Table 4.18 *Ship Resistance in Various Trim Condition at 12 Knot and 80% Displacement*

	75% Displacement at 12 Knot				
	Condition	Trim(m)	Trim(°)	Holtrop(kN)	EHP(kW)
Trim by Stern	1	1.6	1.3	79.9	493.389
	2	1.4	1.14	81	500.134
	3	1.2	0.98	81.7	504.523
	4	1	0.81	82.4	508.488
	5	0.8	0.65	83.1	512.914
	6	0.6	0.49	83.8	517.294
	7	0.4	0.32	84.7	522.612
	8	0.2	0.16	85.3	526.33
	EK	0	0	87.1	537.994
Trim by Bow	9	0.2	0.16	88	543.393
	10	0.4	0.32	88.3	545.12
	11	0.6	0.49	88.3	545.387
	12	0.8	0.65	88.3	545.339
	13	1	0.81	87.9	542.327
	14	1.2	0.98	0	0
	15	1.4	1.14	0	0
	16	1.6	1.3	0	0

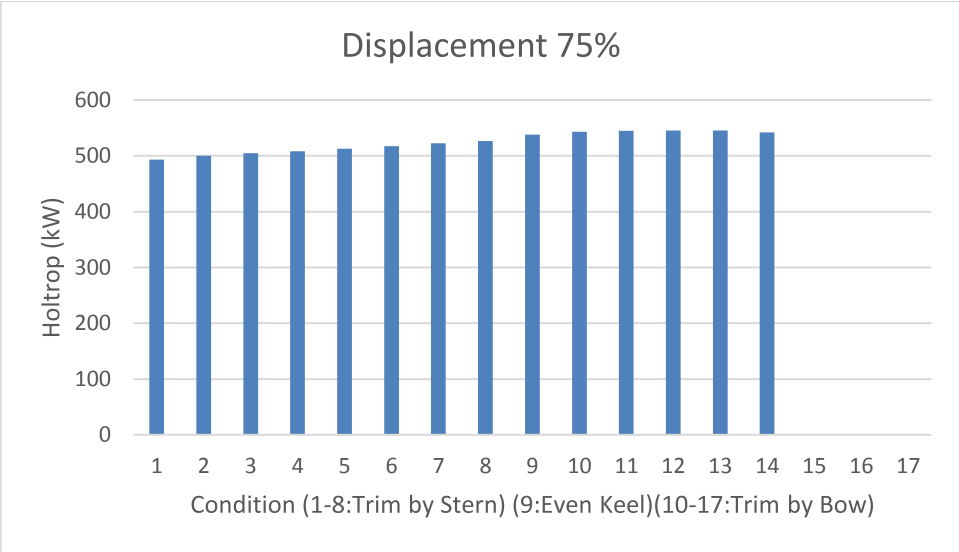


Figure 4.10 *Ship Resistance in Various Trim Condition at 12 Knot and 75% Displacement*

Table 4.19 *Ship Resistance in Various Trim Condition at 12 Knot and 70% Displacement*

	70% Displacement at 12 Knot				
	Condition	Trim(m)	Trim(°)	Holtrop(kN)	EHP(kW)
Trim by Stern	1	1.6	1.3	77.8	480.312
	2	1.4	1.14	78.4	483.765
	3	1.2	0.98	79	487.838
	4	1	0.81	79.6	491.399
	5	0.8	0.65	80.3	495.45
	6	0.6	0.49	80.4	496.606
	7	0.4	0.32	81.3	501.6
	8	0.2	0.16	84.5	521.851
	EK	0	0	85.7	529.2
Trim by Bow	9	0.2	0.16	86.2	532.399
	10	0.4	0.32	86.2	532.077
	11	0.6	0.49	85.1	525.376
	12	0.8	0.65	0	0
	13	1	0.81	0	0
	14	1.2	0.98	0	0
	15	1.4	1.14	0	0
	16	1.6	1.3	0	0

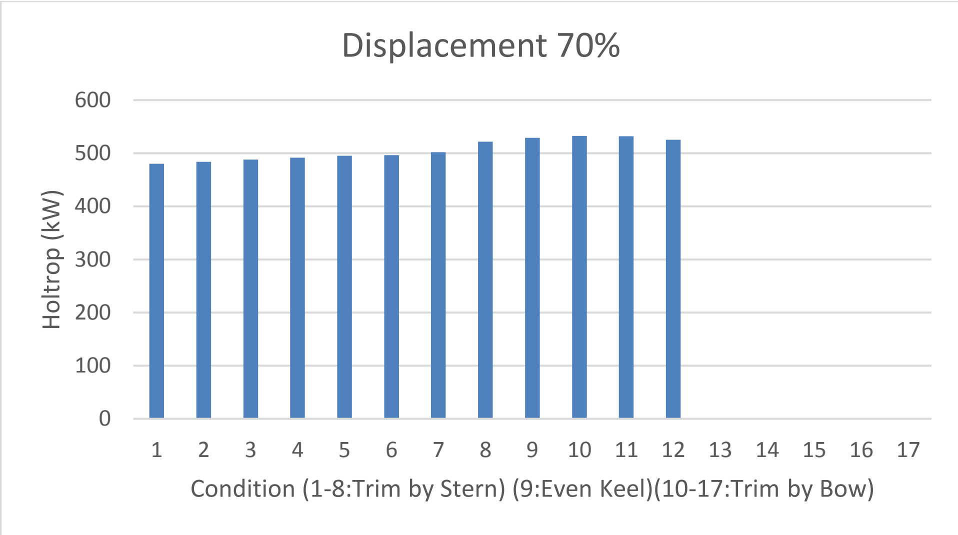


Figure 4.11 *Ship Resistance in Various Trim Condition at 12 Knot and 70% Displacement*

Table 4.20 *Ship Resistance in Various Trim Condition at 12 Knot and 65% Displacement*

	70% Displacement at 12 Knot				
	Condition	Trim(m)	Trim(°)	Holtrop(kN)	EHP(kW)
Trim by Stern	1	1.6	1.3	75.2	464.024
	2	1.4	1.14	75.7	467.408
	3	1.2	0.98	76.2	470.173
	4	1	0.81	76.8	474.243
	5	0.8	0.65	77.8	480.149
	6	0.6	0.49	79.6	491.426
	7	0.4	0.32	81.2	501.529
	8	0.2	0.16	82.5	509.083
	EK	0	0	83.8	517.287
Trim by Bow	9	0.2	0.16	84.1	519.411
	10	0.4	0.32	83.5	515.74
	11	0.6	0.49	0	0
	12	0.8	0.65	0	0
	13	1	0.81	0	0
	14	1.2	0.98	0	0
	15	1.4	1.14	0	0
	16	1.6	1.3	0	0

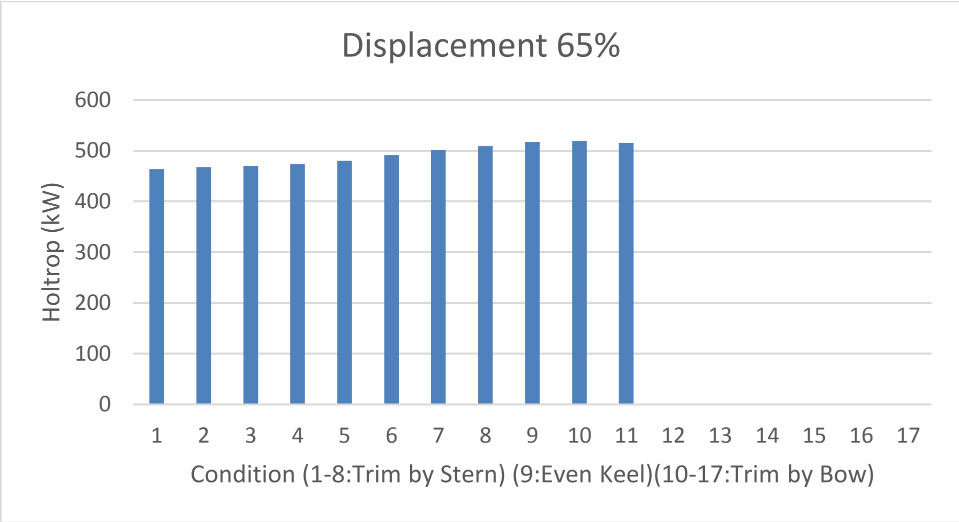


Figure 4.12 *Ship Resistance in Various Trim Condition at 12 Knot and 65% Displacement*

Table 4.21 *Ship Resistance in Various Trim Condition at 12 Knot and 60% Displacement*

	60% Displacement at 12 Knot				
	Condition	Trim(m)	Trim(°)	Holtrop(kN)	EHP(kW)
Trim by Stern	1	1.6	1.3	72.5	447.609
	2	1.4	1.14	73	450.432
	3	1.2	0.98	73.4	453.057
	4	1	0.81	75	462.877
	5	0.8	0.65	76.4	471.745
	6	0.6	0.49	77.7	479.39
	7	0.4	0.32	79.1	488.279
	8	0.2	0.16	80.3	495.849
	EK	0	0	81.3	501.673
Trim by Bow	9	0.2	0.16	0	0
	10	0.4	0.32	0	0
	11	0.6	0.49	0	0
	12	0.8	0.65	0	0
	13	1	0.81	0	0
	14	1.2	0.98	0	0
	15	1.4	1.14	0	0
	16	1.6	1.3	0	0

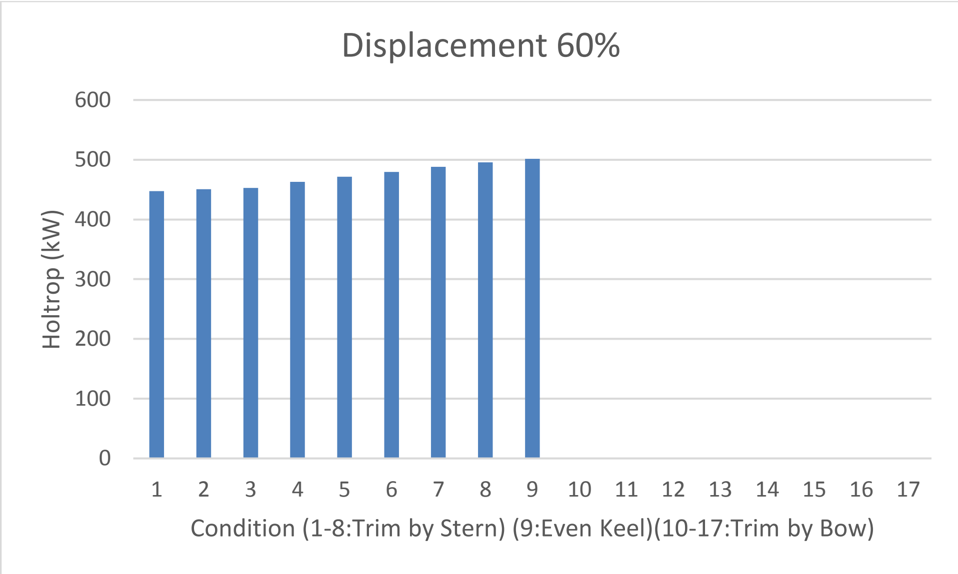


Figure 4.13 *Ship Resistance in Various Trim Condition at 12 Knot and 60% Displacement*

The graphic above shown the trend that trim by stern condition having lower resistance compared to even keel and trim by bow condition. In some displacement condition, trim by bow condition also having lower resistance compared to even keel condition.

Ship resistance itself is a function that consist of sea water density, ship speed, wetted surfaced area and coefficient of resistance of ship. The reduction of resistance in the graph above is the result of the difference of wetted surface area and ship resistance coefficient. Although the ship having lower resistance, the payload of the ship itself is the same as in the even keel condition.

Effect of trim to the resistance in this case having big effect from 100% displacement – 85% displacement. Where in the 80% displacement until 60% displacement, the trim still can optimize the resistance of the ship, but the effect itself is not that significant. In the 80% displacement and bellow, the trim by bow condition is limited in maximum trim allowed, since in the most extreme condition, the propeller will not have immersed in to the water, that lead into loss of efficiency, hamming and cavitation that must be avoided.

4.6. ANALYSIS OF POWER DISTRIBUTION DUE TO TRIM

With the difference of resistance in each trim condition, it will lead into different power required by a ship in different trim condition. In this analysis, for the example, used 100% displacement in speed of 12 knots. Different trim condition will result into different power, since it effect on some variable, such as Lwl, wetted surface area and wake fraction that lead into efficiency. In this research an approach done using approximation based on *Principle of Naval Architecture* about resistance, propulsion and vibration. In the propeller efficiency, in all speed condition is assumed having 50% efficiency, since there is no data of the propeller used on this ship yet. By using this assumption, the main focus is to shown the difference in BHPMcr and fuel consumption in different trim condition.

Table 4.22 *Relation Between Power and Fuel Oil Consumption in Different Trim Condition*

12 Knot 100% Displacement																	
	TRIM BY STERN									TRIM BY BOW							
	1	2	3	4	5	6	7	8	EK	9	10	11	12	13	14	15	16
Trim (m)	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6
BHPMcr (kW)	1733	1748	1760	1774	1791	1805	1817	1833	1839	1857	1862	1856	1809	1785	1759	1752	1754
BHPMcr %	0.76	0.77	0.77	0.78	0.78	0.79	0.79	0.8	0.81	0.81	0.82	0.81	0.79	0.78	0.77	0.77	0.77
SFOC (g/kWH)	190	190	190	190	189	189	189	189	189	189	189	189	189	189	189	190	190
WFO (ton/ hour)	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0.35	0.35	0.35	0.35	0.34	0.34	0.33	0.33	0.33

As we can see in the table above, trend by trim having fewer power requirement compared to trim by bow, as well as even keel condition. By using the trimmest by stern condition, it may reduce the power up to 6% compared to even keel condition in 100% displacement and 12 knots speed.

4.7. ANALYSIS OF SHIP STABILITY DUE TO TRIM

Ship stability analysis was done to ensure the stability and safety aspect of ship in the optimum trim condition. During the optimum trim condition, it is required to keep the stability fulfill the aspect that signed by the International Maritime Organization (IMO). In this research, stability used is the intact stability in Maxsurf Stability. The regulation from IMO that regulate about stability used in this research is IMO 1.749(18) Code on Intact Stability, Chapter 3: Design Criteria Applicable to All Ships.

Table 4.23 *GZ Value in Different Trim Condition at 100% Displacement*

	GZ	Heel to starboard deck (degree)									
Trim by Stern	Trim	0	10	20	30	40	50	60	70	80	90
	1	-0	0.66	1.14	1.01	0.52	-0.1	-0.8	-1.5	-2.1	-2.7
	2	-0	0.67	1.16	1.02	0.52	-0.1	-0.8	-1.5	-2.1	-2.7
	3	-0	0.67	1.17	1.02	0.53	-0.1	-0.8	-1.5	-2.1	-2.7
	4	-0	0.67	1.18	1.03	0.53	-0.1	-0.8	-1.5	-2.1	-2.7
	5	-0	0.67	1.19	1.04	0.53	-0.1	-0.8	-1.5	-2.1	-2.7
	6	-0	0.68	1.2	1.04	0.54	-0.1	-0.8	-1.5	-2.1	-2.7
	7	-0	0.68	1.21	1.05	0.54	-0.1	-0.8	-1.5	-2.1	-2.7
	8	-0	0.68	1.21	1.05	0.54	-0.1	-0.8	-1.5	-2.1	-2.7
	EK	-0	0.68	1.22	1.06	0.54	-0.1	-0.8	-1.5	-2.1	-2.7
Trim by Bow	9	-0	0.68	1.22	1.06	0.54	-0.1	-0.8	-1.5	-2.1	-2.7
	10	-0	0.69	1.22	1.06	0.55	-0.1	-0.8	-1.5	-2.1	-2.7
	11	-0	0.69	1.22	1.06	0.55	-0.1	-0.8	-1.5	-2.1	-2.7
	12	-0	0.69	1.22	1.06	0.54	-0.1	-0.8	-1.5	-2.1	-2.7
	13	-0	0.69	1.22	1.06	0.54	-0.1	-0.8	-1.5	-2.1	-2.7
	14	-0	0.69	1.22	1.05	0.54	-0.1	-0.8	-1.5	-2.1	-2.7
	15	-0	0.69	1.21	1.05	0.54	-0.1	-0.8	-1.5	-2.1	-2.7
	16	-0	0.7	1.2	1.05	0.54	-0.1	-0.8	-1.5	-2.1	-2.7

From the table above, we can see that the GZ value in different condition is affected in a very small value. Thereby we can conclude that the trim condition is not significant to the stability intact of a ship.

Table 4.24 *IMO Criteria Chapter III at Even Keel Condition*

Even Keel		Value	Units	Actual	Status	Margin %
Code	Criteria					
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 30				Pass	
	from the greater of					
	spec. heel angle	0	deg	0		
	to the lesser of					
	spec. heel angle	30	deg	30		
	angle of vanishing stability	48.6	deg			
	shall not be less than (>=)	3.1513	m.deg	25.1359	Pass	697.64
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 40				Pass	
	from the greater of					
	spec. heel angle	0	deg	0		
	to the lesser of					
	spec. heel angle	40	deg	40		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	48.6	deg			
	shall not be less than (>=)	5.1566	m.deg	33.275	Pass	545.29
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 30 to 40				Pass	
	from the greater of					
	spec. heel angle	30	deg	30		
	to the lesser of					
	spec. heel angle	40	deg	40		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	48.6	deg			
	shall not be less than (>=)	1.7189	m.deg	8.1391	Pass	373.51
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater				Pass	
	in the range from the greater of					
	spec. heel angle	30	deg	30		
	to the lesser of					
	spec. heel angle	90	deg	90		
	angle of max. GZ	22.7	deg			
	shall not be less than (>=)	0.2	M	1.055	Pass	427.5
	Intermediate values					

	angle at which this GZ occurs		deg	30		
Even Keel		Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ				Pass	
	shall not be less than (>=)	15	deg	22.7	Pass	51.33333
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt				Pass	
	spec. heel angle	0	deg			
	shall not be less than (>=)	0.15	M	3.897	Pass	2498

Table 4.25 *IMO Criteria Chapter III at Trim by Stern 1.6 m*

Trim by Stern 1.6m	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 30				Pass	
	from the greater of					
	spec. heel angle	0	deg	0		
	to the lesser of					
	spec. heel angle	30	deg	30		
	angle of vanishing stability	48.3	deg			
	shall not be less than (>=)	3.1513	m.deg	23.918	Pass	658.99
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 40				Pass	
	from the greater of					
	spec. heel angle	0	deg	0		
	to the lesser of					
	spec. heel angle	40	deg	40		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	48.3	deg			
	shall not be less than (>=)	5.1566	m.deg	31.6964	Pass	514.68
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 30 to 40				Pass	
	from the greater of					
	spec. heel angle	30	deg	30		
	to the lesser of					
	spec. heel angle	40	deg	40		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	48.3	deg			
	shall not be less than (>=)	1.7189	m.deg	7.7783	Pass	352.52
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater				Pass	
	in the range from the greater of					
	spec. heel angle	30	deg	30		
	to the lesser of					
	spec. heel angle	90	deg	90		
	angle of max. GZ	22.7	deg			
	shall not be less than (>=)	0.2	m	1.006	Pass	403
	Intermediate values					
	angle at which this GZ occurs		deg	30		

Trim by Stern 1.6m	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ				Pass	
	shall not be less than (>=)	15	deg	22.7	Pass	51.33333
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt				Pass	
	spec. heel angle	0	deg			
	shall not be less than (>=)	0.15	m	3.746	Pass	2397.33

Table 4.26 *IMO Criteria Chapter III at Trim by Bow 1.6 m*

Trim by Bow 1.6		Value	Units	Actual	Status	Margin %
Code	Criteria					
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 30				Pass	
	from the greater of					
	spec. heel angle	0	deg	0		
	to the lesser of					
	spec. heel angle	30	deg	30		
	angle of vanishing stability	48.5	deg			
	shall not be less than (>=)	3.1513	m.deg	25.0926	Pass	696.26
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 40				Pass	
	from the greater of					
	spec. heel angle	0	deg	0		
	to the lesser of					
	spec. heel angle	40	deg	40		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	48.5	deg			
	shall not be less than (>=)	5.1566	m.deg	33.16	Pass	543.06
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 30 to 40				Pass	
	from the greater of					
	spec. heel angle	30	deg	30		
	to the lesser of					
	spec. heel angle	40	deg	40		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	48.5	deg			
	shall not be less than (>=)	1.7189	m.deg	8.0675	Pass	369.34
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater				Pass	
	in the range from the greater of					
	spec. heel angle	30	deg	30		
	to the lesser of					

	spec. heel angle	90	deg	90		
	angle of max. GZ	22.7	deg			
	shall not be less than (>=)	0.2	m	1.045	Pass	422.5
	Intermediate values					
	angle at which this GZ occurs		deg	30		
Trim by Bow 1.6		Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ				Pass	
	shall not be less than (>=)	15	deg	22.7	Pass	51.33333
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt				Pass	
	spec. heel angle	0	deg			
	shall not be less than (>=)	0.15	m	3.909	Pass	2506

4.8. DATABASE CREATION

In the step mentioned above, the results are compiled and based on the existing result, will be created a database from 60% displacement up to 100% displacement with variety of 8 knots – 12 knots of speed. The database itself created using interpolation methods, that consist of Effective Horse Power, Trim Condition, Ta-Tf, Power Distribution and Specific Fuel Oil Consumption. Later on, the software created will be showing result with the optimum condition based on the database created in this research. The database itself will attached in the appendix section of this research.

The interpolation used on the known data, thereby more specific condition can be known. Below is the step of database creation.

Table 4.27 *EHP Calculation Holtrop Method – Trim Condition 1.6m by Stern*

Lcg	Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
28.896	100	666.2376	561.0333	473.8403	400.9556	339.2443	286.7295	241.7243	202.8796	169.1731	Holtrop (kW)
28.808	95	647.8905	546.7652	462.4829	391.8533	331.905	280.7484	236.8149	198.8339	165.8381	
28.715	90	628.337	531.5576	450.3768	382.1347	324.0585	274.3509	231.5617	194.5018	162.2662	
28.616	85	608.8641	516.3696	438.2639	372.3746	316.1534	267.8914	226.2464	190.1146	158.6448	
28.516	80	589.8212	501.4702	426.3614	362.7503	308.3334	261.4847	220.9668	185.7503	155.0396	
28.394	75	567.3974	483.8119	412.198	351.2365	298.9287	253.751	214.5728	180.4534	150.6581	
28.31	70	552.3588	471.9083	402.6346	343.4406	292.5405	248.4874	210.2131	176.8367	147.6646	
28.21	65	533.6276	457.0112	390.6527	333.6587	284.5077	241.8577	204.7173	172.2758	143.8869	
28.087	60	514.7504	441.8484	378.3891	323.5985	276.2036	234.9749	198.9949	167.5171	139.9401	

Table 4.28 *Database EHP Trim Condition 1.6 m by Stern*

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
28.896	100	666.2376	645.1967	624.1558	603.115	582.0741	561.0333	543.5947	526.1561	508.7175	491.2789	473.8403
28.8784	99	662.5681	641.6904	620.8127	599.935	579.0573	558.1796	540.8575	523.5353	506.2131	488.8909	471.5688
28.8608	98	658.8987	638.1842	617.4696	596.7551	576.0406	555.326	538.1203	520.9145	503.7088	486.503	469.2973
28.8432	97	655.2293	634.6779	614.1265	593.5752	573.0238	552.4724	535.3831	518.2938	501.2045	484.1151	467.0258
28.8256	96	651.5599	631.1717	610.7834	590.3952	570.007	549.6188	532.6459	515.673	498.7001	481.7272	464.7543
28.808	95	647.8905	627.6654	607.4404	587.2153	566.9903	546.7652	529.9087	513.0523	496.1958	479.3393	462.4829
28.7894	94	643.9798	623.9285	603.8773	583.8261	563.7749	543.7237	526.9913	510.2589	493.5265	476.794	460.0616
28.7708	93	640.0691	620.1917	600.3143	580.4369	560.5595	540.6822	524.0738	507.4655	490.8571	474.2488	457.6404
28.7522	92	636.1584	616.4548	596.7513	577.0477	557.3442	537.6406	521.1564	504.6721	488.1878	471.7035	455.2192
28.7336	91	632.2477	612.718	593.1883	573.6585	554.1288	534.5991	518.2389	501.8787	485.5185	469.1582	452.798
28.715	90	628.337	608.9811	589.6252	570.2694	550.9135	531.5576	515.3214	499.0853	482.8491	466.613	450.3768
28.6952	89	624.4424	605.2579	586.0734	566.889	547.7045	528.52	512.4068	496.2937	480.1805	464.0674	447.9542
28.6754	88	620.5478	601.5347	582.5216	563.5086	544.4955	525.4824	509.4922	493.5021	477.5119	461.5218	445.5316
28.6556	87	616.6532	597.8115	578.9698	560.1282	541.2865	522.4448	506.5776	490.7105	474.8433	458.9762	443.109
28.6358	86	612.7586	594.0883	575.418	556.7478	538.0775	519.4072	503.663	487.9189	472.1747	456.4306	440.6864
28.616	85	608.8641	590.3652	571.8663	553.3674	534.8685	516.3696	500.7484	485.1273	469.5061	453.885	438.2639
28.596	84	605.0555	586.7223	568.3892	550.056	531.7228	513.3897	497.8884	482.3871	466.8859	451.3846	435.8834
28.576	83	601.2469	583.0795	564.9121	546.7446	528.5772	510.4098	495.0284	479.647	464.2656	448.8842	433.5029
28.556	82	597.4383	579.4367	561.435	543.4333	525.4316	507.4299	492.1684	476.9069	461.6454	446.3839	431.1224
28.536	81	593.6298	575.7938	557.9579	540.1219	522.286	504.45	489.3084	474.1668	459.0251	443.8835	428.7419
28.516	80	589.8212	572.151	554.4808	536.8106	519.1404	501.4702	486.4484	471.4266	456.4049	441.3831	426.3614
28.4916	79	585.3364	567.8568	550.3773	532.8977	515.4181	497.9385	483.0565	468.1746	453.2926	438.4106	423.5287

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
28.4672	78	580.8517	563.5627	546.2737	528.9848	511.6958	494.4069	479.6647	464.9225	450.1803	435.4382	420.696
28.4428	77	576.3669	559.2686	542.1702	525.0719	507.9735	490.8752	476.2728	461.6704	447.0681	432.4657	417.8633
28.4184	76	571.8821	554.9744	538.0667	521.159	504.2513	487.3436	472.881	458.4184	443.9558	429.4932	415.0306
28.394	75	567.3974	550.6803	533.9632	517.2461	500.529	483.8119	469.4891	455.1663	440.8435	426.5207	412.198
28.3772	74	564.3896	547.7979	531.2063	514.6146	498.0229	481.4312	467.202	452.9728	438.7436	424.5145	410.2853
28.3604	73	561.3819	544.9156	528.4493	511.983	495.5167	479.0504	464.9149	450.7793	436.6437	422.5082	408.3726
28.3436	72	558.3742	542.0333	525.6924	509.3515	493.0106	476.6697	462.6278	448.5858	434.5438	420.5019	406.4599
28.3268	71	555.3665	539.151	522.9355	506.72	490.5045	474.289	460.3406	446.3923	432.4439	418.4956	404.5472
28.31	70	552.3588	536.2687	520.1786	504.0885	487.9984	471.9083	458.0535	444.1988	430.344	416.4893	402.6346
28.29	69	548.6126	532.6758	516.7391	500.8023	484.8656	468.9288	455.1907	441.4526	427.7144	413.9763	400.2382
28.27	68	544.8663	529.0829	513.2996	497.5162	481.7328	465.9494	452.3279	438.7064	425.0849	411.4633	397.8418
28.25	67	541.1201	525.4901	509.86	494.23	478.6	462.97	449.4651	435.9602	422.4553	408.9504	395.4454
28.23	66	537.3738	521.8972	506.4205	490.9439	475.4672	459.9906	446.6023	433.214	419.8257	406.4374	393.0491
28.21	65	533.6276	518.3043	502.981	487.6577	472.3344	457.0112	443.7395	430.4678	417.1961	403.9244	390.6527
28.1854	64	529.8522	514.6774	499.5027	484.328	469.1533	453.9786	440.8229	427.6672	414.5114	401.3557	388.2
28.1608	63	526.0767	511.0506	496.0244	480.9983	465.9722	450.9461	437.9063	424.8665	411.8268	398.787	385.7473
28.1362	62	522.3013	507.4237	492.5462	477.6686	462.7911	447.9135	434.9897	422.0659	409.1421	396.2183	383.2945
28.1116	61	518.5258	503.7968	489.0679	474.3389	459.6099	444.881	432.0731	419.2653	406.4575	393.6496	380.8418
28.087	60	514.7504	500.17	485.5896	471.0092	456.4288	441.8484	429.1565	416.4647	403.7728	391.081	378.3891

LCG		10.9	10.8	10.7	10.6	10.5	10.4	10.3	10.2	10.1	10
28.896	100	459.2633	444.6864	430.1094	415.5325	400.9556	388.6133	376.271	363.9288	351.5865	339.2443
28.8784	99	457.082	442.5953	428.1086	413.6218	399.1351	386.8634	374.5916	362.3199	350.0481	337.7764
28.8608	98	454.9008	440.5042	426.1077	411.7112	397.3147	385.1134	372.9122	360.711	348.5098	336.3085
28.8432	97	452.7195	438.4132	424.1068	409.8005	395.4942	383.3635	371.2328	359.1021	346.9714	334.8407
28.8256	96	450.5382	436.3221	422.106	407.8899	393.6738	381.6136	369.5534	357.4932	345.433	333.3728
28.808	95	448.3569	434.231	420.1051	405.9792	391.8533	379.8636	367.874	355.8843	343.8946	331.905
28.7894	94	446.0312	432.0008	417.9704	403.94	389.9096	377.9948	366.08	354.1652	342.2504	330.3357
28.7708	93	443.7055	429.7706	415.8357	401.9008	387.9658	376.1259	364.2861	352.4462	340.6063	328.7664
28.7522	92	441.3798	427.5404	413.701	399.8615	386.0221	374.2571	362.4921	350.7271	338.9621	327.1971
28.7336	91	439.0541	425.3102	411.5662	397.8223	384.0784	372.3883	360.6981	349.008	337.3179	325.6278
28.715	90	436.7284	423.0799	409.4315	395.7831	382.1347	370.5194	358.9042	347.289	335.6737	324.0585
28.6952	89	434.3999	420.8456	407.2913	393.737	380.1826	368.6416	357.1006	345.5595	334.0185	322.4775
28.6754	88	432.0714	418.6112	405.151	391.6908	378.2306	366.7638	355.297	343.8301	332.3633	320.8965
28.6556	87	429.7429	416.3769	403.0108	389.6447	376.2786	364.886	353.4933	342.1007	330.7081	319.3154
28.6358	86	427.4145	414.1425	400.8705	387.5986	374.3266	363.0082	351.6897	340.3713	329.0529	317.7344
28.616	85	425.086	411.9082	398.7303	385.5525	372.3746	361.1304	349.8861	338.6419	327.3976	316.1534
28.596	84	422.7966	409.7099	396.6232	383.5365	370.4497	359.2777	348.1056	336.9335	325.7615	314.5894
28.576	83	420.5073	407.5117	394.5161	381.5205	368.5249	357.425	346.3251	335.2252	324.1253	313.0254
28.556	82	418.2179	405.3134	392.4089	379.5045	366.6	355.5723	344.5446	333.5168	322.4891	311.4614
28.536	81	415.9285	403.1152	390.3018	377.4885	364.6751	353.7196	342.764	331.8085	320.8529	309.8974
28.516	80	413.6391	400.9169	388.1947	375.4725	362.7503	351.8669	340.9835	330.1001	319.2168	308.3334
28.4916	79	410.9124	398.2962	385.68	373.0637	360.4475	349.6485	338.8495	328.0505	317.2515	306.4525
28.4672	78	408.1857	395.6755	383.1652	370.655	358.1447	347.4301	336.7154	326.0008	315.2862	304.5715

LCG		10.9	10.8	10.7	10.6	10.5	10.4	10.3	10.2	10.1	10
28.4428	77	405.459	393.0548	380.6505	368.2462	355.842	345.2117	334.5814	323.9511	313.3209	302.6906
28.4184	76	402.7323	390.4341	378.1358	365.8375	353.5392	342.9933	332.4474	321.9015	311.3556	300.8096
28.394	75	400.0057	387.8134	375.6211	363.4288	351.2365	340.7749	330.3134	319.8518	309.3903	298.9287
28.3772	74	398.1637	386.0421	373.9205	361.7989	349.6773	339.272	328.8668	318.4615	308.0563	297.6511
28.3604	73	396.3217	384.2708	372.2199	360.169	348.1181	337.7692	327.4202	317.0713	306.7223	296.3734
28.3436	72	394.4797	382.4995	370.5193	358.5391	346.5589	336.2663	325.9737	315.681	305.3884	295.0958
28.3268	71	392.6377	380.7282	368.8188	356.9093	344.9998	334.7634	324.5271	314.2908	304.0544	293.8181
28.31	70	390.7958	378.957	367.1182	355.2794	343.4406	333.2606	323.0805	312.9005	302.7205	292.5405
28.29	69	388.4874	376.7366	364.9858	353.235	341.4842	331.3742	321.2641	311.154	301.044	290.9339
28.27	68	386.179	374.5162	362.8534	351.1906	339.5278	329.4877	319.4476	309.4075	299.3674	289.3274
28.25	67	383.8706	372.2958	360.7211	349.1463	337.5715	327.6013	317.6312	307.6611	297.6909	287.7208
28.23	66	381.5623	370.0755	358.5887	347.1019	335.6151	325.7149	315.8147	305.9146	296.0144	286.1143
28.21	65	379.2539	367.8551	356.4563	345.0575	333.6587	323.8285	313.9983	304.1681	294.3379	284.5077
28.1854	64	376.8893	365.5787	354.268	342.9573	331.6467	321.8867	312.1267	302.3668	292.6068	282.8469
28.1608	63	374.5247	363.3022	352.0797	340.8571	329.6346	319.9449	310.2552	300.5655	290.8758	281.186
28.1362	62	372.1601	361.0258	349.8914	338.757	327.6226	318.0031	308.3836	298.7642	289.1447	279.5252
28.1116	61	369.7956	358.7493	347.7031	336.6568	325.6105	316.0613	306.5121	296.9628	287.4136	277.8644
28.087	60	367.431	356.4729	345.5147	334.5566	323.5985	314.1195	304.6405	295.1615	285.6825	276.2036

LCG		9.9	9.8	9.7	9.6	9.5	9.4	9.3	9.2	9.1	9
28.896	100	328.7413	318.2384	307.7354	297.2325	286.7295	277.7285	268.7274	259.7264	250.7253	241.7243
28.8784	99	327.3278	316.8791	306.4305	295.9819	285.5333	276.5751	267.6169	258.6587	249.7006	240.7424
28.8608	98	325.9142	315.5199	305.1256	294.7313	284.337	275.4217	266.5064	257.5911	248.6758	239.7605
28.8432	97	324.5007	314.1607	303.8208	293.4808	283.1408	274.2684	265.3959	256.5235	247.6511	238.7786
28.8256	96	323.0872	312.8015	302.5159	292.2302	281.9446	273.115	264.2855	255.4559	246.6263	237.7968
28.808	95	321.6736	311.4423	301.211	290.9797	280.7484	271.9617	263.175	254.3883	245.6016	236.8149
28.7894	94	320.1623	309.9889	299.8156	289.6422	279.4689	270.7279	261.987	253.2461	244.5052	235.7643
28.7708	93	318.651	308.5356	298.4202	288.3048	278.1894	269.4942	260.7991	252.1039	243.4088	234.7136
28.7522	92	317.1396	307.0822	297.0248	286.9673	276.9099	268.2605	259.6111	250.9617	242.3124	233.663
28.7336	91	315.6283	305.6288	295.6294	285.6299	275.6304	267.0268	258.4232	249.8196	241.216	232.6123
28.715	90	314.117	304.1755	294.2339	284.2924	274.3509	265.7931	257.2352	248.6774	240.1195	231.5617
28.6952	89	312.5938	302.7101	292.8264	282.9427	273.059	264.5469	256.0349	247.5228	239.0107	230.4986
28.6754	88	311.0706	301.2447	291.4188	281.593	271.7671	263.3008	254.8345	246.3682	237.9019	229.4356
28.6556	87	309.5474	299.7793	290.0113	280.2432	270.4752	262.0546	253.6341	245.2136	236.7931	228.3725
28.6358	86	308.0242	298.314	288.6037	278.8935	269.1833	260.8085	252.4337	244.059	235.6842	227.3095
28.616	85	306.501	296.8486	287.1962	277.5438	267.8914	259.5624	251.2334	242.9044	234.5754	226.2464
28.596	84	304.9935	295.3976	285.8018	276.2059	266.61	258.3261	250.0422	241.7583	233.4744	225.1905
28.576	83	303.4861	293.9467	284.4074	274.868	265.3287	257.0899	248.851	240.6122	232.3734	224.1345
28.556	82	301.9786	292.4958	283.013	273.5302	264.0474	255.8536	247.6599	239.4661	231.2724	223.0786
28.536	81	300.4711	291.0449	281.6186	272.1923	262.766	254.6174	246.4687	238.32	230.1714	222.0227
28.516	80	298.9637	289.5939	280.2242	270.8544	261.4847	253.3811	245.2775	237.1739	229.0703	220.9668
28.4916	79	297.1496	287.8467	278.5438	269.2409	259.938	251.888	243.838	235.788	227.738	219.688
28.4672	78	295.3355	286.0994	276.8633	267.6273	258.3912	250.3948	242.3984	234.402	226.4056	218.4092

LCG		9.9	9.8	9.7	9.6	9.5	9.4	9.3	9.2	9.1	9
28.4428	77	293.5214	284.3521	275.1829	266.0137	256.8445	248.9016	240.9588	233.016	225.0732	217.1304
28.4184	76	291.7073	282.6049	273.5025	264.4001	255.2977	247.4085	239.5192	231.63	223.7408	215.8516
28.394	75	289.8932	280.8576	271.8221	262.7865	253.751	245.9153	238.0797	230.244	222.4084	214.5728
28.3772	74	288.6605	279.6699	270.6794	261.6888	252.6982	244.8988	237.0993	229.2998	221.5003	213.7008
28.3604	73	287.4278	278.4823	269.5367	260.5911	251.6455	243.8822	236.1189	228.3555	220.5922	212.8289
28.3436	72	286.1952	277.2946	268.394	259.4934	250.5928	242.8656	235.1385	227.4113	219.6841	211.957
28.3268	71	284.9625	276.1069	267.2513	258.3957	249.5401	241.8491	234.1581	226.4671	218.776	211.085
28.31	70	283.7298	274.9192	266.1086	257.298	248.4874	240.8325	233.1777	225.5228	217.868	210.2131
28.29	69	282.1794	273.4249	264.6704	255.9159	247.1615	239.5519	231.9424	224.3329	216.7234	209.1139
28.27	68	280.629	271.9306	263.2322	254.5339	245.8355	238.2714	230.7072	223.1431	215.5789	208.0148
28.25	67	279.0786	270.4363	261.7941	253.1518	244.5096	236.9908	229.472	221.9532	214.4344	206.9156
28.23	66	277.5281	268.942	260.3559	251.7697	243.1836	235.7102	228.2367	220.7633	213.2899	205.8164
28.21	65	275.9777	267.4477	258.9177	250.3877	241.8577	234.4296	227.0015	219.5734	212.1453	204.7173
28.1854	64	274.3737	265.9006	257.4274	248.9543	240.4811	233.0994	225.7178	218.3361	210.9544	203.5728
28.1608	63	272.7697	264.3534	255.9371	247.5208	239.1046	231.7693	224.434	217.0988	209.7635	202.4283
28.1362	62	271.1658	262.8063	254.4469	246.0874	237.728	230.4392	223.1503	215.8615	208.5726	201.2838
28.1116	61	269.5618	261.2592	252.9566	244.654	236.3515	229.109	221.8666	214.6242	207.3818	200.1393
28.087	60	267.9578	259.7121	251.4664	243.2206	234.9749	227.7789	220.5829	213.3869	206.1909	198.9949

LCG		8.9	8.8	8.7	8.6	8.5	8.4	8.3	8.2	8.1	8
28.896	100	233.9553	226.1864	218.4174	210.6485	202.8796	196.1383	189.397	182.6557	175.9144	169.1731
28.8784	99	233.008	225.2736	217.5392	209.8048	202.0704	195.3575	188.6447	181.9318	175.2189	168.5061
28.8608	98	232.0607	224.3608	216.661	208.9611	201.2613	194.5768	187.8924	181.2079	174.5235	167.8391
28.8432	97	231.1133	223.448	215.7827	208.1174	200.4521	193.7961	187.1401	180.4841	173.8281	167.1721
28.8256	96	230.166	222.5353	214.9045	207.2737	199.643	193.0154	186.3878	179.7602	173.1326	166.5051
28.808	95	229.2187	221.6225	214.0263	206.4301	198.8339	192.2347	185.6355	179.0364	172.4372	165.8381
28.7894	94	228.2049	220.6455	213.0862	205.5268	197.9674	191.3987	184.8299	178.2612	171.6924	165.1237
28.7708	93	227.1911	219.6686	212.1461	204.6235	197.101	190.5627	184.0243	177.486	170.9476	164.4093
28.7522	92	226.1773	218.6916	211.206	203.7203	196.2346	189.7267	183.2187	176.7108	170.2029	163.6949
28.7336	91	225.1635	217.7147	210.2659	202.817	195.3682	188.8907	182.4131	175.9356	169.4581	162.9805
28.715	90	224.1497	216.7377	209.3258	201.9138	194.5018	188.0547	181.6075	175.1604	168.7133	162.2662
28.6952	89	223.1238	215.7489	208.3741	200.9992	193.6244	187.2079	180.7914	174.3749	167.9584	161.5419
28.6754	88	222.0978	214.7601	207.4224	200.0846	192.7469	186.361	179.9752	173.5893	167.2035	160.8176
28.6556	87	221.0719	213.7713	206.4707	199.1701	191.8695	185.5142	179.159	172.8038	166.4486	160.0933
28.6358	86	220.046	212.7825	205.519	198.2555	190.992	184.6674	178.3428	172.0182	165.6937	159.3691
28.616	85	219.02	211.7937	204.5673	197.3409	190.1146	183.8206	177.5267	171.2327	164.9388	158.6448
28.596	84	218.0007	210.811	203.6212	196.4315	189.2417	182.9781	176.7145	170.4509	164.1873	157.9238
28.576	83	216.9814	209.8283	202.6751	195.522	188.3689	182.1356	175.9024	169.6692	163.4359	157.2027
28.556	82	215.9621	208.8456	201.729	194.6125	187.496	181.2931	175.0903	168.8874	162.6845	156.4817
28.536	81	214.9428	207.8629	200.783	193.7031	186.6232	180.4506	174.2781	168.1056	161.9331	155.7606
28.516	80	213.9235	206.8802	199.8369	192.7936	185.7503	179.6082	173.466	167.3239	161.1817	155.0396
28.4916	79	212.6885	205.6891	198.6897	191.6903	184.6909	178.5854	172.4799	166.3743	160.2688	154.1633
28.4672	78	211.4536	204.4981	197.5426	190.5871	183.6315	177.5626	171.4937	165.4248	159.3559	153.287

LCG		8.9	8.8	8.7	8.6	8.5	8.4	8.3	8.2	8.1	8
28.4428	77	210.2187	203.3071	196.3954	189.4838	182.5722	176.5399	170.5076	164.4753	158.443	152.4107
28.4184	76	208.9838	202.116	195.2483	188.3805	181.5128	175.5171	169.5214	163.5257	157.53	151.5344
28.394	75	207.7489	200.925	194.1011	187.2773	180.4534	174.4943	168.5353	162.5762	156.6171	150.6581
28.3772	74	206.9067	200.1125	193.3184	186.5242	179.7301	173.7959	167.8618	161.9276	155.9935	150.0594
28.3604	73	206.0645	199.3	192.5356	185.7711	179.0067	173.0975	167.1883	161.2791	155.3699	149.4607
28.3436	72	205.2222	198.4875	191.7528	185.0181	178.2834	172.3991	166.5148	160.6305	154.7463	148.862
28.3268	71	204.38	197.675	190.97	184.265	177.56	171.7007	165.8413	159.982	154.1226	148.2633
28.31	70	203.5378	196.8625	190.1872	183.5119	176.8367	171.0022	165.1678	159.3334	153.499	147.6646
28.29	69	202.476	195.8381	189.2003	182.5624	175.9245	170.1214	164.3183	158.5152	152.7121	146.9091
28.27	68	201.4143	194.8138	188.2133	181.6128	175.0123	169.2405	163.4688	157.697	151.9253	146.1535
28.25	67	200.3525	193.7894	187.2263	180.6632	174.1001	168.3597	162.6192	156.8788	151.1384	145.398
28.23	66	199.2907	192.765	186.2393	179.7136	173.1879	167.4788	161.7697	156.0606	150.3515	144.6424
28.21	65	198.229	191.7407	185.2524	178.7641	172.2758	166.598	160.9202	155.2424	149.5646	143.8869
28.1854	64	197.123	190.6733	184.2235	177.7738	171.324	165.6787	160.0334	154.3881	148.7428	143.0975
28.1608	63	196.0171	189.6059	183.1947	176.7835	170.3723	164.7594	159.1466	153.5338	147.921	142.3081
28.1362	62	194.9112	188.5385	182.1658	175.7932	169.4205	163.8402	158.2598	152.6795	147.0991	141.5188
28.1116	61	193.8052	187.4711	181.137	174.8029	168.4688	162.9209	157.373	151.8252	146.2773	140.7294
28.087	60	192.6993	186.4037	180.1082	173.8126	167.5171	162.0017	156.4863	150.9709	145.4555	139.9401

Table 4.29 *Ta-Tf Trim Database*

	1.60	m	1.40	M	1.20	M	1.00	m	0.80	m	0.60	m	0.40	m	0.20	m	0.00	m
	Trim by Stern																EK	
	1.00		2.00		3.00		4.00		5.00		6.00		7.00		8.00			
	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf
100	4.20	2.60	4.12	2.72	4.03	2.83	3.94	2.94	3.86	3.06	3.77	3.17	3.68	3.28	3.59	3.39	3.50	3.50
99	4.17	2.57	4.09	2.69	4.00	2.80	3.92	2.92	3.83	3.03	3.74	3.14	3.65	3.25	3.56	3.36	3.47	3.47
98	4.15	2.55	4.06	2.66	3.97	2.77	3.89	2.89	3.80	3.00	3.71	3.11	3.62	3.22	3.53	3.33	3.44	3.44
97	4.12	2.52	4.03	2.63	3.95	2.75	3.86	2.86	3.77	2.97	3.68	3.08	3.59	3.19	3.50	3.30	3.41	3.41
96	4.09	2.49	4.00	2.60	3.92	2.72	3.83	2.83	3.74	2.94	3.65	3.05	3.56	3.16	3.47	3.27	3.38	3.38
95	4.06	2.46	3.98	2.58	3.89	2.69	3.80	2.80	3.71	2.91	3.62	3.02	3.53	3.13	3.44	3.24	3.35	3.35
94	4.04	2.44	3.95	2.55	3.86	2.66	3.77	2.77	3.68	2.88	3.59	2.99	3.50	3.10	3.41	3.21	3.32	3.32
93	4.01	2.41	3.92	2.52	3.83	2.63	3.74	2.74	3.65	2.85	3.57	2.97	3.48	3.08	3.39	3.19	3.30	3.30
92	3.98	2.38	3.89	2.49	3.80	2.60	3.71	2.71	3.63	2.83	3.54	2.94	3.45	3.05	3.36	3.16	3.27	3.27
91	3.95	2.35	3.86	2.46	3.77	2.57	3.69	2.69	3.60	2.80	3.51	2.91	3.42	3.02	3.33	3.13	3.24	3.24
90	3.92	2.32	3.83	2.43	3.75	2.55	3.66	2.66	3.57	2.77	3.48	2.88	3.39	2.99	3.30	3.10	3.21	3.21
89	3.89	2.29	3.80	2.40	3.72	2.52	3.63	2.63	3.54	2.74	3.45	2.85	3.36	2.96	3.27	3.07	3.18	3.18
88	3.86	2.26	3.77	2.37	3.69	2.49	3.60	2.60	3.51	2.71	3.42	2.82	3.33	2.93	3.24	3.04	3.15	3.15
87	3.83	2.23	3.74	2.34	3.66	2.46	3.57	2.57	3.48	2.68	3.39	2.79	3.30	2.90	3.22	3.02	3.13	3.13
86	3.80	2.20	3.72	2.32	3.63	2.43	3.54	2.54	3.45	2.65	3.36	2.76	3.28	2.88	3.19	2.99	3.10	3.10
85	3.77	2.17	3.69	2.29	3.60	2.40	3.51	2.51	3.42	2.62	3.34	2.74	3.25	2.85	3.16	2.96	3.07	3.07
84	3.74	2.14	3.66	2.26	3.57	2.37	3.48	2.48	3.39	2.59	3.31	2.71	3.22	2.82	3.13	2.93	3.04	3.04
83	3.71	2.11	3.63	2.23	3.54	2.34	3.45	2.45	3.37	2.57	3.28	2.68	3.19	2.79	3.10	2.90	3.01	3.01
82	3.68	2.08	3.60	2.20	3.51	2.31	3.42	2.42	3.34	2.54	3.25	2.65	3.16	2.76	3.07	2.87	2.98	2.98

81	3.65	2.05	3.57	2.17	3.48	2.28	3.40	2.40	3.31	2.51	3.22	2.62	3.13	2.73	3.04	2.84	2.95	2.95
80	3.63	2.03	3.54	2.14	3.45	2.25	3.37	2.37	3.28	2.48	3.19	2.59	3.10	2.70	3.01	2.81	2.92	2.92
79	3.59	1.99	3.51	2.11	3.42	2.22	3.34	2.34	3.25	2.45	3.16	2.56	3.07	2.67	2.98	2.78	2.89	2.89
78	3.55	1.95	3.48	2.08	3.39	2.19	3.31	2.31	3.22	2.42	3.13	2.53	3.04	2.64	2.95	2.75	2.86	2.86
77	3.52	1.92	3.45	2.05	3.36	2.16	3.28	2.28	3.19	2.39	3.10	2.50	3.01	2.61	2.93	2.73	2.83	2.83
76	3.48	1.88	3.42	2.02	3.33	2.13	3.25	2.25	3.16	2.36	3.07	2.47	2.99	2.59	2.90	2.70	2.80	2.80
75	3.45	1.85	3.39	1.99	3.31	2.11	3.22	2.22	3.13	2.33	3.04	2.44	2.96	2.56	2.87	2.67	2.77	2.77
74	3.42	1.82	3.36	1.96	3.28	2.08	3.19	2.19	3.10	2.30	3.01	2.41	2.93	2.53	2.84	2.64	2.74	2.74
73	3.40	1.80	3.33	1.93	3.25	2.05	3.16	2.16	3.07	2.27	2.98	2.38	2.90	2.50	2.81	2.61	2.71	2.71
72	3.37	1.77	3.30	1.90	3.22	2.02	3.13	2.13	3.04	2.24	2.95	2.35	2.87	2.47	2.78	2.58	2.68	2.68
71	3.35	1.75	3.27	1.87	3.19	1.99	3.10	2.10	3.01	2.21	2.92	2.32	2.84	2.44	2.75	2.55	2.65	2.65
70	3.33	1.73	3.24	1.84	3.16	1.96	3.07	2.07	2.98	2.18	2.89	2.29	2.81	2.41	2.72	2.52	2.62	2.62
69	3.30	1.70	3.21	1.81	3.12	1.92	3.04	2.04	2.95	2.15	2.86	2.26	2.78	2.38	2.69	2.49	2.59	2.59
68	3.27	1.67	3.18	1.78	3.09	1.89	3.01	2.01	2.92	2.12	2.83	2.23	2.75	2.35	2.66	2.46	2.56	2.56
67	3.23	1.63	3.15	1.75	3.06	1.86	2.98	1.98	2.89	2.09	2.80	2.20	2.71	2.31	2.63	2.43	2.53	2.53
66	3.20	1.60	3.12	1.72	3.03	1.83	2.95	1.95	2.86	2.06	2.77	2.17	2.68	2.28	2.59	2.39	2.50	2.50
65	3.17	1.57	3.09	1.69	3.00	1.80	2.92	1.92	2.83	2.03	2.74	2.14	2.65	2.25	2.56	2.36	2.47	2.47
64	3.14	1.54	3.06	1.66	2.97	1.77	2.89	1.89	2.80	2.00	2.71	2.11	2.62	2.22	2.53	2.33	2.44	2.44
63	3.11	1.51	3.03	1.63	2.94	1.74	2.86	1.86	2.77	1.97	2.68	2.08	2.59	2.19	2.50	2.30	2.41	2.41
62	3.08	1.48	3.00	1.60	2.91	1.71	2.83	1.83	2.74	1.94	2.65	2.05	2.56	2.16	2.47	2.27	2.38	2.38
61	3.05	1.45	2.97	1.57	2.88	1.68	2.80	1.80	2.71	1.91	2.62	2.02	2.53	2.13	2.44	2.24	2.35	2.35
60	3.02	1.42	2.94	1.54	2.85	1.65	2.77	1.77	2.68	1.88	2.59	1.99	2.50	2.10	2.41	2.21	2.32	2.32

Table 4.30 *BHP MCr Calculation Result Trim Condition 1.6m by Stern*

Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
100	1733	1459	1232	1043	882	745	628	527	440	BHP MCr (kW)
95	1685	1422	1203	1019	863	730	616	517	431	
90	1634	1382	1171	994	842	713	602	505	422	
85	1583	1343	1140	968	822	696	588	494	412	
80	1534	1304	1109	943	802	680	574	483	403	
75	1476	1258	1072	913	777	660	558	469	392	
70	1436	1227	1047	893	761	646	546	460	384	
65	1388	1188	1016	867	740	629	532.5	448	374	
60	1338	1149	984	841	718	611	517	435	364	

Table 4.31 *BHP MCr Database Trim Condition 1.6 m by Stern*

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
100	1733	1678.2	1623.4	1568.6	1513.8	1459	1413.6	1368.2	1322.8	1277.4	1232	1194.2
99	1723.4	1669.04	1614.68	1560.32	1505.96	1451.6	1406.52	1361.44	1316.36	1271.28	1226.2	1188.6
98	1713.8	1659.88	1605.96	1552.04	1498.12	1444.2	1399.44	1354.68	1309.92	1265.16	1220.4	1183
97	1704.2	1650.72	1597.24	1543.76	1490.28	1436.8	1392.36	1347.92	1303.48	1259.04	1214.6	1177.4
96	1694.6	1641.56	1588.52	1535.48	1482.44	1429.4	1385.28	1341.16	1297.04	1252.92	1208.8	1171.8
95	1685	1632.4	1579.8	1527.2	1474.6	1422	1378.2	1334.4	1290.6	1246.8	1203	1166.2
94	1674.8	1622.64	1570.48	1518.32	1466.16	1414	1370.52	1327.04	1283.56	1240.08	1196.6	1160.08
93	1664.6	1612.88	1561.16	1509.44	1457.72	1406	1362.84	1319.68	1276.52	1233.36	1190.2	1153.96
92	1654.4	1603.12	1551.84	1500.56	1449.28	1398	1355.16	1312.32	1269.48	1226.64	1183.8	1147.84
91	1644.2	1593.36	1542.52	1491.68	1440.84	1390	1347.48	1304.96	1262.44	1219.92	1177.4	1141.72
90	1634	1583.6	1533.2	1482.8	1432.4	1382	1339.8	1297.6	1255.4	1213.2	1171	1135.6
89	1623.8	1573.88	1523.96	1474.04	1424.12	1374.2	1332.32	1290.44	1248.56	1206.68	1164.8	1129.6
88	1613.6	1564.16	1514.72	1465.28	1415.84	1366.4	1324.84	1283.28	1241.72	1200.16	1158.6	1123.6
87	1603.4	1554.44	1505.48	1456.52	1407.56	1358.6	1317.36	1276.12	1234.88	1193.64	1152.4	1117.6
86	1593.2	1544.72	1496.24	1447.76	1399.28	1350.8	1309.88	1268.96	1228.04	1187.12	1146.2	1111.6
85	1583	1535	1487	1439	1391	1343	1302.4	1261.8	1221.2	1180.6	1140	1105.6
84	1573.2	1525.6	1478	1430.4	1382.8	1335.2	1294.92	1254.64	1214.36	1174.08	1133.8	1099.64
83	1563.4	1516.2	1469	1421.8	1374.6	1327.4	1287.44	1247.48	1207.52	1167.56	1127.6	1093.68
82	1553.6	1506.8	1460	1413.2	1366.4	1319.6	1279.96	1240.32	1200.68	1161.04	1121.4	1087.72
81	1543.8	1497.4	1451	1404.6	1358.2	1311.8	1272.48	1233.16	1193.84	1154.52	1115.2	1081.76
80	1534	1488	1442	1396	1350	1304	1265	1226	1187	1148	1109	1075.8
79	1522.4	1476.88	1431.36	1385.84	1340.32	1294.8	1256.16	1217.52	1178.88	1140.24	1101.6	1068.68

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
78	1510.8	1465.76	1420.72	1375.68	1330.64	1285.6	1247.32	1209.04	1170.76	1132.48	1094.2	1061.56
77	1499.2	1454.64	1410.08	1365.52	1320.96	1276.4	1238.48	1200.56	1162.64	1124.72	1086.8	1054.44
76	1487.6	1443.52	1399.44	1355.36	1311.28	1267.2	1229.64	1192.08	1154.52	1116.96	1079.4	1047.32
75	1476	1432.4	1388.8	1345.2	1301.6	1258	1220.8	1183.6	1146.4	1109.2	1072	1040.2
74	1468	1424.76	1381.52	1338.28	1295.04	1251.8	1214.84	1177.88	1140.92	1103.96	1067	1035.4
73	1460	1417.12	1374.24	1331.36	1288.48	1245.6	1208.88	1172.16	1135.44	1098.72	1062	1030.6
72	1452	1409.48	1366.96	1324.44	1281.92	1239.4	1202.92	1166.44	1129.96	1093.48	1057	1025.8
71	1444	1401.84	1359.68	1317.52	1275.36	1233.2	1196.96	1160.72	1124.48	1088.24	1052	1021
70	1436	1394.2	1352.4	1310.6	1268.8	1227	1191	1155	1119	1083	1047	1016.2
69	1426.4	1384.96	1343.52	1302.08	1260.64	1219.2	1183.52	1147.84	1112.16	1076.48	1040.8	1010.2
68	1416.8	1375.72	1334.64	1293.56	1252.48	1211.4	1176.04	1140.68	1105.32	1069.96	1034.6	1004.2
67	1407.2	1366.48	1325.76	1285.04	1244.32	1203.6	1168.56	1133.52	1098.48	1063.44	1028.4	998.2
66	1397.6	1357.24	1316.88	1276.52	1236.16	1195.8	1161.08	1126.36	1091.64	1056.92	1022.2	992.2
65	1388	1348	1308	1268	1228	1188	1153.6	1119.2	1084.8	1050.4	1016	986.2
64	1378	1338.44	1298.88	1259.32	1219.76	1180.2	1146.08	1111.96	1077.84	1043.72	1009.6	980.04
63	1368	1328.88	1289.76	1250.64	1211.52	1172.4	1138.56	1104.72	1070.88	1037.04	1003.2	973.88
62	1358	1319.32	1280.64	1241.96	1203.28	1164.6	1131.04	1097.48	1063.92	1030.36	996.8	967.72
61	1348	1309.76	1271.52	1233.28	1195.04	1156.8	1123.52	1090.24	1056.96	1023.68	990.4	961.56
60	1338	1300.2	1262.4	1224.6	1186.8	1149	1116	1083	1050	1017	984	955.4

	10.8	10.7	10.6	10.5	10.4	10.3	10.2	10.1	10	9.9	9.8	9.7
100	1156.4	1118.6	1080.8	1043	1010.8	978.6	946.4	914.2	882	854.6	827.2	799.8
99	1151	1113.4	1075.8	1038.2	1006.2	974.2	942.2	910.2	878.2	850.96	823.72	796.48
98	1145.6	1108.2	1070.8	1033.4	1001.6	969.8	938	906.2	874.4	847.32	820.24	793.16
97	1140.2	1103	1065.8	1028.6	997	965.4	933.8	902.2	870.6	843.68	816.76	789.84
96	1134.8	1097.8	1060.8	1023.8	992.4	961	929.6	898.2	866.8	840.04	813.28	786.52
95	1129.4	1092.6	1055.8	1019	987.8	956.6	925.4	894.2	863	836.4	809.8	783.2
94	1123.56	1087.04	1050.52	1014	982.96	951.92	920.88	889.84	858.8	832.36	805.92	779.48
93	1117.72	1081.48	1045.24	1009	978.12	947.24	916.36	885.48	854.6	828.32	802.04	775.76
92	1111.88	1075.92	1039.96	1004	973.28	942.56	911.84	881.12	850.4	824.28	798.16	772.04
91	1106.04	1070.36	1034.68	999	968.44	937.88	907.32	876.76	846.2	820.24	794.28	768.32
90	1100.2	1064.8	1029.4	994	963.6	933.2	902.8	872.4	842	816.2	790.4	764.6
89	1094.4	1059.2	1024	988.8	958.64	928.48	898.32	868.16	838	812.32	786.64	760.96
88	1088.6	1053.6	1018.6	983.6	953.68	923.76	893.84	863.92	834	808.44	782.88	757.32
87	1082.8	1048	1013.2	978.4	948.72	919.04	889.36	859.68	830	804.56	779.12	753.68
86	1077	1042.4	1007.8	973.2	943.76	914.32	884.88	855.44	826	800.68	775.36	750.04
85	1071.2	1036.8	1002.4	968	938.8	909.6	880.4	851.2	822	796.8	771.6	746.4
84	1065.48	1031.32	997.16	963	934	905	876	847	818	792.96	767.92	742.88
83	1059.76	1025.84	991.92	958	929.2	900.4	871.6	842.8	814	789.12	764.24	739.36
82	1054.04	1020.36	986.68	953	924.4	895.8	867.2	838.6	810	785.28	760.56	735.84
81	1048.32	1014.88	981.44	948	919.6	891.2	862.8	834.4	806	781.44	756.88	732.32
80	1042.6	1009.4	976.2	943	914.8	886.6	858.4	830.2	802	777.6	753.2	728.8
79	1035.76	1002.84	969.92	937	909	881	853	825	797	772.8	748.6	724.4
78	1028.92	996.28	963.64	931	903.2	875.4	847.6	819.8	792	768	744	720

	10.8	10.7	10.6	10.5	10.4	10.3	10.2	10.1	10	9.9	9.8	9.7
77	1022.08	989.72	957.36	925	897.4	869.8	842.2	814.6	787	763.2	739.4	715.6
76	1015.24	983.16	951.08	919	891.6	864.2	836.8	809.4	782	758.4	734.8	711.2
75	1008.4	976.6	944.8	913	885.8	858.6	831.4	804.2	777	753.6	730.2	706.8
74	1003.8	972.2	940.6	909	881.96	854.92	827.88	800.84	773.8	750.48	727.16	703.84
73	999.2	967.8	936.4	905	878.12	851.24	824.36	797.48	770.6	747.36	724.12	700.88
72	994.6	963.4	932.2	901	874.28	847.56	820.84	794.12	767.4	744.24	721.08	697.92
71	990	959	928	897	870.44	843.88	817.32	790.76	764.2	741.12	718.04	694.96
70	985.4	954.6	923.8	893	866.6	840.2	813.8	787.4	761	738	715	692
69	979.6	949	918.4	887.8	861.6	835.4	809.2	783	756.8	733.96	711.12	688.28
68	973.8	943.4	913	882.6	856.6	830.6	804.6	778.6	752.6	729.92	707.24	684.56
67	968	937.8	907.6	877.4	851.6	825.8	800	774.2	748.4	725.88	703.36	680.84
66	962.2	932.2	902.2	872.2	846.6	821	795.4	769.8	744.2	721.84	699.48	677.12
65	956.4	926.6	896.8	867	841.6	816.2	790.8	765.4	740	717.8	695.6	673.4
64	950.48	920.92	891.36	861.8	836.56	811.32	786.08	760.84	735.6	713.56	691.52	669.48
63	944.56	915.24	885.92	856.6	831.52	806.44	781.36	756.28	731.2	709.32	687.44	665.56
62	938.64	909.56	880.48	851.4	826.48	801.56	776.64	751.72	726.8	705.08	683.36	661.64
61	932.72	903.88	875.04	846.2	821.44	796.68	771.92	747.16	722.4	700.84	679.28	657.72
60	926.8	898.2	869.6	841	816.4	791.8	767.2	742.6	718	696.6	675.2	653.8

	9.5	9.4	9.3	9.2	9.1	9	8.9	8.8	8.7	8.6	8.5	8.4
100	745	721.6	698.2	674.8	651.4	628	607.8	587.6	567.4	547.2	527	509.6
99	742	718.72	695.44	672.16	648.88	625.6	605.48	585.36	565.24	545.12	525	507.64
98	739	715.84	692.68	669.52	646.36	623.2	603.16	583.12	563.08	543.04	523	505.68
97	736	712.96	689.92	666.88	643.84	620.8	600.84	580.88	560.92	540.96	521	503.72
96	733	710.08	687.16	664.24	641.32	618.4	598.52	578.64	558.76	538.88	519	501.76
95	730	707.2	684.4	661.6	638.8	616	596.2	576.4	556.6	536.8	517	499.8
94	726.6	703.92	681.24	658.56	635.88	613.2	593.48	573.76	554.04	534.32	514.6	497.52
93	723.2	700.64	678.08	655.52	632.96	610.4	590.76	571.12	551.48	531.84	512.2	495.24
92	719.8	697.36	674.92	652.48	630.04	607.6	588.04	568.48	548.92	529.36	509.8	492.96
91	716.4	694.08	671.76	649.44	627.12	604.8	585.32	565.84	546.36	526.88	507.4	490.68
90	713	690.8	668.6	646.4	624.2	602	582.6	563.2	543.8	524.4	505	488.4
89	709.6	687.52	665.44	643.36	621.28	599.2	579.92	560.64	541.36	522.08	502.8	486.24
88	706.2	684.24	662.28	640.32	618.36	596.4	577.24	558.08	538.92	519.76	500.6	484.08
87	702.8	680.96	659.12	637.28	615.44	593.6	574.56	555.52	536.48	517.44	498.4	481.92
86	699.4	677.68	655.96	634.24	612.52	590.8	571.88	552.96	534.04	515.12	496.2	479.76
85	696	674.4	652.8	631.2	609.6	588	569.2	550.4	531.6	512.8	494	477.6
84	692.8	671.28	649.76	628.24	606.72	585.2	566.52	547.84	529.16	510.48	491.8	475.48
83	689.6	668.16	646.72	625.28	603.84	582.4	563.84	545.28	526.72	508.16	489.6	473.36
82	686.4	665.04	643.68	622.32	600.96	579.6	561.16	542.72	524.28	505.84	487.4	471.24
81	683.2	661.92	640.64	619.36	598.08	576.8	558.48	540.16	521.84	503.52	485.2	469.12
80	680	658.8	637.6	616.4	595.2	574	555.8	537.6	519.4	501.2	483	467
79	676	654.96	633.92	612.88	591.84	570.8	552.68	534.56	516.44	498.32	480.2	464.32
78	672	651.12	630.24	609.36	588.48	567.6	549.56	531.52	513.48	495.44	477.4	461.64

	9.5	9.4	9.3	9.2	9.1	9	8.9	8.8	8.7	8.6	8.5	8.4
77	668	647.28	626.56	605.84	585.12	564.4	546.44	528.48	510.52	492.56	474.6	458.96
76	664	643.44	622.88	602.32	581.76	561.2	543.32	525.44	507.56	489.68	471.8	456.28
75	660	639.6	619.2	598.8	578.4	558	540.2	522.4	504.6	486.8	469	453.6
74	657.2	636.88	616.56	596.24	575.92	555.6	537.92	520.24	502.56	484.88	467.2	451.84
73	654.4	634.16	613.92	593.68	573.44	553.2	535.64	518.08	500.52	482.96	465.4	450.08
72	651.6	631.44	611.28	591.12	570.96	550.8	533.36	515.92	498.48	481.04	463.6	448.32
71	648.8	628.72	608.64	588.56	568.48	548.4	531.08	513.76	496.44	479.12	461.8	446.56
70	646	626	606	586	566	546	528.8	511.6	494.4	477.2	460	444.8
69	642.6	622.74	602.88	583.02	563.16	543.3	526.16	509.02	491.88	474.74	457.6	442.48
68	639.2	619.48	599.76	580.04	560.32	540.6	523.52	506.44	489.36	472.28	455.2	440.16
67	635.8	616.22	596.64	577.06	557.48	537.9	520.88	503.86	486.84	469.82	452.8	437.84
66	632.4	612.96	593.52	574.08	554.64	535.2	518.24	501.28	484.32	467.36	450.4	435.52
65	629	609.7	590.4	571.1	551.8	532.5	515.6	498.7	481.8	464.9	448	433.2
64	625.4	606.2	587	567.8	548.6	529.4	512.6	495.8	479	462.2	445.4	430.72
63	621.8	602.7	583.6	564.5	545.4	526.3	509.6	492.9	476.2	459.5	442.8	428.24
62	618.2	599.2	580.2	561.2	542.2	523.2	506.6	490	473.4	456.8	440.2	425.76
61	614.6	595.7	576.8	557.9	539	520.1	503.6	487.1	470.6	454.1	437.6	423.28
60	611	592.2	573.4	554.6	535.8	517	500.6	484.2	467.8	451.4	435	420.8

100	8.3	8.2	8.1	8
99	492.2	474.8	457.4	440
98	490.28	472.92	455.56	438.2
97	488.36	471.04	453.72	436.4
96	486.44	469.16	451.88	434.6
95	484.52	467.28	450.04	432.8
94	482.6	465.4	448.2	431
93	480.44	463.36	446.28	429.2
92	478.28	461.32	444.36	427.4
91	476.12	459.28	442.44	425.6
90	473.96	457.24	440.52	423.8
89	471.8	455.2	438.6	422
88	469.68	453.12	436.56	420
87	467.56	451.04	434.52	418
86	465.44	448.96	432.48	416
85	463.32	446.88	430.44	414
84	461.2	444.8	428.4	412
83	459.16	442.84	426.52	410.2
82	457.12	440.88	424.64	408.4
81	455.08	438.92	422.76	406.6
80	453.04	436.96	420.88	404.8
79	451	435	419	403
78	448.44	432.56	416.68	400.8
77	445.88	430.12	414.36	398.6

76	443.32	427.68	412.04	396.4
75	440.76	425.24	409.72	394.2
74	438.2	422.8	407.4	392
73	436.48	421.12	405.76	390.4
72	434.76	419.44	404.12	388.8
71	433.04	417.76	402.48	387.2
70	431.32	416.08	400.84	385.6
69	429.6	414.4	399.2	384
68	427.36	412.24	397.12	382
67	425.12	410.08	395.04	380
66	422.88	407.92	392.96	378
65	420.64	405.76	390.88	376
64	418.4	403.6	388.8	374
63	416.04	401.36	386.68	372
62	413.68	399.12	384.56	370
61	411.32	396.88	382.44	368
60	408.96	394.64	380.32	366
60	406.6	392.4	378.2	364

4.9. SOFTWARE DEVELOPMENT

The software developed in this research using C# language program in Microsoft Visual Studio 2015. Before start the coding phase, first required to determine the algorithm of the software, thereby the step of the coding can be easily created.

The algorithm itself start from the homepage with the start button to initiate the program. After the program initiated, users are required to determine the speed of the ship, number of containers and the weight of containers. The limitation number of speed, containers and weight of containers must be specified in defined range, thereby the users only able to operate the software in the specified range.

After knowing the number of the container, software will find out the percentage of the displacement by using this formula:

$$\nabla = \frac{Weight\ of\ Empty\ Ship + Weight\ of\ Oil\ and\ Water + (Number\ Container\ x\ Weight\ of\ Container)}{3109}$$

$$\nabla = \frac{1018+348+(nContainer * wContainer)}{3109}$$

With the known ship and displacement percentage, thereby the program will find the library in excel to find the least resistance known in the possible condition.

In the program, specified the maximum number allowed of each cargo hold and the sequence of the container arrangement in each sector. From the data known that the LCG of container in each bay from zero point is:

R1	:	17.226	m
R2	:	23.4	m
R3	:	29.534	m
R4	:	41.266	m
R5	:	47.4	m
R6	:	53.884	m
LCG Hull	:	28.4	m
LCG Fuel Oil	:	33.34	m
LCG Oil	:	3.3	m
LCG Fresh Water	:	18.3	m

To determine the new LCG is using the following formula:

$$LCG = \frac{(A*R1)+(B*R2)+(C*R3)+(D*R4)+(E*R5)+(F*R6)+(Wship*LCG\ Ship)+(W\ oil*LCG\ oil)}{(A+B+C+D+E+F+Wship+Woil)}$$

with

A	: Total Weight of Container in Bay 1	ton
B	: Total Weight of Container in Bay 2	ton
C	: Total Weight of Container in Bay 3	ton
D	: Total Weight of Container in Bay 4	ton
E	: Total Weight of Container in Bay 5	ton
F	: Total Weight of Container in Bay 6	ton

Known the number of containers, software will loop the arrangement to find the available arrangement to achieve LCG with the least resistance known from the database in excel. After knowing the trim condition, software will automatically connect the resistance with the BHP MCr and trim information. From the known BHP MCr can be calculate the Fuel Consumption using this formula:

$$\text{Fuel Consumption} = \left(\frac{BHP\ Mcr}{2280} \times 100\%\right) \times SFOC \qquad \text{(g/kWh)}$$

The SFOC known from project guide will be interpolated to predict the amount of SFOC in specified condition. The result from fuel consumption will be changed into ton/hour.

The result from the software will be shown and software will automatically show the result if ship in even keel condition, thereby users can see the differences of EHP, BHP Mcr, Fuel Consumption and Trim Condition.

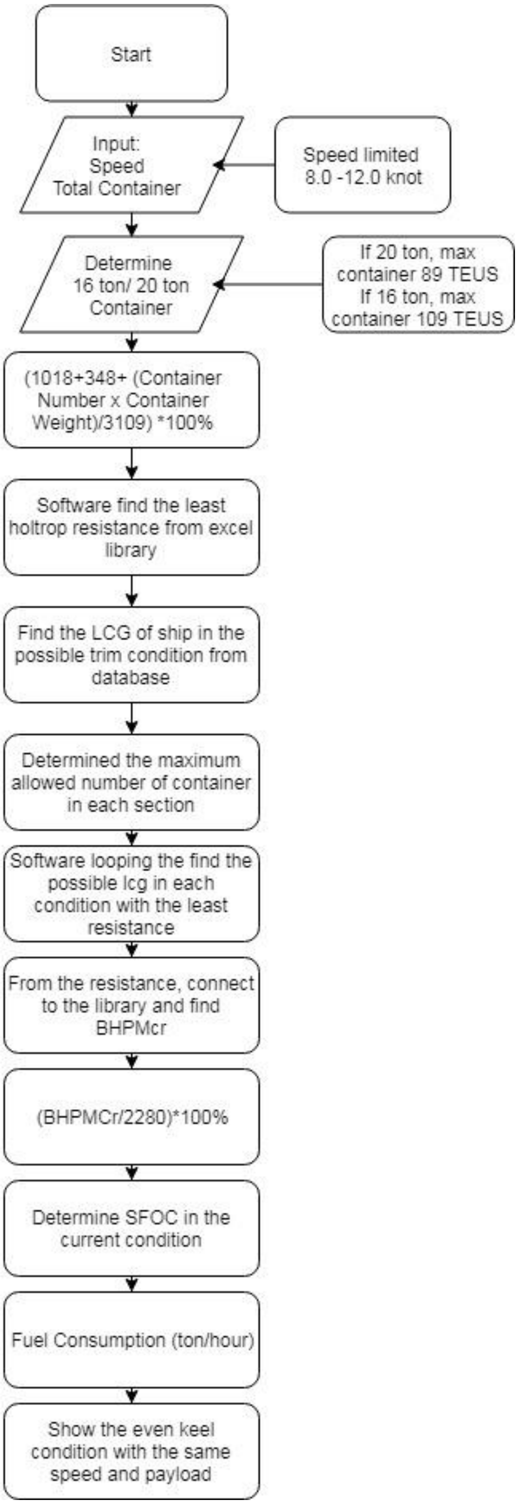


Figure 4.14 *Software Algorithm*

After creating the algorithm, further step can be done, which is coding. The command mentioned bellow is used in the beginning of the coding.

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using System.Windows.Forms;
using System.IO;
using ExcelDataReader;
using System.Text.RegularExpressions;

namespace Kapal
```

Where the *Using* command used above is taken from the visual studio library, the default provided by Microsoft Visual Studio 2016. The namespace declaration, *using System;*, indicates the reference to the *System* namespace, and telling the program that it can reference the code in the *System* namespace without pre-pending the word *System* to every reference.

The *System.Collections.Generic* namespace contains interfaces and classes that define generic collections. Where the *System.Data* provides access to classes that represent the ADO.NET architecture. It allows the user to build components that efficiently manage data from multiple sources. The *System.Drawing* provides access to basic graphics functionality, the *System.Text* contains classes that converting blocks of characters to and from blocks of bytes. *System.Threading.Task* allow namespace provides types that simplify the work of writing code. *System.Windows.Form* represents window or dialog box that makes up software's user interface and *System.IO* contains types that allow reading and writing to files and data streams.

using ExcelDataReader function allow the software to read the input/output data from the excel, while *using System.Text.RegularExpression* used to read mathematical expression in Visual Studio, such as absolute and random.

```
public partial class MainForm : System.Windows.Forms.Form
    {
        double BeratKapalKosong;
        double BeratAir;
        double BeratOli;
        double BeratBahanBakar;
        long BahanBakar;
        double KapasitasMaksKontainer;
        long JumlahKontainerMin;
        long JumlahKontainerMax;
        long Displacement;
        long BeratTotalKontainer;
        long[,] arrMaxTeus = new long[6, 4] { { 0, 0, 0, 0 }, { 0,
0, 0, 0 }, { 0, 0, 0, 0 }, { 0, 0, 0, 0 }, { 0, 0, 0, 0 }, { 0, 0,
0, 0 } };
        long jumlah, berat;
        double kecKapal;
        double LCGValue;
        double L1 = 17.226;
        double L2 = 23.4;
        double L3 = 29.534;
        double L4 = 41.266;
        double L5 = 47.4;
        double L6 = 53.884;
        double LCGKapalKosong;
        double LCGAir;
        double LCGOli;
        double LCGBahanBakar;
        int saveCondition = 0;
        double HoltropValue;
        double PowerDistributionValue;
        double FuelConsumptionValueNormal;
        double FuelConsumptionValue;
        double HoltropValueEK;
        double PowerDistributionValueEK;
        double FuelConsumptionValueNormalEK;
        double FuelConsumptionValueEK;
        double dividedCylinder;
        double TAValue;
        double TFValue;
        double TAValueEK;
        double TFValueEK;
        int cols = 0, rows = 0;
        List<string> priorityFill = new List<string>();
        List<int> sidePosX = new List<int>();
```

```
        List<int> sidePosY = new List<int>();
        List<int> frontPosX = new List<int>();
        List<int> frontPosY = new List<int>();
        Image containerFront;
        Image containerSide;
        long tmpJumlahAnimate = 0;
        int[] rules = new int[] { 2, 1, 3, 0, 4};

        Timer animated = new Timer();
        bool btnResultCheck = false;
        bool btnResultSide = false;
        int tmpCount = 0;
        int newY = 0, newX = 0;
        int ctrFront = 0;

        public MainForm()
        {
            InitializeComponent();
            containerFront =
        Kapal.Properties.Resources.container_1;
            containerSide = Kapal.Properties.Resources.container_2;
            transparentPanel();
        }
```

The following command used as the input variable in the interface. The command used here is *double*, *long, List, Image, bool, int* is the type of the data, such as Boolean, Image, Longitudinal, Integer and Double Integer.

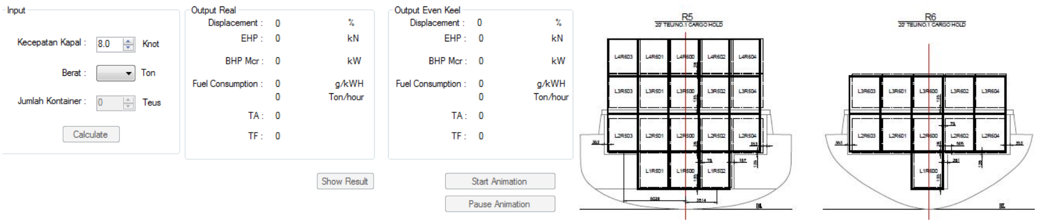


Figure 4.15 *Result of Command in public MainForm*

```
private void numericUpDown1_ValueChanged(object sender,
EventArgs e)
 {
     btnCalculate.Enabled = true;
 }
```

Numeric command used to create the following box function to up and down the value:

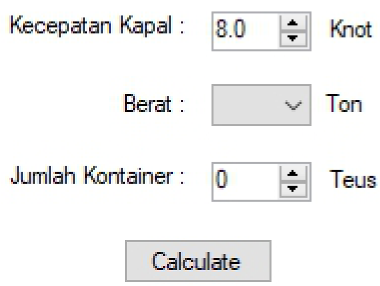


Figure 4.16 *numericUpDown Function*

```
 private void calc()
{
    load_initial();

    berat =
Convert.ToInt64(cbBerat.SelectedItem.ToString());
    jumlah = Convert.ToInt64(numJmlKtr.Value.ToString());
    tmpJumlahAnimate = jumlah;
    kecKapal =
Convert.ToDouble(numKcptKpl.Value.ToString());
    double temp = (berat * jumlah) + BeratKapalKosong +
BahanBakar;
    double result = (temp / 3109) * 100; //percent
    Displacement = (long)Math.Round(result);
    BeratTotalKontainer = berat * jumlah;
    //MessageBox.Show("Displacement:
"+Displacement.ToString());
```

In this calc command, the coding input the value from the user input in the interface and thereby calculate the value using the determined formula. The result from this formula will be used to find out the result from the database library in excel.

```
        readLCG();
            readHoltrop();
            readPowerDistribution();
            readUtama();
            readFuelConsumption();
            //real
            lblValueHoltrop.Text = Math.Round(HoltropValue, 
2).ToString();
            lblValuePowerDist.Text = 
Math.Round(PowerDistributionValue, 2).ToString();
            lblvalueTA.Text = Math.Round(TAValue, 2).ToString();
            lblvalueTF.Text = Math.Round(TFValue, 2).ToString();
            lblValueFuelConsNormal.Text = 
Math.Round(FuelConsumptionValueNormal, 5).ToString();
            lblValueFuelCons.Text = 
Math.Round(FuelConsumptionValue, 5).ToString();
            lblValueDisplacement.Text = Displacement.ToString();

            //even keel
            lblValueHoltropEK.Text = Math.Round(HoltropValueEK, 
2).ToString();
            lblValuePowerDistEK.Text = 
Math.Round(PowerDistributionValueEK, 2).ToString();
            lblvalueTAEK.Text = Math.Round(TAValueEK, 
2).ToString();
            lblvalueTFEK.Text = Math.Round(TFValueEK, 
2).ToString();
            lblValueFuelConsNormalEK.Text = 
Math.Round(FuelConsumptionValueNormalEK, 5).ToString();
            lblValueFuelConsEK.Text = 
Math.Round(FuelConsumptionValueEK, 5).ToString();
            lblValueDisplacementEK.Text = Displacement.ToString();
```

The read command here used to find the value of EHP, BHP MCr, Trim Condition and Fuel Consumption in the optimum trim condition. The function also designed to read the value in Even Keel Condition to be shown at the user interface, thereby the user can see the difference in optimum condition and even keel condition.

```
private void drawSide(int posx, int posy)
        {
            Graphics g = panelSide1.CreateGraphics();
            Graphics g2 = panelSide2.CreateGraphics();
            Pen blackPen = new Pen(Color.Black, 3);
            if (posx >= 3)
            {
                int panelWidth = panelSide2.Width;
                int panelHeight = panelSide2.Height;
                int rectWidth = panelWidth / 3;
                int rectHeight = panelHeight / 4;
                Rectangle rect = new Rectangle((posx - 3) *
rectWidth, posy * rectHeight, rectWidth, rectHeight);
                g2.DrawImage(containerSide, rect);
                g2.DrawRectangle(blackPen, rect);
            }
            else
            {
                int panelWidth = panelSide1.Width;
                int panelHeight = panelSide1.Height;
                int rectWidth = panelWidth / 3;
                int rectHeight = panelHeight / 4;
                Rectangle rect = new Rectangle(posx * rectWidth,
posy * rectHeight, rectWidth, rectHeight);
                g.DrawImage(containerSide, rect);
                g.DrawRectangle(blackPen, rect);
            }
        }

        private void drawFront(int posx, int posy, long maxTeus)
        {
            Graphics g = panelFront1.CreateGraphics();
            Graphics g2 = panelFront2.CreateGraphics();
            Graphics g3 = panelFront3.CreateGraphics();
            Graphics g4 = panelFront4.CreateGraphics();
            Graphics g5 = panelFront5.CreateGraphics();
            Graphics g6 = panelFront6.CreateGraphics();
            Pen blackPen = new Pen(Color.Black, 3);
```

The final step is using the drawFront and drawSide command to show the animation in the user interface. The animation itself created to help the user to arrange the container to achieve optimum trim condition.

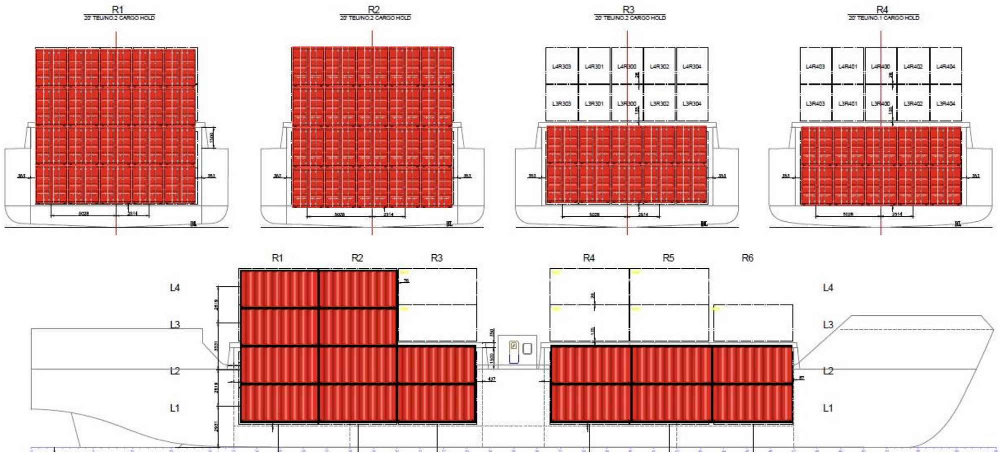


Figure 4.17 *drawFront and drawSide Command*

4.10. SOFTWARE INTERFACE

In this software, the users are able to determine the speed from 8.0 – 12.0 knot, displacement from 60% - 80%, container with specified weight 16 ton or 20 ton. After input the required data, software will calculate and match the result from the database using library function of the software, where it will also arrange the container based on the available trim condition with the least power required. In the final result of the software, it will show the differences between optimal trim condition and even keel condition, thereby user can easily arrange the software to obtain the least fuel oil consumption.

User are required to input the speed, weight and number of container. Thereby the software will automatically find the result of power and fuel consumption in the recommended condition and even keel condition. Software will also show the container arrangement to achieve the recommended condition.

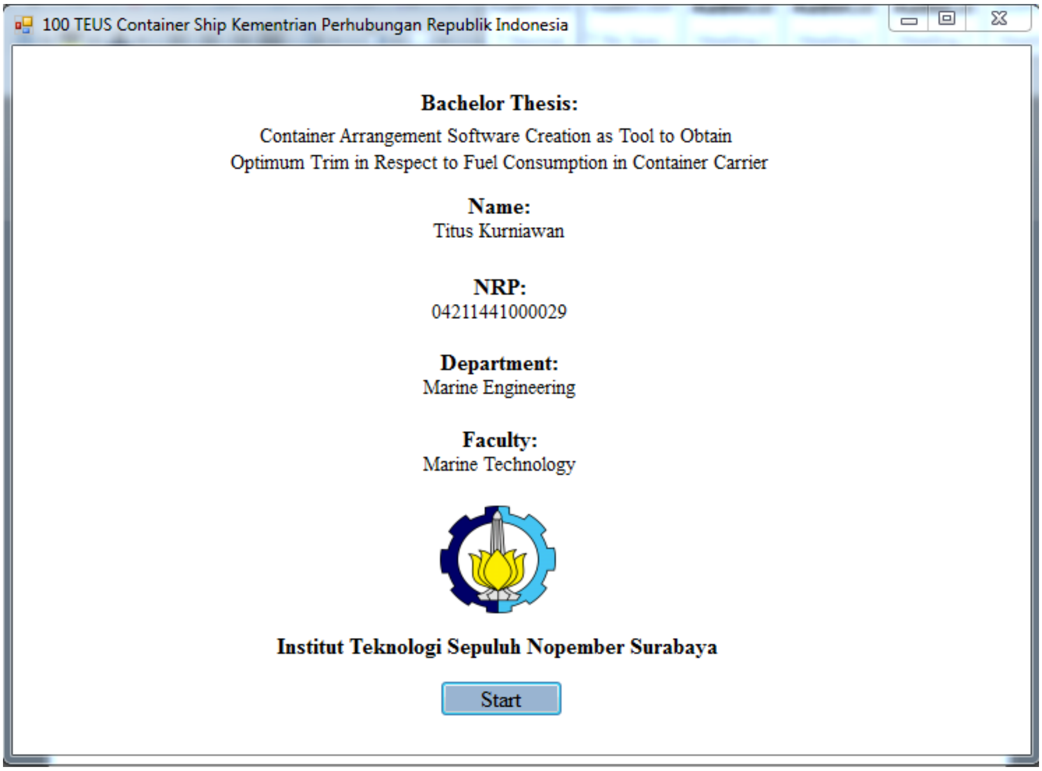
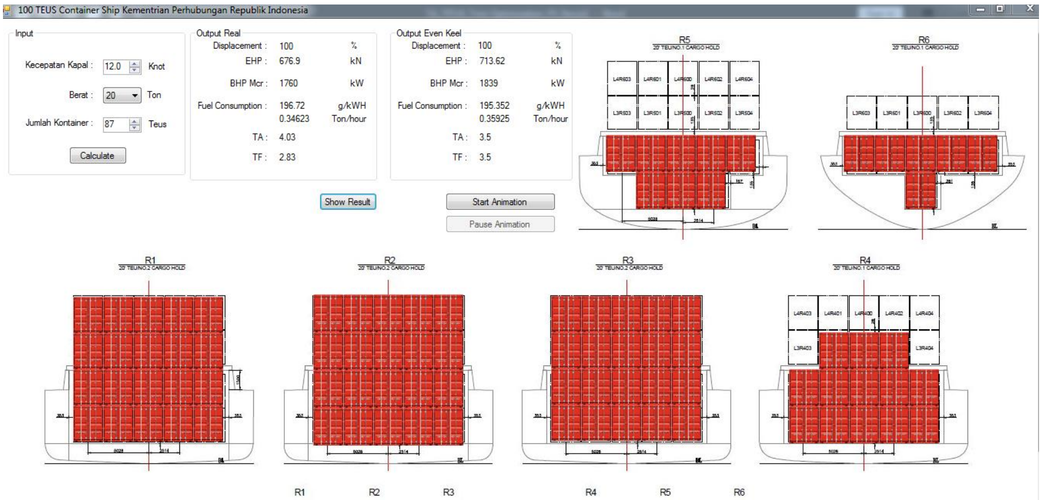


Figure 4.18 *Software Homepage*



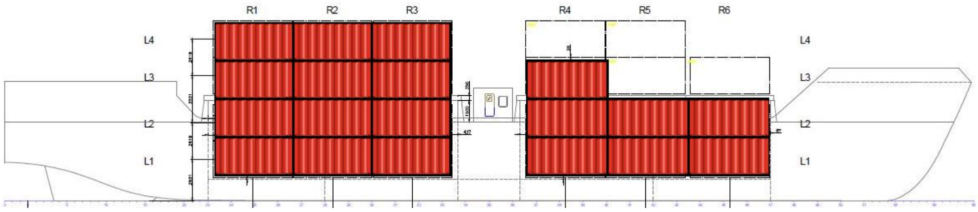


Figure 4.19 *Software Interface*

4.11. VALIDATION

Validation is the final step in this research, where the purpose is to ensure the result shown in the software is accurate. The validation step itself crosschecked the result created in the software with the result that has been created in the database section.

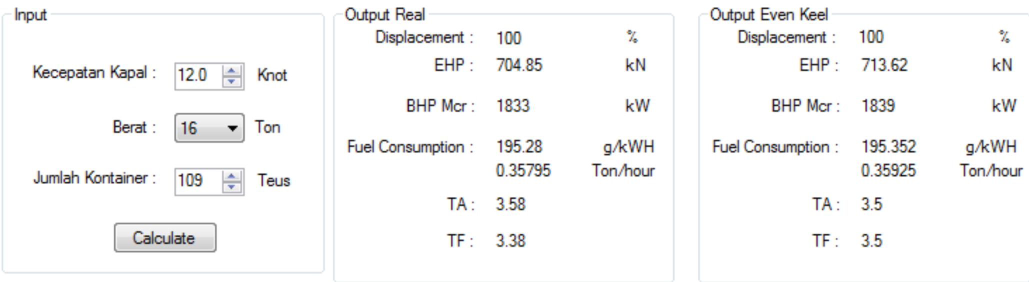


Figure 4.20 *Output Created by Software*

EHP			
Disp	12	11.9	11.8
100	704.8534	681.9909	659.1285
99	700.5772	677.8887	655.2001
98	696.3011	673.7864	651.2717
97	692.0249	669.6841	647.3433

BHP MCr			
Disp	12	11.9	11.8
100	1833	1773.6	1714.2
99	1821.8	1762.84	1703.88
98	1810.6	1752.08	1693.56
97	1799.4	1741.32	1683.24

	Ta	Tf
100	3.585	3.385
99	3.5566	3.3566
98	3.5282	3.3282
97	3.4998	3.2998
96	3.4714	3.2714

Figure 4.21 *Result from Calculation in Database*

CHAPTER V: CONCLUSION

5.1. CONCLUSION

The least resistance condition of container carrier of Kementrian Perhubungan Republik Indonesia 100 TEUS is on trim by stern 1.6 m condition. The trend in trem by stern condition having less resistance compared to even keel condition. In some trim by bow condition, it is also having less resistance compared to even keel condition. By applying the optimum trim condition, it may reduce the power required up to 6%. While the ship itself still have no service route, hence the analysis of fuel consumption based on Ton/hour, where it can save up to 5% fuel consumption in the optimal trim condition.

By applying trim condition in a ship, it will affect the LWL and WSA of a ship, as well as resistance coefficient, wake fraction and thrust deduction. The reduction of resistance in optimum trim condition lead to less power required in the same displacement and speed.

The stability of ship applying optimum trim condition itself still fulfill the IMO (IS Code Chapter 3.1.).

5.2. SUGGESTION

For the further research, the resistance calculation of ship for trim optimization can use Computational Fluid Dynamic (CFD), towing tank test or Reynolds-Navier-Stroke (RANSE) that representing in fluid dynamics calculation.

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APPENDIX 1

Trim Condition

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	1.60	m	1.40	M	1.20	m	1.00	m	0.80	m	0.60	M	0.40	m	0.20	m	0.00	m
	Trim by Stern																EK	
	1.00		2.00		3.00		4.00		5.00		6.00		7.00		8.00			
	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf	Ta	Tf
100	4.20	2.60	4.12	2.72	4.03	2.83	3.94	2.94	3.86	3.06	3.77	3.17	3.68	3.28	3.59	3.39	3.50	3.50
99	4.17	2.57	4.09	2.69	4.00	2.80	3.92	2.92	3.83	3.03	3.74	3.14	3.65	3.25	3.56	3.36	3.47	3.47
98	4.15	2.55	4.06	2.66	3.97	2.77	3.89	2.89	3.80	3.00	3.71	3.11	3.62	3.22	3.53	3.33	3.44	3.44
97	4.12	2.52	4.03	2.63	3.95	2.75	3.86	2.86	3.77	2.97	3.68	3.08	3.59	3.19	3.50	3.30	3.41	3.41
96	4.09	2.49	4.00	2.60	3.92	2.72	3.83	2.83	3.74	2.94	3.65	3.05	3.56	3.16	3.47	3.27	3.38	3.38
95	4.06	2.46	3.98	2.58	3.89	2.69	3.80	2.80	3.71	2.91	3.62	3.02	3.53	3.13	3.44	3.24	3.35	3.35
94	4.04	2.44	3.95	2.55	3.86	2.66	3.77	2.77	3.68	2.88	3.59	2.99	3.50	3.10	3.41	3.21	3.32	3.32
93	4.01	2.41	3.92	2.52	3.83	2.63	3.74	2.74	3.65	2.85	3.57	2.97	3.48	3.08	3.39	3.19	3.30	3.30
92	3.98	2.38	3.89	2.49	3.80	2.60	3.71	2.71	3.63	2.83	3.54	2.94	3.45	3.05	3.36	3.16	3.27	3.27
91	3.95	2.35	3.86	2.46	3.77	2.57	3.69	2.69	3.60	2.80	3.51	2.91	3.42	3.02	3.33	3.13	3.24	3.24
90	3.92	2.32	3.83	2.43	3.75	2.55	3.66	2.66	3.57	2.77	3.48	2.88	3.39	2.99	3.30	3.10	3.21	3.21
89	3.89	2.29	3.80	2.40	3.72	2.52	3.63	2.63	3.54	2.74	3.45	2.85	3.36	2.96	3.27	3.07	3.18	3.18
88	3.86	2.26	3.77	2.37	3.69	2.49	3.60	2.60	3.51	2.71	3.42	2.82	3.33	2.93	3.24	3.04	3.15	3.15
87	3.83	2.23	3.74	2.34	3.66	2.46	3.57	2.57	3.48	2.68	3.39	2.79	3.30	2.90	3.22	3.02	3.13	3.13
86	3.80	2.20	3.72	2.32	3.63	2.43	3.54	2.54	3.45	2.65	3.36	2.76	3.28	2.88	3.19	2.99	3.10	3.10
85	3.77	2.17	3.69	2.29	3.60	2.40	3.51	2.51	3.42	2.62	3.34	2.74	3.25	2.85	3.16	2.96	3.07	3.07
84	3.74	2.14	3.66	2.26	3.57	2.37	3.48	2.48	3.39	2.59	3.31	2.71	3.22	2.82	3.13	2.93	3.04	3.04
83	3.71	2.11	3.63	2.23	3.54	2.34	3.45	2.45	3.37	2.57	3.28	2.68	3.19	2.79	3.10	2.90	3.01	3.01
82	3.68	2.08	3.60	2.20	3.51	2.31	3.42	2.42	3.34	2.54	3.25	2.65	3.16	2.76	3.07	2.87	2.98	2.98
81	3.65	2.05	3.57	2.17	3.48	2.28	3.40	2.40	3.31	2.51	3.22	2.62	3.13	2.73	3.04	2.84	2.95	2.95

80	3.63	2.03	3.54	2.14	3.45	2.25	3.37	2.37	3.28	2.48	3.19	2.59	3.10	2.70	3.01	2.81	2.92	2.92
79	3.59	1.99	3.51	2.11	3.42	2.22	3.34	2.34	3.25	2.45	3.16	2.56	3.07	2.67	2.98	2.78	2.89	2.89
78	3.55	1.95	3.48	2.08	3.39	2.19	3.31	2.31	3.22	2.42	3.13	2.53	3.04	2.64	2.95	2.75	2.86	2.86
77	3.52	1.92	3.45	2.05	3.36	2.16	3.28	2.28	3.19	2.39	3.10	2.50	3.01	2.61	2.93	2.73	2.83	2.83
76	3.48	1.88	3.42	2.02	3.33	2.13	3.25	2.25	3.16	2.36	3.07	2.47	2.99	2.59	2.90	2.70	2.80	2.80
75	3.45	1.85	3.39	1.99	3.31	2.11	3.22	2.22	3.13	2.33	3.04	2.44	2.96	2.56	2.87	2.67	2.77	2.77
74	3.42	1.82	3.36	1.96	3.28	2.08	3.19	2.19	3.10	2.30	3.01	2.41	2.93	2.53	2.84	2.64	2.74	2.74
73	3.40	1.80	3.33	1.93	3.25	2.05	3.16	2.16	3.07	2.27	2.98	2.38	2.90	2.50	2.81	2.61	2.71	2.71
72	3.37	1.77	3.30	1.90	3.22	2.02	3.13	2.13	3.04	2.24	2.95	2.35	2.87	2.47	2.78	2.58	2.68	2.68
71	3.35	1.75	3.27	1.87	3.19	1.99	3.10	2.10	3.01	2.21	2.92	2.32	2.84	2.44	2.75	2.55	2.65	2.65
70	3.33	1.73	3.24	1.84	3.16	1.96	3.07	2.07	2.98	2.18	2.89	2.29	2.81	2.41	2.72	2.52	2.62	2.62
69	3.30	1.70	3.21	1.81	3.12	1.92	3.04	2.04	2.95	2.15	2.86	2.26	2.78	2.38	2.69	2.49	2.59	2.59
68	3.27	1.67	3.18	1.78	3.09	1.89	3.01	2.01	2.92	2.12	2.83	2.23	2.75	2.35	2.66	2.46	2.56	2.56
67	3.23	1.63	3.15	1.75	3.06	1.86	2.98	1.98	2.89	2.09	2.80	2.20	2.71	2.31	2.63	2.43	2.53	2.53
66	3.20	1.60	3.12	1.72	3.03	1.83	2.95	1.95	2.86	2.06	2.77	2.17	2.68	2.28	2.59	2.39	2.50	2.50
65	3.17	1.57	3.09	1.69	3.00	1.80	2.92	1.92	2.83	2.03	2.74	2.14	2.65	2.25	2.56	2.36	2.47	2.47
64	3.14	1.54	3.06	1.66	2.97	1.77	2.89	1.89	2.80	2.00	2.71	2.11	2.62	2.22	2.53	2.33	2.44	2.44
63	3.11	1.51	3.03	1.63	2.94	1.74	2.86	1.86	2.77	1.97	2.68	2.08	2.59	2.19	2.50	2.30	2.41	2.41
62	3.08	1.48	3.00	1.60	2.91	1.71	2.83	1.83	2.74	1.94	2.65	2.05	2.56	2.16	2.47	2.27	2.38	2.38
61	3.05	1.45	2.97	1.57	2.88	1.68	2.80	1.80	2.71	1.91	2.62	2.02	2.53	2.13	2.44	2.24	2.35	2.35
60	3.02	1.42	2.94	1.54	2.85	1.65	2.77	1.77	2.68	1.88	2.59	1.99	2.50	2.10	2.41	2.21	2.32	2.32

APPENDIX 2

EHP Calculation – Holtrop Method

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EHP Trim by Stern 1.6 m

		Speed (Knot)									
Lcg	Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
28.896	100	666.2376	561.0333	473.8403	400.9556	339.2443	286.7295	241.7243	202.8796	169.1731	Holtrop (kW)
28.808	95	647.8905	546.7652	462.4829	391.8533	331.905	280.7484	236.8149	198.8339	165.8381	
28.715	90	628.337	531.5576	450.3768	382.1347	324.0585	274.3509	231.5617	194.5018	162.2662	
28.616	85	608.8641	516.3696	438.2639	372.3746	316.1534	267.8914	226.2464	190.1146	158.6448	
28.516	80	589.8212	501.4702	426.3614	362.7503	308.3334	261.4847	220.9668	185.7503	155.0396	
28.394	75	567.3974	483.8119	412.198	351.2365	298.9287	253.751	214.5728	180.4534	150.6581	
28.31	70	552.3588	471.9083	402.6346	343.4406	292.5405	248.4874	210.2131	176.8367	147.6646	
28.21	65	533.6276	457.0112	390.6527	333.6587	284.5077	241.8577	204.7173	172.2758	143.8869	
28.087	60	514.7504	441.8484	378.3891	323.5985	276.2036	234.9749	198.9949	167.5171	139.9401	

EHP Database Trim by Stern 1.6 m

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
28.896	**100**	666.2376	645.1967	624.1558	603.115	582.0741	561.0333	543.5947	526.1561	508.7175	491.2789	473.8403
28.8784	**99**	662.5681	641.6904	620.8127	599.935	579.0573	558.1796	540.8575	523.5353	506.2131	488.8909	471.5688
28.8608	**98**	658.8987	638.1842	617.4696	596.7551	576.0406	555.326	538.1203	520.9145	503.7088	486.503	469.2973
28.8432	**97**	655.2293	634.6779	614.1265	593.5752	573.0238	552.4724	535.3831	518.2938	501.2045	484.1151	467.0258
28.8256	**96**	651.5599	631.1717	610.7834	590.3952	570.007	549.6188	532.6459	515.673	498.7001	481.7272	464.7543
28.808	**95**	647.8905	627.6654	607.4404	587.2153	566.9903	546.7652	529.9087	513.0523	496.1958	479.3393	462.4829
28.7894	**94**	643.9798	623.9285	603.8773	583.8261	563.7749	543.7237	526.9913	510.2589	493.5265	476.794	460.0616
28.7708	**93**	640.0691	620.1917	600.3143	580.4369	560.5595	540.6822	524.0738	507.4655	490.8571	474.2488	457.6404
28.7522	**92**	636.1584	616.4548	596.7513	577.0477	557.3442	537.6406	521.1564	504.6721	488.1878	471.7035	455.2192
28.7336	**91**	632.2477	612.718	593.1883	573.6585	554.1288	534.5991	518.2389	501.8787	485.5185	469.1582	452.798
28.715	**90**	628.337	608.9811	589.6252	570.2694	550.9135	531.5576	515.3214	499.0853	482.8491	466.613	450.3768
28.6952	**89**	624.4424	605.2579	586.0734	566.889	547.7045	528.52	512.4068	496.2937	480.1805	464.0674	447.9542
28.6754	**88**	620.5478	601.5347	582.5216	563.5086	544.4955	525.4824	509.4922	493.5021	477.5119	461.5218	445.5316
28.6556	**87**	616.6532	597.8115	578.9698	560.1282	541.2865	522.4448	506.5776	490.7105	474.8433	458.9762	443.109
28.6358	**86**	612.7586	594.0883	575.418	556.7478	538.0775	519.4072	503.663	487.9189	472.1747	456.4306	440.6864
28.616	**85**	608.8641	590.3652	571.8663	553.3674	534.8685	516.3696	500.7484	485.1273	469.5061	453.885	438.2639
28.596	**84**	605.0555	586.7223	568.3892	550.056	531.7228	513.3897	497.8884	482.3871	466.8859	451.3846	435.8834
28.576	**83**	601.2469	583.0795	564.9121	546.7446	528.5772	510.4098	495.0284	479.647	464.2656	448.8842	433.5029
28.556	**82**	597.4383	579.4367	561.435	543.4333	525.4316	507.4299	492.1684	476.9069	461.6454	446.3839	431.1224
28.536	**81**	593.6298	575.7938	557.9579	540.1219	522.286	504.45	489.3084	474.1668	459.0251	443.8835	428.7419
28.516	**80**	589.8212	572.151	554.4808	536.8106	519.1404	501.4702	486.4484	471.4266	456.4049	441.3831	426.3614

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
28.4916	**79**	585.3364	567.8568	550.3773	532.8977	515.4181	497.9385	483.0565	468.1746	453.2926	438.4106	423.5287
28.4672	**78**	580.8517	563.5627	546.2737	528.9848	511.6958	494.4069	479.6647	464.9225	450.1803	435.4382	420.696
28.4428	**77**	576.3669	559.2686	542.1702	525.0719	507.9735	490.8752	476.2728	461.6704	447.0681	432.4657	417.8633
28.4184	**76**	571.8821	554.9744	538.0667	521.159	504.2513	487.3436	472.881	458.4184	443.9558	429.4932	415.0306
28.394	**75**	567.3974	550.6803	533.9632	517.2461	500.529	483.8119	469.4891	455.1663	440.8435	426.5207	412.198
28.3772	**74**	564.3896	547.7979	531.2063	514.6146	498.0229	481.4312	467.202	452.9728	438.7436	424.5145	410.2853
28.3604	**73**	561.3819	544.9156	528.4493	511.983	495.5167	479.0504	464.9149	450.7793	436.6437	422.5082	408.3726
28.3436	**72**	558.3742	542.0333	525.6924	509.3515	493.0106	476.6697	462.6278	448.5858	434.5438	420.5019	406.4599
28.3268	**71**	555.3665	539.151	522.9355	506.72	490.5045	474.289	460.3406	446.3923	432.4439	418.4956	404.5472
28.31	**70**	552.3588	536.2687	520.1786	504.0885	487.9984	471.9083	458.0535	444.1988	430.344	416.4893	402.6346
28.29	**69**	548.6126	532.6758	516.7391	500.8023	484.8656	468.9288	455.1907	441.4526	427.7144	413.9763	400.2382
28.27	**68**	544.8663	529.0829	513.2996	497.5162	481.7328	465.9494	452.3279	438.7064	425.0849	411.4633	397.8418
28.25	**67**	541.1201	525.4901	509.86	494.23	478.6	462.97	449.4651	435.9602	422.4553	408.9504	395.4454
28.23	**66**	537.3738	521.8972	506.4205	490.9439	475.4672	459.9906	446.6023	433.214	419.8257	406.4374	393.0491
28.21	**65**	533.6276	518.3043	502.981	487.6577	472.3344	457.0112	443.7395	430.4678	417.1961	403.9244	390.6527
28.1854	**64**	529.8522	514.6774	499.5027	484.328	469.1533	453.9786	440.8229	427.6672	414.5114	401.3557	388.2
28.1608	**63**	526.0767	511.0506	496.0244	480.9983	465.9722	450.9461	437.9063	424.8665	411.8268	398.787	385.7473
28.1362	**62**	522.3013	507.4237	492.5462	477.6686	462.7911	447.9135	434.9897	422.0659	409.1421	396.2183	383.2945
28.1116	**61**	518.5258	503.7968	489.0679	474.3389	459.6099	444.881	432.0731	419.2653	406.4575	393.6496	380.8418
28.087	**60**	514.7504	500.17	485.5896	471.0092	456.4288	441.8484	429.1565	416.4647	403.7728	391.081	378.3891

EHP Trim by Stern 1.4 m

Lcb	Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
29.226	100	671.968	565.2584	477.0936	403.412	341.082	288.121	242.788	203.7041	169.8205	Holtrop (kW)
29.146	95	652.5503	550.1198	465.0221	393.7393	333.2804	281.7615	237.567	199.3997	166.2716	
29.063	90	633.113	534.9754	452.9459	384.0471	325.4546	275.379	232.3253	195.078	162.7078	
28.978	85	613.4894	519.6666	440.7272	374.21	317.4955	268.8781	226.9801	190.6666	159.0669	
28.936	80	604.6884	512.7873	435.229	369.7733	313.8983	265.9352	224.5559	188.6644	157.4155	
28.804	75	575.1541	489.6217	416.6726	354.7382	301.6588	255.8946	216.2713	181.8116	151.7506	
28.716	70	556.3298	474.7453	404.7034	344.9805	293.6686	249.3108	210.8203	177.2898	148.0085	
28.625	65	537.5192	459.8195	392.6894	335.1698	285.6163	242.6673	205.3141	172.7208	144.2238	
28.529	60	517.9968	444.1553	379.9991	324.7439	277.0074	235.5292	199.3778	167.7816	140.1275	

EHP Database Trim by Stern 1.4 m

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
29.226	**100**	671.968	650.6261	629.2841	607.9422	586.6003	565.2584	547.6254	529.9925	512.3595	494.7266	477.0936
29.21	**99**	668.0845	646.9137	625.7429	604.5722	583.4014	562.2306	544.7204	527.2101	509.6998	492.1896	474.6793
29.194	**98**	664.2009	643.2013	622.2017	601.2021	580.2025	559.2029	541.8153	524.4277	507.0402	489.6526	472.265
29.178	**97**	660.3174	639.4889	618.6605	597.8321	577.0036	556.1752	538.9103	521.6454	504.3805	487.1156	469.8507
29.162	**96**	656.4338	635.7765	615.1193	594.462	573.8047	553.1475	536.0052	518.863	501.7208	484.5786	467.4364
29.146	**95**	652.5503	632.0642	611.5781	591.092	570.6059	550.1198	533.1002	516.0807	499.0611	482.0416	465.0221
29.1294	**94**	648.6628	628.3484	608.034	587.7196	567.4053	547.0909	530.1941	513.2973	496.4004	479.5036	462.6068
29.1128	**93**	644.7753	624.6327	604.49	584.3473	564.2047	544.062	527.2879	510.5138	493.7398	476.9657	460.1916
29.0962	**92**	640.8879	620.9169	600.946	580.975	561.0041	541.0331	524.3818	507.7304	491.0791	474.4277	457.7764
29.0796	**91**	637.0004	617.2012	597.402	577.6027	557.8035	538.0043	521.4756	504.947	488.4184	471.8898	455.3611
29.063	**90**	633.113	613.4854	593.8579	574.2304	554.6029	534.9754	518.5695	502.1636	485.7577	469.3518	452.9459
29.046	**89**	629.1882	609.7333	590.2784	570.8235	551.3686	531.9136	515.6313	499.349	483.0667	466.7844	450.5022
29.029	**88**	625.2635	605.9812	586.6989	567.4165	548.1342	528.8519	512.6932	496.5345	480.3758	464.2171	448.0584
29.012	**87**	621.3388	602.2291	583.1193	564.0096	544.8999	525.7901	509.755	493.7199	477.6848	461.6497	445.6147
28.995	**86**	617.4141	598.4769	579.5398	560.6026	541.6655	522.7284	506.8169	490.9054	474.9939	459.0824	443.1709
28.978	**85**	613.4894	594.7248	575.9603	557.1957	538.4312	519.6666	503.8787	488.0908	472.3029	456.515	440.7272
28.9696	**84**	611.7292	593.0415	574.3538	555.6661	536.9784	518.2907	502.5581	486.8255	471.0928	455.3602	439.6275
28.9612	**83**	609.969	591.3582	572.7473	554.1365	535.5257	516.9149	501.2375	485.5601	469.8827	454.2053	438.5279
28.9528	**82**	608.2088	589.6748	571.1409	552.6069	534.073	515.539	499.9169	484.2947	468.6726	453.0504	437.4283
28.9444	**81**	606.4486	587.9915	569.5344	551.0773	532.6202	514.1632	498.5963	483.0293	467.4624	451.8955	436.3286
28.936	**80**	604.6884	586.3082	567.928	549.5477	531.1675	512.7873	497.2756	481.764	466.2523	450.7407	435.229

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
28.9096	**79**	598.7815	580.6561	562.5306	544.4051	526.2797	508.1542	492.8269	477.4996	462.1723	446.845	431.5177
28.8832	**78**	592.8747	575.004	557.1332	539.2625	521.3918	503.5211	488.3781	473.2352	458.0923	442.9494	427.8064
28.8568	**77**	586.9678	569.3518	551.7359	534.1199	516.5039	498.8879	483.9294	468.9708	454.0123	439.0537	424.0952
28.8304	**76**	581.061	563.6997	546.3385	528.9773	511.616	494.2548	479.4806	464.7064	449.9323	435.1581	420.3839
28.804	**75**	575.1541	558.0476	540.9411	523.8347	506.7282	489.6217	475.0319	460.4421	445.8522	431.2624	416.6726
28.7864	**74**	571.3892	554.4407	537.4921	520.5435	503.595	486.6464	472.1729	457.6994	443.2258	428.7523	414.2788
28.7688	**73**	567.6244	550.8337	534.0431	517.2524	500.4618	483.6711	469.3139	454.9567	440.5994	426.2422	411.8849
28.7512	**72**	563.8595	547.2268	530.594	513.9613	497.3286	480.6959	466.4549	452.2139	437.973	423.732	409.4911
28.7336	**71**	560.0946	543.6198	527.145	510.6702	494.1954	477.7206	463.5959	449.4712	435.3466	421.2219	407.0972
28.716	**70**	556.3298	540.0129	523.696	507.3791	491.0622	474.7453	460.7369	446.7285	432.7202	418.7118	404.7034
28.6978	**69**	552.5676	536.4061	520.2446	504.0831	487.9216	471.7601	457.8682	443.9763	430.0844	416.1925	402.3006
28.6796	**68**	548.8055	532.7994	516.7933	500.7872	484.7811	468.775	454.9995	441.2241	427.4487	413.6732	399.8978
28.6614	**67**	545.0434	529.1927	513.342	497.4912	481.6405	465.7898	452.1308	438.4719	424.8129	411.1539	397.495
28.6432	**66**	541.2813	525.586	509.8906	494.1953	478.5	462.8046	449.2621	435.7196	422.1771	408.6347	395.0922
28.625	**65**	537.5192	521.9793	506.4393	490.8994	475.3594	459.8195	446.3934	432.9674	419.5414	406.1154	392.6894
28.6058	**64**	533.6147	518.2291	502.8435	487.4579	472.0722	456.6866	443.3796	430.0725	416.7654	403.4584	390.1513
28.5866	**63**	529.7102	514.479	499.2477	484.0164	468.7851	453.5538	440.3657	427.1776	413.9895	400.8014	387.6133
28.5674	**62**	525.8058	510.7288	495.6518	480.5749	465.4979	450.421	437.3518	424.2827	411.2135	398.1444	385.0752
28.5482	**61**	521.9013	506.9787	492.056	477.1334	462.2108	447.2881	434.3379	421.3877	408.4375	395.4873	382.5372
28.529	**60**	517.9968	503.2285	488.4602	473.6919	458.9236	444.1553	431.3241	418.4928	405.6616	392.8303	379.9991

EHP Trim by Stern 1.2 m

Lcb	Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
29.553	100	676.8958	568.9096	479.9146	405.5257	342.6506	289.2975	243.6781	204.3861	170.3518	Holtrop (kW)
29.483	95	657.8058	553.9803	467.9891	395.9692	334.9364	283.0047	238.51	200.1242	166.8351	
29.415	90	638.8572	539.1752	456.159	386.4725	327.2636	276.7429	233.3626	195.8772	163.3322	
29.341	85	618.5839	523.3351	443.4964	376.2846	319.0215	270.0085	227.8254	191.3083	159.5614	
29.266	80	598.5141	507.6284	430.9223	366.1347	310.7887	263.2718	222.2789	186.7255	155.779	
29.199	75	580.2015	493.2557	419.3924	356.791	303.1849	257.0331	217.1304	182.4671	152.2589	
29.127	70	561.0137	478.1229	407.2162	346.8768	295.0797	250.3631	211.6115	177.8935	148.4742	
29.049	65	540.699	461.9734	394.1602	336.1853	286.2891	243.0962	205.5809	172.883	144.3216	
28.971	60	521.0156	446.1736	381.3193	325.6156	277.5571	235.8535	199.5561	167.8724	140.1655	

EHP Database Trim by Stern 1.2 m

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
29.553	**100**	676.8958	655.2985	633.7013	612.1041	590.5068	568.9096	551.1106	533.3116	515.5126	497.7136	479.9146
29.539	**99**	673.0778	651.6469	630.2161	608.7853	587.3545	565.9237	548.2449	530.566	512.8872	495.2083	477.5295
29.525	**98**	669.2598	647.9954	626.731	605.4666	584.2023	562.9379	545.3792	527.8205	510.2618	492.7031	475.1444
29.511	**97**	665.4418	644.3438	623.2459	602.1479	581.05	559.952	542.5135	525.0749	507.6364	490.1978	472.7593
29.497	**96**	661.6238	640.6922	619.7607	598.8292	577.8977	556.9662	539.6478	522.3294	505.011	487.6926	470.3742
29.483	**95**	657.8058	637.0407	616.2756	595.5105	574.7454	553.9803	536.7821	519.5838	502.3856	485.1873	467.9891
29.4694	**94**	654.016	633.4167	612.8173	592.218	571.6186	551.0193	533.94	516.8608	499.7815	482.7023	465.623
29.4558	**93**	650.2263	629.7927	609.3591	588.9255	568.4919	548.0583	531.098	514.1378	497.1775	480.2173	463.257
29.4422	**92**	646.4366	626.1687	605.9009	585.633	565.3651	545.0972	528.256	511.4148	494.5735	477.7323	460.891
29.4286	**91**	642.6469	622.5448	602.4426	582.3405	562.2384	542.1362	525.414	508.6917	491.9695	475.2473	458.525
29.415	**90**	638.8572	618.9208	598.9844	579.048	559.1116	539.1752	522.572	505.9687	489.3655	472.7622	456.159
29.4002	**89**	634.8025	615.0435	595.2844	575.5253	555.7663	536.0072	519.531	503.0549	486.5788	470.1026	453.6265
29.3854	**88**	630.7479	611.1661	591.5844	572.0026	552.4209	532.8392	516.4901	500.1411	483.792	467.443	451.0939
29.3706	**87**	626.6932	607.2888	587.8844	568.48	549.0756	529.6711	513.4492	497.2272	481.0053	464.7834	448.5614
29.3558	**86**	622.6385	603.4114	584.1844	564.9573	545.7302	526.5031	510.4083	494.3134	478.2186	462.1237	446.0289
29.341	**85**	618.5839	599.5341	580.4844	561.4346	542.3849	523.3351	507.3674	491.3996	475.4319	459.4641	443.4964
29.326	**84**	614.5699	595.6947	576.8194	557.9442	539.069	520.1938	504.3513	488.5089	472.6664	456.824	440.9815
29.311	**83**	610.5559	591.8552	573.1545	554.4538	535.7531	517.0524	501.3353	485.6181	469.901	454.1839	438.4667
29.296	**82**	606.542	588.0158	569.4896	550.9634	532.4373	513.9111	498.3192	482.7274	467.1356	451.5437	435.9519
29.281	**81**	602.528	584.1764	565.8247	547.473	529.1214	510.7697	495.3032	479.8367	464.3701	448.9036	433.4371
29.266	**80**	598.5141	580.3369	562.1598	543.9827	525.8055	507.6284	492.2872	476.9459	461.6047	446.2635	430.9223

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
29.2526	**79**	594.8515	576.832	558.8125	540.7929	522.7734	504.7539	489.5263	474.2988	459.0713	443.8438	428.6163
29.2392	**78**	591.189	573.3271	555.4651	537.6032	519.7413	501.8793	486.7655	471.6517	456.5379	441.4241	426.3103
29.2258	**77**	587.5265	569.8221	552.1178	534.4135	516.7091	499.0048	484.0047	469.0046	454.0045	439.0044	424.0043
29.2124	**76**	583.864	566.3172	548.7705	531.2237	513.677	496.1302	481.2439	466.3575	451.4711	436.5847	421.6983
29.199	**75**	580.2015	562.8123	545.4232	528.034	510.6449	493.2557	478.483	463.7104	448.9377	434.165	419.3924
29.1846	**74**	576.3639	559.1369	541.91	524.683	507.4561	490.2291	475.5747	460.9203	446.2659	431.6115	416.9571
29.1702	**73**	572.5264	555.4616	538.3968	521.3321	504.2673	487.2026	472.6664	458.1303	443.5941	429.058	414.5219
29.1558	**72**	568.6888	551.7862	534.8837	517.9811	501.0786	484.176	469.7581	455.3402	440.9224	426.5045	412.0866
29.1414	**71**	564.8513	548.1109	531.3705	514.6302	497.8898	481.1494	466.8498	452.5502	438.2506	423.951	409.6514
29.127	**70**	561.0137	544.4355	527.8574	511.2792	494.701	478.1229	463.9415	449.7602	435.5788	421.3975	407.2162
29.1114	**69**	556.9508	540.5392	524.1276	507.7161	491.3045	474.893	460.8354	446.7778	432.7202	418.6626	404.605
29.0958	**68**	552.8878	536.6429	520.3979	504.153	487.908	471.6631	457.7292	443.7954	429.8615	415.9276	401.9938
29.0802	**67**	548.8249	532.7465	516.6682	500.5898	484.5115	468.4332	454.6231	440.8129	427.0028	413.1927	399.3826
29.0646	**66**	544.7619	528.8502	512.9385	497.0267	481.115	465.2033	451.5169	437.8305	424.1442	410.4578	396.7714
29.049	**65**	540.699	524.9538	509.2087	493.4636	477.7185	461.9734	448.4108	434.8481	421.2855	407.7228	394.1602
29.0334	**64**	536.7623	521.1725	505.5827	489.993	474.4032	458.8134	445.3691	431.9249	418.4806	405.0363	391.592
29.0178	**63**	532.8256	517.3912	501.9567	486.5223	471.0879	455.6535	442.3275	429.0016	415.6757	402.3498	389.0238
29.0022	**62**	528.8889	513.6098	498.3307	483.0517	467.7726	452.4935	439.2859	426.0784	412.8708	399.6632	386.4557
28.9866	**61**	524.9522	509.8285	494.7047	479.581	464.4573	449.3335	436.2443	423.1551	410.0659	396.9767	383.8875
28.971	**60**	521.0156	506.0472	491.0788	476.1104	461.142	446.1736	433.2027	420.2319	407.261	394.2902	381.3193

EHP Trim by Stern 1 m

Lcb	Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
29.903	100	682.0685	572.7909	482.9264	407.7728	344.3146	290.5429	244.6154	205.1014	170.9061	Holtrop (kW)
29.846	95	663.1337	557.9191	471.0216	398.2301	336.6039	284.2467	239.4415	200.8326	167.3825	
29.787	90	643.6815	542.6827	458.8374	388.4585	328.7114	277.8067	234.1515	196.4695	163.7842	
29.728	85	624.0188	527.2854	446.5094	378.5455	320.6936	271.2563	228.7638	192.0236	160.1157	
29.672	80	604.4285	511.9271	434.1929	368.6095	312.6344	264.6599	223.3323	187.5363	156.4104	
29.616	75	584.7612	496.5148	421.8384	358.6241	304.5269	258.0186	217.8595	183.0122	152.6729	
29.561	70	565.1089	480.9749	409.2839	348.3833	296.1434	251.1071	212.1336	178.2627	148.7399	
29.505	65	545.3795	465.2877	396.5695	337.9632	287.5736	244.0197	206.2491	173.3717	144.6861	
29.435	60	517.9968	444.1553	379.9991	324.7439	277.0074	235.5292	199.3778	167.7816	140.1275	

Database EHP Trim by Stern 1 m

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
29.903	**100**	682.0685	660.2129	638.3574	616.5019	594.6464	572.7909	554.818	536.8451	518.8722	500.8993	482.9264
29.8916	**99**	678.2815	656.5885	634.8955	613.2025	591.5095	569.8165	551.9623	534.1081	516.2539	498.3997	480.5454
29.8802	**98**	674.4946	652.9641	631.4336	609.9031	588.3726	566.8421	549.1066	531.3711	513.6355	495.9	478.1645
29.8688	**97**	670.7076	649.3396	627.9717	606.6037	585.2357	563.8678	546.2509	528.6341	511.0172	493.4004	475.7835
29.8574	**96**	666.9207	645.7152	624.5098	603.3043	582.0989	560.8934	543.3952	525.8971	508.3989	490.9007	473.4026
29.846	**95**	663.1337	642.0908	621.0478	600.0049	578.962	557.9191	540.5396	523.1601	505.7806	488.4011	471.0216
29.8342	**94**	659.2433	638.369	617.4947	596.6204	575.7461	554.8718	537.6144	520.357	503.0996	485.8422	468.5848
29.8224	**93**	655.3528	634.6471	613.9415	593.2358	572.5302	551.8245	534.6892	517.5539	500.4185	483.2832	466.1479
29.8106	**92**	651.4624	630.9253	610.3883	589.8513	569.3143	548.7772	531.764	514.7508	497.7375	480.7243	463.7111
29.7988	**91**	647.5719	627.2035	606.8351	586.4667	566.0984	545.73	528.8388	511.9477	495.0565	478.1654	461.2742
29.787	**90**	643.6815	623.4817	603.282	583.0822	562.8825	542.6827	525.9136	509.1446	492.3755	475.6064	458.8374
29.7752	**89**	639.7489	619.7198	599.6906	579.6615	559.6324	539.6032	522.9569	506.3106	489.6643	473.018	456.3718
29.7634	**88**	635.8164	615.9578	596.0993	576.2408	556.3823	536.5238	520.0002	503.4767	486.9532	470.4297	453.9062
29.7516	**87**	631.8838	612.1959	592.508	572.8201	553.1322	533.4443	517.0435	500.6428	484.242	467.8413	451.4406
29.7398	**86**	627.9513	608.434	588.9167	569.3994	549.8821	530.3648	514.0868	497.8089	481.5309	465.2529	448.975
29.728	**85**	624.0188	604.6721	585.3254	565.9787	546.632	527.2854	511.1302	494.975	478.8198	462.6646	446.5094
29.7168	**84**	620.1007	600.9233	581.7459	562.5685	543.3911	524.2137	508.1802	492.1466	476.1131	460.0796	444.0461
29.7056	**83**	616.1827	597.1745	578.1664	559.1583	540.1502	521.1421	505.2302	489.3183	473.4065	457.4946	441.5828
29.6944	**82**	612.2646	593.4258	574.5869	555.7481	536.9092	518.0704	502.2802	486.49	470.6998	454.9096	439.1195
29.6832	**81**	608.3466	589.677	571.0074	552.3379	533.6683	514.9988	499.3302	483.6617	467.9932	452.3247	436.6562
29.672	**80**	604.4285	585.9282	567.4279	548.9277	530.4274	511.9271	496.3803	480.8334	465.2866	449.7397	434.1929

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
29.6608	**79**	600.495	582.165	563.8349	545.5048	527.1747	508.8446	493.4201	477.9956	462.571	447.1465	431.722
29.6496	**78**	596.5616	578.4017	560.2418	542.0819	523.9221	505.7622	490.46	475.1577	459.8555	444.5533	429.2511
29.6384	**77**	592.6281	574.6384	556.6488	538.6591	520.6694	502.6797	487.4998	472.3199	457.14	441.9601	426.7802
29.6272	**76**	588.6947	570.8752	553.0557	535.2362	517.4167	499.5973	484.5397	469.4821	454.4245	439.3669	424.3093
29.616	**75**	584.7612	567.1119	549.4626	531.8134	514.1641	496.5148	481.5795	466.6442	451.709	436.7737	421.8384
29.605	**74**	580.8307	563.3459	545.8612	528.3764	510.8916	493.4068	478.5909	463.7751	448.9592	434.1434	419.3275
29.594	**73**	576.9003	559.58	542.2597	524.9394	507.6191	490.2988	475.6024	460.9059	446.2095	431.513	416.8166
29.583	**72**	572.9698	555.814	538.6582	521.5024	504.3466	487.1908	472.6138	458.0368	443.4597	428.8827	414.3057
29.572	**71**	569.0393	552.048	535.0567	518.0654	501.0741	484.0828	469.6252	455.1676	440.71	426.2524	411.7948
29.561	**70**	565.1089	548.2821	531.4553	514.6285	497.8017	480.9749	466.6367	452.2985	437.9603	423.6221	409.2839
29.5498	**69**	561.163	544.4979	527.8328	511.1676	494.5025	477.8374	463.6181	449.3988	435.1796	420.9603	406.741
29.5386	**68**	557.2171	540.7137	524.2103	507.7068	491.2034	474.7	460.5996	446.4992	432.3989	418.2985	404.1981
29.5274	**67**	553.2712	536.9295	520.5878	504.246	487.9043	471.5626	457.5811	443.5996	429.6182	415.6367	401.6552
29.5162	**66**	549.3253	533.1453	516.9653	500.7852	484.6052	468.4251	454.5626	440.7	426.8375	412.9749	399.1123
29.505	**65**	545.3795	529.3611	513.3428	497.3244	481.3061	465.2877	451.5441	437.8004	424.0568	410.3131	396.5695
29.491	**64**	539.9029	524.1346	508.3662	492.5979	476.8296	461.0612	447.5001	433.9389	420.3777	406.8165	393.2554
29.477	**63**	534.4264	518.9081	503.3897	487.8714	472.3531	456.8347	443.4561	430.0774	416.6987	403.32	389.9413
29.463	**62**	528.9499	513.6815	498.4132	483.1449	467.8766	452.6083	439.4121	426.2159	413.0196	399.8234	386.6272
29.449	**61**	523.4733	508.455	493.4367	478.4184	463.4001	448.3818	435.3681	422.3543	409.3406	396.3269	383.3132
29.435	**60**	517.9968	503.2285	488.4602	473.6919	458.9236	444.1553	431.3241	418.4928	405.6616	392.8303	379.9991

EHP Trim by Stern 0.8 m

Lcb	Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
30.241	100	688.5729	577.775	486.8238	410.7191	346.5433	292.2472	245.9298	206.126	171.7134	Holtrop (kW)
30.187	95	668.2041	561.7394	473.9921	400.4496	338.2484	285.4783	240.3684	201.5387	167.9288	
30.143	90	649.198	546.7825	461.9999	390.8241	330.4629	279.1154	235.1359	197.2193	164.3638	
30.094	85	628.9431	530.8711	449.2418	380.5707	322.1645	272.3338	229.5573	192.6147	160.563	
30.055	80	609.9209	515.9073	437.2128	370.8624	314.2858	265.88	224.2397	188.2205	156.9336	
30.014	75	589.8511	500.1592	424.5754	360.6607	306.0093	259.1031	218.6587	183.609	153.126	
29.974	70	569.7675	484.28	411.7414	350.2095	297.4671	252.0685	212.8374	178.7836	149.132	
29.931	65	552.1714	469.9981	399.9079	340.3471	289.2342	245.1674	207.046	173.9329	145.0886	
29.865	60	521.0156	446.1736	381.3193	325.6156	277.5571	235.8535	199.5561	167.8724	140.1655	

Database EHP Trim by Stern 0.8 m

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
30.241	**100**	688.5729	666.4133	644.2537	622.0941	599.9345	577.775	559.5847	541.3945	523.2042	505.014	486.8238
30.2302	**99**	684.4991	662.5128	640.5266	618.5403	596.5541	574.5678	556.5057	538.4437	520.3816	502.3195	484.2574
30.2194	**98**	680.4253	658.6124	636.7995	614.9866	593.1736	571.3607	553.4268	535.4929	517.5589	499.625	481.6911
30.2086	**97**	676.3516	654.712	633.0724	611.4328	589.7932	568.1536	550.3478	532.542	514.7363	496.9305	479.1247
30.1978	**96**	672.2778	650.8115	629.3453	607.879	586.4127	564.9465	547.2689	529.5912	511.9136	494.236	476.5584
30.187	**95**	668.2041	646.9111	625.6182	604.3252	583.0323	561.7394	544.1899	526.6404	509.091	491.5415	473.9921
30.1782	**94**	664.4028	643.2719	622.1409	601.0099	579.8789	558.748	541.3171	523.8862	506.4554	489.0245	471.5936
30.1694	**93**	660.6016	639.6326	618.6636	597.6946	576.7256	555.7566	538.4443	521.132	503.8197	486.5075	469.1952
30.1606	**92**	656.8004	635.9934	615.1863	594.3793	573.5723	552.7652	535.5715	518.3778	501.1841	483.9904	466.7967
30.1518	**91**	652.9992	632.3541	611.7091	591.064	570.4189	549.7738	532.6987	515.6236	498.5485	481.4734	464.3983
30.143	**90**	649.198	628.7149	608.2318	587.7487	567.2656	546.7825	529.8259	512.8694	495.9129	478.9564	461.9999
30.1332	**89**	645.147	624.8376	604.5283	584.2189	563.9095	543.6002	526.7698	509.9394	493.109	476.2786	459.4482
30.1234	**88**	641.096	620.9604	600.8248	580.6891	560.5535	540.4179	523.7136	507.0094	490.3051	473.6009	456.8966
30.1136	**87**	637.045	617.0831	597.1213	577.1594	557.1975	537.2356	520.6575	504.0794	487.5012	470.9231	454.345
30.1038	**86**	632.994	613.2059	593.4178	573.6296	553.8415	534.0533	517.6013	501.1493	484.6974	468.2454	451.7934
30.094	**85**	628.9431	609.3287	589.7143	570.0999	550.4855	530.8711	514.5452	498.2193	481.8935	465.5676	449.2418
30.0862	**84**	625.1386	605.6866	586.2345	566.7824	547.3304	527.8783	511.6698	495.4614	479.2529	463.0444	446.836
30.0784	**83**	621.3342	602.0445	582.7547	563.465	544.1753	524.8855	508.7945	492.7034	476.6123	460.5212	444.4302
30.0706	**82**	617.5298	598.4024	579.275	560.1476	541.0202	521.8928	505.9191	489.9454	473.9717	457.998	442.0244
30.0628	**81**	613.7253	594.7603	575.7952	556.8301	537.8651	518.9	503.0437	487.1874	471.3311	455.4748	439.6186
30.055	**80**	609.9209	591.1182	572.3154	553.5127	534.71	515.9073	500.1684	484.4295	468.6906	452.9517	437.2128

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
30.0468	**79**	605.9069	587.2771	568.6472	550.0174	531.3875	512.7576	497.1432	481.5287	465.9142	450.2998	434.6853
30.0386	**78**	601.893	583.436	564.979	546.522	528.065	509.608	494.118	478.6279	463.1379	447.6479	432.1578
30.0304	**77**	597.879	579.5949	561.3108	543.0266	524.7425	506.4584	491.0928	475.7272	460.3616	444.996	429.6303
30.0222	**76**	593.8651	575.7538	557.6425	539.5313	521.42	503.3088	488.0676	472.8264	457.5852	442.3441	427.1029
30.014	**75**	589.8511	571.9127	553.9743	536.0359	518.0975	500.1592	485.0424	469.9257	454.8089	439.6922	424.5754
30.006	**74**	585.8344	568.0642	550.294	532.5237	514.7535	496.9833	481.9884	466.9934	451.9985	437.0035	422.0086
29.998	**73**	581.8177	564.2156	546.6136	529.0115	511.4095	493.8075	478.9343	464.0612	449.1881	434.3149	419.4418
29.99	**72**	577.8009	560.3671	542.9332	525.4994	508.0655	490.6316	475.8803	461.129	446.3777	431.6263	416.875
29.982	**71**	573.7842	556.5185	539.2528	521.9872	504.7215	487.4558	472.8263	458.1968	443.5672	428.9377	414.3082
29.974	**70**	569.7675	552.67	535.5725	518.475	501.3775	484.28	469.7722	455.2645	440.7568	426.2491	411.7414
29.9654	**69**	566.2483	549.2833	532.3184	515.3535	498.3885	481.4236	467.0138	452.604	438.1943	423.7845	409.3747
29.9568	**68**	562.729	545.8967	529.0643	512.2319	495.3996	478.5672	464.2554	449.9435	435.6317	421.3198	407.008
29.9482	**67**	559.2098	542.51	525.8102	509.1104	492.4106	475.7108	461.4969	447.283	433.0691	418.8552	404.6413
29.9396	**66**	555.6906	539.1234	522.5561	505.9889	489.4217	472.8545	458.7385	444.6225	430.5065	416.3906	402.2746
29.931	**65**	552.1714	535.7367	519.3021	502.8674	486.4328	469.9981	455.9801	441.962	427.944	413.9259	399.9079
29.9178	**64**	545.9402	529.7988	513.6574	497.516	481.3746	465.2332	451.4246	437.616	423.8074	409.9988	396.1902
29.9046	**63**	539.709	523.8609	508.0127	492.1646	476.3164	460.4683	446.8691	433.27	419.6708	406.0716	392.4725
29.8914	**62**	533.4779	517.923	502.3681	486.8132	471.2583	455.7034	442.3136	428.9239	415.5342	402.1445	388.7547
29.8782	**61**	527.2467	511.9851	496.7234	481.4618	466.2001	450.9385	437.7582	424.5779	411.3976	398.2173	385.037
29.865	**60**	521.0156	506.0472	491.0788	476.1104	461.142	446.1736	433.2027	420.2319	407.261	394.2902	381.3193

EHP Trim by Stern 0.6 m

Lcb	Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
30.576	100	694.0089	581.9782	490.0944	413.1502	348.3534	293.6054	246.9545	206.9092	172.3206	Holtrop (kW)
30.535	95	673.57	565.8334	477.1764	402.8197	340.0079	286.7939	241.3586	202.2931	168.5107	
30.498	90	654.6651	550.9006	465.1946	393.2069	332.227	280.4321	236.1249	197.9714	164.9434	
30.469	85	635.4831	535.7494	453.0103	383.4008	324.2747	273.922	230.7625	193.5404	161.2841	
30.439	80	615.1523	519.7184	440.1165	373.0094	315.8441	267.0174	225.0746	188.8404	157.4028	
30.412	75	594.8881	503.7265	427.2227	362.5778	307.3582	260.053	219.3269	184.0851	153.471	
30.3805	70	571.0969	485.3311	412.5913	350.903	298.034	252.5354	213.2238	179.1033	149.3977	
30.349	65	565.1399	479.2683	406.6998	345.3703	292.9039	247.8607	209.0482	175.444	146.2501	
30.292	60	551.2985	467.9212	397.1479	337.3261	286.1315	242.136	204.2113	171.3719	142.8438	

Database EHP Trim by Stern 0.6 m

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
30.576	**100**	694.0089	671.6028	649.1966	626.7905	604.3843	581.9782	563.6014	545.2247	526.8479	508.4711	490.0944
30.5678	**99**	689.9211	667.6867	645.4524	623.218	600.9836	578.7492	560.5015	542.2538	524.0061	505.7585	487.5108
30.5596	**98**	685.8333	663.7707	641.7081	619.6455	597.5829	575.5203	557.4016	539.283	521.1644	503.0458	484.9272
30.5514	**97**	681.7455	659.8547	637.9638	616.073	594.1821	572.2913	554.3017	536.3122	518.3227	500.3331	482.3436
30.5432	**96**	677.6577	655.9387	634.2196	612.5005	590.7814	569.0623	551.2019	533.3414	515.4809	497.6205	479.76
30.535	**95**	673.57	652.0226	630.4753	608.928	587.3807	565.8334	548.102	530.3706	512.6392	494.9078	477.1764
30.5276	**94**	669.789	648.4005	627.0121	605.6237	584.2352	562.8468	545.2334	527.6201	510.0067	492.3934	474.78
30.5202	**93**	666.008	644.7785	623.5489	602.3194	581.0898	559.8603	542.3649	524.8696	507.3743	489.879	472.3837
30.5128	**92**	662.227	641.1564	620.0857	599.015	577.9444	556.8737	539.4964	522.1191	504.7419	487.3646	469.9873
30.5054	**91**	658.4461	637.5343	616.6225	595.7107	574.7989	553.8872	536.6279	519.3687	502.1094	484.8502	467.5909
30.498	**90**	654.6651	633.9122	613.1593	592.4064	571.6535	550.9006	533.7594	516.6182	499.477	482.3358	465.1946
30.4922	**89**	650.8287	630.237	609.6454	589.0537	568.462	547.8704	530.8478	513.8253	496.8028	479.7802	462.7577
30.4864	**88**	646.9923	626.5619	606.1314	585.701	565.2705	544.8401	527.9363	511.0324	494.1286	477.2247	460.3209
30.4806	**87**	643.1559	622.8867	602.6175	582.3483	562.0791	541.8099	525.0247	508.2395	491.4543	474.6692	457.884
30.4748	**86**	639.3195	619.2115	599.1035	578.9956	558.8876	538.7796	522.1131	505.4466	488.7801	472.1136	455.4472
30.469	**85**	635.4831	615.5364	595.5896	575.6429	555.6961	535.7494	519.2015	502.6537	486.1059	469.5581	453.0103
30.463	**84**	631.4169	611.6422	591.8674	572.0927	552.3179	532.5432	516.1208	499.6985	483.2762	466.8539	450.4315
30.457	**83**	627.3508	607.748	588.1452	568.5425	548.9397	529.337	513.0401	496.7433	480.4464	464.1496	447.8528
30.451	**82**	623.2846	603.8538	584.4231	564.9923	545.5615	526.1308	509.9594	493.7881	477.6167	461.4454	445.274
30.445	**81**	619.2184	599.9596	580.7009	561.4421	542.1833	522.9246	506.8787	490.8328	474.787	458.7411	442.6953
30.439	**80**	615.1523	596.0655	576.9787	557.8919	538.8051	519.7184	503.798	487.8776	471.9572	456.0369	440.1165

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
30.4336	**79**	611.0994	592.1835	573.2676	554.3518	535.4359	516.52	500.7235	484.9271	469.1306	453.3342	437.5377
30.4282	**78**	607.0466	588.3016	569.5566	550.8116	532.0666	513.3216	497.6491	481.9765	466.304	450.6315	434.959
30.4228	**77**	602.9938	584.4197	565.8455	547.2714	528.6973	510.1232	494.5746	479.026	463.4774	447.9288	432.3802
30.4174	**76**	598.9409	580.5377	562.1345	543.7313	525.3281	506.9248	491.5002	476.0755	460.6508	445.2261	429.8015
30.412	**75**	594.8881	576.6558	558.4234	540.1911	521.9588	503.7265	488.4257	473.125	457.8242	442.5235	427.2227
30.4057	**74**	590.1299	572.1134	554.0969	536.0804	518.0639	500.0474	484.8972	469.747	454.5968	439.4466	424.2964
30.3994	**73**	585.3716	567.571	549.7703	531.9696	514.169	496.3683	481.3687	466.369	451.3694	436.3698	421.3701
30.3931	**72**	580.6134	563.0285	545.4437	527.8589	510.274	492.6892	477.8401	462.9911	448.142	433.2929	418.4438
30.3868	**71**	575.8551	558.4861	541.1171	523.7481	506.3791	489.0101	474.3116	459.6131	444.9146	430.2161	415.5175
30.3805	**70**	571.0969	553.9437	536.7906	519.6374	502.4842	485.3311	470.7831	456.2351	441.6872	427.1392	412.5913
30.3742	**69**	569.9055	552.7481	535.5907	518.4333	501.2759	484.1185	469.5774	455.0363	440.4952	425.9541	411.413
30.3679	**68**	568.7141	551.5525	534.3908	517.2292	500.0676	482.9059	468.3717	453.8374	439.3032	424.7689	410.2347
30.3616	**67**	567.5227	550.3568	533.191	516.0251	498.8592	481.6934	467.166	452.6386	438.1112	423.5838	409.0564
30.3553	**66**	566.3313	549.1612	531.9911	514.821	497.6509	480.4808	465.9603	451.4397	436.9192	422.3986	407.8781
30.349	**65**	565.1399	547.9656	530.7912	513.6169	496.4426	479.2683	464.7546	450.2409	435.7272	421.2135	406.6998
30.3376	**64**	562.3716	545.2971	528.2225	511.148	494.0734	476.9988	462.557	448.1151	433.6732	419.2313	404.7894
30.3262	**63**	559.6033	542.6286	525.6538	508.679	491.7042	474.7294	460.3594	445.9893	431.6192	417.2491	402.879
30.3148	**62**	556.8351	539.9601	523.085	506.21	489.335	472.46	458.1617	443.8635	429.5652	415.2669	400.9687
30.3034	**61**	554.0668	537.2915	520.5163	503.7411	486.9658	470.1906	455.9641	441.7377	427.5112	413.2847	399.0583
30.292	**60**	551.2985	534.623	517.9476	501.2721	484.5967	467.9212	453.7665	439.6119	425.4572	411.3026	397.1479

EHP Trim by Stern 0.4 m

Lcb	Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
30.93	100	698.8274	585.756	493.0188	415.2926	349.9266	294.7657	247.8124	207.552	172.8082	Holtrop (kW)
30.903	95	679.1705	570.1723	480.5517	405.3256	341.8697	288.1866	242.4051	203.0889	169.1248	
30.883	90	660.3611	555.2534	468.5756	395.7196	334.0877	281.8202	237.1645	198.7603	165.5506	
30.864	85	640.7145	539.6651	456.0222	385.6157	325.8824	275.0961	231.6227	194.1775	161.7636	
30.85	80	620.7988	523.8814	443.2974	375.3508	317.5415	268.2548	225.9796	189.5108	157.9065	
30.839	75	601.0038	508.1908	430.6187	365.0894	309.1833	261.387	220.3078	184.8142	154.0218	
30.82	70	576.84	489.4078	415.6227	353.1271	299.6245	253.6751	214.0438	179.7002	149.8393	
30.79	65	576.7584	487.6564	412.9984	350.0876	296.3803	250.4424	210.9836	176.9137	147.3829	
30.744	60	561.5209	475.3123	402.7312	341.5569	289.2745	244.4831	205.9788	172.7174	143.8823	

Database EHP Trim by Stern 0.4 m

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
30.93	**100**	698.8274	676.2131	653.5988	630.9845	608.3702	585.756	567.2085	548.6611	530.1137	511.5662	493.0188
30.9246	**99**	694.896	672.4447	649.9933	627.5419	605.0906	582.6392	564.2165	545.7937	527.3709	508.9481	490.5254
30.9192	**98**	690.9646	668.6762	646.3878	624.0993	601.8109	579.5225	561.2244	542.9263	524.6282	506.3301	488.0319
30.9138	**97**	687.0332	664.9077	642.7822	620.6567	598.5313	576.4058	558.2323	540.0589	521.8854	503.712	485.5385
30.9084	**96**	683.1018	661.1393	639.1767	617.2142	595.2516	573.289	555.2402	537.1915	519.1427	501.0939	483.0451
30.903	**95**	679.1705	657.3708	635.5712	613.7716	591.9719	570.1723	552.2482	534.324	516.3999	498.4758	480.5517
30.899	**94**	675.4086	653.7646	632.1205	610.4765	588.8325	567.1885	549.3821	531.5757	513.7693	495.9628	478.1564
30.895	**93**	671.6467	650.1583	628.6699	607.1815	585.6931	564.2047	546.516	528.8273	511.1386	493.4499	475.7612
30.891	**92**	667.8848	646.552	625.2193	603.8865	582.5537	561.2209	543.6499	526.079	508.508	490.937	473.366
30.887	**91**	664.1229	642.9458	621.7686	600.5915	579.4143	558.2371	540.7839	523.3306	505.8773	488.424	470.9708
30.883	**90**	660.3611	639.3395	618.318	597.2964	576.2749	555.2534	537.9178	520.5822	503.2467	485.9111	468.5756
30.8792	**89**	656.4317	635.5725	614.7133	593.8541	572.9949	552.1357	534.9215	517.7074	500.4932	483.279	466.0649
30.8754	**88**	652.5024	631.8055	611.1087	590.4118	569.7149	549.0181	531.9253	514.8325	497.7397	480.647	463.5542
30.8716	**87**	648.5731	628.0386	607.504	586.9695	566.4349	545.9004	528.929	511.9576	494.9863	478.0149	461.0435
30.8678	**86**	644.6438	624.2716	603.8994	583.5272	563.155	542.7828	525.9328	509.0828	492.2328	475.3828	458.5328
30.864	**85**	640.7145	620.5046	600.2947	580.0848	559.875	539.6651	522.9365	506.2079	489.4793	472.7507	456.0222
30.8612	**84**	636.7313	616.6867	596.6421	576.5975	556.5529	536.5084	519.9021	503.2959	486.6897	470.0834	453.4772
30.8584	**83**	632.7482	612.8689	592.9895	573.1102	553.2309	533.3516	516.8677	500.3839	483.9	467.4161	450.9323
30.8556	**82**	628.765	609.051	589.337	569.6229	549.9089	530.1949	513.8333	497.4718	481.1103	464.7488	448.3873
30.8528	**81**	624.7819	605.2331	585.6844	566.1356	546.5869	527.0381	510.799	494.5598	478.3207	462.0815	445.8424
30.85	**80**	620.7988	601.4153	582.0318	562.6483	543.2648	523.8814	507.7646	491.6478	475.531	459.4142	443.2974

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
30.8478	**79**	616.8398	597.6205	578.4011	559.1818	539.9625	520.7432	504.7469	488.7506	472.7543	456.758	440.7617
30.8456	**78**	612.8808	593.8256	574.7705	555.7154	536.6602	517.6051	501.7293	485.8534	469.9776	454.1017	438.2259
30.8434	**77**	608.9218	590.0308	571.1399	552.2489	533.3579	514.467	498.7116	482.9563	467.2009	451.4455	435.6902
30.8412	**76**	604.9628	586.236	567.5092	548.7824	530.0557	511.3289	495.694	480.0591	464.4242	448.7893	433.1544
30.839	**75**	601.0038	582.4412	563.8786	545.316	526.7534	508.1908	492.6763	477.1619	461.6475	446.1331	430.6187
30.8352	**74**	596.171	577.8237	559.4763	541.1289	522.7815	504.4342	489.0712	473.7083	458.3453	442.9824	427.6195
30.8314	**73**	591.3383	573.2061	555.074	536.9419	518.8097	500.6776	485.4661	470.2546	455.0432	439.8317	424.6203
30.8276	**72**	586.5055	568.5886	550.6717	532.7548	514.8379	496.921	481.861	466.801	451.741	436.681	421.6211
30.8238	**71**	581.6728	563.9711	546.2694	528.5677	510.8661	493.1644	478.2559	463.3474	448.4389	433.5304	418.6219
30.82	**70**	576.84	559.3536	541.8671	524.3807	506.8942	489.4078	474.6508	459.8937	445.1367	430.3797	415.6227
30.814	**69**	576.8237	559.2704	541.7172	524.164	506.6107	489.0575	474.2656	459.4736	444.6817	429.8897	415.0978
30.808	**68**	576.8073	559.1873	541.5673	523.9473	506.3272	488.7072	473.8804	459.0535	444.2266	429.3998	414.5729
30.802	**67**	576.791	559.1042	541.4174	523.7306	506.0437	488.3569	473.4952	458.6334	443.7716	428.9098	414.0481
30.796	**66**	576.7747	559.0211	541.2675	523.5139	505.7602	488.0066	473.11	458.2133	443.3166	428.4199	413.5232
30.79	**65**	576.7584	558.938	541.1176	523.2972	505.4768	487.6564	472.7248	457.7932	442.8616	427.93	412.9984
30.7808	**64**	573.7109	556.0062	538.3015	520.5969	502.8922	485.1875	470.339	455.4905	440.642	425.7934	410.9449
30.7716	**63**	570.6634	553.0744	535.4855	517.8966	500.3076	482.7187	467.9533	453.1878	438.4224	423.6569	408.8915
30.7624	**62**	567.6159	550.1427	532.6695	515.1963	497.7231	480.2499	465.5675	450.8851	436.2028	421.5204	406.838
30.7532	**61**	564.5684	547.2109	529.8534	512.496	495.1385	477.7811	463.1818	448.5825	433.9832	419.3839	404.7846
30.744	**60**	561.5209	544.2791	527.0374	509.7957	492.554	475.3123	460.796	446.2798	431.7636	417.2474	402.7312

EHP Trim by Stern 0.2 m

Lcb	Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
31.262	100	704.8534	590.5411	496.7517	418.1067	352.0725	296.4102	249.0831	208.5445	173.5914	Holtrop (kW)
31.257	95	683.4726	573.5073	483.1024	407.1748	343.2129	289.1641	243.1181	203.6144	169.5204	
31.246	90	664.4608	558.4009	470.9917	397.4745	335.3573	282.7402	237.8327	199.249	165.9151	
31.24	85	644.8717	542.8184	458.4487	387.389	327.1693	276.0334	232.3058	194.6812	162.1408	
31.238	80	625.8714	527.6798	446.2104	377.5013	319.1147	269.414	226.8375	190.1537	158.3953	
31.232	75	605.2795	511.1175	432.6818	366.4498	310.0262	261.8861	220.5804	184.9465	154.0747	
31.226	70	600.1287	505.8988	427.6701	361.8303	305.7942	258.0692	217.2005	182.0036	151.5574	
31.195	65	585.4455	493.8963	417.6858	353.5549	298.8919	252.2755	212.3303	177.9165	148.143	
31.163	60	570.2264	481.52	407.3921	345.0207	291.7838	246.3116	207.3197	173.7121	144.6321	

Database EHP Trim by Stern 0.2 m

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
31.262	**100**	704.8534	681.9909	659.1285	636.266	613.4036	590.5411	571.7832	553.0253	534.2675	515.5096	496.7517
31.261	**99**	700.5772	677.8887	655.2001	632.5115	609.8229	587.1343	568.5118	549.8893	531.2668	512.6443	494.0218
31.26	**98**	696.3011	673.7864	651.2717	628.757	606.2423	583.7276	565.2405	546.7533	528.2662	509.7791	491.292
31.259	**97**	692.0249	669.6841	647.3433	625.0025	602.6616	580.3208	561.9691	543.6173	525.2656	506.9138	488.5621
31.258	**96**	687.7488	665.5818	643.4149	621.2479	599.081	576.9141	558.6977	540.4813	522.265	504.0486	485.8322
31.257	**95**	683.4726	661.4795	639.4865	617.4934	595.5004	573.5073	555.4263	537.3453	519.2643	501.1833	483.1024
31.2548	**94**	679.6702	657.8334	635.9966	614.1597	592.3229	570.486	552.5249	534.5637	516.6025	498.6414	480.6802
31.2526	**93**	675.8679	654.1873	632.5066	610.826	589.1454	567.4647	549.6234	531.7821	513.9408	496.0994	478.2581
31.2504	**92**	672.0655	650.5411	629.0167	607.4923	585.9679	564.4435	546.722	529.0005	511.279	493.5575	475.836
31.2482	**91**	668.2632	646.895	625.5268	604.1586	582.7904	561.4222	543.8205	526.2188	508.6172	491.0155	473.4138
31.246	**90**	664.4608	643.2488	622.0368	600.8249	579.6129	558.4009	540.9191	523.4372	505.9554	488.4735	470.9917
31.2448	**89**	660.543	639.4913	618.4395	597.3878	576.3361	555.2844	537.9241	520.5639	503.2036	485.8434	468.4831
31.2436	**88**	656.6252	635.7337	614.8423	593.9508	573.0594	552.1679	534.9292	517.6905	500.4518	483.2132	465.9745
31.2424	**87**	652.7073	631.9762	611.245	590.5138	569.7826	549.0514	531.9343	514.8172	497.7001	480.583	463.4659
31.2412	**86**	648.7895	628.2186	607.6477	587.0767	566.5058	545.9349	528.9394	511.9438	494.9483	477.9528	460.9573
31.24	**85**	644.8717	624.461	604.0504	583.6397	563.2291	542.8184	525.9445	509.0705	492.1966	475.3226	458.4487
31.2396	**84**	641.0716	620.8154	600.5593	580.3031	560.0469	539.7907	523.0327	506.2748	489.5169	472.7589	456.001
31.2392	**83**	637.2716	617.1699	597.0681	576.9664	556.8647	536.763	520.121	503.4791	486.8372	470.1953	453.5533
31.2388	**82**	633.4715	613.5243	593.577	573.6298	553.6825	533.7352	517.2093	500.6834	484.1575	467.6316	451.1057
31.2384	**81**	629.6715	609.8787	590.0859	570.2931	550.5003	530.7075	514.2976	497.8877	481.4778	465.0679	448.658
31.238	**80**	625.8714	606.2331	586.5948	566.9564	547.3181	527.6798	511.3859	495.092	478.7981	462.5042	446.2104

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
31.2368	**79**	621.753	602.2759	582.7987	563.3216	543.8445	524.3673	508.1948	492.0223	475.8497	459.6772	443.5046
31.2356	**78**	617.6346	598.3187	579.0027	559.6868	540.3708	521.0549	505.0037	488.9525	472.9013	456.8501	440.7989
31.2344	**77**	613.5163	594.3615	575.2067	556.052	536.8972	517.7424	501.8126	485.8827	469.9529	454.023	438.0932
31.2332	**76**	609.3979	590.4043	571.4107	552.4171	533.4235	514.43	498.6215	482.813	467.0045	451.196	435.3875
31.232	**75**	605.2795	586.4471	567.6147	548.7823	529.9499	511.1175	495.4304	479.7432	464.0561	448.3689	432.6818
31.2308	**74**	604.2493	585.4142	566.5791	547.744	528.9089	510.0738	494.3949	478.716	463.0372	447.3583	431.6794
31.2296	**73**	603.2192	584.3813	565.5435	546.7057	527.8678	509.03	493.3594	477.6888	462.0183	446.3477	430.6771
31.2284	**72**	602.189	583.3484	564.5079	545.6674	526.8268	507.9863	492.324	476.6617	460.9994	445.337	429.6747
31.2272	**71**	601.1588	582.3156	563.4723	544.6291	525.7858	506.9425	491.2885	475.6345	459.9805	444.3264	428.6724
31.226	**70**	600.1287	581.2827	562.4367	543.5907	524.7448	505.8988	490.2531	474.6073	458.9616	443.3158	427.6701
31.2198	**69**	597.192	578.4533	559.7145	540.9758	522.237	503.4983	487.9333	472.3683	456.8032	441.2382	425.6732
31.2136	**68**	594.2554	575.6239	556.9923	538.3608	519.7293	501.0978	485.6135	470.1292	454.6449	439.1606	423.6763
31.2074	**67**	591.3187	572.7944	554.2701	535.7459	517.2216	498.6973	483.2937	467.8902	452.4866	437.083	421.6795
31.2012	**66**	588.3821	569.965	551.548	533.1309	514.7138	496.2968	480.9739	465.6511	450.3283	435.0054	419.6826
31.195	**65**	585.4455	567.1356	548.8258	530.5159	512.2061	493.8963	478.6542	463.4121	448.17	432.9279	417.6858
31.1886	**64**	582.4016	564.2055	546.0094	527.8132	509.6171	491.421	476.2622	461.1034	445.9446	430.7858	415.627
31.1822	**63**	579.3578	561.2754	543.193	525.1106	507.0281	488.9457	473.8702	458.7948	443.7193	428.6438	413.5683
31.1758	**62**	576.314	558.3453	540.3766	522.4079	504.4392	486.4705	471.4783	456.4861	441.4939	426.5017	411.5096
31.1694	**61**	573.2702	555.4152	537.5602	519.7052	501.8502	483.9952	469.0863	454.1775	439.2686	424.3597	409.4508
31.163	**60**	570.2264	552.4851	534.7438	517.0025	499.2612	481.52	466.6944	451.8688	437.0432	422.2177	407.3921

EHP Even Keel

Lcg	Displacement ((%)	12	11.5	11	10.5	10	9.5	9	8.5	8	
31.611	100	713.6245	596.8431	501.1631	421.0587	354.0229	297.6821	249.9054	209.0781	173.9467	Holtrop (kW)
31.607	95	688.0025	577.116	485.913	409.2701	344.7873	290.352	244.0185	204.3056	170.0563	
31.609	90	668.9527	561.9418	473.754	399.5342	336.8983	283.9005	238.709	199.9183	166.4326	
31.616	85	649.1302	546.0925	460.9695	389.2313	328.5102	277.012	233.0211	195.2091	162.5376	
31.627	80	628.3761	529.4531	447.4742	378.2948	319.5701	269.6451	226.9226	190.1514	158.3481	
31.633	75	618.6931	520.8017	439.8681	371.68	313.7936	264.6231	222.5883	186.4461	155.2155	
31.625	70	608.58	512.0283	432.2885	365.1986	308.2081	259.8126	218.4644	182.9328	152.252	
31.613	65	594.8801	500.7882	422.9436	357.4695	301.76	254.3973	213.9092	179.1068	149.0538	
31.59	60	576.924	486.3408	411.0721	347.7359	293.7284	247.7123	208.3283	174.4447	145.1714	

Database EHP Even Keel

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
31.611	**100**	713.6245	690.2682	666.9119	643.5556	620.1994	596.8431	577.7071	558.5711	539.4351	520.2991	501.1631
31.6102	**99**	708.5001	685.3796	662.2591	639.1386	616.0182	592.8977	573.9408	554.9838	536.0269	517.07	498.1131
31.6094	**98**	703.3757	680.491	657.6063	634.7216	611.8369	588.9523	570.1744	551.3966	532.6187	513.8409	495.063
31.6086	**97**	698.2513	675.6024	652.9535	630.3046	607.6557	585.0068	566.4081	547.8093	529.2105	510.6118	492.013
31.6078	**96**	693.1269	670.7138	648.3007	625.8876	603.4745	581.0614	562.6417	544.222	525.8024	507.3827	488.963
31.607	**95**	688.0025	665.8252	643.6479	621.4706	599.2933	577.116	558.8754	540.6348	522.3942	504.1536	485.913
31.6074	**94**	684.1925	662.1702	640.148	618.1257	596.1034	574.0812	555.9612	537.8412	519.7212	501.6012	483.4812
31.6078	**93**	680.3826	658.5153	636.6481	614.7808	592.9136	571.0463	553.0469	535.0475	517.0481	499.0488	481.0494
31.6082	**92**	676.5726	654.8604	633.1481	611.4359	589.7237	568.0115	550.1327	532.2539	514.3751	496.4964	478.6176
31.6086	**91**	672.7627	651.2054	629.6482	608.091	586.5338	564.9766	547.2184	529.4603	511.7021	493.944	476.1858
31.609	**90**	668.9527	647.5505	626.1483	604.7461	583.3439	561.9418	544.3042	526.6667	509.0291	491.3916	473.754
31.6104	**89**	664.9882	643.7449	622.5017	601.2584	580.0152	558.7719	541.2569	523.742	506.227	488.7121	471.1971
31.6118	**88**	661.0237	639.9394	618.855	597.7707	576.6864	555.602	538.2097	520.8173	503.4249	486.0326	468.6402
31.6132	**87**	657.0592	636.1338	615.2084	594.283	573.3576	552.4322	535.1624	517.8926	500.6228	483.3531	466.0833
31.6146	**86**	653.0947	632.3282	611.5617	590.7953	570.0288	549.2623	532.1151	514.9679	497.8207	480.6736	463.5264
31.616	**85**	649.1302	628.5226	607.9151	587.3075	566.7	546.0925	529.0679	512.0433	495.0187	477.9941	460.9695
31.6182	**84**	644.9793	624.5364	604.0934	583.6505	563.2075	542.7646	525.8657	508.9669	492.0681	475.1692	458.2704
31.6204	**83**	640.8285	620.5502	600.2718	579.9934	559.7151	539.4367	522.6636	505.8906	489.1175	472.3444	455.5714
31.6226	**82**	636.6777	616.5639	596.4502	576.3364	556.2226	536.1088	519.4615	502.8142	486.1669	469.5196	452.8723
31.6248	**81**	632.5269	612.5777	592.6285	572.6793	552.7302	532.781	516.2594	499.7379	483.2163	466.6948	450.1733
31.627	**80**	628.3761	608.5915	588.8069	569.0223	549.2377	529.4531	513.0573	496.6615	480.2658	463.87	447.4742

LCG		12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11
31.6282	**79**	626.4395	606.6962	586.9528	567.2095	547.4661	527.7228	511.3688	495.0149	478.6609	462.3069	445.953
31.6294	**78**	624.5029	604.8008	585.0987	565.3967	545.6946	525.9925	509.6804	493.3682	477.0561	460.7439	444.4318
31.6306	**77**	622.5663	602.9055	583.2447	563.5839	543.923	524.2622	507.9919	491.7216	475.4512	459.1809	442.9105
31.6318	**76**	620.6297	601.0101	581.3906	561.771	542.1515	522.5319	506.3034	490.0749	473.8464	457.6178	441.3893
31.633	**75**	618.6931	599.1148	579.5365	559.9582	540.3799	520.8017	504.6149	488.4282	472.2415	456.0548	439.8681
31.6314	**74**	616.6705	597.1458	577.6211	558.0964	538.5717	519.047	502.908	486.7691	470.6301	454.4911	438.3522
31.6298	**73**	614.6479	595.1768	575.7056	556.2345	536.7634	517.2923	501.2011	485.1099	469.0187	452.9275	436.8362
31.6282	**72**	612.6252	593.2077	573.7902	554.3727	534.9552	515.5376	499.4942	483.4507	467.4072	451.3638	435.3203
31.6266	**71**	610.6026	591.2387	571.8748	552.5108	533.1469	513.783	497.7873	481.7915	465.7958	449.8001	433.8044
31.625	**70**	608.58	589.2697	569.9593	550.649	531.3386	512.0283	496.0803	480.1324	464.1844	448.2364	432.2885
31.6226	**69**	605.84	586.6281	567.4161	548.2042	528.9922	509.7803	493.9081	478.036	462.1638	446.2916	430.4195
31.6202	**68**	603.1	583.9865	564.8729	545.7594	526.6458	507.5323	491.7359	475.9396	460.1432	444.3468	428.5505
31.6178	**67**	600.36	581.3449	562.3297	543.3146	524.2994	505.2842	489.5637	473.8431	458.1226	442.4021	426.6815
31.6154	**66**	597.62	578.7033	559.7865	540.8697	521.953	503.0362	487.3915	471.7467	456.102	440.4573	424.8125
31.613	**65**	594.8801	576.0617	557.2433	538.4249	519.6066	500.7882	485.2193	469.6503	454.0814	438.5125	422.9436
31.6084	**64**	591.2888	572.6108	553.9328	535.2548	516.5767	497.8987	482.4328	466.9669	451.501	436.0352	420.5693
31.6038	**63**	587.6976	569.1599	550.6223	532.0846	513.5469	495.0092	479.6464	464.2835	448.9207	433.5578	418.195
31.5992	**62**	584.1064	565.7091	547.3117	528.9144	510.5171	492.1197	476.8599	461.6001	446.3403	431.0805	415.8207
31.5946	**61**	580.5152	562.2582	544.0012	525.7442	507.4872	489.2302	474.0735	458.9167	443.7599	428.6032	413.4464
31.59	**60**	576.924	558.8073	540.6907	522.574	504.4574	486.3408	471.287	456.2333	441.1796	426.1258	411.0721

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APPENDIX 3

BHP MCr Calculation

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Power Distribution Approach

100%

Power Calculation

EHP	=	666.2376	kW
		905.7499	HP

DHP = EHP/Pc

Pc = ηH x ηrr x ηo

cb = 0.7

a. Hull Efficiency

ηH = (1-t)/(1-w)

t =	k.w	k = 0.7 - 0.9	
t=	0.0063	k=	0.9
w =	0.007		

ηH = 1.000705

Table 4—Values of Wake Fraction from Taylor

Block coefficient C_B	Wake fraction (Taylor) Twin-screw ships	Single-screw ships
0.50	−0.038	0.230
0.55	−0.021	0.234
0.60	+0.007	0.243
0.65	0.045	0.260
0.70	0.091	0.283
0.75	0.143	0.314
0.80	—	0.354
0.85	—	0.400
0.90	—	0.477

b. Relatif Rotation Efficiency

nrr = 1

c. Propulsive Efficiency

No = 0.5

d. Coefficient Propulsive

Pc = nH x nrr x no

= 0.500352

e. DHP = EHP/Pc

= 1331.536 kW

= 1810.224 HP

f. SHP

nsnb = 0.98

SHP = DHP/nsnb

= 1358.711 kW

= 1847.167 HP

g.	BHPScr			
	nG	=	0.98	
		=	SHP/nG	
	BHPScr	=	1386.439	kW
		=	1884.864	HP
h.	BHPMcr			
	Efficiency	=	0.8	
	BHPMcr	=	BHPScr/0.8	
		=	1733.049	kW
		=	2356.081	HP

BHP MCr 1.6m by Stern

Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
100	1733	1459	1232	1043	882	745	628	527	440	BHP MCr (kW)
95	1685	1422	1203	1019	863	730	616	517	431	
90	1634	1382	1171	994	842	713	602	505	422	
85	1583	1343	1140	968	822	696	588	494	412	
80	1534	1304	1109	943	802	680	574	483	403	
75	1476	1258	1072	913	777	660	558	469	392	
70	1436	1227	1047	893	761	646	546	460	384	
65	1388	1188	1016	867	740	629	532.5	448	374	
60	1338	1149	984	841	718	611	517	435	364	

BHP MCr 1.6m by Stern Database

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
100	1733	1678.2	1623.4	1568.6	1513.8	1459	1413.6	1368.2	1322.8	1277.4	1232	1194.2
99	1723.4	1669.04	1614.68	1560.32	1505.96	1451.6	1406.52	1361.44	1316.36	1271.28	1226.2	1188.6
98	1713.8	1659.88	1605.96	1552.04	1498.12	1444.2	1399.44	1354.68	1309.92	1265.16	1220.4	1183
97	1704.2	1650.72	1597.24	1543.76	1490.28	1436.8	1392.36	1347.92	1303.48	1259.04	1214.6	1177.4
96	1694.6	1641.56	1588.52	1535.48	1482.44	1429.4	1385.28	1341.16	1297.04	1252.92	1208.8	1171.8
95	1685	1632.4	1579.8	1527.2	1474.6	1422	1378.2	1334.4	1290.6	1246.8	1203	1166.2
94	1674.8	1622.64	1570.48	1518.32	1466.16	1414	1370.52	1327.04	1283.56	1240.08	1196.6	1160.08
93	1664.6	1612.88	1561.16	1509.44	1457.72	1406	1362.84	1319.68	1276.52	1233.36	1190.2	1153.96
92	1654.4	1603.12	1551.84	1500.56	1449.28	1398	1355.16	1312.32	1269.48	1226.64	1183.8	1147.84
91	1644.2	1593.36	1542.52	1491.68	1440.84	1390	1347.48	1304.96	1262.44	1219.92	1177.4	1141.72
90	1634	1583.6	1533.2	1482.8	1432.4	1382	1339.8	1297.6	1255.4	1213.2	1171	1135.6
89	1623.8	1573.88	1523.96	1474.04	1424.12	1374.2	1332.32	1290.44	1248.56	1206.68	1164.8	1129.6
88	1613.6	1564.16	1514.72	1465.28	1415.84	1366.4	1324.84	1283.28	1241.72	1200.16	1158.6	1123.6
87	1603.4	1554.44	1505.48	1456.52	1407.56	1358.6	1317.36	1276.12	1234.88	1193.64	1152.4	1117.6
86	1593.2	1544.72	1496.24	1447.76	1399.28	1350.8	1309.88	1268.96	1228.04	1187.12	1146.2	1111.6
85	1583	1535	1487	1439	1391	1343	1302.4	1261.8	1221.2	1180.6	1140	1105.6
84	1573.2	1525.6	1478	1430.4	1382.8	1335.2	1294.92	1254.64	1214.36	1174.08	1133.8	1099.64
83	1563.4	1516.2	1469	1421.8	1374.6	1327.4	1287.44	1247.48	1207.52	1167.56	1127.6	1093.68
82	1553.6	1506.8	1460	1413.2	1366.4	1319.6	1279.96	1240.32	1200.68	1161.04	1121.4	1087.72
81	1543.8	1497.4	1451	1404.6	1358.2	1311.8	1272.48	1233.16	1193.84	1154.52	1115.2	1081.76
80	1534	1488	1442	1396	1350	1304	1265	1226	1187	1148	1109	1075.8

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
79	1522.4	1476.88	1431.36	1385.84	1340.32	1294.8	1256.16	1217.52	1178.88	1140.24	1101.6	1068.68
78	1510.8	1465.76	1420.72	1375.68	1330.64	1285.6	1247.32	1209.04	1170.76	1132.48	1094.2	1061.56
77	1499.2	1454.64	1410.08	1365.52	1320.96	1276.4	1238.48	1200.56	1162.64	1124.72	1086.8	1054.44
76	1487.6	1443.52	1399.44	1355.36	1311.28	1267.2	1229.64	1192.08	1154.52	1116.96	1079.4	1047.32
75	1476	1432.4	1388.8	1345.2	1301.6	1258	1220.8	1183.6	1146.4	1109.2	1072	1040.2
74	1468	1424.76	1381.52	1338.28	1295.04	1251.8	1214.84	1177.88	1140.92	1103.96	1067	1035.4
73	1460	1417.12	1374.24	1331.36	1288.48	1245.6	1208.88	1172.16	1135.44	1098.72	1062	1030.6
72	1452	1409.48	1366.96	1324.44	1281.92	1239.4	1202.92	1166.44	1129.96	1093.48	1057	1025.8
71	1444	1401.84	1359.68	1317.52	1275.36	1233.2	1196.96	1160.72	1124.48	1088.24	1052	1021
70	1436	1394.2	1352.4	1310.6	1268.8	1227	1191	1155	1119	1083	1047	1016.2
69	1426.4	1384.96	1343.52	1302.08	1260.64	1219.2	1183.52	1147.84	1112.16	1076.48	1040.8	1010.2
68	1416.8	1375.72	1334.64	1293.56	1252.48	1211.4	1176.04	1140.68	1105.32	1069.96	1034.6	1004.2
67	1407.2	1366.48	1325.76	1285.04	1244.32	1203.6	1168.56	1133.52	1098.48	1063.44	1028.4	998.2
66	1397.6	1357.24	1316.88	1276.52	1236.16	1195.8	1161.08	1126.36	1091.64	1056.92	1022.2	992.2
65	1388	1348	1308	1268	1228	1188	1153.6	1119.2	1084.8	1050.4	1016	986.2
64	1378	1338.44	1298.88	1259.32	1219.76	1180.2	1146.08	1111.96	1077.84	1043.72	1009.6	980.04
63	1368	1328.88	1289.76	1250.64	1211.52	1172.4	1138.56	1104.72	1070.88	1037.04	1003.2	973.88
62	1358	1319.32	1280.64	1241.96	1203.28	1164.6	1131.04	1097.48	1063.92	1030.36	996.8	967.72
61	1348	1309.76	1271.52	1233.28	1195.04	1156.8	1123.52	1090.24	1056.96	1023.68	990.4	961.56
60	1338	1300.2	1262.4	1224.6	1186.8	1149	1116	1083	1050	1017	984	955.4

BHP MCr 1.4m by Stern

Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
100	1748	1470	1241	1049	887	749	631	529	441	BHP MCr (kW)
95	1697	1430	1209	1024	867	732	617	518	432	
90	1646	1391	1178	999	846	716	604	507	423	
85	1595	1351	1146	973	825	699	590	495	413	
80	1572	1333	1132	961	816	691	584	490	409	
75	1496	1273	1083	922	784	665	562	472	394	
70	1447	1234	1052	897	763	648	548	461	385	
65	1398	1196	1021	871	743	631	534	449	375	
60	1347	1155	988	844	720	612	518	436	364	

BHP MCr 1.4m by Stern Database

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
100	1748	1692.4	1636.8	1581.2	1525.6	1470	1424.2	1378.4	1332.6	1286.8	1241	1202.6
99	1737.8	1682.64	1627.48	1572.32	1517.16	1462	1416.52	1371.04	1325.56	1280.08	1234.6	1196.48
98	1727.6	1672.88	1618.16	1563.44	1508.72	1454	1408.84	1363.68	1318.52	1273.36	1228.2	1190.36
97	1717.4	1663.12	1608.84	1554.56	1500.28	1446	1401.16	1356.32	1311.48	1266.64	1221.8	1184.24
96	1707.2	1653.36	1599.52	1545.68	1491.84	1438	1393.48	1348.96	1304.44	1259.92	1215.4	1178.12
95	1697	1643.6	1590.2	1536.8	1483.4	1430	1385.8	1341.6	1297.4	1253.2	1209	1172
94	1686.8	1633.88	1580.96	1528.04	1475.12	1422.2	1378.32	1334.44	1290.56	1246.68	1202.8	1166.04
93	1676.6	1624.16	1571.72	1519.28	1466.84	1414.4	1370.84	1327.28	1283.72	1240.16	1196.6	1160.08
92	1666.4	1614.44	1562.48	1510.52	1458.56	1406.6	1363.36	1320.12	1276.88	1233.64	1190.4	1154.12
91	1656.2	1604.72	1553.24	1501.76	1450.28	1398.8	1355.88	1312.96	1270.04	1227.12	1184.2	1148.16
90	1646	1595	1544	1493	1442	1391	1348.4	1305.8	1263.2	1220.6	1178	1142.2
89	1635.8	1585.24	1534.68	1484.12	1433.56	1383	1340.72	1298.44	1256.16	1213.88	1171.6	1136.04
88	1625.6	1575.48	1525.36	1475.24	1425.12	1375	1333.04	1291.08	1249.12	1207.16	1165.2	1129.88
87	1615.4	1565.72	1516.04	1466.36	1416.68	1367	1325.36	1283.72	1242.08	1200.44	1158.8	1123.72
86	1605.2	1555.96	1506.72	1457.48	1408.24	1359	1317.68	1276.36	1235.04	1193.72	1152.4	1117.56
85	1595	1546.2	1497.4	1448.6	1399.8	1351	1310	1269	1228	1187	1146	1111.4
84	1590.4	1541.8	1493.2	1444.6	1396	1347.4	1306.56	1265.72	1224.88	1184.04	1143.2	1108.68
83	1585.8	1537.4	1489	1440.6	1392.2	1343.8	1303.12	1262.44	1221.76	1181.08	1140.4	1105.96
82	1581.2	1533	1484.8	1436.6	1388.4	1340.2	1299.68	1259.16	1218.64	1178.12	1137.6	1103.24
81	1576.6	1528.6	1480.6	1432.6	1384.6	1336.6	1296.24	1255.88	1215.52	1175.16	1134.8	1100.52
80	1572	1524.2	1476.4	1428.6	1380.8	1333	1292.8	1252.6	1212.4	1172.2	1132	1097.8

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
79	1556.8	1509.64	1462.48	1415.32	1368.16	1321	1281.24	1241.48	1201.72	1161.96	1122.2	1088.4
78	1541.6	1495.08	1448.56	1402.04	1355.52	1309	1269.68	1230.36	1191.04	1151.72	1112.4	1079
77	1526.4	1480.52	1434.64	1388.76	1342.88	1297	1258.12	1219.24	1180.36	1141.48	1102.6	1069.6
76	1511.2	1465.96	1420.72	1375.48	1330.24	1285	1246.56	1208.12	1169.68	1131.24	1092.8	1060.2
75	1496	1451.4	1406.8	1362.2	1317.6	1273	1235	1197	1159	1121	1083	1050.8
74	1486.2	1442	1397.8	1353.6	1309.4	1265.2	1227.52	1189.84	1152.16	1114.48	1076.8	1044.84
73	1476.4	1432.6	1388.8	1345	1301.2	1257.4	1220.04	1182.68	1145.32	1107.96	1070.6	1038.88
72	1466.6	1423.2	1379.8	1336.4	1293	1249.6	1212.56	1175.52	1138.48	1101.44	1064.4	1032.92
71	1456.8	1413.8	1370.8	1327.8	1284.8	1241.8	1205.08	1168.36	1131.64	1094.92	1058.2	1026.96
70	1447	1404.4	1361.8	1319.2	1276.6	1234	1197.6	1161.2	1124.8	1088.4	1052	1021
69	1437.2	1395.04	1352.88	1310.72	1268.56	1226.4	1190.28	1154.16	1118.04	1081.92	1045.8	1015
68	1427.4	1385.68	1343.96	1302.24	1260.52	1218.8	1182.96	1147.12	1111.28	1075.44	1039.6	1009
67	1417.6	1376.32	1335.04	1293.76	1252.48	1211.2	1175.64	1140.08	1104.52	1068.96	1033.4	1003
66	1407.8	1366.96	1326.12	1285.28	1244.44	1203.6	1168.32	1133.04	1097.76	1062.48	1027.2	997
65	1398	1357.6	1317.2	1276.8	1236.4	1196	1161	1126	1091	1056	1021	991
64	1387.8	1347.8	1307.8	1267.8	1227.8	1187.8	1153.12	1118.44	1083.76	1049.08	1014.4	984.64
63	1377.6	1338	1298.4	1258.8	1219.2	1179.6	1145.24	1110.88	1076.52	1042.16	1007.8	978.28
62	1367.4	1328.2	1289	1249.8	1210.6	1171.4	1137.36	1103.32	1069.28	1035.24	1001.2	971.92
61	1357.2	1318.4	1279.6	1240.8	1202	1163.2	1129.48	1095.76	1062.04	1028.32	994.6	965.56
60	1347	1308.6	1270.2	1231.8	1193.4	1155	1121.6	1088.2	1054.8	1021.4	988	959.2

BHP MCr 1.2m by Stern

Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
100	1760	1479	1248	1054	891	752	633	531	443	BHP MCr (kW)
95	1711	1441	1217	1030	871	736	620	520	433	
90	1661	1402	1186	1005	851	719	607	509	424	
85	1609	1361	1153	978	829	702	592	497	415	
80	1556	1320	1120	952	808	684	578	485	405	
75	1509	1283	1090	928	788	668	564	474	396	
70	1459	1243	1059	902	767	651	550	462	386	
65	1406	1201	1025	874	744	632	534	449	375	
60	1355	1160	991	847	721	613	519	436	364	

BHP MCr 1.2m by Stern Database

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
100	1760	1703.8	1647.6	1591.4	1535.2	1479	1432.8	1386.6	1340.4	1294.2	1248	1209.2
99	1750.2	1694.44	1638.68	1582.92	1527.16	1471.4	1425.48	1379.56	1333.64	1287.72	1241.8	1203.28
98	1740.4	1685.08	1629.76	1574.44	1519.12	1463.8	1418.16	1372.52	1326.88	1281.24	1235.6	1197.36
97	1730.6	1675.72	1620.84	1565.96	1511.08	1456.2	1410.84	1365.48	1320.12	1274.76	1229.4	1191.44
96	1720.8	1666.36	1611.92	1557.48	1503.04	1448.6	1403.52	1358.44	1313.36	1268.28	1223.2	1185.52
95	1711	1657	1603	1549	1495	1441	1396.2	1351.4	1306.6	1261.8	1217	1179.6
94	1701	1647.44	1593.88	1540.32	1486.76	1433.2	1388.72	1344.24	1299.76	1255.28	1210.8	1173.64
93	1691	1637.88	1584.76	1531.64	1478.52	1425.4	1381.24	1337.08	1292.92	1248.76	1204.6	1167.68
92	1681	1628.32	1575.64	1522.96	1470.28	1417.6	1373.76	1329.92	1286.08	1242.24	1198.4	1161.72
91	1671	1618.76	1566.52	1514.28	1462.04	1409.8	1366.28	1322.76	1279.24	1235.72	1192.2	1155.76
90	1661	1609.2	1557.4	1505.6	1453.8	1402	1358.8	1315.6	1272.4	1229.2	1186	1149.8
89	1650.6	1599.24	1547.88	1496.52	1445.16	1393.8	1350.92	1308.04	1265.16	1222.28	1179.4	1143.44
88	1640.2	1589.28	1538.36	1487.44	1436.52	1385.6	1343.04	1300.48	1257.92	1215.36	1172.8	1137.08
87	1629.8	1579.32	1528.84	1478.36	1427.88	1377.4	1335.16	1292.92	1250.68	1208.44	1166.2	1130.72
86	1619.4	1569.36	1519.32	1469.28	1419.24	1369.2	1327.28	1285.36	1243.44	1201.52	1159.6	1124.36
85	1609	1559.4	1509.8	1460.2	1410.6	1361	1319.4	1277.8	1236.2	1194.6	1153	1118
84	1598.4	1549.28	1500.16	1451.04	1401.92	1352.8	1311.52	1270.24	1228.96	1187.68	1146.4	1111.68
83	1587.8	1539.16	1490.52	1441.88	1393.24	1344.6	1303.64	1262.68	1221.72	1180.76	1139.8	1105.36
82	1577.2	1529.04	1480.88	1432.72	1384.56	1336.4	1295.76	1255.12	1214.48	1173.84	1133.2	1099.04
81	1566.6	1518.92	1471.24	1423.56	1375.88	1328.2	1287.88	1247.56	1207.24	1166.92	1126.6	1092.72
80	1556	1508.8	1461.6	1414.4	1367.2	1320	1280	1240	1200	1160	1120	1086.4

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
79	1546.6	1499.8	1453	1406.2	1359.4	1312.6	1272.88	1233.16	1193.44	1153.72	1114	1080.64
78	1537.2	1490.8	1444.4	1398	1351.6	1305.2	1265.76	1226.32	1186.88	1147.44	1108	1074.88
77	1527.8	1481.8	1435.8	1389.8	1343.8	1297.8	1258.64	1219.48	1180.32	1141.16	1102	1069.12
76	1518.4	1472.8	1427.2	1381.6	1336	1290.4	1251.52	1212.64	1173.76	1134.88	1096	1063.36
75	1509	1463.8	1418.6	1373.4	1328.2	1283	1244.4	1205.8	1167.2	1128.6	1090	1057.6
74	1499	1454.2	1409.4	1364.6	1319.8	1275	1236.76	1198.52	1160.28	1122.04	1083.8	1051.6
73	1489	1444.6	1400.2	1355.8	1311.4	1267	1229.12	1191.24	1153.36	1115.48	1077.6	1045.6
72	1479	1435	1391	1347	1303	1259	1221.48	1183.96	1146.44	1108.92	1071.4	1039.6
71	1469	1425.4	1381.8	1338.2	1294.6	1251	1213.84	1176.68	1139.52	1102.36	1065.2	1033.6
70	1459	1415.8	1372.6	1329.4	1286.2	1243	1206.2	1169.4	1132.6	1095.8	1059	1027.6
69	1448.4	1405.64	1362.88	1320.12	1277.36	1234.6	1198.12	1161.64	1125.16	1088.68	1052.2	1021.04
68	1437.8	1395.48	1353.16	1310.84	1268.52	1226.2	1190.04	1153.88	1117.72	1081.56	1045.4	1014.48
67	1427.2	1385.32	1343.44	1301.56	1259.68	1217.8	1181.96	1146.12	1110.28	1074.44	1038.6	1007.92
66	1416.6	1375.16	1333.72	1292.28	1250.84	1209.4	1173.88	1138.36	1102.84	1067.32	1031.8	1001.36
65	1406	1365	1324	1283	1242	1201	1165.8	1130.6	1095.4	1060.2	1025	994.8
64	1395.8	1355.2	1314.6	1274	1233.4	1192.8	1157.88	1122.96	1088.04	1053.12	1018.2	988.28
63	1385.6	1345.4	1305.2	1265	1224.8	1184.6	1149.96	1115.32	1080.68	1046.04	1011.4	981.76
62	1375.4	1335.6	1295.8	1256	1216.2	1176.4	1142.04	1107.68	1073.32	1038.96	1004.6	975.24
61	1365.2	1325.8	1286.4	1247	1207.6	1168.2	1134.12	1100.04	1065.96	1031.88	997.8	968.72
60	1355	1316	1277	1238	1199	1160	1126.2	1092.4	1058.6	1024.8	991	962.2

BHP MCr 1m by Stern

Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
100	1774	1489	1256	1060	895	755	636	533	444	BHP MCr (kW)
95	1724	1451	1225	1035	875	739	622	522	435	
90	1674	1411	1193	1010	855	722	609	511	426	
85	1623	1371	1161	984	834	705	595	499	416	
80	1572	1331	1129	958	813	688	580	487	406	
75	1521	1291	1097	932	792	671	566	476	397	
70	1469	1251	1064	906	770	653	551	463	386	
65	1418	1210	1031	879	748	634	536	450	376	
60	1347	1155	988	844	720	612	518	436	364	

BHP MCr 1m by Stern Database

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
100	1774	1717	1660	1603	1546	1489	1442.4	1395.8	1349.2	1302.6	1256	1216.8
99	1764	1707.48	1650.96	1594.44	1537.92	1481.4	1435.08	1388.76	1342.44	1296.12	1249.8	1210.84
98	1754	1697.96	1641.92	1585.88	1529.84	1473.8	1427.76	1381.72	1335.68	1289.64	1243.6	1204.88
97	1744	1688.44	1632.88	1577.32	1521.76	1466.2	1420.44	1374.68	1328.92	1283.16	1237.4	1198.92
96	1734	1678.92	1623.84	1568.76	1513.68	1458.6	1413.12	1367.64	1322.16	1276.68	1231.2	1192.96
95	1724	1669.4	1614.8	1560.2	1505.6	1451	1405.8	1360.6	1315.4	1270.2	1225	1187
94	1714	1659.8	1605.6	1551.4	1497.2	1443	1398.12	1353.24	1308.36	1263.48	1218.6	1180.88
93	1704	1650.2	1596.4	1542.6	1488.8	1435	1390.44	1345.88	1301.32	1256.76	1212.2	1174.76
92	1694	1640.6	1587.2	1533.8	1480.4	1427	1382.76	1338.52	1294.28	1250.04	1205.8	1168.64
91	1684	1631	1578	1525	1472	1419	1375.08	1331.16	1287.24	1243.32	1199.4	1162.52
90	1674	1621.4	1568.8	1516.2	1463.6	1411	1367.4	1323.8	1280.2	1236.6	1193	1156.4
89	1663.8	1611.64	1559.48	1507.32	1455.16	1403	1359.72	1316.44	1273.16	1229.88	1186.6	1150.24
88	1653.6	1601.88	1550.16	1498.44	1446.72	1395	1352.04	1309.08	1266.12	1223.16	1180.2	1144.08
87	1643.4	1592.12	1540.84	1489.56	1438.28	1387	1344.36	1301.72	1259.08	1216.44	1173.8	1137.92
86	1633.2	1582.36	1531.52	1480.68	1429.84	1379	1336.68	1294.36	1252.04	1209.72	1167.4	1131.76
85	1623	1572.6	1522.2	1471.8	1421.4	1371	1329	1287	1245	1203	1161	1125.6
84	1612.8	1562.84	1512.88	1462.92	1412.96	1363	1321.32	1279.64	1237.96	1196.28	1154.6	1119.44
83	1602.6	1553.08	1503.56	1454.04	1404.52	1355	1313.64	1272.28	1230.92	1189.56	1148.2	1113.28
82	1592.4	1543.32	1494.24	1445.16	1396.08	1347	1305.96	1264.92	1223.88	1182.84	1141.8	1107.12
81	1582.2	1533.56	1484.92	1436.28	1387.64	1339	1298.28	1257.56	1216.84	1176.12	1135.4	1100.96
80	1572	1523.8	1475.6	1427.4	1379.2	1331	1290.6	1250.2	1209.8	1169.4	1129	1094.8

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
79	1561.8	1514.04	1466.28	1418.52	1370.76	1323	1282.92	1242.84	1202.76	1162.68	1122.6	1088.64
78	1551.6	1504.28	1456.96	1409.64	1362.32	1315	1275.24	1235.48	1195.72	1155.96	1116.2	1082.48
77	1541.4	1494.52	1447.64	1400.76	1353.88	1307	1267.56	1228.12	1188.68	1149.24	1109.8	1076.32
76	1531.2	1484.76	1438.32	1391.88	1345.44	1299	1259.88	1220.76	1181.64	1142.52	1103.4	1070.16
75	1521	1475	1429	1383	1337	1291	1252.2	1213.4	1174.6	1135.8	1097	1064
74	1510.6	1465.08	1419.56	1374.04	1328.52	1283	1244.48	1205.96	1167.44	1128.92	1090.4	1057.68
73	1500.2	1455.16	1410.12	1365.08	1320.04	1275	1236.76	1198.52	1160.28	1122.04	1083.8	1051.36
72	1489.8	1445.24	1400.68	1356.12	1311.56	1267	1229.04	1191.08	1153.12	1115.16	1077.2	1045.04
71	1479.4	1435.32	1391.24	1347.16	1303.08	1259	1221.32	1183.64	1145.96	1108.28	1070.6	1038.72
70	1469	1425.4	1381.8	1338.2	1294.6	1251	1213.6	1176.2	1138.8	1101.4	1064	1032.4
69	1458.8	1415.6	1372.4	1329.2	1286	1242.8	1205.72	1168.64	1131.56	1094.48	1057.4	1026.04
68	1448.6	1405.8	1363	1320.2	1277.4	1234.6	1197.84	1161.08	1124.32	1087.56	1050.8	1019.68
67	1438.4	1396	1353.6	1311.2	1268.8	1226.4	1189.96	1153.52	1117.08	1080.64	1044.2	1013.32
66	1428.2	1386.2	1344.2	1302.2	1260.2	1218.2	1182.08	1145.96	1109.84	1073.72	1037.6	1006.96
65	1418	1376.4	1334.8	1293.2	1251.6	1210	1174.2	1138.4	1102.6	1066.8	1031	1000.6
64	1403.8	1362.84	1321.88	1280.92	1239.96	1199	1163.68	1128.36	1093.04	1057.72	1022.4	992.32
63	1389.6	1349.28	1308.96	1268.64	1228.32	1188	1153.16	1118.32	1083.48	1048.64	1013.8	984.04
62	1375.4	1335.72	1296.04	1256.36	1216.68	1177	1142.64	1108.28	1073.92	1039.56	1005.2	975.76
61	1361.2	1322.16	1283.12	1244.08	1205.04	1166	1132.12	1098.24	1064.36	1030.48	996.6	967.48
60	1347	1308.6	1270.2	1231.8	1193.4	1155	1121.6	1088.2	1054.8	1021.4	988	959.2

BHP MCr 0.8m by Stern

Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
100	1791	1502	1266	1068	901	760	639	536	446	BHP MCr (kW)
95	1738	1461	1232	1041	880	742	625	524	436	
90	1688	1422	1201	1016	859	726	611	513	427	
85	1636	1380	1168	989	838	708	597	501	417	
80	1586	1342	1137	964	817	691	583	489	408	
75	1534	1301	1104	938	796	673	568	477	398	
70	1482	1259	1071	910	773	655	553	465	387	
65	1436	1222	1040	885	752	637	538	452	377	
60	1355	1160	991	847	721	613	519	436	364	

BHP MCr 0.8m by Stern Database

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
100	1791	1733.2	1675.4	1617.6	1559.8	1502	1454.8	1407.6	1360.4	1313.2	1266	1226.4
99	1780.4	1723.08	1665.76	1608.44	1551.12	1493.8	1446.88	1399.96	1353.04	1306.12	1259.2	1219.88
98	1769.8	1712.96	1656.12	1599.28	1542.44	1485.6	1438.96	1392.32	1345.68	1299.04	1252.4	1213.36
97	1759.2	1702.84	1646.48	1590.12	1533.76	1477.4	1431.04	1384.68	1338.32	1291.96	1245.6	1206.84
96	1748.6	1692.72	1636.84	1580.96	1525.08	1469.2	1423.12	1377.04	1330.96	1284.88	1238.8	1200.32
95	1738	1682.6	1627.2	1571.8	1516.4	1461	1415.2	1369.4	1323.6	1277.8	1232	1193.8
94	1728	1673.04	1618.08	1563.12	1508.16	1453.2	1407.72	1362.24	1316.76	1271.28	1225.8	1187.84
93	1718	1663.48	1608.96	1554.44	1499.92	1445.4	1400.24	1355.08	1309.92	1264.76	1219.6	1181.88
92	1708	1653.92	1599.84	1545.76	1491.68	1437.6	1392.76	1347.92	1303.08	1258.24	1213.4	1175.92
91	1698	1644.36	1590.72	1537.08	1483.44	1429.8	1385.28	1340.76	1296.24	1251.72	1207.2	1169.96
90	1688	1634.8	1581.6	1528.4	1475.2	1422	1377.8	1333.6	1289.4	1245.2	1201	1164
89	1677.6	1624.8	1572	1519.2	1466.4	1413.6	1369.76	1325.92	1282.08	1238.24	1194.4	1157.64
88	1667.2	1614.8	1562.4	1510	1457.6	1405.2	1361.72	1318.24	1274.76	1231.28	1187.8	1151.28
87	1656.8	1604.8	1552.8	1500.8	1448.8	1396.8	1353.68	1310.56	1267.44	1224.32	1181.2	1144.92
86	1646.4	1594.8	1543.2	1491.6	1440	1388.4	1345.64	1302.88	1260.12	1217.36	1174.6	1138.56
85	1636	1584.8	1533.6	1482.4	1431.2	1380	1337.6	1295.2	1252.8	1210.4	1168	1132.2
84	1626	1575.28	1524.56	1473.84	1423.12	1372.4	1330.28	1288.16	1246.04	1203.92	1161.8	1126.24
83	1616	1565.76	1515.52	1465.28	1415.04	1364.8	1322.96	1281.12	1239.28	1197.44	1155.6	1120.28
82	1606	1556.24	1506.48	1456.72	1406.96	1357.2	1315.64	1274.08	1232.52	1190.96	1149.4	1114.32
81	1596	1546.72	1497.44	1448.16	1398.88	1349.6	1308.32	1267.04	1225.76	1184.48	1143.2	1108.36
80	1586	1537.2	1488.4	1439.6	1390.8	1342	1301	1260	1219	1178	1137	1102.4

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
79	1575.6	1527.24	1478.88	1430.52	1382.16	1333.8	1293.12	1252.44	1211.76	1171.08	1130.4	1096.08
78	1565.2	1517.28	1469.36	1421.44	1373.52	1325.6	1285.24	1244.88	1204.52	1164.16	1123.8	1089.76
77	1554.8	1507.32	1459.84	1412.36	1364.88	1317.4	1277.36	1237.32	1197.28	1157.24	1117.2	1083.44
76	1544.4	1497.36	1450.32	1403.28	1356.24	1309.2	1269.48	1229.76	1190.04	1150.32	1110.6	1077.12
75	1534	1487.4	1440.8	1394.2	1347.6	1301	1261.6	1222.2	1182.8	1143.4	1104	1070.8
74	1523.6	1477.4	1431.2	1385	1338.8	1292.6	1253.56	1214.52	1175.48	1136.44	1097.4	1064.4
73	1513.2	1467.4	1421.6	1375.8	1330	1284.2	1245.52	1206.84	1168.16	1129.48	1090.8	1058
72	1502.8	1457.4	1412	1366.6	1321.2	1275.8	1237.48	1199.16	1160.84	1122.52	1084.2	1051.6
71	1492.4	1447.4	1402.4	1357.4	1312.4	1267.4	1229.44	1191.48	1153.52	1115.56	1077.6	1045.2
70	1482	1437.4	1392.8	1348.2	1303.6	1259	1221.4	1183.8	1146.2	1108.6	1071	1038.8
69	1472.8	1428.56	1384.32	1340.08	1295.84	1251.6	1214.24	1176.88	1139.52	1102.16	1064.8	1032.84
68	1463.6	1419.72	1375.84	1331.96	1288.08	1244.2	1207.08	1169.96	1132.84	1095.72	1058.6	1026.88
67	1454.4	1410.88	1367.36	1323.84	1280.32	1236.8	1199.92	1163.04	1126.16	1089.28	1052.4	1020.92
66	1445.2	1402.04	1358.88	1315.72	1272.56	1229.4	1192.76	1156.12	1119.48	1082.84	1046.2	1014.96
65	1436	1393.2	1350.4	1307.6	1264.8	1222	1185.6	1149.2	1112.8	1076.4	1040	1009
64	1419.8	1377.76	1335.72	1293.68	1251.64	1209.6	1173.72	1137.84	1101.96	1066.08	1030.2	999.64
63	1403.6	1362.32	1321.04	1279.76	1238.48	1197.2	1161.84	1126.48	1091.12	1055.76	1020.4	990.28
62	1387.4	1346.88	1306.36	1265.84	1225.32	1184.8	1149.96	1115.12	1080.28	1045.44	1010.6	980.92
61	1371.2	1331.44	1291.68	1251.92	1212.16	1172.4	1138.08	1103.76	1069.44	1035.12	1000.8	971.56
60	1355	1316	1277	1238	1199	1160	1126.2	1092.4	1058.6	1024.8	991	962.2

BHP MCr 0.6m by Stern

Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
100	1805	1513	1274	1074	906	763	642	538	448	BHP MCr (kW)
95	1752	1471	1241	1047	884	746	627	526	438	
90	1702	1433	1210	1022	864	729	614	514	429	
85	1653	1393	1178	997	843	712	600	503	419	
80	1600	1351	1144	970	821	694	585	491	409	
75	1547	1310	1111	943	799	676	570	478	399	
70	1485	1262	1073	912	775	656	554	465	388	
65	1470	1246	1057	898	761	644	543	456	380	
60	1434	1217	1033	877	744	630	531	445	371	

BHP MCr 0.6m by Stern Database

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
100	1805	1746.6	1688.2	1629.8	1571.4	1513	1465.2	1417.4	1369.6	1321.8	1274	1234
99	1794.4	1736.44	1678.48	1620.52	1562.56	1504.6	1457.16	1409.72	1362.28	1314.84	1267.4	1227.64
98	1783.8	1726.28	1668.76	1611.24	1553.72	1496.2	1449.12	1402.04	1354.96	1307.88	1260.8	1221.28
97	1773.2	1716.12	1659.04	1601.96	1544.88	1487.8	1441.08	1394.36	1347.64	1300.92	1254.2	1214.92
96	1762.6	1705.96	1649.32	1592.68	1536.04	1479.4	1433.04	1386.68	1340.32	1293.96	1247.6	1208.56
95	1752	1695.8	1639.6	1583.4	1527.2	1471	1425	1379	1333	1287	1241	1202.2
94	1742	1686.28	1630.56	1574.84	1519.12	1463.4	1417.68	1371.96	1326.24	1280.52	1234.8	1196.24
93	1732	1676.76	1621.52	1566.28	1511.04	1455.8	1410.36	1364.92	1319.48	1274.04	1228.6	1190.28
92	1722	1667.24	1612.48	1557.72	1502.96	1448.2	1403.04	1357.88	1312.72	1267.56	1222.4	1184.32
91	1712	1657.72	1603.44	1549.16	1494.88	1440.6	1395.72	1350.84	1305.96	1261.08	1216.2	1178.36
90	1702	1648.2	1594.4	1540.6	1486.8	1433	1388.4	1343.8	1299.2	1254.6	1210	1172.4
89	1692.2	1638.76	1585.32	1531.88	1478.44	1425	1380.72	1336.44	1292.16	1247.88	1203.6	1166.28
88	1682.4	1629.32	1576.24	1523.16	1470.08	1417	1373.04	1329.08	1285.12	1241.16	1197.2	1160.16
87	1672.6	1619.88	1567.16	1514.44	1461.72	1409	1365.36	1321.72	1278.08	1234.44	1190.8	1154.04
86	1662.8	1610.44	1558.08	1505.72	1453.36	1401	1357.68	1314.36	1271.04	1227.72	1184.4	1147.92
85	1653	1601	1549	1497	1445	1393	1350	1307	1264	1221	1178	1141.8
84	1642.4	1590.84	1539.28	1487.72	1436.16	1384.6	1341.92	1299.24	1256.56	1213.88	1171.2	1135.28
83	1631.8	1580.68	1529.56	1478.44	1427.32	1376.2	1333.84	1291.48	1249.12	1206.76	1164.4	1128.76
82	1621.2	1570.52	1519.84	1469.16	1418.48	1367.8	1325.76	1283.72	1241.68	1199.64	1157.6	1122.24
81	1610.6	1560.36	1510.12	1459.88	1409.64	1359.4	1317.68	1275.96	1234.24	1192.52	1150.8	1115.72
80	1600	1550.2	1500.4	1450.6	1400.8	1351	1309.6	1268.2	1226.8	1185.4	1144	1109.2

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
79	1589.4	1540.08	1490.76	1441.44	1392.12	1342.8	1301.72	1260.64	1219.56	1178.48	1137.4	1102.84
78	1578.8	1529.96	1481.12	1432.28	1383.44	1334.6	1293.84	1253.08	1212.32	1171.56	1130.8	1096.48
77	1568.2	1519.84	1471.48	1423.12	1374.76	1326.4	1285.96	1245.52	1205.08	1164.64	1124.2	1090.12
76	1557.6	1509.72	1461.84	1413.96	1366.08	1318.2	1278.08	1237.96	1197.84	1157.72	1117.6	1083.76
75	1547	1499.6	1452.2	1404.8	1357.4	1310	1270.2	1230.4	1190.6	1150.8	1111	1077.4
74	1534.6	1487.76	1440.92	1394.08	1347.24	1300.4	1261	1221.6	1182.2	1142.8	1103.4	1070.08
73	1522.2	1475.92	1429.64	1383.36	1337.08	1290.8	1251.8	1212.8	1173.8	1134.8	1095.8	1062.76
72	1509.8	1464.08	1418.36	1372.64	1326.92	1281.2	1242.6	1204	1165.4	1126.8	1088.2	1055.44
71	1497.4	1452.24	1407.08	1361.92	1316.76	1271.6	1233.4	1195.2	1157	1118.8	1080.6	1048.12
70	1485	1440.4	1395.8	1351.2	1306.6	1262	1224.2	1186.4	1148.6	1110.8	1073	1040.8
69	1482	1437.36	1392.72	1348.08	1303.44	1258.8	1221	1183.2	1145.4	1107.6	1069.8	1037.68
68	1479	1434.32	1389.64	1344.96	1300.28	1255.6	1217.8	1180	1142.2	1104.4	1066.6	1034.56
67	1476	1431.28	1386.56	1341.84	1297.12	1252.4	1214.6	1176.8	1139	1101.2	1063.4	1031.44
66	1473	1428.24	1383.48	1338.72	1293.96	1249.2	1211.4	1173.6	1135.8	1098	1060.2	1028.32
65	1470	1425.2	1380.4	1335.6	1290.8	1246	1208.2	1170.4	1132.6	1094.8	1057	1025.2
64	1462.8	1418.28	1373.76	1329.24	1284.72	1240.2	1202.6	1165	1127.4	1089.8	1052.2	1020.52
63	1455.6	1411.36	1367.12	1322.88	1278.64	1234.4	1197	1159.6	1122.2	1084.8	1047.4	1015.84
62	1448.4	1404.44	1360.48	1316.52	1272.56	1228.6	1191.4	1154.2	1117	1079.8	1042.6	1011.16
61	1441.2	1397.52	1353.84	1310.16	1266.48	1222.8	1185.8	1148.8	1111.8	1074.8	1037.8	1006.48
60	1434	1390.6	1347.2	1303.8	1260.4	1217	1180.2	1143.4	1106.6	1069.8	1033	1001.8

BHP MCr 0.4m by Stern

Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
100	1817	1523	1282	1080	910	766	644	539	449	
95	1766	1483	1250	1054	890	750	630	528	440	
90	1717	1444	1218	1029	869	733	616	517	430	
85	1666	1403	1186	1003	847	715	602	505	420	
80	1614	1362	1153	976	826	697	587	492	410	BHP MCr (kW)
75	1563	1321	1120	949	804	679	573	480	400	
70	1500	1273	1081	918	779	660	556	467	389	
65	1500	1268	1074	910	770	651	548	460	383	
60	1460	1236	1047	888	752	635	535	449	374	

BHP MCr 0.4m by Stern Database

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
100	1817	1758.2	1699.4	1640.6	1581.8	1523	1474.8	1426.6	1378.4	1330.2	1282	1241.6
99	1806.8	1748.44	1690.08	1631.72	1573.36	1515	1467.12	1419.24	1371.36	1323.48	1275.6	1235.44
98	1796.6	1738.68	1680.76	1622.84	1564.92	1507	1459.44	1411.88	1364.32	1316.76	1269.2	1229.28
97	1786.4	1728.92	1671.44	1613.96	1556.48	1499	1451.76	1404.52	1357.28	1310.04	1262.8	1223.12
96	1776.2	1719.16	1662.12	1605.08	1548.04	1491	1444.08	1397.16	1350.24	1303.32	1256.4	1216.96
95	1766	1709.4	1652.8	1596.2	1539.6	1483	1436.4	1389.8	1343.2	1296.6	1250	1210.8
94	1756.2	1700	1643.8	1587.6	1531.4	1475.2	1428.88	1382.56	1336.24	1289.92	1243.6	1204.68
93	1746.4	1690.6	1634.8	1579	1523.2	1467.4	1421.36	1375.32	1329.28	1283.24	1237.2	1198.56
92	1736.6	1681.2	1625.8	1570.4	1515	1459.6	1413.84	1368.08	1322.32	1276.56	1230.8	1192.44
91	1726.8	1671.8	1616.8	1561.8	1506.8	1451.8	1406.32	1360.84	1315.36	1269.88	1224.4	1186.32
90	1717	1662.4	1607.8	1553.2	1498.6	1444	1398.8	1353.6	1308.4	1263.2	1218	1180.2
89	1706.8	1652.6	1598.4	1544.2	1490	1435.8	1390.96	1346.12	1301.28	1256.44	1211.6	1174.04
88	1696.6	1642.8	1589	1535.2	1481.4	1427.6	1383.12	1338.64	1294.16	1249.68	1205.2	1167.88
87	1686.4	1633	1579.6	1526.2	1472.8	1419.4	1375.28	1331.16	1287.04	1242.92	1198.8	1161.72
86	1676.2	1623.2	1570.2	1517.2	1464.2	1411.2	1367.44	1323.68	1279.92	1236.16	1192.4	1155.56
85	1666	1613.4	1560.8	1508.2	1455.6	1403	1359.6	1316.2	1272.8	1229.4	1186	1149.4
84	1655.6	1603.44	1551.28	1499.12	1446.96	1394.8	1351.72	1308.64	1265.56	1222.48	1179.4	1143.04
83	1645.2	1593.48	1541.76	1490.04	1438.32	1386.6	1343.84	1301.08	1258.32	1215.56	1172.8	1136.68
82	1634.8	1583.52	1532.24	1480.96	1429.68	1378.4	1335.96	1293.52	1251.08	1208.64	1166.2	1130.32
81	1624.4	1573.56	1522.72	1471.88	1421.04	1370.2	1328.08	1285.96	1243.84	1201.72	1159.6	1123.96
80	1614	1563.6	1513.2	1462.8	1412.4	1362	1320.2	1278.4	1236.6	1194.8	1153	1117.6

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
79	1603.8	1553.8	1503.8	1453.8	1403.8	1353.8	1312.32	1270.84	1229.36	1187.88	1146.4	1111.24
78	1593.6	1544	1494.4	1444.8	1395.2	1345.6	1304.44	1263.28	1222.12	1180.96	1139.8	1104.88
77	1583.4	1534.2	1485	1435.8	1386.6	1337.4	1296.56	1255.72	1214.88	1174.04	1133.2	1098.52
76	1573.2	1524.4	1475.6	1426.8	1378	1329.2	1288.68	1248.16	1207.64	1167.12	1126.6	1092.16
75	1563	1514.6	1466.2	1417.8	1369.4	1321	1280.8	1240.6	1200.4	1160.2	1120	1085.8
74	1550.4	1502.6	1454.8	1407	1359.2	1311.4	1271.56	1231.72	1191.88	1152.04	1112.2	1078.32
73	1537.8	1490.6	1443.4	1396.2	1349	1301.8	1262.32	1222.84	1183.36	1143.88	1104.4	1070.84
72	1525.2	1478.6	1432	1385.4	1338.8	1292.2	1253.08	1213.96	1174.84	1135.72	1096.6	1063.36
71	1512.6	1466.6	1420.6	1374.6	1328.6	1282.6	1243.84	1205.08	1166.32	1127.56	1088.8	1055.88
70	1500	1454.6	1409.2	1363.8	1318.4	1273	1234.6	1196.2	1157.8	1119.4	1081	1048.4
69	1500	1454.4	1408.8	1363.2	1317.6	1272	1233.52	1195.04	1156.56	1118.08	1079.6	1046.96
68	1500	1454.2	1408.4	1362.6	1316.8	1271	1232.44	1193.88	1155.32	1116.76	1078.2	1045.52
67	1500	1454	1408	1362	1316	1270	1231.36	1192.72	1154.08	1115.44	1076.8	1044.08
66	1500	1453.8	1407.6	1361.4	1315.2	1269	1230.28	1191.56	1152.84	1114.12	1075.4	1042.64
65	1500	1453.6	1407.2	1360.8	1314.4	1268	1229.2	1190.4	1151.6	1112.8	1074	1041.2
64	1492	1445.92	1399.84	1353.76	1307.68	1261.6	1223	1184.4	1145.8	1107.2	1068.6	1036
63	1484	1438.24	1392.48	1346.72	1300.96	1255.2	1216.8	1178.4	1140	1101.6	1063.2	1030.8
62	1476	1430.56	1385.12	1339.68	1294.24	1248.8	1210.6	1172.4	1134.2	1096	1057.8	1025.6
61	1468	1422.88	1377.76	1332.64	1287.52	1242.4	1204.4	1166.4	1128.4	1090.4	1052.4	1020.4
60	1460	1415.2	1370.4	1325.6	1280.8	1236	1198.2	1160.4	1122.6	1084.8	1047	1015.2

BHP MCr 0.2m by Stern

Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
100	1833	1536	1292	1087	915	771	647	542	451	BHP MCr (kW)
95	1777	1491	1256	1059	892	752	632	529	440	
90	1728	1452	1225	1033	872	735	618	518	431	
85	1677	1412	1192	1007	851	718	604	506	421	
80	1628	1372	1160	981	830	700	590	494	412	
75	1574	1329	1125	953	806	681	573	481	400	
70	1561	1315	1112	941	795	671	564	473	394	
65	1522	1284	1086	919	777	656	552	462	385	
60	1483	1252	1059	897	759	640	539	451	376	

BHP MCr 0.2m by Stern Database

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
100	1833	1773.6	1714.2	1654.8	1595.4	1536	1487.2	1438.4	1389.6	1340.8	1292	1251
99	1821.8	1762.84	1703.88	1644.92	1585.96	1527	1478.56	1430.12	1381.68	1333.24	1284.8	1244.12
98	1810.6	1752.08	1693.56	1635.04	1576.52	1518	1469.92	1421.84	1373.76	1325.68	1277.6	1237.24
97	1799.4	1741.32	1683.24	1625.16	1567.08	1509	1461.28	1413.56	1365.84	1318.12	1270.4	1230.36
96	1788.2	1730.56	1672.92	1615.28	1557.64	1500	1452.64	1405.28	1357.92	1310.56	1263.2	1223.48
95	1777	1719.8	1662.6	1605.4	1548.2	1491	1444	1397	1350	1303	1256	1216.6
94	1767.2	1710.4	1653.6	1596.8	1540	1483.2	1436.52	1389.84	1343.16	1296.48	1249.8	1210.6
93	1757.4	1701	1644.6	1588.2	1531.8	1475.4	1429.04	1382.68	1336.32	1289.96	1243.6	1204.6
92	1747.6	1691.6	1635.6	1579.6	1523.6	1467.6	1421.56	1375.52	1329.48	1283.44	1237.4	1198.6
91	1737.8	1682.2	1626.6	1571	1515.4	1459.8	1414.08	1368.36	1322.64	1276.92	1231.2	1192.6
90	1728	1672.8	1617.6	1562.4	1507.2	1452	1406.6	1361.2	1315.8	1270.4	1225	1186.6
89	1717.8	1663.04	1608.28	1553.52	1498.76	1444	1398.88	1353.76	1308.64	1263.52	1218.4	1180.28
88	1707.6	1653.28	1598.96	1544.64	1490.32	1436	1391.16	1346.32	1301.48	1256.64	1211.8	1173.96
87	1697.4	1643.52	1589.64	1535.76	1481.88	1428	1383.44	1338.88	1294.32	1249.76	1205.2	1167.64
86	1687.2	1633.76	1580.32	1526.88	1473.44	1420	1375.72	1331.44	1287.16	1242.88	1198.6	1161.32
85	1677	1624	1571	1518	1465	1412	1368	1324	1280	1236	1192	1155
84	1667.2	1614.56	1561.92	1509.28	1456.64	1404	1360.32	1316.64	1272.96	1229.28	1185.6	1148.84
83	1657.4	1605.12	1552.84	1500.56	1448.28	1396	1352.64	1309.28	1265.92	1222.56	1179.2	1142.68
82	1647.6	1595.68	1543.76	1491.84	1439.92	1388	1344.96	1301.92	1258.88	1215.84	1172.8	1136.52
81	1637.8	1586.24	1534.68	1483.12	1431.56	1380	1337.28	1294.56	1251.84	1209.12	1166.4	1130.36
80	1628	1576.8	1525.6	1474.4	1423.2	1372	1329.6	1287.2	1244.8	1202.4	1160	1124.2

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
79	1617.2	1566.44	1515.68	1464.92	1414.16	1363.4	1321.32	1279.24	1237.16	1195.08	1153	1117.48
78	1606.4	1556.08	1505.76	1455.44	1405.12	1354.8	1313.04	1271.28	1229.52	1187.76	1146	1110.76
77	1595.6	1545.72	1495.84	1445.96	1396.08	1346.2	1304.76	1263.32	1221.88	1180.44	1139	1104.04
76	1584.8	1535.36	1485.92	1436.48	1387.04	1337.6	1296.48	1255.36	1214.24	1173.12	1132	1097.32
75	1574	1525	1476	1427	1378	1329	1288.2	1247.4	1206.6	1165.8	1125	1090.6
74	1571.4	1522.36	1473.32	1424.28	1375.24	1326.2	1285.44	1244.68	1203.92	1163.16	1122.4	1088.04
73	1568.8	1519.72	1470.64	1421.56	1372.48	1323.4	1282.68	1241.96	1201.24	1160.52	1119.8	1085.48
72	1566.2	1517.08	1467.96	1418.84	1369.72	1320.6	1279.92	1239.24	1198.56	1157.88	1117.2	1082.92
71	1563.6	1514.44	1465.28	1416.12	1366.96	1317.8	1277.16	1236.52	1195.88	1155.24	1114.6	1080.36
70	1561	1511.8	1462.6	1413.4	1364.2	1315	1274.4	1233.8	1193.2	1152.6	1112	1077.8
69	1553.2	1504.32	1455.44	1406.56	1357.68	1308.8	1268.4	1228	1187.6	1147.2	1106.8	1072.76
68	1545.4	1496.84	1448.28	1399.72	1351.16	1302.6	1262.4	1222.2	1182	1141.8	1101.6	1067.72
67	1537.6	1489.36	1441.12	1392.88	1344.64	1296.4	1256.4	1216.4	1176.4	1136.4	1096.4	1062.68
66	1529.8	1481.88	1433.96	1386.04	1338.12	1290.2	1250.4	1210.6	1170.8	1131	1091.2	1057.64
65	1522	1474.4	1426.8	1379.2	1331.6	1284	1244.4	1204.8	1165.2	1125.6	1086	1052.6
64	1514.2	1466.88	1419.56	1372.24	1324.92	1277.6	1238.2	1198.8	1159.4	1120	1080.6	1047.4
63	1506.4	1459.36	1412.32	1365.28	1318.24	1271.2	1232	1192.8	1153.6	1114.4	1075.2	1042.2
62	1498.6	1451.84	1405.08	1358.32	1311.56	1264.8	1225.8	1186.8	1147.8	1108.8	1069.8	1037
61	1490.8	1444.32	1397.84	1351.36	1304.88	1258.4	1219.6	1180.8	1142	1103.2	1064.4	1031.8
60	1483	1436.8	1390.6	1344.4	1298.2	1252	1213.4	1174.8	1136.2	1097.6	1059	1026.6

BHP MCr Even Keel Condition

Displacement	12	11.5	11	10.5	10	9.5	9	8.5	8	
100	1839	1538	1291	1085	912	767	644	538	448	BHP MCr (kW)
95	1773	1487	1252	1054	888	748	628	526	438	
90	1724	1448	1220	1029	868	731	615	515	428	
85	1672	1407	1188	1003	846	713	600	503	418	
80	1619	1364	1153	974	823	694	584	490	408	
75	1594	1342	1133	957	808	682	573	480	400	
70	1568	1319	1114	941	794	669	563	471	392	
65	1533	1290	1090	921	777	655	551	461	384	
60	1486	1253	1059	896	757	638	536	449	374	

BHP MCr Even Keel Condition Database

	12	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11	10.9
100	1839	1778.8	1718.6	1658.4	1598.2	1538	1488.6	1439.2	1389.8	1340.4	1291	1249.8
99	1825.8	1766.2	1706.6	1647	1587.4	1527.8	1478.88	1429.96	1381.04	1332.12	1283.2	1242.32
98	1812.6	1753.6	1694.6	1635.6	1576.6	1517.6	1469.16	1420.72	1372.28	1323.84	1275.4	1234.84
97	1799.4	1741	1682.6	1624.2	1565.8	1507.4	1459.44	1411.48	1363.52	1315.56	1267.6	1227.36
96	1786.2	1728.4	1670.6	1612.8	1555	1497.2	1449.72	1402.24	1354.76	1307.28	1259.8	1219.88
95	1773	1715.8	1658.6	1601.4	1544.2	1487	1440	1393	1346	1299	1252	1212.4
94	1763.2	1706.4	1649.6	1592.8	1536	1479.2	1432.48	1385.76	1339.04	1292.32	1245.6	1206.28
93	1753.4	1697	1640.6	1584.2	1527.8	1471.4	1424.96	1378.52	1332.08	1285.64	1239.2	1200.16
92	1743.6	1687.6	1631.6	1575.6	1519.6	1463.6	1417.44	1371.28	1325.12	1278.96	1232.8	1194.04
91	1733.8	1678.2	1622.6	1567	1511.4	1455.8	1409.92	1364.04	1318.16	1272.28	1226.4	1187.92
90	1724	1668.8	1613.6	1558.4	1503.2	1448	1402.4	1356.8	1311.2	1265.6	1220	1181.8
89	1713.6	1658.84	1604.08	1549.32	1494.56	1439.8	1394.56	1349.32	1304.08	1258.84	1213.6	1175.64
88	1703.2	1648.88	1594.56	1540.24	1485.92	1431.6	1386.72	1341.84	1296.96	1252.08	1207.2	1169.48
87	1692.8	1638.92	1585.04	1531.16	1477.28	1423.4	1378.88	1334.36	1289.84	1245.32	1200.8	1163.32
86	1682.4	1628.96	1575.52	1522.08	1468.64	1415.2	1371.04	1326.88	1282.72	1238.56	1194.4	1157.16
85	1672	1619	1566	1513	1460	1407	1363.2	1319.4	1275.6	1231.8	1188	1151
84	1661.4	1608.8	1556.2	1503.6	1451	1398.4	1354.92	1311.44	1267.96	1224.48	1181	1144.24
83	1650.8	1598.6	1546.4	1494.2	1442	1389.8	1346.64	1303.48	1260.32	1217.16	1174	1137.48
82	1640.2	1588.4	1536.6	1484.8	1433	1381.2	1338.36	1295.52	1252.68	1209.84	1167	1130.72
81	1629.6	1578.2	1526.8	1475.4	1424	1372.6	1330.08	1287.56	1245.04	1202.52	1160	1123.96
80	1619	1568	1517	1466	1415	1364	1321.8	1279.6	1237.4	1195.2	1153	1117.2

	12	**11.9**	**11.8**	**11.7**	**11.6**	**11.5**	**11.4**	**11.3**	**11.2**	**11.1**	**11**	**10.9**
79	1614	1563.12	1512.24	1461.36	1410.48	1359.6	1317.48	1275.36	1233.24	1191.12	1149	1113.32
78	1609	1558.24	1507.48	1456.72	1405.96	1355.2	1313.16	1271.12	1229.08	1187.04	1145	1109.44
77	1604	1553.36	1502.72	1452.08	1401.44	1350.8	1308.84	1266.88	1224.92	1182.96	1141	1105.56
76	1599	1548.48	1497.96	1447.44	1396.92	1346.4	1304.52	1262.64	1220.76	1178.88	1137	1101.68
75	1594	1543.6	1493.2	1442.8	1392.4	1342	1300.2	1258.4	1216.6	1174.8	1133	1097.8
74	1588.8	1538.52	1488.24	1437.96	1387.68	1337.4	1295.76	1254.12	1212.48	1170.84	1129.2	1094.12
73	1583.6	1533.44	1483.28	1433.12	1382.96	1332.8	1291.32	1249.84	1208.36	1166.88	1125.4	1090.44
72	1578.4	1528.36	1478.32	1428.28	1378.24	1328.2	1286.88	1245.56	1204.24	1162.92	1121.6	1086.76
71	1573.2	1523.28	1473.36	1423.44	1373.52	1323.6	1282.44	1241.28	1200.12	1158.96	1117.8	1083.08
70	1568	1518.2	1468.4	1418.6	1368.8	1319	1278	1237	1196	1155	1114	1079.4
69	1561	1511.44	1461.88	1412.32	1362.76	1313.2	1272.4	1231.6	1190.8	1150	1109.2	1074.76
68	1554	1504.68	1455.36	1406.04	1356.72	1307.4	1266.8	1226.2	1185.6	1145	1104.4	1070.12
67	1547	1497.92	1448.84	1399.76	1350.68	1301.6	1261.2	1220.8	1180.4	1140	1099.6	1065.48
66	1540	1491.16	1442.32	1393.48	1344.64	1295.8	1255.6	1215.4	1175.2	1135	1094.8	1060.84
65	1533	1484.4	1435.8	1387.2	1338.6	1290	1250	1210	1170	1130	1090	1056.2
64	1523.6	1475.4	1427.2	1379	1330.8	1282.6	1242.84	1203.08	1163.32	1123.56	1083.8	1050.24
63	1514.2	1466.4	1418.6	1370.8	1323	1275.2	1235.68	1196.16	1156.64	1117.12	1077.6	1044.28
62	1504.8	1457.4	1410	1362.6	1315.2	1267.8	1228.52	1189.24	1149.96	1110.68	1071.4	1038.32
61	1495.4	1448.4	1401.4	1354.4	1307.4	1260.4	1221.36	1182.32	1143.28	1104.24	1065.2	1032.36
60	1486	1439.4	1392.8	1346.2	1299.6	1253	1214.2	1175.4	1136.6	1097.8	1059	1026.4

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APPENDIX 4

SFOC Engine

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Performance Data	Cylinder	6		8		9	
Maximum continuous rating acc. ISO 3046/1	kW	1,020	1,140	1,360	1,520	1,530	1,710
Speed	1/min	900	1,000	900	1,000	900	1,000
Minimum speed	1/min	280	300	280	300	280	300
Brake mean effective pressure	bar	24.06	24.2	24.06	24.2	24.06	24.2
Charge air pressure	bar	3.3	3.4	3.3	3.4	3.3	3.4
Firing pressure	bar	185	185	185	185	185	185
Combustion air demand (ta = 20°C)	m³/h	6,135	6,790	9,240	9,485	10,395	10,663
Specific fuel oil consumption							
n = const [1] 100%	g/kWh	189	190	189	190	189	190
85%	g/kWh	188	189	188	189	188	189
75%	g/kWh	190	190	190	190	190	190
50%	g/kWh	203	202	203	202	203	202
Lubricating oil consumption [2]	g/kWh	0.6		0.6		0.6	
NO_x emission [5]	g/kWh	8.5		8.5		8.5	
Turbocharger type		KBB HPR4000		KBB HPR5000		KBB HPR5000	

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APPENDIX 5

Container Arrangement

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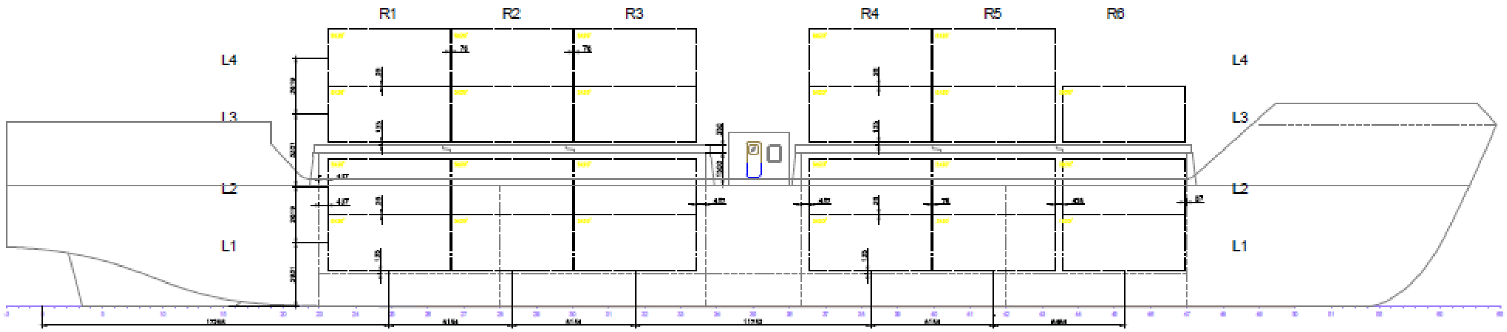
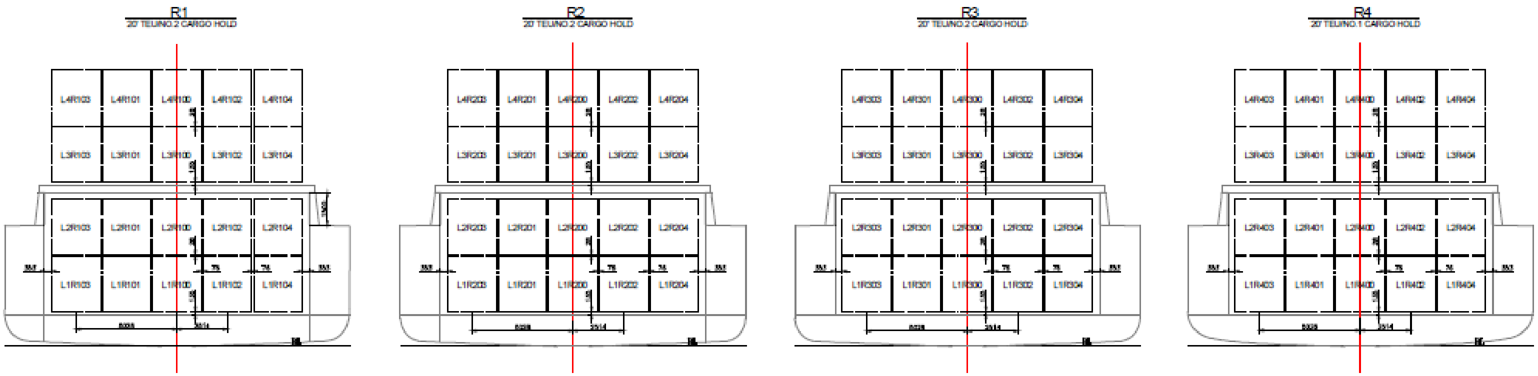
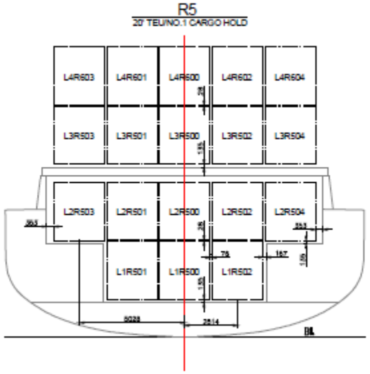
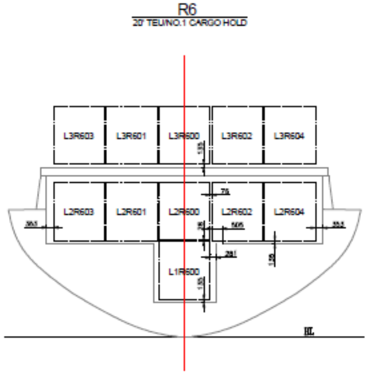
Container arrangement and distribution center of gravity









CONTAINER CENTER OF GRAVITY (in meter)

HOLD	NO.2 CARGO HOLD			NO.1 CARGO HOLD		
BAY NO.	R1	R2	R3	R4	R5	R6
TIER NO.	CONTAINER IN HOLDS					
L1 VCG	2.931	2.931	2.931	2.931	2.931	2.931
L2 VCG	5.550	5.550	5.550	5.550	5.550	5.550
LCG for 20' container From 0	17.226	23.400	29.534	41.266	47.400	53.884
TIER NO.	CONTAINER ON DECK					
L3 VCG	8.881	8.881	8.881	8.881	8.881	8.881
L4 VCG	11.500	11.500	11.500	11.500	11.500	11.500
LCG for 20' container From 0	17.226	23.400	29.534	41.266	47.400	53.884

REMARK: VCG of all containers 50% of container(8'-6") height.

CAPACITY OF CONTAINER

CONTAINER CAPACITY 20'x8'x8.6'							
HOLD	NO.2 CARGO HOLD			NO.1 CARGO HOLD			TOTAL
BAY NO.	R1	R2	R3	R4	R5	R6	
TIER NO.	CONTAINER IN HOLDS						
L1	5	5	5	5	3	1	24
L2	5	5	5	5	5	5	30
TOTAL	10	10	10	10	8	6	54
	CONTAINER ON DECK						
L3	5	5	5	5	5	5	30
L4	5	5	5	5	5	–	25
TOTAL	10	10	10	10	10	5	55
GRAND TOTAL	20	20	20	20	18	11	109

AUTHOR BIOGPRAPHY

Titus Kurniawan is born in Kediri, 30th April 1995. The first son of second sibling from Mr. Didiet Suyatno and Mrs. Pudji Minarni. Author has finished several formal education, from SDK Santa Maria Kediri (2001-2007), SMPK Santa Maria Kediri (2008-2010), SMAN 2 Kediri (2010-2012, 2013-2014) and Sint Jans College, Poperinge (2012-2013). Graduated from senior high school, author continue his education to Double Degree Program of Marine Engineering Department, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember, Surabaya with Hochschule Wismar, Germany. During the study, author active in some organization and activities, such as ITS Expo 2015, XL Future Leaders Batch 4 Surabaya and Bina Antarbudaya Surabaya. Author also had joined exchange program to King Mongkut University of Technology Thonburi, Bangkok for a semester and Global Project Based Learning at Shibaura Institut of Technology, Japan held by ITS International Office.

In Department of Marine Engineering, author takes the research focused of RAMS Laboratory (Reliability, Availability, Management and Safety Laboratory) as the study of interest.

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