Initial Design of a Ship shaped Self-Propelled Drillship

Guner Donmez

Master Thesis

presented in partial fulfillment
of the requirements for the double degree:
“Advanced Master in Naval Architecture” conferred by University of Liege
"Master of Sciences in Applied Mechanics, specialization in Hydrodynamics,
Energetics and Propulsion” conferred by Ecole Centrale de Nantes

developed at "Dunarea de Jos" University of Galati
in the framework of the

“EMSHIP”
Erasmus Mundus Master Course
in “Integrated Advanced Ship Design”

Ref. 159652-1-2009-1-BE-ERA MUNDUS-EMMC

Supervisor: Prof. Mihaela Amoraritei, "Dunarea de Jos" University of Galati

Reviewer: Prof. Dario Boote, Università degli Studi di Genova

Galati, February 2017

Table of Contents

ABSTRACT

Drillships are special purpose vessels, which are equipped with goal-oriented state of the art technology products. The main objective of this drillship design is to focus on functionality while maintaining flexibility in operations. The initial/concept design will be concentrated on two major aspects: general design and hydrodynamic performance investigation. The general design will include ship forms, preliminary freeboard calculation, preliminary general arrangement, tanks and compartmentation, lightship weight (distribution) initial estimation, intact stability calculations, still water shear force and bending moment evaluation. The general design shall not include damage stability calculations, scantling evaluation, and midship section design. The hydrodynamic performance study will include ship speed/power prediction, the study of moonpool effect on resistance and dynamic positioning initial prediction. Hydrodynamic studies shall not include seakeeping calculations.

In addition, the behavior of the flow in open moonpool has been observed by Computational Fluid Dynamic (CFD) software NUMECA/Fine Marine V5.1. Confirmation of the CFD studies was carried out on similar moonpool dimensions as used in a model test constructed by Delft University of Technology, Ship Hydrodynamics Laboratory. The approaches available in this study can be used in the preliminary design phase of a drillship.

Keywords: Drillship, Initial design, Hydrodynamic performance, Moonpool effect on resistance, Dynamic positioning

ACKNOWLEDGEMENTS

Completion of this work was made possible by the support and efforts of many individuals. Firstly, I would like to express my sincere gratitude to my advisor Dragos Totolici for the continuous support of my Master Thesis study and related research, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my Master Thesis.

My sincere thanks also go to Prof. Dr. Philippe Rigo, who provided me an opportunity to join EMship program as a student. I could not have these valuable experiences without this program, which I had difficulty even dreaming of. I would also like to my thanks to Prof. Dr. Serdar Beji for being a reference to me in all milestone of my life.

I would like to thank all ICE Marine Design family for their participation in the survey who supported my work in this way and helped me get results of better quality. I am also grateful to the members of Initial Design department for their friendship and support in overcoming numerous obstacles I have been facing through my research.

I would like to thank all member of the University of Galati; Prof. Dr. Leonard Domnişoru, Prof. Dr. Dan Obreja, Asst. Prof. Mihaela Amorăriţei and Asst. Prof. Florin Păcuraru, who gave access to the laboratory and research facilities. Without they precious support it would not be possible to conduct this research.

Finally, I must express my very profound gratitude to my parents, my sisters, my girlfriend, my niece and to my nephew for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis.

This Master Thesis is dedicated to my family, who have love in their hearts and unconditional support for all that I dare to dream. This accomplishment would not have been possible without them.

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. Ship design considerations in general

A ship is a complex vehicle that holds many engineering disciplines. According to reference [Mollard, 2008], ship design is not always a science, but it is a combination of theoretical analysis and numerical data with an excellent experience. For the naval architects and designers, a really well-understood design in the past can be guided with their data. This information can easily be used during the preliminary design phase to make quick estimates of principal characteristics and costs of alternative concepts for another ship. On the other hand, for the unique design, the naval architect(s) must determine priorities. For example, during the development of a high-speed craft, to estimate the required propulsion power and its cost is the most critical steps during the early design stage. This process has unchangeable essential principles such as, to understand the requirements perfectly, the time and cost constraints, co-operating work between art, science, creativity, and teamwork. [Lamb, 2003]

1.1.1. Preliminary design criteria of service ships and offshore working vessels

Ship design process consists of many interwoven topics, and each type of ship has its own requirements. On the other hand, a ship has to satisfy imposed production objective by owner's requirements. The following are some examples of distinctive requirements for common service ships and offshore working vessels, [Watson, 1988]

- ***Tugs*** – The Pollard pulls skill, fuel capacity, the turning capability, high maneuvering capability particularly harbor tugs.
- ***Dredgers*** – The hopper, the range of the water depth, the type of dredging gear and the quality of the spoil have to verify as far as possible compatible.
- ***Icebreakers*** – The thickness of the ice on the road that ship will clean, the Pollard pull skill during the cleaning period, fuel and stores capacity, high standard accommodation for a large crew.
- ***Research vessels*** – Good seakeeping and reliability for safety case in stormy regions, noise, and vibration for some scientific researches, attainability to scientific equipment.
- ***Fishing vessels*** – Storage ability according to the types of fish caught, the time that has to spend the fishing and distance.

1.1.2. Design spiral

For many years, designers and engineers used the design spiral to make clear and understandable decisions regarding the ship design process. Figure 1.1 illustrates that the ship design process is subdivided into phases based on nature of the work done, the design skills required, the number of contributors, the level of detail of the design and other features. The spiral is repeating the iterative procedure until spiral core that represents detail design for the determination of ship characteristics and other properties. [Lamb, 2003]

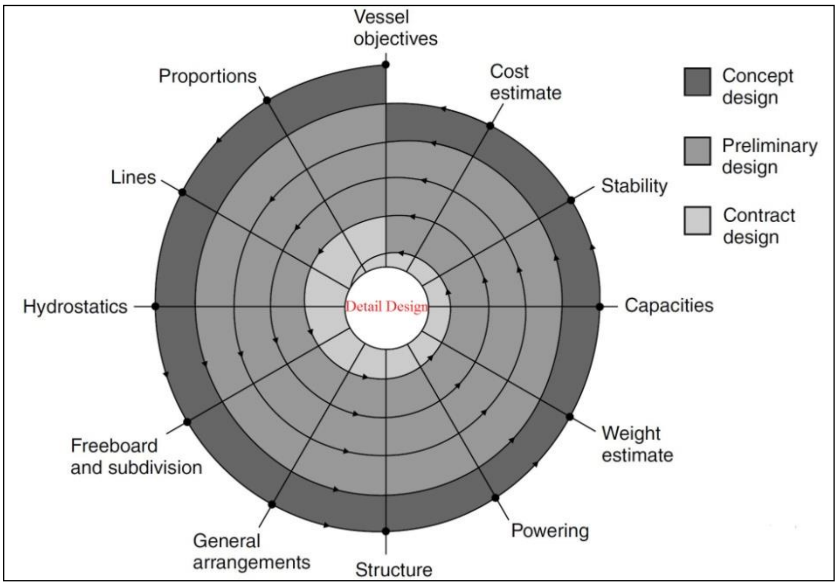


Figure 1.1 Design Spiral [Eyres & Bruce, 2012]

According to design spiral method, all process can be broken down broadly into four stages. The idea is the results are used as feedback in the next steps. Main parameters of those stages are following, [19]

- ***Concept design*** – Indication of the feasibility of the proposed ship as described by design requirements. Preliminary estimation of ship dimensions, layout, major items, powering & propulsion system.
- ***Preliminary design*** – The accurate determination of ship’s main characteristics, progress in the hull form design, calculation of the stability, resistance and strength.
- ***Contract design*** – Technical specification document, GA plan, shaft & engine arrangement, structural plan, Interior plans, electric load analysis, bridge layout.
- ***Detail design*** – Each detail is investigated to initiate construction. Trim & stability calculations as per weight, noise & vibration calculations, structural details.

1.2. Offshore Drilling Vessels

Offshore vessels are the most important structures for the oil industry to explore and uncover resources located below the seabed. The increase in technological developments and the competition between companies were naturally the factors that brought the drilling industry a step further [Lamb, 2003]. These developments have increased day by day, allowing drilling vessels to work on deeper ocean bases, as shown in Figure 1.2. Also, engineers and designers working on the design of such vessels have endeavored to produce innovative solutions to meet the growing requirements. The flowing sections have summarized those most common types of offshore drilling vessels.

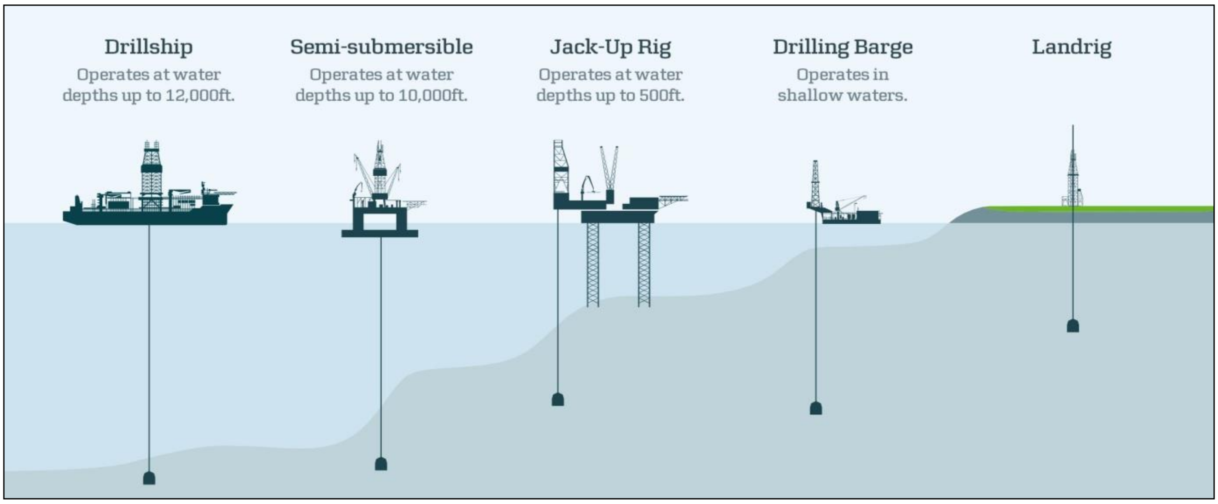


Figure 1.2 Major types of offshore drilling vessels. Available from http://www.maersk.com/en/industries/energy

1.2.1. *Jack-ups*

These mobile offshore drilling units are generally used in water depths up to 400 feet (120 m). Jack-ups are used for development drilling and well servicing operations also, these units are not designed to move from place to place [Lamb, 2003].

1.2.2. *Semi-submersibles*

Semi-submersibles may qualify as the group in which technological developments show the greatest impact. It is possible to encounter five different generations in literature. Especially, fifth semi-submersible generations can be used in water depths up to 10,000 feet (3,000 m) with their own dynamic positioning ability [Lamb, 2003].

1.2.3. Drillships

Drillships are special purpose vessels, which are equipped with goal-oriented state of the art technology products. Essentially, these ships designed for use in the exploratory offshore drilling of new oil and gas wells or scientific drilling purposes on the ocean beds at deep seas. Drillships are completely independent with their mobility characteristic, contrary with deepwater semi-submersibles. New generation ultra-deep-water drillships provide large variable load capacity and internal storage capacity. In addition, another attractive feature of the ships is their advanced positioning control system. Compared with earlier generation design, using their dynamic positioned system (DP), these ultra-deepwater drillships are capable of operating at drilling depths of up to 40,000 feet and at water depths of up to 12,000 feet.

The first drillships were developed by American maritime engineers in the late 1950s [1].At the very beginning, tankers and cargo ships were converted as drillship, having equipment such as drilling derrick, moonpool, and positioning systems. In the upcoming years, the reliability of drillships was revealed by progressively developing technology. Meanwhile, increasing operational and performance needs had played a fundamental role in designing drillships. To take into consideration the ever-increasing needs of the energy sector, drillship technologies have developed rapidly. Especially, developments on the positioning control system have improved operation capability of drillships at any water depth.

As a result of this section, like every design process, the vessels are designed with their design requirements and special considerations. Certainly, drillships are not the only offshore units only capable of drilling in deep waters. Semi-submersibles, platform rigs, and jackups can also perform these operations. However, drillships are more effective for long period operations.

1.2.3.1. Drillship Concept and literature view

As mentioned before, at the end of the 1950s, drillship studies were being started. Though, studies related to full drillship' design exists in special literature; and there are many studies which relate to design purposes that will provide the most important two design criteria, such as dynamic positioning and moonpool effect on the hull resistance. As an opinion, while subjects of dynamic positioning concern about ship stability and speed power prediction. In addition, subjects related to the impact of the moonpool, which is concerning ship hull resistance and stability, can be said have an direct effect on ship design. Particularly, as per the study reference [Hammargren & Tornblom, 2012] concerning the effects of moonpools on ship resistance will be used for comparing results of resistance done in this study. Types of moonpools that are used in the reference [Veer & Tholen, 2008]. of ships are mentioned. Then, the most effective type of the moonpool, which is explained in the part of this study, is used for the designed drillship.

The design criteria differences for drillships compared to other ship and drilling unit designs can be summarized, for preliminary studies, as follows [Lamb, 2003],

- The load carrying capability
- Deck space for drilling equipment
- Propulsion system by retractable thrusters
- Motion characteristics, stability, and seakeeping
- Dynamic positioning system
- Crew carrying capability (Accommodation)

1.2.3.2. Drilling Process Steps

Step 1 – The conductor pipes are installed as the drill pipes are connected the conductor pipe and guide run down to the sea floor after the conductor pipe penetrates the seabed the drill pipe is released and pulled back to the vessel. [15].

Step 2 – To begin an easier drilling, firstly, A large drill bit connected to the bottom of the drill run down to the sea floor, the drill bit is led down to the bottom of the hole through the conductor pipe the drill bit rotates and drills the sediment and rock below the seabed. Meanwhile, seawater is sprayed from nozzles on the drill bit to raise the cuttings to the sea floor. After drilling several hundred meters, the drill bit is pulled back to the vessel. [15].

Step 3 – A casing pipe about 50 centimeters in diameter is set into the drilled hole to keep it from collapsing. The casing pipe is run down through the conductor pipe and is inserted into the hole using the drill pipe. [15].

Step 4 – Cement is pumped into the space between the hole and the casing pipe to fix the pipe in place. The drill pipe is withdrawn to the ship, after cementing operation,. The drillship is equipped with a riser system in order to drill into the earth even deeper. As the riser pipes are added one after the other, the Blow out Preventer (BOP) is run down to the sea floor. The Blow out Preventer is connected to a well head which is located on top of the casing pipe. After this stage, the marine vessel is connected to the seabed with the riser pipe. [15].

Step 5 – A drill bit, smaller than the one first used is run down the through riser pipe and casing pipe. The drilling begins. Once the riser pipe has been connected, drilling mud is used instead of sea water. When the target depth is reached the drill bit is pulled back to the vessel. To drill the hole even deeper, a narrower casing pipe is sent to set in the drilled hole. After the casing pipe has been installed, cement is pumped into the space between the hole and the casing pipe to fix the pipe in place. Again, an even smaller drill bit is run down through the riser pipe and casing pipe and the drilling continues. The drill ship will drill the ocean floor by repeating this operation. [15].

1.3. Aims and Objectives

The academic aims of the study are to contribute to existing initial ship design steps for the drillship that present research with the following objectives,

- To design a modern drillship vessel with some required specifications like marine operations at deep waters all around the world.
- To investigate the existing literature about drillship design considerations through a database search.
- Generation of ship forms and hydrostatic particulars.
- Preliminary Freeboard Calculation.
- Preliminary design of General Arrangement and Tank Plan.
- To clearly define and investigate the importance of dynamic position (DP) that has spotlighted in the offshore drilling industry.
- To reveal the hydrodynamic performance of the drillship hull by using the computational fluid dynamic software and investigate the moonpool effects on resistance.
- To compare the results from the numerical method and computational fluid dynamics software for moonpool effect on the resistance of the ship hull.
- Generate a set of minimal loading conditions as required by chosen Classification Society (ABS).
- To investigate ship Intact Stability compliance (by IS CODE 2008 standards) and Longitudinal Strength.

1.4. Methods

1.4.1. Software

Aveva Marine Initial Design Module was used for all static calculations and check for compliance rules and regulations. For hydrodynamic calculation, NUMECA/Fine Marine and ship flow were used. Where deemed necessary, hand calculations were made to supplement or replace software computations.

1.4.2. Rules and Regulations

The concept design was based on following rules, standarts, and regulations,

- ABS Rules for Building and Classing Mobile Offshore Drilling Units, 2012.
- IMO SOLAS – International Convention for the Safety of Life at Sea
- IMO MARPOL – International Convention for the Prevention of Pollution from Ships
- IMO ICLL – International Convention on Load Lines,
- IMO COLREG – International Convention for the Prevention of Collisions at Sea
- IMO MSC/Circ.645 Guidelines for Vessels with Dynamic Positioning Systems

1.4.3. Calculations summary

At the beginning of the thesis, AVEVA Lines Module is used with the aim of forming hull body plan. By using available ships' main dimensions, a database (available in Appendix 1) is created to perform the regression analysis. Then, AVEVA's modules which are needed to design of drillship are used such as AVEVA Surface and Compartment Module and AVEVA Hydrostatics and Hydrodynamic Module. Also, During the hull design; it is taken advantage of numeric approaches for main dimensions of the drillship. The relationship between main dimensions was checked by the references (Watson, 1988), (K. Von Dokkum, 2003) and (Barras, 2004). Essentially, classification rules and regulations are followed. During the hull resistance estimation and moonpool effect on the resistance of drillship, the computational fluid dynamic software NUMECA/Fine Marine was used. In addition, Holtrop-Mennen method was performed for resistance and powering estimation with Microsoft Excel.

2. LINES PLAN

2.1. Regression analysis

In order to define the dimensions of the ship, a database was generated from existing drillship designs. This method helped to determine principle dimensions and performance characteristics based on statistical data of the drillship database. For this study, the existing ships listed in appendices part will be referred as similar drillships. There are important parameters to choose from the analysis of the similar ships, such as the length overall (LOA), the length of waterline (LWL), Displacement (Δ). In addition, operation parameters were considered in the data analysis, such as drilling depth, water depth, and moonpool dimensions. A statistical measure was needed to filter the information from the database to find the strength between dependent variables and changing variables. The following Figure 2.1 shows that a linear regression was used for principal dimensions. The linear regression results in a line equation, which minimizes the distance between the fitted line and all of the data points using the least squares method. It means that an R^2 coefficient of determination is found that defines the precision of the regression.

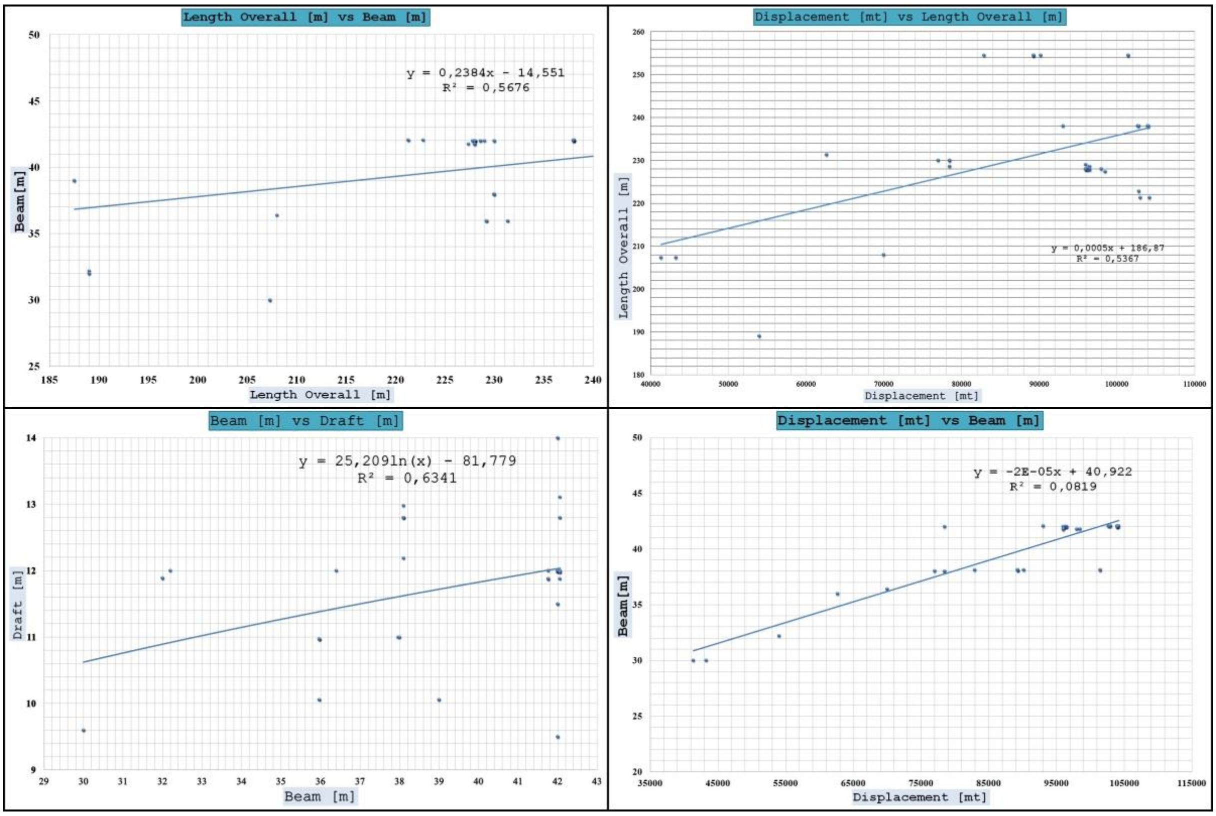


Figure 2.1 Regression Analysis by created database

From the linear regression, the main dimensions were estimated for the initial design of the drillship. Also, dimensional relationships have been used based on the reference (Watson, 1988) which has described six-dimensional relationships linking the four main ship dimensions of Length (L), Beam (B), Depth (D) and Draft (T). According to reference (Watson, 1988), it is possible to solve that the weight or volume equations with these three main dimensions. The reference (Von Dokkum, 2003) defines that B/D ratio effect on stability and the strength. On the other hand, L/D ratio plays a role in the determination of freeboard and longitudinal strength. Also, the relationships are following:

$$B = f(L) \quad , D = f(L) \quad , \quad T = f(L)$$
$$D = f(B) \quad , \quad T = f(D) \quad , T = f(B)$$

After all this, the values obtained in **Table 2.1** were not the final results obtained for the designed ship. They were used just as an initial step to have the main dimensions of the drillship for the subsequent analyses.

Table 2.1 Estimated Main Dimensions of the Drillship

Parameters	Values
Length overall (LOA)	231 m
Beam (B)	36 m
Depth (D)	19 m
Draft (T)	12 m

2.2. Surface Generation

For the design of the hull form, the 3D hull modeling software AVEVA Initial Design Module v.12.1.SP4 was used. Although it was possible to start the design after obtaining the main dimensions of the drillship without an initial hull form, however, first body plan generated in AVEVA LINES Module based on existing drillship lines plan. The main properties of existing drillship are presented in **Table 2.2**.

Table 2.2 Main Properties of the Original Hull Form

Parameters	Values
Length overall (LOA)	210,00 [m]
Length Between Perpendicular (LPP)	198,01 [m]
Length Waterline (LWL)	200,38 [m]
Beam (B)	34,00 [m]
Draft (T), summer	10,81 [m]
Depth (D), at Center Line	17,50 [m]
Depth (D), at Side	17,35 [m]
Displacement , at T=10,81 m	60566,80 [t]
Longitudinal Center of Buoyancy (LCB)	100,65 [m]
Vertical Center of Buoyancy (VCB)	5,64 [m]
Cb	0,8094
Cm	0,6260
Cw	0,8893
Cp	1,2937

Many modifications were made to the initial hull form after hull generation from its lines. Then, existing hull form scaled to match the characteristics determined at regression analysis. Some modifications were induced by design preferences, such as the moonpool dimensions, main deck transition, and dimension of the forecastle. For sure, after every modification, the hull lines had to fair in detail so that the hull would provide smooth sections, waterlines, and buttocks. Respectively, frame and longitudinal spacing defined as 700 mm for both transverse and longitudinal.

Firstly, according to ICLL Regulation 43(1), Regulation 33 and Regulation 3(g), forecastle height (3300 mm) and length (≤ 0,07*L) determined for the drillship. In addition, L is defined in the ICLL Regulation 3(1). Secondly, the gunwale (150 mm) and bulwark height also determined based on ICLL Regulation 43(3). Thirdly, sheer (taken= 0 mm) and camber height (≈ B/50, taken 700 mm) determined based on ICLL Regulation 38. Also, B is defined in ICLL Regulation 3(4). Then, deck at side curve generated based on camber and sheer. Lastly, for obtaining the exact main parameters of the hull, the model was exported to another module of AVEVA, which is Surface and Compartment Module. On this module respectively, the main deck generated including forecastle and transition.

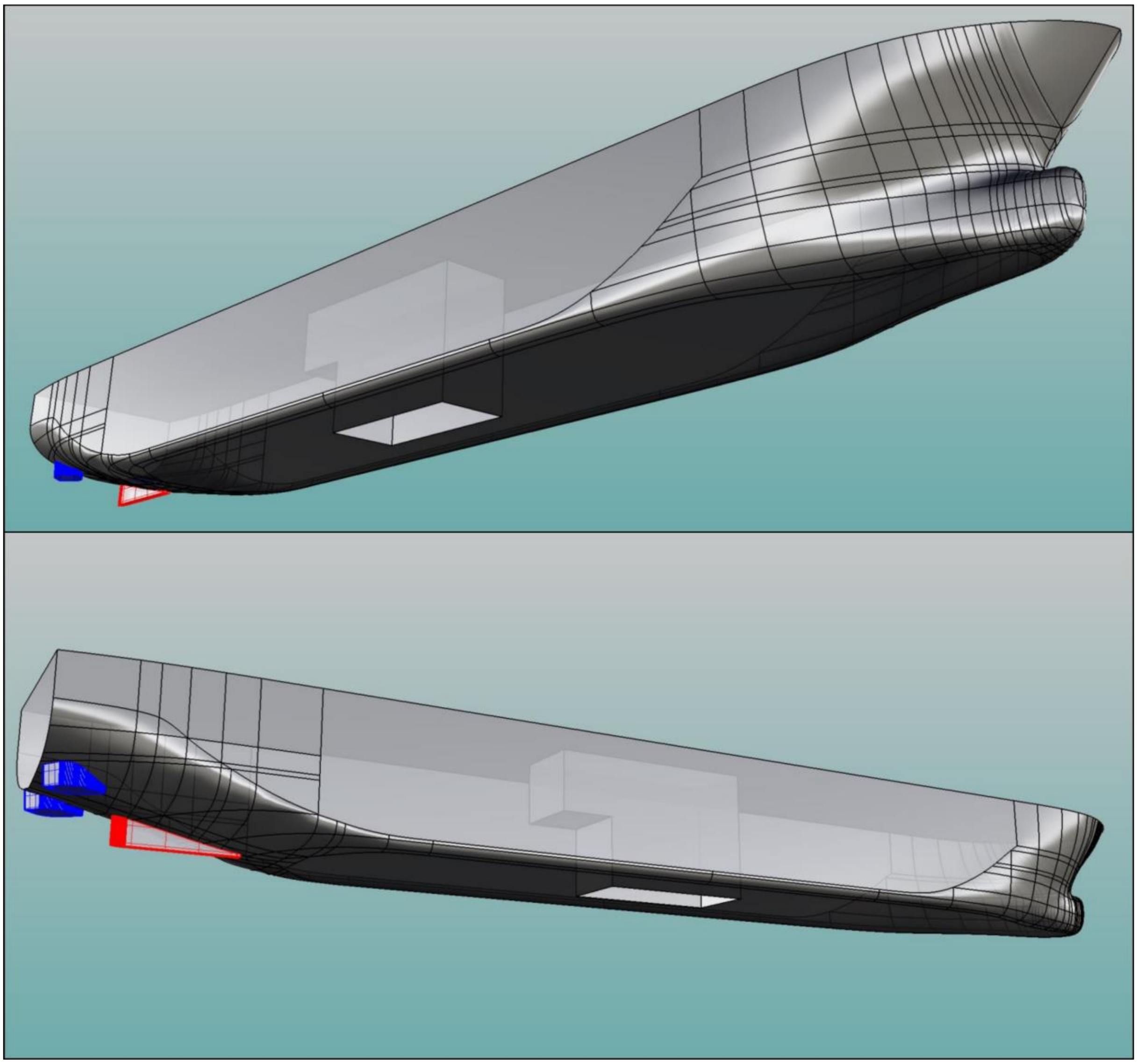


Figure 2.2 Drillship surface with appendices, Skeg,Thruster supports and Moonpool

2.3. Moonpool Definition

In simplest explanation, moonpool is an opening designed to facilitate drilling operations. The moonpool, which is one of the most important "parts" of the drillship, was generated based on drillship database, the resistance of moonpool studies [Veer & Tholen, 2008], [Hammargren & Tornblom, 2012] and frame spacing. To estimate the dimensions and characteristics of the moonpool, methods from reference [Hammargren & Tornblom, 2012] were used. In this reference, the result of the most effective moonpool type are available. For this reason, moonpool with aft recess was used on the designed ship. The dimensions of the moonpool are shown in **Figure 2.3** and its properties are shown in the following **Table 2.3**, respectively.

Table 2.3 Moonpool Dimensions

Parameters	Values	
Length of Moonpool min (Lmin)	28	[m]
Length of Moonpool max (Lmax)	37,8	[m]
Breadth of Moonpool	12,6	[m]
Length of Recess (Lrecess)	9,8	[m]
Height of Recess	12,5	[m]

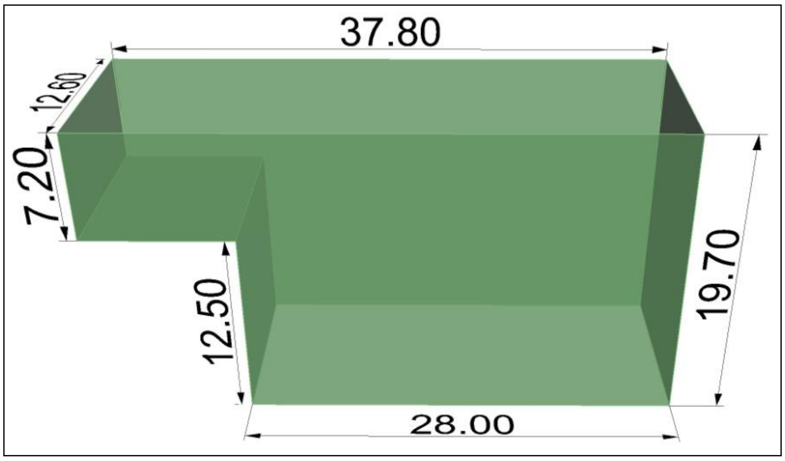


Figure 2.3 Moonpool Dimensions

After moonpool definition, other important appendices are included on the ship hull, such as a preliminary established a center skeg, preliminarily positioned sea chests, preliminarily generated thruster geometry and thruster supports. Finally, preliminary Lines plan was completed after adding to the model all appendices. The final lines plan of designed ship model is shown as Appendix 2 in the study, and its properties are shown in **Table 2.4**.

2.4. Axes Convention

The x-axis is the longitudinal axis directed from aft to fore, and positive y-axis is directed to the port side of the vessel while the positive z-axis is the normal axis to the horizontal plane pointing upwards.

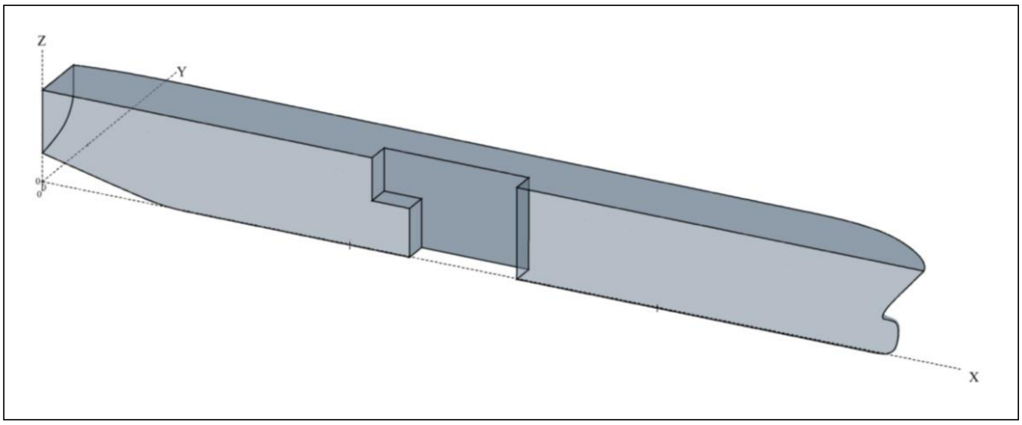


Figure 2.4 Drillship axis convention for all calculation (Half body view)

Table 2.4 Main Properties of the Final Hull Form

Parameters	Values
Length overall (LOA)	230,89 [m]
Length Between Perpendicular (LPP)	220,61 [m]
Length Waterline (LWL)	220,61 [m]
Beam (B)	36,00 [m]
Draft (T), summer	12,89 [m]
Depth (D), at Center Line	19,70 [m]
Depth (D), at Side	19,00 [m]
Displacement , at T=12 m	79990,05 [t]
Longitudinal Center of Buoyancy (LCB)	110,711 [m]
Vertical Center of Buoyancy (VCB)	6,27 [m]
Cb	0,819
Cm	0,996
Cw	0,898
Cp	1,267

The surface of the drillship has exported to another module of AVEVA to continue with hydrostatics and hydrodynamics calculations.

3. HYDROSTATIC PARTICULARS

The scope of this part of the study is to define the hydrostatic particulars of the hull shape of the drillship. AVEVA Hydrostatics and Hydrodynamics module was used to perform the hydrostatic analysis and obtain the hydrostatics curves, which are shown below **Figure 3.1**. Using the generated surface, this module was able to provide all of the hydrostatic quantities such as buoyancy center (LCB & VCB), displacement and sectional areas of the drillship at multiple drafts. Also, the specific gravity used in this part of the report is 1,025 t/m^3.

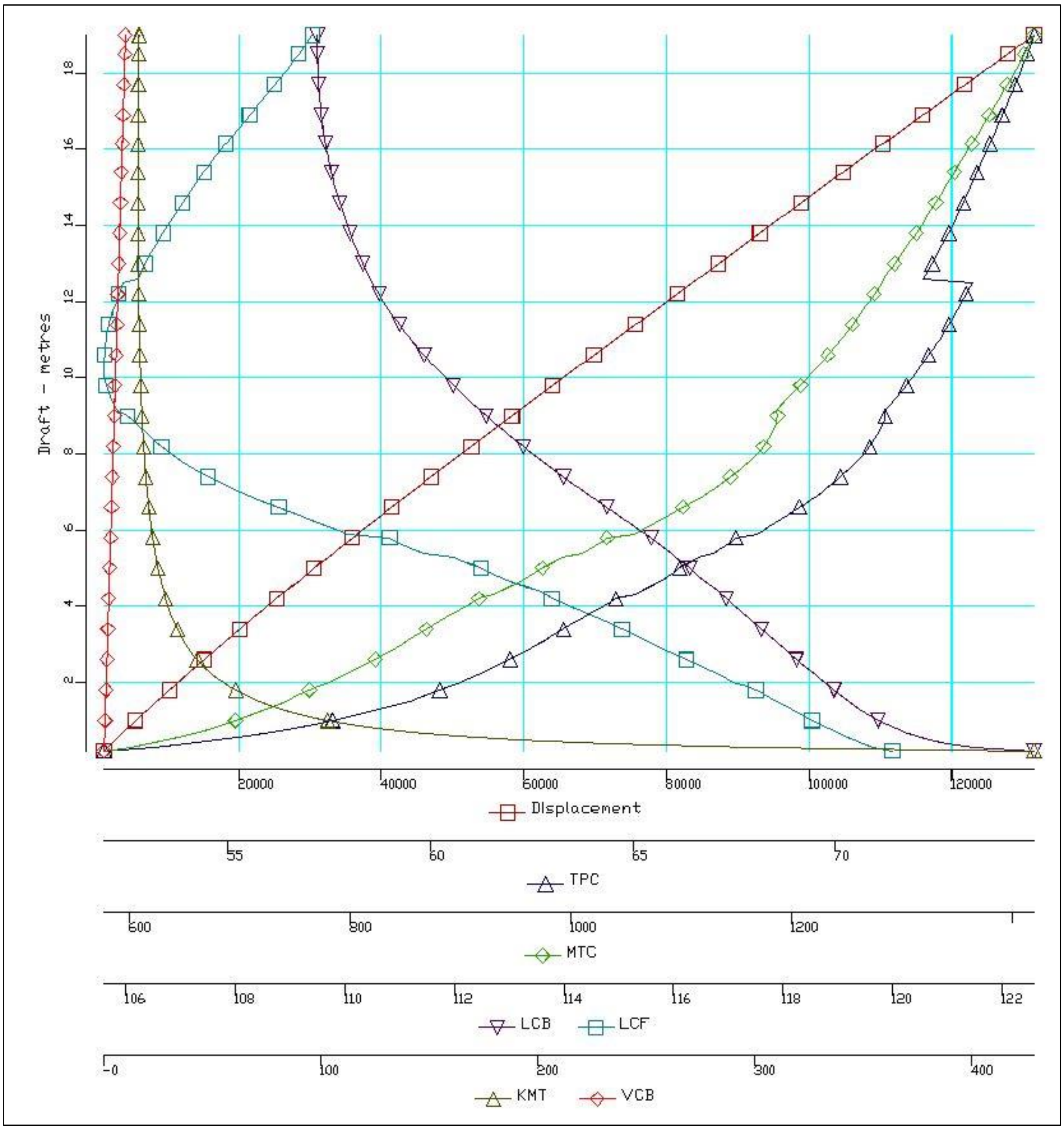


Figure 3.1 Hydrostatic curves of the Drillship

To estimate the hydrostatics and hydrodynamic parameters are almost always most significant step during the early stages of the design. Naval architect must estimate correctly main dimensions of ship and design coefficient such as Cb , Cm, Cp and Cw which are identified on the abbreviation part of the thesis. The erroneous estimations of hydrostatics can cause an unbalance for all design steps. For example; According to reference (Barras,2004) [Barras, 2004], Even to making a little change in the breadth of the ship may solve a problem of instability. The main particulars of the vessel are presented below in **Table 3.1**. In addition, another hydrostatics parameters for other drafts are included as Appendix 3. It's necessary to say that there is concurrence about Cm and Cp values that are rather small and the other is above 1. It is due to the moonpool presence.

Table 3.1 Hydrostatic Particulars of the Drillship

Parameters		Values				
Draft	[m]	8,00	10,00	12,00	14,00	16,15
Displacement	[t]	51410,22	65698,0	80235,04	94810,88	110612
LCB	[m]	113,438	111,833	110,711	110,039	109,645
VCB	[m]	6,89	7,01	7,13	7,11	7,20
WPA	[m^2]	4,167	5,22	6,27	7,305	8,417
LCF	[m]	106,826	105,599	105,821	106,771	107,826
KML	[m]	507,732	414,647	356,563	314,777	280,071
KMT	[m]	18,463	16,802	16,013	15,715	15,737
WSA	[m^2]	11717,7	12907,65	14059,7	15368,95	16662,98
TPC	[t/cm]	70,71	71,91	73,12	72,9	73,82
MTC	[t-m/cm]	1168,84	1215,11	1270,12	1317,69	1363,48
Cb		0,786	0,804	0,819	0,83	0,839
Cm		0,644	0,645	0,646	0,647	0,647
Cp		1,221	1,246	1,267	1,283	1,297
Cw		0,869	0,883	0,898	0,895	0,907

The hydrostatic model of the drillship is shown in the following **Figure 3.2**. Moonpool and sea water inlet chests are excluded from the hull volume. Skeg and the buoyant parts of the thrusters are included on the hull form.

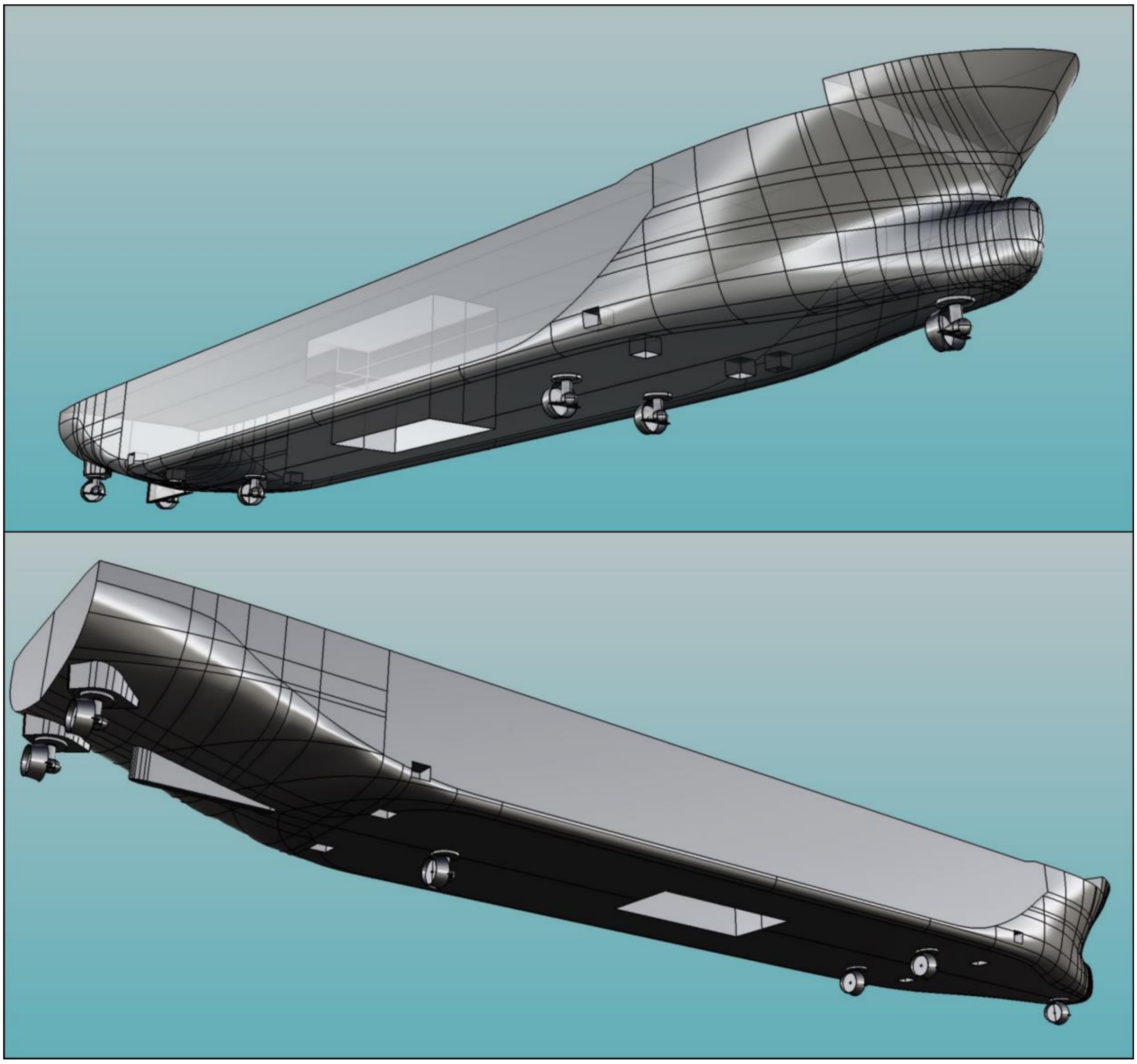


Figure 3.2 Designed Drillship bare Hull for Hydrostatic Calculations

4. FREEBOARD CALCULATIONS

The purpose of this part of the study is to obtain the results of the freeboard calculation. All ships are required to be surveyed and marked with permanent load line markings as per international conventions. By definition, the freeboard assigned to a ship is the distance measured vertically downwards amidships from the upper edge of the deck lineat side to the upper edge of the related load line mark. This freeboard calculation was performed according to the provisions of the "International Convention on Load Lines, 1966 including Protocol of 1988, also Resolution MSC143 (77)". The calculation was performed for Type of ship "B" drillship with following parameters, which are shown, on **Table 4.1**.

Table 4.1 Principal Dimensions for Freeboard Calculation

Parameters	Values	
Length overall (LOA)	230,89	[m]
Length Between Perpendiculars (LBP)	220,61	[m]
Breadth (B)	36,00	[m]
Design Draught (T)	12,00	[m]
Scantling Draught	12,40	[m]
Depth (D), at Center Line	19,00	[m]
Depth (D), at Side	19,70	[m]
Stern Overhang	0	[m]
Stem Overhang	10,28	[m]
Bilge Radius	1,80	[m]
Main Deck Thickness	17,00	[mm]

4.1. Description of Terms

Various regulations have described the terms, which are used for freeboard calculation, respectively.

Length: Regulation 3(1)

$$d_1 = 0{,}85 * D = 0{,}85 * 19{,}0 = 16{,}15\ m$$

$$L_{0{,}85D} = 223,96\ m\ \rightarrow\ 0{,}96 * 223{,}96 = 214{,}999\ m\ \approx 215\ m\ (taken)$$

$$L_{Freeboard} = 215\ m$$

Where;

$L_{Freeboard}$ = Freeboard Length [m]

D = Moulded Depth [m]

d_1 = Draft at 85% of the side depth D [m]

Perpendiculars: Regulation 3(2)

The forward and after perpendiculars shall be taken at the forward and after ends of the length.

Amidships & Breadth : Regulation 3(4)

Amidships is at the middle of the length, L.

$$\frac{L_{Freeboard}}{2} = 107{,}5\ m$$

Moulded Depth: Regulation 3(5)

$$D = 19\ m$$

Depth for Freeboard: Regulation 3(6)(a)

$$D_F = D + t\ \rightarrow\ 19 + 0{,}017 = 19{,}017\ m$$

Where;

t = Thickness of freeboard deck [m]

Block Coefficient: Regulation 3(7)

$$C_B = 0{,}819$$

Freeboard Deck: Regulation 3(9)

The freeboard deck is the main deck.

4.2. Tabular Freeboard & Freeboard Corrections

The tabular freeboard for type ‘B’ ships shall be determined from ‘Table B – Regulation 28(2)’ in International Convention on Load Lines.

$$L_{Freeboard} = 215\, m \ \rightarrow \ F_{BO} = 3505\, mm$$

Where;

F_{BO} = Tabular freeboard from the regulation’s table

- ***Correction for Block Coefficient (Cb)***

It is necessary to correction for block coefficient (C_B > 0,68) so, multiply factor for Cb is determined by following equations that are described in regulation 30;

$$C_B = 0{,}819 \ > 0{,}68$$

$$f_{CB} = \frac{C_B + \ 0{,}68}{1{,}36} = \frac{0{,}819 + \ 0{,}68}{1{,}36} = 1{,}1$$

$$F_{BO} * \ f_{CB} = \ 3505\, mm * 1{,}1 \ \ \rightarrow \ 3863{,}23\, mm$$

$$f_1 \ = 3863.23\, mm - 3505\, mm \ = 358{,}23\, mm$$

Where;

f_{CB} = Multiply factor for C_B

f_1 = First correction value

- ***Correction for depth***

It is necessary correction for depth (D_f > $L_{freeboard}$/15) so, that is determined by following equations which are described in regulation 31;

$$\frac{L_{Freeboard}}{15} = \frac{215\, m}{15} = 14{,}333\, m$$

$$D_F = 19{,}17\, m \ > 14{,}333\, m$$

$$for\ ship\ length\ above\ 120\, m \ \rightarrow \ f_2 = \left(D_F - \ \frac{L_{Freeboard}}{15}\right) * R$$

$$f_2 = \ \left(19{,}17\, m - \ \frac{215\, m}{15}\right) * 250 = 1170{,}917\, mm$$

Where;

f_2 = Second correction value

R = 250 (for length above 120m)

➢ *Superstructure Particulars and Standard height*

According to regulation 33, standard height of superstructure for $L_{Freeboard}$ = 215 mm is 2,30 m. In addition, Table 4.2 describes the length of the superstructure and its particulars based as defined in regulation 34.

Table 4.2 Superstuctures Particulars for freeboard correction

Superstructure	Length [m]	Breadth [m]	Set-in [%]	Height [m]	Standard Height [m]	Effective Length [m]
Forecastle	39,158	24,00	0,00	3,30	2,30	39,158

➢ *Correction for Superstructure*

It is a necessary correction for the superstructure. According to length ratio, the deduction percentage is obtained by linear interpolation as shown in Table 4.3 (See table 37.1 in regulation 37 to determine the percentage of deduction for all types of superstructures). The deduction percentage is determined by following equations that are described in regulation 37;

$$Length\ ratio \rightarrow \frac{L_e}{L_{Freeboard}} = \frac{39{,}158\ m}{215\ m} = 0{,}1821$$

Table 4.3 Interpolation for Effective Lenght

	Deduction Percentage [%]
0,1 L	7,00
0,1821 L	12,749
0,2 L	14,00

The standard deduction is 1070 mm for superstructure correction for ship length above 122 m.

$$f_3 = -1070 * \frac{12{,}749}{100} = -\ 136{,}415\ mm$$

Where;

f_3= Third correction value

L_e= Effective Forecastle Length, (see Table 7)

➢ *Correction for Sheer*

The drillship has no actual sheer. However, it is a necessary correction for sheer that is determined by following equations that are described in regulation 38. Table 4.4 and Table 4.5 illustrate that aft half and forward part of sheer correction for the drillship, respectively. (See Regulation 38(8)).

Table 4.4 Sheer correction for Aft half

		Standard			Actual		
After half	Station	Ordinate [mm]	Factor	Product	Ordinate [mm]	Factor	Product
	AP	2041,67	1	2041,67	0	1	0
	1/6L from AP	906,50	3	2719,50	0	3	0
	1/3L from AP	228,67	3	686,00	0	3	0
	Amidships	0,00	1	0,00	0	1	0
	SUM		AS=	5447,17		AA=	0

$$Deficiency\ of\ aft\ sheer\ \rightarrow \frac{AS-AA}{8}=\frac{5447{,}17\ mm}{8}=680{,}896\ mm$$

Table 4.5 Sheer correction for Forward half

		Standard			Actual		
Forward half	Station	Ordinate [mm]	Factor	Product	Ordinate [mm]	Factor	Product
	AP	0,0	1	0,0	0	1	0
	1/6L from FP	457,3	3	1372,0	0	3	0
	1/3L from FP	1813,0	3	5439,0	0	3	0
	Amidships	4083,3	1	4083,3	0	1	0
	SUM		FS=	10894,3		FA=	0

$$Deficiency\ of\ forward\ sheer\ \rightarrow \frac{FS-FA}{8}=\frac{10894{,}3\ mm}{8}=1361{,}791\ mm$$

$$Total\ Deficiency\ of\ sheer\ \rightarrow \frac{(Aft\ sheer+Forward\ sheer)}{2}$$

$$\rightarrow \frac{680{,}896\ mm+\ 1361{,}791\ mm}{2}=\ 1021{,}35\ mm$$

According to regulation 38(11), sheer credit for forecastle should determine by (FA< 0,5*FS). For this case, no credit shall be given for excess sheer forward. It means that sheer credit is zero.

$$f_4 = (Total\ Deficiency\ of\ sheer + Sheer\ Credit) * (0{,}75 - \left(\frac{S}{2 * L_{Freeboard}}\right))$$

$$f_4 = (1021{,}35\ mm + 0) * (0{,}75 - \left(\frac{39{,}158\ m}{2 * 215\ m}\right))$$

$$f_4 = 672{,}999\ mm$$

Where;

f_4= Forth correction value

S= Forecastle Length, (See **Table 4.2**)

- ***Correction for Recess in freeboard deck***

According to regulation 32(1), the correction applied an addition to the freeboard obtained after all other corrections have been applied. Total freeboard corrections until recess correction is 5617,12 mm. The correction factor is determined by following equations;

$$R_r = \frac{Recess\ Volume}{Water\ plane\ area\ at\ 0{,}85D} = \frac{7839{,}216\ m^3}{7206{,}508\ m^2} = 1{,}0878$$

$$f_5 = (1{,}0878 * 5617{,}12\ mm) - 5617{,}12mm$$

$$f_5 = 493{,}17\ mm$$

Where;

R_r = Recess correction factor

f_5 = Fifth correction value

4.3. Freeboard Calculation

- ***Minimum Summer Freeboard (F)***

$$F = \ F_{BO} + f_1 + f_2 + f_3 + f_4 + f_5$$
$$F = \ 3505 + 358.23 + 1170{,}917 + (-136{,}415) + 672{,}999 + 493{,}17$$
$$F = 6063{,}9\ mm$$

For the proposed draught d=12.40m (scantling draught), the summer freeboard adopted is determined.

$$F = D_f - d = 19{,}017\ m - 12{,}40\ m = \ 6617{,}0\ mm$$

Determined F, is greater than calculated minimum F value. According to regulation 40 for this summer draught the fallowing freeboards calculated;

- ***Tropical Freeboard (F_T)***

$$F_T = F - \frac{d}{48} = 6617\ mm - \left(\frac{12{,}4\ m}{48}\right)$$
$$F_T = 6{,}359\ m$$

- ***Winter Freeboard (F_W)***

$$F_W = F + \frac{d}{48} = 6617\ mm + \left(\frac{12{,}4\ m}{48}\right)$$
$$F_W = 6{,}875\ m$$

- ***Winter North Atlantic Freeboard (F_{WNA})***

According to regulation 40(6), for the drillship, Winter North Atlantic Freeboard shall be Winter Freeboard.

$$F_{WNA} = F + \frac{d}{48} = 6617\ mm + \left(\frac{12{,}4\ m}{48}\right)$$
$$F_{WNA} = 6{,}875\ m$$

- ***Fresh Water Freeboard (F_{FW})***

$$f_{FW} = \frac{\Delta}{40 * T} = \frac{80235{,}04\, t}{40 * 72{,}38\, t/cm}$$

$$f_{FW} = 0{,}277\, m$$

$$F_{FW} = F - f_{FW} = 6{,}617\, m - 0{,}277\, m$$

$$F_{FW} = 6{,}34\, m$$

Where;

T = tonnes per centimeter immersion in salt water at summer load waterline, T= 72,38 t/cm.

Δ = Displacement in salt water in tons at the summer load waterline, Δ = 80235,04 t

- ***Tropical Fresh Water Freeboard (F_{TFW})***

$$F_{TFW} = F_{FW} - \frac{d}{48} = 6{,}34\, m - \left(\frac{12{,}4\, m}{48}\right)$$

$$F_{TFW} = 6{,}088\, m$$

The tropical, winter, Winter North Atlantic and Freshwater freeboards are then calculated as illustrated in Table 4.6.

Table 4.6 Freeboard Values with applied all Corrections

Parameters	Values
Tabular Freeboard Fbo	3,505 [m]
Block Coefficient Correction (f1)	0,3582 [m]
Depth Correction (f2)	1,1709 [m]
Superstructure Correction (f3)	-0,1364 [m]
Sheer Correction (f4)	0,6730 [m]
Recess Correction (f5)	0,4932 [m]
Summer Freeboard	6,617 [m]
Maximum Draught at Summer Draught	12.40 [m]
Proposed Summer Draught	12,40 [m]
Assigned Summer Freeboard	6,617 [m]
Tropical Freeboard	6,359 [m]
Winter Freeboard	6,875 [m]
Winter Nirth Atlantic Freeboard	6,875 [m]
Fresh Water Freeboard	6,34 [m]
Tropical Fresh Water Freeboard	6,088 [m]

- ***Minimum bow height***

According to Regulation 39(1) required bow height calculated by the following equation,

$$F_b = \left(6075 * \left(\frac{L}{100}\right) - 1875 * \left(\frac{L}{100}\right)^2 + 200 * \left(\frac{L}{100}\right)^3\right) * (2{,}08 + 0{,}609 * C_B - 1{,}603 * C_{wf} - 0{,}0129 * \left(\frac{L}{d_1}\right))$$

$$C_{wf} = \frac{A_{Wf}}{\left({}^{L}/{}_{2}\right) * B} = \frac{3530{,}86\, m^2}{\left(215\, {}^{m}/{}_{2}\right) * 36\, m} = 0{,}912$$

$$F_b = \left(6075 * \left(\frac{215}{100}\right) - 1875 * \left(\frac{215}{100}\right)^2 + 200 * \left(\frac{215}{100}\right)^3\right) * (2{,}08 + 0{,}609 * 0{,}837 - 1{,}603 * 0{,}912 - 0{,}0129 * \left(\frac{215}{16{,}15}\right))$$

$$F_b = 6293{,}236\, mm$$

Where,

F_B = Calculated minimum bow height [mm]

L = Freeboard Length

B = Moulded Breadth

d_1 = Draught at 85%D, d_1= 0,85*19 =16,15 m

C_B = Block Coefficient

C_{wf} = Water plane Coefficient forward of L/2

A_{wf} = Water plane area forward of L/2, 3530,86 m^2

- ***Actual bow height***

The actual boy height as defined by the rule, regulation 39(2).

$$H_a = D + Sheer\ at\ FP + Height\ of\ Forecastle\ at\ FP - Proposed\ Summer\ Draught$$

$$H_a = 19000\, mm + 0 + 3300\, mm - 12400\, mm$$

$$H_a = 9900\, mm$$

$$H_a > F_b = 6293{,}236\, mm\ (Rule\ compliance\ satisfied)$$

4.4. Freeboard Mark

The summation of the freeboard is shown following Table 4.7. Also, below Figure 4.1 represented final freeboard mark, which located on the starboard side of the drillship as an illustration.

Table 4.7 Load line Mark Values

Parameters	Freeboard [m]	Corresp. Draught [m]
Assigned Summer Freeboard	6,6170	12,400
Tropical Freeboard	6,3590	12,658
Winter Freeboard	6,8750	12,142
Winter Nirth Atlantic Freeboard	6,8750	12,142
Fresh Water Freeboard	6,3245	12,693
Tropical Fresh Water Freeboard	6,088	12,951

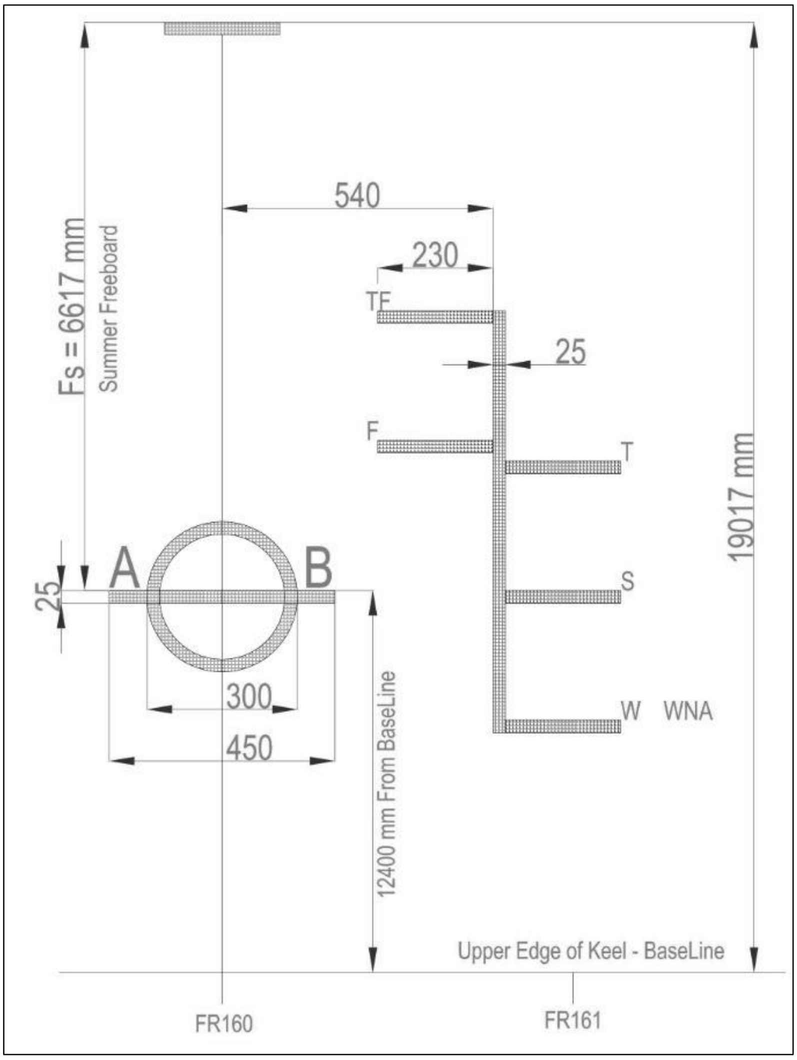


Figure 4.1 Freeboard Mark

5. SPEED AND POWER PREDICTION

In order to calculate the resistance of the drillship, two different approaches were used. Firstly, Holtrop-Mennen method [Holtrop & Mennen, 1982] was performed as a statistical regression method at the initial design of the ship, which focused on improving the power prediction of the high block, ships with low L/B ratios with main appendages and immersed transom sterns. Thus, the moonpool resistance of the vessel was also taken into account as an extra component of the total resistance based on the reference [Veer & Tholen, 2008]. Total ship resistance was estimated for design speed, which is 12 knots in following section 5.1.

Secondly, computational fluid dynamics (CFD) method was performed for both, drillship bare hull with moonpool and bare hull without moonpool. End of this part of the study, to have resistance comparison between bare hull with moonpool and without moonpool will be possible. It should be noted that, this is the same as the displacement CFD study used in the Holtrop-Mennen method to make this comparison more realistic.

5.1. Power prediction by Holtrop-Mennen Method 1982

In publication [Holtrop & Mennen, 1982], the total resistance of a ship has been subdivided as an equation is following.

$$R_{Total} = R_F * (1 + k_1) + R_{APP} + R_W + R_B + R_{TR} + R_A$$

Where:

R_F = Frictional Resistance according to ITTC 1957.

$(1+k_1)$ = Form factor describing the viscous resistance of the hull form about R_F.

R_{APP} = Resistance of appendages.

R_W = Wave-making and wave-breaking resistance.

R_B = Additional pressure resistance of bulbous bow near the water surface.

R_{TR} = Additional pressure resistance of immersed transom stern.

R_A = Allowance resistance.

- ***Step 1 – Determination of R_F***

$$R_e = \frac{V * L_{WL}}{\nu} \rightarrow \frac{(12 * 0{,}51444) * 220{,}61}{1{,}19 * 10^{-6}} = 1144452008$$

$$C_f = \frac{0{,}075}{(\log_{10}(R_e - 2))^2} = 0{,}001505$$

$$S_{Hull} = 11982{,}12\, m^2 \qquad Determined\ by\ Aveva$$

$$R_F = C_f * \ 0{,}5 * \rho_w * V^2 * S_{Hull}$$
$$R_F = 0{,}001505 * 0{,}5 * 1{,}025 * (12 * 0{,}51444)^2 * 11982{,}12 = 352{,}22\ [kN]$$

Where,

R_e = Reynold Number

C_f = The coefficient of frictional resistance, ITTC-1957

S_{Hull} = The wetted area of the bare hull [m^2]

ν = Kinematic viscosity of water [m^2/s]

V = Ship velocity [knots]

L_{WL} = Waterline lenght [m]

ρ_w = the water density [t/m^3]

- ***Step 2 – Determination of $(1+k_1)$***

This step calculated by Holtrop 1984 method [Holtrop,1984] to have more accuracy for form factor, $(1+k_1)$.

$$c_{12} = \left(\frac{T}{L_{WL}}\right)^{0{,}2228446} \quad , for \quad {}^{T}/_{L_{WL}} > 0{,}05$$

$$c_{12} = \left(\frac{12\, m}{220{,}61\, m}\right)^{0{,}2228446} = 0{,}5227$$

$$c_{14} = 1 + 0{,}011 * c_{stern} \qquad when, aft\ part\ U\ shape\ section\ \ c_{stern} = 7$$

$$c_{14} = 1 + (0{,}011 * 7) = 1{,}077$$

$$L_{CB} = \ -0{,}42\ \%\ L\ from\ 1/2\ L$$

$$C_P = 0{,}844$$

$$\frac{L_R}{L_{WL}} = 1 - C_P + (0{,}06 * C_P * L_{CB})/(4 * C_P - 1)$$

$$L_R = 37{,}75\, m$$

$$(1+k_1) = 0{,}93 + c_{14} * 0{,}487118 * \left(\frac{B}{L_{WL}}\right)^{1{,}06806} * \left(\frac{T}{L_{WL}}\right)^{0{,}46106} * \left(\frac{L_{WL}}{L_R}\right)^{0{,}121563} * \left(\frac{L_{WL}^3}{\nabla}\right)^{0{,}121563} * \left(1-C_p\right)^{-0{,}604247}$$

$$(1+k_1) = 1{,}3796$$

Where,

T = Moulded draught [m]

L_R = Reflecting the length of the run

B = Breath of the ship [m]

C_p = Prismatic coefficient

As mentioned before in Hydrostatic calculations, C_P of the drillship is more than one, because of moonpool on the middle of the ship. However, the Holtrop-Mennen 1982 [Holtrop & Mennen, 1982] method is not able to calculate ship resistance with condition ($1 \leq C_P$). That's why, during the resistance calculations, the prismatic coefficient is found based on the numerical approximation. This approximation is shown as following,

$$C_P = \frac{\Delta}{(A_M * L_{WL})} = \frac{80136{,}2927\, m^3}{(430{,}364\, m^2 * 220{,}61\, m)} = 0{,}844$$

Where,

A_M = Midship section area

Δ = Displacement Volume Moulded [m^3] (was taken same as CFD value)

- ***Step 3 – Determination of R_{APP}***

$$S_{APP} = 272{,}533\, m^2 \qquad \mathit{Calculated\ by\ Aveva}$$

$$(1+k_2)_{eq} = \frac{\Sigma(1+k_2) * S_{APP}}{\Sigma S_{APP}}$$

$$(1+k_2) = 2, \qquad \mathit{Approximation\ with\ skeg}$$

$$R_{APP} = 0{,}5 * \rho_w * V^2 * S_{APP} * (1+k_2)_{eq} * C_f$$

$$R_{APP} = 0{,}5 * 1{,}025 * (12 * 0{,}51444)^2 * 272{,}533 * 2 * 0{,}001505$$

$$R_{APP} = 16{,}025\ [kN]$$

Where,

$(1+k_2)$ = Appendages Resistance factor

S_{APP} = Total wetted area of the appendages [m^2]

- ***Step 4 – Determination of R_W***

$$c_7 = \frac{B}{L_{WL}} = 0{,}1632 \ , \quad for \ 0{,}11 < \frac{B}{L_{WL}} < 0{,}25$$

$$i_E = 24{,}80^o$$

$$c_1 = 2223105 * c_7^{3{,}78613} * \left(\frac{T}{B}\right)^{1{,}07961} * (90 - i_E)^{-1{,}37565} = 2{,}266$$

$$A_{BT} = 57{,}092 \, m^2, \ \ T_F = 12 \, m, \ \ h_B = 4{,}832 \, m$$

$$c_3 = 0{,}56 * A_{BT}^{1{,}5}/(\left(B * T * \left(0{,}31 * \sqrt{A_{BT}} + T_F - h_B\right)\right) = 0{,}05880$$

$$c_2 = \exp\left(-1{,}89\sqrt{c_3}\right) = 0{,}6324$$

$$C_M = 0{,}9961$$

$$c_5 = 1 - 0{,}8 * \frac{A_T}{B * T * C_M} = 0{,}8406$$

$$c_{16} = 1{,}73014 - 0{,}7067 * C_P = 1{,}1336 \, , \quad for \, C_P > 0{,}80$$

$$\nabla^{\frac{1}{3}} = \frac{L_{WL}^3}{\Delta} = 133{,}982$$

$$m_1 = \left(0{,}0140407 * \frac{L_{WL}}{T}\right) - \left(1{,}75254 * \frac{\nabla^{\frac{1}{3}}}{L_{WL}}\right) - (4{,}79323 * B * L_{WL}) - c_{16} = -2{,}0002$$

$$F_n = \frac{12 * 0{,}51444}{\sqrt{g * L_{WL}}} = 0{,}1327$$

$$\lambda = 1{,}446 * C_p - 0{,}03 * \frac{L_{WL}}{B} = 1{,}0367 \, , \quad for \ \ L_{WL}/B < 12$$

$$c_{15} = -1{,}6939, \quad for \ \frac{L_{WL}^3}{\Delta} < 512$$

$$m_2 = c_{15} * C_p^2 \exp(-0{,}1 * F_n^{-2}) = \ -0{,}0041$$

$$R_W = c_1 * c_2 * c_5 * \nabla * \rho_w * g * \exp(m_1 * F_n^d + m_2 * \cos(\lambda * F_n^{-2}))$$

$$R_W = 4{,}345\ [kN]$$

Where,

A_T = Immersed part of the transverse area of Transom [m^2], at zero velocity

C_M = Midship section coefficient

F_n = Froude number based on the L_{WL}

A_{BT} = Transverse bulbous area at the position where the still water surface intersects the stern [m^2]

T_F = Forward draught of the ship [m]

h_B = Position of the centre of the transverse area [m]

i_E = Angle of the waterline at bow [degrees]

g = Gravitational acceleration [m/s^2]

- ***Step 5 – Determination of R_B***

$$P_B = 0{,}56 * \frac{\sqrt{A_{BT}}}{T_F - 1{,}5 * h_B} = 0{,}8904$$

$$F_{ni} = \frac{V}{\sqrt{(g * \left(T_F - h_B - 0{,}25 * \sqrt{A_{BT}}\right) + 0{,}15 * V^2}} = 0{,}8141$$

$$R_B = 0{,}11 \exp(-3 * P_B^{-2}) * F_{ni}^3 * A_{BT}^{1{,}5} * \rho_w * \frac{g}{1 + F_{ni}^2}$$

$$R_B = 3{,}520\ [kN]$$

Where,

P_B = A measure for the emergence of the bow

F_{ni} = Froude number based on the immersion

- ***Step 6 – Determination of R_{TR}***

$$F_{nT} = \frac{V}{\sqrt{2 * g * \left(\frac{A_T}{(B + (B * C_{WP}))}\right)}} = 1{,}244$$

$$c_6 = 0{,}2 * (1 - 0{,}2 * F_{nT}) = 0{,}150232\,, \qquad for\ F_{nT} < 5$$

$$R_{TR} = 0{,}5 * \rho_w * V^2 * A_T * c_6 = 0{,}5 * 1{,}025 * (12 * 0{,}51444)^2 * 85{,}736 * 0{,}149641$$

$$R_{TR} = 251{,}57\ [kN]$$

Where,

F_{nT} = Froude number based on Transom immersion

A_T = Immersed Transom area [m^2]

C_{WP} = Waterplane area coefficient

- ***Step 7 – Determination of R_A***

The allowance resistance, R_A calculated by Holtrop method 1988 [Holtrop,1988]. In this method, the resistance separated two components, which are hull roughness and air resistance. The Hull roughness resistance calculated with following equations,

$$c_4 = 0{,}04\,, \qquad for\ \ \frac{T_F}{L_{WL}} = 0{,}054395 > 0{,}04$$

$$C_A = 0{,}006 * (L_{WL} + 100)^{-0{,}16} - 0{,}00205 + 0{,}003 * \sqrt{\frac{L_{WL}}{7{,}5}} * C_B^4 * c_2 * (0{,}04 - c_4)$$

$$C_A = 0{,}000267$$

$$R_A = 0{,}5 * \rho_w * {V_{Ship}}^2 * (S_{Hull} + S_{App}) * C_A$$

$$R_A = 63{,}953\ [kN]$$

As mentioned the beginning of section 5.1, the total bare hull resistance of the ship is composed of components such as; R_F, $(1+k_1)$, R_{APP}, R_W, R_B, R_{TR} and R_A.

$$R_{Total} = R_F * (1 + k_1) + R_{APP} + R_W + R_B + R_{TR} + R_A$$

$$R_{Total} = 352{,}222 * 1{,}3796 + 16{,}025 + 4{,}345 + 3{,}52 + 251{,}57 + 63{,}953$$

$$R_{Total} = 825{,}355\ [kN]$$

Table 5.1 Resistance results for each speed by using Holtrop-Mennen method

Holtrop-Mennen Resistance Components							
V [knots]	Rf*(1+k1) [kN]	Rapp [kN]	Rw [kN]	Rb [kN]	Rtr [kN]	Ra[kN]	Tot.Res. [kN]
6	132,55	4,37	0,00	0,70	73,31	15,99	226,91
7	176,89	5,83	0,00	1,04	97,42	21,76	302,94
8	227,16	7,49	0,02	1,44	124,16	28,42	388,69
9	283,27	9,34	0,11	1,90	153,23	35,97	483,83
10	345,15	11,38	0,48	2,41	184,35	44,41	588,18
11	412,72	13,61	1,59	2,95	217,22	53,74	701,84
12	485,94	16,03	4,35	3,52	251,57	63,95	825,35
13	564,71	18,62	10,23	4,11	287,10	75,06	959,82
14	649,03	21,40	21,13	4,71	323,51	87,05	1106,83

The resistance due to the moonpool and air were also taken into account. The contribution of the moonpool to the total drillship resistance is derived from the results presented in the reference [Veer & Tholen, 2008]. According to the reference, (R. Van’t Veer and H.-J. Tholen, 2008) the resistance increase due to the moonpool is expressed as a percentage of the bare hull resistance. The L/B ratio of the moonpool is 2,22 (see section 2.3). For the initial design of the drillship, the added resistance because of moonpool had taken 20% of the bare hull resistance based on the reference (R. Van’t Veer and H.-J. Tholen, 2008). In addition, in the CFD tests, the resistance caused by moonpool was calculated as an average of twenty-one percent. This value is very close to the recommended percentage of the reference [Veer & Tholen, 2008] based on moonpool length and beam ratio.

The contribution of the air resistance, Holtrop 1988 method had suggested a simple rule incorporated in the ITTC-1978 method it is suggested to determine the air drag. However, this approach is for normal ships and superstructures. On the other hand, the drillships have special structures above the ship hull. To being more accuracy, another approach proposed by [Fujiwara et al. 2006] was used. The method describes the calculations for wind force parameters such as lateral force coefficient, yaw moment coefficient and roll moment coefficient in following section 5.2. For the resistance point of view, the only lateral force was calculated. In the end, the air resistance also was added to the total resistance.

5.2. Wind Resistance Prediction by Fujiwara et al. 2006

Fujiwara et al. [2006] calculate the wind-induced loads. Fujiwara identifies the components of the external forces and moments acting on the ship. He used subscripts as being the wind, A. The results for the wind resistance in the following equations;

$$F_{XA} = C_{AX}(\Psi_A) * q_A * A_F$$

Where,

F_{XA} = External force for wind

C_{AX} = Longitudinal-force coefficient

Ψ_A = Apparent wind angle

q_A = Aerodynamic pressure

A_F = Frontal projected area

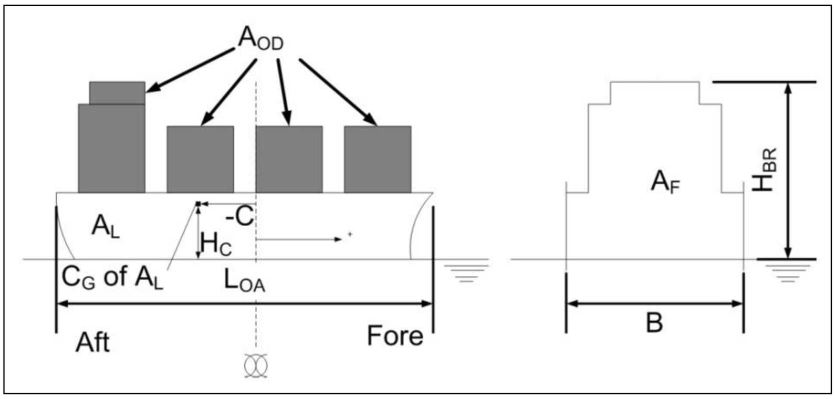


Figure 5.1 Parameters used by Fujiwara et al.[2006]

Table 5.2 Non-dimensional parameters for wind load estimation equations [Fujiwara,2006]

		j→	0	1	2	3	4
	i↓						
α j			0,404	0,368	0,902		
β ij	1		-0,922	0,507	1,162		
	2		0,018	-5,091	10,367	-3,011	-0,341
γ ij	1		0,116	3,345			
	2		0,446	2,192			
δ ij	1		0,458	3,245	-2,313		
	2		-1,901	12,727	24,407	-40,31	-5,481
ε ij	1		-0,585	-0,906	3,239		
	2		-0,314	-1,117			

The longitudinal force coefficient is defined and solved for 12 knots with average wind speed, 20 knots at 180^{o} head angle as in follows;

$$C_{AX}(\Psi_A) = F_{LF}^{'} + F_{XLI}^{'} + F_{ALF}^{'}$$

$$C_{LF} = \beta_{20} + \beta_{21} * \frac{B}{L_{OA}} + \beta_{22} * \frac{H_C}{L_{OA}} + \beta_{23} * \frac{A_{OD}}{L_{OA}^2} + \beta_{24} * \frac{A_F}{B^2} \quad for\ \Psi_A = 180^o$$

$$C_{LF} = 0{,}018 + \left(-5{,}091 * \frac{36}{230{,}89}\right) + \left(10{,}367 * \frac{3{,}5}{230{,}89}\right) + \left(-3{,}011 * \frac{1000}{230{,}89^2}\right) + \left(-0{,}341 * \frac{500}{36^2}\right) = -0{,}8067$$

$$F_{LF}^{'} = C_{LF} * cos\Psi_A = -0{,}8067 * cos180 = 0{,}8067$$

$$C_{XLI} = \delta_{20} + \delta_{21} * \frac{A_L}{L_{OA} * H_{BR}} + \delta_{22} * \frac{A_F}{A_L} + \delta_{23} * \frac{B}{L_{OA}} + \delta_{24} * \frac{A_F}{B * H_{BR}} \quad for\ \Psi_A = 180^o$$

$$C_{XLI} = -1{,}901 + \left(12{,}727 * \frac{1600}{230{,}89 * 35}\right) + \left(24{,}407 * \frac{500}{1600}\right) + \left(-40{,}31 * \frac{36}{230{,}89}\right) + \left(-5{,}481 * \frac{500}{36 * 35}\right) = -0{,}21404$$

$$F_{XLI}^{'} = C_{XLI}(sin\Psi_A - 1/2 sin\Psi_A * cos^2\Psi_A) * sin\Psi_A * cos\Psi_A$$

$$F_{XLI}^{'} = -0{,}21404 * (sin180 - 1/2 sin180 * cos^2 180) * sin180 * cos180$$

$$F_{XLI}^{'} = 1{,}6064 * 10^{-13} \approx 0$$

$$C_{ALF} = \varepsilon_{20} + \varepsilon_{21} * \frac{A_{OD}}{L_{OA}} \quad for\ \Psi_A = 180^o$$

$$C_{ALF} = -0{,}314 + \left(-1{,}17 * \frac{1000}{230{,}89}\ \right) = -1{,}01213$$

$$F_{ALF}^{'} = C_{ALF} * sin\Psi_A * cos^3\Psi_A$$

$$F_{ALF}^{'} = -1{,}01213 * sin180 * cos^3 180$$

$$F_{ALF}^{'} = \ -1{,}24 * 10^{-16} \approx 0$$

$$C_{AX}(\Psi_A) = \ F_{LF}^{'} + \ F_{XLI}^{'} + F_{ALF}^{'}$$

$$C_{AX}(\Psi_A) = \ 0{,}8067 + \ 0 + 0$$

$$C_{AX}(\Psi_A) = 0{,}8067$$

$$q_A = \frac{1}{2} * \rho_A * (U_A + V_{ship})^2$$

$$q_A = \frac{1}{2} * 0{,}001225 * ((20 + 12) * 0{,}51444)^2$$

$$q_A = 165{,}988\ \ [\frac{kg}{s^2 * m}]$$

$$F_{XA} = C_{AX}(\Psi_A) * q_A * A_F$$

$$F_{XA} = 0{,}8067 * 165{,}988 * 500$$

$$F_{XA} = 66{,}949\ [kN]$$

Where;

ρ_A = Air density [g/cm^3]

U_A = Apparent wind velocity [m/s]

V_{ship} = Design ship speed [m/s]

A_L = Frontal cross-sectional area [m^2]

A_{OD} = Over deck cross-sectional area [m^2]

H_{BR} = Bridge height [m]

H_C = Vertical distance from waterline to aerodynamic pressure center [m]

F'_{LF} = Longitudinal flow drag

F'_{XLI} = Lift-induced drag

F'_{ALF} = Additional longitudinal drag

All parameters of total resistance were obtained for an each speed of the drillship as shown in Figure 5.2 and Table 5.3, respectively. The blue area represents the ship hull resistance calculated by Holtrop Mennen method. The Red zone represents the percentage of the moonpool's resistance, which is estimated as %20 percent based on moonpool dimension by the reference [Veer & Tholen, 2008], affecting the total resistance of the ship. Lastly, the brown zone represents wind resistance, which is calculated by another method [Fujiwara, 2006].

Table 5.3 Total Resistance components for each speed

V [knots]	Total Resistance by Holtrop [kN]	Moonpool Resistance [kN]	Wind Resistance by(Fujiwara) [kN]	Total Resistance [kN]
6	226,91	45,38	44,20	316,49
7	302,94	60,59	47,66	411,19
8	388,69	77,74	51,26	517,68
9	483,83	96,77	54,98	635,58
10	588,18	117,64	58,84	764,65
11	701,84	140,37	62,83	905,03
12	825,35	165,07	66,95	1057,37
13	959,82	191,96	71,20	1222,99
14	1106,83	221,37	75,58	1403,78

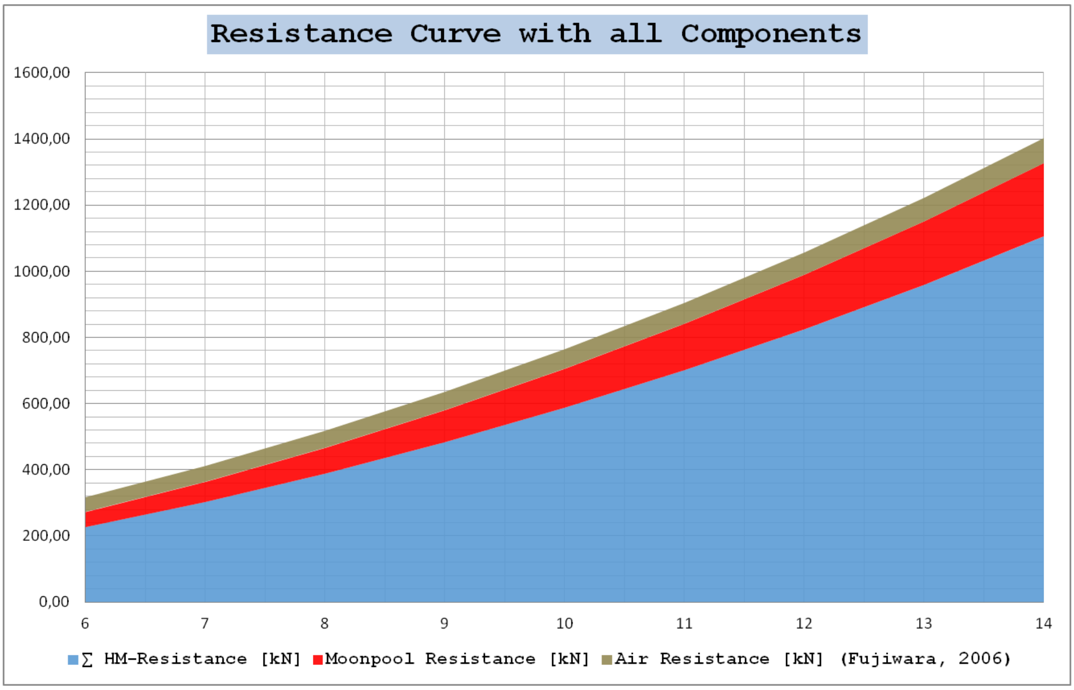


Figure 5.2 Total Resistance Curve with all components based on Holtrop-Mennen

5.3. Power prediction by Computational Fluid Dynamics (CFD)

As mentioned before, the focuses will be on resistance effect of moonpool and flow behavior in the moonpool to define the moonpool characteristics for preliminary design stage. The dimensions of the moonpool and its properties are described in the one of the previous section 2.3. Two identical ship models were used in resistance calculations during this study were designed as with moonpool and without moonpool. The models were exported to computational fluid dynamic software NUMECA/Fine Marine V5.1, which provides resistance calculations and observations of flow behavior around ship and moonpool. The ship hull and moonpool mesh for simulation are shown in Figure 5.3 and this mesh setup was used for all the different ship speeds, with a varying number of cells around moonpool walls and critical locations. Inside of the moonpool, there are many circulations of the flow and also the presence of the free surface that leads to high requirements on quality of the mesh.

The literature shows that generally research on moonpools has been carried out using experimental model tests, which are closest to reality. The resistance results and observed flow behavior in moonpool available in this study were compared with the results from such model tests [Veer & Tholen, 2008] & [Hammargren & Tornblom, 2012]. The accuracy of the results presented in the thesis study was checked by this method for the simple design phase.

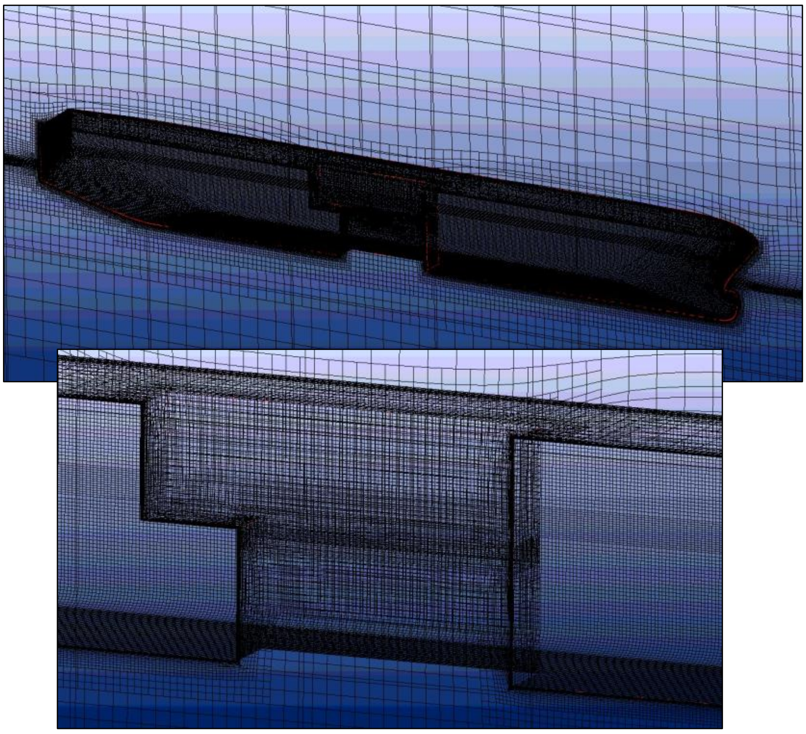


Figure 5.3 Mesh for Ship bare Hull and Moonpool area

5.3.1. *Drillship resistance without Moonpool*

Table 5.4 CFD Results without Moonpool

V [knots]	CFD - Resistance [kN]
6	132,20
7	177,60
8	245,10
9	288,86
10	372,78
11	432,62
12	514,06
13	610,88
14	740,21

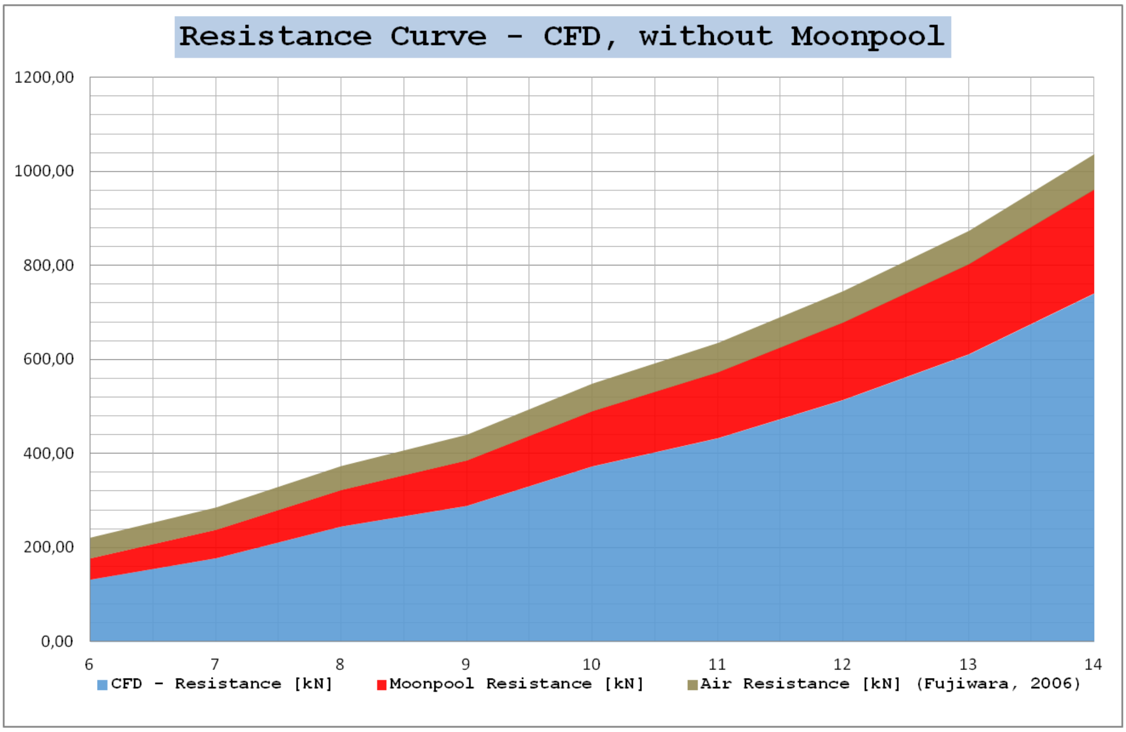


Figure 5.4 Drillship Hull Resistance results without Moonpool – CFD

Table 5.4 shows the results of the resistance of the ship designed without the moonpool. The blue area represents the ship hull resistance calculated by Holtrop Mennen method. The Red zone represents the percentage of the moonpool's resistance, which is estimated as %20 percent based on moonpool dimension by the reference [Veer & Tholen, 2008], affecting the total resistance of the ship. Lastly, the brown zone represents wind resistance, which is calculated by another method [Fujiwara, 2006].

5.3.2. Drillship resistance with Moonpool

Table 5.5 CFD Results with Moonpool

V [knots]	CFD - Resistance [kN]
6	172,98
7	230,64
8	290,60
9	365,02
10	513,06
11	549,80
12	658,76
13	791,10
14	967,08

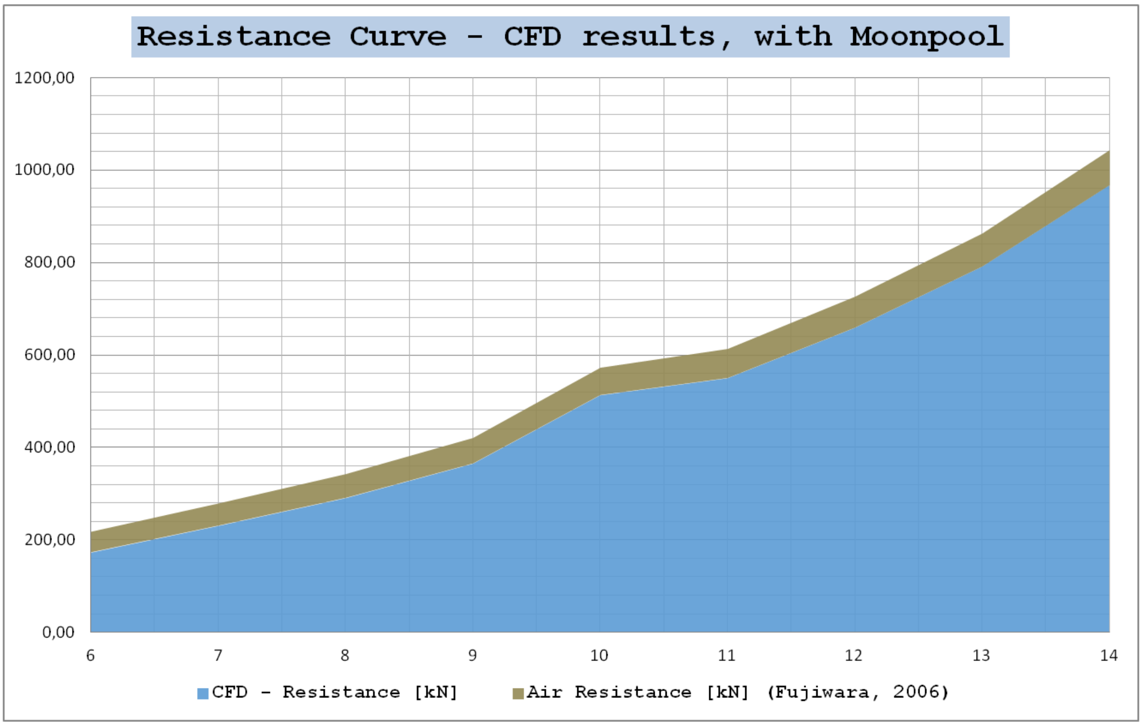


Figure 5.5 Drillship Hull Resistance results with Moonpool - CFD

Table 5.5 shows the results of the resistance of the ship designed with the moonpool. In addition, the blue area shown in Figure 5.4 represents the total ship resistance calculated by CFD method for drillship with moonpool. The brown zone represents wind resistance, which is calculated by another reference [Fujiwara, 2006].

5.3.2.1. *Moonpool effect on ship resistance*

One of the most important aims of this thesis study is to investigate and calculate the effect of moonpool on ship resistance by CFD method. The resistance caused by moonpool increases with the effect of increasing surface area. According to reference [Veer & Tholen, 2008], there are two fundamental water behaviors that can directly affect this resistance. The first one is the piston effect, and the other is the sloshing effect. It is seen that the force acting according to the moonpool dimensions of the designed drillship model is sloshing based on this reference. With this assumption, the cause of the incensement in ship resistance shown in Table 5.5 is the water oscillation in the moonpool. Also, the flow around the moonpool very complicated and included both strong vortices together with a free surface, which is shown in Figure 5.5 with different views.

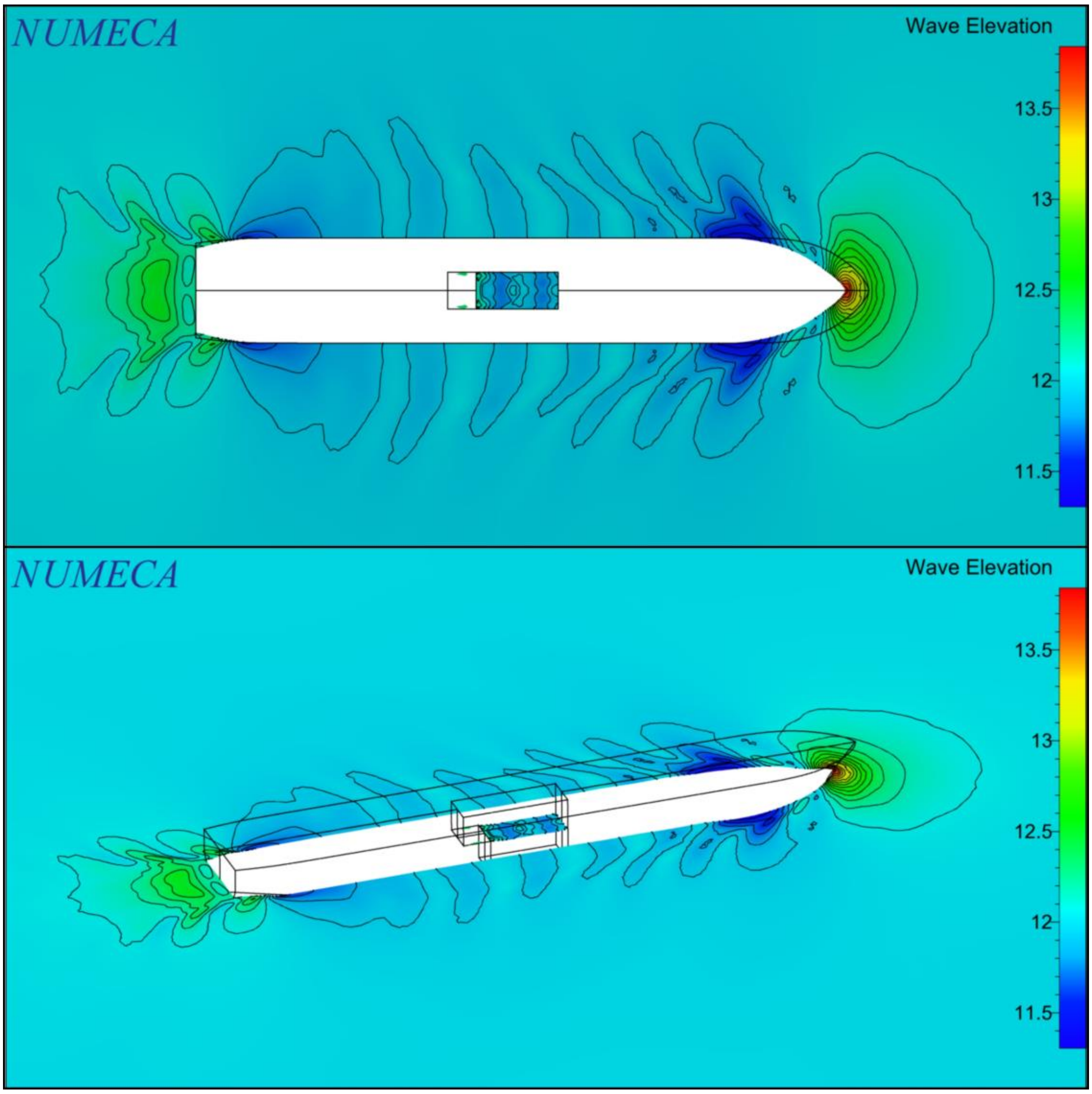


Figure 5.6 Free surface effect around the Drillship bare hull

5.3.2.2. Flow behavior inside of the Moonpool

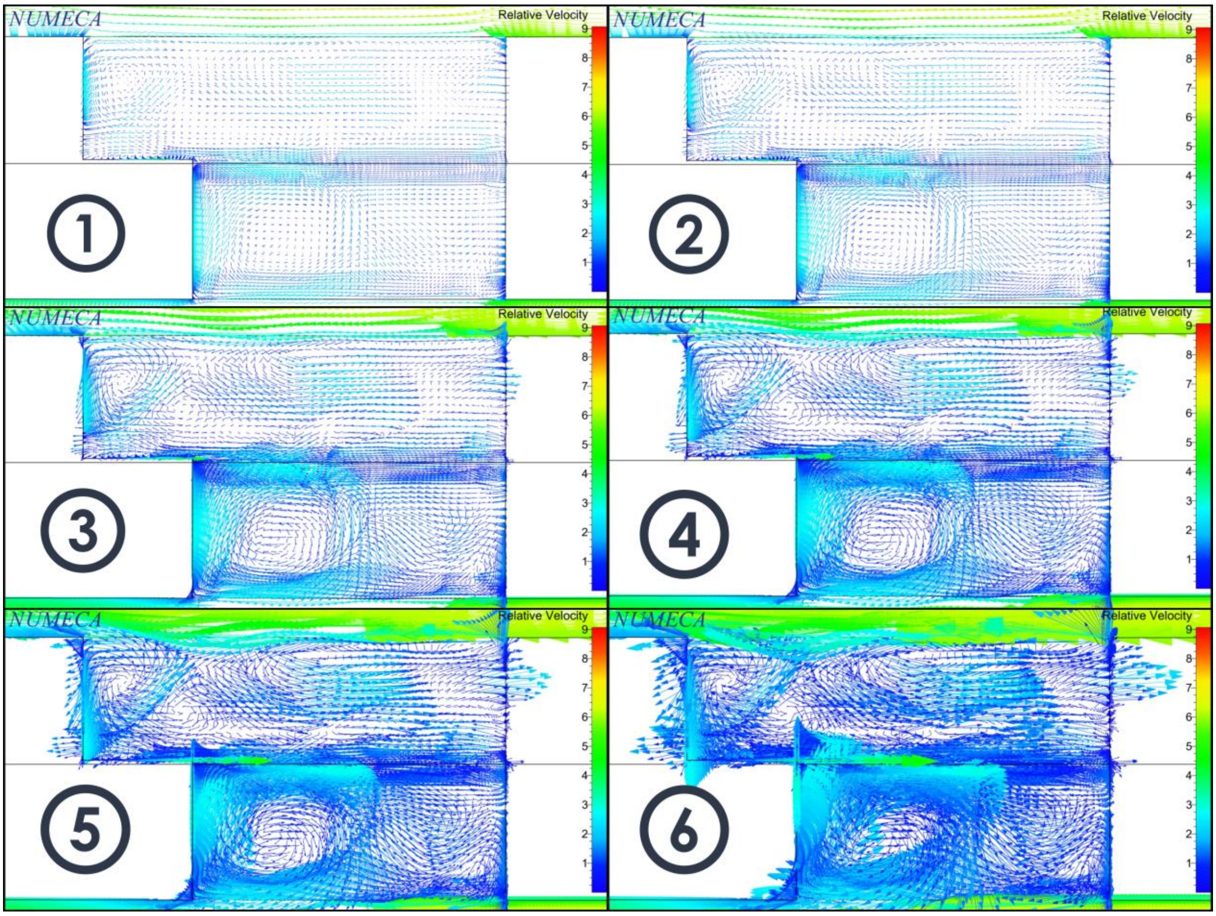


Figure 5.7 Initiation of vortices inside Moonpool at design speed

In this study, the flow behavior in the moonpool has been investigated by the same use method. The movement of the free surface is initiated by vortices created at the aft, and fore edge of moonpool are shown in Figure 5.7, respectively. As mentioned above, the sloshing effect is due to observed vortices. A study to reduce this oscillation might be another study topic; such work is not done for the preliminary design phase. Also, in this figure, the design water line can be seen as a black line which located below the recess. By varying the height of waterline or the recess, the amount of flow allowed to enter above the recess is varied. The comparison of the simulations for the flow in the moonpool, a master thesis [Hammargren & Tornblom, 2012] has been used which presents results and figures for another CFD simulations with different recess moonpool types.

5.4. Conclusions for Resistance results

As mentioned before, in the thesis the resistance of a drillship has been investigated by the statistical method is called Holtrop-Mennen and computational fluid dynamics (CFD) method was performed for both, drillship bare hull with and without moonpool.

Holtrop -Mennen Method – Taking into account the parameters used to calculate this method, the ship's resistance increases greatly depending on the displacement. It is impossible to formulate the resistance of the moonpool on a drillship, numerically. So, the approximate value observed in another study carried out and calculated according to the main dimensions of the moonpool was added to the total ship resistance. For these vessels in these main dimensions, the calculated resistance values are in a range that can be normal. But the results obtained from the Holtrop method will not be used for machine selection, assuming that the results calculated in the CFD method may also be closer to the truth.

CFD without moonpool – In the drill ship modeled for CFD operation, appendages resistance is not considered. Therefore, to obtain a more realistic approach, the R_{app} value calculated in the Holrtop method is also subtracted from the total ship resistance calculated by this method. However, there is a difference of 36 percent between the two approaches at design speed. The main reason for this difference may be the constant values on which the numerical approach is based such as, numerically estimated block and volumetric coefficients. Table 5.6 illustrated that all errors between two approaches for some other needed speeds. The error rate between the two approaches is visibly reduced compared to the increased speed values. For this, it may be appropriate to calculate both calculation methods at increasing speeds.

Table 5.6 Comparison between Holtrop Mennen and CFD Without Moonpool

V [knots]	HM-Resistance [kN]	CFD - without Moonpool [kN]	Error %
6	222,540	132,20	40,59%
7	297,106	177,60	40,22%
8	381,196	245,10	35,70%
9	474,485	288,86	39,12%
10	576,796	372,78	35,37%
11	688,224	432,62	37,14%
12	809,330	514,06	36,48%
13	941,200	610,88	35,10%
14	1085,426	740,21	31,80%

CFD with moonpool – The same ship model has been simulated with the same CFD parameters so that only the effect of the moonpool on the ship resistance can be observed. Table 5.7 shows clearly that the resistance trends at the calculated speeds are close to each other for the same speeds of ships with moonpool and those without moonpool. This value varies according to the calculated speed of the ship and is approximately 15 to 23 percent. These calculated values are carried out on similar moonpool dimensions as used in a model test constructed by reference [Veer & Tholen, 2008]. As mentioned in section 5.3.1.1, the flow in the moonpool also affects moonpool resistance based on dominate oscillation modes of water such as a piston and sloshing [Veer & Tholen, 2008].

Table 5.7 Comparison between CFD With Moonpool and CFD Without Moonpool

V [knots]	CFD - with Moonpool [kN]	CFD - without Moonpool [kN]	Error %
6	172,98	132,20	23,57%
7	230,64	177,60	23,00%
8	290,60	245,10	15,66%
9	365,02	288,86	20,86%
10	513,06	372,78	27,34%
11	549,80	432,62	21,31%
12	658,76	514,06	21,97%
13	791,10	610,88	22,78%
14	967,08	740,21	23,46%

It should be underlined that the ship resistance value determined by the CFD method also, the other important resistance parameter, which is the wind, has been added to total ship resistance to select the thrusters as shown in Table 5.8.

Table 5.8 Drillship resistance with added wind resistance to estimate thruster power

V [knots]	CFD - with Moonpool [kN]	Wind Resistance by(Fujiwara) [kN]	Total Resistance [kN]
6	172,98	44,20	217,18
7	230,64	47,66	278,30
8	290,60	51,26	341,86
9	365,02	54,98	420,00
10	513,06	58,84	571,90
11	549,80	62,83	612,63
12	658,76	66,95	725,71
13	791,10	71,20	862,30
14	967,08	75,58	1042,66

5.5. Propulsion system

5.5.1. Thrusters

As mentioned before, thrusters are one of the most important equipment for drilling rigs. For dynamically positioned drillship, the choice of thruster that can provide enough thrust is a crucial step. The major reasons for the selection of thrusters for this type of ship can be summarized as follows:

- The minimum impact in the general arrangement
- Capability of dynamic position operation
- Efficiency in transit operation
- Direct thrust at any angle
- Operation ability in all kinds of environmental conditions

The characteristic features of the propeller calculated by the AVEVA software are included in next the sections of the study. For the drillship, only two of the six thrusters were used for the transit operation.

5.5.1.1. Thruster design

By varying the characteristics of the propeller, an optimum thruster was developed by maximizing the open water efficiency based on AVEVA determination. The optimum propeller characteristics determined are outlined in Table 5.9 and Figure 5.5, respectively.

Table 5.9 Optimum propeller characteristics based on AVEVA

Parameters	Values
Diameter [m]	4,20
Pitch ratio (P/D)	0,796
Effective BAR	0,672 (0,667 min)
Number of Blades	4
Thrust load. coeff.	0,184 (0.185 max)
Kt/J^2	1,409
Adv. coeff. J	0,390
Thrust coeff. Kt	0,215
Torque coeff. Kq	0,0285
Open water efficiency	0,468

The thrusters developed in previous section 5.5.1.1 the required thrust to overcome the ship's resistance at 12 knots, which is design speed. Figure 5.5 illustrated those,

- During the operating at a low advance coefficient; thrusters develop higher thrust and
- Comparison Kt, Kq and their effect on open water efficiency the propeller curves at design speed for a Wageningen B-series propeller.

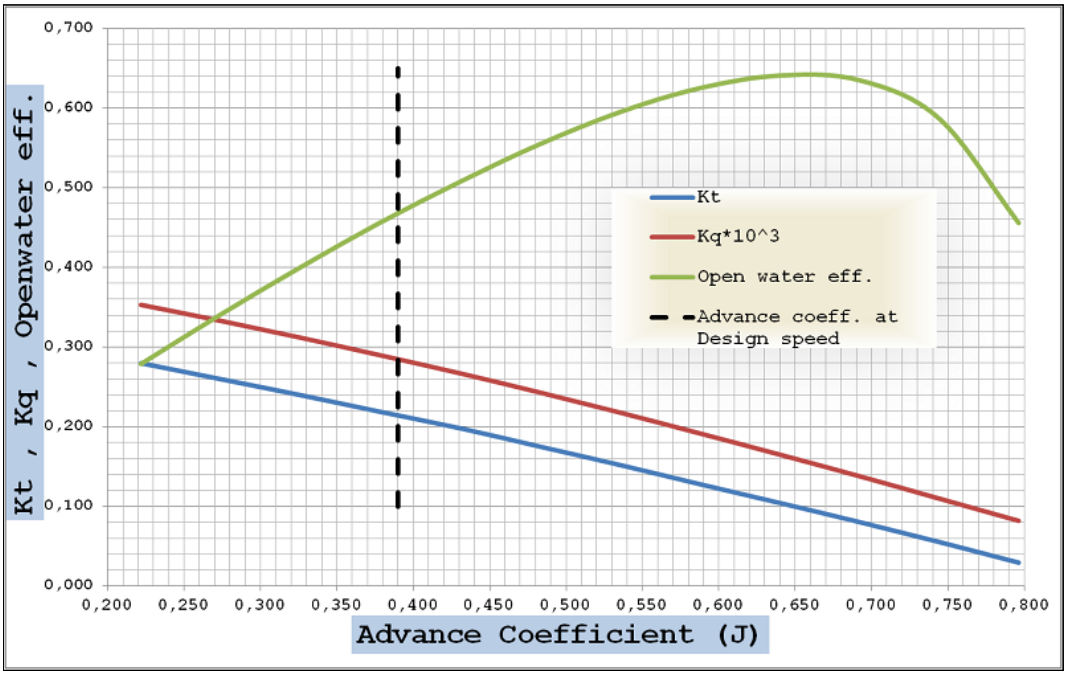


Figure 5.8 Kt & Kq curve by Wageningen B-series propeller [AVEVA]

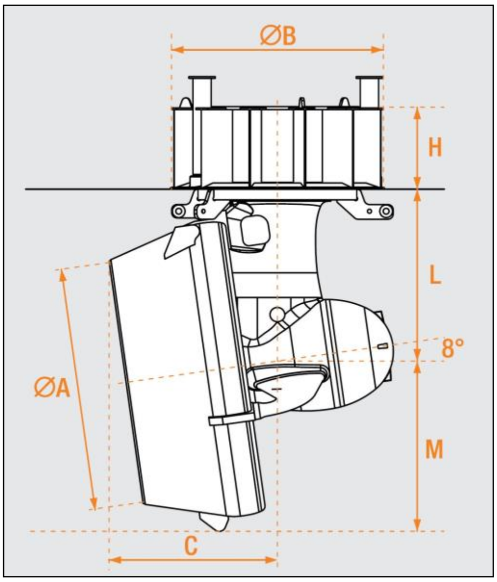


Figure 5.9 Selected thruster Avaliable from http://www.wartsila.com/products/marine-oil-gas/propulsors-gears/thrusters/

Table 5.10 Technical specification of selected Thruster

Thruster type	WST-65U
Thruster power range [kW]	5000-6500
A [mm]	4200
B [mm]	3820
C [mm]	3006
M [mm]	2716
L [mm]	3025
H [mm]	1390

5.5.2. Powering

5.5.2.1. Requirements

As previously determined, two thrusters will provide the propulsion. For an overview of the thruster, their configuration is shown Table 6.1. Also, Table 5.11 illustrated that needed parameters to estimate minimum brake power required. According to resistance calculation, the transit condition requires 725, 71 kN at transit speed.

Table 5.11 Determined parameters by AVEVA to estimate required Brake Power at design speed

Parameters	Values
Propeller Diameter [m]	4.200
Open water efficiency (η_o)	0.468
Wake fraction (w)	0,243
Thrust deduction (t)	0,243
Transit speed [knots]	12

Table 5.12 Efficiencies used in Brake Power Calculation [Parsons, 2002]

Parameters	Values
Mechanical efficiency of Thruster	0,95
Load correction factor	0,99
Gearing (one reduction & reversing)	0,985
Electrical Transmission and Conversion	0,985
Generator	0,96
Electric Motor	0,97

$$P_E = R_T * V$$

$$P_E = 725{,}71\, kN * (12 * 0{,}51444)\, m/s = 4480{,}005\, kW$$

$$V_A = V * (1 - w)$$

$$V_A = (12 * 0{,}51444)\, m/s * (1 - 0{,}243) = 4{,}673\, m/s$$

$$T = \frac{R_T}{(1-t)}$$

$$T = \frac{R_T}{(1-t)} = \frac{725{,}71\, kN}{(1 - 0{,}243)} = 958{,}664\, kN$$

$$P_T = T * V_A$$

$$P_T = 958{,}664\ kN * 4{,}673\ m/s = 4480{,}005\ kW$$

$$P_D = \frac{P_T}{\eta_o}$$

$$P_D = \frac{4480{,}005\ kW}{0{,}468} = 9572{,}66\ kW$$

$$P_B = \frac{P_D}{\eta_{Thruster} * \eta_{LC} * \eta_{Gear} * \eta_{Trans\&Conv} * \eta_{Generator} * \eta_{Motor}}$$

$$P_B = \frac{9572{,}66\ kW}{0{,}8242} = 11614{,}1296\ kW$$

Where,

R_T = Ship Resistance [kN]

P_E = Effective Power [kW]

P_T = Thrust Power [kW]

P_D = Delivered Power [kW]

P_B = Brake Power [kW]

V_A =Velocity of Advance [m/s]

T = Thrust [kN]

The Brake Power calculation was performed for the transit condition, and it will check later in the dynamic position analysis to ensure adequate brake power is installed. The above calculation shows that each thruster selected in Table 5.10 should provide 5807.06 kW, which is half of the estimated brake power (P_B). That means only two thrusters must be provided when the ship is transitting. It should be underlined that different efficiencies according to reference [Parsons, 2002] have been used for electrical equipment in the power transfer and these efficiencies are shown in Table 5.12.

5.5.2.2. *Diesel generating sets and endurance*

At this part of work, the choice of the diesel generating sets to provide the adequate power that has been investigated from the sources. Also, the generating set has to provide adequate power to remain on station in extreme weather conditions. The generating sets, which best meet the power requirements are six Wartsila 12V32, which can provide 6720 kW per engine. Detailed information about selected diesel generating set can be found in Appendix 6.

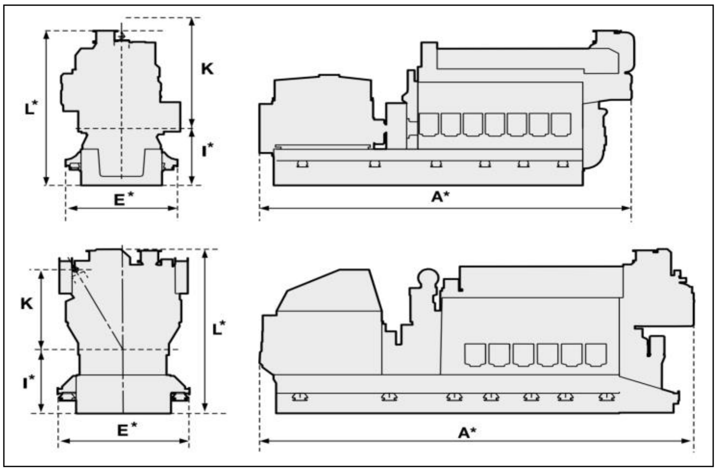


Figure 5.10 Wartsila Genset Main Dimensions Avaliable from http://www.wartsila.com/products/marine-oil-gas/engines-generating-sets/diesel-engines/wartsila-32

Table 5.13 Wartsila Genset 32 Main Dimensions and Weight

Parameters	Values
Engine type	12V32
A [mm]	10700
E [mm]	3060
I [mm]	1700
K [mm]	2120
L [mm]	4130
Weight [tonnes]	100

Although the drillship’s transit distance for the operation was specified in the company requirements, it is significant to ensure that these engines will not exceed the fuel consumption for the defined endurance. The operation area and prescribed endurance information can be found in Appendix 6. The endurance calculation to verify the ship’s range of 11800 nautical miles is shown in following equations. According to diesel generating the producer company, using the fuel consumption rate of each genset is 174 g/kWh and knowing that only two engines are required to be running when transiting.

$$Range \rightarrow 11800\, nm\ \ at\ 12\ knots \rightarrow 11800/12 = 983{,}33\ hours$$

$$Fuel\ consuption = 174\ g/kWh\ *\ (1E-6)\ tonnes/s\ * 6720\ kW/engine$$

$$Fuel\ consuption = 1{,}169\ tonnes/hour$$

$$Total\ fuel\ consuption = 1{,}169\ tonnes/hr\ * 2\ engines * 983{,}33\ hours$$

$$Total\ fuel\ consuption = 2299{,}58\ tonnes$$

6. DYNAMIC POSITION PREDICTION

Estimation of the dynamic position power requirement for drillships is one of the most important topics in this study. The environmental loads, which are the wind, waves, and current forces, should be analyzed together with the propulsion-located thrusters configuration of the drillships.

The dynamic positioning system is one of the complex computer controlled system, which can control automatically maintain a drillship position and heading by using its propellers and thrusters. Its need to be added that any vessel has six freedoms of movement, called yaw, surge, sway, heave, pitch and roll, respectively. The dynamic positioning systems are not able to control the heave, pitch, and roll of the vessel. These movements are concerned within the context of sea keeping the behavior of the ship [Steddum & Herrmann, 1997].

The results and approaches will present in following sections, which clarify the vessel can maintain position and keep heading with the riser connected and normal drilling operations when submitted to the worst annual environmental loads acting in the same direction for the following areas;

- Offshore Brazil
- The Gulf of Mexico
- Southeast Asia
- West and Central Africa
- South Africa
- Mediterranean Sea
- Australia

The main elements of a Dynamic positioning system are, Sensor system, Power system, controller, and Thruster system, to control the yaw, surge, and sway by using thrusters of the drillship automatically. Those three axes are concerned primarily for drillship in the horizontal plane [Steddum & Herrmann, 1997].

6.1. Axes Convention and Thrusters Configuration

The axis convention used for the dynamic positioning calculation shown in Figure 6.1 [de Wit, 2009]. The forces and moments are calculated in the fixed vessel reference system. The right-hand sign convention is used for the horizontal forces, F_x, F_y and the horizontal moment M_z. All forces and moments are given about the center of gravity of the vessel. As mentioned in section 5.5.1.1, the drillship is equipped with six 6000 kW azimuth thrusters. The thruster configuration and its particulars are illustrated in Figure 6.1 and Figure 6.2, respectively.

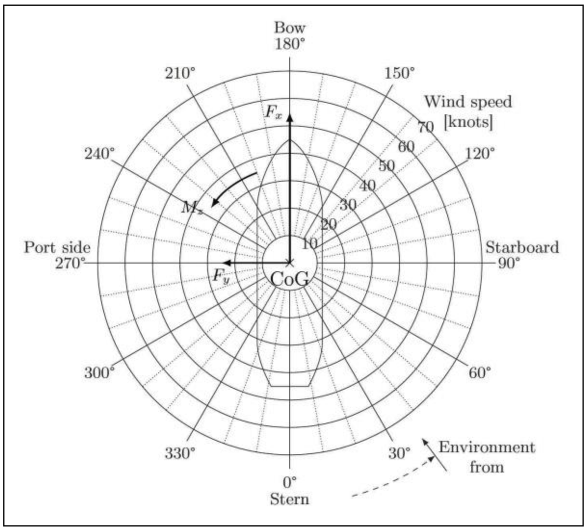


Figure 6.1 Axes convention for Dynamic Position Calculations [de Wit, 2009]

Table 6.1 Thrusters Particulars

Thruster Number	Position	X cord. From APP [m]	Y cord. From CL [m]	Power [kW]
1	PS aft	4,20	8,40	6000
2	SB aft	4,20	-8,40	6000
3	CL aft	56,70	0	6000
4	PS fwd	165,90	9,10	6000
5	SB fwd	165,90	-9,10	6000
6	CL fwd	210,70	0	6000

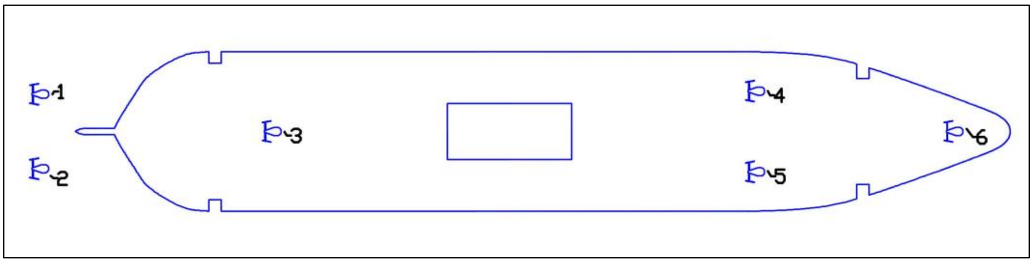


Figure 6.2 Thrusters Configurations

6.2. Thrust and Power

6.2.1. Effective Thrust

In dynamic position calculations, there are several thrust degradation effects which should be accounted, such as thruster-hull interaction, thruster-thruster interaction, thruster-wave interaction and thruster-current interaction [12]. An approach will be made in the following sections of this Study by using AVEVA Hydrostatic and Hydrodynamic Module for some of the forces that cause these interactions. The finding of hydrodynamic constants is a very important information and is very useful for the further design phase of the ship.

Based on a thrust – power ratio of 0,177 kN/kW which is typical for Dynamic Position (DP) calculations the selected thrusters are capable delivering 1062 kN of effective thrust at zero speed.

6.2.2. Design requirements

As mentioned before, the ability of a drillship to keep on the station is a critical design criterion. That’s why the vessel will be designed for DP class 3 that can be defined by automatic and manual position and heading control under specified maximum environmental conditions. At the very begin of the chapter, most important parameters of DP systems was listed, respectively. To perform a design requirement of the drillship shall be able to maintain position and keep heading towards the lesser environment resulting forces within a sector of 45.0^0 ($\pm 22.5^0$). After worst DP3 failure, the vessel also should require the forces within a sector of 30.0^0 ($\pm 15.0^0$). The failures, which will be considered for the DP class 3, are designed such that a designated combination of failing thrusters is presented with all details in Appendix 6. Least & most effective thrusters and least & most effective pairs of thrusters will be available in the conclusion part of the study, based on AVEVA dynamic position estimation.

6.3. Environmental Conditions

6.3.1. *IMCA and ITTC Conditions*

The following table has illustrated that relationship between significant wave height, wave period and wind speed which are defined based on International Marine Contractors Association (IMCA) [12]. Also, a constant current velocity is defined. According to the sea conditions can be summarized as surface current speed [V_c] is 1 knots, Peak enhancement factor [γ] is 3,5 also the wind, waves and current are collinear.

Table 6.2 International Marine Contractors Association (IMCA) sea state conditions

Sig. Wave Height, Hs [m]	Crossing Period, Tz [s]	Peak Period Tp [s]	Wind Speed, Vw [m/s]
0	0	0	0
1,28	4,14	5,3	2,5
1,78	4,89	6,26	5
2,44	5,72	7,32	7,5
3,21	6,57	8,41	10
4,09	7,41	9,49	12,5
5,07	8,25	10,56	15
6,12	9,07	11,61	17,5
7,26	9,87	12,64	20
8,47	10,67	13,65	22,5
9,75	11,44	14,65	25

Table 6.3 ITTC Spectrum based on AVEVA module [Wind-Wave relationship]

Significant Wave Height [m]	Average Wave Period [sec]	Wind Speed [knots]	Wind Speed [m/s]
0,00	5,50	0	0,00
0,86	5,93	5	2,57
1,40	6,20	10	5,14
1,97	6,49	15	7,72
2,68	6,84	20	10,29
3,43	7,22	25	12,86
4,17	7,59	30	15,43
5,01	8,01	35	18,01
5,80	8,40	40	20,58
6,66	8,83	45	23,15
7,26	9,13	50	25,72

6.3.2. Weather Conditions

As mentioned before, operational areas have been specified at the beginning of the chapter. About this, the weathering requirements are illustrated for two conditions of Brazil in Table 6.4 and worldwide environmental conditions in Table 6.5and Table 6.6, respectively.

Table 6.4 Offshore Brazil worst annual conditions [18] & [19]

Parameters	Offshore Brazil Condition A	Offshore Brazil Condition B
Significant Wave Height Hs [m]	6,0	4,5
Peak Period Tp [s]	9 -15	9 -15
Peak Enh. Factor, γ	2,2 – 1,7	2,2 -1,7
Wind Speed [m/s] ten-min	19,0	18,0
Wind Speed [m/s] one-min	20,9	19,8
Surf current speed Vc, [m/s]	1,2	1,5

Table 6.5 Worldwide worst annual conditions group 1 [18] & [19]

Parameters	The Gulf of Mexico	South-East Asia	West/ Central Africa
Significant Wave Height Hs [m]	4,4	3,9	3,4
Peak Period Tp [s]	8,8	8,5	12,9
Peak Enh. Factor, γ	2,0	2,6	4,0
Wind Speed [m/s] ten-min	22,7	20,0	22,7
Wind Speed [m/s] one-min	25	22,0	25,0
Surf current speed Vc, [m/s]	1,5	1,3	1,5

Table 6.6 Worldwide worst annual conditions group 2 [18] & [19]

Parameters	South Africa	Mediterranean Sea	Australia
Significant Wave Height Hs [m]	6,0	4,5	4,2
Peak Period Tp [s]	12,0	10,0	9,9
Peak Enh. Factor, γ	1,0	1,5	1,3
Wind Speed [m/s] ten-min	19,8	21,8	17,3
Wind Speed [m/s] one-min	21,8	24,0	19,0
Surf current speed Vc, [m/s]	0,6	0,5	0,7

The values are shown in Table 6.3, Table 6.4and Table 6.5were taken from websites serving as open source [18] and [19]. One-min value is usually used when calculating the dynamic position.

6.4. Environmental Loads

Three environmental loads are considered for the Dynamic position estimation. To determine the coefficients of the loads, AVEVA Hydrostatics and Hydrodynamic Calculation module was used.

6.4.1. Wave Drift Force

The wave drift force coefficients for the typical operating draught, an H_S =5,8 meters is shown in following Figure 6.3for the three degrees of freedom.

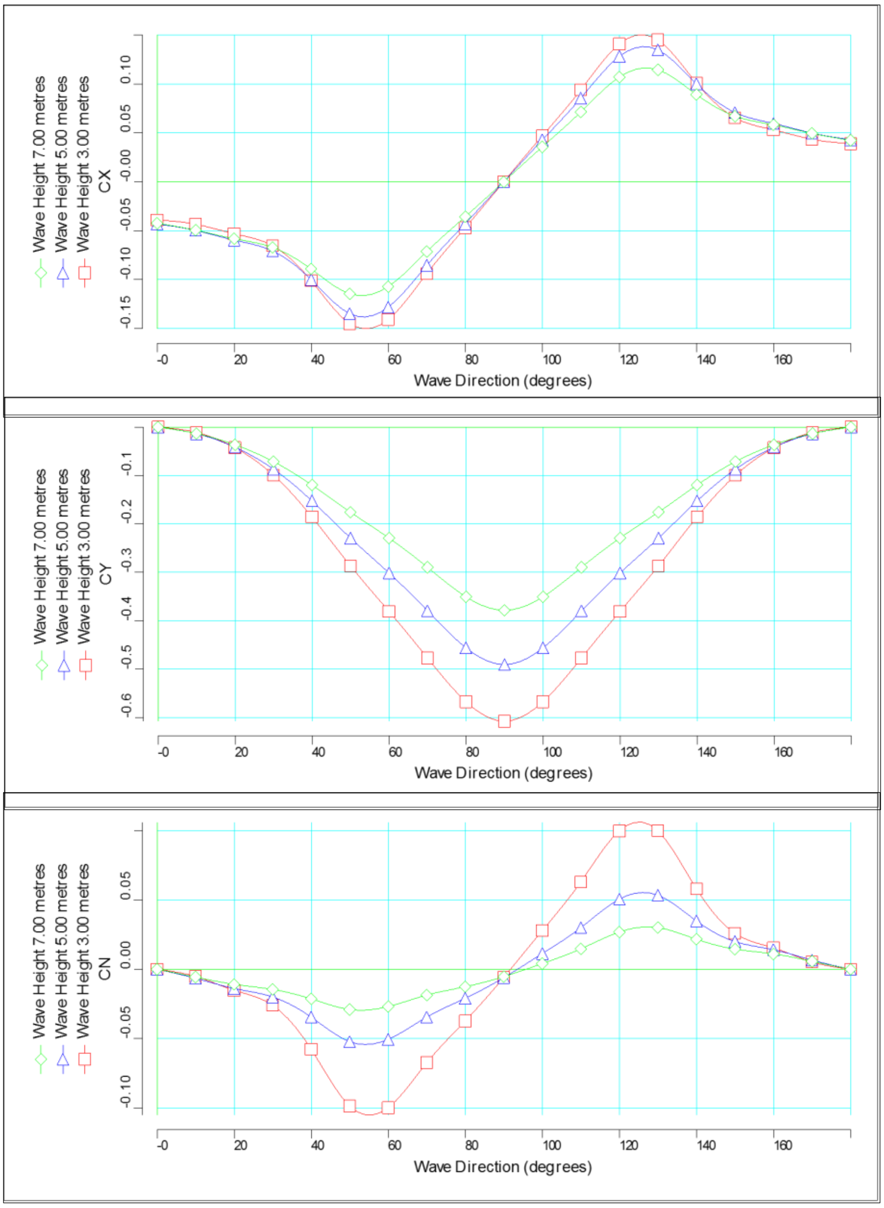


Figure 6.3 Estimated wave drift force coefficients - Cf_X, Cf_Y, Cf_N

6.4.2. *Wind Forces*

The wind profile was drawn based on general arrangement plan and the ship profile by using AutoCAD software. This drawing was also used to make wind resistance calculations with Fujiwara, 2006 method. The results of the wind forces calculation are presented in following Figure 6.4. The wind loads are calculated by using these force and moment coefficients with the actual wind speed which is updated to software by manually.

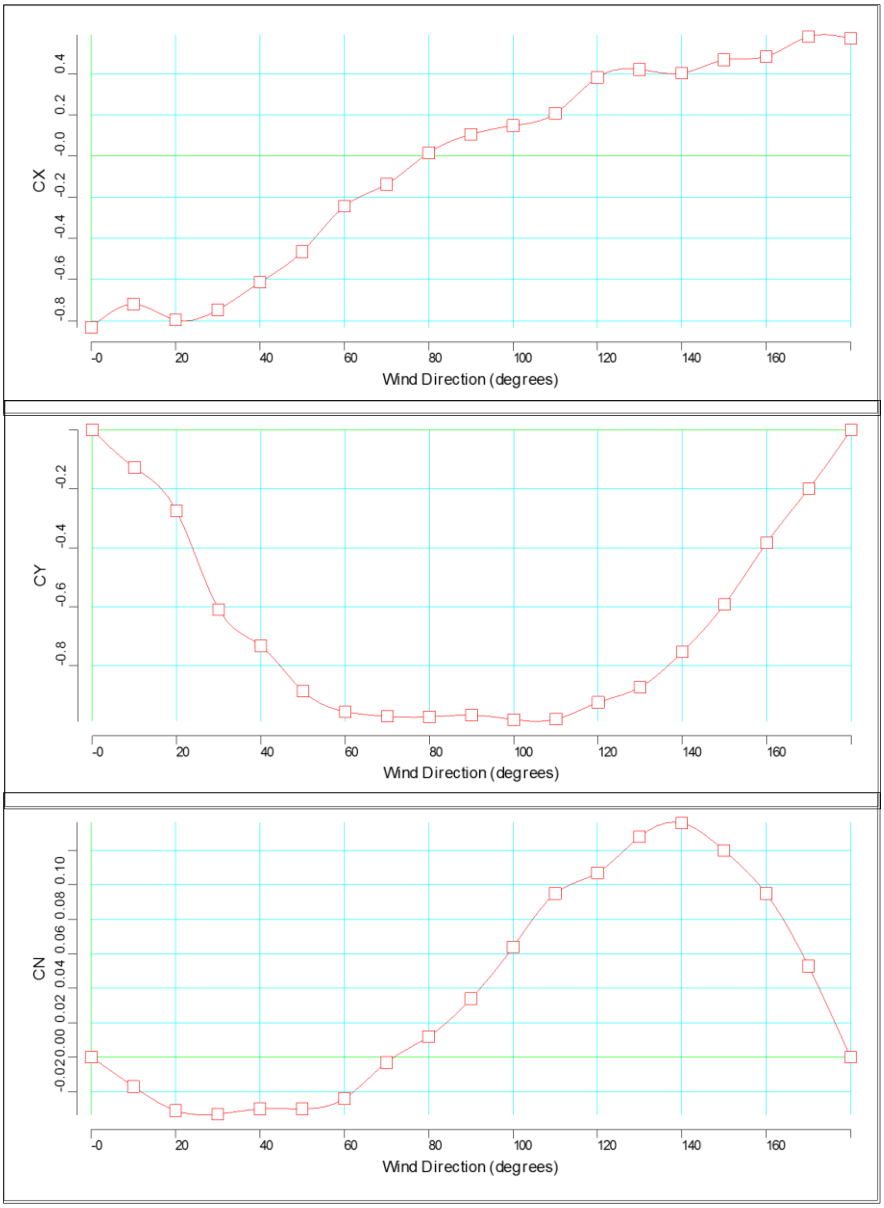


Figure 6.4 Estimated wind forces coefficients – Cf_X, Cf_Y, Cf_N

6.4.3. *Current Forces*

The results of the current forces calculation are presented in following Figure 6.5.

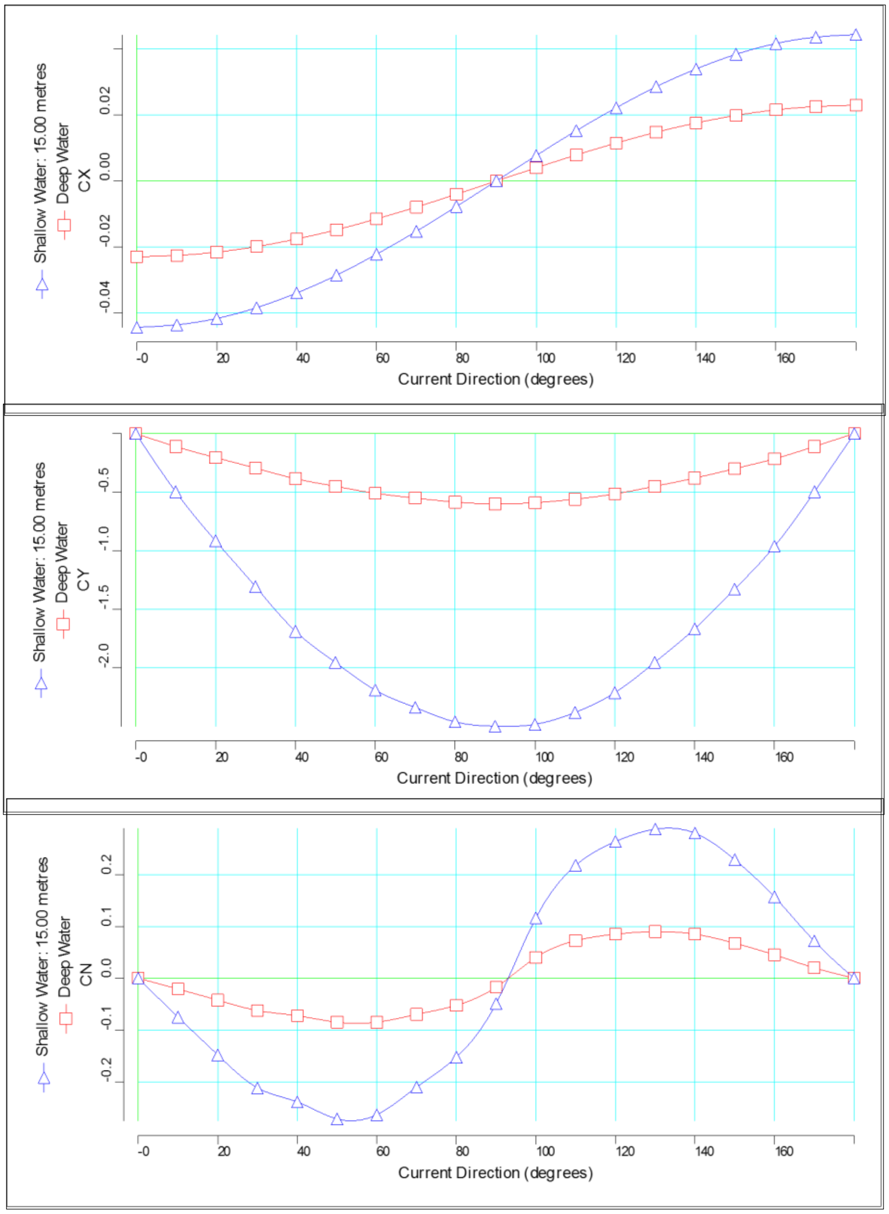


Figure 6.5 Estimated current force coefficients – Cf_X, Cf_Y, Cf_N

All environmental conditions can be summarized in Table 6.3 as, Significant Wave Height 5.80 meters coincident with wind direction, Current speed 1 knots coincident with the wind, Wind speed 40 knots between 0 to 360 degrees and Wave Period 8.40 seconds.

6.5. Conclusions for Dynamic Position Estimation

AVEVA Hydrostatics and Hydrodynamic module determine the thrust required in each unit to balance specified wind, wave, and current conditions. The following Table 6.7 illustrated that maximum thrust and power required by each unit for all environmental directions considered.

Table 6.7 Maximum thrust [tones] and max. Power required results by AVEVA

Thruster Number	Maximum Thrust [tones]	Maximum Power [kW]
1	77,04	4787,45
2	77,04	4787,45
3	81,12	5040,78
4	90,72	5637,49
5	90,72	5637,48
6	94,65	5881,53

Least & most effective thrusters and least & most effective pairs of thrusters can be listed as follows based on AVEVA dynamic position estimation,

- Least important thruster is thruster number 3
- Most important thruster is thruster number 6
- Least important pair are thruster numbers 1 and 4
- Most important pair are thruster numbers 4 and 6

As a result, the estimated power for the transit operation was then compared with the required thrust force to provide the dynamic position of the drillship. The selected 6000 kW thrusters are sufficient for this operation. The estimated values and all information about dynamic position estimation can be found in Appendix 7A, 7B and 7C.

7. GENERAL ARRANGEMENT

Overall the general arrangement for drillships is defined as a plan that shows in detail the living spaces of the crew and all equipment that will provide the operational requirements of a ship. The process followed when designing a general layout plan for a drill ship is like other ship types. However, this plan varies according to the own requirements that need to be fulfilled. For example, the accommodation is located in the fore part of the ship. Around the drill hole located in the middle of the ship, there is equipment to perform the drilling.

The design of the general arrangement plan for drillship in the preliminary design phase includes the following details [Papanikolaou, 2009].

- Identification of the main space of the ship according to their main purposes. (Hold spaces, engine room, superstructure, ballast and fuel tanks, watertight bulkheads.)
- The design of the plan according to complex operation flow.
- Easy and safe access to operation areas and equipment.

The ship hull was subdivided according to recommendations established by ABS rules for Building and Classing Steel Vessels Part 3, Chapter 2, Section 9. Also, the double bottom was dimensioned according to ABS rules Part 3, Chapter2, Section 3. The numbers of transverse watertight bulkhead provided were 7. In addition, frame spacing provided 700 mm based on existing ship that mentioned in **Table 2.2**. The general arrangement plan of the designed ship is explained with the following headings and AutoCAD drawing can be found in Appendix 3.

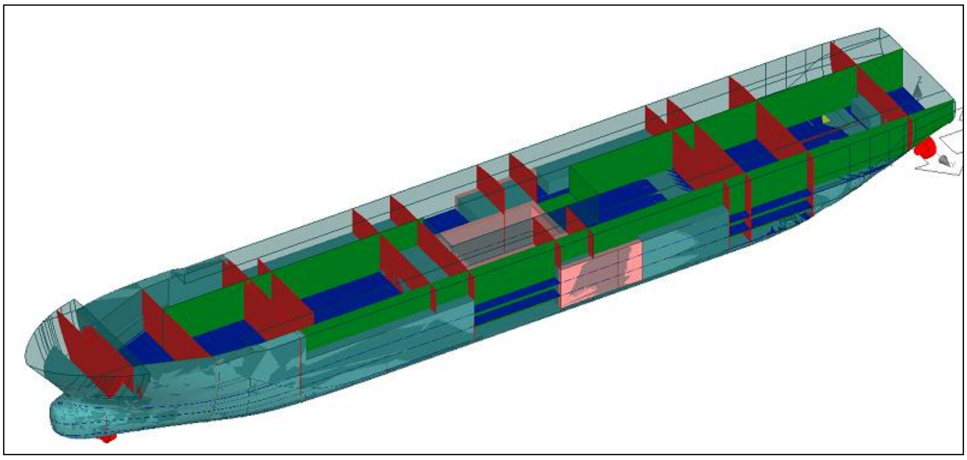


Figure 7.1 Initial locations of Transverse and Longitudinal bulkheads by AVEVA

The drillship general arrangement plan is divided into three independent areas, machinery spaces, accommodation and drilling as detailed in followingTable 7.1.

Table 7.1 Subdivided independent areas

Machinery Spaces	Accommodation	Drilling
Engine rooms	Cabins	Cement unit
Propulsion rooms	Toilets	ROV modules
Thruster rooms	Galley	Subsea facilities
Thruster trunks	Mess room	Heavy tool store
Mud pump room	Recreation room	Drilling switchboard
Mud pits	Changing rooms	Drill fluid storage Tanks
Fluids laboratory	Pantry	Driller's cabin
Pump rooms	Hospital	Pipe Racks and Storage Racks
Workshops	Gymnasium	BOP Control Area
Stores	Laundry	X-mas Tree
Switchboard rooms	Offices	Driller control Room
Sack storage & mixing area	Wheelhouse and DP control room	Mud Lab
Passageways	Radio room	Derrick
Engine control room	Server room	Mud storage Tanks
Silo rooms	Battery room	Substructure
Emergency generator room		

7.1. Moonpool Area

As mentioned before, the moonpool used on designed ship is ‘’Moonpool with aft recess’’. The moonpool (28,00 m x 12,60 m) was integrated into the hull between frames 123 and 177, extending from baseline level upwards to the Main deck. The Moonpool is shown in **Figure 2.3** and its characteristics are shown in **Table 2.3**. Around the moonpool area, two important equipment should be underlined, firstly, the Blow-out Preventer (BOP) equipment on the forward of moonpool and on the aft recess of moonpool, there is a Christmas tree to control the flow of oil out of the well. The moonpool has been surrounded by cofferdams (1400 mm in width) to reduce the effect of hydrodynamic forces and to protecting MDO tanks in case.

7.2. Drillfloor and Drilling Materials Storage

The designed drillship has the Drillfloor capability to perform drilling operations. The Drillfloor is located 32,8 m from baseline, above the main deck in order to give adequate clearance for the subsea and other equipment. The components and main equipment which are related with drill floor can be seen as a listed in Table 7.1, respectively.

7.3. Main Deck and Forecastle Deck

The main deck has camber, forward of frame 260, of 700 mm extending from the vessel’s side and 6,0 m off CL (PS and SB). The forecastle height in general arrangement was designed reinforced in way of windlasses, mooring winches, mooring fittings, and other concentrated loads where necessary accordance to Load Line IMO Res. 143 (77) Forecastle and Freeboard. Forecastle deck has camber, forward of frame 312, of 700 mm extending from the vessel’s side and approximately 6,0 m off CL (PS and SB). The Forecastle deck is located forward of frame 328 at a height of 23,0 m above base.

7.4. Accommodations

An accommodation block for a total complement of around two hundred persons shall be arranged forward, on Main deck. The accommodation shall comply with the rules and regulations of all applicable authorities including IMO MODU Code and SOLAS regulations with regard to fire resistance and sanitation and in accordance with the requirements of ABS. The overall vertical extent of the accommodation block above Main deck, is subdivided into the following decks:

➢ Main deck	19,70 m
➢ A-deck	22,90 m
➢ B-deck	26,20 m
➢ C-deck	29,50 m
➢ Drilling Floor D-deck	32,80 m
➢ Navigation Bridge deck	37,10 m
➢ Top deck	40,40 m

8. TANK ARRANGEMENT AND CAPACITIES

The primary factors that directly affect the tank plan are the locations of the moonpool and the drilling derrick. The location of the derrick is determined according to ships' longitudinal center of the gravity to limit the motions of the derrick during drilling operations. The tanks of drillship were positioned below the main deck and with big enough size so that the minimum requirements of fresh water capacities and fuel for the operating range were surpassed (See the calculations of fuel consumption in section5.5.2.2). Exceptionally, fresh water tanks are limited to main deck level.

Three services and two settling marine diesel oil (MDO) tanks were positioned directly to the engine room, which located aft part of the ship. In addition, rest of MDO tanks for storage purpose were located around the moonpool and their positions can be seen in Figure 8.1 with magenta color. The MDO tanks were subdivided according to MARPOL regulations for the prevention of pollution by oil, Chapter 3, Regulation 12A. The calculation was made by following equations and Figure 8.1 shows that oil fuel tank boundary lines, respectively.

The amount of ballast capacity was presented in Table 8.1, which totaled more than 20,000 tons. There is a total of 31 water ballast tanks along the ship. All of the tanks associated with the drilling operations were situated around the moonpool. The Mud tanks, Brine tanks, Drilling water tanks and Base oil tanks were kept close to the drilling area. With this location, less piping and equipment are needed. This arrangement provides, therefore, many possibilities for equilibrium or stability corrections. Some of the watertight surfaces that separate the tanks are not part of the transversal bulkheads. This means that they do not provide structural resistance; they are present solely for isolating the tanks. Table 8.1created below summarizes the capacity of the tanks, locations and their densities present in the ship. All details such as LCG, TCG, VCG and weight of each tank are located in ship shown in Appendix 6.

Table 8.1 The total capacities plan of Tanks

Idendity	Density [t/m^3]	Volume [m^3]	Weight [t]	LCG [m]	TCG [m]	VCG [m]
Ballast	1,025	21179,0	21179	118,313	0	3,64
Fresh water	1,00	1969,08	1969,08	199,988	0	12,44
Marine Diesel Oil	0,89	4317,38	3842,47	109,428	0	7,51
Lube Oil	0,90	235,30	211,77	10,150	0	10,85
Base Oil	0,80	524,38	419,50	105,700	12,25	7,35
Drill Water	1,00	3163,56	3163,56	108,500	0	7,35
Brine	1,92	1230,28	2362,14	130,200	0	7,35
Mud	2,16	3959,76	8553,08	75,839	0	5,60
Miscellaneous	2,00	607,21	1214,42	85,050	4,73	6,74
Dirty Oil	1,00	302,54	302,54	21,000	0	7,35
Total	**-**	**37488,49**	**43217,56**	**110,501**	**0,252**	**5,432**

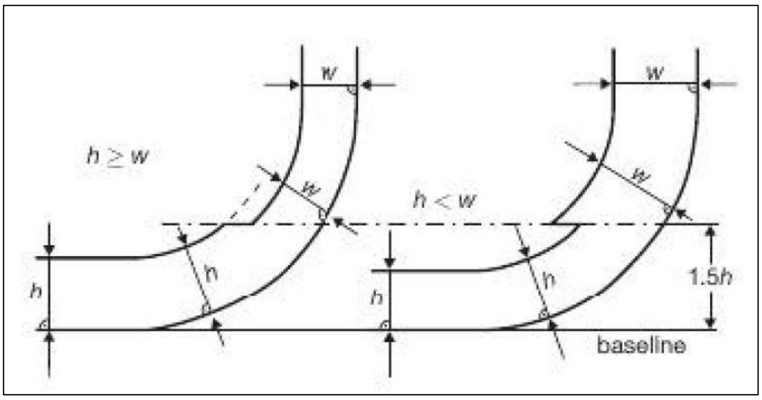


Figure 8.1 Oil fuel tank boundary lines Available from http://www.marpoltraining.com/MMSKOREAN/MARPOL/Annex_I/

For ships having an aggregate oil capacity between 600 - 5000 m^3, oil fuel tanks should be located according to the rule. The minimum value of w and h are 1 m and 2 m, respectively. Therefore, the taken value for drawing w is 1,3 m, and h is 2,1 m. Where C is the total oil capacity.

$$h = \frac{B}{20} = \frac{36\,m}{20} = 1{,}8\,m$$

$$w = 0{,}5 + \frac{C}{20000}(m) = 0{,}5 + \frac{4317{,}38\,m^3}{20000\ \ m^3} = 0{,}7159\ or\ 2{,}0\ m\ (which\ is\ the\ lesser)$$

A list of content types of the tanks that were used can be seen in Table 8.1 below. In addition, the table illustrated that all the tank types and their attributes, on the ship, are represented by different colors. Figure 8.1shown below shows the layout of the tanks in the designed drillship. During the detailing of the tank layout, the information of the previous ship was used because of time constraints.

Table 8.2 Content types of Tanks

Identity	Type	Density [t/m^3]	Colour	
Ballast (WB)	Liquid	1,025	🟩	Green
Fresh water (FW)	Liquid	1,00	🟦	Dark Blue
Marine Diesel Oil (MDO)	Liquid	0,89	🟪	Magenta
Lube Oil (LO)	Liquid	0,90	🟫	Olive
Base Oil (BO)	Liquid	0,80	🟦	Cyan
Drill Water (DW)	Liquid	1,00	🟦	Blue
Brine (BO)	Liquid	1,92	◼	Gray
Mud (MUD)	Liquid	2,16	🟨	Yellow
Miscellaneous (MIS)	Liquid	2,00	🟩	Dark Green
Void	-	-	🟦	Turquoise
Dirty Oil (DO)	Liquid	1,00		White

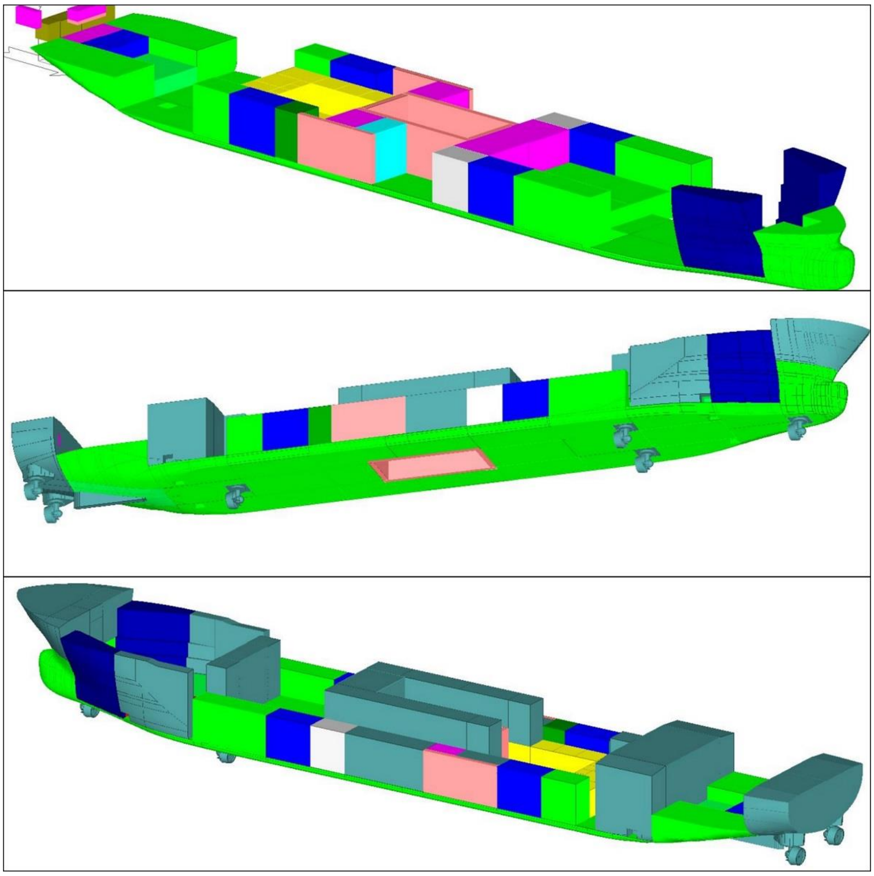


Figure 8.2 Colored Tank Arrangements for designed ship by AVEVA

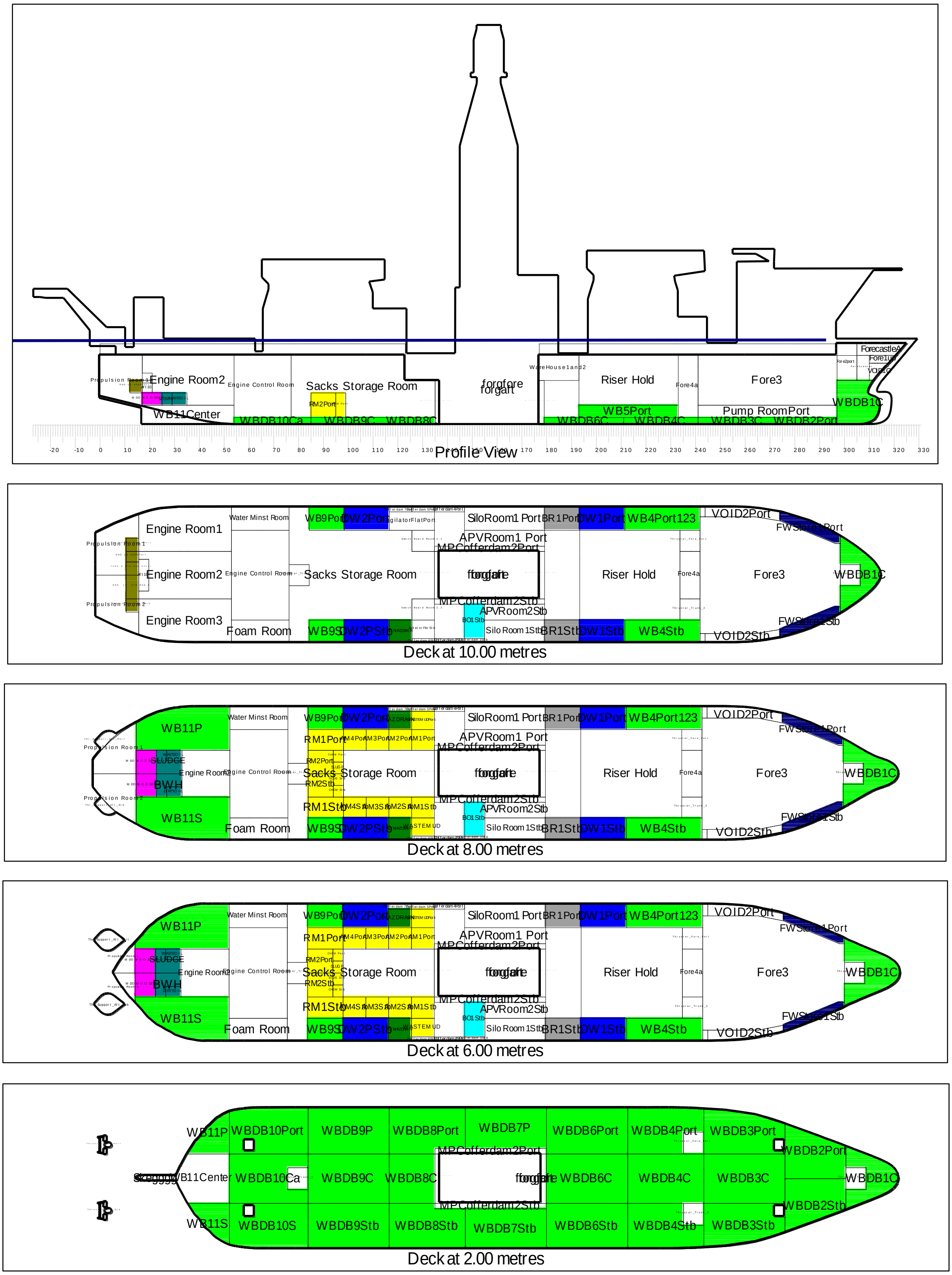


Figure 8.3 Configuration for Water Ballast, Fresh Water, and Marine oil Tanks

The above figures illustrated perceptibly the tanks arrangement with the colors used in Figure 8.2 is taken as a basis.

9. LIGHTSHIP WEIGHT ESTIMATION

The lightship weight is the actual weight of a ship when ready for service but empty of cargo. This includes the weight of scantling, painting, furniture, all machinery, propulsion, mooring, piping, and electrical systems. In order to calculate LCG, TCG, and VCG, the 3D modeling software AVEVA Hydrostatics, and Hydrodynamic module were used.

9.1. Definition of Weight Composition

The weight parameters used by the company throughout the lightship calculation are shown in Table 9.1 below.

Table 9.1 Lightship components followed by the company

Deadweight (DWT)	Loads		Weight & Load Budget
	Future Growth Margin		
	Design Margin		Gross Weight
Lightship Weight (LSW)	Contingency		
	Allowance	Constant Fluids	Net Weight
	Steel Weight	Item Weight	Dry Weight

The below section 9.2 is explained that equipment and component weights with summary tables which break down weights by 13 main weight groups. The ship hull (below main deck), X-Mas Tree, Substructure, Burner Booms, Accommodation, Derrick, Mud Module, Reel Module, Well Test Area, Superstructures aft and fore, Helideck, Funnel was listed along with each item's weight and LCG, TCG, and VCG from the origin of the reference system (Frame 0, centerline, baseline).

9.2. Lightweight Groups

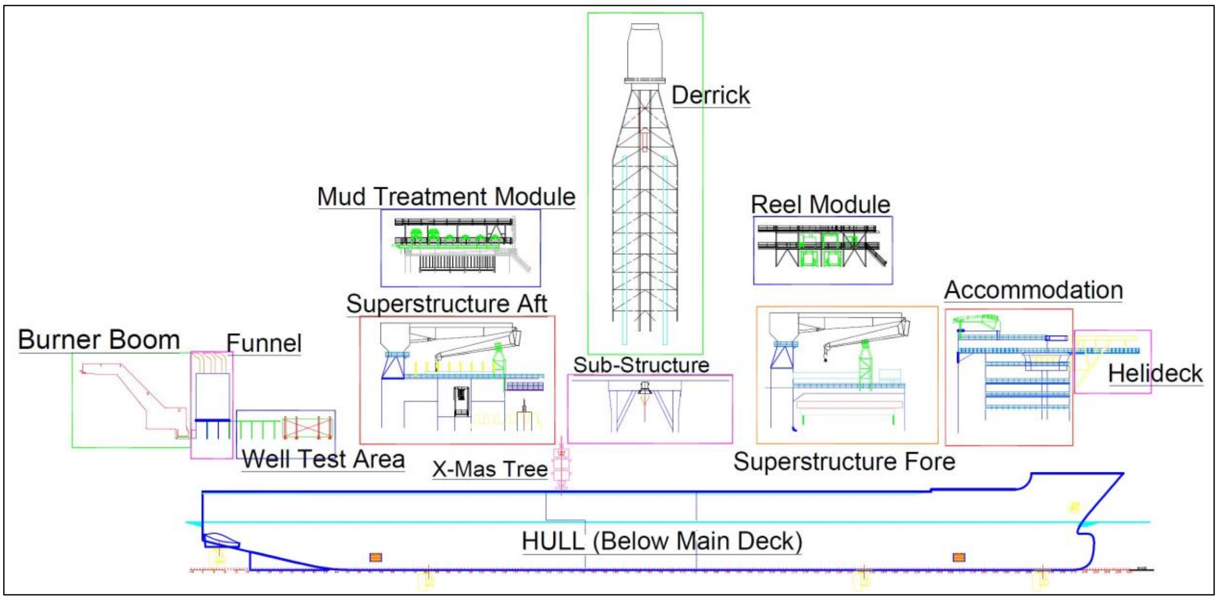


Figure 9.1 Estimated Lightweight Groups

Table 9.2 Estimated Lightweight Summary

Description	Net Weight [t]	Contingency %	Gross Weight [t]	LCG [m] from Fr0	TCG [m] from CL +PS	VCG [m] from BL	Frame Aft-Fore	xA [m]	xF [m]
Hull (Below Main D.)	16000	20%	19200	108,6	0,1	12,0	0-329	0,0	230,3
X-Mas Tree	80	30%	104	91,0	0,6	22,0	128-132	89,6	92,4
Substructure (İncl.Drillfloor)	2000	30%	2600	112,7	0,7	33,0	135-187	94,5	130,9
Burner Booms	90	30%	117	13,3	0,0	28,0	1-137	0,7	25,9
Accomodaion	1600	20%	1920	197,4	0,1	32,0	267-297	186,9	207,9
Derrick	800	30%	1040	108,5	-1,1	67,0	144-166	100,8	116,2
Mud Module (Starboard)	200	30%	260	77,0	-12,8	25,0	68-152	47,6	106,4
Reel Module (Portside)	150	30%	195	142,0	11,4	26,0	14-220	130,0	154,0
Well Test Area	130	30%	169	24,5	-0,1	24,0	26-44	18,2	30,8
Superstructure (Fore)	1100	20%	1320	157,5	0,2	31,0	197-253	137,9	177,1
Superstructure (Aft)	1800	20%	2160	61,6	0,6	31,0	66-110	46,2	77,0
Helideck	500	20%	600	217,0	0,0	44,0	296-324	207,2	226,8
Funnel	200	20%	240	14,0	0,3	28,0	14-26	9,8	18,2
Total			**29925**	**113,86**	**-0,11**	**20,37**			

9.3. Lightweight Distribution

AVEVA Hydrostatics and Hydrodynamics module were used to perform the lightship estimation and obtain the lightweight distribution, which is shown below in Figure 9.2.

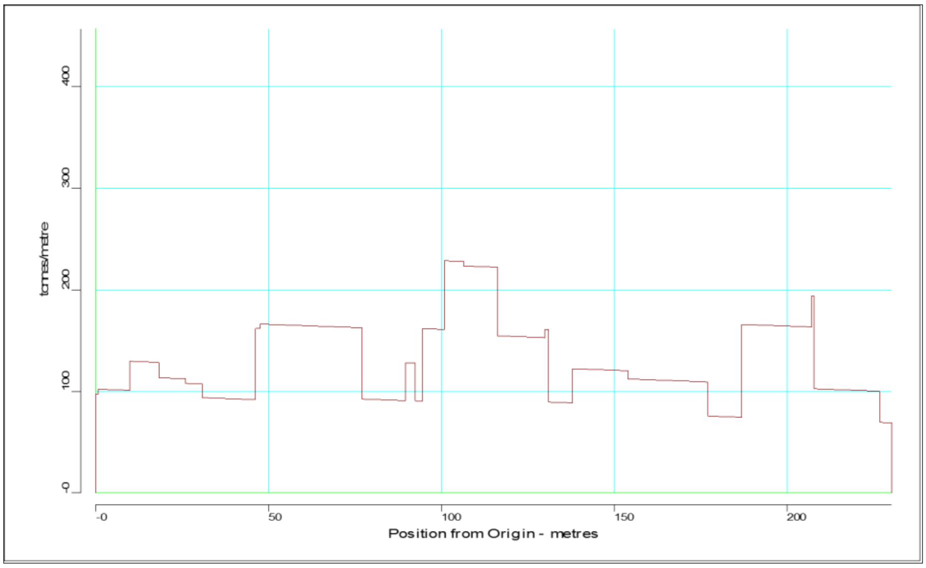


Figure 9.2 Estimated Lightweight Distribution

9.4. Deadweight Estimation

At the summer draught of 12, 0 m the deadweight is 503310, 04 tons by using following items.

Table 9.3 Deadweight Items

1 -	BOP Stack	11 -	Heavy Weight Drill Pipes
2 -	Casing 10"	12 -	Pipe Joints
3 -	Casing 14"	13 -	Provisions
4 -	Casing 20"	14 -	Riser system
5 -	Casing 30"	15 -	Riser yokes
6 -	Crew & Effects	16 -	Sacks
7 -	Drill Collars	17 -	Static Hook Load
8 -	Drill Pipes 5 7/8"	18 -	Third Part Equipment
9 -	Drill Pipes 5"	19 -	Tools and Equipment
10 -	Drill Pipes 7 & 6 5/8"		

10.LOADING CONDITIONS

For the design of the vessel, a limited of loading conditions have been considered representing the boundaries of the design envelope with respect to weight, the center of gravity and wind area. The loading conditions can be divided into following four categories;

- Harbor conditions
- Transit conditions
- Operating conditions
- In-field conditions

The loading conditions will be presented in a qualitative way which describes with schematic illustration. Only the loading conditions required by the classification have been considered for this study. For each individual loading conditions, the deadweight items loaded can be seen as an overview end of the chapter.

10.1.1. Harbour Conditions

10.1.1.1. Lightship

This loading condition represents the empty outfitted hull of the vessel (lightship weight) and including margins. This is a non-sailing condition.

10.1.1.2. Docking

This loading condition represents the vessel during dry docking as shown in Figure 10.1, the BOP is on board, riser joints and third part equipment have been offloaded. No casing and cuttings are stored on board. All drill pipe and drill collars are stored in tubular racks on superstructure deck aft.

- Drilling consumable levels (Cement, sacks, drill water, brine, and base oil) and all vessel consumable levels (Provisions, potable water, marine diesel oil and lubrication oil) are defined as %5.
- Water ballast was taken in to compensate for even heel and trim.

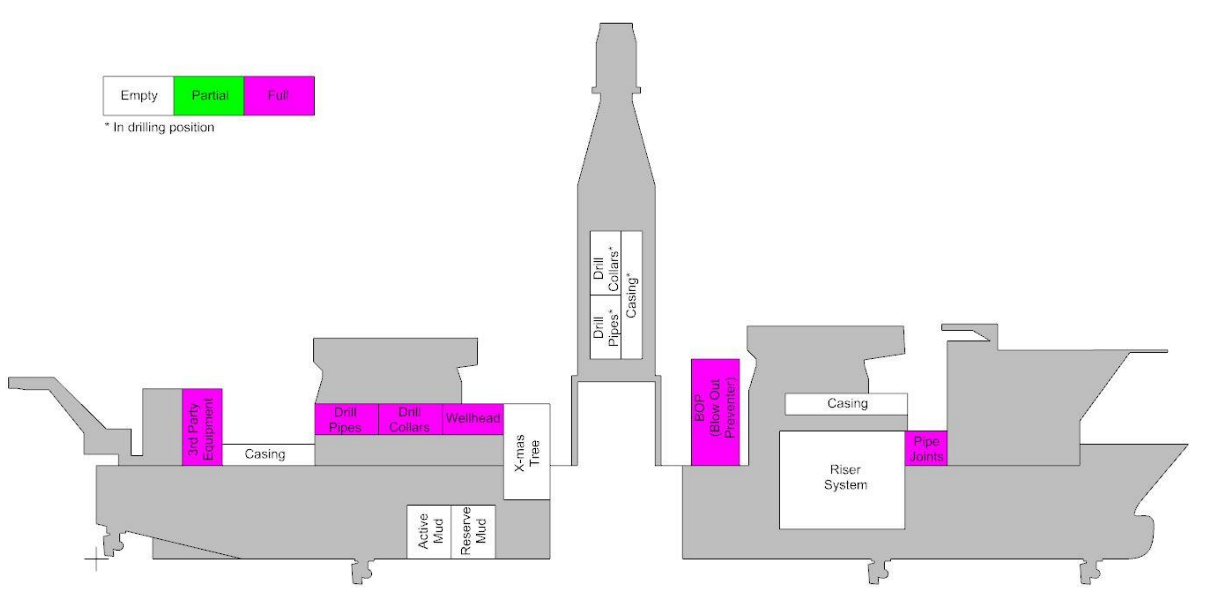


Figure 10.1 Docking Conditions

10.1.2. Transit Conditions

10.1.2.1. Transit with Casing – %100

This loading condition represents the vessel in departure condition as shown in Figure 10.2 with 100% consumables. There are no drilling loads (Static hook load, no riser tensioning load and setback load). All stored riser joints and the BOP are located forward of the moonpool. All drilling tubular (drill pipe, drill collars, and casing) are stored in tubular racks on superstructure deck forward, superstructure deck aft and main deck.

- Drilling consumable and vessel consumable levels are maximum. Active and reserve mud tanks are empty also, no cuttings and no waste are stored on board.
- Water ballast was taken in to compensate for even heel and trim.

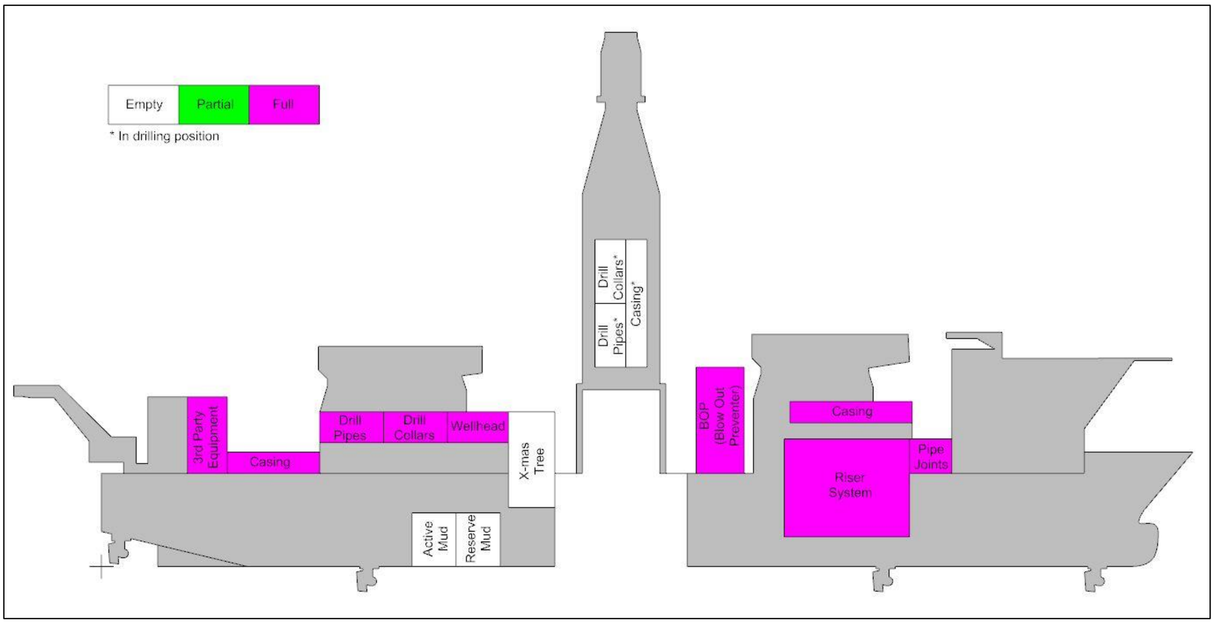


Figure 10.2 Transit with Casing Conditions

10.1.2.2. Transit with Casing – %10

This loading condition represents the vessel in arrival condition with 10% consumables. This condition is identical to transit with casing 100% except for following;

- 10% drilling consumables are on board.
- 10% vessel consumables are on board.
- 90% dirty oil and waste are produced.

10.1.2.3. Transit without Casing – %10

This loading condition represents the vessel in arrival condition with 10% consumables. This condition is identical to transit with casing 10% except for following,

- No casing is stored on board.

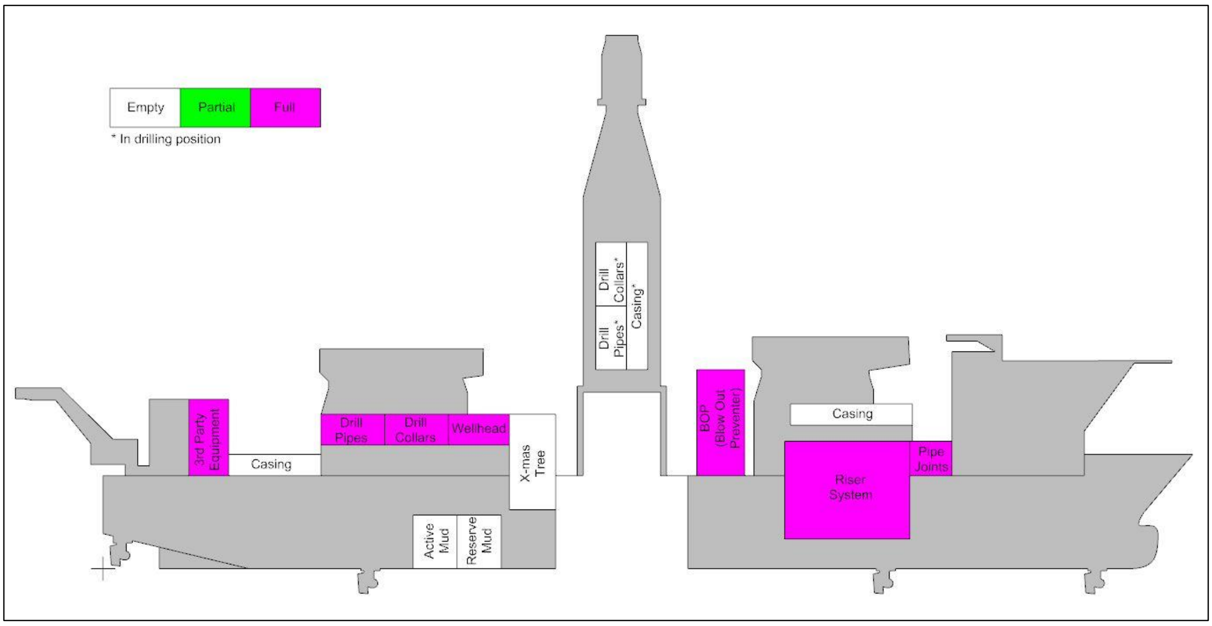


Figure 10.3 Transit without Casing Conditions

10.1.3. Operating Conditions

10.1.3.1. Drilling – %100

This loading condition represents the vessel during drilling as shown in Figure 10.4 with %100 consumables. The drill string has been built up and drilling operations have been started after connecting to the well. It is assumed that a hole section of the well is being drilled.

- The most drill pipe and drill collars are being used for the drilling operation. The large part of the casing string is transferred to the setback and is prepared for running. In addition, the third part of the equipment is on board as required.
- All riser joints are removed from the riser hold. The remainder of the casing is stored in tubular racks on superstructure deck forward and main deck.
- Drilling consumable levels are at maximum. Mud is circulated that means, minimum volume residing in the active mud tanks is equal to the volume of the cased hole plus the volume of the open hole, including excess. Active and reserve mud tanks are filled up to 30% and 50%, respectively. In addition, cuttings are stored on board.
- Drilling consumable and vessel consumable levels are maximum. Dirty water and dirty oil tanks are empty also no waste on board.
- Water ballast was taken in to compensate for even heel and trim.

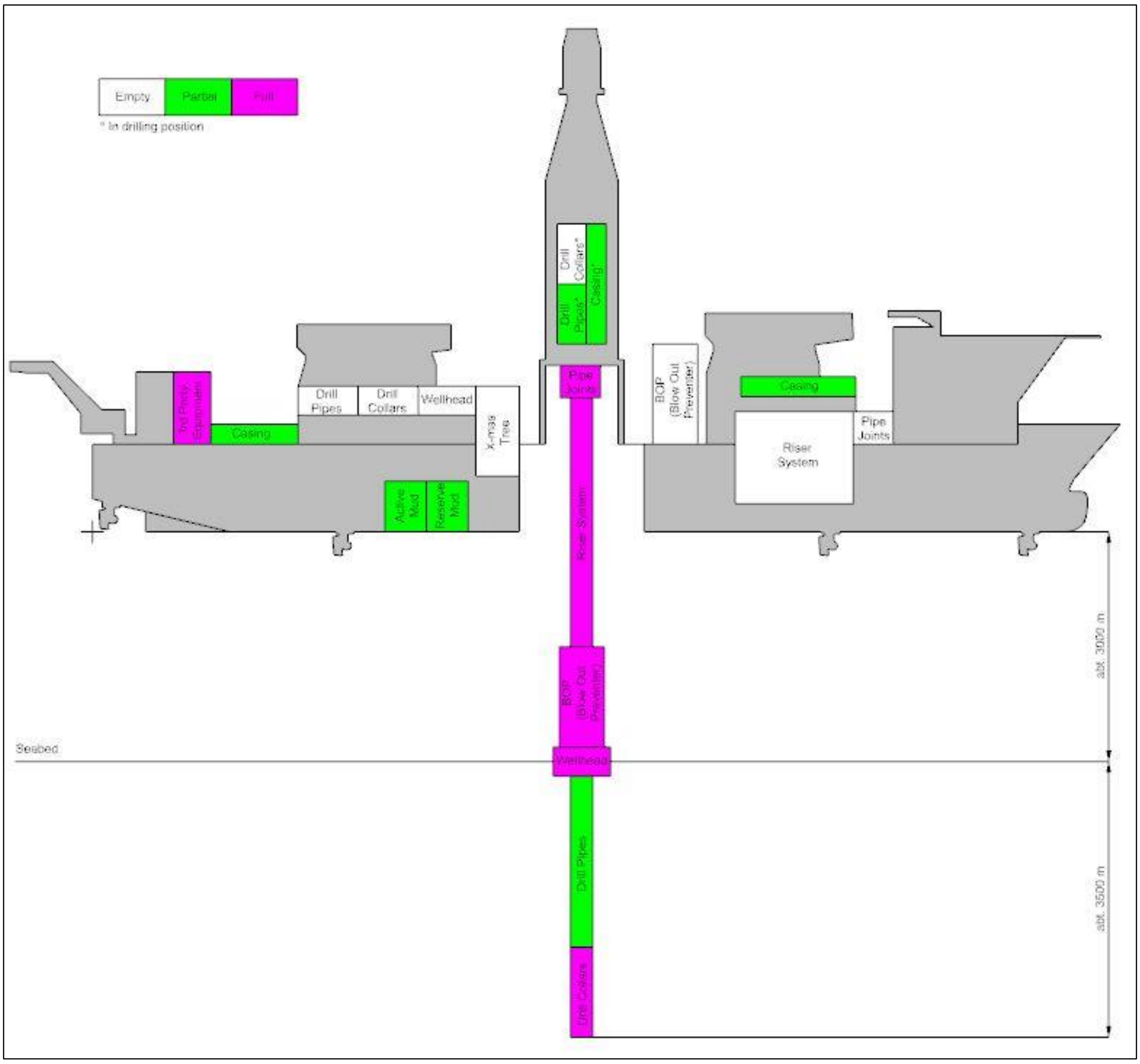


Figure 10.4 Drilling Conditions

10.1.3.2. Drilling – %10

This loading condition represents the vessel during the drilling operation with 10% consumables. This condition is identical to drilling 100% except for following;

- 10% drilling consumables are on board.
- 10% vessel consumables are on board.
- 90% dirty oil and waste are produced.

10.1.3.3. Start Running Casing – %100

This loading condition represents the vessel ready for running casing as shown in Figure 10.5 with 100% consumables. The drill string is tripped out and racked back in the setback when having drilled a hole section of the well. The larger part of the casing string is stored in the setback to being ready for running.

- All riser joints are removed from the riser hold. The remainder of the casing is stored in tubular racks on superstructure deck forward and main deck. Third part equipment and cuttings are stored on board as required. Also, there is no hook load.
- Drilling consumable levels are at maximum. Active and reserve mud tanks are filled up to 30% and 50%, respectively.
- Drilling consumable and vessel consumable levels are maximum. Dirty water and dirty oil tanks are empty also no waste on board.
- Water ballast was taken in to compensate for even heel and trim.

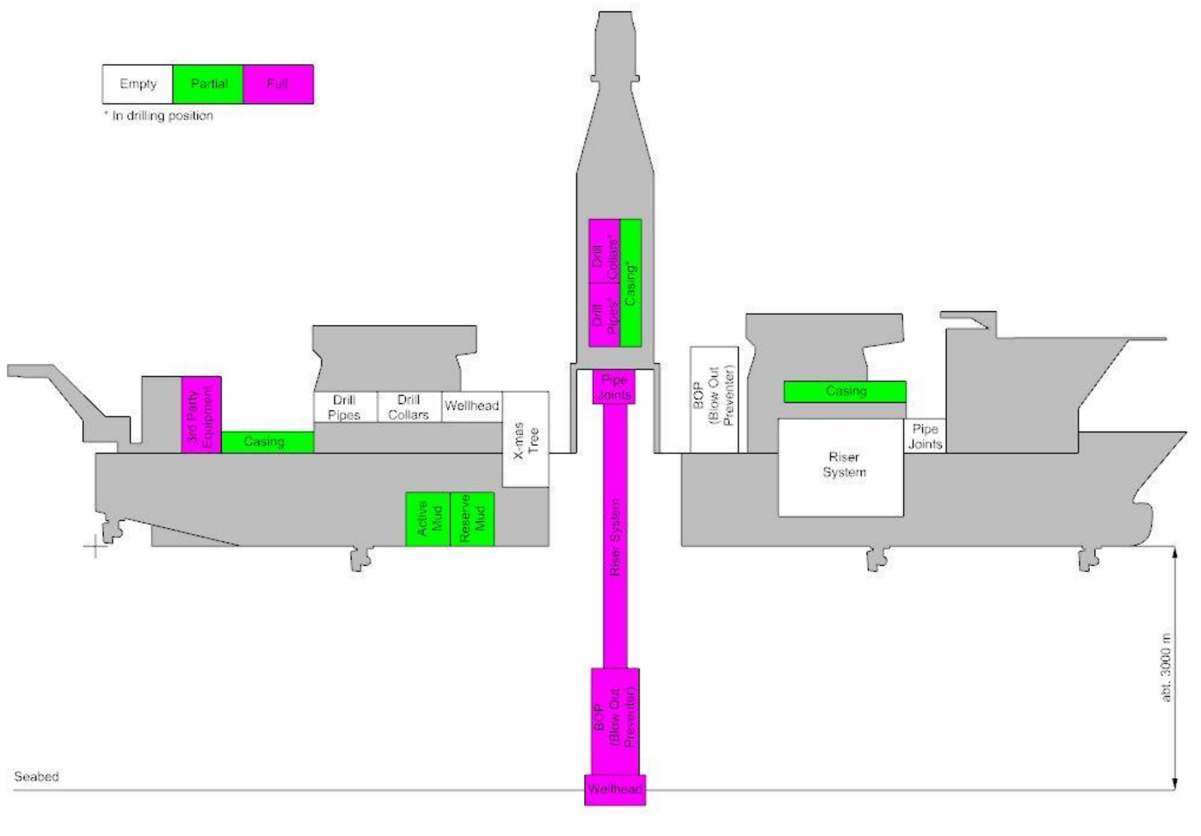


Figure 10.5 Starting Running Casing Conditions

10.1.3.4. Start Running Casing – %10

This loading condition represents the vessel ready for running casing with 10% consumables. This condition is identical to start running casing 100% except for following;

- 10% drilling consumables are on board.
- 10% vessel consumables are on board.
- 90% dirty oil and waste are produced.

10.1.3.5. Running Casing – %100

This loading condition represents the vessel during running casing as shown in Figure 10.6 with 100% consumables. The heaviest casing string is being lowered into the well using the landing string. Maximum riser tensioning load assumed. The setback is filled with drill pipe and drill collars.

- All riser joints are removed from the riser hold. The remainder of the casing is stored in tubular racks on superstructure deck forward and main deck. Third part equipment and cuttings are stored on board as required. Also, there is no hook load.
- Drilling consumable levels are at maximum. Active and reserve mud tanks are filled up to 30% and 50%, respectively.
- Drilling consumable and vessel consumable levels are maximum. Dirty water and dirty oil tanks are empty also no waste on board.
- Water ballast was taken in to compensate for even heel and trim.

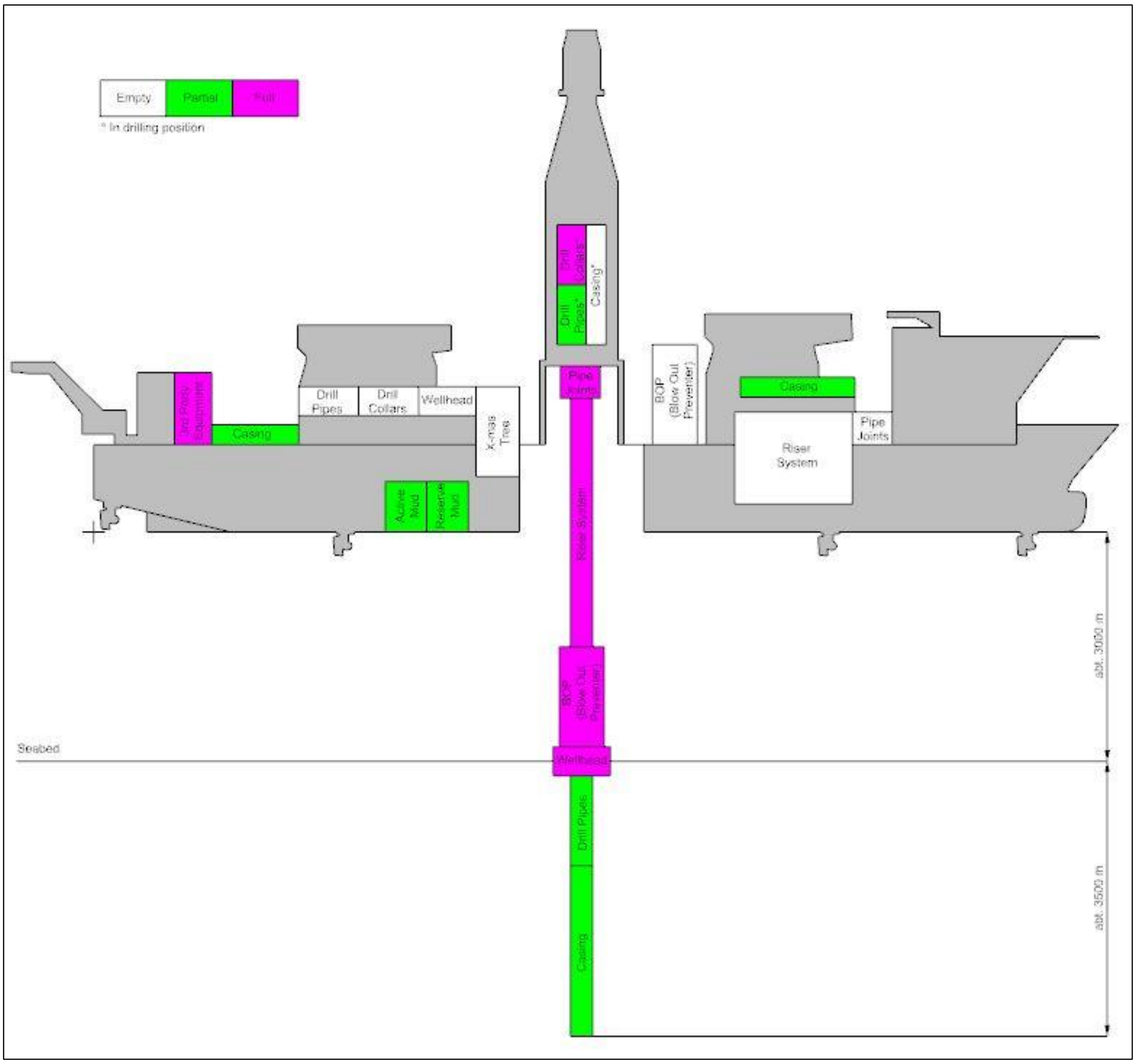


Figure 10.6 Running Casing Conditions

10.1.3.6. Running Casing – %10

This loading condition represents the vessel during running casing with 10% consumables. This condition is identical to running casing 100% except for following;

- 10% drilling consumables are on board.
- 10% vessel consumables are on board.
- 90% dirty oil and waste are produced.

10.1.4. In-Field Conditions

10.1.4.1. Stand by – %100

This loading condition represents the vessel in stand-by condition as shown in Figure 10.7 with 100% consumables. Drilling operations are suspended and preparations are made for a disconnect. The vessel is connected to the well, however, the drill string has already been tripped out. Maximum riser tensioning load assumed. The setback is filled with drill pipe and drill collars.

- All riser joints are removed from the riser hold. The remainder of the casing is stored in tubular racks on superstructure deck forward and main deck. Third part equipment and cuttings are stored on board as required. In addition, there is no hook load.
- Drilling consumable and vessel consumable levels are maximum. Mud circulation is stopped also, active and reserve mud tanks are filled up 50%. Dirty water and dirty oil tanks are empty also, no waste on board.
- Water ballast was taken in to compensate for even heel and trim.

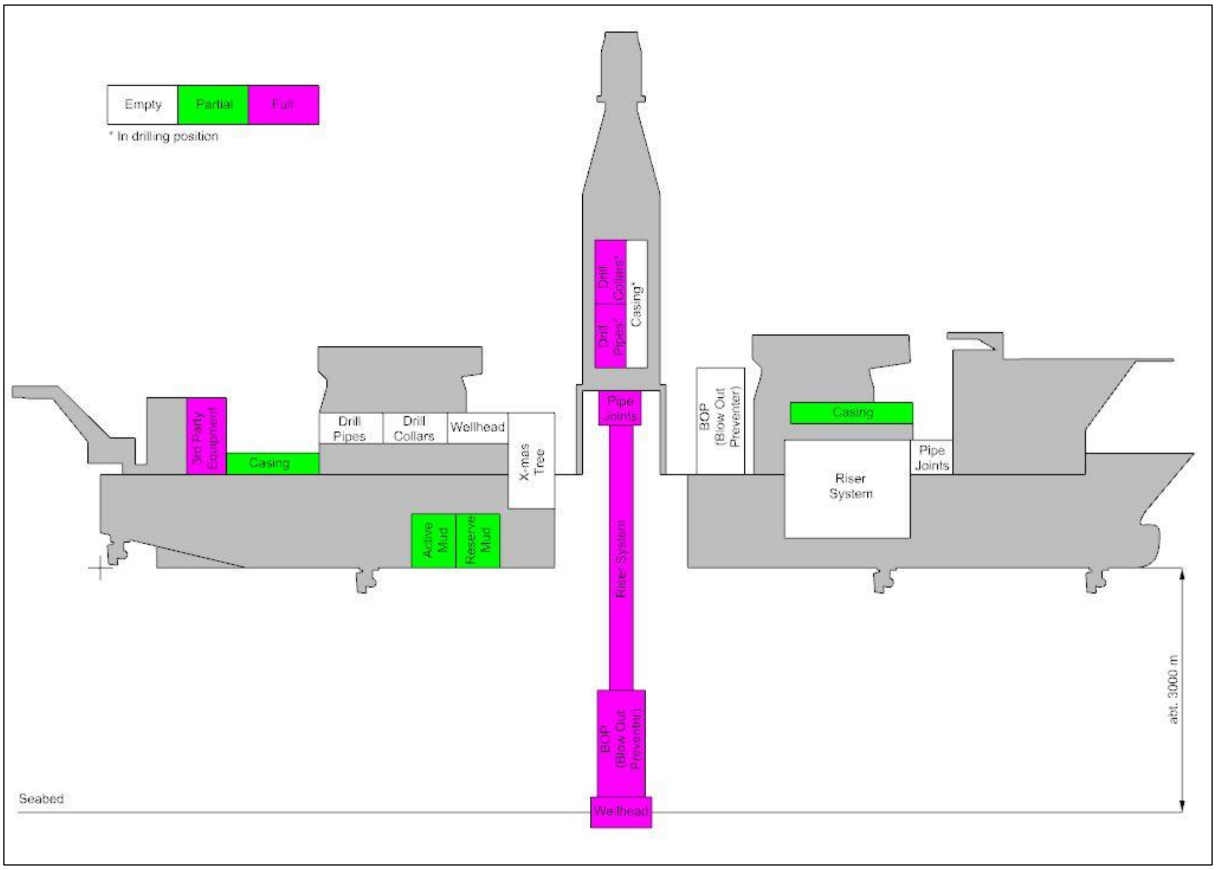


Figure 10.7 Stand-by Conditions

10.1.4.2. Stand by – %10

This loading condition represents the vessel in stand-by condition with 10% consumables. This condition is identical to stand-by 100% except for following;

- 10% drilling consumables are on board.
- 10% vessel consumables are on board.
- 90% dirty oil and waste are produced.

10.1.4.3. In-Field Survival – %100

The loading condition represents the vessel during in-field survival as shown in Figure 10.8 with 100% consumables. The vessel stays dynamically positioned in the field to ride out a storm, after planned disconnected. The setback is partially filled with drill pipe. There is no static hook load and no riser tensioning load. The BOP is sea fastened in the transporter forward in the moonpool. Third part equipment and cuttings are stored on board as required.

- All riser joints are stored in the riser hold. Drill tubular (drill pipe, drill collars, and casing) are stored in tubular racks on superstructure deck forward, superstructure deck aft and main deck.
- Drilling consumable and vessel consumable levels are maximum. The active mud tanks are filled up to their maximum capacity and the reserve mud tanks are filled up to 50%. Dirty water and dirty oil tanks are empty also, no waste on board.
- Water ballast was taken in to compensate for even heel and trim.

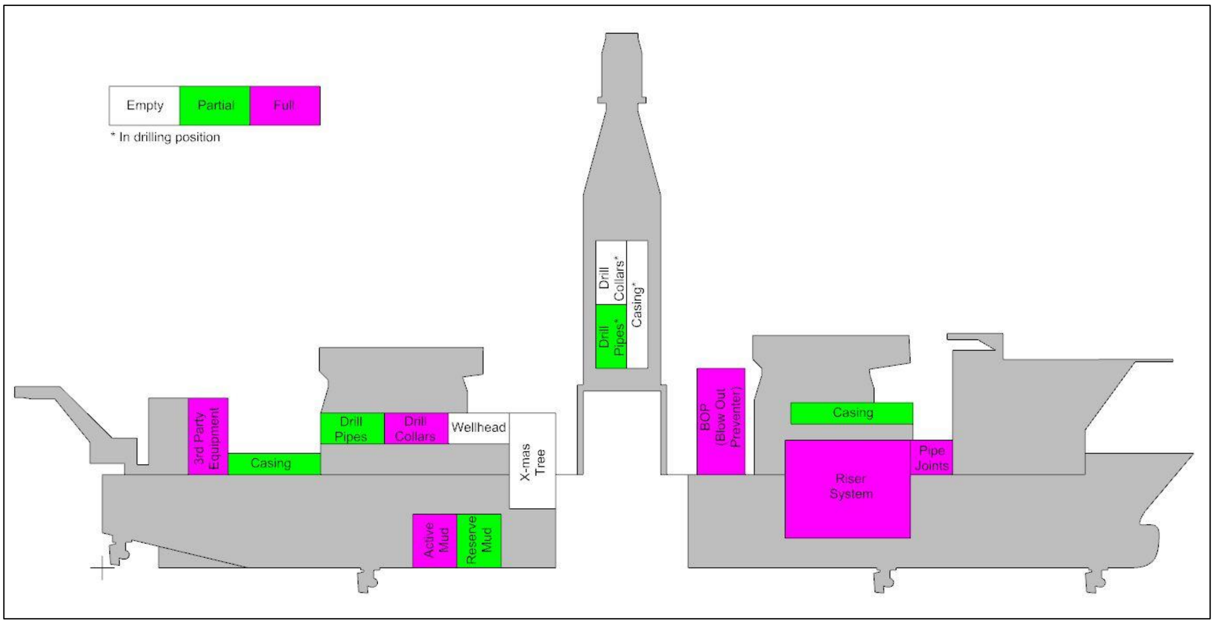


Figure 10.8 In-field Survival Conditions

10.1.4.4. In-Field Survival – %10

This loading condition represents the vessel during in-field survival with 10% consumables. This condition is identical to in-field survival 100% except for following;

- 10% drilling consumables are on board.
- 10% vessel consumables are on board.
- 90% dirty oil and waste are produced.

11.INTACT STABILITY & SFBM PRELIMINARY EVALUATION

11.1.General

The loading conditions defined in Chapter can be analyzed with regard to Intact stability criteria as required by the 2008 Intact Stability Code.

In general commercial ships which have a conventional propulsion arrangement in the aft part (engine & propeller) the maximum acceptable trim is 1,5% of aft perpendicular. This is to ensure propeller immersion. The trim can also be limited by equipment (e.g. Cranes) functionality profile. As for this design, propulsion is by thrusters and at this stage, we have no information of any of the equipment maximum operational profiles, we will limit the trim by 1,5% of aft perpendicular. This means a trim of max 3,3 m or 0,8 degrees.

11.2.Intact Stability Calculation

11.2.1. Criteria

The following criteria were considered during the intact stability calculation. The criteria can be further explained and defined in Appendix 8.

- International Code on Intact Stability 2008.
- Severe wind and rolling criterion (Weather criteria).
- MARPOL 73/78 Annex 1 (2011 Edition) Reg.
- ABS Rules For Building And Classing Steel Vessels 2012 / Part 3 Hull Construction And Equipment.

11.2.2. Wind Profile

The wind profile used for stability calculations was made based on the General Arrangement plan and is presented in Appendix 3.

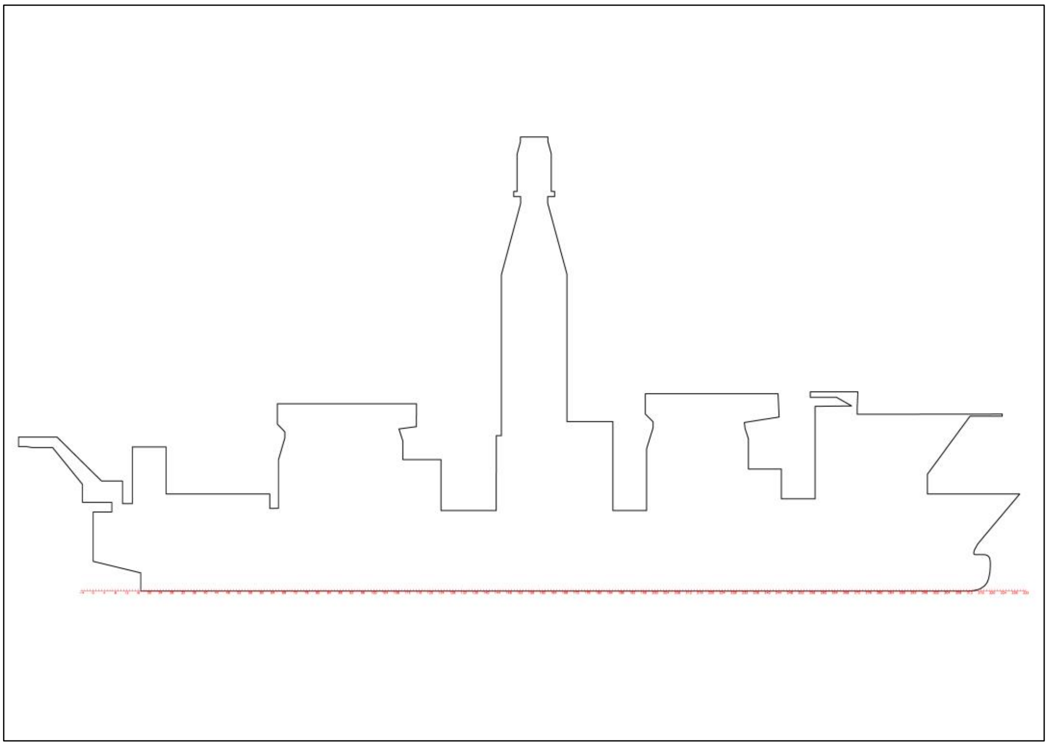


Figure 11.1 Drillship Wind Profile

11.2.3. Watertight and Weathertight Integrity

For stability calculating purposes, the number of deck openings and a deck margin line were specified. These openings can be categorized in the following categories,

- **Unprotected** – Gives no protection to the ingress of water into the connected compartment(s).
- **Weathertight** – Protects connected compartment(s) from unrestricted ingress of water during a brief submergence of the openings. However weathertight openings have to remain above the final waterline in both damaged and intact conditions.
- **Watertight** – Protects any compartment from flooding above or below the final waterline in damaged or intact condition.

All openings considered in the stability calculations are in the most vulnerable locations, such as weathertight vent pipes on the side forward and aft. Special attention will be made to non-watertight doors, ventilation inlet, and outlets. List of unprotected openings used in intact stability calculations is shown in following Table 11.1. In addition, deck margin line is defined as a table in Appendix 9.

Table 11.1 Un-Protected Opening List

Number of Un-Protected Openings	x [m]	y [m]	z [m]	Compartment
0	9,84	-3,07	32,52	EngineRoom3
1	9,84	3,07	32,52	EngineRoom1
2	9,81	-6,11	34,25	EngineRoom2
3	9,81	6,11	34,25	EngineRoom2
4	10,02	-6,38	28,43	EngineRoom1
5	12,85	-6,38	28,43	EngineRoom1
6	10,02	-6,38	30,24	EngineRoom1
7	12,85	-6,38	30,24	EngineRoom1
8	10,02	-6,38	32,4	EngineRoom2
9	12,85	-6,38	32,4	EngineRoom2
10	10,02	6,38	28,43	EngineRoom3
11	12,85	6,38	28,43	EngineRoom3
12	10,02	6,38	30,24	EngineRoom3
13	12,85	6,38	30,24	EngineRoom3
14	10,02	6,38	32,52	EngineRoom2
15	12,85	6,38	32,52	EngineRoom2
16	69,34	9,91	24,34	SacksStorageRoom
17	69,34	-9,91	24,34	SacksStorageRoom
18	119,42	8,3	27,69	APVRoom2Stb
19	120,79	10,4	27,69	APVRoom2Stb
20	119,06	9,53	27,14	WareHouse1and2
21	137,18	-12,8	24,97	APVRoom1 Port
22	143,5	11,2	21,35	RiserHold
23	143,5	-11,2	21,35	RiserHold
24	171,5	11,2	21,35	RiserHold
25	171,5	-11,2	21,35	RiserHold

11.2.4. Free Surface Corrections

The free surface effects were considered according to their filling level for all cargo, ballast and process tanks.

For bunker tanks, the free surface moments were considered such that for each type of liquid at least one transverse pair or a single centerline tank has a free surface and the tank or combination of tanks taken into account should be those where the effect of free surfaces is the greatest.

Provided a tank is completely filled with liquid no movement of the liquid is possible and the effect on the ship's stability is precisely the same as if the tank contained solid material.

As soon as a quantity of liquid is withdrawn, from a tank, the situation changes completely and the stability of the ship is adversely affected by what is called the "free surface effect". This adverse effect on the stability is referred as a "loss in GM" or as a "virtual rise in VCG" and is calculated as follows:

$$Loss\ in\ GM(Rise\ of\ KG)\ due\ to\ Free\ Surface\ Effec\ t =$$

$$\frac{\sum Free\ Surface\ Moments\ [m^4]\ X\ Density\ of\ Liquid\ in\ Tanks\ [\frac{t}{m^3}]}{Displacement\ of\ Vessel\ [t]}$$

11.2.5. Cross Curves of Stability

The Cross Curves of Stability are used to determine the length of the righting arm at any angle of inclination for a given displacement. Using the ship's displacement (from the Draft Diagram and Functions of form) a statical stability curve for the ship can be constructed. The process can be summarized as following steps. Each righting arm is plotted at the corresponding angle of inclination on graph paper.

- Determine Ships Displacement and Vertical Centre of Gravity (KG).
- Enter the Cross Curves Table corresponding to the Draught and Net Volume of the Buoyant Hull (Displacement/Water Density).
- Extract the corresponding form stability levers (KN) values for each angle of inclination.
- Determine the righting arm (GZ) for each KN value: $GZ = KN – KG * \sin\theta$

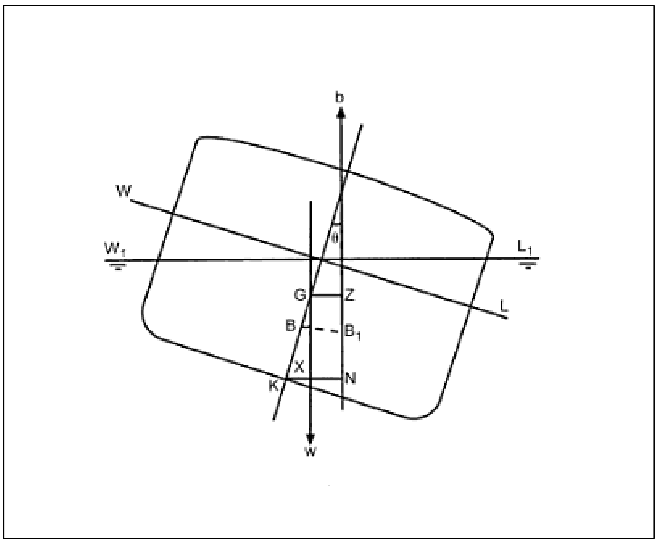


Figure 11.2 GZ-Curve definition for Intact Stability Calculations Available from http://www.boatdesign.net/forums/stability/kn-curves-problem-46049.html

$$GZ = KN - KG * sin\theta$$

Where,

M= Metacenter

G= Centre of Gravity

K=Keel

θ= Angle of Inclination

GZ= Righting Moment Lever

KN= Stability from Lever

11.2.6. Intact Stability Check Results

The simulated loading conditions are generated for the purpose of classifications. Appendix 12A and Appendix 12B are included all intact stability results. GZ curve, one of the most important parameters of stability calculations, has been added into study as an Appendix 13.

11.3. Shear Force and Bending Moment Envelope

The Shear Force and Bending Moment assessment, based on the same loading conditions, at the concept design stage determines the effective strength limits of the ship based on defined loading conditions, which will serve as input for the Midship section design and the effective Shear Force and Bending Moment envelope will serve as input for the generation of the longitudinal strength limits of the ship (scantling evaluation). The maximum shearing force and bending moment falling on the ship in relation to loading conditions can be easily seen from the list below. Furthermore, the distribution of loading conditions according to each frame is shown in Appendix 14.

Table 11.2 Maximum Shear Force and Bending Moments for all conditions

	Max. Shearing Force [kN]	Max Bending Moment [kNm]	Max. Shearing Force Position [m]	Max Bending Moment Position [m]
Docking	20013.7	920576.7	26.16	86.1
Transit with casing %10	23808.6	1056878.1	38	81.9
Transit with casing %100	21699.33	652750.5	168.7	86.1
Transit without casing %10	-18822.2	660406.4	189.13	163.77
Transit without casing %100	-23036.1	695413	191.1	168.7
Drilling 10%	-33180	1413052.4	188.9	152.35
Drilling 100%	22347.4	485741.8	163.1	179.56
Start Running Casing 10%	-25677.7	919209.6	197.69	172.3
Start Running Casing 100%	-30408.3	972504.9	193.05	175
Running Casing 10%	-27838.6	1032525.1	195.1	134.47
Running Casing 100%	-45325.6	1627980.9	191.1	161.53
Stand by 10%	-3330.2	1322191.5	188.9	157
Stand by 100%	-32990.4	1027598.2	191.73	174.75
In-field Survival 10%	-23229	756026.7	201.55	179.56
In-field Survival 100%	27957.8	756160.4	163.1	180.89

12.CONCLUSIONS

The initial design stage of a ship is of utmost importance as it will define ship characteristics which are very hard (with great costs) or almost impossible to modify after the design process goes into the basic and detail design stages. All calculations and drawing done should be revised and optimized at least by one iteration. Further iterations on the above design spiral are necessary for all the areas of the vessel before arriving at the optimum results.

Using numerical approaches to calculating the resistance of special modern ships can really be a bit far away. It was seen in the CFD runs that the effect of the Moonpool on the total resistance of the ship is at least twenty percent. Moonpool covers a very large part of the total ship's resistance. One of the most important parameters for drilling vessels, estimation of thrust power is in relation to dynamic position. For this reason, calculating the power of the main engine power and thrusts calculated in the preliminary calculations can provide convenience for future design phases.

For drilling vessels, it is very important that the stability calculations are carried out in accordance with all kinds of operation scenarios. The stability issue of the drillship is not only important during the journey, but also has to be, safety, profitable and rigorous throughout the operation.

This thesis covers some major aspects of the initial design process of a drillship but can and for a complete analysis should be followed, at a minimum, by the following calculations:

- Damage stability calculations
- Scantling evaluation
- Midship section design
- Seakeeping evaluation
- Cost evaluation

13.REFERENCES

[1]@2015 Drillships and Semisubs for Dummies. Retrieved July 12, 2016, from https://rigzonenews.wordpress.com/2014/10/01/drillships-and-semisubs-for-dummies/

[2] Veer, R. V., & Tholen, H. J. (2008). Added Resistance of Moonpools in Calm Water. Volume 6: Nick Newman Symposium on Marine Hydrodynamics; Yoshida and Maeda Special Symposium on Ocean Space Utilization; Special Symposium on Offshore Renewable Energy. doi:10.1115/omae2008-57246

[3] Hammargren, E., & Tornblom, J. (n.d.). Effect of the Moonpool on the Total Resistance of a Drillship. Retrieved February 2012, from Chalmers University of Technology, Division of Marine Design. Master of Science Thesis

[4] Watson, D. G. (1998). Practical ship design. Amsterdam: Elsevier.

[5] Barrass, C. B., Derrett, D. R., & Barrass, B. (2012). Ship stability for masters and mates (7th ed.). Oxford: Butterworth-Heinemann.

[6] Barrass, C. (2004). Ship Trials. Ship Design and Performance for Masters and Mates, 116-119. doi:10.1016/b978-075066000-6/50014-3

[7] Holtrop, J., and Mennen, G.G.J., An Approximate Power Prediction Method, International Shipbuilding Progress, Volume 89, 1982.

[8] J. Holtrop. A statistical re-analysis of resistance and propulsion data. International Shipbuilding Progress, 31(363):272-276, November 1984.

[9] J. Holtrop, "A Statistical Resistance Prediction Method with a Speed Dependent Form Factor. " 1988.

[10] Toshifumi Fujiwara, Michio Ueno, and Yoshiho Ikeda. Cruising performance of a large passenger ship in heavy sea. In Proceedings of the Sixteenth (2006) International Oshore and Polar Engineering Conference, pages 304-311. The International Society of Oshore and Polar Engineers, 2006.

[11] Steddum, Riddle; Herrmann, Robert P. "Thrust Required and Holding Capacity". Houston, USA: Dynamic Positioning Conference, 21 – 22 October, 1997.

[12] The International Marine Contractors Association, Specification for DP Capability Plots, Report no: IMCA M 140 Rev. 1, June 2000

[13] Eyres, D. J., & Bruce, G. J. (2012). Ship construction (6th ed.). Oxford: Butterworth-Heinemann.

[14] Papanikolaou A (2009a) Ship design—methodologies of preliminary ship design (in Greek: Μελέτη Πλοίου - Μεθοδολογίες Προμελέτης Πλοίου), SYMEON Publisher, Athens, Vol 1, ISBN 978-960-9600-09-01 & Vol. 2, ISBN 978-969-9400-11-4, October 2009

[15] Trees Full of Money. Retrieved November 19, 2016, from http://www.treesfullofmoney.com/an-introduction-to-drilling-offshore-oil-wells/

[16] NA 470. Course Notes. Parsons, M.G. University of Michigan. Ann Arbor, MI. Fall, 2002

[17] Christiaan de Wit. Wave Optimal Thrust Allocation Methods for Dynamic Positioning of Ships. Master's thesis, Delft University of Technology, July 2009.

[18] Weather and ocean forecast maps. (n.d.). Retrieved December 3, 2016, from http://globalsailingweather.com/showMap.php?dom=cari1&sn=01

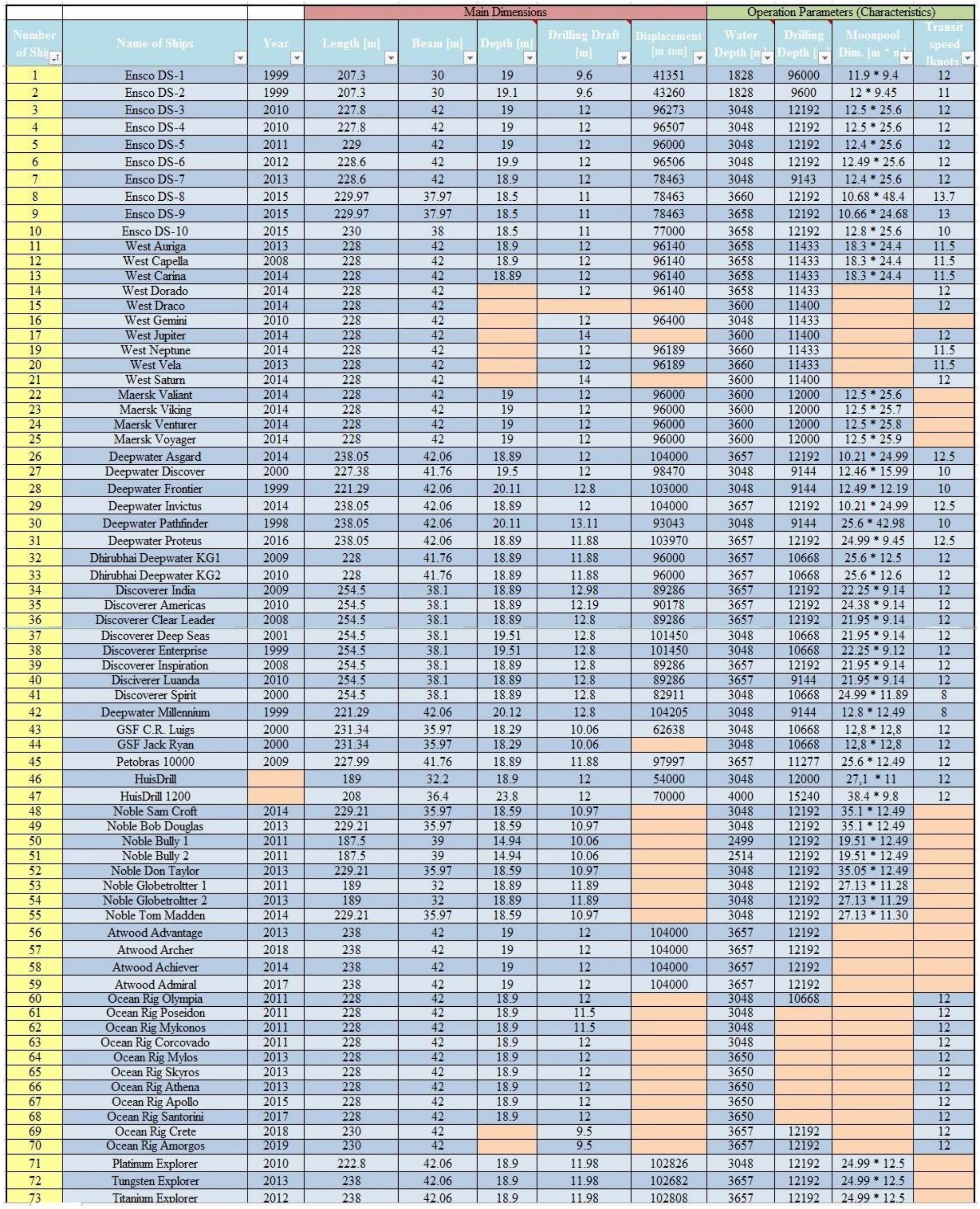
[19] Current Marine Data Oceanweather Inc. (n.d.). Retrieved December 3, 2016, from http://www.oceanweather.com/data/

[20] Molland, A. F. (2008). The maritime engineering reference book: a guide to ship design, construction and operation. Amsterdam: Butterworth-Heinemann.

[21] Lamb, T. (2003). Ship design and construction. Jersey City, NJ: Society of Naval Architects and Marine Engineers.

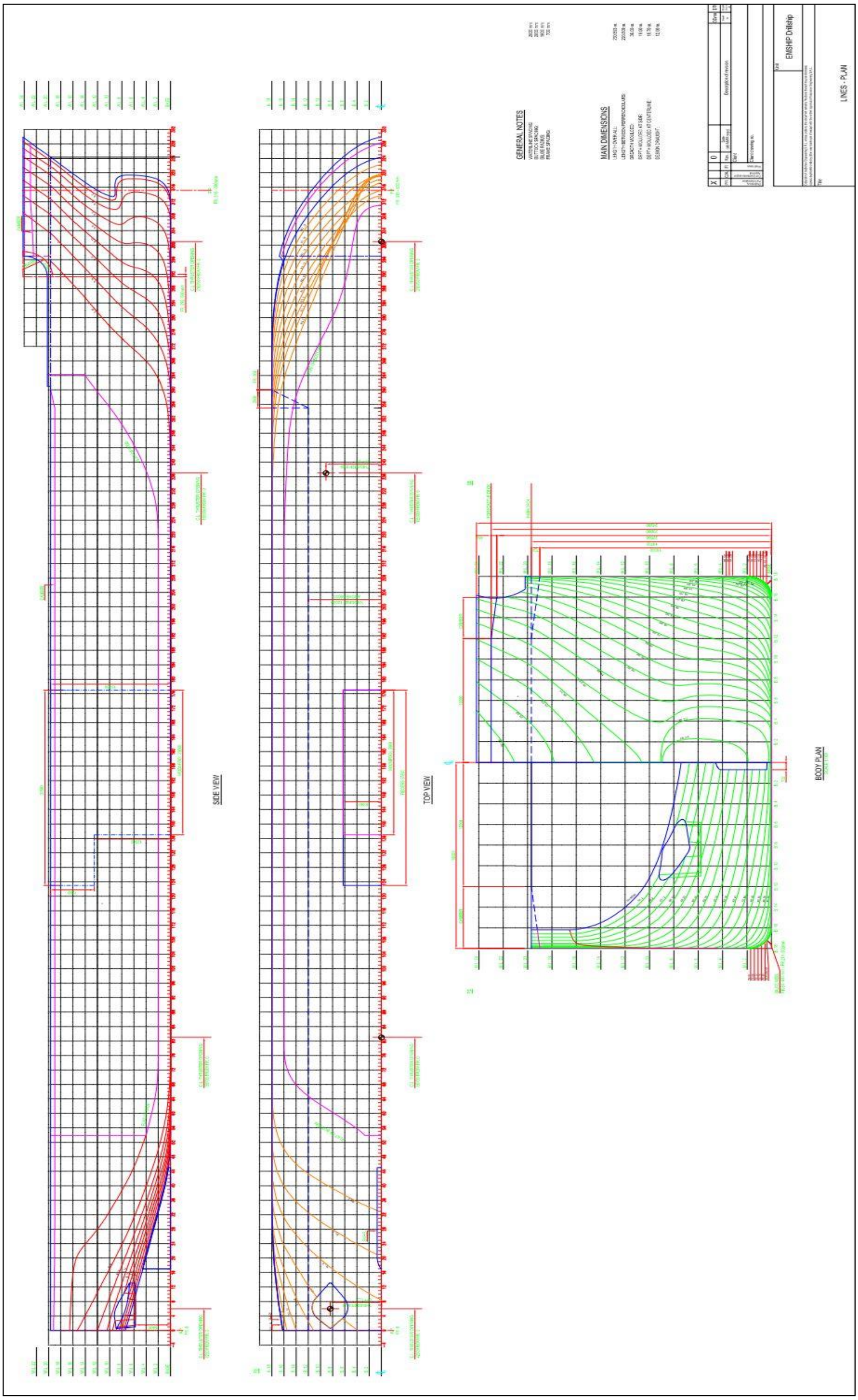
14.APPENDIX

Appendix 1 – Database

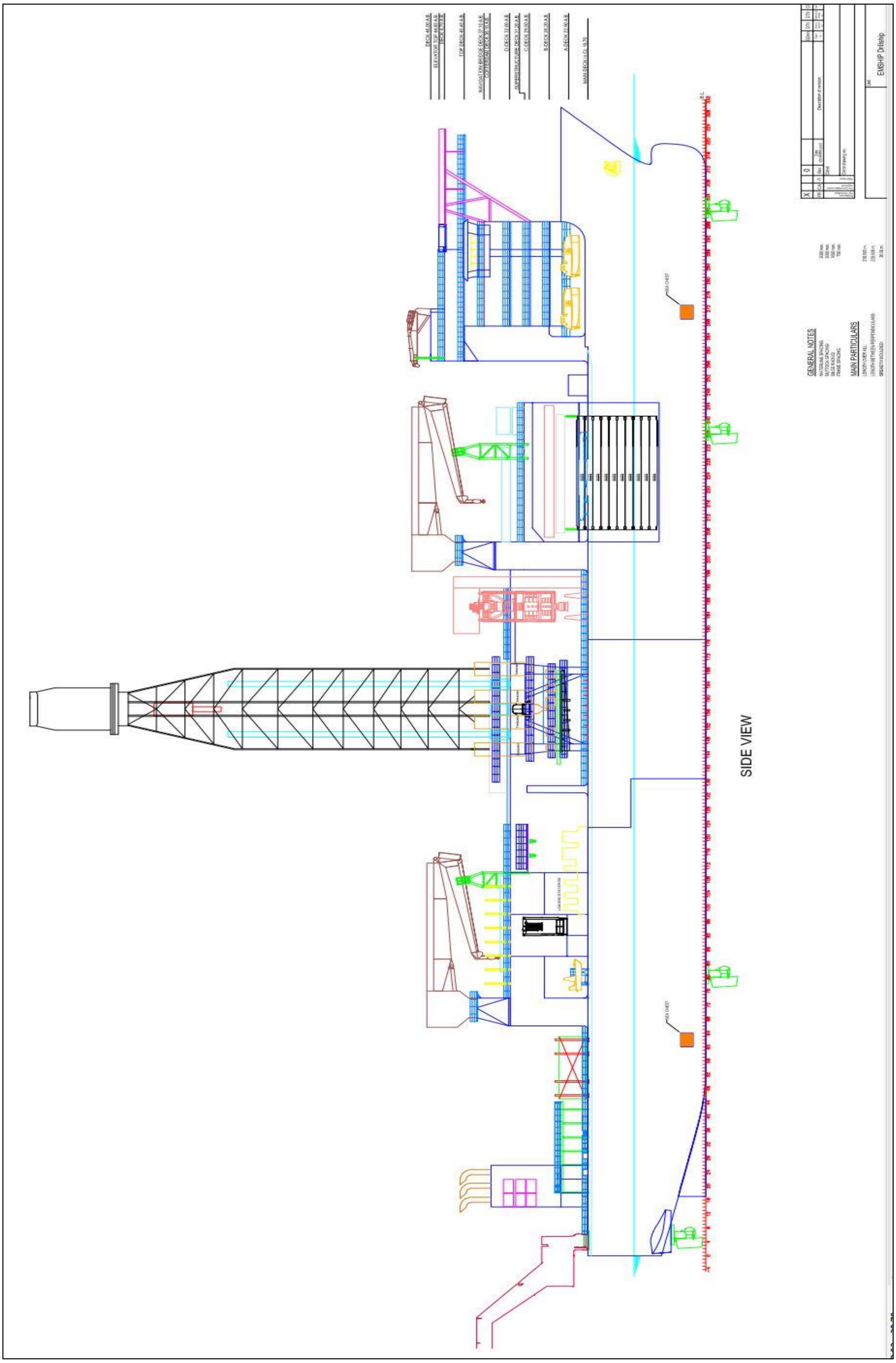


			Main Dimensions					Operation Parameters (Characteristics)			
Number of Shi	Name of Ships	Year	Length [m]	Beam [m]	Depth [m]	Drilling Draft [m]	Displacement [m ton]	Water Depth [n	Drilling Depth [	Moonpool Dim. [m * n	Transit speed [knots
1	Ensco DS-1	1999	207.3	30	19	9.6	41351	1828	96000	11.9 * 9.4	12
2	Ensco DS-2	1999	207.3	30	19.1	9.6	43260	1828	9600	12 * 9.45	11
3	Ensco DS-3	2010	227.8	42	19	12	96273	3048	12192	12.5 * 25.6	12
4	Ensco DS-4	2010	227.8	42	19	12	96507	3048	12192	12.5 * 25.6	12
5	Ensco DS-5	2011	229	42	19	12	96000	3048	12192	12.4 * 25.6	12
6	Ensco DS-6	2012	228.6	42	19.9	12	96506	3048	12192	12.49 * 25.6	12
7	Ensco DS-7	2013	228.6	42	18.9	12	78463	3048	9143	12.4 * 25.6	12
8	Ensco DS-8	2015	229.97	37.97	18.5	11	78463	3660	12192	10.68 * 48.4	13.7
9	Ensco DS-9	2015	229.97	37.97	18.5	11	78463	3658	12192	10.66 * 24.68	13
10	Ensco DS-10	2015	230	38	18.5	11	77000	3658	12192	12.8 * 25.6	10
11	West Auriga	2013	228	42	18.9	12	96140	3658	11433	18.3 * 24.4	11.5
12	West Capella	2008	228	42	18.9	12	96140	3658	11433	18.3 * 24.4	11.5
13	West Carina	2014	228	42	18.89	12	96140	3658	11433	18.3 * 24.4	11.5
14	West Dorado	2014	228	42		12	96140	3658	11433		12
15	West Draco	2014	228	42				3600	11400		12
16	West Gemini	2010	228	42		12	96400	3048	11433		
17	West Jupiter	2014	228	42		14		3600	11400		12
19	West Neptune	2014	228	42		12	96189	3660	11433		11.5
20	West Vela	2013	228	42		12	96189	3660	11433		11.5
21	West Saturn	2014	228	42		14		3600	11400		12
22	Maersk Valiant	2014	228	42	19	12	96000	3600	12000	12.5 * 25.6	
23	Maersk Viking	2014	228	42	19	12	96000	3600	12000	12.5 * 25.7	
24	Maersk Venturer	2014	228	42	19	12	96000	3600	12000	12.5 * 25.8	
25	Maersk Voyager	2014	228	42	19	12	96000	3600	12000	12.5 * 25.9	
26	Deepwater Asgard	2014	238.05	42.06	18.89	12	104000	3657	12192	10.21 * 24.99	12.5
27	Deepwater Discover	2000	227.38	41.76	19.5	12	98470	3048	9144	12.46 * 15.99	10
28	Deepwater Frontier	1999	221.29	42.06	20.11	12.8	103000	3048	9144	12.49 * 12.19	10
29	Deepwater Invictus	2014	238.05	42.06	18.89	12	104000	3657	12192	10.21 * 24.99	12.5
30	Deepwater Pathfinder	1998	238.05	42.06	20.11	13.11	93043	3048	9144	25.6 * 42.98	10
31	Deepwater Proteus	2016	238.05	42.06	18.89	11.88	103970	3657	12192	24.99 * 9.45	12.5
32	Dhirubhai Deepwater KG1	2009	228	41.76	18.89	11.88	96000	3657	10668	25.6 * 12.5	12
33	Dhirubhai Deepwater KG2	2010	228	41.76	18.89	11.88	96000	3657	10668	25.6 * 12.6	12
34	Discoverer India	2009	254.5	38.1	18.89	12.98	89286	3657	12192	22.25 * 9.14	12
35	Discoverer Americas	2010	254.5	38.1	18.89	12.19	90178	3657	12192	24.38 * 9.14	12
36	Discoverer Clear Leader	2008	254.5	38.1	18.89	12.8	89286	3657	12192	21.95 * 9.14	12
37	Discoverer Deep Seas	2001	254.5	38.1	19.51	12.8	101450	3048	10668	21.95 * 9.14	12
38	Discoverer Enterprise	1999	254.5	38.1	19.51	12.8	101450	3048	10668	22.25 * 9.12	12
39	Discoverer Inspiration	2008	254.5	38.1	18.89	12.8	89286	3657	12192	21.95 * 9.14	12
40	Disciverer Luanda	2010	254.5	38.1	18.89	12.8	89286	3657	9144	21.95 * 9.14	12
41	Discoverer Spirit	2000	254.5	38.1	18.89	12.8	82911	3048	10668	24.99 * 11.89	8
42	Deepwater Millennium	1999	221.29	42.06	20.12	12.8	104205	3048	9144	12.8 * 12.49	8
43	GSF C.R. Luigs	2000	231.34	35.97	18.29	10.06	62638	3048	10668	12,8 * 12,8	12
44	GSF Jack Ryan	2000	231.34	35.97	18.29	10.06		3048	10668	12,8 * 12,8	12
45	Petobras 10000	2009	227.99	41.76	18.89	11.88	97997	3657	11277	25.6 * 12.49	12
46	HuisDrill		189	32.2	18.9	12	54000	3048	12000	27,1 * 11	12
47	HuisDrill 1200		208	36.4	23.8	12	70000	4000	15240	38.4 * 9.8	12
48	Noble Sam Croft	2014	229.21	35.97	18.59	10.97		3048	12192	35.1 * 12.49	
49	Noble Bob Douglas	2013	229.21	35.97	18.59	10.97		3048	12192	35.1 * 12.49	
50	Noble Bully 1	2011	187.5	39	14.94	10.06		2499	12192	19.51 * 12.49	
51	Noble Bully 2	2011	187.5	39	14.94	10.06		2514	12192	19.51 * 12.49	
52	Noble Don Taylor	2013	229.21	35.97	18.59	10.97		3048	12192	35.05 * 12.49	
53	Noble Globetroltter 1	2011	189	32	18.89	11.89		3048	12192	27.13 * 11.28	
54	Noble Globetroltter 2	2013	189	32	18.89	11.89		3048	12192	27.13 * 11.29	
55	Noble Tom Madden	2014	229.21	35.97	18.59	10.97		3048	12192	27.13 * 11.30	
56	Atwood Advantage	2013	238	42	19	12	104000	3657	12192		
57	Atwood Archer	2018	238	42	19	12	104000	3657	12192		
58	Atwood Achiever	2014	238	42	19	12	104000	3657	12192		
59	Atwood Admiral	2017	238	42	19	12	104000	3657	12192		
60	Ocean Rig Olympia	2011	228	42	18.9	12		3048	10668		12
61	Ocean Rig Poseidon	2011	228	42	18.9	11.5		3048			12
62	Ocean Rig Mykonos	2011	228	42	18.9	11.5		3048			12
63	Ocean Rig Corcovado	2011	228	42	18.9	12		3048			12
64	Ocean Rig Mylos	2013	228	42	18.9	12		3650			12
65	Ocean Rig Skyros	2013	228	42	18.9	12		3650			12
66	Ocean Rig Athena	2013	228	42	18.9	12		3650			12
67	Ocean Rig Apollo	2015	228	42	18.9	12		3650			12
68	Ocean Rig Santorini	2017	228	42	18.9	12		3650			12
69	Ocean Rig Crete	2018	230	42		9.5		3657	12192		12
70	Ocean Rig Amorgos	2019	230	42		9.5		3657	12192		12
71	Platinum Explorer	2010	222.8	42.06	18.9	11.98	102826	3048	12192	24.99 * 12.5	
72	Tungsten Explorer	2013	238	42.06	18.9	11.98	102682	3657	12192	24.99 * 12.5	
73	Titanium Explorer	2012	238	42.06	18.9	11.98	102808	3657	12192	24.99 * 12.5	

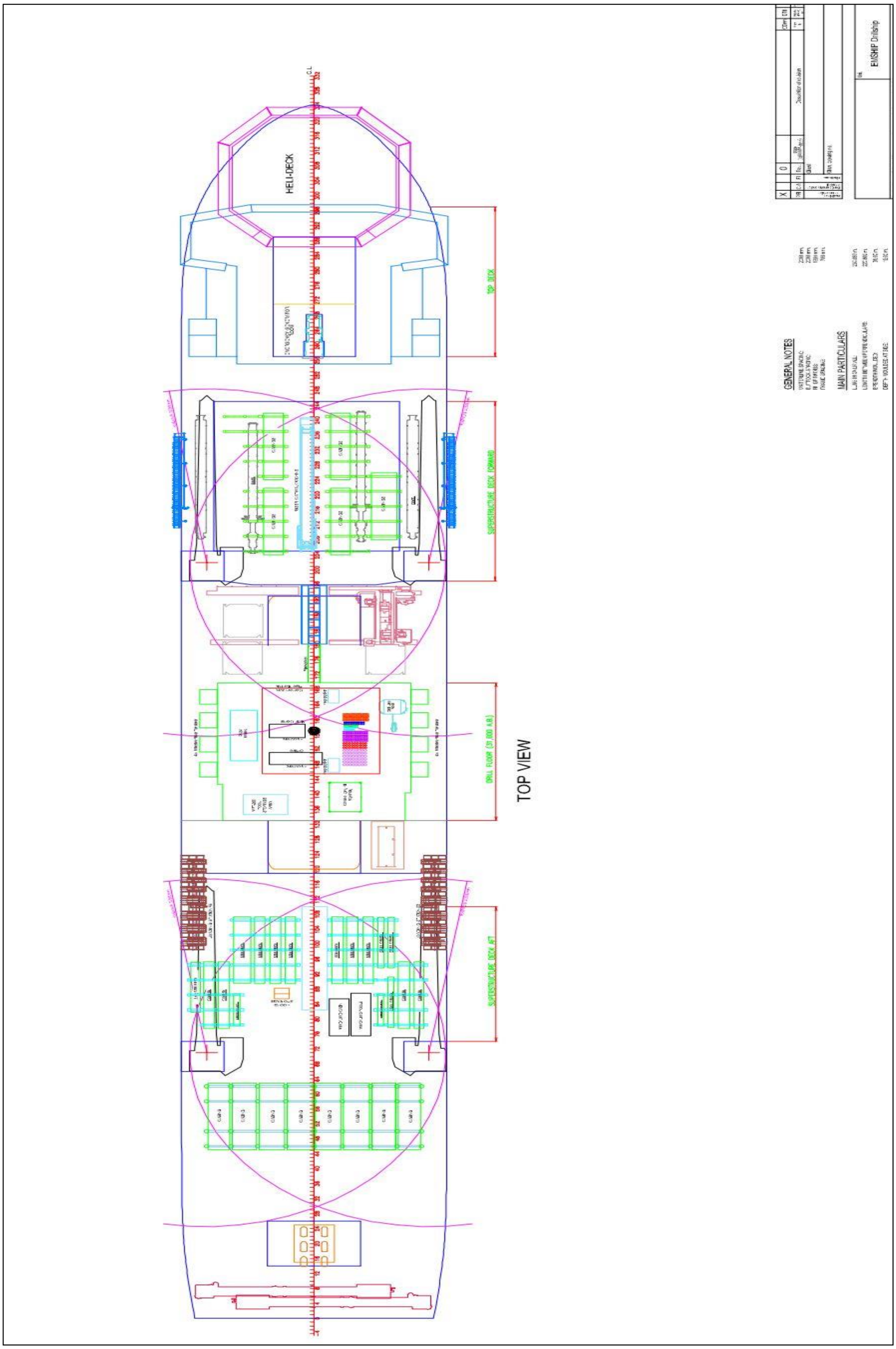
Appendix 2 – Lines Plan AutoCAD



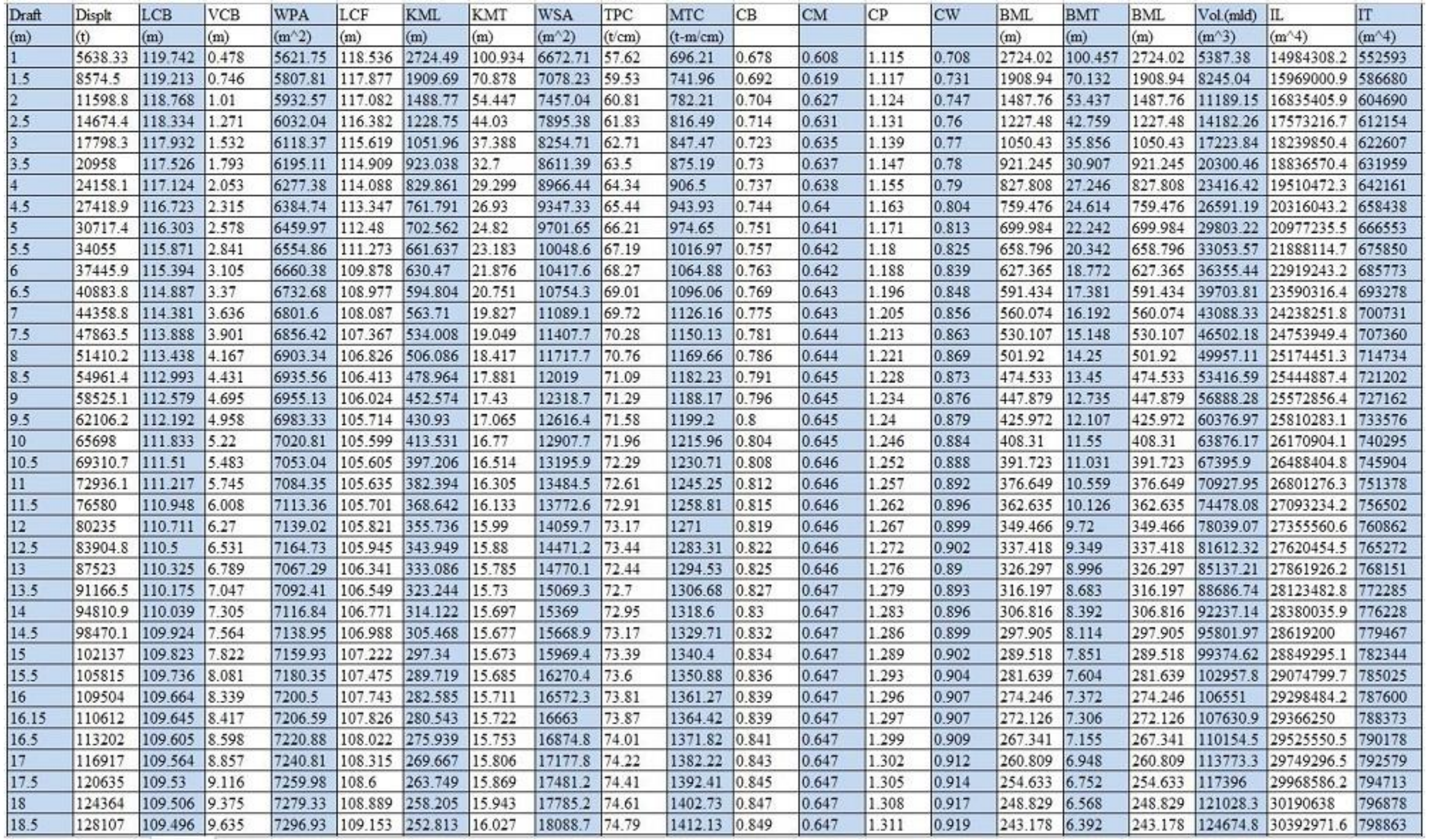
Appendix 3 – General Arrangement Plan Profile View



Appendix 3 – General Arrangement Plan – Main Deck

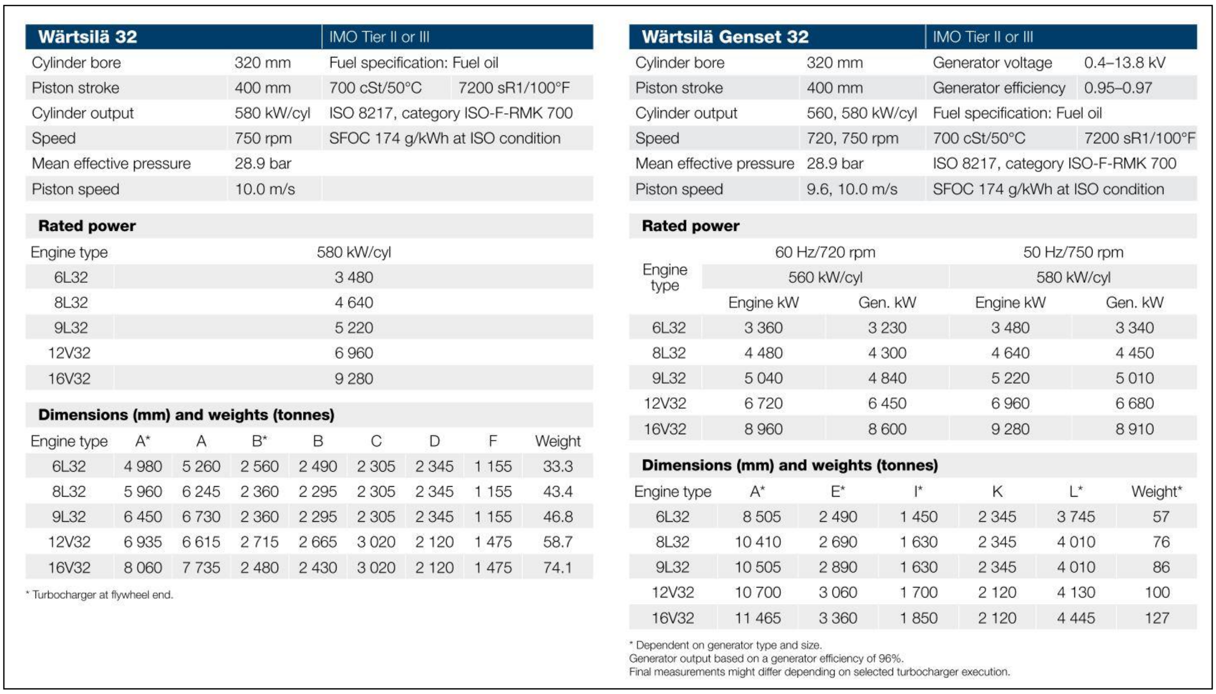


Appendix 4 – Hydrostatics Table



Draft	Displt	LCB	VCB	WPA	LCF	KML	KMT	WSA	TPC	MTC	CB	CM	CP	CW	BML	BMT	BML	Vol.(mld)	IL	IT
(m)	(t)	(m)	(m)	(m^2)	(m)	(m)	(m)	(m^2)	(t/cm)	(t-m/cm)					(m)	(m)	(m)	(m^3)	(m^4)	(m^4)
1	5638.33	119.742	0.478	5621.75	118.536	2724.49	100.934	6672.71	57.62	696.21	0.678	0.608	1.115	0.708	2724.02	100.457	2724.02	5387.38	14984308.2	552593
1.5	8574.5	119.213	0.746	5807.81	117.877	1909.69	70.878	7078.23	59.53	741.96	0.692	0.619	1.117	0.731	1908.94	70.132	1908.94	8245.04	15969000.9	586680
2	11598.8	118.768	1.01	5932.57	117.082	1488.77	54.447	7457.04	60.81	782.21	0.704	0.627	1.124	0.747	1487.76	53.437	1487.76	11189.15	16835405.9	604690
2.5	14674.4	118.334	1.271	6032.04	116.382	1228.75	44.03	7895.38	61.83	816.49	0.714	0.631	1.131	0.76	1227.48	42.759	1227.48	14182.26	17573216.7	612154
3	17798.3	117.932	1.532	6118.37	115.619	1051.96	37.388	8254.71	62.71	847.47	0.723	0.635	1.139	0.77	1050.43	35.856	1050.43	17223.84	18239850.4	622607
3.5	20958	117.526	1.793	6195.11	114.909	923.038	32.7	8611.39	63.5	875.19	0.73	0.637	1.147	0.78	921.245	30.907	921.245	20300.46	18836570.4	631959
4	24158.1	117.124	2.053	6277.38	114.088	829.861	29.299	8966.44	64.34	906.5	0.737	0.638	1.155	0.79	827.808	27.246	827.808	23416.42	19510472.3	642161
4.5	27418.9	116.723	2.315	6384.74	113.347	761.791	26.93	9347.33	65.44	943.93	0.744	0.64	1.163	0.804	759.476	24.614	759.476	26591.19	20316043.2	658438
5	30717.4	116.303	2.578	6459.97	112.48	702.562	24.82	9701.65	66.21	974.65	0.751	0.641	1.171	0.813	699.984	22.242	699.984	29803.22	20977235.5	666553
5.5	34055	115.871	2.841	6554.86	111.273	661.637	23.183	10048.6	67.19	1016.97	0.757	0.642	1.18	0.825	658.796	20.342	658.796	33053.57	21888114.7	675850
6	37445.9	115.394	3.105	6660.38	109.878	630.47	21.876	10417.6	68.27	1064.88	0.763	0.642	1.188	0.839	627.365	18.772	627.365	36355.44	22919243.2	685773
6.5	40883.8	114.887	3.37	6732.68	108.977	594.804	20.751	10754.3	69.01	1096.06	0.769	0.643	1.196	0.848	591.434	17.381	591.434	39703.81	23590316.4	693278
7	44358.8	114.381	3.636	6801.6	108.087	563.71	19.827	11089.1	69.72	1126.16	0.775	0.643	1.205	0.856	560.074	16.192	560.074	43088.33	24238251.8	700731
7.5	47863.5	113.888	3.901	6856.42	107.367	534.008	19.049	11407.7	70.28	1150.13	0.781	0.644	1.213	0.863	530.107	15.148	530.107	46502.18	24753949.4	707360
8	51410.2	113.438	4.167	6903.34	106.826	506.086	18.417	11717.7	70.76	1169.66	0.786	0.644	1.221	0.869	501.92	14.25	501.92	49957.11	25174451.3	714734
8.5	54961.4	112.993	4.431	6935.56	106.413	478.964	17.881	12019	71.09	1182.23	0.791	0.645	1.228	0.873	474.533	13.45	474.533	53416.59	25444887.4	721202
9	58525.1	112.579	4.695	6955.13	106.024	452.574	17.43	12318.7	71.29	1188.17	0.796	0.645	1.234	0.876	447.879	12.735	447.879	56888.28	25572856.4	727162
9.5	62106.2	112.192	4.958	6983.33	105.714	430.93	17.065	12616.4	71.58	1199.2	0.8	0.645	1.24	0.879	425.972	12.107	425.972	60376.97	25810283.1	733576
10	65698	111.833	5.22	7020.81	105.599	413.531	16.77	12907.7	71.96	1215.96	0.804	0.645	1.246	0.884	408.31	11.55	408.31	63876.17	26170904.1	740295
10.5	69310.7	111.51	5.483	7053.04	105.605	397.206	16.514	13195.9	72.29	1230.71	0.808	0.646	1.252	0.888	391.723	11.031	391.723	67395.9	26488404.8	745904
11	72936.1	111.217	5.745	7084.35	105.635	382.394	16.305	13484.5	72.61	1245.25	0.812	0.646	1.257	0.892	376.649	10.559	376.649	70927.95	26801276.3	751378
11.5	76580	110.948	6.008	7113.36	105.701	368.642	16.133	13772.6	72.91	1258.81	0.815	0.646	1.262	0.896	362.635	10.126	362.635	74478.08	27093234.2	756502
12	80235	110.711	6.27	7139.02	105.821	355.736	15.99	14059.7	73.17	1271	0.819	0.646	1.267	0.899	349.466	9.72	349.466	78039.07	27355560.6	760862
12.5	83904.8	110.5	6.531	7164.73	105.945	343.949	15.88	14471.2	73.44	1283.31	0.822	0.646	1.272	0.902	337.418	9.349	337.418	81612.32	27620454.5	765272
13	87523	110.325	6.789	7067.29	106.341	333.086	15.785	14770.1	72.44	1294.53	0.825	0.646	1.276	0.89	326.297	8.996	326.297	85137.21	27861926.2	768151
13.5	91166.5	110.175	7.047	7092.41	106.549	323.244	15.73	15069.3	72.7	1306.68	0.827	0.647	1.279	0.893	316.197	8.683	316.197	88686.74	28123482.8	772285
14	94810.9	110.039	7.305	7116.84	106.771	314.122	15.697	15369	72.95	1318.6	0.83	0.647	1.283	0.896	306.816	8.392	306.816	92237.14	28380035.9	776228
14.5	98470.1	109.924	7.564	7138.95	106.988	305.468	15.677	15668.9	73.17	1329.71	0.832	0.647	1.286	0.899	297.905	8.114	297.905	95801.97	28619200	779467
15	102137	109.823	7.822	7159.93	107.222	297.34	15.673	15969.4	73.39	1340.4	0.834	0.647	1.289	0.902	289.518	7.851	289.518	99374.62	28849295.1	782344
15.5	105815	109.736	8.081	7180.35	107.475	289.719	15.685	16270.4	73.6	1350.88	0.836	0.647	1.293	0.904	281.639	7.604	281.639	102957.8	29074799.7	785025
16	109504	109.664	8.339	7200.5	107.743	282.585	15.711	16572.3	73.81	1361.27	0.839	0.647	1.296	0.907	274.246	7.372	274.246	106551	29298484.2	787600
16.15	110612	109.645	8.417	7206.59	107.826	280.543	15.722	16663	73.87	1364.42	0.839	0.647	1.297	0.907	272.126	7.306	272.126	107630.9	29366250	788373
16.5	113202	109.605	8.598	7220.88	108.022	275.939	15.753	16874.8	74.01	1371.82	0.841	0.647	1.299	0.909	267.341	7.155	267.341	110154.5	29525550.5	790178
17	116917	109.564	8.857	7240.81	108.315	269.667	15.806	17177.8	74.22	1382.22	0.843	0.647	1.302	0.912	260.809	6.948	260.809	113773.3	29749296.5	792579
17.5	120635	109.53	9.116	7259.98	108.6	263.749	15.869	17481.2	74.41	1392.41	0.845	0.647	1.305	0.914	254.633	6.752	254.633	117396	29968586.2	794713
18	124364	109.506	9.375	7279.33	108.889	258.205	15.943	17785.2	74.61	1402.73	0.847	0.647	1.308	0.917	248.829	6.568	248.829	121028.3	30190638	796878
18.5	128107	109.496	9.635	7296.93	109.153	252.813	16.027	18088.7	74.79	1412.13	0.849	0.647	1.311	0.919	243.178	6.392	243.178	124674.8	30392971.6	798863

Appendix 5 – Main Engine Spec, Thruster Spec and Endurance Range



Wärtsilä 32		IMO Tier II or III	
Cylinder bore	320 mm	Fuel specification: Fuel oil	
Piston stroke	400 mm	700 cSt/50°C	7200 sR1/100°F
Cylinder output	580 kW/cyl	ISO 8217, category ISO-F-RMK 700	
Speed	750 rpm	SFOC 174 g/kWh at ISO condition	
Mean effective pressure	28.9 bar		
Piston speed	10.0 m/s		

Rated power

Engine type	580 kW/cyl
6L32	3 480
8L32	4 640
9L32	5 220
12V32	6 960
16V32	9 280

Dimensions (mm) and weights (tonnes)

Engine type	A*	A	B*	B	C	D	F	Weight
6L32	4 980	5 260	2 560	2 490	2 305	2 345	1 155	33.3
8L32	5 960	6 245	2 360	2 295	2 305	2 345	1 155	43.4
9L32	6 450	6 730	2 360	2 295	2 305	2 345	1 155	46.8
12V32	6 935	6 615	2 715	2 665	3 020	2 120	1 475	58.7
16V32	8 060	7 735	2 480	2 430	3 020	2 120	1 475	74.1

* Turbocharger at flywheel end.

Wärtsilä Genset 32		IMO Tier II or III	
Cylinder bore	320 mm	Generator voltage	0.4–13.8 kV
Piston stroke	400 mm	Generator efficiency	0.95–0.97
Cylinder output	560, 580 kW/cyl	Fuel specification: Fuel oil	
Speed	720, 750 rpm	700 cSt/50°C	7200 sR1/100°F
Mean effective pressure	28.9 bar	ISO 8217, category ISO-F-RMK 700	
Piston speed	9.6, 10.0 m/s	SFOC 174 g/kWh at ISO condition	

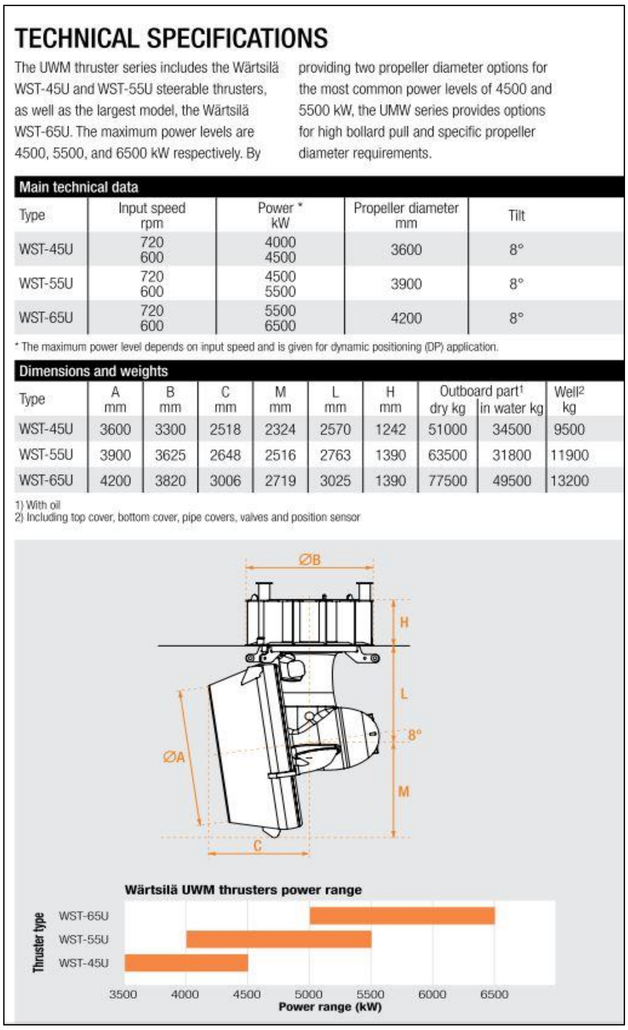
Rated power

Engine type	60 Hz/720 rpm		50 Hz/750 rpm	
	560 kW/cyl		580 kW/cyl	
	Engine kW	Gen. kW	Engine kW	Gen. kW
6L32	3 360	3 230	3 480	3 340
8L32	4 480	4 300	4 640	4 450
9L32	5 040	4 840	5 220	5 010
12V32	6 720	6 450	6 960	6 680
16V32	8 960	8 600	9 280	8 910

Dimensions (mm) and weights (tonnes)

Engine type	A*	E*	I*	K	L*	Weight*
6L32	8 505	2 490	1 450	2 345	3 745	57
8L32	10 410	2 690	1 630	2 345	4 010	76
9L32	10 505	2 890	1 630	2 345	4 010	86
12V32	10 700	3 060	1 700	2 120	4 130	100
16V32	11 465	3 360	1 850	2 120	4 445	127

* Dependent on generator type and size.
Generator output based on a generator efficiency of 96%.
Final measurements might differ depending on selected turbocharger execution.



TECHNICAL SPECIFICATIONS

The UWM thruster series includes the Wärtsilä WST-45U and WST-55U steerable thrusters, as well as the largest model, the Wärtsilä WST-65U. The maximum power levels are 4500, 5500, and 6500 kW respectively. By providing two propeller diameter options for the most common power levels of 4500 and 5500 kW, the UMW series provides options for high bollard pull and specific propeller diameter requirements.

Main technical data

Type	Input speed rpm	Power * kW	Propeller diameter mm	Tilt
WST-45U	720 600	4000 4500	3600	8°
WST-55U	720 600	4500 5500	3900	8°
WST-65U	720 600	5500 6500	4200	8°

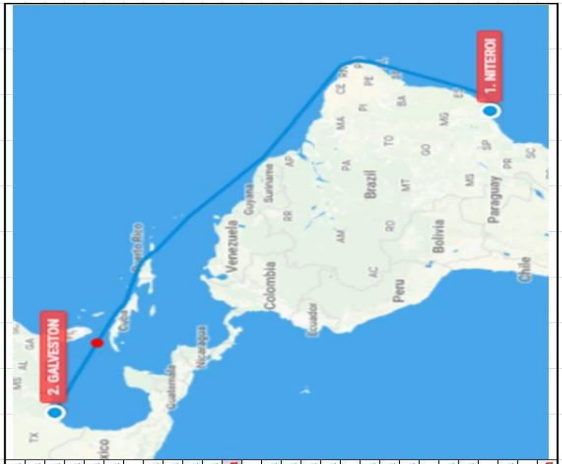
* The maximum power level depends on input speed and is given for dynamic positioning (DP) application.

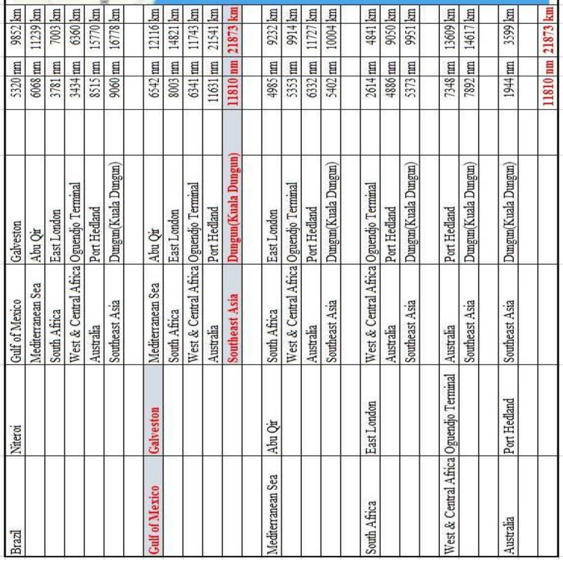
Dimensions and weights

Type	A mm	B mm	C mm	M mm	L mm	H mm	Outboard part[1] dry kg	in water kg	Well[2] kg
WST-45U	3600	3300	2518	2324	2570	1242	51000	34500	9500
WST-55U	3900	3625	2648	2516	2763	1390	63500	31800	11900
WST-65U	4200	3820	3006	2719	3025	1390	77500	49500	13200

1) With oil
2) Including top cover, bottom cover, pipe covers, valves and position sensor

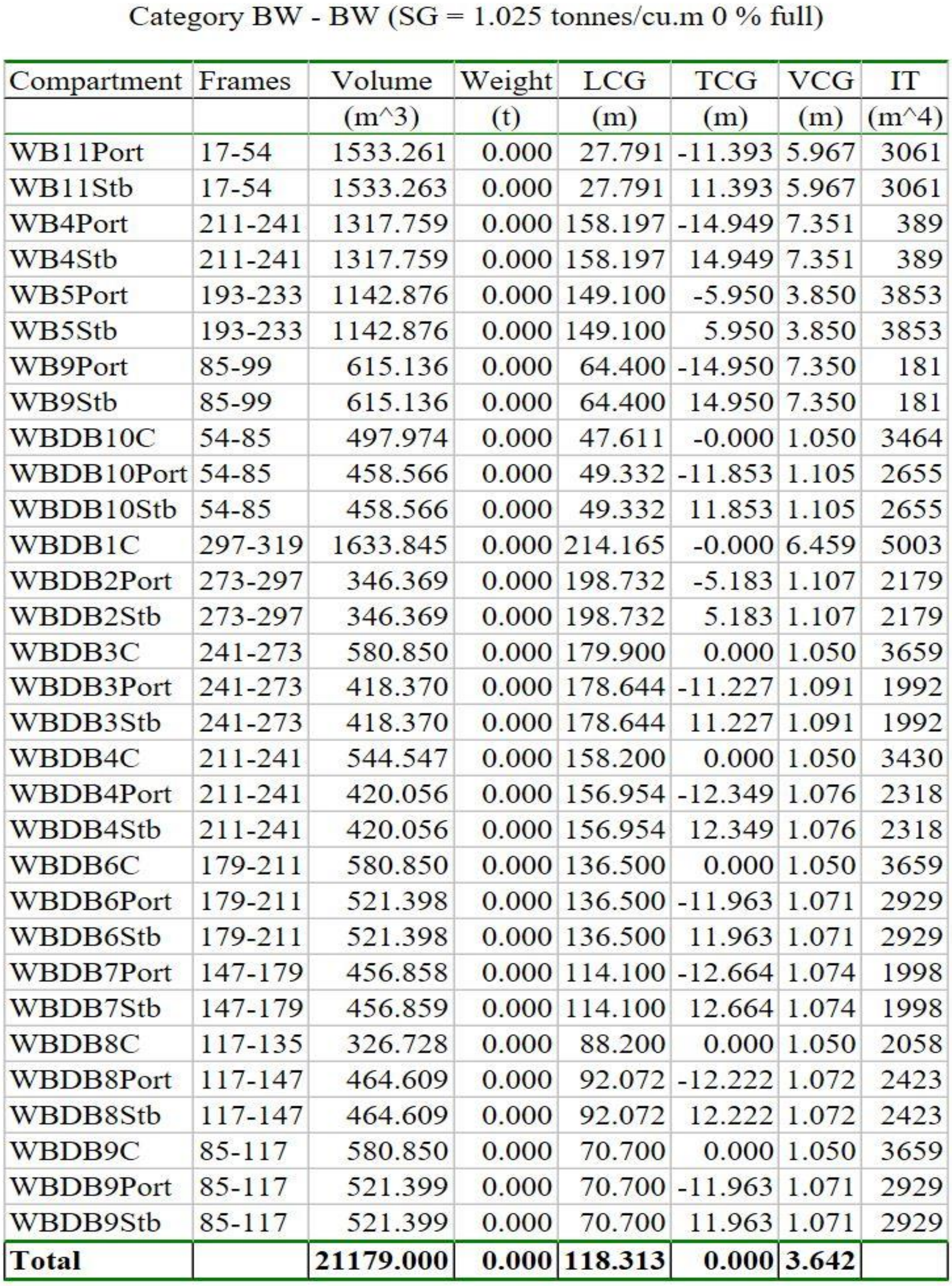
Wärtsilä UWM thrusters power range





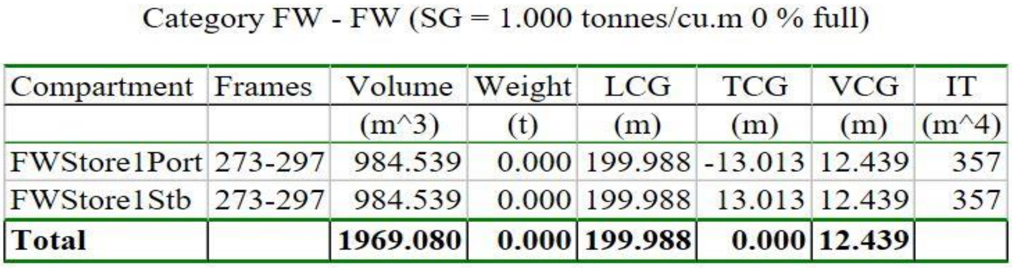
Brazil	Niteroi	Gulf of Mexico	Galveston		5320	nm	9852	km
		Mediterranean Sea	Abu Qir		6068	nm	11239	km
		South Africa	East London		3781	nm	7003	km
		West & Central Africa	Oguendjo Terminal		3434	nm	6360	km
		Australia	Port Hedland		8515	nm	15770	km
		Southeast Asia	Dungun(Kuala Dungun)		9060	nm	16778	km
Gulf of Mexico	**Galveston**	Mediterranean Sea	Abu Qir		6542	nm	12116	km
		South Africa	East London		8003	nm	14821	km
		West & Central Africa	Oguendjo Terminal		6341	nm	11743	km
		Australia	Port Hedland		11631	nm	21541	km
		Southeast Asia	**Dungun(Kuala Dungun)**		**11810**	**nm**	**21873**	**km**
Mediterranean Sea	Abu Qir	South Africa	East London		4985	nm	9232	km
		West & Central Africa	Oguendjo Terminal		5353	nm	9914	km
		Australia	Port Hedland		6332	nm	11727	km
		Southeast Asia	Dungun(Kuala Dungun)		5402	nm	10004	km
South Africa	East London	West & Central Africa	Oguendjo Terminal		2614	nm	4841	km
		Australia	Port Hedland		4886	nm	9050	km
		Southeast Asia	Dungun(Kuala Dungun)		5373	nm	9951	km
West & Central Africa	Oguendjo Terminal	Australia	Port Hedland		7348	nm	13609	km
		Southeast Asia	Dungun(Kuala Dungun)		7892	nm	14617	km
Australia	Port Hedland	Southeast Asia	Dungun(Kuala Dungun)		1944	nm	3599	km
					11810	**nm**	**21873**	**km**

Appendix 6 –Tanks Contents and Capacities A



Category BW - BW (SG = 1.025 tonnes/cu.m 0 % full)

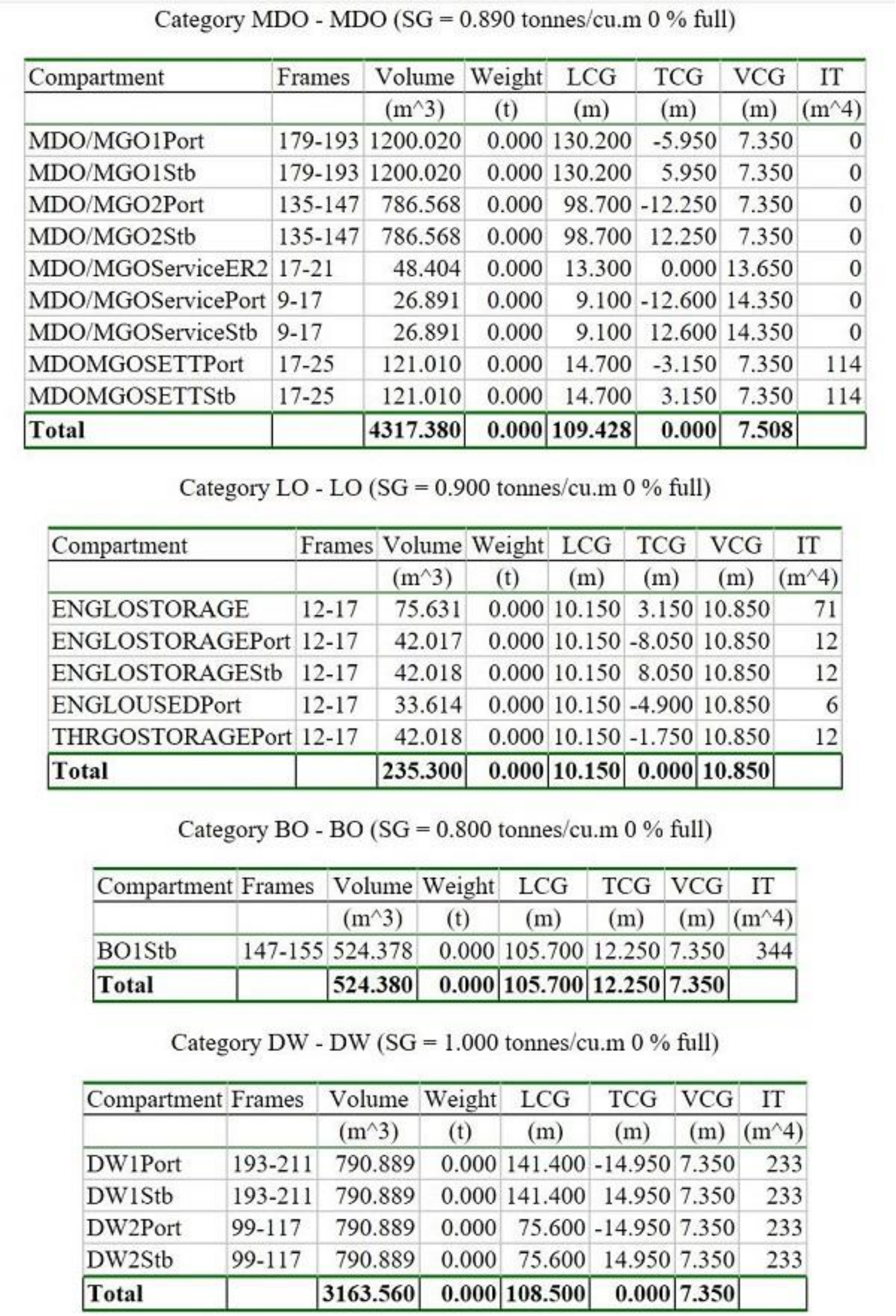
Compartment	Frames	Volume	Weight	LCG	TCG	VCG	IT
		(m^3)	(t)	(m)	(m)	(m)	(m^4)
WB11Port	17-54	1533.261	0.000	27.791	-11.393	5.967	3061
WB11Stb	17-54	1533.263	0.000	27.791	11.393	5.967	3061
WB4Port	211-241	1317.759	0.000	158.197	-14.949	7.351	389
WB4Stb	211-241	1317.759	0.000	158.197	14.949	7.351	389
WB5Port	193-233	1142.876	0.000	149.100	-5.950	3.850	3853
WB5Stb	193-233	1142.876	0.000	149.100	5.950	3.850	3853
WB9Port	85-99	615.136	0.000	64.400	-14.950	7.350	181
WB9Stb	85-99	615.136	0.000	64.400	14.950	7.350	181
WBDB10C	54-85	497.974	0.000	47.611	-0.000	1.050	3464
WBDB10Port	54-85	458.566	0.000	49.332	-11.853	1.105	2655
WBDB10Stb	54-85	458.566	0.000	49.332	11.853	1.105	2655
WBDB1C	297-319	1633.845	0.000	214.165	-0.000	6.459	5003
WBDB2Port	273-297	346.369	0.000	198.732	-5.183	1.107	2179
WBDB2Stb	273-297	346.369	0.000	198.732	5.183	1.107	2179
WBDB3C	241-273	580.850	0.000	179.900	0.000	1.050	3659
WBDB3Port	241-273	418.370	0.000	178.644	-11.227	1.091	1992
WBDB3Stb	241-273	418.370	0.000	178.644	11.227	1.091	1992
WBDB4C	211-241	544.547	0.000	158.200	0.000	1.050	3430
WBDB4Port	211-241	420.056	0.000	156.954	-12.349	1.076	2318
WBDB4Stb	211-241	420.056	0.000	156.954	12.349	1.076	2318
WBDB6C	179-211	580.850	0.000	136.500	0.000	1.050	3659
WBDB6Port	179-211	521.398	0.000	136.500	-11.963	1.071	2929
WBDB6Stb	179-211	521.398	0.000	136.500	11.963	1.071	2929
WBDB7Port	147-179	456.858	0.000	114.100	-12.664	1.074	1998
WBDB7Stb	147-179	456.859	0.000	114.100	12.664	1.074	1998
WBDB8C	117-135	326.728	0.000	88.200	0.000	1.050	2058
WBDB8Port	117-147	464.609	0.000	92.072	-12.222	1.072	2423
WBDB8Stb	117-147	464.609	0.000	92.072	12.222	1.072	2423
WBDB9C	85-117	580.850	0.000	70.700	0.000	1.050	3659
WBDB9Port	85-117	521.399	0.000	70.700	-11.963	1.071	2929
WBDB9Stb	85-117	521.399	0.000	70.700	11.963	1.071	2929
Total		**21179.000**	**0.000**	**118.313**	**0.000**	**3.642**	



Category FW - FW (SG = 1.000 tonnes/cu.m 0 % full)

Compartment	Frames	Volume	Weight	LCG	TCG	VCG	IT
		(m^3)	(t)	(m)	(m)	(m)	(m^4)
FWStore1Port	273-297	984.539	0.000	199.988	-13.013	12.439	357
FWStore1Stb	273-297	984.539	0.000	199.988	13.013	12.439	357
Total		**1969.080**	**0.000**	**199.988**	**0.000**	**12.439**	

Appendix 6 –Tanks Contents and Capacities B



Category MDO - MDO (SG = 0.890 tonnes/cu.m 0 % full)

Compartment	Frames	Volume	Weight	LCG	TCG	VCG	IT
		(m^3)	(t)	(m)	(m)	(m)	(m^4)
MDO/MGO1Port	179-193	1200.020	0.000	130.200	-5.950	7.350	0
MDO/MGO1Stb	179-193	1200.020	0.000	130.200	5.950	7.350	0
MDO/MGO2Port	135-147	786.568	0.000	98.700	-12.250	7.350	0
MDO/MGO2Stb	135-147	786.568	0.000	98.700	12.250	7.350	0
MDO/MGOServiceER2	17-21	48.404	0.000	13.300	0.000	13.650	0
MDO/MGOServicePort	9-17	26.891	0.000	9.100	-12.600	14.350	0
MDO/MGOServiceStb	9-17	26.891	0.000	9.100	12.600	14.350	0
MDOMGOSETTPort	17-25	121.010	0.000	14.700	-3.150	7.350	114
MDOMGOSETTStb	17-25	121.010	0.000	14.700	3.150	7.350	114
Total		**4317.380**	**0.000**	**109.428**	**0.000**	**7.508**	

Category LO - LO (SG = 0.900 tonnes/cu.m 0 % full)

Compartment	Frames	Volume	Weight	LCG	TCG	VCG	IT
		(m^3)	(t)	(m)	(m)	(m)	(m^4)
ENGLOSTORAGE	12-17	75.631	0.000	10.150	3.150	10.850	71
ENGLOSTORAGEPort	12-17	42.017	0.000	10.150	-8.050	10.850	12
ENGLOSTORAGEStb	12-17	42.018	0.000	10.150	8.050	10.850	12
ENGLOUSEDPort	12-17	33.614	0.000	10.150	-4.900	10.850	6
THRGOSTORAGEPort	12-17	42.018	0.000	10.150	-1.750	10.850	12
Total		**235.300**	**0.000**	**10.150**	**0.000**	**10.850**	

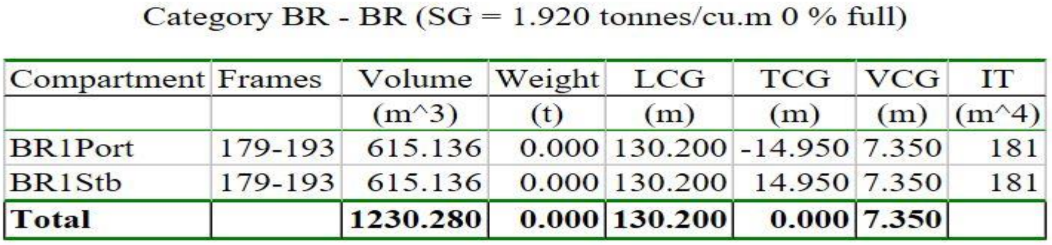
Category BO - BO (SG = 0.800 tonnes/cu.m 0 % full)

Compartment	Frames	Volume	Weight	LCG	TCG	VCG	IT
		(m^3)	(t)	(m)	(m)	(m)	(m^4)
BO1Stb	147-155	524.378	0.000	105.700	12.250	7.350	344
Total		**524.380**	**0.000**	**105.700**	**12.250**	**7.350**	

Category DW - DW (SG = 1.000 tonnes/cu.m 0 % full)

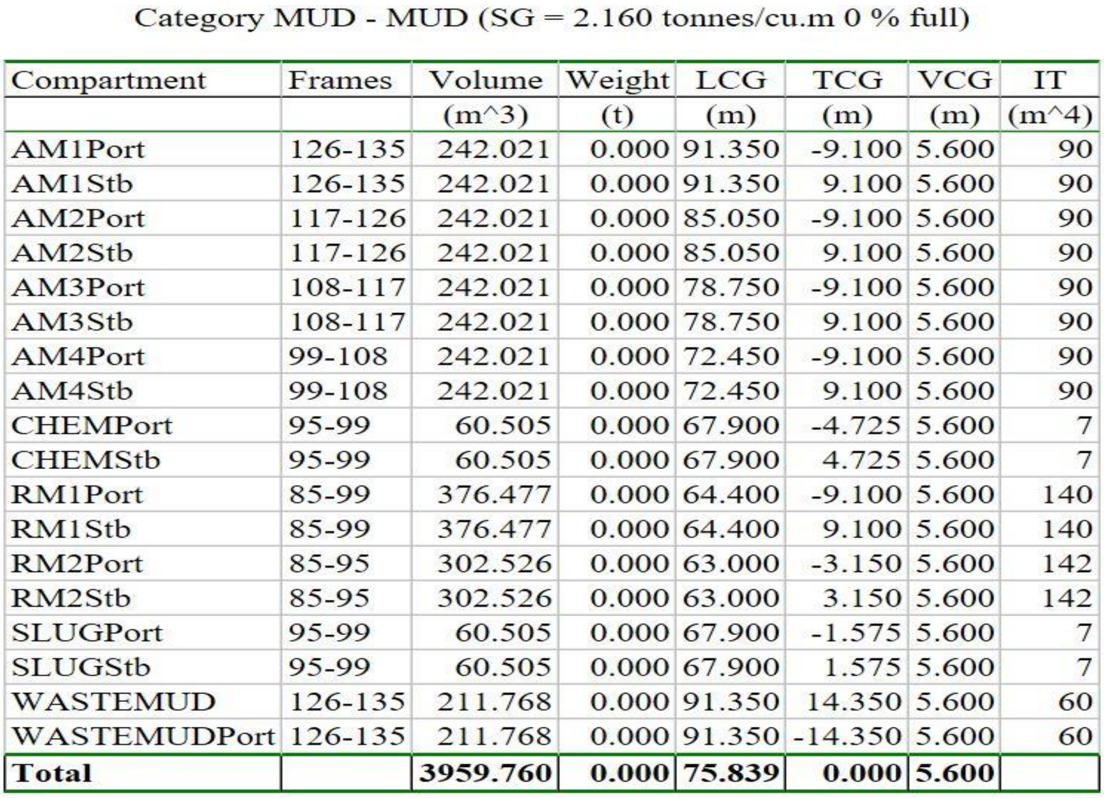
Compartment	Frames	Volume	Weight	LCG	TCG	VCG	IT
		(m^3)	(t)	(m)	(m)	(m)	(m^4)
DW1Port	193-211	790.889	0.000	141.400	-14.950	7.350	233
DW1Stb	193-211	790.889	0.000	141.400	14.950	7.350	233
DW2Port	99-117	790.889	0.000	75.600	-14.950	7.350	233
DW2Stb	99-117	790.889	0.000	75.600	14.950	7.350	233
Total		**3163.560**	**0.000**	**108.500**	**0.000**	**7.350**	

Appendix 6 –Tanks Contents and Capacities C



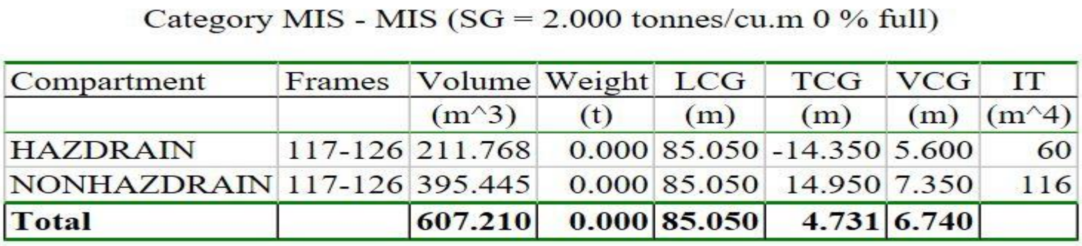
Category BR - BR (SG = 1.920 tonnes/cu.m 0 % full)

Compartment	Frames	Volume	Weight	LCG	TCG	VCG	IT
		(m^3)	(t)	(m)	(m)	(m)	(m^4)
BR1Port	179-193	615.136	0.000	130.200	-14.950	7.350	181
BR1Stb	179-193	615.136	0.000	130.200	14.950	7.350	181
Total		**1230.280**	**0.000**	**130.200**	**0.000**	**7.350**	



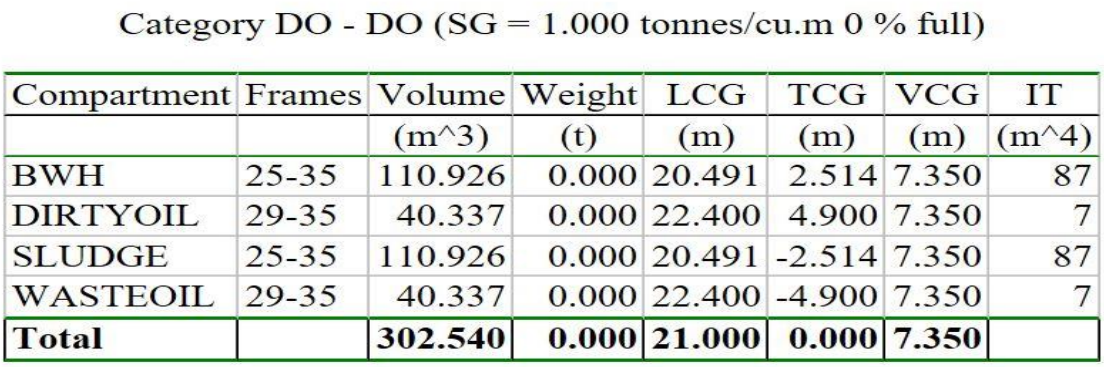
Category MUD - MUD (SG = 2.160 tonnes/cu.m 0 % full)

Compartment	Frames	Volume	Weight	LCG	TCG	VCG	IT
		(m^3)	(t)	(m)	(m)	(m)	(m^4)
AM1Port	126-135	242.021	0.000	91.350	-9.100	5.600	90
AM1Stb	126-135	242.021	0.000	91.350	9.100	5.600	90
AM2Port	117-126	242.021	0.000	85.050	-9.100	5.600	90
AM2Stb	117-126	242.021	0.000	85.050	9.100	5.600	90
AM3Port	108-117	242.021	0.000	78.750	-9.100	5.600	90
AM3Stb	108-117	242.021	0.000	78.750	9.100	5.600	90
AM4Port	99-108	242.021	0.000	72.450	-9.100	5.600	90
AM4Stb	99-108	242.021	0.000	72.450	9.100	5.600	90
CHEMPort	95-99	60.505	0.000	67.900	-4.725	5.600	7
CHEMStb	95-99	60.505	0.000	67.900	4.725	5.600	7
RM1Port	85-99	376.477	0.000	64.400	-9.100	5.600	140
RM1Stb	85-99	376.477	0.000	64.400	9.100	5.600	140
RM2Port	85-95	302.526	0.000	63.000	-3.150	5.600	142
RM2Stb	85-95	302.526	0.000	63.000	3.150	5.600	142
SLUGPort	95-99	60.505	0.000	67.900	-1.575	5.600	7
SLUGStb	95-99	60.505	0.000	67.900	1.575	5.600	7
WASTEMUD	126-135	211.768	0.000	91.350	14.350	5.600	60
WASTEMUDPort	126-135	211.768	0.000	91.350	-14.350	5.600	60
Total		**3959.760**	**0.000**	**75.839**	**0.000**	**5.600**	



Category MIS - MIS (SG = 2.000 tonnes/cu.m 0 % full)

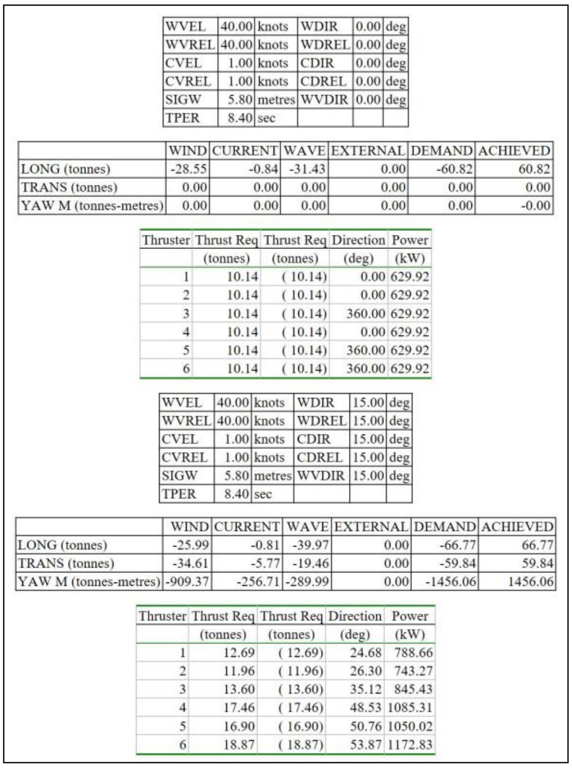
Compartment	Frames	Volume	Weight	LCG	TCG	VCG	IT
		(m^3)	(t)	(m)	(m)	(m)	(m^4)
HAZDRAIN	117-126	211.768	0.000	85.050	-14.350	5.600	60
NONHAZDRAIN	117-126	395.445	0.000	85.050	14.950	7.350	116
Total		**607.210**	**0.000**	**85.050**	**4.731**	**6.740**	



Category DO - DO (SG = 1.000 tonnes/cu.m 0 % full)

Compartment	Frames	Volume	Weight	LCG	TCG	VCG	IT
		(m^3)	(t)	(m)	(m)	(m)	(m^4)
BWH	25-35	110.926	0.000	20.491	2.514	7.350	87
DIRTYOIL	29-35	40.337	0.000	22.400	4.900	7.350	7
SLUDGE	25-35	110.926	0.000	20.491	-2.514	7.350	87
WASTEOIL	29-35	40.337	0.000	22.400	-4.900	7.350	7
Total		**302.540**	**0.000**	**21.000**	**0.000**	**7.350**	

Appendix 7 – Dynamic Position Calculation A



WVEL	40.00	knots	WDIR	0.00	deg
WVREL	40.00	knots	WDREL	0.00	deg
CVEL	1.00	knots	CDIR	0.00	deg
CVREL	1.00	knots	CDREL	0.00	deg
SIGW	5.80	metres	WVDIR	0.00	deg
TPER	8.40	sec			

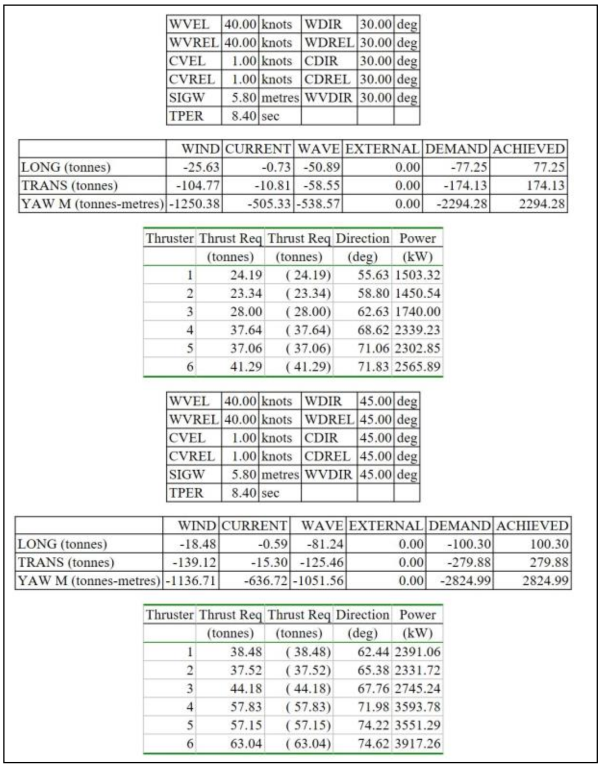
	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-28.55	-0.84	-31.43	0.00	-60.82	60.82
TRANS (tonnes)	0.00	0.00	0.00	0.00	0.00	0.00
YAW M (tonnes-metres)	0.00	0.00	0.00	0.00	0.00	-0.00

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	10.14	(10.14)	0.00	629.92
2	10.14	(10.14)	0.00	629.92
3	10.14	(10.14)	360.00	629.92
4	10.14	(10.14)	0.00	629.92
5	10.14	(10.14)	360.00	629.92
6	10.14	(10.14)	360.00	629.92

WVEL	40.00	knots	WDIR	15.00	deg
WVREL	40.00	knots	WDREL	15.00	deg
CVEL	1.00	knots	CDIR	15.00	deg
CVREL	1.00	knots	CDREL	15.00	deg
SIGW	5.80	metres	WVDIR	15.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-25.99	-0.81	-39.97	0.00	-66.77	66.77
TRANS (tonnes)	-34.61	-5.77	-19.46	0.00	-59.84	59.84
YAW M (tonnes-metres)	-909.37	-256.71	-289.99	0.00	-1456.06	1456.06

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	12.69	(12.69)	24.68	788.66
2	11.96	(11.96)	26.30	743.27
3	13.60	(13.60)	35.12	845.43
4	17.46	(17.46)	48.53	1085.31
5	16.90	(16.90)	50.76	1050.02
6	18.87	(18.87)	53.87	1172.83



WVEL	40.00	knots	WDIR	30.00	deg
WVREL	40.00	knots	WDREL	30.00	deg
CVEL	1.00	knots	CDIR	30.00	deg
CVREL	1.00	knots	CDREL	30.00	deg
SIGW	5.80	metres	WVDIR	30.00	deg
TPER	8.40	sec			

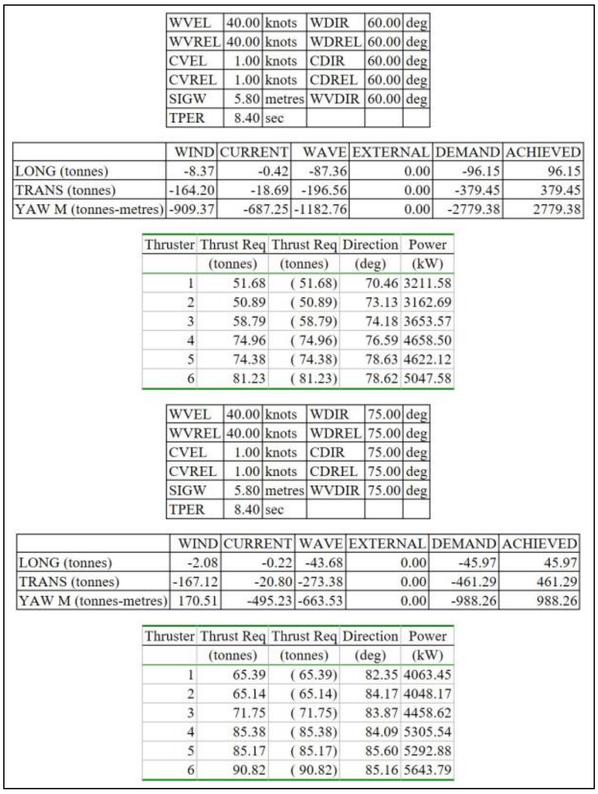
	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-25.63	-0.73	-50.89	0.00	-77.25	77.25
TRANS (tonnes)	-104.77	-10.81	-58.55	0.00	-174.13	174.13
YAW M (tonnes-metres)	-1250.38	-505.33	-538.57	0.00	-2294.28	2294.28

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	24.19	(24.19)	55.63	1503.32
2	23.34	(23.34)	58.80	1450.54
3	28.00	(28.00)	62.63	1740.00
4	37.64	(37.64)	68.62	2339.23
5	37.06	(37.06)	71.06	2302.85
6	41.29	(41.29)	71.83	2565.89

WVEL	40.00	knots	WDIR	45.00	deg
WVREL	40.00	knots	WDREL	45.00	deg
CVEL	1.00	knots	CDIR	45.00	deg
CVREL	1.00	knots	CDREL	45.00	deg
SIGW	5.80	metres	WVDIR	45.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-18.48	-0.59	-81.24	0.00	-100.30	100.30
TRANS (tonnes)	-139.12	-15.30	-125.46	0.00	-279.88	279.88
YAW M (tonnes-metres)	-1136.71	-636.72	-1051.56	0.00	-2824.99	2824.99

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	38.48	(38.48)	62.44	2391.06
2	37.52	(37.52)	65.38	2331.72
3	44.18	(44.18)	67.76	2745.24
4	57.83	(57.83)	71.98	3593.78
5	57.15	(57.15)	74.22	3551.29
6	63.04	(63.04)	74.62	3917.26



WVEL	40.00	knots	WDIR	60.00	deg
WVREL	40.00	knots	WDREL	60.00	deg
CVEL	1.00	knots	CDIR	60.00	deg
CVREL	1.00	knots	CDREL	60.00	deg
SIGW	5.80	metres	WVDIR	60.00	deg
TPER	8.40	sec			

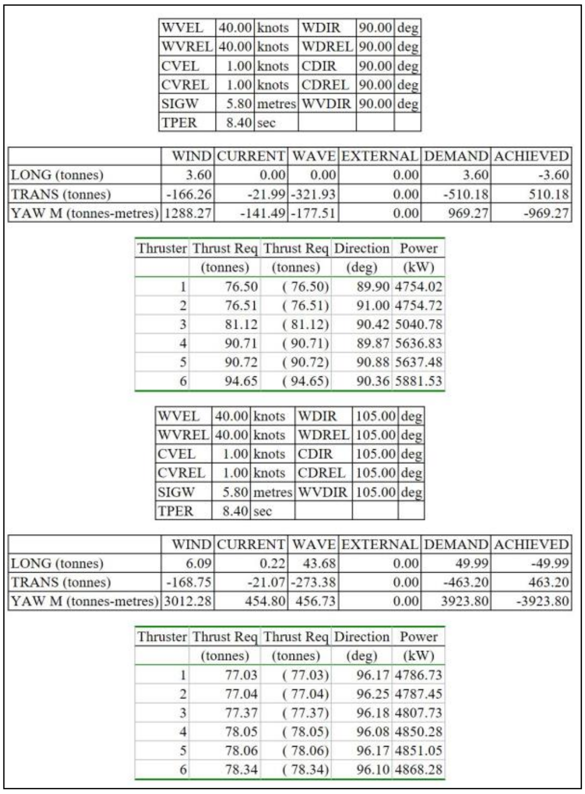
	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-8.37	-0.42	-87.36	0.00	-96.15	96.15
TRANS (tonnes)	-164.20	-18.69	-196.56	0.00	-379.45	379.45
YAW M (tonnes-metres)	-909.37	-687.25	-1182.76	0.00	-2779.38	2779.38

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	51.68	(51.68)	70.46	3211.58
2	50.89	(50.89)	73.13	3162.69
3	58.79	(58.79)	74.18	3653.57
4	74.96	(74.96)	76.59	4658.50
5	74.38	(74.38)	78.63	4622.12
6	81.23	(81.23)	78.62	5047.58

WVEL	40.00	knots	WDIR	75.00	deg
WVREL	40.00	knots	WDREL	75.00	deg
CVEL	1.00	knots	CDIR	75.00	deg
CVREL	1.00	knots	CDREL	75.00	deg
SIGW	5.80	metres	WVDIR	75.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-2.08	-0.22	-43.68	0.00	-45.97	45.97
TRANS (tonnes)	-167.12	-20.80	-273.38	0.00	-461.29	461.29
YAW M (tonnes-metres)	170.51	-495.23	-663.53	0.00	-988.26	988.26

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	65.39	(65.39)	82.35	4063.45
2	65.14	(65.14)	84.17	4048.17
3	71.75	(71.75)	83.87	4458.62
4	85.38	(85.38)	84.09	5305.54
5	85.17	(85.17)	85.60	5292.88
6	90.82	(90.82)	85.16	5643.79



WVEL	40.00	knots	WDIR	90.00	deg
WVREL	40.00	knots	WDREL	90.00	deg
CVEL	1.00	knots	CDIR	90.00	deg
CVREL	1.00	knots	CDREL	90.00	deg
SIGW	5.80	metres	WVDIR	90.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	3.60	0.00	0.00	0.00	3.60	-3.60
TRANS (tonnes)	-166.26	-21.99	-321.93	0.00	-510.18	510.18
YAW M (tonnes-metres)	1288.27	-141.49	-177.51	0.00	969.27	-969.27

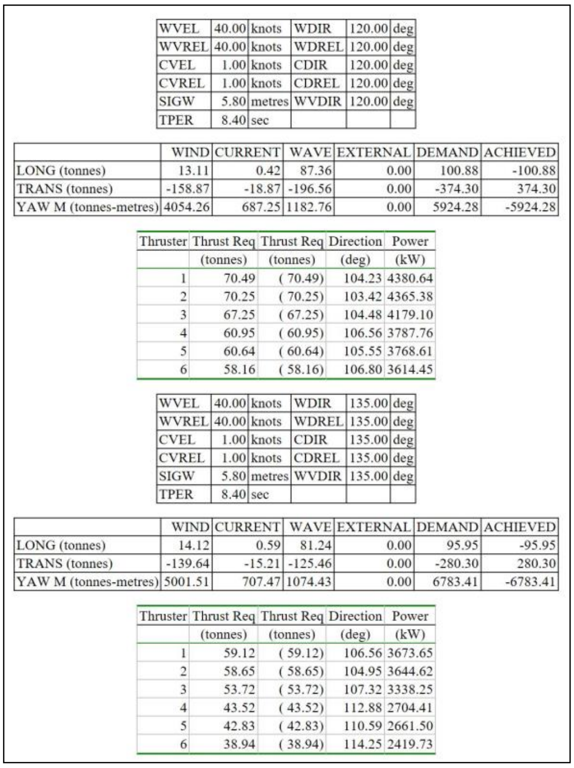
Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	76.50	(76.50)	89.90	4754.02
2	76.51	(76.51)	91.00	4754.72
3	81.12	(81.12)	90.42	5040.78
4	90.71	(90.71)	89.87	5636.83
5	90.72	(90.72)	90.88	5637.48
6	94.65	(94.65)	90.36	5881.53

WVEL	40.00	knots	WDIR	105.00	deg
WVREL	40.00	knots	WDREL	105.00	deg
CVEL	1.00	knots	CDIR	105.00	deg
CVREL	1.00	knots	CDREL	105.00	deg
SIGW	5.80	metres	WVDIR	105.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	6.09	0.22	43.68	0.00	49.99	-49.99
TRANS (tonnes)	-168.75	-21.07	-273.38	0.00	-463.20	463.20
YAW M (tonnes-metres)	3012.28	454.80	456.73	0.00	3923.80	-3923.80

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	77.03	(77.03)	96.17	4786.73
2	77.04	(77.04)	96.25	4787.45
3	77.37	(77.37)	96.18	4807.73
4	78.05	(78.05)	96.08	4850.28
5	78.06	(78.06)	96.17	4851.05
6	78.34	(78.34)	96.10	4868.28

Appendix 7 – Dynamic Position Calculation B



WVEL	40.00	knots	WDIR	120.00	deg
WVREL	40.00	knots	WDREL	120.00	deg
CVEL	1.00	knots	CDIR	120.00	deg
CVREL	1.00	knots	CDREL	120.00	deg
SIGW	5.80	metres	WVDIR	120.00	deg
TPER	8.40	sec			

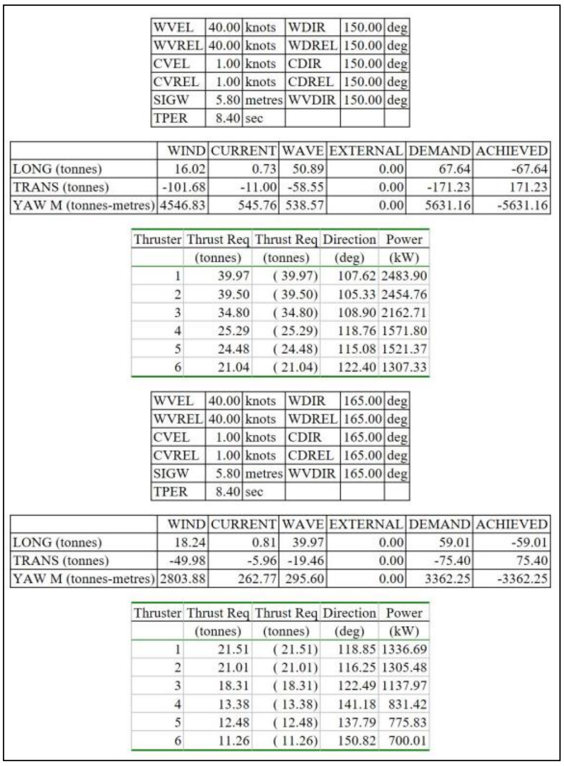
	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	13.11	0.42	87.36	0.00	100.88	-100.88
TRANS (tonnes)	-158.87	-18.87	-196.56	0.00	-374.30	374.30
YAW M (tonnes-metres)	4054.26	687.25	1182.76	0.00	5924.28	-5924.28

Thruster	Thrust Req (tonnes)	Thrust Req (tonnes)	Direction (deg)	Power (kW)
1	70.49	(70.49)	104.23	4380.64
2	70.25	(70.25)	103.42	4365.38
3	67.25	(67.25)	104.48	4179.10
4	60.95	(60.95)	106.56	3787.76
5	60.64	(60.64)	105.55	3768.61
6	58.16	(58.16)	106.80	3614.45

WVEL	40.00	knots	WDIR	135.00	deg
WVREL	40.00	knots	WDREL	135.00	deg
CVEL	1.00	knots	CDIR	135.00	deg
CVREL	1.00	knots	CDREL	135.00	deg
SIGW	5.80	metres	WVDIR	135.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	14.12	0.59	81.24	0.00	95.95	-95.95
TRANS (tonnes)	-139.64	-15.21	-125.46	0.00	-280.30	280.30
YAW M (tonnes-metres)	5001.51	707.47	1074.43	0.00	6783.41	-6783.41

Thruster	Thrust Req (tonnes)	Thrust Req (tonnes)	Direction (deg)	Power (kW)
1	59.12	(59.12)	106.56	3673.65
2	58.65	(58.65)	104.95	3644.62
3	53.72	(53.72)	107.32	3338.25
4	43.52	(43.52)	112.88	2704.41
5	42.83	(42.83)	110.59	2661.50
6	38.94	(38.94)	114.25	2419.73



WVEL	40.00	knots	WDIR	150.00	deg
WVREL	40.00	knots	WDREL	150.00	deg
CVEL	1.00	knots	CDIR	150.00	deg
CVREL	1.00	knots	CDREL	150.00	deg
SIGW	5.80	metres	WVDIR	150.00	deg
TPER	8.40	sec			

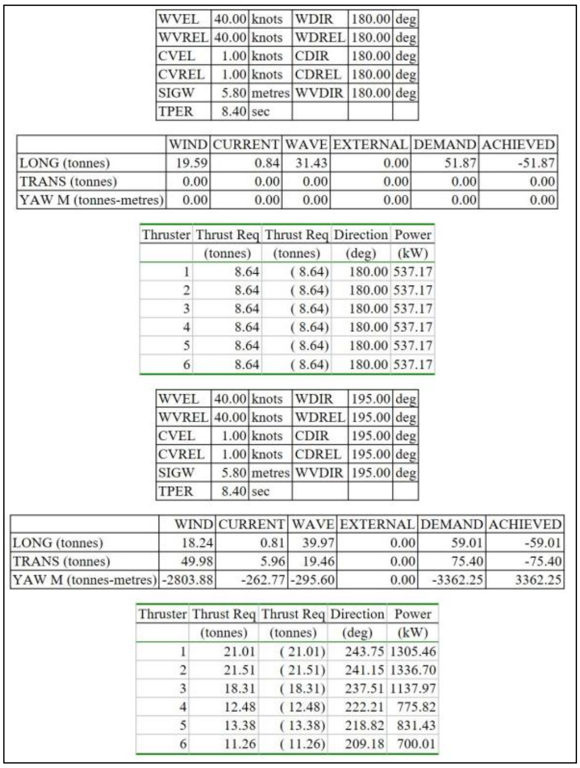
	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	16.02	0.73	50.89	0.00	67.64	-67.64
TRANS (tonnes)	-101.68	-11.00	-58.55	0.00	-171.23	171.23
YAW M (tonnes-metres)	4546.83	545.76	538.57	0.00	5631.16	-5631.16

Thruster	Thrust Req (tonnes)	Thrust Req (tonnes)	Direction (deg)	Power (kW)
1	39.97	(39.97)	107.62	2483.90
2	39.50	(39.50)	105.33	2454.76
3	34.80	(34.80)	108.90	2162.71
4	25.29	(25.29)	118.76	1571.80
5	24.48	(24.48)	115.08	1521.37
6	21.04	(21.04)	122.40	1307.33

WVEL	40.00	knots	WDIR	165.00	deg
WVREL	40.00	knots	WDREL	165.00	deg
CVEL	1.00	knots	CDIR	165.00	deg
CVREL	1.00	knots	CDREL	165.00	deg
SIGW	5.80	metres	WVDIR	165.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	18.24	0.81	39.97	0.00	59.01	-59.01
TRANS (tonnes)	-49.98	-5.96	-19.46	0.00	-75.40	75.40
YAW M (tonnes-metres)	2803.88	262.77	295.60	0.00	3362.25	-3362.25

Thruster	Thrust Req (tonnes)	Thrust Req (tonnes)	Direction (deg)	Power (kW)
1	21.51	(21.51)	118.85	1336.69
2	21.01	(21.01)	116.25	1305.48
3	18.31	(18.31)	122.49	1137.97
4	13.38	(13.38)	141.18	831.42
5	12.48	(12.48)	137.79	775.83
6	11.26	(11.26)	150.82	700.01



WVEL	40.00	knots	WDIR	180.00	deg
WVREL	40.00	knots	WDREL	180.00	deg
CVEL	1.00	knots	CDIR	180.00	deg
CVREL	1.00	knots	CDREL	180.00	deg
SIGW	5.80	metres	WVDIR	180.00	deg
TPER	8.40	sec			

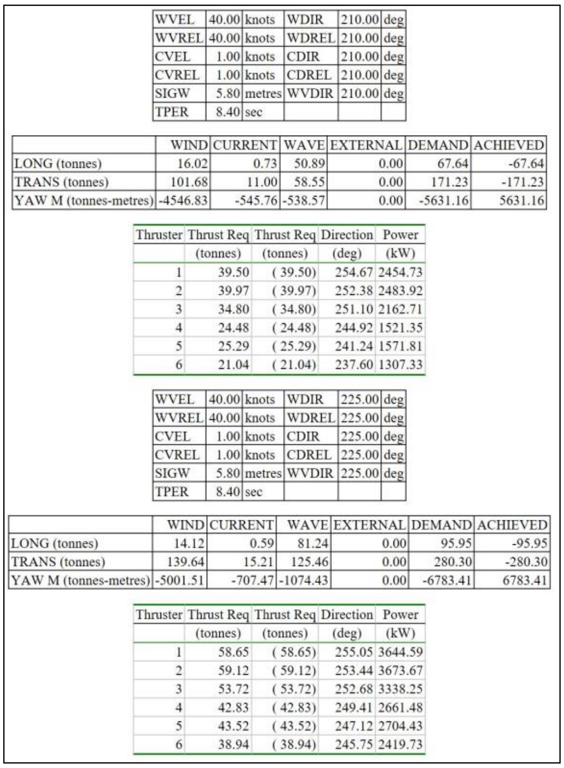
	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	19.59	0.84	31.43	0.00	51.87	-51.87
TRANS (tonnes)	0.00	0.00	0.00	0.00	0.00	0.00
YAW M (tonnes-metres)	0.00	0.00	0.00	0.00	0.00	0.00

Thruster	Thrust Req (tonnes)	Thrust Req (tonnes)	Direction (deg)	Power (kW)
1	8.64	(8.64)	180.00	537.17
2	8.64	(8.64)	180.00	537.17
3	8.64	(8.64)	180.00	537.17
4	8.64	(8.64)	180.00	537.17
5	8.64	(8.64)	180.00	537.17
6	8.64	(8.64)	180.00	537.17

WVEL	40.00	knots	WDIR	195.00	deg
WVREL	40.00	knots	WDREL	195.00	deg
CVEL	1.00	knots	CDIR	195.00	deg
CVREL	1.00	knots	CDREL	195.00	deg
SIGW	5.80	metres	WVDIR	195.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	18.24	0.81	39.97	0.00	59.01	-59.01
TRANS (tonnes)	49.98	5.96	19.46	0.00	75.40	-75.40
YAW M (tonnes-metres)	-2803.88	-262.77	-295.60	0.00	-3362.25	3362.25

Thruster	Thrust Req (tonnes)	Thrust Req (tonnes)	Direction (deg)	Power (kW)
1	21.01	(21.01)	243.75	1305.46
2	21.51	(21.51)	241.15	1336.70
3	18.31	(18.31)	237.51	1137.97
4	12.48	(12.48)	222.21	775.82
5	13.38	(13.38)	218.82	831.43
6	11.26	(11.26)	209.18	700.01



WVEL	40.00	knots	WDIR	210.00	deg
WVREL	40.00	knots	WDREL	210.00	deg
CVEL	1.00	knots	CDIR	210.00	deg
CVREL	1.00	knots	CDREL	210.00	deg
SIGW	5.80	metres	WVDIR	210.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	16.02	0.73	50.89	0.00	67.64	-67.64
TRANS (tonnes)	101.68	11.00	58.55	0.00	171.23	-171.23
YAW M (tonnes-metres)	-4546.83	-545.76	-538.57	0.00	-5631.16	5631.16

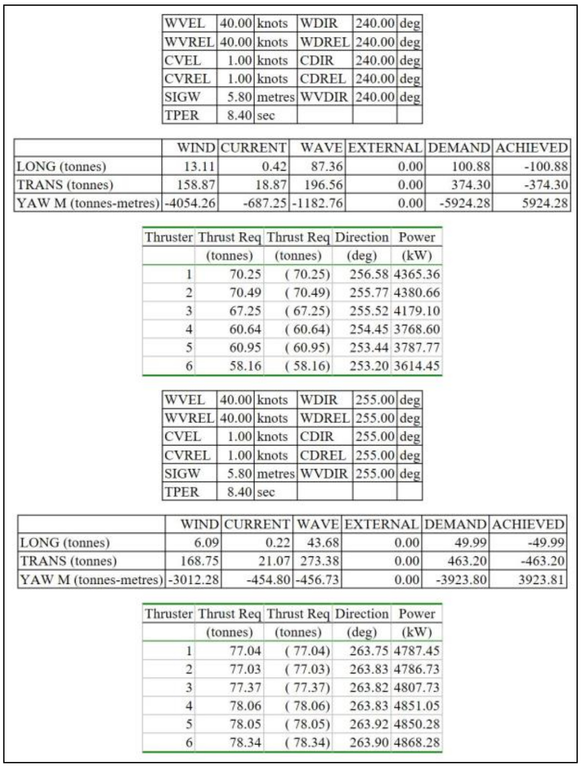
Thruster	Thrust Req (tonnes)	Thrust Req (tonnes)	Direction (deg)	Power (kW)
1	39.50	(39.50)	254.67	2454.73
2	39.97	(39.97)	252.38	2483.92
3	34.80	(34.80)	251.10	2162.71
4	24.48	(24.48)	244.92	1521.35
5	25.29	(25.29)	241.24	1571.81
6	21.04	(21.04)	237.60	1307.33

WVEL	40.00	knots	WDIR	225.00	deg
WVREL	40.00	knots	WDREL	225.00	deg
CVEL	1.00	knots	CDIR	225.00	deg
CVREL	1.00	knots	CDREL	225.00	deg
SIGW	5.80	metres	WVDIR	225.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	14.12	0.59	81.24	0.00	95.95	-95.95
TRANS (tonnes)	139.64	15.21	125.46	0.00	280.30	-280.30
YAW M (tonnes-metres)	-5001.51	-707.47	-1074.43	0.00	-6783.41	6783.41

Thruster	Thrust Req (tonnes)	Thrust Req (tonnes)	Direction (deg)	Power (kW)
1	58.65	(58.65)	255.05	3644.59
2	59.12	(59.12)	253.44	3673.67
3	53.72	(53.72)	252.68	3338.25
4	42.83	(42.83)	249.41	2661.48
5	43.52	(43.52)	247.12	2704.43
6	38.94	(38.94)	245.75	2419.73

Appendix 7 – Dynamic Position Calculation C



WVEL	40.00	knots	WDIR	240.00	deg
WVREL	40.00	knots	WDREL	240.00	deg
CVEL	1.00	knots	CDIR	240.00	deg
CVREL	1.00	knots	CDREL	240.00	deg
SIGW	5.80	metres	WVDIR	240.00	deg
TPER	8.40	sec			

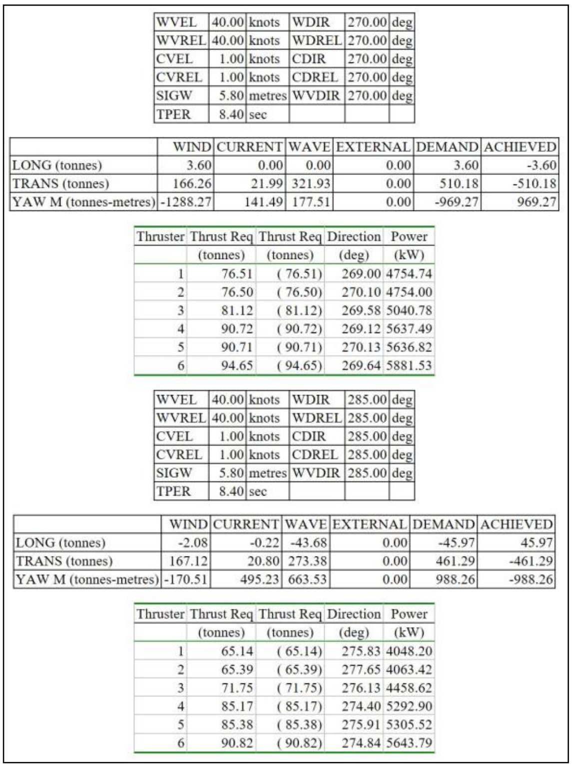
	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	13.11	0.42	87.36	0.00	100.88	-100.88
TRANS (tonnes)	158.87	18.87	196.56	0.00	374.30	-374.30
YAW M (tonnes-metres)	-4054.26	-687.25	-1182.76	0.00	-5924.28	5924.28

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	70.25	(70.25)	256.58	4365.36
2	70.49	(70.49)	255.77	4380.66
3	67.25	(67.25)	255.52	4179.10
4	60.64	(60.64)	254.45	3768.60
5	60.95	(60.95)	253.44	3787.77
6	58.16	(58.16)	253.20	3614.45

WVEL	40.00	knots	WDIR	255.00	deg
WVREL	40.00	knots	WDREL	255.00	deg
CVEL	1.00	knots	CDIR	255.00	deg
CVREL	1.00	knots	CDREL	255.00	deg
SIGW	5.80	metres	WVDIR	255.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	6.09	0.22	43.68	0.00	49.99	-49.99
TRANS (tonnes)	168.75	21.07	273.38	0.00	463.20	-463.20
YAW M (tonnes-metres)	-3012.28	-454.80	-456.73	0.00	-3923.80	3923.81

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	77.04	(77.04)	263.75	4787.45
2	77.03	(77.03)	263.83	4786.73
3	77.37	(77.37)	263.82	4807.73
4	78.06	(78.06)	263.83	4851.05
5	78.05	(78.05)	263.92	4850.28
6	78.34	(78.34)	263.90	4868.28



WVEL	40.00	knots	WDIR	270.00	deg
WVREL	40.00	knots	WDREL	270.00	deg
CVEL	1.00	knots	CDIR	270.00	deg
CVREL	1.00	knots	CDREL	270.00	deg
SIGW	5.80	metres	WVDIR	270.00	deg
TPER	8.40	sec			

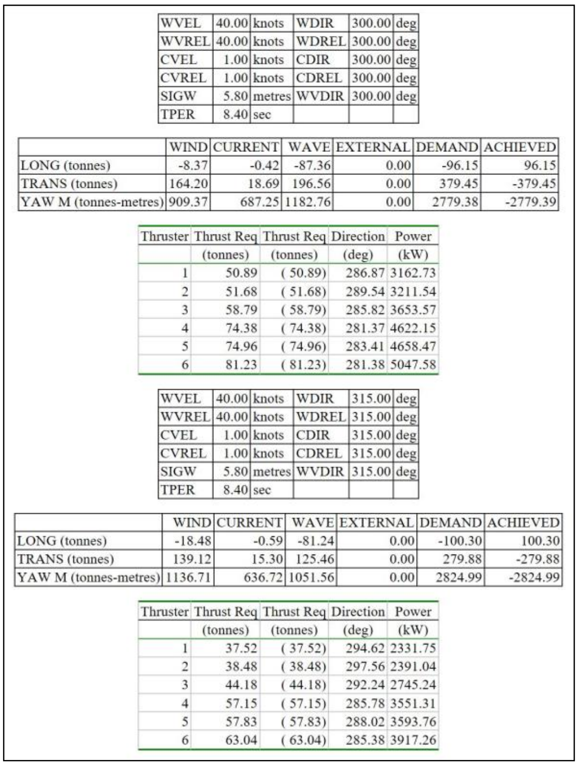
	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	3.60	0.00	0.00	0.00	3.60	-3.60
TRANS (tonnes)	166.26	21.99	321.93	0.00	510.18	-510.18
YAW M (tonnes-metres)	-1288.27	141.49	177.51	0.00	-969.27	969.27

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	76.51	(76.51)	269.00	4754.74
2	76.50	(76.50)	270.10	4754.00
3	81.12	(81.12)	269.58	5040.78
4	90.72	(90.72)	269.12	5637.49
5	90.71	(90.71)	270.13	5636.82
6	94.65	(94.65)	269.64	5881.53

WVEL	40.00	knots	WDIR	285.00	deg
WVREL	40.00	knots	WDREL	285.00	deg
CVEL	1.00	knots	CDIR	285.00	deg
CVREL	1.00	knots	CDREL	285.00	deg
SIGW	5.80	metres	WVDIR	285.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-2.08	-0.22	-43.68	0.00	-45.97	45.97
TRANS (tonnes)	167.12	20.80	273.38	0.00	461.29	-461.29
YAW M (tonnes-metres)	-170.51	495.23	663.53	0.00	988.26	-988.26

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	65.14	(65.14)	275.83	4048.20
2	65.39	(65.39)	277.65	4063.42
3	71.75	(71.75)	276.13	4458.62
4	85.17	(85.17)	274.40	5292.90
5	85.38	(85.38)	275.91	5305.52
6	90.82	(90.82)	274.84	5643.79



WVEL	40.00	knots	WDIR	300.00	deg
WVREL	40.00	knots	WDREL	300.00	deg
CVEL	1.00	knots	CDIR	300.00	deg
CVREL	1.00	knots	CDREL	300.00	deg
SIGW	5.80	metres	WVDIR	300.00	deg
TPER	8.40	sec			

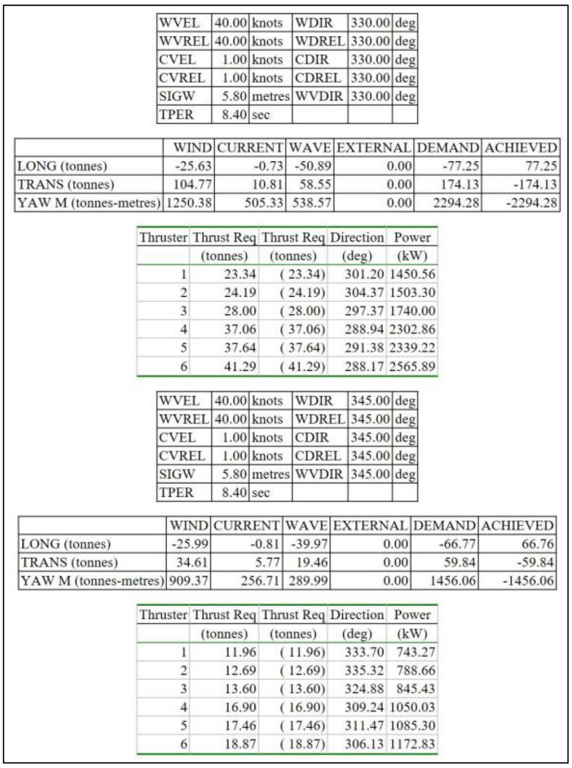
	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-8.37	-0.42	-87.36	0.00	-96.15	96.15
TRANS (tonnes)	164.20	18.69	196.56	0.00	379.45	-379.45
YAW M (tonnes-metres)	909.37	687.25	1182.76	0.00	2779.38	-2779.39

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	50.89	(50.89)	286.87	3162.73
2	51.68	(51.68)	289.54	3211.54
3	58.79	(58.79)	285.82	3653.57
4	74.38	(74.38)	281.37	4622.15
5	74.96	(74.96)	283.41	4658.47
6	81.23	(81.23)	281.38	5047.58

WVEL	40.00	knots	WDIR	315.00	deg
WVREL	40.00	knots	WDREL	315.00	deg
CVEL	1.00	knots	CDIR	315.00	deg
CVREL	1.00	knots	CDREL	315.00	deg
SIGW	5.80	metres	WVDIR	315.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-18.48	-0.59	-81.24	0.00	-100.30	100.30
TRANS (tonnes)	139.12	15.30	125.46	0.00	279.88	-279.88
YAW M (tonnes-metres)	1136.71	636.72	1051.56	0.00	2824.99	-2824.99

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	37.52	(37.52)	294.62	2331.75
2	38.48	(38.48)	297.56	2391.04
3	44.18	(44.18)	292.24	2745.24
4	57.15	(57.15)	285.78	3551.31
5	57.83	(57.83)	288.02	3593.76
6	63.04	(63.04)	285.38	3917.26



WVEL	40.00	knots	WDIR	330.00	deg
WVREL	40.00	knots	WDREL	330.00	deg
CVEL	1.00	knots	CDIR	330.00	deg
CVREL	1.00	knots	CDREL	330.00	deg
SIGW	5.80	metres	WVDIR	330.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-25.63	-0.73	-50.89	0.00	-77.25	77.25
TRANS (tonnes)	104.77	10.81	58.55	0.00	174.13	-174.13
YAW M (tonnes-metres)	1250.38	505.33	538.57	0.00	2294.28	-2294.28

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	23.34	(23.34)	301.20	1450.56
2	24.19	(24.19)	304.37	1503.30
3	28.00	(28.00)	297.37	1740.00
4	37.06	(37.06)	288.94	2302.86
5	37.64	(37.64)	291.38	2339.22
6	41.29	(41.29)	288.17	2565.89

WVEL	40.00	knots	WDIR	345.00	deg
WVREL	40.00	knots	WDREL	345.00	deg
CVEL	1.00	knots	CDIR	345.00	deg
CVREL	1.00	knots	CDREL	345.00	deg
SIGW	5.80	metres	WVDIR	345.00	deg
TPER	8.40	sec			

	WIND	CURRENT	WAVE	EXTERNAL	DEMAND	ACHIEVED
LONG (tonnes)	-25.99	-0.81	-39.97	0.00	-66.77	66.76
TRANS (tonnes)	34.61	5.77	19.46	0.00	59.84	-59.84
YAW M (tonnes-metres)	909.37	256.71	289.99	0.00	1456.06	-1456.06

Thruster	Thrust Req	Thrust Req	Direction	Power
	(tonnes)	(tonnes)	(deg)	(kW)
1	11.96	(11.96)	333.70	743.27
2	12.69	(12.69)	335.32	788.66
3	13.60	(13.60)	324.88	845.43
4	16.90	(16.90)	309.24	1050.03
5	17.46	(17.46)	311.47	1085.30
6	18.87	(18.87)	306.13	1172.83

Appendix 8 – Intact Stability Criteria

ISCode2008 / MARPOL / ABS

International Code on Intact Stability 2008

Criteria regarding lever curve properties intact assumptions:

- The area under the righting lever curve from equilibrium to 30 deg. (or down flooding) > 0.055 m.rad.
- The area under the righting lever curve from equilibrium to 40 deg. (or down flooding) > 0.090 m.rad.
- The area under the righting lever curve from 30 to 40 deg. (or down flooding) > 0.030 m.rad.
- The righting lever GZ > 0.20m, for at least 30 deg. angle of heel.
- The maximum GZ occurs to a min angle of heel of 25.00 deg.
- Initial GM > 0.15 m.

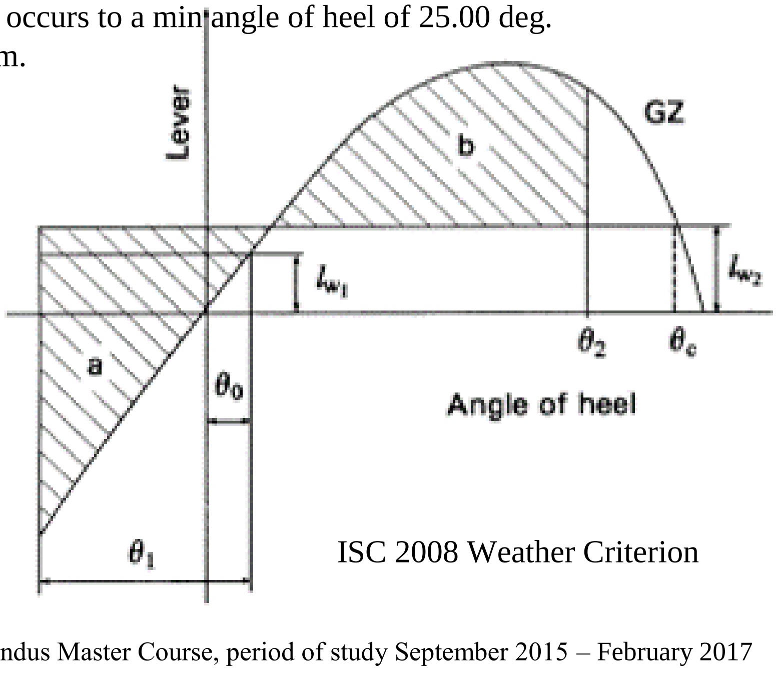
Severe wind and rolling criterion (Weather criterion):

- Angle of heel due to steady wind (pressure of 504 [Pa]) preferably less than 16.00 deg. or 80% of the angle of deck edge immersion, whichever is less.
- Angle of windward roll as per International Code on Intact Stability 2008 2.3.4.
- Stability area (b) should be equal to or greater than the “gust” area (a) (gust wind pressure = 1.5*steady wind pressure).
- Stability area (b) assumed to end at the least of either 50.00 deg or down flooding angle or second intercept with wind.

MARPOL 73/78 Annex 1 (2011 Edition) Reg.27

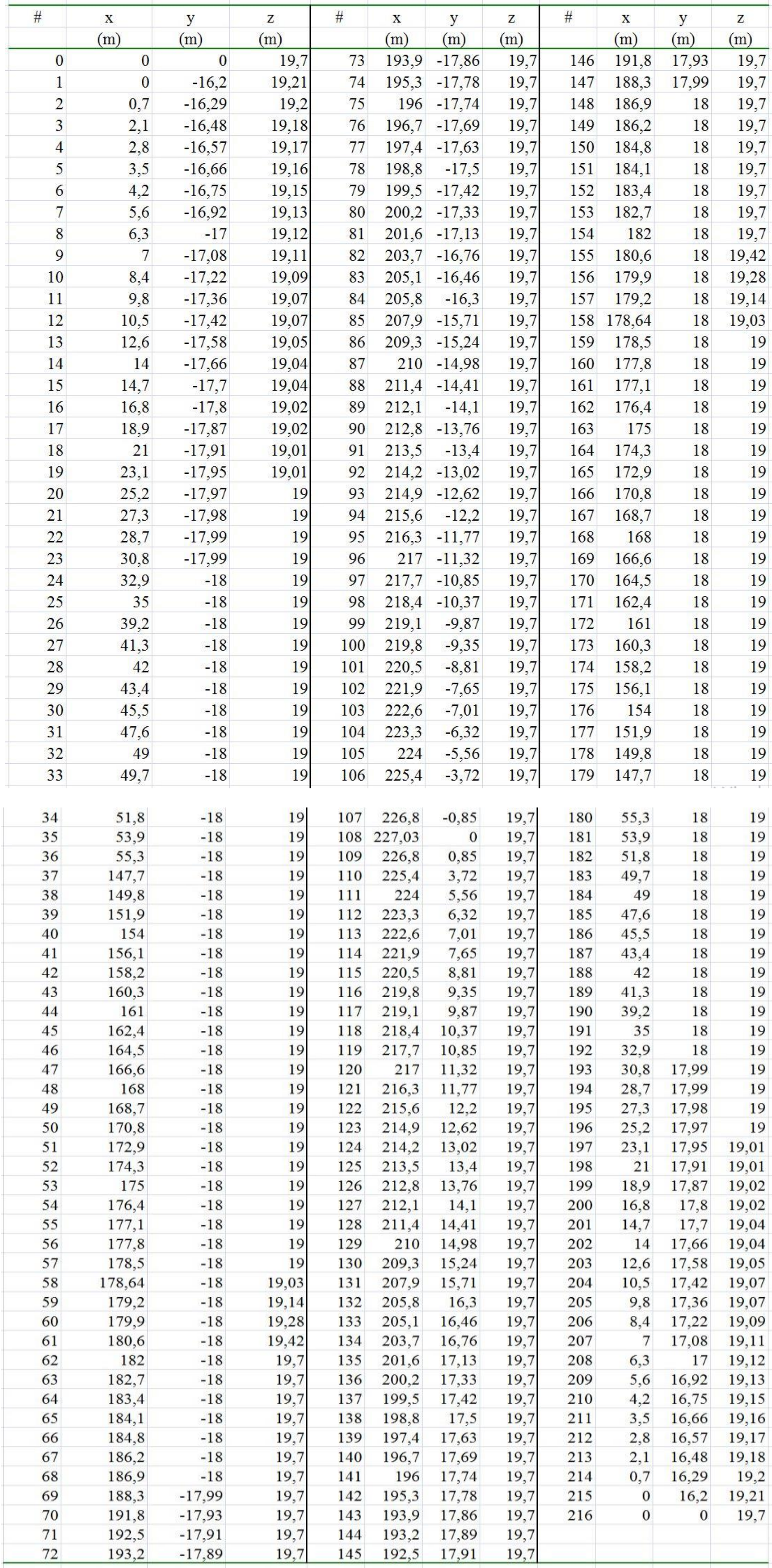
Criteria regarding lever curve properties intact assumptions:

- The area under the righting lever curve from equilibrium to 30 deg. (or down flooding) > 0.055 m.rad.
- The area under the righting lever curve from equilibrium to 40 deg. (or down flooding) > 0.090 m.rad.
- The area under the righting lever curve from 30 to 40 deg. (or down flooding) > 0.030 m.rad.
- The righting lever GZ > 0.20m, for at least 30 deg. angle of heel.
- The maximum GZ occurs to a min angle of heel of 25.00 deg.
- Initial GM > 0.15 m.



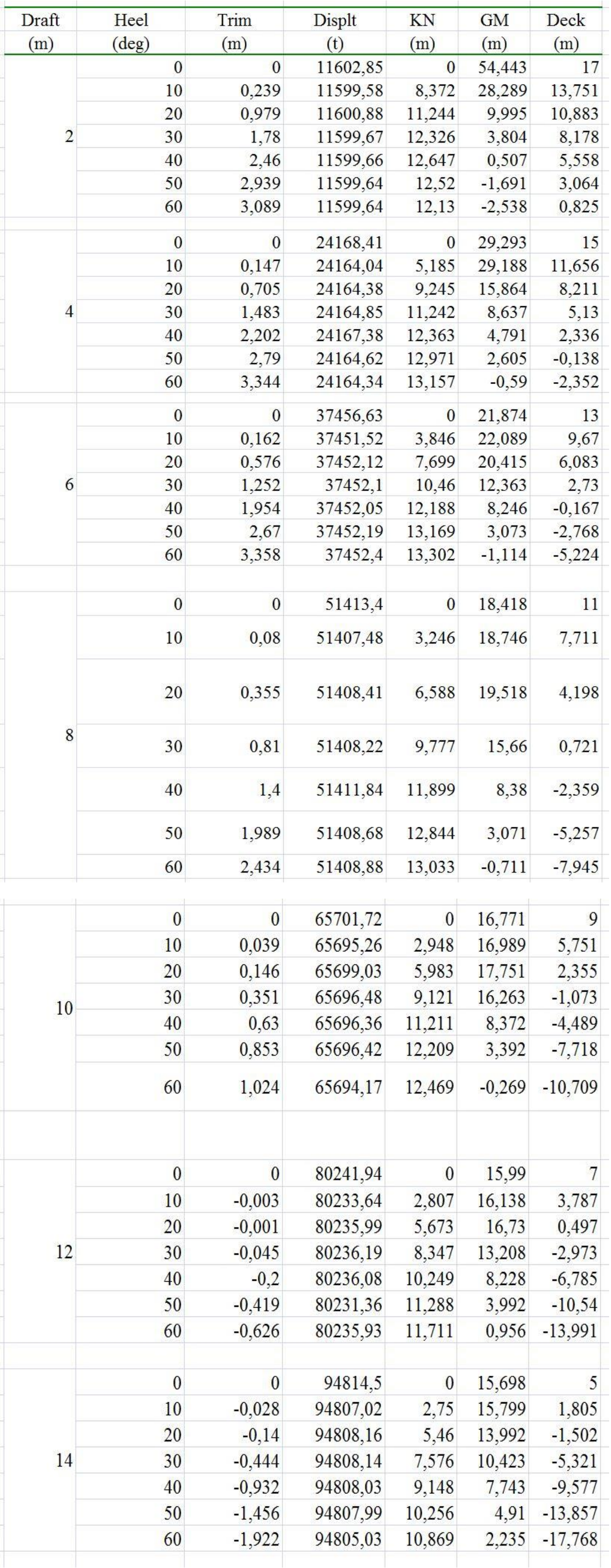
ISC 2008 Weather Criterion

Appendix 9 – Deck Margin Line Table



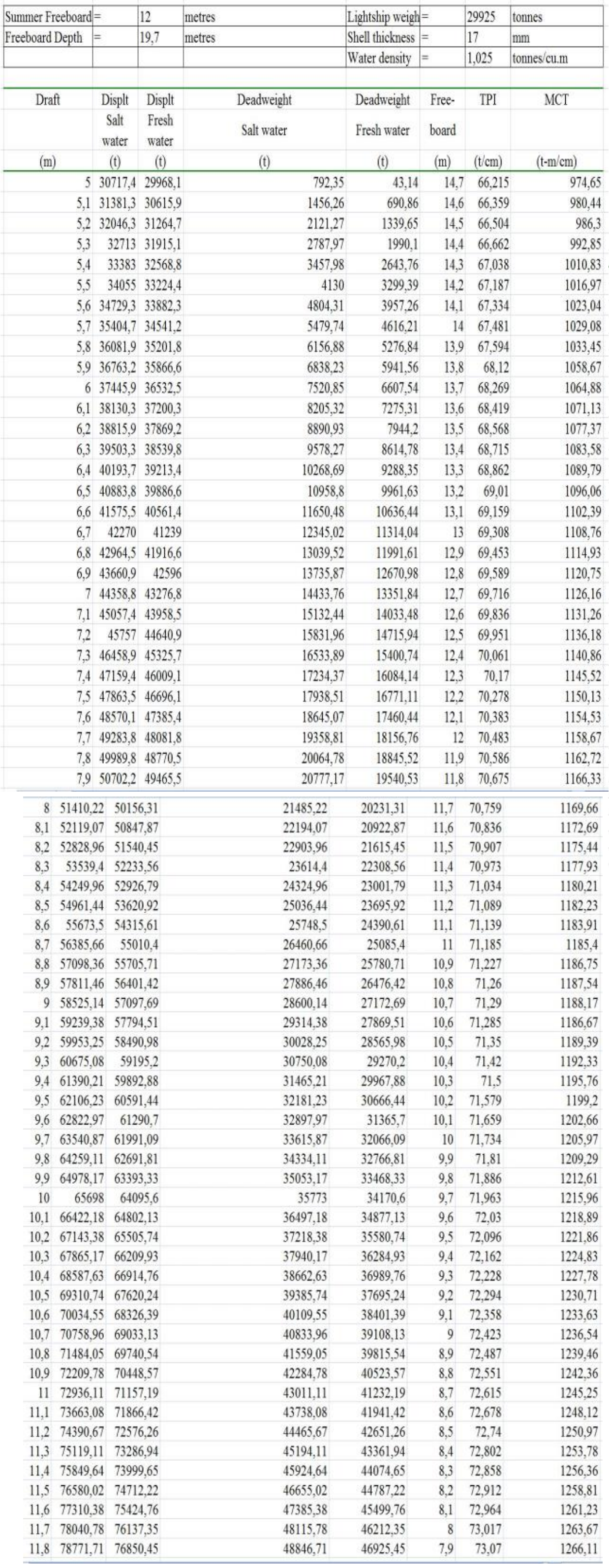
#	x	y	z	#	x	y	z	#	x	y	z
	(m)	(m)	(m)		(m)	(m)	(m)		(m)	(m)	(m)
0	0	0	19,7	73	193,9	-17,86	19,7	146	191,8	17,93	19,7
1	0	-16,2	19,21	74	195,3	-17,78	19,7	147	188,3	17,99	19,7
2	0,7	-16,29	19,2	75	196	-17,74	19,7	148	186,9	18	19,7
3	2,1	-16,48	19,18	76	196,7	-17,69	19,7	149	186,2	18	19,7
4	2,8	-16,57	19,17	77	197,4	-17,63	19,7	150	184,8	18	19,7
5	3,5	-16,66	19,16	78	198,8	-17,5	19,7	151	184,1	18	19,7
6	4,2	-16,75	19,15	79	199,5	-17,42	19,7	152	183,4	18	19,7
7	5,6	-16,92	19,13	80	200,2	-17,33	19,7	153	182,7	18	19,7
8	6,3	-17	19,12	81	201,6	-17,13	19,7	154	182	18	19,7
9	7	-17,08	19,11	82	203,7	-16,76	19,7	155	180,6	18	19,42
10	8,4	-17,22	19,09	83	205,1	-16,46	19,7	156	179,9	18	19,28
11	9,8	-17,36	19,07	84	205,8	-16,3	19,7	157	179,2	18	19,14
12	10,5	-17,42	19,07	85	207,9	-15,71	19,7	158	178,64	18	19,03
13	12,6	-17,58	19,05	86	209,3	-15,24	19,7	159	178,5	18	19
14	14	-17,66	19,04	87	210	-14,98	19,7	160	177,8	18	19
15	14,7	-17,7	19,04	88	211,4	-14,41	19,7	161	177,1	18	19
16	16,8	-17,8	19,02	89	212,1	-14,1	19,7	162	176,4	18	19
17	18,9	-17,87	19,02	90	212,8	-13,76	19,7	163	175	18	19
18	21	-17,91	19,01	91	213,5	-13,4	19,7	164	174,3	18	19
19	23,1	-17,95	19,01	92	214,2	-13,02	19,7	165	172,9	18	19
20	25,2	-17,97	19	93	214,9	-12,62	19,7	166	170,8	18	19
21	27,3	-17,98	19	94	215,6	-12,2	19,7	167	168,7	18	19
22	28,7	-17,99	19	95	216,3	-11,77	19,7	168	168	18	19
23	30,8	-17,99	19	96	217	-11,32	19,7	169	166,6	18	19
24	32,9	-18	19	97	217,7	-10,85	19,7	170	164,5	18	19
25	35	-18	19	98	218,4	-10,37	19,7	171	162,4	18	19
26	39,2	-18	19	99	219,1	-9,87	19,7	172	161	18	19
27	41,3	-18	19	100	219,8	-9,35	19,7	173	160,3	18	19
28	42	-18	19	101	220,5	-8,81	19,7	174	158,2	18	19
29	43,4	-18	19	102	221,9	-7,65	19,7	175	156,1	18	19
30	45,5	-18	19	103	222,6	-7,01	19,7	176	154	18	19
31	47,6	-18	19	104	223,3	-6,32	19,7	177	151,9	18	19
32	49	-18	19	105	224	-5,56	19,7	178	149,8	18	19
33	49,7	-18	19	106	225,4	-3,72	19,7	179	147,7	18	19
34	51,8	-18	19	107	226,8	-0,85	19,7	180	55,3	18	19
35	53,9	-18	19	108	227,03	0	19,7	181	53,9	18	19
36	55,3	-18	19	109	226,8	0,85	19,7	182	51,8	18	19
37	147,7	-18	19	110	225,4	3,72	19,7	183	49,7	18	19
38	149,8	-18	19	111	224	5,56	19,7	184	49	18	19
39	151,9	-18	19	112	223,3	6,32	19,7	185	47,6	18	19
40	154	-18	19	113	222,6	7,01	19,7	186	45,5	18	19
41	156,1	-18	19	114	221,9	7,65	19,7	187	43,4	18	19
42	158,2	-18	19	115	220,5	8,81	19,7	188	42	18	19
43	160,3	-18	19	116	219,8	9,35	19,7	189	41,3	18	19
44	161	-18	19	117	219,1	9,87	19,7	190	39,2	18	19
45	162,4	-18	19	118	218,4	10,37	19,7	191	35	18	19
46	164,5	-18	19	119	217,7	10,85	19,7	192	32,9	18	19
47	166,6	-18	19	120	217	11,32	19,7	193	30,8	17,99	19
48	168	-18	19	121	216,3	11,77	19,7	194	28,7	17,99	19
49	168,7	-18	19	122	215,6	12,2	19,7	195	27,3	17,98	19
50	170,8	-18	19	123	214,9	12,62	19,7	196	25,2	17,97	19
51	172,9	-18	19	124	214,2	13,02	19,7	197	23,1	17,95	19,01
52	174,3	-18	19	125	213,5	13,4	19,7	198	21	17,91	19,01
53	175	-18	19	126	212,8	13,76	19,7	199	18,9	17,87	19,02
54	176,4	-18	19	127	212,1	14,1	19,7	200	16,8	17,8	19,02
55	177,1	-18	19	128	211,4	14,41	19,7	201	14,7	17,7	19,04
56	177,8	-18	19	129	210	14,98	19,7	202	14	17,66	19,04
57	178,5	-18	19	130	209,3	15,24	19,7	203	12,6	17,58	19,05
58	178,64	-18	19,03	131	207,9	15,71	19,7	204	10,5	17,42	19,07
59	179,2	-18	19,14	132	205,8	16,3	19,7	205	9,8	17,36	19,07
60	179,9	-18	19,28	133	205,1	16,46	19,7	206	8,4	17,22	19,09
61	180,6	-18	19,42	134	203,7	16,76	19,7	207	7	17,08	19,11
62	182	-18	19,7	135	201,6	17,13	19,7	208	6,3	17	19,12
63	182,7	-18	19,7	136	200,2	17,33	19,7	209	5,6	16,92	19,13
64	183,4	-18	19,7	137	199,5	17,42	19,7	210	4,2	16,75	19,15
65	184,1	-18	19,7	138	198,8	17,5	19,7	211	3,5	16,66	19,16
66	184,8	-18	19,7	139	197,4	17,63	19,7	212	2,8	16,57	19,17
67	186,2	-18	19,7	140	196,7	17,69	19,7	213	2,1	16,48	19,18
68	186,9	-18	19,7	141	196	17,74	19,7	214	0,7	16,29	19,2
69	188,3	-17,99	19,7	142	195,3	17,78	19,7	215	0	16,2	19,21
70	191,8	-17,93	19,7	143	193,9	17,86	19,7	216	0	0	19,7
71	192,5	-17,91	19,7	144	193,2	17,89	19,7				
72	193,2	-17,89	19,7	145	192,5	17,91	19,7				

Appendix 10 – Cross Curve Stability



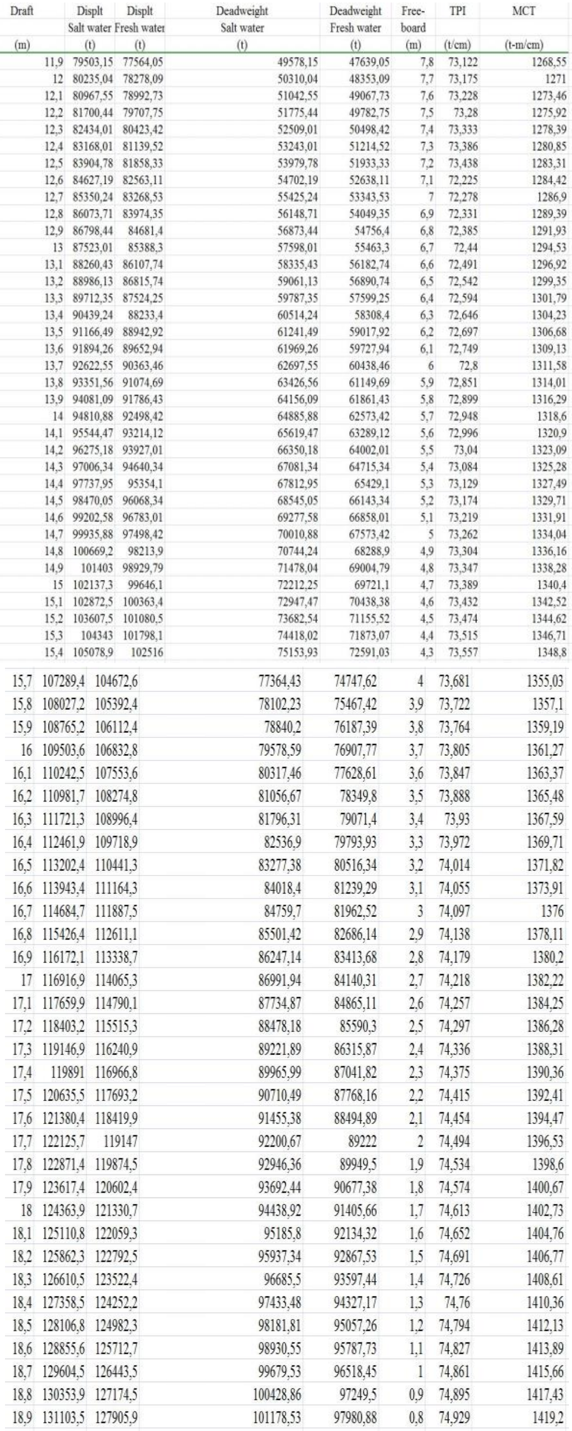
Draft (m)	Heel (deg)	Trim (m)	Displt (t)	KN (m)	GM (m)	Deck (m)
2	0	0	11602,85	0	54,443	17
	10	0,239	11599,58	8,372	28,289	13,751
	20	0,979	11600,88	11,244	9,995	10,883
	30	1,78	11599,67	12,326	3,804	8,178
	40	2,46	11599,66	12,647	0,507	5,558
	50	2,939	11599,64	12,52	-1,691	3,064
	60	3,089	11599,64	12,13	-2,538	0,825
4	0	0	24168,41	0	29,293	15
	10	0,147	24164,04	5,185	29,188	11,656
	20	0,705	24164,38	9,245	15,864	8,211
	30	1,483	24164,85	11,242	8,637	5,13
	40	2,202	24167,38	12,363	4,791	2,336
	50	2,79	24164,62	12,971	2,605	-0,138
	60	3,344	24164,34	13,157	-0,59	-2,352
6	0	0	37456,63	0	21,874	13
	10	0,162	37451,52	3,846	22,089	9,67
	20	0,576	37452,12	7,699	20,415	6,083
	30	1,252	37452,1	10,46	12,363	2,73
	40	1,954	37452,05	12,188	8,246	-0,167
	50	2,67	37452,19	13,169	3,073	-2,768
	60	3,358	37452,4	13,302	-1,114	-5,224
8	0	0	51413,4	0	18,418	11
	10	0,08	51407,48	3,246	18,746	7,711
	20	0,355	51408,41	6,588	19,518	4,198
	30	0,81	51408,22	9,777	15,66	0,721
	40	1,4	51411,84	11,899	8,38	-2,359
	50	1,989	51408,68	12,844	3,071	-5,257
	60	2,434	51408,88	13,033	-0,711	-7,945
10	0	0	65701,72	0	16,771	9
	10	0,039	65695,26	2,948	16,989	5,751
	20	0,146	65699,03	5,983	17,751	2,355
	30	0,351	65696,48	9,121	16,263	-1,073
	40	0,63	65696,36	11,211	8,372	-4,489
	50	0,853	65696,42	12,209	3,392	-7,718
	60	1,024	65694,17	12,469	-0,269	-10,709
12	0	0	80241,94	0	15,99	7
	10	-0,003	80233,64	2,807	16,138	3,787
	20	-0,001	80235,99	5,673	16,73	0,497
	30	-0,045	80236,19	8,347	13,208	-2,973
	40	-0,2	80236,08	10,249	8,228	-6,785
	50	-0,419	80231,36	11,288	3,992	-10,54
	60	-0,626	80235,93	11,711	0,956	-13,991
14	0	0	94814,5	0	15,698	5
	10	-0,028	94807,02	2,75	15,799	1,805
	20	-0,14	94808,16	5,46	13,992	-1,502
	30	-0,444	94808,14	7,576	10,423	-5,321
	40	-0,932	94808,03	9,148	7,743	-9,577
	50	-1,456	94807,99	10,256	4,91	-13,857
	60	-1,922	94805,03	10,869	2,235	-17,768

Appendix 11 – Deadweight Scale



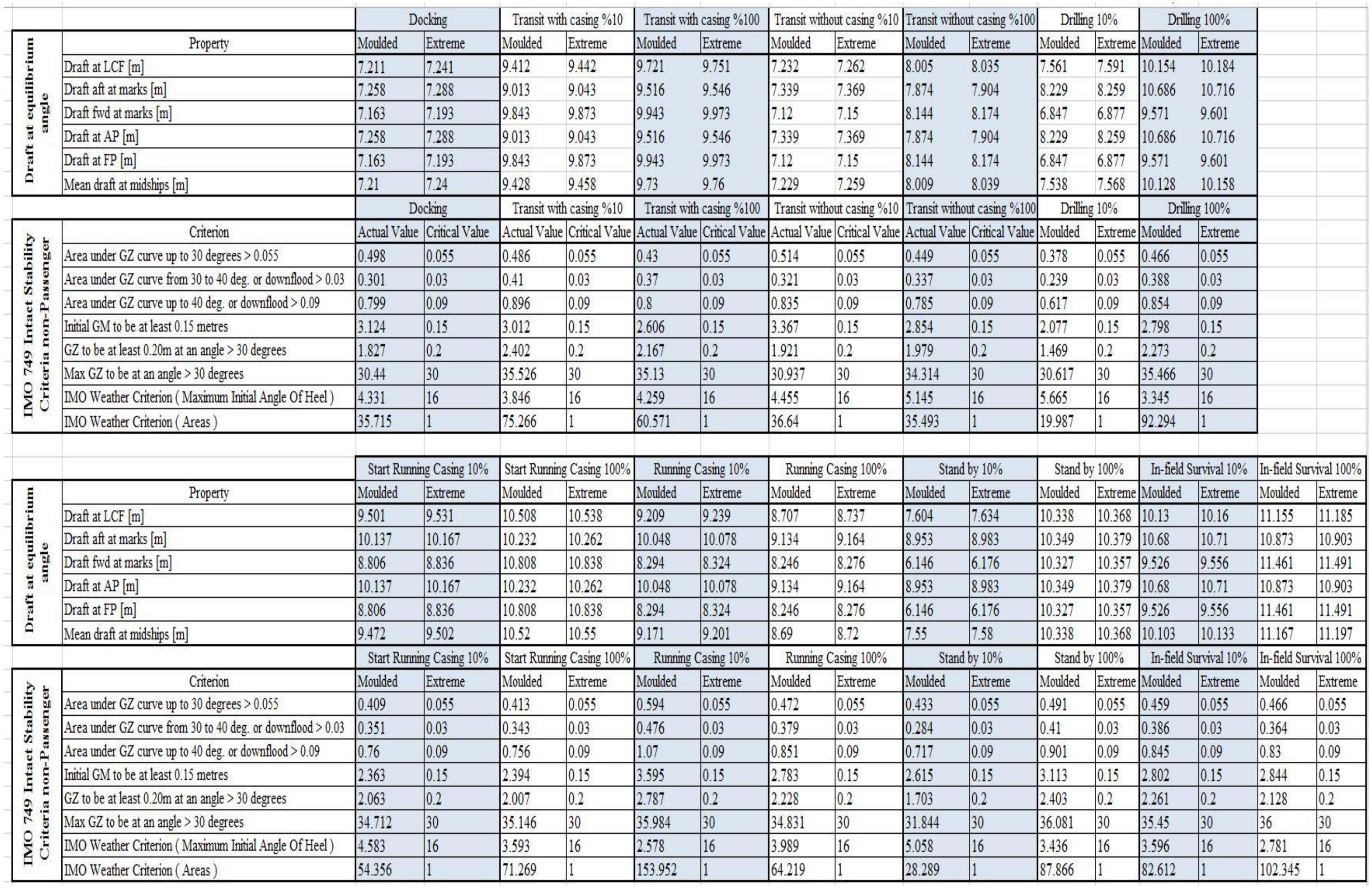
Summer Freeboard	=	12	metres	Lightship weigh	=	29925	tonnes
Freeboard Depth	=	19,7	metres	Shell thickness	=	17	mm
				Water density	=	1,025	tonnes/cu.m

Draft	Displt	Displt	Deadweight	Deadweight	Free-	TPI	MCT
	Salt water	Fresh water	Salt water	Fresh water	board		
(m)	(t)	(t)	(t)	(t)	(m)	(t/cm)	(t-m/cm)
5	30717,4	29968,1	792,35	43,14	14,7	66,215	974,65
5,1	31381,3	30615,9	1456,26	690,86	14,6	66,359	980,44
5,2	32046,3	31264,7	2121,27	1339,65	14,5	66,504	986,3
5,3	32713	31915,1	2787,97	1990,1	14,4	66,662	992,85
5,4	33383	32568,8	3457,98	2643,76	14,3	67,038	1010,83
5,5	34055	33224,4	4130	3299,39	14,2	67,187	1016,97
5,6	34729,3	33882,3	4804,31	3957,26	14,1	67,334	1023,04
5,7	35404,7	34541,2	5479,74	4616,21	14	67,481	1029,08
5,8	36081,9	35201,8	6156,88	5276,84	13,9	67,594	1033,45
5,9	36763,2	35866,6	6838,23	5941,56	13,8	68,12	1058,67
6	37445,9	36532,5	7520,85	6607,54	13,7	68,269	1064,88
6,1	38130,3	37200,3	8205,32	7275,31	13,6	68,419	1071,13
6,2	38815,9	37869,2	8890,93	7944,2	13,5	68,568	1077,37
6,3	39503,3	38539,8	9578,27	8614,78	13,4	68,715	1083,58
6,4	40193,7	39213,4	10268,69	9288,35	13,3	68,862	1089,79
6,5	40883,8	39886,6	10958,8	9961,63	13,2	69,01	1096,06
6,6	41575,5	40561,4	11650,48	10636,44	13,1	69,159	1102,39
6,7	42270	41239	12345,02	11314,04	13	69,308	1108,76
6,8	42964,5	41916,6	13039,52	11991,61	12,9	69,453	1114,93
6,9	43660,9	42596	13735,87	12670,98	12,8	69,589	1120,75
7	44358,8	43276,8	14433,76	13351,84	12,7	69,716	1126,16
7,1	45057,4	43958,5	15132,44	14033,48	12,6	69,836	1131,26
7,2	45757	44640,9	15831,96	14715,94	12,5	69,951	1136,18
7,3	46458,9	45325,7	16533,89	15400,74	12,4	70,061	1140,86
7,4	47159,4	46009,1	17234,37	16084,14	12,3	70,17	1145,52
7,5	47863,5	46696,1	17938,51	16771,11	12,2	70,278	1150,13
7,6	48570,1	47385,4	18645,07	17460,44	12,1	70,383	1154,53
7,7	49283,8	48081,8	19358,81	18156,76	12	70,483	1158,67
7,8	49989,8	48770,5	20064,78	18845,52	11,9	70,586	1162,72
7,9	50702,2	49465,5	20777,17	19540,53	11,8	70,675	1166,33
8	51410,22	50156,31	21485,22	20231,31	11,7	70,759	1169,66
8,1	52119,07	50847,87	22194,07	20922,87	11,6	70,836	1172,69
8,2	52828,96	51540,45	22903,96	21615,45	11,5	70,907	1175,44
8,3	53539,4	52233,56	23614,4	22308,56	11,4	70,973	1177,93
8,4	54249,96	52926,79	24324,96	23001,79	11,3	71,034	1180,21
8,5	54961,44	53620,92	25036,44	23695,92	11,2	71,089	1182,23
8,6	55673,5	54315,61	25748,5	24390,61	11,1	71,139	1183,91
8,7	56385,66	55010,4	26460,66	25085,4	11	71,185	1185,4
8,8	57098,36	55705,71	27173,36	25780,71	10,9	71,227	1186,75
8,9	57811,46	56401,42	27886,46	26476,42	10,8	71,26	1187,54
9	58525,14	57097,69	28600,14	27172,69	10,7	71,29	1188,17
9,1	59239,38	57794,51	29314,38	27869,51	10,6	71,285	1186,67
9,2	59953,25	58490,98	30028,25	28565,98	10,5	71,35	1189,39
9,3	60675,08	59195,2	30750,08	29270,2	10,4	71,42	1192,33
9,4	61390,21	59892,88	31465,21	29967,88	10,3	71,5	1195,76
9,5	62106,23	60591,44	32181,23	30666,44	10,2	71,579	1199,2
9,6	62822,97	61290,7	32897,97	31365,7	10,1	71,659	1202,66
9,7	63540,87	61991,09	33615,87	32066,09	10	71,734	1205,97
9,8	64259,11	62691,81	34334,11	32766,81	9,9	71,81	1209,29
9,9	64978,17	63393,33	35053,17	33468,33	9,8	71,886	1212,61
10	65698	64095,6	35773	34170,6	9,7	71,963	1215,96
10,1	66422,18	64802,13	36497,18	34877,13	9,6	72,03	1218,89
10,2	67143,38	65505,74	37218,38	35580,74	9,5	72,096	1221,86
10,3	67865,17	66209,93	37940,17	36284,93	9,4	72,162	1224,83
10,4	68587,63	66914,76	38662,63	36989,76	9,3	72,228	1227,78
10,5	69310,74	67620,24	39385,74	37695,24	9,2	72,294	1230,71
10,6	70034,55	68326,39	40109,55	38401,39	9,1	72,358	1233,63
10,7	70758,96	69033,13	40833,96	39108,13	9	72,423	1236,54
10,8	71484,05	69740,54	41559,05	39815,54	8,9	72,487	1239,46
10,9	72209,78	70448,57	42284,78	40523,57	8,8	72,551	1242,36
11	72936,11	71157,19	43011,11	41232,19	8,7	72,615	1245,25
11,1	73663,08	71866,42	43738,08	41941,42	8,6	72,678	1248,12
11,2	74390,67	72576,26	44465,67	42651,26	8,5	72,74	1250,97
11,3	75119,11	73286,94	45194,11	43361,94	8,4	72,802	1253,78
11,4	75849,64	73999,65	45924,64	44074,65	8,3	72,858	1256,36
11,5	76580,02	74712,22	46655,02	44787,22	8,2	72,912	1258,81
11,6	77310,38	75424,76	47385,38	45499,76	8,1	72,964	1261,23
11,7	78040,78	76137,35	48115,78	46212,35	8	73,017	1263,67
11,8	78771,71	76850,45	48846,71	46925,45	7,9	73,07	1266,11



Draft	Displt	Displt	Deadweight	Deadweight	Free-	TPI	MCT
	Salt water	Fresh water	Salt water	Fresh water	board		
(m)	(t)	(t)	(t)	(t)	(m)	(t/cm)	(t-m/cm)
11,9	79503,15	77564,05	49578,15	47639,05	7,8	73,122	1268,55
12	80235,04	78278,09	50310,04	48353,09	7,7	73,175	1271
12,1	80967,55	78992,73	51042,55	49067,73	7,6	73,228	1273,46
12,2	81700,44	79707,75	51775,44	49782,75	7,5	73,28	1275,92
12,3	82434,01	80423,42	52509,01	50498,42	7,4	73,333	1278,39
12,4	83168,01	81139,52	53243,01	51214,52	7,3	73,386	1280,85
12,5	83904,78	81858,33	53979,78	51933,33	7,2	73,438	1283,31
12,6	84627,19	82563,11	54702,19	52638,11	7,1	72,225	1284,42
12,7	85350,24	83268,53	55425,24	53343,53	7	72,278	1286,9
12,8	86073,71	83974,35	56148,71	54049,35	6,9	72,331	1289,39
12,9	86798,44	84681,4	56873,44	54756,4	6,8	72,385	1291,93
13	87523,01	85388,3	57598,01	55463,3	6,7	72,44	1294,53
13,1	88260,43	86107,74	58335,43	56182,74	6,6	72,491	1296,92
13,2	88986,13	86815,74	59061,13	56890,74	6,5	72,542	1299,35
13,3	89712,35	87524,25	59787,35	57599,25	6,4	72,594	1301,79
13,4	90439,24	88233,4	60514,24	58308,4	6,3	72,646	1304,23
13,5	91166,49	88942,92	61241,49	59017,92	6,2	72,697	1306,68
13,6	91894,26	89652,94	61969,26	59727,94	6,1	72,749	1309,13
13,7	92622,55	90363,46	62697,55	60438,46	6	72,8	1311,58
13,8	93351,56	91074,69	63426,56	61149,69	5,9	72,851	1314,01
13,9	94081,09	91786,43	64156,09	61861,43	5,8	72,899	1316,29
14	94810,88	92498,42	64885,88	62573,42	5,7	72,948	1318,6
14,1	95544,47	93214,12	65619,47	63289,12	5,6	72,996	1320,9
14,2	96275,18	93927,01	66350,18	64002,01	5,5	73,04	1323,09
14,3	97006,34	94640,34	67081,34	64715,34	5,4	73,084	1325,28
14,4	97737,95	95354,1	67812,95	65429,1	5,3	73,129	1327,49
14,5	98470,05	96068,34	68545,05	66143,34	5,2	73,174	1329,71
14,6	99202,58	96783,01	69277,58	66858,01	5,1	73,219	1331,91
14,7	99935,88	97498,42	70010,88	67573,42	5	73,262	1334,04
14,8	100669,2	98213,9	70744,24	68288,9	4,9	73,304	1336,16
14,9	101403	98929,79	71478,04	69004,79	4,8	73,347	1338,28
15	102137,3	99646,1	72212,25	69721,1	4,7	73,389	1340,4
15,1	102872,5	100363,4	72947,47	70438,38	4,6	73,432	1342,52
15,2	103607,5	101080,5	73682,54	71155,52	4,5	73,474	1344,62
15,3	104343	101798,1	74418,02	71873,07	4,4	73,515	1346,71
15,4	105078,9	102516	75153,93	72591,03	4,3	73,557	1348,8
15,7	107289,4	104672,6	77364,43	74747,62	4	73,681	1355,03
15,8	108027,2	105392,4	78102,23	75467,42	3,9	73,722	1357,1
15,9	108765,2	106112,4	78840,2	76187,39	3,8	73,764	1359,19
16	109503,6	106832,8	79578,59	76907,77	3,7	73,805	1361,27
16,1	110242,5	107553,6	80317,46	77628,61	3,6	73,847	1363,37
16,2	110981,7	108274,8	81056,67	78349,8	3,5	73,888	1365,48
16,3	111721,3	108996,4	81796,31	79071,4	3,4	73,93	1367,59
16,4	112461,9	109718,9	82536,9	79793,93	3,3	73,972	1369,71
16,5	113202,4	110441,3	83277,38	80516,34	3,2	74,014	1371,82
16,6	113943,4	111164,3	84018,4	81239,29	3,1	74,055	1373,91
16,7	114684,7	111887,5	84759,7	81962,52	3	74,097	1376
16,8	115426,4	112611,1	85501,42	82686,14	2,9	74,138	1378,11
16,9	116172,1	113338,7	86247,14	83413,68	2,8	74,179	1380,2
17	116916,9	114065,3	86991,94	84140,31	2,7	74,218	1382,22
17,1	117659,9	114790,1	87734,87	84865,11	2,6	74,257	1384,25
17,2	118403,2	115515,3	88478,18	85590,3	2,5	74,297	1386,28
17,3	119146,9	116240,9	89221,89	86315,87	2,4	74,336	1388,31
17,4	119891	116966,8	89965,99	87041,82	2,3	74,375	1390,36
17,5	120635,5	117693,2	90710,49	87768,16	2,2	74,415	1392,41
17,6	121380,4	118419,9	91455,38	88494,89	2,1	74,454	1394,47
17,7	122125,7	119147	92200,67	89222	2	74,494	1396,53
17,8	122871,4	119874,5	92946,36	89949,5	1,9	74,534	1398,6
17,9	123617,4	120602,4	93692,44	90677,38	1,8	74,574	1400,67
18	124363,9	121330,7	94438,92	91405,66	1,7	74,613	1402,73
18,1	125110,8	122059,3	95185,8	92134,32	1,6	74,652	1404,76
18,2	125862,3	122792,5	95937,34	92867,53	1,5	74,691	1406,77
18,3	126610,5	123522,4	96685,5	93597,44	1,4	74,726	1408,61
18,4	127358,5	124252,2	97433,48	94327,17	1,3	74,76	1410,36
18,5	128106,8	124982,3	98181,81	95057,26	1,2	74,794	1412,13
18,6	128855,6	125712,7	98930,55	95787,73	1,1	74,827	1413,89
18,7	129604,5	126443,5	99679,53	96518,45	1	74,861	1415,66
18,8	130353,9	127174,5	100428,86	97249,5	0,9	74,895	1417,43
18,9	131103,5	127905,9	101178,53	97980,88	0,8	74,929	1419,2

Appendix 12 – Intact Stability Results for all Conditions A



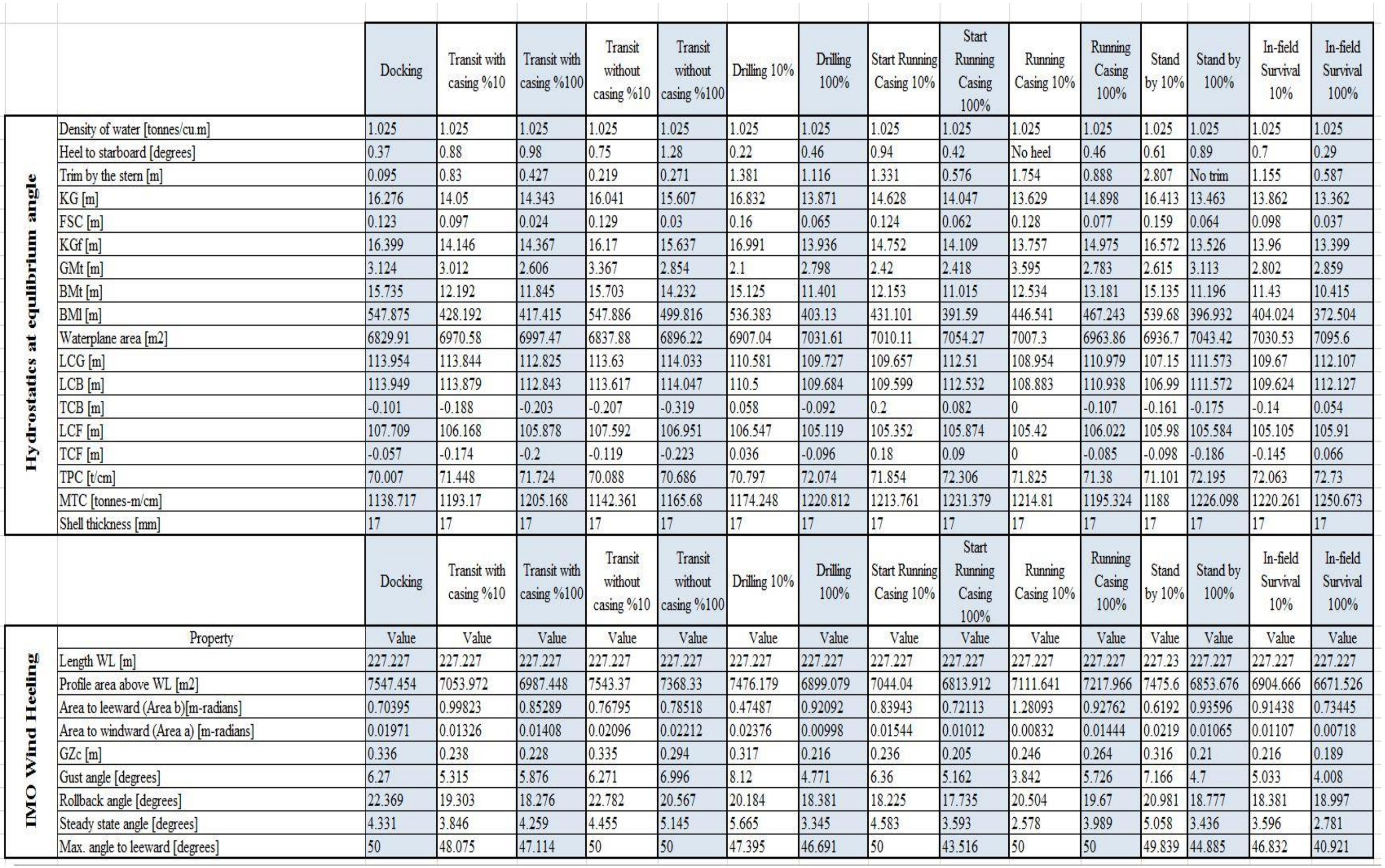
		Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%	
Draft at equilibrium angle	Property	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme
	Draft at LCF [m]	7.211	7.241	9.412	9.442	9.721	9.751	7.232	7.262	8.005	8.035	7.561	7.591	10.154	10.184
	Draft aft at marks [m]	7.258	7.288	9.013	9.043	9.516	9.546	7.339	7.369	7.874	7.904	8.229	8.259	10.686	10.716
	Draft fwd at marks [m]	7.163	7.193	9.843	9.873	9.943	9.973	7.12	7.15	8.144	8.174	6.847	6.877	9.571	9.601
	Draft at AP [m]	7.258	7.288	9.013	9.043	9.516	9.546	7.339	7.369	7.874	7.904	8.229	8.259	10.686	10.716
	Draft at FP [m]	7.163	7.193	9.843	9.873	9.943	9.973	7.12	7.15	8.144	8.174	6.847	6.877	9.571	9.601
	Mean draft at midships [m]	7.21	7.24	9.428	9.458	9.73	9.76	7.229	7.259	8.009	8.039	7.538	7.568	10.128	10.158

		Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%	
IMO 749 Intact Stability Criteria non-Passenger	Criterion	Actual Value	Critical Value	Actual Value	Critical Value	Actual Value	Critical Value	Actual Value	Critical Value	Actual Value	Critical Value	Moulded	Extreme	Moulded	Extreme
	Area under GZ curve up to 30 degrees > 0.055	0.498	0.055	0.486	0.055	0.43	0.055	0.514	0.055	0.449	0.055	0.378	0.055	0.466	0.055
	Area under GZ curve from 30 to 40 deg. or downflood > 0.03	0.301	0.03	0.41	0.03	0.37	0.03	0.321	0.03	0.337	0.03	0.239	0.03	0.388	0.03
	Area under GZ curve up to 40 deg. or downflood > 0.09	0.799	0.09	0.896	0.09	0.8	0.09	0.835	0.09	0.785	0.09	0.617	0.09	0.854	0.09
	Initial GM to be at least 0.15 metres	3.124	0.15	3.012	0.15	2.606	0.15	3.367	0.15	2.854	0.15	2.077	0.15	2.798	0.15
	GZ to be at least 0.20m at an angle > 30 degrees	1.827	0.2	2.402	0.2	2.167	0.2	1.921	0.2	1.979	0.2	1.469	0.2	2.273	0.2
	Max GZ to be at an angle > 30 degrees	30.44	30	35.526	30	35.13	30	30.937	30	34.314	30	30.617	30	35.466	30
	IMO Weather Criterion (Maximum Initial Angle Of Heel)	4.331	16	3.846	16	4.259	16	4.455	16	5.145	16	5.665	16	3.345	16
	IMO Weather Criterion (Areas)	35.715	1	75.266	1	60.571	1	36.64	1	35.493	1	19.987	1	92.294	1

		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
Draft at equilibrium angle	Property	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme
	Draft at LCF [m]	9.501	9.531	10.508	10.538	9.209	9.239	8.707	8.737	7.604	7.634	10.338	10.368	10.13	10.16	11.155	11.185
	Draft aft at marks [m]	10.137	10.167	10.232	10.262	10.048	10.078	9.134	9.164	8.953	8.983	10.349	10.379	10.68	10.71	10.873	10.903
	Draft fwd at marks [m]	8.806	8.836	10.808	10.838	8.294	8.324	8.246	8.276	6.146	6.176	10.327	10.357	9.526	9.556	11.461	11.491
	Draft at AP [m]	10.137	10.167	10.232	10.262	10.048	10.078	9.134	9.164	8.953	8.983	10.349	10.379	10.68	10.71	10.873	10.903
	Draft at FP [m]	8.806	8.836	10.808	10.838	8.294	8.324	8.246	8.276	6.146	6.176	10.327	10.357	9.526	9.556	11.461	11.491
	Mean draft at midships [m]	9.472	9.502	10.52	10.55	9.171	9.201	8.69	8.72	7.55	7.58	10.338	10.368	10.103	10.133	11.167	11.197

		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
IMO 749 Intact Stability Criteria non-Passenger	Criterion	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme	Moulded	Extreme
	Area under GZ curve up to 30 degrees > 0.055	0.409	0.055	0.413	0.055	0.594	0.055	0.472	0.055	0.433	0.055	0.491	0.055	0.459	0.055	0.466	0.055
	Area under GZ curve from 30 to 40 deg. or downflood > 0.03	0.351	0.03	0.343	0.03	0.476	0.03	0.379	0.03	0.284	0.03	0.41	0.03	0.386	0.03	0.364	0.03
	Area under GZ curve up to 40 deg. or downflood > 0.09	0.76	0.09	0.756	0.09	1.07	0.09	0.851	0.09	0.717	0.09	0.901	0.09	0.845	0.09	0.83	0.09
	Initial GM to be at least 0.15 metres	2.363	0.15	2.394	0.15	3.595	0.15	2.783	0.15	2.615	0.15	3.113	0.15	2.802	0.15	2.844	0.15
	GZ to be at least 0.20m at an angle > 30 degrees	2.063	0.2	2.007	0.2	2.787	0.2	2.228	0.2	1.703	0.2	2.403	0.2	2.261	0.2	2.128	0.2
	Max GZ to be at an angle > 30 degrees	34.712	30	35.146	30	35.984	30	34.831	30	31.844	30	36.081	30	35.45	30	36	30
	IMO Weather Criterion (Maximum Initial Angle Of Heel)	4.583	16	3.593	16	2.578	16	3.989	16	5.058	16	3.436	16	3.596	16	2.781	16
	IMO Weather Criterion (Areas)	54.356	1	71.269	1	153.952	1	64.219	1	28.289	1	87.866	1	82.612	1	102.345	1

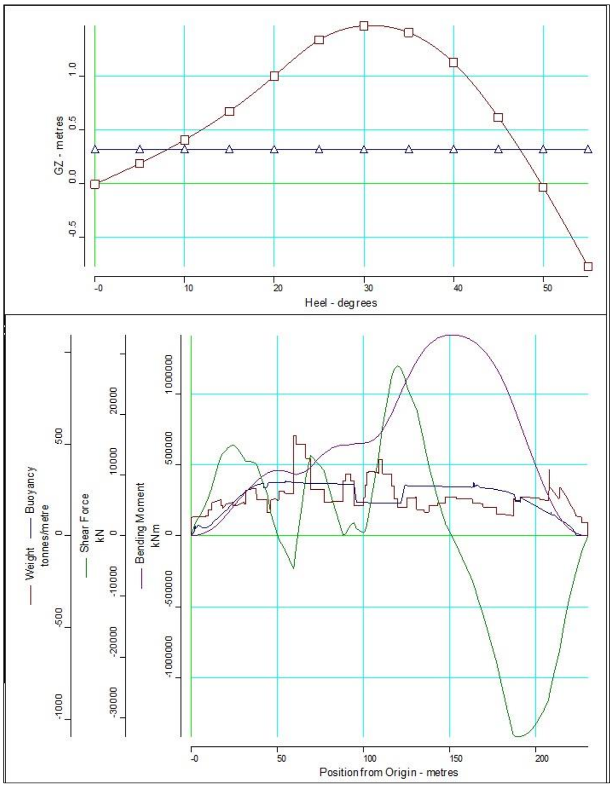
Appendix 12 – Intact Stability Results for all Conditions B



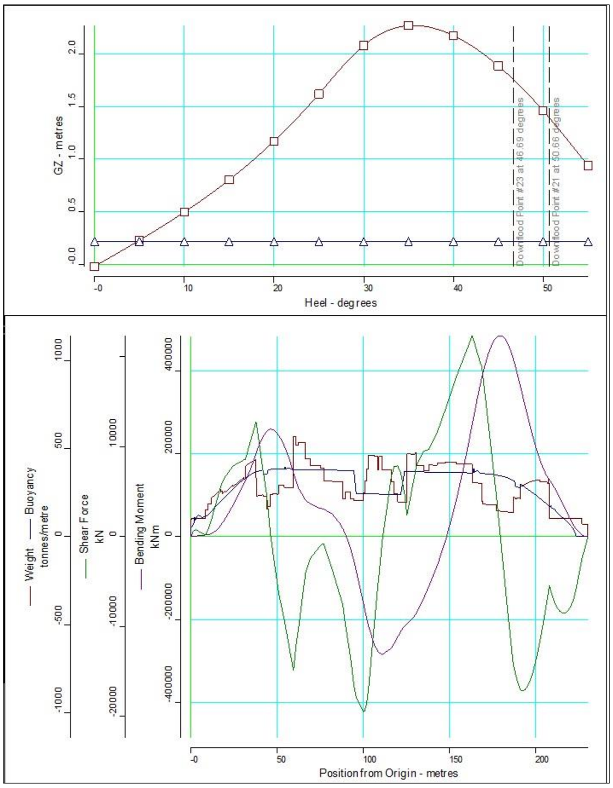
		Docking	Transit with casing %10	Transit with casing %100	Transit without casing %10	Transit without casing %100	Drilling 10%	Drilling 100%	Start Running Casing 10%	Start Running Casing 100%	Running Casing 10%	Running Casing 100%	Stand by 10%	Stand by 100%	In-field Survival 10%	In-field Survival 100%
Hydrostatics at equilibrium angle	Density of water [tonnes/cu.m]	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025
	Heel to starboard [degrees]	0.37	0.88	0.98	0.75	1.28	0.22	0.46	0.94	0.42	No heel	0.46	0.61	0.89	0.7	0.29
	Trim by the stern [m]	0.095	0.83	0.427	0.219	0.271	1.381	1.116	1.331	0.576	1.754	0.888	2.807	No trim	1.155	0.587
	KG [m]	16.276	14.05	14.343	16.041	15.607	16.832	13.871	14.628	14.047	13.629	14.898	16.413	13.463	13.862	13.362
	FSC [m]	0.123	0.097	0.024	0.129	0.03	0.16	0.065	0.124	0.062	0.128	0.077	0.159	0.064	0.098	0.037
	KGf [m]	16.399	14.146	14.367	16.17	15.637	16.991	13.936	14.752	14.109	13.757	14.975	16.572	13.526	13.96	13.399
	GMt [m]	3.124	3.012	2.606	3.367	2.854	2.1	2.798	2.42	2.418	3.595	2.783	2.615	3.113	2.802	2.859
	BMt [m]	15.735	12.192	11.845	15.703	14.232	15.125	11.401	12.153	11.015	12.534	13.181	15.135	11.196	11.43	10.415
	BMl [m]	547.875	428.192	417.415	547.886	499.816	536.383	403.13	431.101	391.59	446.541	467.243	539.68	396.932	404.024	372.504
	Waterplane area [m2]	6829.91	6970.58	6997.47	6837.88	6896.22	6907.04	7031.61	7010.11	7054.27	7007.3	6963.86	6936.7	7043.42	7030.53	7095.6
	LCG [m]	113.954	113.844	112.825	113.63	114.033	110.581	109.727	109.657	112.51	108.954	110.979	107.15	111.573	109.67	112.107
	LCB [m]	113.949	113.879	112.843	113.617	114.047	110.5	109.684	109.599	112.532	108.883	110.938	106.99	111.572	109.624	112.127
	TCB [m]	-0.101	-0.188	-0.203	-0.207	-0.319	0.058	-0.092	0.2	0.082	0	-0.107	-0.161	-0.175	-0.14	0.054
	LCF [m]	107.709	106.168	105.878	107.592	106.951	106.547	105.119	105.352	105.874	105.42	106.022	105.98	105.584	105.105	105.91
	TCF [m]	-0.057	-0.174	-0.2	-0.119	-0.223	0.036	-0.096	0.18	0.09	0	-0.085	-0.098	-0.186	-0.145	0.066
	TPC [t/cm]	70.007	71.448	71.724	70.088	70.686	70.797	72.074	71.854	72.306	71.825	71.38	71.101	72.195	72.063	72.73
	MTC [tonnes-m/cm]	1138.717	1193.17	1205.168	1142.361	1165.68	1174.248	1220.812	1213.761	1231.379	1214.81	1195.324	1188	1226.098	1220.261	1250.673
	Shell thickness [mm]	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17

		Docking	Transit with casing %10	Transit with casing %100	Transit without casing %10	Transit without casing %100	Drilling 10%	Drilling 100%	Start Running Casing 10%	Start Running Casing 100%	Running Casing 10%	Running Casing 100%	Stand by 10%	Stand by 100%	In-field Survival 10%	In-field Survival 100%
IMO Wind Heeling	Property	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
	Length WL [m]	227.227	227.227	227.227	227.227	227.227	227.227	227.227	227.227	227.227	227.227	227.227	227.23	227.227	227.227	227.227
	Profile area above WL [m2]	7547.454	7053.972	6987.448	7543.37	7368.33	7476.179	6899.079	7044.04	6813.912	7111.641	7217.966	7475.6	6853.676	6904.666	6671.526
	Area to leeward (Area b)[m-radians]	0.70395	0.99823	0.85289	0.76795	0.78518	0.47487	0.92092	0.83943	0.72113	1.28093	0.92762	0.6192	0.93596	0.91438	0.73445
	Area to windward (Area a) [m-radians]	0.01971	0.01326	0.01408	0.02096	0.02212	0.02376	0.00998	0.01544	0.01012	0.00832	0.01444	0.0219	0.01065	0.01107	0.00718
	GZc [m]	0.336	0.238	0.228	0.335	0.294	0.317	0.216	0.236	0.205	0.246	0.264	0.316	0.21	0.216	0.189
	Gust angle [degrees]	6.27	5.315	5.876	6.271	6.996	8.12	4.771	6.36	5.162	3.842	5.726	7.166	4.7	5.033	4.008
	Rollback angle [degrees]	22.369	19.303	18.276	22.782	20.567	20.184	18.381	18.225	17.735	20.504	19.67	20.981	18.777	18.381	18.997
	Steady state angle [degrees]	4.331	3.846	4.259	4.455	5.145	5.665	3.345	4.583	3.593	2.578	3.989	5.058	3.436	3.596	2.781
	Max. angle to leeward [degrees]	50	48.075	47.114	50	50	47.395	46.691	50	43.516	50	50	49.839	44.885	46.832	40.921

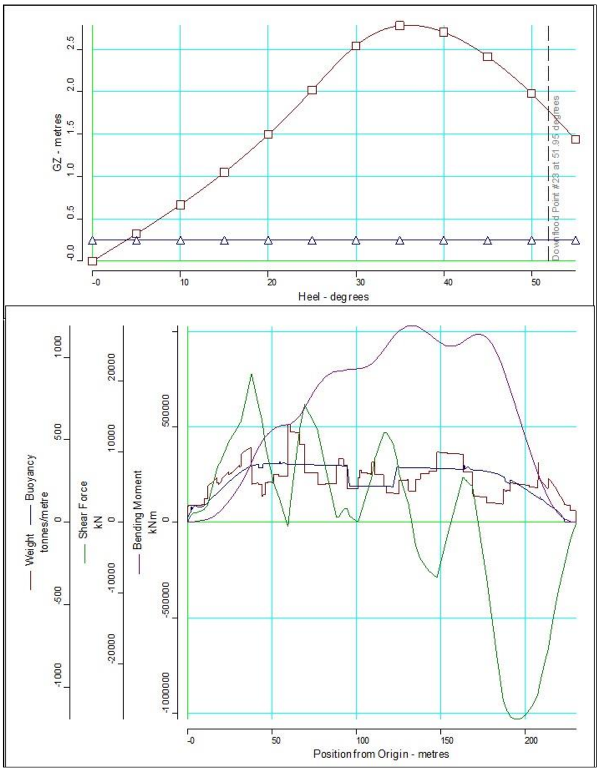
Appendix 13 – GZ Curves and SFBM Diagrams for all Conditions A



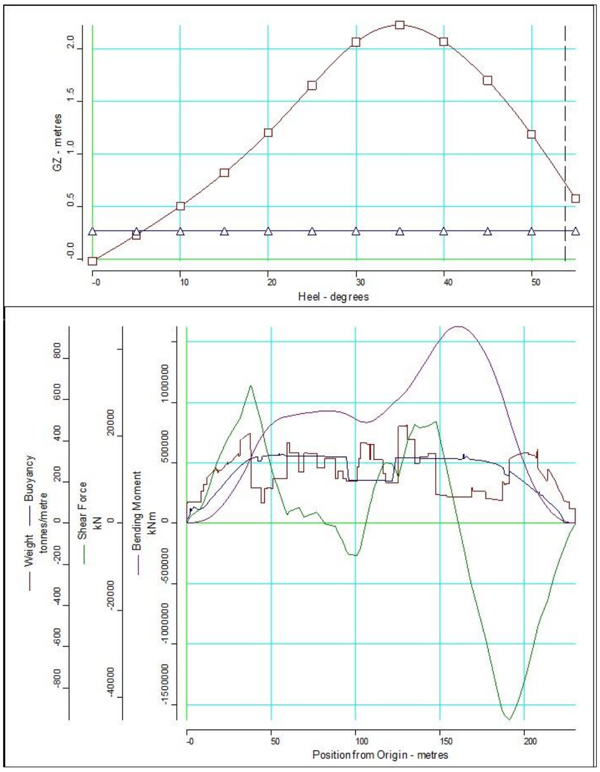
Drilling %10



Drilling %100

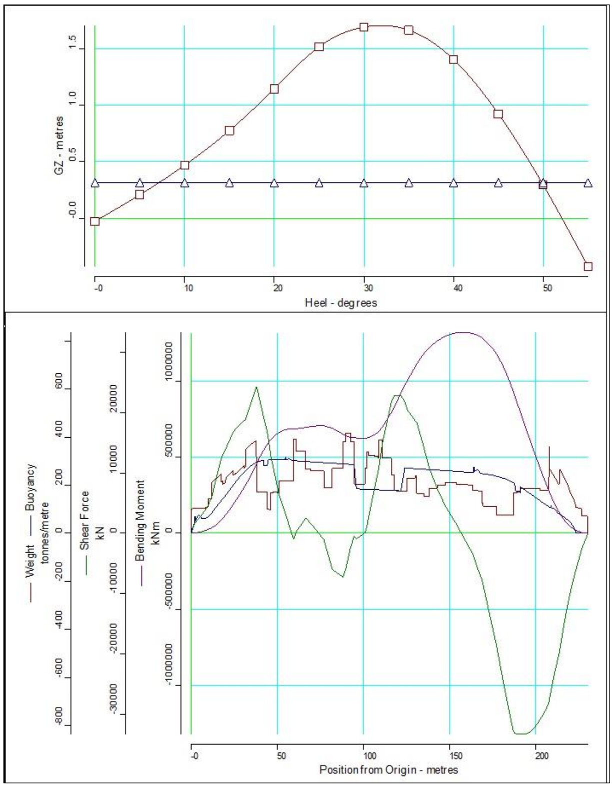


Running casing %10

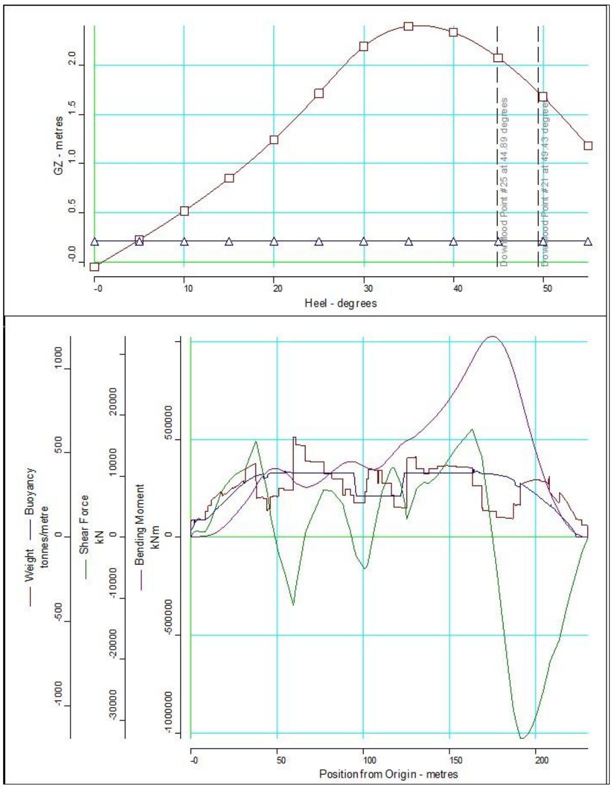


Running casing %100

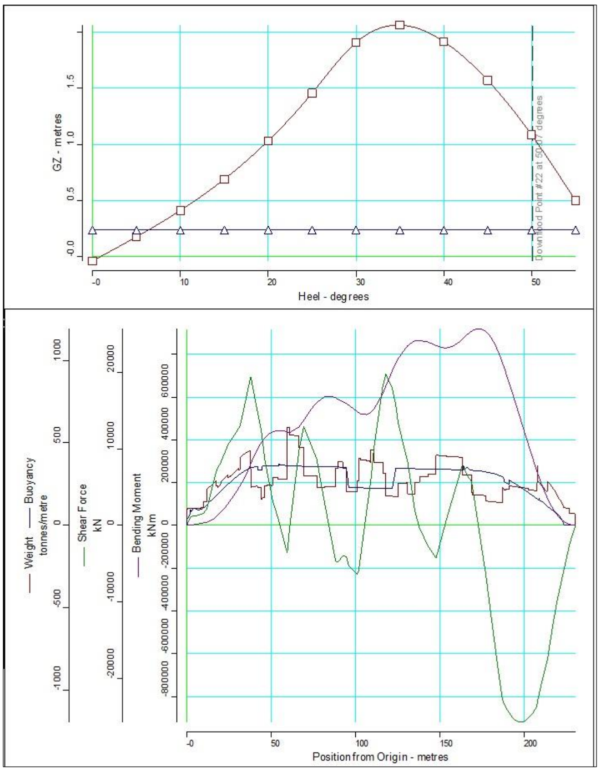
Appendix 13 – GZ Curves and SFBM Diagrams for all Conditions B



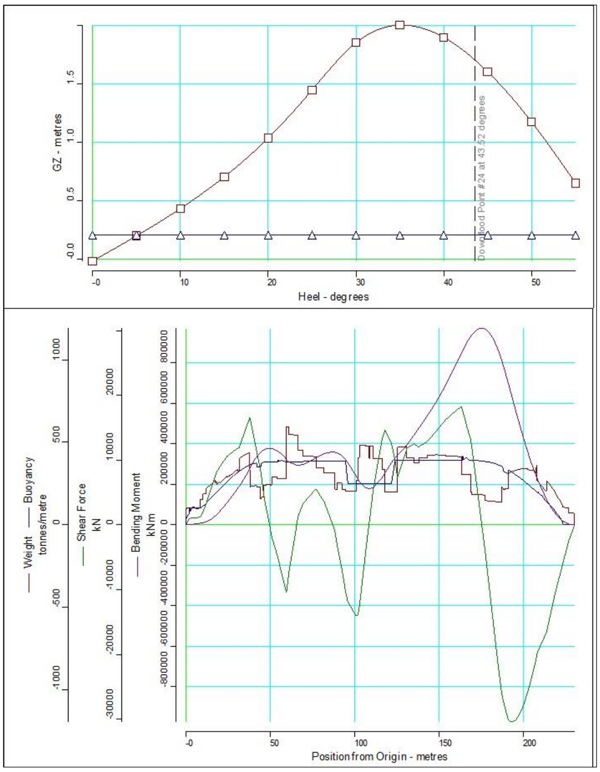
Stand - by %10



Stand by %100

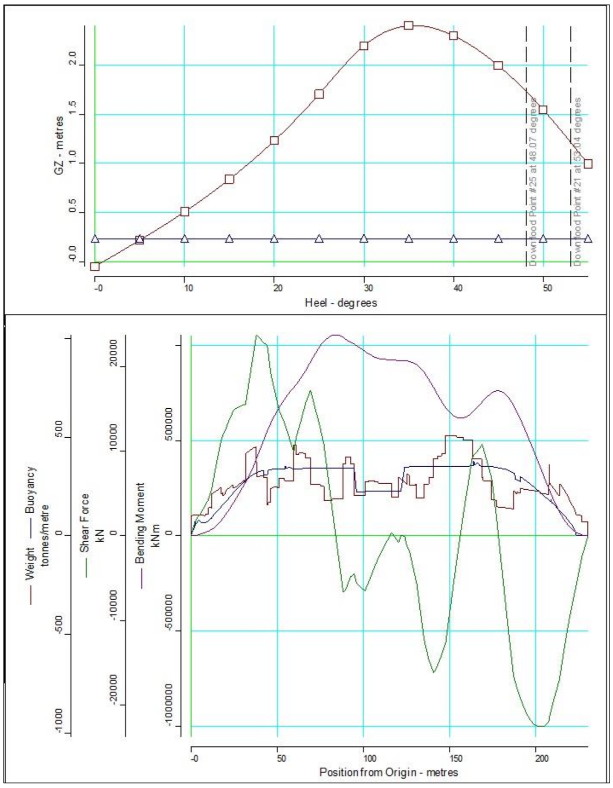


Start Running casing %10

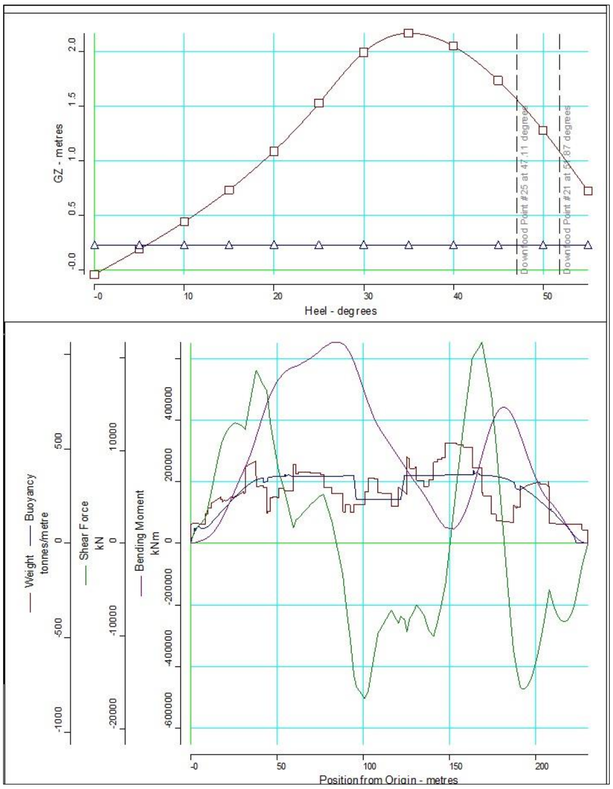


Start Running casing %100

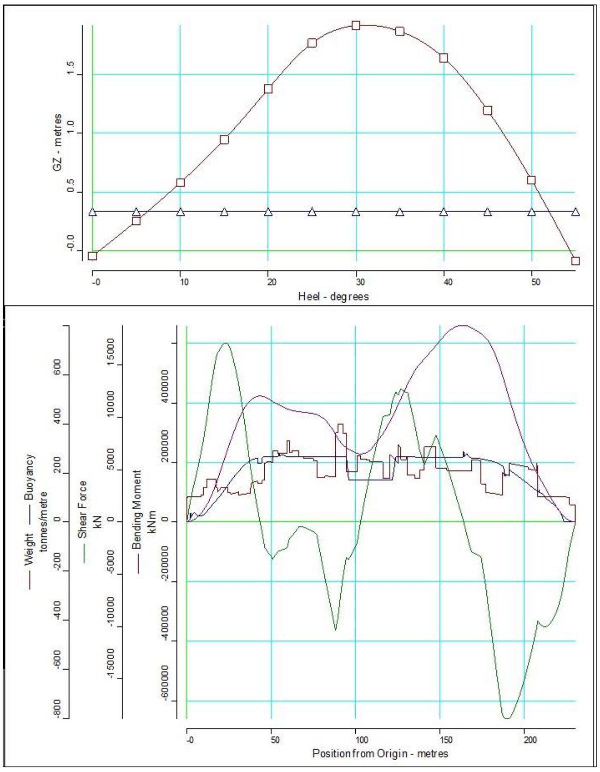
Appendix 13 – GZ Curves and SFBM Diagrams for all Conditions C



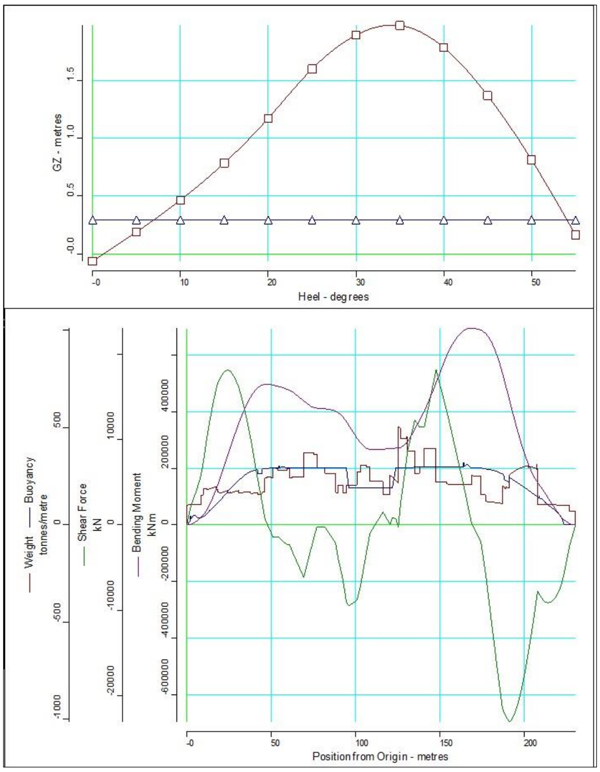
Transit with casing %10



Transit with casing%100

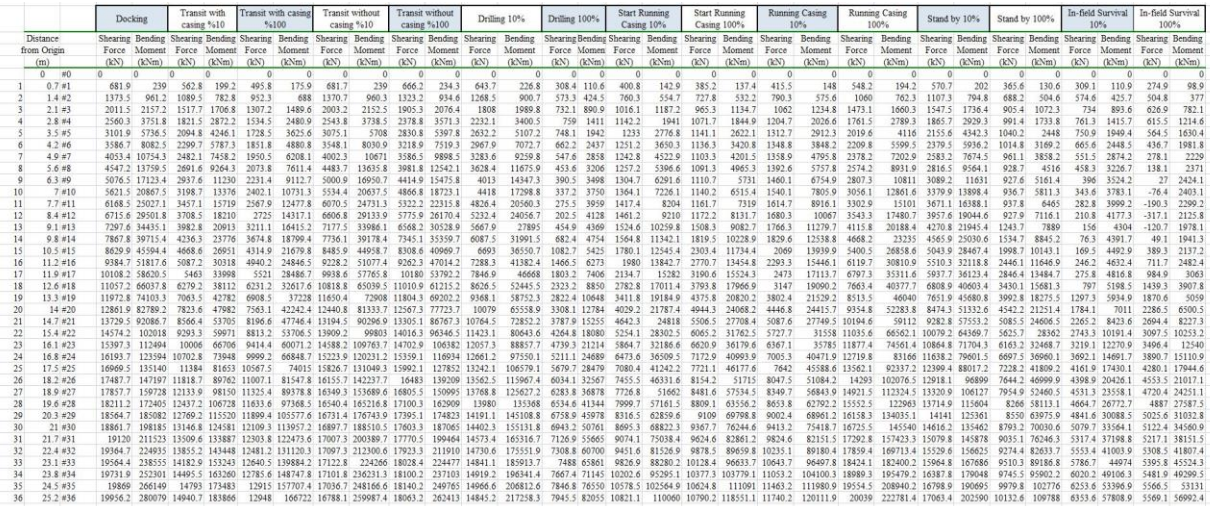


Transit without casing %10

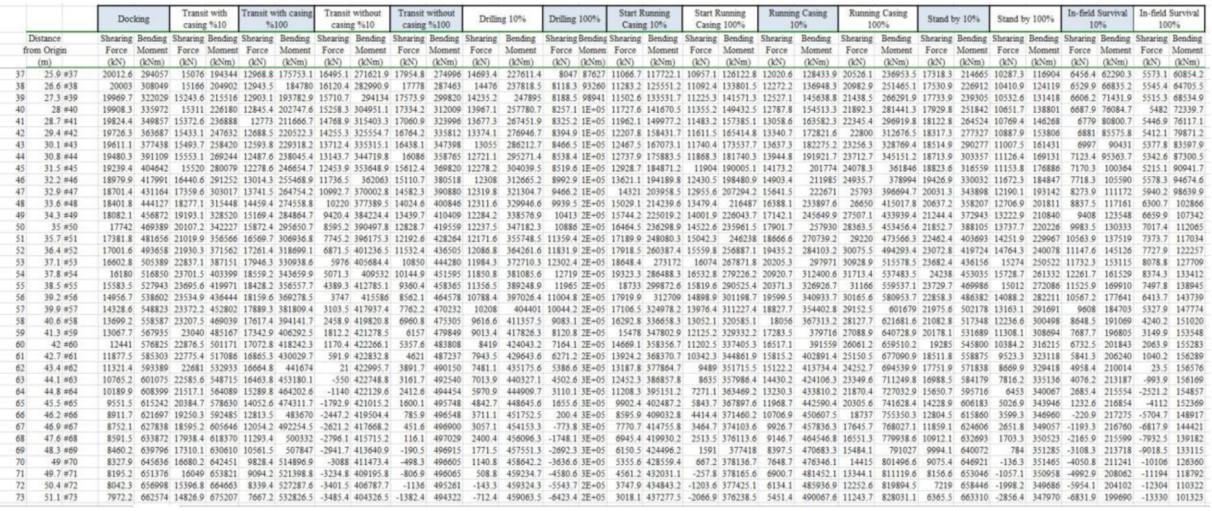


Transit without casing%100

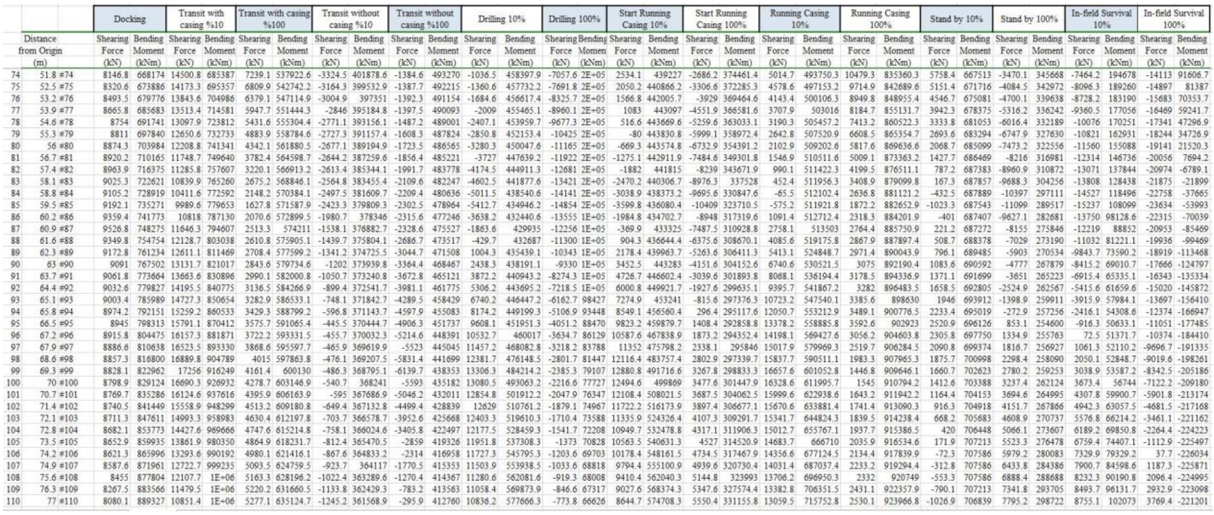
Appendix 14 Maximum Shear Force and Bending Moments A



			Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
	Distance from Origin (m)		Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Momen (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)
	0	#0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.7	#1	681.9	239	562.8	199.2	495.8	175.9	681.7	239	666.2	234.3	643.7	226.8	308.4	110.6	400.8	142.9	385.2	137.4	415.5	148	548.2	194.2	570.7	202	365.6	130.6	309.1	110.9	274.9	98.9
2	1.4	#2	1373.5	961.2	1089.5	782.8	952.3	688	1370.7	960.3	1323.2	934.6	1268.5	900.7	573.3	424.5	760.3	554.7	727.8	532.2	790.3	575.6	1060	762.3	1107.3	794.8	688.2	504.6	574.6	425.7	504.8	377
3	2.1	#3	2011.5	2157.2	1517.7	1706.8	1307.2	1489.6	2003.2	2152.5	1905.3	2076.4	1808	1989.8	732.1	890.9	1016.1	1187.2	965.3	1134.7	1062	1234.8	1473.1	1660.3	1547.5	1736.4	905.4	1072.3	734	893.6	626.9	782.1
4	2.8	#4	2560.3	3751.8	1821.5	2872.2	1534.5	2480.9	2543.8	3738.5	2378.8	3571.3	2232.1	3400.5	759	1411	1142.2	1941	1071.7	1844.9	1204.7	2026.6	1761.5	2789.3	1865.7	2929.3	991.4	1733.8	761.3	1415.7	615.5	1214.6
5	3.5	#5	3101.9	5736.5	2094.8	4246.1	1728.5	3625.6	3075.1	5708	2830.8	5397.8	2632.2	5107.2	748.1	1942	1233	2776.8	1141.1	2622.1	1312.7	2912.3	2019.6	4116	2155.6	4342.3	1040.2	2448	750.9	1949.4	564.5	1630.4
6	4.2	#6	3586.7	8082.5	2299.7	5787.3	1851.8	4880.8	3548.1	8030.9	3218.9	7519.3	2967.9	7072.7	662.2	2437	1251.2	3650.3	1136.3	3420.8	1348.8	3848.2	2209.8	5599.5	2379.5	5936.2	1014.8	3169.2	665.6	2448.5	436.7	1981.8
7	4.9	#7	4053.4	10754.3	2482.1	7458.2	1950.5	6208.1	4002.3	10671	3586.5	9898.5	3283.6	9259.8	547.6	2858	1242.8	4522.9	1103.3	4201.5	1358.9	4795.8	2378.2	7202.9	2583.2	7674.5	961.1	3858.2	551.5	2874.2	278.1	2229
8	5.6	#8	4547.2	13759.5	2691.6	9264.3	2073.8	7611.4	4483.7	13635.8	3981.8	12542.1	3628.4	11675.9	453.6	3206	1257.2	5396.6	1091.3	4965.3	1392.6	5757.8	2574.2	8931.9	2816.5	9564.1	928.7	4516	458.3	3226.7	138.1	2371
9	6.3	#9	5076.5	17123.4	2937.6	11230	2231.4	9112.7	5000.9	16950.7	4414.9	15475.8	4013	14347.3	390.5	3498	1304.7	6291.6	1110.7	5731	1460.1	6754.9	2807.3	10811	3089.2	11631	927.6	5161.4	396	3524.2	27	2424.1
10	7	#10	5621.5	20867.5	3198.7	13376	2402.1	10731.3	5534.4	20637.5	4866.8	18723.1	4418	17298.8	337.2	3750	1364.1	7226.1	1140.2	6515.4	1540.1	7805.9	3056.1	12861.6	3379.9	13898.4	936.7	5811.3	343.6	3783.1	-76.4	2403.1
11	7.7	#11	6168.5	25027.1	3457.1	15719	2567.9	12477.8	6070.5	24731.3	5322.2	22315.8	4826.4	20560.3	275.5	3959	1417.4	8204	1161.7	7319	1614.7	8916.1	3302.9	15101	3671.1	16388.1	937.8	6465	282.8	3999.2	-190.3	2299.2
12	8.4	#12	6715.6	29501.8	3708.5	18210	2725	14317.1	6606.8	29133.9	5775.9	26170.4	5232.4	24056.7	202.5	4128	1461.2	9210	1172.2	8131.7	1680.3	10067	3543.3	17480.7	3957.6	19044.6	927.9	7116.1	210.8	4177.3	-317.1	2125.8
13	9.1	#13	7297.6	34435.1	3982.8	20913	3211.1	16415.2	7177.5	33986.1	6568.2	30528.9	5667.9	27895	454.9	4369	1524.6	10259.8	1508.3	9082.7	1766.3	11279.7	4115.8	20188.4	4270.8	21945.4	1243.7	7889	156	4304	-120.7	1978.1
14	9.8	#14	7867.8	39715.4	4236.3	23776	3674.8	18799.4	7736.1	39178.4	7345.1	35359.7	6087.5	31991.5	682.4	4754	1564.8	11342.1	1819.5	10228.9	1829.6	12538.8	4668.2	23235	4565.9	25030.6	1534.7	8845.2	76.3	4391.7	49.1	1941.3
15	10.5	#15	8629.9	45594.4	4668.6	26951	4314.9	21679.8	8485.9	44958.7	8308.6	40969.7	6693	36550.7	1082.7	5425	1780.1	12545.4	2303.4	11734.4	2069	13939.9	5400.5	26858.6	5043.9	28467.4	1998.7	10143.1	169.5	4492.9	389.3	2137.2
16	11.2	#16	9384.7	51817.6	5087.2	30318	4940.2	24846.5	9228.2	51077.4	9262.3	47014.2	7288.3	41382.4	1466.5	6273	1980	13842.7	2770.7	13454.8	2293.3	15446.1	6119.7	30810.9	5510.3	32118.8	2446.1	11646.9	246.2	4632.4	711.7	2482.4
17	11.9	#17	10108.2	58620.5	5463	33998	5521	28486.7	9938.6	57765.8	10180	53792.2	7846.9	46668	1803.2	7406	2134.7	15282	3190.6	15524.3	2473	17113.7	6797.3	35311.6	5937.7	36123.4	2846.4	13484.7	275.8	4816.8	984.9	3063
18	12.6	#18	11057.2	66037.8	6279.2	38112	6231.2	32617.6	10818.8	65039.5	11010.9	61215.2	8626.5	52445.5	2323.2	8850	2782.8	17011.4	3793.8	17966.9	3147	19090.2	7663.4	40377.7	6808.9	40603.4	3430.1	15681.3	797	5198.5	1439.3	3907.8
19	13.3	#19	11972.8	74103.3	7063.5	42782	6908.5	37228	11650.4	72908	11804.3	69202.2	9368.1	58752.3	2822.4	10648	3411.8	19184.9	4375.8	20820.2	3802.4	21529.2	8513.5	46040	7651.9	45680.8	3992.8	18275.5	1297.3	5934.9	1870.6	5059
20	14	#20	12861.9	82789.2	7823.6	47982	7563.1	42242.4	12440.8	81333.7	12567.3	77723.7	10079	65558.9	3308.1	12784	4029.2	21787.4	4944.3	24068.2	4446.8	24415.7	9354.8	52283.8	8474.3	51332.6	4542.2	21251.4	1784.1	7011	2286.5	6500.5
21	14.7	#21	13729.5	92086.7	8566.4	53705	8196.6	47746.4	13194.5	90296.9	13305.1	86767.3	10764.5	72852.2	3787.9	15255	4642.3	24818	5506.5	27708.4	5087.6	27749.5	10194.6	59112	9282.8	57553.2	5085.5	24606.5	2265.2	8423.6	2694.4	8227.3
22	15.4	#22	14574.2	102018	9293.3	59971	8813.2	53706.5	13909.2	99803	14016.3	96346.5	11423.1	80643.6	4264.8	18080	5254.1	28302.5	6065.2	31762.5	5727.7	31558	11035.6	66562.1	10079.2	64369.7	5625.7	28362	2743.3	10191.4	3097.5	10253.2
23	16.1	#23	15397.3	112494	10006	66706	9414.4	60071.2	14588.2	109763.7	14702.9	106382	12057.3	88857.7	4739.3	21214	5864.7	32186.6	6620.9	36179.6	6367.1	35785	11877.4	74561.4	10864.8	71704.3	6163.2	32468.7	3219.1	12270.9	3496.4	12540
24	16.8	#24	16193.7	123594	10702.8	73948	9999.2	66848.7	15223.9	120231.2	15359.1	116934	12661.2	97550.1	5211.1	24689	6473.6	36509.5	7172.9	40993.9	7005.3	40471.9	12719.8	83166	11638.2	79601.5	6697.5	36960.1	3692.1	14691.7	3890.7	15110.9
25	17.5	#25	16969.5	135140	11384	81653	10567.5	74015	15826.7	131049.3	15992.1	127852	13242.1	106579.1	5679.7	28479	7080.4	41242.2	7721.1	46177.6	7642	45588.6	13562.1	92337.2	12399.4	88017.2	7228.2	41809.2	4161.9	17430.1	4280.1	17944.6
26	18.2	#26	17487.7	147197	11818.7	89762	11007.1	81547.8	16155.7	142237.7	16483	139209	13562.5	115967.4	6034.1	32567	7455.5	46331.6	8154.2	51715	8047.5	51084.2	14293	102076.5	12918.1	96899	7644.2	46999.9	4398.9	20426.1	4553.5	21017.1
27	18.9	#27	17857.7	159728	12133.9	98150	11325.4	89378.8	16349.3	153689.6	16805.5	150995	13768.8	125627.2	6283.8	36878	7726.8	51662	8481.6	57534.5	8349.7	56843.9	14921.5	112324.5	13320.9	106127	7954.9	52460.5	4531.3	23558.1	4720.4	24251.1
28	19.6	#28	18211.2	172405	12437.2	106728	11633.6	97368.5	16540.4	165216.8	17100.3	162909	13980	135368	6534.6	41344	7999.7	57161.5	8809.1	63556.2	8653.8	62792.2	15552.5	122963	13714.9	115604	8266	58113.1	4664.7	26772.7	4887	27587.5
29	20.3	#29	18564.7	185082	12769.2	115520	11899.4	105577.6	16731.4	176743.9	17395.1	174823	14191.1	145108.8	6758.9	45978	8316.5	62859.6	9109	69798.8	9002.4	68961.2	16158.3	134035.1	14141	125361	8550	63975.9	4841.6	30088.5	5025.6	31032.8
30	21	#30	18861.7	198185	13146.8	124581	12109.3	113957.2	16897.7	188510.5	17603.3	187065	14402.3	155131.8	6943.2	50761	8695.3	68822.3	9367.7	76244.6	9413.2	75418.7	16725.5	145540	14616.2	135462	8793.2	70030.6	5079.7	33564.1	5122.4	34560.9
31	21.7	#31	19120	211523	13509.6	133887	12303.8	122473.6	17007.3	200389.7	17770.5	199464	14573.4	165316.7	7126.9	55665	9074.1	75038.4	9624.6	82861.2	9824.6	82151.5	17292.8	157423.3	15079.8	145878	9035.1	76246.3	5317.4	37198.8	5217.1	38151.5
32	22.4	#32	19364.7	224935	13855.2	143448	12481.2	131120.3	17097.3	212300.6	17923.3	211910	14730.6	175551.9	7308.8	60700	9451.6	81526.9	9878.5	89659.8	10235.1	89180.4	17859.4	169713.4	15529.6	156625	9274.4	82633.7	5553.4	41003.9	5308.5	41807.4
33	23.1	#33	19564.4	238555	14182.9	153243	12640.5	139884.2	17122.8	224266	18028.4	224477	14841.1	185913.7	7488	65861	9826.9	88280.2	10128.4	96633.7	10643.7	96497.8	18424.1	182400.2	15964.8	167686	9510.3	89186.8	5786.7	44974	5395.8	45524.3
34	23.8	#34	19731.9	252301	14495.5	163260	12785.6	148747.8	17101.8	236231.3	18100.2	237103	14919.2	196341.4	7667.4	71145	10202.6	95295.1	10377.3	103779.1	11053.2	104100.3	18989.3	195479.2	16387.8	179048	9745.5	95902.2	6020.2	49106.3	5481.9	49299.5
35	24.5	#35	19869	266149	14793	173483	12915	157707.4	17036.7	248166.6	18140.2	249765	14966.6	206812.6	7846.8	76550	10578.5	102564.9	10624.8	111091	11463.2	111980.9	19554.5	208940.2	16798.9	190695	9979.8	102776	6253.6	53396.9	5566.5	53131
36	25.2	#36	19956.2	280079	14940.7	183866	12948	166722	16788.1	259987.4	18063.2	262413	14845.2	217258.3	7945.5	82055	10821.1	110060	10790.2	118551.1	11740.2	120111.9	20039	222781.4	17063.4	202590	10132.6	109788	6353.6	57808.9	5569.1	56992.4

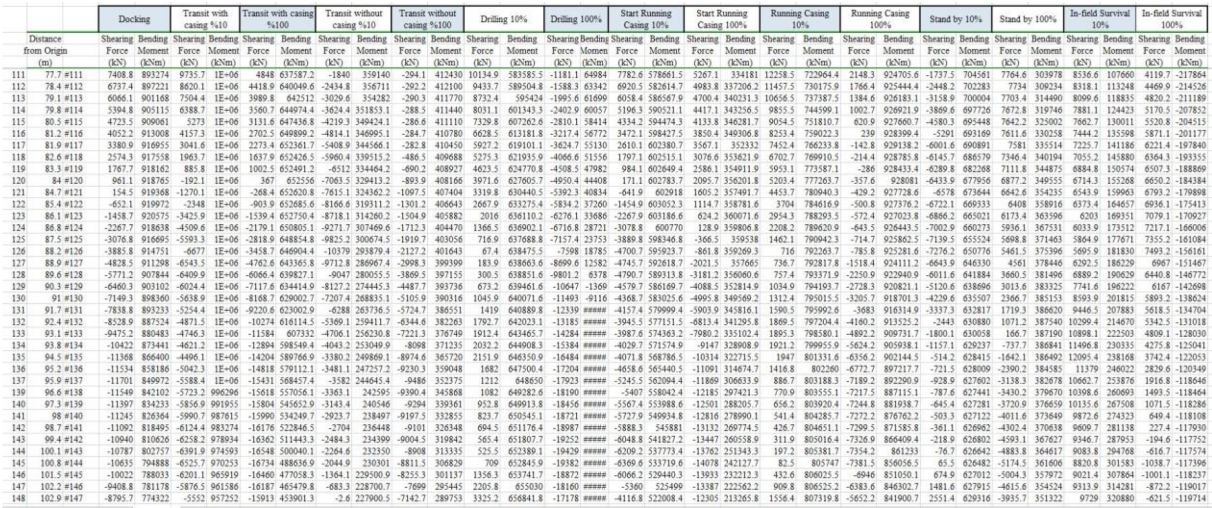


			Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
	Distance from Origin (m)		Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Momen (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)
37	25.9	#37	20012.6	294057	15076	194344	12968.8	175753.1	16495.1	271621.9	17954.8	274996	14693.4	227611.4	8047	87627	11066.7	117722.1	10957.1	126122.8	12020.6	128433.9	20526.1	236953.5	17318.3	214665	10287.3	116904	6456.4	62290.3	5573.1	60854.2
38	26.6	#38	20003	308049	15166	204902	12943.5	184780	16120.4	282990.9	17778	287463	14476	237818.5	8118.3	93260	11283.2	125551.2	11092.4	133801.5	12272.2	136948.3	20982.9	251465.1	17530.9	226912	10410.9	124119	6529.9	66835.2	5545.4	64705.5
39	27.3	#39	19969.7	322029	15243.6	215516	12903.1	193782.9	15710.7	294134	17573.9	299820	14235.2	247895	8188.5	98941	11502.6	133531.7	11225.3	141571.3	12527.1	145638.8	21438.5	266291.9	17733.9	239305	10532.6	131418	6606.2	71431.9	5515.3	68534.9
40	28	#40	19908.3	335972	15311	226180	12845.4	202747.6	15258.3	304951.1	17334.2	312009	13967.1	257780.7	8257.1	1E+05	11727.6	141670.5	11355.2	149432.5	12787.8	154513.3	21892.3	281441.3	17929.8	251842	10651.7	138801	6687.9	76084.7	5482	72339.7
41	28.7	#41	19824.4	349857	15372.6	236888	12773	211666.7	14768.9	315403.3	17060.9	323996	13677.3	267451.9	8325.2	1E+05	11962.1	149977.2	11483.2	157385.1	13058.6	163582.3	22345.4	296919.8	18122.8	264524	10769.4	146268	6779	80800.7	5446.9	76117.1
42	29.4	#42	19726.3	363687	15433.1	247632	12688.5	220522.3	14255.3	325554.7	16764.2	335812	13374.1	276946.7	8394.9	1E+05	12207.8	158431.7	11611.5	165414.8	13340.7	172821.6	22800	312676.5	18317.3	277327	10887.9	153806	6881	85575.8	5412.1	79871.2
43	30.1	#43	19611.1	377438	15493.7	258420	12593.8	229318.2	13712.4	335315.1	16438.1	347398	13055	286212.7	8466.5	1E+05	12467.5	167073.1	11740.4	173537.7	13637.3	182275.2	23256.3	328769.4	18514.9	290277	11007.5	161431	6997	90431	5377.8	83597.9
44	30.8	#44	19480.3	391109	15553.1	269244	12487.6	238045.4	13143.7	344719.8	16086	358765	12721.1	295271.4	8538.4	1E+05	12737.9	175883.5	11868.3	181740.3	13944.8	191921.7	23712.7	345151.2	18713.9	303357	11126.4	169131	7123.4	95363.7	5342.6	87300.5
45	31.5	#45	19239.4	404642	15520	280079	12278.6	246654.7	12453.9	353648.9	15612.4	369820	12278.2	304039.5	8519.6	1E+05	12928.7	184871.2	11904	190005.1	14173.2	201774	24078.3	361846	18823.6	316559	11153.8	176886	7170.3	100364	5215.1	90941.7
46	32.2	#46	18979.9	417991	16440.6	291252	13014.3	255468.9	11736.5	362063	15110.7	380518	12308	312665.2	8992.9	1E+05	13621.1	194189.8	12430.5	198480.9	14903.4	211985	24935.7	378994	19426.9	330032	11672.3	184847	7718.3	105590	5578.3	94674.6
47	32.9	#47	18701.4	431164	17359.6	303017	13741.5	264754.2	10992.7	370002.8	14582.3	390880	12319.8	321304.7	9466.2	1E+05	14321	203958.5	12955.6	207294.2	15641.5	222671	25793	396694.7	20031.3	343898	12190.1	193142	8273.9	111172	5940.2	98639.9
48	33.6	#48	18401.8	444127	18277.1	315448	14459.4	274558.8	10220	377389.5	14024.6	400846	12311.6	329946.6	9939.5	2E+05	15029.1	214239.6	13479.4	216487	16388.1	233897.6	26650	415017.8	20637.2	358207	12706.9	201811	8837.5	117161	6300.7	102866
49	34.3	#49	18082.1	456872	19193.1	328520	15169.4	284864.7	9420.4	384224.4	13439.7	410409	12284.2	338576.9	10413	2E+05	15744.2	225019.2	14001.9	226043.7	17142.1	245649.9	27507.1	433939.4	21244.4	372943	13222.9	210840	9408	123548	6659.9	107342
50	35	#50	17742	469389	20107.2	342227	15872.4	295650.7	8595.2	390497.8	12828.7	419559	12237.5	347182.3	10886	2E+05	16464.5	236298.9	14522.6	235961.5	17901.7	257930	28363.5	453456.4	21852.7	388105	13737.7	220226	9983.5	130333	7017.4	112065
51	35.7	#51	17381.8	481656	21019.9	356566	16569.7	306936.8	7745.2	396175.3	12192.6	428264	12171.6	355748.5	11359.4	2E+05	17189.9	248080.3	15042.3	246238	18666.6	270739.2	29220	473566.3	22462.4	403693	14251.9	229967	10563.9	137519	7373.7	117034
52	36.4	#52	17001.6	493658	21930.3	371562	17261.4	318699.1	6871.5	401236.5	11532.4	436505	12086.8	364261.6	11831.9	2E+05	17918.5	260387.4	15559.8	256887.1	19435.2	284103.2	30075.5	494293.4	23072.8	419724	14764.3	240078	11147.6	145126	7727.9	122257
53	37.1	#53	16602.8	505389	22837.1	387151	17946.3	330938.6	5976	405684.4	10850	444280	11984.3	372710.3	12302.4	2E+05	18648.4	273172	16074	267871.8	20205.3	297971	30928.9	515578.5	23682.4	436156	15274	250522	11732.3	153115	8078.8	127709
54	37.8	#54	16180	516850	23701.5	403399	18559.2	343659.9	5071.3	409532	10144.9	451595	11850.8	381085.6	12719	2E+05	19323.3	286488.3	16532.8	279226.2	20920.7	312400.6	31713.4	537483.5	24238	453035	15728.7	261332	12261.7	161529	8374.3	133412
55	38.5	#55	15583.5	527943	23695.6	419971	18428.2	356557.7	4389.3	412785.1	9360.4	458365	11356.5	389248.9	11965	2E+05	18733	299872.6	15819.6	290525.4	20371.3	326926.7	31166	559537.1	23729.7	469986	15012	272086	11525.9	169910	7497.8	138945
56	39.2	#56	14956.7	538602	23534.9	436444	18159.6	369278.5	3747	415586	8562.1	464578	10788.4	397026.4	11004.8	2E+05	17919.9	312709	14898.9	301198.7	19599.5	340933.7	30165.6	580953.7	22858.3	486382	14088.2	282211	10567.2	177641	6413.7	143739
57	39.9	#57	14328.6	548823	23372.2	452802	17889.3	381809.4	3103.5	417937.4	7762.2	470232	10208	404401	10044.2	2E+05	17106.5	324978.2	13976.4	311227.4	18827.7	354402.8	29152.5	601679	21975.6	502178	13163.1	291691	9608	184703	5327.9	147774
58	40.6	#58	13699.2	558587	23207.5	469039	17617.4	394141.7	2458.9	419820.8	6960.8	475305	9616.6	411357.5	9083.1	2E+05	16292.8	336658.3	13052.1	320585.1	18056	367313.2	28127.7	621681.6	21082.8	517348	12236.6	300498	8648.5	191069	4240.2	151020
59	41.3	#59	13067.7	567935	23040	485167	17342.9	406292.5	1812.2	421278.5	6157	479849	9013.4	417826.3	8120.8	2E+05	15478	347802.9	12125.2	329332.2	17283.5	379716	27088.9	640728.9	20178.1	531689	11308.1	308694	7687.7	196805	3149.9	153548
60	42	#60	12441	576825	22876.5	501171	17072.8	418242.3	1170.4	422266.1	5357.6	483808	8419	424043.2	7164.1	2E+05	14669.1	358356.7	11202.5	337405.3	16517.1	391559	26061.2	659510.2	19285	545800	10384.2	316215	6732.5	201843	2063.9	155283
61	42.7	#61	11877.5	585303	22775.4	517086	16865.3	430029.7	591.9	422832.8	4621	487237	7943.5	429643.6	6271.2	2E+05	13924.2	368370.7	10342.3	344861.9	15815.2	402891.4	25150.5	677090.9	18511.8	558875	9523.3	323118	5841.3	206240	1040.2	156289
62	43.4	#62	11321.4	593389	22681	532933	16664.8	441674	21	422995.7	3891.7	490150	7481.1	435175.6	5386.6	3E+05	13187.8	377864.7	9489	351715.5	15122.2	413734.4	24252.7	694539.9	17751.9	571838	8669.9	329418	4958.4	210014	23.5	156576
63	44.1	#63	10765.2	601075	22585.6	548715	16463.8	453180.1	-550	422748.8	3161.7	492540	7013.9	440327.1	4502.6	3E+05	12452.3	386857.8	8635	357986.4	14430.2	424106.3	23349.6	711249.8	16988.5	584179	7816.2	335136	4076.2	213187	-993.9	156169
64	44.8	#64	10189.9	608399	21517.1	564089	15289.8	464202.6	-1140	422129.6	2412.6	494454	5970.9	444909.7	3110.1	3E+05	11208.3	395151.2	7271.1	363469.2	13230.3	433810.2	21870.4	727032.9	15650.7	595716	6453	340067	2685.4	215554	-2521.2	154857
65	45.5	#65	9551.5	615242	20384.7	578630	14052.6	474311.7	-1792.9	421015.2	1600.1	495748	4842.7	448645.6	1655.6	3E+05	9902.4	402487.2	5843.7	367897.6	11968.7	442590.4	20305.6	741628.4	14228.9	606183	5026.9	343946	1232.6	216854	-4112	152369
66	46.2	#66	8911.7	621697	19250.3	592485	12813.5	483670	-2447.2	419504.4	785.9	496548	3711.1	451752.5	200.4	3E+05	8595.9	409032.8	4414.4	371460.2	10706.9	450607.5	18737	755350.3	12804.5	615860	3599.3	346960	-220.9	217275	-5704.7	148917
67	46.9	#67	8752.1	627838	18595.2	605646	12054.2	492254.5	-2621.2	417668.2	451.6	496900	3057.1	454153.3	-773.8	3E+05	7770.7	414755.8	3464.7	374103.6	9926.7	457836.3	17645.7	768027.1	11859.1	624606	2651.8	349057	-1193.3	216760	-6817.9	144421
68	47.6	#68	8591.5	633872	17938.4	618370	11293.4	500332	-2796.1	415715.2	116.1	497029	2400.4	456096.3	-1748.1	3E+05	6945.4	419930.2	2513.5	376113.6	9146.7	464546.8	16551.3	779938.6	10912.1	632693	1703.3	350523	-2165.9	215599	-7932.5	139182
69	48.3	#69	8460.2	639796	17310.1	630610	10561.5	507847	-2941.7	413640.9	-190.5	496915	1771.5	457551.3	-2692.3	3E+05	6150.5	424496.2	1591	377418	8397.5	470683.3	15484.1	791027	9994.1	640072	784	351285	-3108.3	213718	-9018.5	133115
70	49	#70	8327.9	645636	16680.2	642451	9828.4	514896.9	-3088	411473.4	-498.3	496605	1140.8	458642.2	-3636.6	3E+05	5355.6	428559.4	667.2	378136.7	7648.7	476346.1	14415	801496.6	9075.4	646921	-136.3	351465	-4050.8	211241	-10106	126360
71	49.7	#71	8195.2	651376	16049	653821	9094.2	521398.8	-3234.8	409195.8	-806.9	496065	508.8	459234.7	-4580.6	3E+05	4561.2	432031.1	-257.8	378165.6	6900.7	481452.1	13344.1	811119.6	8156.6	653046	-1057.1	350958	-4992.9	208062	-11194	118792
72	50.4	#72	8042.3	656998	15396.8	664663	8339.4	527287.6	-3401.5	406787.7	-1136	495261	-143.3	459324.3	-5543.7	2E+05	3747.9	434843.2	-1203.6	377425.1	6134.1	485936.9	12252.6	819894.5	7219	658446	-1998.2	349686	-5954.1	204102	-12304	110322
73	51.1	#73	7972.2	662574	14826.9	675207	7667.2	532826.5	-3485.4	404326.5	-1382.4	494322	-712.4	459063.5	-6423.4	2E+05	3018.1	437277.5	-2066.9	376238.5	5451.4	490067.6	11243.7	828031.1	6365.5	663310	-2856.4	347970	-6831.9	199690	-13330	101323

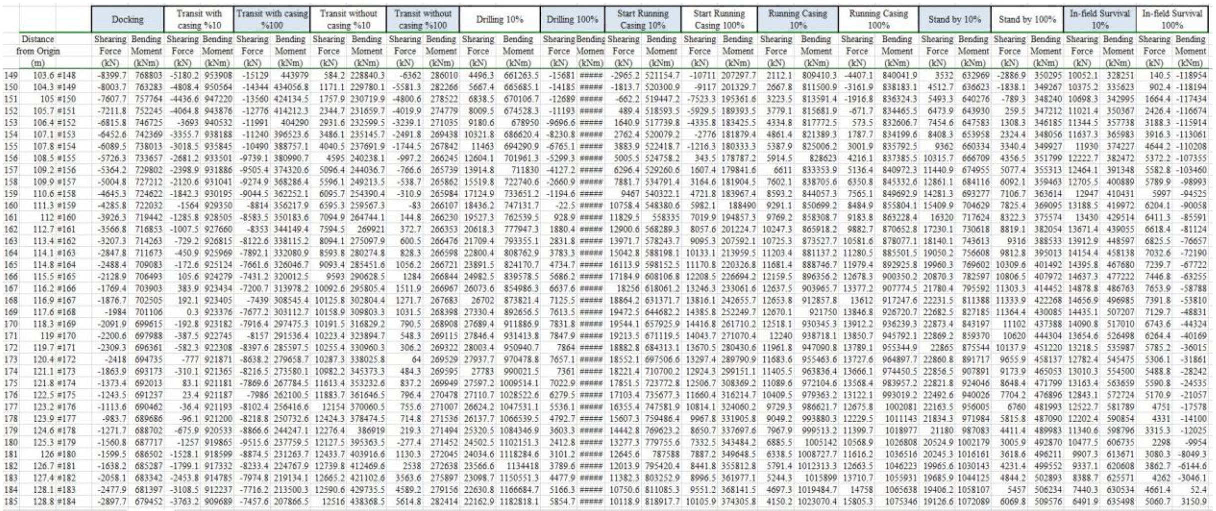


			Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
	Distance from Origin (m)		Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Momen (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)
74	51.8	#74	8146.8	668174	14500.8	685387	7239.1	537922.6	-3324.5	401878.6	-1384.6	493270	-1036.5	458397.9	-7057.6	2E+05	2534.1	439227	-2686.2	374461.4	5014.7	493750.3	10479.3	835360.3	5758.4	667513	-3470.1	345668	-7464.2	194678	-14113	91606.7
75	52.5	#75	8320.6	673886	14173.3	695357	6809.9	542742.2	-3164.3	399532.9	-1387.7	492215	-1360.6	457732.2	-7691.8	2E+05	2050.2	440866.2	-3306.6	372285.3	4578.6	497153.2	9714.9	842689.6	5151.4	671716	-4084.5	342972	-8096.3	189260	-14897	81387
76	53.2	#76	8493.5	679776	13843.6	704986	6379.1	547114.9	-3004.9	397351	-1392.3	491154	-1684.6	456617.4	-8325.7	2E+05	1566.8	442005.7	-3929	369464.6	4143.4	500106.3	8949.8	848955.4	4546.7	675081	-4700.1	339638	-8728.2	183190	-15683	70353.7
77	53.9	#77	8665.8	685683	13513.4	714581	5947.7	551444.3	-2846	395184.8	-1397.5	490093	-2009	455465.1	-8960.1	2E+05	1083	443097	-4551.9	366581.6	3707.9	503016	8184.7	855131.7	3942.3	678375	-5316.2	336242	-9360.5	177056	-16469	59241.7
78	54.6	#78	8754	691741	13097.9	723812	5431.6	555304.4	-2771.1	393156.1	-1487.2	489001	-2407.1	453959.7	-9677.3	2E+05	516.6	443669.6	-5259.6	363033.1	3190.3	505457.2	7413.2	860522.3	3333.8	681053	-6016.4	332189	-10076	170251	-17341	47296.9
79	55.3	#79	8811	697840	12650.6	732733	4883.9	558784.6	-2727.3	391157.4	-1608.3	487824	-2850.8	452153.4	-10425	2E+05	-80	443830.8	-5999.1	358972.4	2642.8	507520.9	6608.5	865354.7	2693.6	683294	-6747.9	327630	-10821	162931	-18244	34726.9
80	56	#80	8874.3	703984	12208.8	741341	4342.1	561880.5	-2677.1	389194.9	-1723.5	486565	-3280.3	450047.6	-11165	2E+05	-669.3	443574.8	-6732.9	354391.2	2102.9	509202.6	5817.6	869636.6	2068.7	685099	-7473.2	322556	-11560	155088	-19141	21520.3
81	56.7	#81	8920.2	710165	11748.7	749640	3782.4	564598.7	-2644.2	387259.6	-1856.4	485221	-3727	447639.2	-11922	2E+05	-1275.1	442911.9	-7484.6	349301.8	1546.9	510511.6	5009.1	873363.2	1427.7	686469	-8216	316981	-12314	146736	-20056	7694.2
82	57.4	#82	8963.9	716375	11285.8	757607	3220.1	566913.2	-2613.4	385344.1	-1991.7	483778	-4174.5	444911.3	-12681	2E+05	-1882	441815	-8239	343671.9	990.1	511422.3	4199.5	876511.1	787.2	687383	-8960.9	310872	-13071	137844	-20974	-6789.1
83	58.1	#83	9025.3	722621	10839.9	765260	2675.2	568846.1	-2564.8	383455.4	-2109.6	482247	-4602.5	441877.6	-13421	2E+05	-2470.2	440306.7	-8976.3	337528	452.4	511956.3	3408.9	879099.8	167.3	687857	-9688.3	304256	-13808	128438	-21875	-21899
84	58.8	#84	9105.2	728919	10411.6	772592	2148.2	570384.1	-2497.5	381609.7	-2209.4	480636	-5011.5	438540.6	-14141	2E+05	-3038.9	438373.2	-9695.6	330847.6	-65.5	512102.4	2636.8	881121.2	-432.5	687889	-10397	297111	-14527	118496	-22758	-37665
85	59.5	#85	9192.1	735271	9989.6	779653	1627.8	571587.9	-2423.3	379809.3	-2302.5	478964	-5412.7	434946.2	-14854	2E+05	-3599.8	436080.4	-10409	323710.5	-575.2	511921.8	1872.2	882652.9	-1023.3	687543	-11099	289517	-15237	108099	-23634	-53993
86	60.2	#86	9359.4	741773	10818	787130	2070.6	572899.5	-1980.7	378346	-2315.6	477246	-3638.2	432440.6	-13555	1E+05	-1984.8	434702.7	-8948	317319.6	1091.4	512712.4	2318.3	884201.9	-401	687407	-9627.1	282681	-13750	98128.6	-22315	-70039
87	60.9	#87	9526.8	748275	11646.3	794607	2513.3	574211	-1538.1	376882.7	-2328.6	475527	-1863.6	429935	-12256	1E+05	-369.9	433325	-7487.5	310928.8	2758.1	513503	2764.4	885750.9	221.2	687272	-8155	275846	-12219	88852	-20953	-85469
88	61.6	#88	9349.8	754754	12128.7	803038	2610.8	575905.1	-1439.7	375804.1	-2686.7	473517	-429.7	432687	-11300	1E+05	904.3	436644.4	-6375.6	308670.1	4085.6	519175.8	2867.9	887897.4	508.7	688378	-7029	273190	-11032	81221.1	-19936	-99469
89	62.3	#89	9172.8	761234	12611.1	811469	2708.4	577599.2	-1341.2	374725.5	-3044.7	471508	1004.3	435439.1	-10343	1E+05	2178.4	439963.7	-5263.6	306411.3	5413.1	524848.7	2971.4	890043.9	796.1	689485	-5903	270534	-9843.7	73590.2	-18919	-113468
90	63	#90	9091	767502	13131.7	821017	2843.6	579734.6	-1202	373939.8	-3364.4	468467	2438.3	438191.1	-9330	1E+05	3452.5	443283	-4151.6	304152.6	6740.6	530521.5	3075	892190.4	1083.6	690592	-4777	267879	-8415.2	69010.7	-17666	-124797
91	63.7	#91	9061.8	773664	13663.6	830896	2990.1	582000.8	-1050.7	373240.8	-3672.8	465121	3872.2	440943.2	-8274.3	1E+05	4726.7	446602.4	-3039.6	301893.8	8068.1	536194.4	3178.5	894336.9	1371.1	691699	-3651	265223	-6915.4	65335.1	-16343	-135334
92	64.4	#92	9032.6	779827	14195.5	840775	3136.5	584266.9	-899.4	372541.7	-3981.1	461775	5306.2	443695.2	-7218.5	1E+05	6000.8	449921.7	-1927.6	299635.1	9395.7	541867.2	3282	896483.5	1658.5	692805	-2524.9	262567	-5415.6	61659.6	-15020	-145872
93	65.1	#93	9003.4	785989	14727.3	850654	3282.9	586533.1	-748.1	371842.7	-4289.5	458429	6740.2	446447.2	-6162.7	98427	7274.9	453241	-815.6	297376.3	10723.2	547540.1	3385.6	898630	1946	693912	-1398.9	259911	-3915.9	57984.1	-13697	-156410
94	65.8	#94	8974.2	792151	15259.2	860533	3429.3	588799.2	-596.8	371143.7	-4597.9	455083	8174.2	449199.3	-5106.9	93448	8549.1	456560.4	296.4	295117.6	12050.7	553212.9	3489.1	900776.5	2233.4	695019	-272.9	257256	-2416.1	54308.6	-12374	-166947
95	66.5	#95	8945	798313	15791.1	870412	3575.7	591065.4	-445.5	370444.7	-4906.3	451737	9608.1	451951.3	-4051.2	88470	9823.2	459879.7	1408.4	292858.8	13378.2	558885.8	3592.6	902923	2520.9	696126	853.1	254600	-916.3	50633.1	-11051	-177485
96	67.2	#96	8915.8	804475	16157.3	881871	3722.2	593331.5	-455.7	370032.3	-5214.6	448391	10532.7	460017	-3634.7	86129	10587.6	467838.9	1873.2	294352.4	14198.1	569427.6	3056.2	904603.8	2305.8	697750	1334.9	255763	72.5	51371.7	-10374	-184410
97	67.9	#97	8886.6	810638	16523.5	893330	3868.6	595597.7	-465.9	369619.9	-5523	445045	11457.2	468082.8	-3218.2	83788	11352	475798.2	2338.1	295846	15017.9	579969.3	2519.7	906284.5	2090.8	699374	1816.7	256927	1061.3	52110.2	-9696.7	-191335
98	68.6	#98	8857.3	816800	16889.8	904789	4015	597863.8	-476.1	369207.5	-5831.4	441699	12381.7	476148.5	-2801.7	81447	12116.4	483757.4	2802.9	297339.7	15837.7	590511.1	1983.3	907965.3	1875.7	700998	2298.4	258090	2050.1	52848.7	-9019.6	-198261
99	69.3	#99	8828.1	822962	17256	916249	4161.4	600130	-486.3	368795.1	-6139.7	438353	13306.3	484214.2	-2385.3	79107	12880.8	491716.6	3267.8	298833.3	16657.6	601052.8	1446.8	909646.1	1660.7	702623	2780.2	259253	3038.9	53587.2	-8342.5	-205186
100	70	#100	8798.9	829124	16690.3	926932	4278.7	603146.9	-540.7	368241	-5593	435182	13080.5	493063.2	-2216.6	77727	12494.6	499869	3477.6	301447.9	16328.6	611995.7	1545	910794.2	1412.6	703388	3237.4	262124	3673.4	56744	-7122.2	-209180
101	70.7	#101	8769.7	835286	16124.6	937616	4395.9	606163.9	-595	367686.9	-5046.2	432011	12854.8	501912.2	-2047.9	76347	12108.4	508021.5	3687.5	304062.5	15999.6	622938.6	1643.2	911942.2	1164.4	704153	3694.6	264995	4307.8	59900.7	-5901.8	-213174
102	71.4	#102	8740.5	841449	15558.9	948299	4513.2	609180.8	-649.4	367132.8	-4499.4	428839	12629	510761.2	-1879.1	74967	11722.2	516173.9	3897.4	306677.1	15670.6	633881.4	1741.4	913090.3	916.3	704918	4151.7	267866	4942.3	63057.5	-4681.5	-217168
103	72.1	#103	8711.3	847611	14993.3	958983	4630.4	612197.8	-703.7	366578.7	-3952.6	425668	12403.3	519610.3	-1710.4	73588	11335.9	524326.4	4107.3	309291.7	15341.7	644824.3	1839.5	914238.4	668.2	705683	4608.9	270737	5576.8	66214.2	-3461.1	-221162
104	72.8	#104	8682.1	853773	14427.6	969666	4747.6	615214.8	-758.1	366024.6	-3405.8	422497	12177.5	528459.3	-1541.7	72208	10949.7	532478.8	4317.1	311906.3	15012.7	655767.1	1937.7	915386.5	420	706448	5066.1	273607	6189.2	69850.8	-2264.4	-224223
105	73.5	#105	8652.9	859935	13861.9	980350	4864.9	618231.7	-812.4	365470.5	-2859	419326	11951.8	537308.3	-1373	70828	10563.5	540631.3	4527	314520.9	14683.7	666710	2035.9	916534.6	171.9	707213	5523.3	276478	6759.4	74407.1	-1112.9	-225497
106	74.2	#106	8621.3	865996	13293.6	990192	4980.1	621416.1	-867.6	364833.2	-2314	416958	11727.3	545795.3	-1203.6	69703	10178.4	548161.5	4734.5	317467.9	14356.6	677124.5	2134.4	917839.9	-72.3	707586	5979.2	280083	7329.9	79329.2	37.7	-226034
107	74.9	#107	8587.6	871961	12722.7	999235	5093.5	624759.5	-923.7	364117	-1770.5	415353	11503.9	553938.5	-1033.6	68818	9794.4	555100.9	4939.6	320730.4	14031.4	687037.4	2233.2	919294.4	-312.8	707586	6433.8	284386	7900.7	84598.6	1187.3	-225871
108	75.6	#108	8455	877804	12107.7	1E+06	5163.3	628196.2	-1022.4	363289.6	-1270.4	414367	11280.6	562081.6	-919.3	68008	9410.4	562040.3	5144.8	323993	13706.2	696950.3	2332	920749	-553.3	707586	6888.4	288688	8232.3	90190.8	2096.4	-224995
109	76.3	#109	8267.5	883566	11479.5	1E+06	5220.2	631660.5	-1133.8	362429.3	-783.2	413563	11058.4	569873.9	-846.6	67317	9027.6	568374.3	5347.6	327574.4	13382.8	706351.5	2431.1	922357.9	-790.1	707213	7341.8	293705	8493.7	96131.7	2932.9	-223098
110	77	#110	8080.1	889327	10851.4	1E+06	5277.1	635124.7	-1245.2	361568.9	-295.9	412760	10836.2	577666.3	-773.8	66626	8644.7	574708.3	5550.4	331155.8	13059.5	715752.8	2530.1	923966.8	-1026.9	706839	7795.2	298722	8755.1	102073	3769.4	-221201

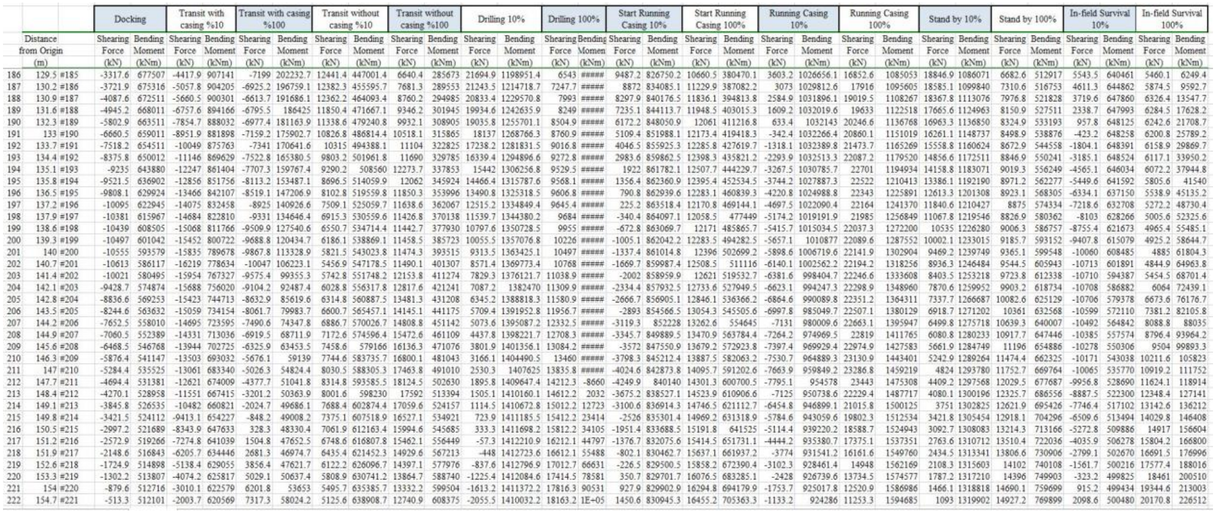
Appendix 14 Maximum Shear Force and Bending Moments B



			Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
	Distance from Origin (m)		Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Momen (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)
111	77.7	#111	7408.8	893274	9735.7	1E+06	4848	637587.2	-1840	359140	-294.1	412430	10134.9	583585.5	-1181.1	64984	7782.6	578661.5	5267.1	334181	12258.5	722964.4	2148.3	924705.6	-1737.5	704561	7764.6	303978	8536.6	107660	4119.7	-217864
112	78.4	#112	6737.4	897221	8620.1	1E+06	4418.9	640049.6	-2434.8	356711	-292.2	412100	9433.7	589504.8	-1588.3	63342	6920.5	582614.7	4983.8	337206.2	11457.5	730175.9	1766.4	925444.4	-2448.2	702283	7734	309234	8318.1	113248	4469.9	-214526
113	79.1	#113	6066.1	901168	7504.4	1E+06	3989.8	642512	-3029.6	354282	-290.3	411770	8732.4	595424	-1995.6	61699	6058.4	586567.9	4700.4	340231.3	10656.5	737387.5	1384.6	926183.1	-3158.9	700004	7703.4	314490	8099.6	118835	4820.2	-211189
114	79.8	#114	5394.8	905115	6388.7	1E+06	3560.7	644974.4	-3624.4	351853.1	-288.5	411440	8031.1	601343.3	-2402.9	60057	5196.3	590521.1	4417.1	343256.5	9855.5	744599.1	1002.7	926921.9	-3869.6	697726	7672.8	319746	7881.1	124423	5170.5	-207852
115	80.5	#115	4723.5	909061	5273	1E+06	3131.6	647436.8	-4219.3	349424.1	-286.6	411110	7329.8	607262.6	-2810.1	58414	4334.2	594474.3	4133.8	346281.7	9054.5	751810.7	620.9	927660.7	-4580.3	695448	7642.2	325002	7662.7	130011	5520.8	-204515
116	81.2	#116	4052.2	913008	4157.3	1E+06	2702.5	649899.2	-4814.1	346995.1	-284.7	410780	6628.5	613181.8	-3217.4	56772	3472.1	598427.5	3850.4	349306.8	8253.4	759022.3	239	928399.4	-5291	693169	7611.6	330258	7444.2	135598	5871.1	-201177
117	81.9	#117	3380.9	916955	3041.6	1E+06	2273.4	652361.7	-5408.9	344566.1	-282.8	410450	5927.2	619101.1	-3624.7	55130	2610.1	602380.7	3567.1	352332	7452.4	766233.8	-142.8	929138.2	-6001.6	690891	7581	335514	7225.7	141186	6221.4	-197840
118	82.6	#118	2574.3	917558	1963.7	1E+06	1637.9	652426.5	-5960.4	339515.2	-486.5	409688	5275.3	621935.9	-4066.6	51556	1797.1	602515.1	3076.6	353621.9	6702.7	769910.5	-214.4	928785.8	-6145.7	686579	7346.4	340194	7055.2	145880	6364.3	-193355
119	83.3	#119	1767.7	918162	885.8	1E+06	1002.5	652491.2	-6512	334464.2	-690.2	408927	4623.5	624770.8	-4508.5	47982	984.1	602649.4	2586.1	354911.9	5953.1	773587.1	-286	928433.4	-6289.8	682268	7111.8	344875	6884.8	150574	6507.3	-188869
120	84	#120	961.1	918765	-192.1	1E+06	367	652556	-7063.5	329413.2	-893.9	408166	3971.6	627605.7	-4950.4	44408	171.1	602783.7	2095.7	356201.8	5203.4	777263.7	-357.6	928081	-6433.9	677956	6877.2	349555	6714.3	155268	6650.2	-184384
121	84.7	#121	154.5	919368	-1270.1	1E+06	-268.4	652620.8	-7615.1	324362.2	-1097.5	407404	3319.8	630440.5	-5392.3	40834	-641.9	602918	1605.2	357491.7	4453.7	780940.3	-429.2	927728.6	-6578	673644	6642.6	354235	6543.9	159963	6793.2	-179898
122	85.4	#122	-652.1	919972	-2348	1E+06	-903.9	652685.6	-8166.6	319311.2	-1301.2	406643	2667.9	633275.4	-5834.2	37260	-1454.9	603052.3	1114.7	358781.6	3704	784616.9	-500.8	927376.2	-6722.1	669333	6408	358916	6373.4	164657	6936.1	-175413
123	86.1	#123	-1458.7	920575	-3425.9	1E+06	-1539.4	652750.4	-8718.1	314260.2	-1504.9	405882	2016	636110.2	-6276.1	33686	-2267.9	603186.6	624.2	360071.6	2954.3	788293.5	-572.4	927023.8	-6866.2	665021	6173.4	363596	6203	169351	7079.1	-170927
124	86.8	#124	-2267.7	918638	-4509.6	1E+06	-2179.1	650805.1	-9271.7	307469.6	-1712.3	404470	1366.5	636902.1	-6716.8	28721	-3078.8	600770	128.9	359806.8	2208.2	789620.9	-643.5	926443.5	-7002.9	660273	5936.1	367531	6033.9	173512	7217.1	-166006
125	87.5	#125	-3076.8	916695	-5593.3	1E+06	-2818.9	648854.8	-9825.2	300674.5	-1919.7	403056	716.9	637688.8	-7157.4	23753	-3889.8	598346.8	-366.5	359538	1462.1	790942.3	-714.7	925862.5	-7139.5	655524	5698.8	371463	5864.9	177671	7355.2	-161084
126	88.2	#126	-3885.8	914751	-6677	1E+06	-3458.7	646904.4	-10379	293879.4	-2127.2	401643	67.4	638475.5	-7598	18785	-4700.7	595923.7	-861.8	359269.3	716	792263.7	-785.8	925281.6	-7276.2	650776	5461.5	375396	5695.9	181830	7493.2	-156161
127	88.9	#127	-4828.5	911298	-6543.5	1E+06	-4762.6	643365.8	-9712.8	286967.4	-2998.3	399399	183.9	638663.6	-8699.6	12582	-4745.7	592618.7	-2021.5	357665	736.7	792817.8	-1518.4	924111.2	-6643.9	646330	4561	378446	6292.5	186229	6967	-151467
128	89.6	#128	-5771.2	907844	-6409.9	1E+06	-6066.4	639827.1	-9047	280055.5	-3869.5	397155	300.5	638851.6	-9801.2	6378	-4790.7	589313.8	-3181.2	356060.6	757.4	793371.9	-2250.9	922940.9	-6011.6	641884	3660.5	381496	6889.2	190629	6440.8	-146772
129	90.3	#129	-6460.3	903102	-6024.4	1E+06	-7117.6	634414.9	-8127.2	274445.3	-4487.7	393736	673.2	639461.6	-10647	-1369	-4579.7	586169.7	-4088.5	352814.9	1034.9	794193.7	-2728.3	920821.1	-5120.6	638696	3013.6	383325	7741.6	196222	6167	-142698
130	91	#130	-7149.3	898360	-5638.9	1E+06	-8168.7	629002.7	-7207.4	268835.1	-5105.9	390316	1045.9	640071.6	-11493	-9116	-4368.7	583025.6	-4995.8	349569.2	1312.4	795015.5	-3205.7	918701.3	-4229.6	635507	2366.7	385153	8593.9	201815	5893.2	-138624
131	91.7	#131	-7838.8	893233	-5254.4	1E+06	-9220.6	623002.9	-6288	263736.5	-5724.7	386551	1419	640889.8	-12339	#####	-4157.4	579999.4	-5903.9	345816.1	1590.5	795992.6	-3683	916314.9	-3337.3	632817	1719.3	386620	9446.5	207883	5618.5	-134704
132	92.4	#132	-8528.9	887524	-4871.5	1E+06	-10274	616114.5	-5369.1	259411.7	-6344.6	382263	1792.7	642023.1	-13185	#####	-3945.5	577151.5	-6813.4	341295.8	1869.5	797204.4	-4160.2	913525.2	-2443	630880	1071.2	387540	10299.4	214670	5342.5	-131018
133	93.1	#133	-9475.2	880483	-4746.3	1E+06	-11584	607332	-4706.1	256230.8	-7221.3	376749	1912.4	643465.7	-14284	#####	-3987.6	574363.2	-7980.2	335102.4	1895.3	798580.1	-4892.2	909731.7	-1800.1	630058	166.7	387190	10898.1	222503	4809.1	-128030
134	93.8	#134	-10422	873441	-4621.2	1E+06	-12894	598549.4	-4043.2	253049.9	-8098	371235	2032.2	644908.3	-15384	#####	-4029.7	571574.9	-9147	328908.9	1921.2	799955.9	-5624.2	905938.1	-1157.1	629237	-737.7	386841	11496.8	230335	4275.8	-125041
135	94.5	#135	-11368	866400	-4496.1	1E+06	-14204	589766.9	-3380.2	249869.1	-8974.6	365720	2151.9	646350.9	-16484	#####	-4071.8	568786.5	-10314	322715.5	1947	801331.6	-6356.2	902144.5	-514.2	628415	-1642.1	386492	12095.4	238168	3742.4	-122053
136	95.2	#136	-11534	858186	-5042.3	1E+06	-14818	579112.1	-3481.1	247257.2	-9230.3	359048	1682	647500.4	-17204	#####	-4658.6	565440.5	-11091	314674.7	1416.8	802260	-6772.7	897217.7	-721.5	628009	-2390.2	384585	11379	246022	2829.6	-120349
137	95.9	#137	-11701	849972	-5588.4	1E+06	-15431	568457.4	-3582	244645.4	-9486	352375	1212	648650	-17923	#####	-5245.5	562094.4	-11869	306633.9	886.7	803188.3	-7189.2	892290.9	-928.9	627602	-3138.3	382678	10662.7	253876	1916.8	-118646
139	96.6	#138	-11549	842102	-5723.2	996296	-15618	557056.1	-3363.1	242595	-9390.4	345868	1082	649282.6	-18190	#####	-5407	558042.4	-12185	297421.3	770.9	803555.1	-7217.5	887115.1	-787.6	627441	-3430.2	379670	10398.6	260693	1493.5	-118464
140	97.3	#139	-11397	834233	-5856.9	991955	-15804	545652.9	-3143.4	240546	-9294	339361	952.8	649913.8	-18456	#####	-5567.4	553988.6	-12501	288205.7	656.2	803920.4	-7244.8	881938.7	-645.4	627281	-3720.9	376659	10135.6	267508	1071.5	-118286
141	98	#140	-11245	826364	-5990.7	987615	-15990	534249.7	-2923.7	238497	-9197.5	332855	823.7	650545.1	-18721	#####	-5727.9	549934.8	-12816	278990.1	541.4	804285.7	-7272.2	876762.2	-503.3	627122	-4011.6	373649	9872.6	274323	649.4	-118108
142	98.7	#141	-11092	818495	-6124.4	983274	-16176	522846.5	-2704	236448	-9101	326348	694.5	651176.4	-18987	#####	-5888.3	545881	-13132	269774.5	426.7	804651.1	-7299.5	871585.8	-361.1	626962	-4302.4	370638	9609.7	281138	227.4	-117930
143	99.4	#142	-10940	810626	-6258.2	978934	-16362	511443.3	-2484.3	234399	-9004.5	319842	565.4	651807.7	-19252	#####	-6048.8	541827.2	-13447	260558.9	311.9	805016.4	-7326.9	866409.4	-218.9	626802	-4593.1	367627	9346.7	287953	-194.6	-117752
144	100.1	#143	-10787	802757	-6391.9	974593	-16548	500040.1	-2264.6	232350	-8908	313335	525.5	652389.1	-19429	#####	-6209.2	537773.4	-13762	251343.3	197.2	805381.7	-7354.2	861233	-76.7	626642	-4883.8	364617	9083.8	294768	-616.7	-117574
145	100.8	#144	-10635	794888	-6525.7	970253	-16734	488636.9	-2044.9	230301	-8811.5	306829	709	652845.9	-19382	#####	-6369.6	533719.6	-14078	242127.7	82.5	805747	-7381.5	856056.5	65.5	626482	-5174.5	361606	8820.8	301583	-1038.7	-117396
146	101.5	#145	-10022	788033	-6201.1	965919	-16460	477058.3	-1364.1	229500.9	-8255.3	301137	1356.3	653741.7	-18872	#####	-6066.2	529440.3	-13933	232212.3	432.6	806025.5	-6946	851050.1	674.9	627012	-5004.3	357972	9021.4	307864	-1001.1	-118237
147	102.2	#146	-9408.8	781178	-5876.5	961586	-16187	465479.8	-683.3	228700.7	-7699	295445	2205.8	655030	-18160	#####	-5360	525499	-13387	222562.2	909.8	806525.2	-6383.6	846302.7	1481.6	627915	-4615.6	354524	9313.9	314281	-872.2	-119017
148	102.9	#147	-8795.7	774322	-5552	957252	-15913	453901.3	-2.6	227900.5	-7142.7	289753	3325.2	656841.8	-17178	#####	-4116.8	522008.4	-12305	213265.8	1556.4	807319.8	-5652.2	841900.7	2551.4	629316	-3935.7	351322	9729	320880	-621.5	-119714

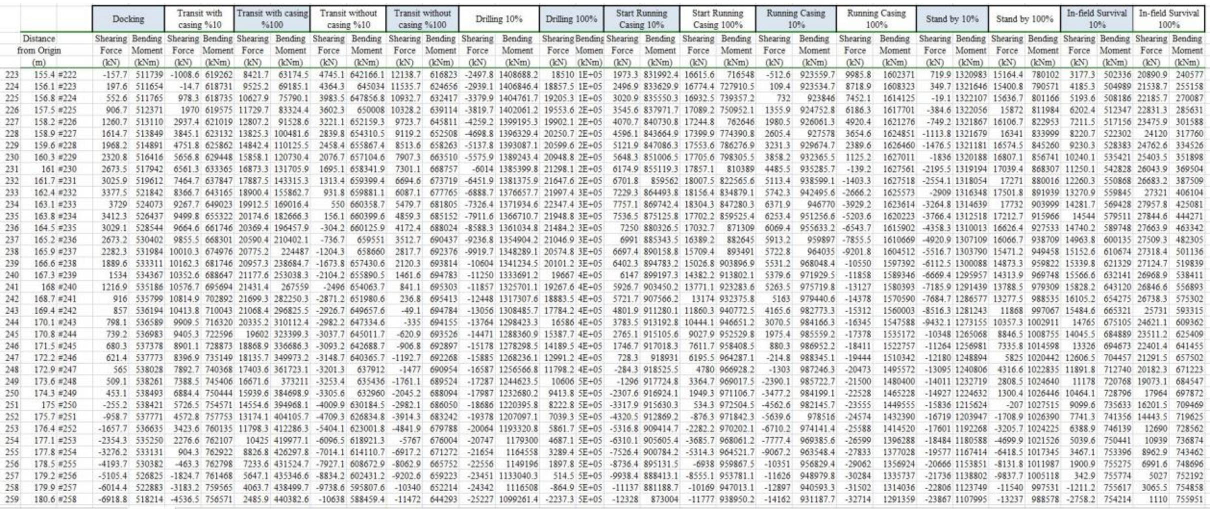


			Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
	Distance from Origin (m)		Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Momen (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)
149	103.6	#148	-8399.7	768803	-5180.2	953908	-15129	443979	584.2	228840.3	-6362	286010	4496.3	661263.5	-15681	#####	-2965.2	521154.7	-10711	207297.7	2112.1	809410.3	-4407.1	840041.9	3532	632969	-2886.9	350295	10052.1	328251	140.5	-118954
150	104.3	#149	-8003.7	763283	-4808.4	950564	-14344	434056.8	1171.1	229780.1	-5581.3	282266	5667.4	665685.1	-14185	#####	-1813.7	520300.9	-9117	201329.7	2667.8	811500.9	-3161.9	838183.1	4512.7	636623	-1838.1	349267	10375.2	335623	902.4	-118194
151	105	#150	-7607.7	757764	-4436.6	947220	-13560	424134.5	1757.9	230719.9	-4800.6	278522	6838.5	670106.7	-12689	#####	-662.2	519447.2	-7523.3	195361.6	3223.5	813591.4	-1916.8	836324.3	5493.3	640276	-789.3	348240	10698.3	342995	1664.4	-117434
152	105.7	#151	-7211.8	752245	-4064.8	943876	-12776	414212.3	2344.7	231659.7	-4019.9	274779	8009.5	674528.3	-11193	#####	489.4	518593.5	-5929.5	189393.5	3779.1	815681.9	-671.7	834465.5	6473.9	643930	259.5	347212	11021.4	350367	2426.4	-116674
153	106.4	#152	-6815.8	746725	-3693	940532	-11991	404290	2931.6	232599.5	-3239.1	271035	9180.6	678950	-9696.6	#####	1640.9	517739.8	-4335.8	183425.5	4334.8	817772.5	573.5	832606.7	7454.6	647583	1308.3	346185	11344.5	357738	3188.3	-115914
154	107.1	#153	-6452.6	742369	-3355.7	938188	-11240	396523.6	3486.1	235145.7	-2491.8	269438	10321.8	686620.4	-8230.8	#####	2762.4	520079.2	-2776	181879.4	4861.4	821389.3	1787.7	834199.6	8408.3	653958	2324.4	348056	11637.3	365983	3916.3	-113061
155	107.8	#154	-6089.5	738013	-3018.5	935845	-10490	388757.1	4040.5	237691.9	-1744.5	267842	11463	694290.9	-6765.1	#####	3883.9	522418.7	-1216.3	180333.3	5387.9	825006.2	3001.9	835792.5	9362	660334	3340.4	349927	11930	374227	4644.2	-110208
156	108.5	#155	-5726.3	733657	-2681.2	933501	-9739.1	380990.7	4595	240238.1	-997.2	266245	12604.1	701961.3	-5299.3	#####	5005.5	524758.2	343.5	178787.2	5914.5	828623	4216.1	837385.5	10315.7	666709	4356.5	351799	12222.7	382472	5372.2	-107355
157	109.2	#156	-5364.2	729802	-2398.9	931886	-9505.4	374320.6	5096.4	244036.7	-766.6	265739	13914.8	711830	-4127.2	#####	6296.4	529260.6	1607.4	179841.6	6611	833353.9	5136.4	840972.3	11440.9	674955	5077.4	355313	12464.1	391348	5582.8	-103460
158	109.9	#157	-5004.8	727212	-2120.6	931041	-9274.9	368286.4	5596.1	249213.5	-538.7	265862	15519.8	722740.6	-2660.9	#####	7881.7	534791.4	3164.6	181904.5	7602.1	838705.6	6350.8	845332.6	12861.1	684116	6092.1	359463	12705.5	400889	5789.9	-98993
159	110.6	#158	-4645.3	724622	-1842.3	930195	-9044.5	362252.1	6095.7	254390.4	-310.9	265984	17124.9	733651.2	-1194.6	#####	9467	540322.1	4721.8	183967.4	8593.2	844057.3	7565.1	849692.9	14281.3	693277	7106.7	363614	12947	410431	5997	-94525
160	111.3	#159	-4285.8	722032	-1564	929350	-8814	356217.9	6595.3	259567.3	-83	266107	18436.2	747131.7	-22.5	#####	10758.4	548380.6	5982.1	188490	9291.1	850699.2	8484.9	855804.1	15409.9	704629	7825.4	369095	13188.5	419972	6204.1	-90058
161	112	#160	-3926.3	719442	-1285.8	928505	-8583.5	350183.6	7094.9	264744.1	144.8	266230	19527.3	762539.5	928.9	#####	11829.5	558335	7019.9	194857.3	9769.2	858308.7	9183.8	863228.4	16320	717624	8322.3	375574	13430	429514	6411.3	-85591
162	112.7	#161	-3566.8	716853	-1007.5	927660	-8353	344149.4	7594.5	269921	372.7	266353	20618.3	777947.3	1880.4	#####	12900.6	568289.3	8057.6	201224.7	10247.3	865918.2	9882.7	870652.8	17230.1	730618	8819.1	382054	13671.4	439055	6618.4	-81124
163	113.4	#162	-3207.3	714263	-729.2	926815	-8122.6	338115.2	8094.1	275097.9	600.5	266476	21709.4	793355.1	2831.8	#####	13971.7	578243.7	9095.3	207592.1	10725.3	873527.7	10581.6	878077.1	18140.1	743613	9316	388533	13912.9	448597	6825.5	-76657
164	114.1	#163	-2847.8	711673	-450.9	925969	-7892.1	332080.9	8593.8	280274.8	828.3	266598	22800.4	808762.9	3783.3	#####	15042.8	588198.1	10133.1	213959.5	11203.4	881137.2	11280.5	885501.5	19050.2	756608	9812.8	395013	14154.4	458138	7032.6	-72190
165	114.8	#164	-2488.4	709083	-172.6	925124	-7661.6	326046.7	9093.4	285451.6	1056.2	266721	23891.5	824170.7	4734.7	#####	16113.9	598152.5	11170.8	220326.8	11681.4	888746.7	11979.4	892925.8	19960.3	769602	10309.6	401492	14395.8	467680	7239.7	-67722
166	115.5	#165	-2128.9	706493	105.6	924279	-7431.2	320012.5	9593	290628.5	1284	266844	24982.5	839578.5	5686.2	#####	17184.9	608106.8	12208.5	226694.2	12159.5	896356.2	12678.3	900350.2	20870.3	782597	10806.5	407972	14637.3	477222	7446.8	-63255
167	116.2	#166	-1769.4	703903	383.9	923434	-7200.7	313978.2	10092.6	295805.4	1511.9	266967	26073.6	854986.3	6637.6	#####	18256	618061.2	13246.3	233061.6	12637.5	903965.7	13377.2	907774.5	21780.4	795592	11303.3	414452	14878.8	486763	7653.9	-58788
168	116.9	#167	-1876.7	702505	192.1	923405	-7439	308545.4	10125.8	302804.4	1271.7	267683	26702	873821.4	7125.5	#####	18864.2	631371.7	13816.1	242655.7	12653.8	912857.8	13612	917247.6	22231.5	811388	11333.9	422268	14656.9	496985	7391.8	-53810
169	117.6	#168	-1984	701106	0.3	923376	-7677.2	303112.7	10158.9	309803.3	1031.5	268398	27330.4	892656.5	7613.5	#####	19472.5	644682.2	14385.8	252249.7	12670.1	921750	13846.8	926720.7	22682.5	827185	11364.4	430085	14435.1	507207	7129.7	-48831
170	118.3	#169	-2091.9	699615	-192.8	923182	-7916.4	297475.3	10191.5	316829.2	790.5	268908	27689.4	911886.9	7831.8	#####	19544.1	657925.9	14416.8	261710.2	12518.1	930345.3	13912.2	936239.3	22873.4	843197	11102	437388	14090.8	517010	6743.6	-44324
171	119	#170	-2200.6	697988	-387.5	922745	-8157	291536.4	10223.4	323894.7	548.3	269115	27846.4	931413.8	7847.9	#####	19213.5	671119.5	14043.7	271070.4	12240	938718.1	13850.7	945792.1	22869.2	859370	10620	444304	13654.6	526498	6264.4	-40169
172	119.7	#171	-2309.3	696361	-582.3	922308	-8397.6	285597.5	10255.4	330960.3	306.2	269322	28003.4	950940.7	7864	#####	18882.8	684313.1	13670.5	280430.6	11961.8	947090.8	13789.1	955344.9	22865	875544	10137.9	451220	13218.5	535987	5785.2	-36015
173	120.4	#172	-2418	694735	-777	921871	-8638.2	279658.7	10287.3	338025.8	64	269529	27937.7	970478.8	7657.1	#####	18552.1	697506.6	13297.4	289790.9	11683.6	955463.6	13727.6	964897.7	22860.8	891717	9655.9	458137	12782.4	545475	5306.1	-31861
174	121.1	#173	-1863.9	693173	-310.1	921365	-8216.5	273580.1	10982.2	345373.3	484.3	269595	27783	990021.5	7361	#####	18221.4	710700.2	12924.3	299151.1	11405.5	963836.4	13666.1	974450.5	22856.5	907891	9173.9	465053	13010.3	554500	5488.8	-28242
175	121.8	#174	-1373.4	692013	83.1	921181	-7869.6	267784.5	11613.4	353232.6	837.2	269949	27597.2	1009514.1	7022.9	#####	17851.5	723772.8	12506.7	308369.2	11089.6	972104.6	13568.4	983957.2	22821.8	924046	8648.4	471799	13163.4	563659	5590.8	-24535
176	122.5	#175	-1243.5	691237	23.4	921187	-7986	262100.5	11883.7	361646.5	796.4	270478	27110.7	1028522.6	6279.5	#####	17103.4	735677.3	11660.4	316214.7	10409.5	979363.2	13122.1	993019.2	22492.6	940026	7704.2	476896	12843.1	572724	5170.9	-21057
177	123.2	#176	-1113.6	690462	-36.4	921193	-8102.4	256416.6	12154	370060.5	755.6	271007	26624.2	1047531.1	5536.1	#####	16355.4	747581.9	10814.1	324060.2	9729.3	986621.7	12675.8	1002081	22163.5	956005	6760	481993	12522.7	581789	4751	-17578
178	123.9	#177	-983.7	689686	-96.1	921200	-8218.8	250732.6	12424.3	378474.5	714.8	271536	26137.7	1066539.5	4792.7	#####	15607.3	759486.4	9967.8	331905.8	9049.2	993880.3	12229.5	1011143	21834.3	971984	5815.8	487090	12202.4	590854	4331	-14100
179	124.6	#178	-1271.7	688702	-675.9	920533	-8866.6	244247.1	12276.4	386919	219.3	271494	25320.5	1084346.9	3603.3	#####	14442.8	769623.2	8650.7	337697.6	7967.9	999513.2	11399.7	1018977	21180	987083	4411.4	489983	11340.6	598796	3315.3	-12025
180	125.3	#179	-1560.8	687717	-1257	919865	-9515.6	237759.5	12127.5	395363.5	-277.4	271452	24502.5	1102151.3	2412.8	#####	13277.3	779755.6	7332.5	343484.2	6885.5	1005142	10568.9	1026808	20524.9	1002179	3005.9	492870	10477.5	606735	2298	-9954
181	126	#180	-1599.5	686502	-1528.1	918599	-8874.5	231263.7	12433.7	403916.6	1130.3	272045	24034.6	1118284.6	3101.2	#####	12645.6	787588	7887.2	349648.5	6338.5	1008727.7	11616.2	1036516	20245.3	1016161	3618.6	496211	9907.3	613671	3080.3	-8049.3
182	126.7	#181	-1638.2	685287	-1799.1	917332	-8233.4	224767.9	12739.8	412469.6	2538	272638	23566.6	1134418	3789.6	#####	12013.9	795420.4	8441.8	355812.8	5791.4	1012313.3	12663.5	1046223	19965.6	1030143	4231.4	499552	9337.1	620608	3862.7	-6144.6
183	127.4	#182	-2058.1	683342	-2453.8	914785	-7974.8	219134.1	12665.2	421102.6	3563.6	275897	23098.7	1150551.3	4477.9	#####	11382.3	803252.9	8996.5	361977.1	5244.3	1015899	13710.7	1055931	19685.9	1044125	4844.2	502893	8388.7	625571	4262	-3046.1
184	128.1	#183	-2477.9	681397	-3108.5	912237	-7716.2	213500.3	12590.6	429735.5	4589.2	279156	22630.8	1166684.7	5166.3	#####	10750.6	811085.3	9551.2	368141.5	4697.3	1019484.7	14758	1065638	19406.2	1058107	5457	506234	7440.3	630534	4661.4	52.4
185	128.8	#184	-2897.7	679452	-3763.2	909689	-7457.6	207866.5	12516	438368.5	5614.8	282414	22162.9	1182818.1	5854.7	#####	10118.9	818917.7	10105.9	374305.8	4150.2	1023070.4	15805.3	1075346	19126.6	1072089	6069.8	509576	6491.9	635498	5060.7	3150.9

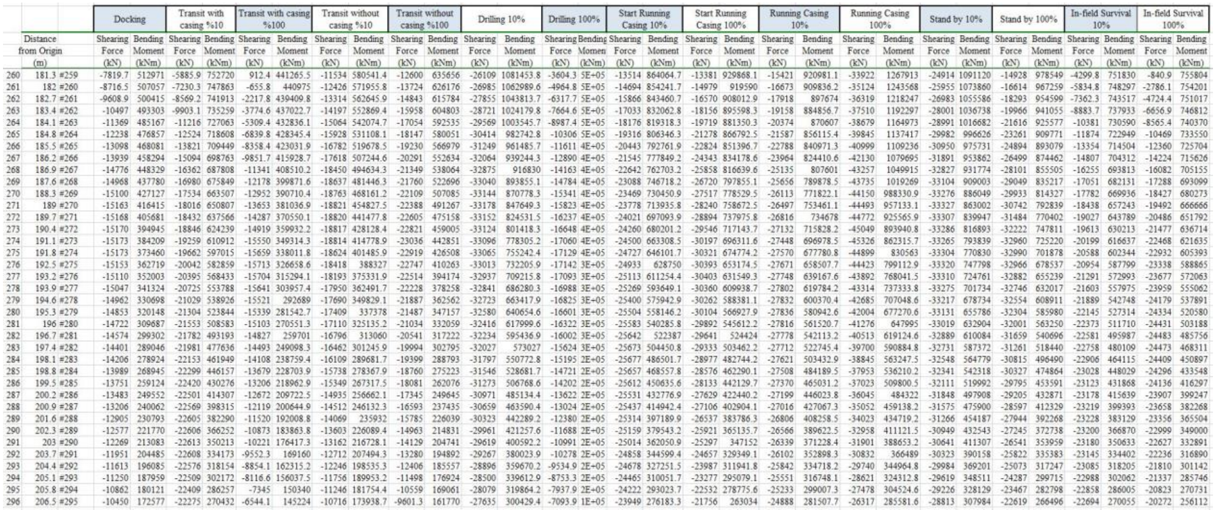


			Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
	Distance from Origin (m)		Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Momen (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)
186	129.5	#185	-3317.6	677507	-4417.9	907141	-7199	202232.7	12441.4	447001.4	6640.4	285673	21694.9	1198951.4	6543	#####	9487.2	826750.2	10660.5	380470.1	3603.2	1026656.1	16852.6	1085053	18846.9	1086071	6682.6	512917	5543.5	640461	5460.1	6249.4
187	130.2	#186	-3721.9	675316	-5057.8	904205	-6925.2	196759.1	12382.3	455595.7	7681.3	289553	21243.5	1214718.7	7247.7	#####	8872	834085.1	11229.9	387082.2	3073	1029812.6	17916	1095605	18585.1	1099840	7310.6	516753	4611.3	644862	5874.5	9592.7
188	130.9	#187	-4087.6	672511	-5660.5	900301	-6613.7	191686.1	12362.2	464093.4	8760.2	294985	20833.4	1229570.8	7993	#####	8297.9	840176.5	11836.1	394813.8	2584.9	1031896.1	19019.5	1108267	18367.8	1113076	7976.8	521828	3719.6	647860	6326.4	13547.7
189	131.6	#188	-4945.2	668011	-6757.6	894166	-6795.5	186425	11850.4	471667.1	9346.2	301945	19934.6	1242635.9	8249	#####	7235.1	844113.7	11948.5	403015.3	1609.2	1032019.6	19633	1122518	17665.6	1124963	8150.9	527511	2338.7	647993	6284.5	17628.2
190	132.3	#189	-5802.9	663511	-7854.7	888032	-6977.4	181163.9	11338.6	479240.8	9932.1	308905	19035.8	1255701.1	8504.9	#####	6172.2	848050.9	12061	411216.8	633.4	1032143	20246.6	1136768	16963.3	1136850	8324.9	533193	957.8	648125	6242.6	21708.7
191	133	#190	-6660.5	659011	-8951.9	881898	-7159.2	175902.7	10826.8	486814.4	10518.1	315865	18137	1268766.3	8760.9	#####	5109.4	851988.1	12173.4	419418.3	-342.4	1032266.4	20860.1	1151019	16261.1	1148737	8498.9	538876	-423.2	648258	6200.8	25789.2
192	133.7	#191	-7518.2	654511	-10049	875763	-7341	170641.6	10315	494388.1	11104	322825	17238.2	1281831.5	9016.8	#####	4046.5	855925.3	12285.8	427619.7	-1318.1	1032389.8	21473.7	1165269	15558.8	1160624	8672.9	544558	-1804.1	648391	6158.9	29869.7
193	134.4	#192	-8375.8	650012	-11146	869629	-7522.8	165380.5	9803.2	501961.8	11690	329785	16339.4	1294896.6	9272.8	#####	2983.6	859862.5	12398.3	435821.2	-2293.9	1032513.3	22087.2	1179520	14856.6	1172511	8846.9	550241	-3185.1	648524	6117.1	33950.2
194	135.1	#193	-9235	643880	-12247	861404	-7707.3	159767.4	9290.2	508560	12273.7	337853	15442	1306256.8	9529.5	#####	1922	861782.1	12507.7	444229.7	-3267.5	1030785.7	22701	1194934	14158.8	1183071	9019.3	556249	-4565.1	646034	6072.2	37944.8
195	135.8	#194	-9521.5	636902	-12856	851756	-8113.2	153487.1	8696.5	514059.9	12062	345924	14466.4	1315787.6	9568.1	#####	1356.4	862360.9	12395.4	452534.5	-3744.2	1027887.3	22522	1210413	13386.1	1192190	8971.2	562277	-5449.6	641592	5805.6	41540
196	136.5	#195	-9808.1	629924	-13466	842107	-8519.1	147206.9	8102.8	519559.8	11850.3	353996	13490.8	1325318.5	9606.8	#####	790.8	862939.6	12283.1	460839.3	-4220.8	1024988.8	22343	1225891	12613.3	1201308	8923.1	568305	-6334.1	637150	5538.9	45135.2
197	137.2	#196	-10095	622945	-14075	832458	-8925	140926.6	7509.1	525059.7	11638.6	362067	12515.2	1334849.4	9645.4	#####	225.2	863518.4	12170.8	469144.1	-4697.5	1022090.4	22164	1241370	11840.6	1210427	8875	574334	-7218.6	632708	5272.2	48730.4
198	137.9	#197	-10381	615967	-14684	822810	-9331	134646.4	6915.3	530559.6	11426.8	370138	11539.7	1344380.2	9684	#####	-340.4	864097.1	12058.5	477449	-5174.2	1019191.9	21985	1256849	11067.8	1219546	8826.9	580362	-8103	628266	5005.6	52325.6
199	138.6	#198	-10439	608505	-15068	811766	-9509.9	127540.6	6550.7	534714.4	11442.7	377930	10797.6	1350728.5	9955	#####	-672.8	863069.7	12171	485865.7	-5415.7	1015034.5	22037.3	1272200	10535	1226280	9006.3	586757	-8755.4	621673	4965.4	55485.1
200	139.3	#199	-10497	601042	-15452	800722	-9688.8	120434.7	6186.1	538869.1	11458.5	385723	10055.5	1357076.8	10226	#####	-1005.1	862042.2	12283.5	494282.5	-5657.1	1010877	22089.6	1287552	10002.1	1233015	9185.7	593152	-9407.8	615079	4925.2	58644.7
201	140	#200	-10555	593579	-15835	789678	-9867.8	113328.9	5821.5	543023.8	11474.3	393515	9313.5	1363425.1	10497	#####	-1337.4	861014.8	12396	502699.2	-5898.6	1006719.6	22141.9	1302904	9469.2	1239749	9365.1	599548	-10060	608485	4885	61804.3
202	140.7	#201	-10613	586117	-16219	778634	-10047	106223.1	5456.9	547178.5	11490.1	401307	8571.4	1369773.4	10768	#####	-1669.7	859987.4	12508.5	511116	-6140.1	1002562.2	22194.2	1318256	8936.3	1246484	9544.5	605943	-10713	601891	4844.9	64963.8
203	141.4	#202	-10021	580495	-15954	767327	-9575.4	99355.3	5742.8	551748.2	12153.8	411274	7829.3	1376121.7	11038.9	#####	-2002	858959.9	12621	519532.7	-6381.6	998404.7	22246.6	1333608	8403.5	1253218	9723.8	612338	-10710	594387	5454.5	68701.4
204	142.1	#203	-9428.7	574874	-15688	756020	-9104.2	92487.4	6028.8	556317.8	12817.6	421241	7087.2	1382470	11309.9	#####	-2334.4	857932.5	12733.6	527949.5	-6623.1	994247.3	22298.9	1348960	7870.6	1259952	9903.2	618734	-10708	586882	6064	72439.1
205	142.8	#204	-8836.6	569253	-15423	744713	-8632.9	85619.6	6314.8	560887.5	13481.3	431208	6345.2	1388818.3	11580.9	#####	-2666.7	856905.1	12846.1	536366.2	-6864.6	990089.8	22351.2	1364311	7337.7	1266687	10082.6	625129	-10706	579378	6673.6	76176.7
206	143.5	#205	-8244.6	563632	-15059	734154	-8061.7	79983.7	6600.7	565457.1	14145.1	441175	5709.4	1391952.8	11956.7	#####	-2893	854566.5	13054.3	545505.6	-6997.8	985049.7	22507.1	1380129	6918.7	1271202	10361	632568	-10599	572110	7381.2	82105.8
207	144.2	#206	-7652.5	558010	-14695	723595	-7490.6	74347.8	6886.7	570026.7	14808.8	451142	5073.6	1395087.2	12332.5	#####	-3119.3	852228	13262.6	554645	-7131	980009.6	22663.1	1395947	6499.8	1275718	10639.3	640007	-10492	564842	8088.8	88035
208	144.9	#207	-7060.5	552389	-14331	713036	-6919.5	68711.9	7172.6	574596.4	15472.6	461109	4437.8	1398221.7	12708.3	#####	-3345.7	849889.5	13470.9	563784.4	-7264.2	974969.5	22819	1411765	6080.8	1280233	10917.7	647446	-10385	557574	8796.4	93964.2
209	145.6	#208	-6468.5	546768	-13944	702725	-6325.9	63453.5	7458.6	579166	16136.3	471076	3801.9	1401356.1	13084.2	#####	-3572	847550.9	13679.2	572923.8	-7397.4	969929.4	22974.9	1427583	5661.9	1284749	11196	654886	-10278	550306	9504	99893.3
210	146.3	#209	-5876.4	541147	-13503	693032	-5676.1	59139	7744.6	583735.7	16800.1	481043	3166.1	1404490.5	13460	#####	-3798.3	845212.4	13887.5	582063.2	-7530.7	964889.3	23130.9	1443401	5242.9	1289264	11474.4	662325	-10171	543038	10211.6	105823
211	147	#210	-5284.4	535525	-13061	683340	-5026.3	54824.4	8030.5	588305.3	17463.8	491010	2530.3	1407625	13835.8	#####	-4024.6	842873.8	14095.7	591202.6	-7663.9	959849.2	23286.8	1459219	4824	1293780	11752.7	669764	-10065	535770	10919.2	111752
212	147.7	#211	-4694.4	531381	-12621	674009	-4377.7	51041.8	8314.8	593585.5	18124.5	502630	1895.8	1409647.4	14212.3	-8660	-4249.9	840140	14301.3	600700.5	-7795.1	954578	23443	1475308	4409.2	1297568	12029.5	677687	-9956.8	528690	11624.1	118914
213	148.4	#212	-4270.1	528958	-11551	667415	-3201.2	50363.9	8001.6	598230	17592	513394	1505.1	1410160.1	14612.2	2032	-3675.2	838527.1	14523.9	610906.6	-7125	950738.6	22229.4	1487717	4080.1	1300196	12325.7	686556	-8887.5	522300	12348.4	127141
214	149.1	#213	-3845.8	526535	-10482	660821	-2024.7	49686.1	7688.4	602874.4	17059.6	524157	1114.5	1410672.8	15012.2	12723	-3100.6	836914.3	14746.5	621112.7	-6454.8	946899.1	21015.8	1500125	3751	1302825	12621.9	695426	-7746.4	517102	13142.6	136212
215	149.8	#214	-3421.5	524112	-9413.1	654227	-848.2	49008.2	7375.1	607518.9	16527.1	534921	723.9	1411185.5	15412.2	23414	-2526	835301.4	14969.2	631318.9	-5784.6	943059.6	19802.3	1512534	3421.8	1305454	12918.1	704296	-6509.6	513494	14029.8	146408
216	150.5	#215	-2997.2	521689	-8343.9	647633	328.3	48330.4	7061.9	612163.4	15994.6	545685	333.3	1411698.2	15812.2	34105	-1951.4	833688.5	15191.8	641525	-5114.4	939220.2	18588.7	1524943	3092.7	1308083	13214.3	713166	-5272.8	509886	14917	156604
217	151.2	#216	-2572.9	519266	-7274.8	641039	1504.8	47652.5	6748.6	616807.8	15462.1	556449	-57.3	1412210.9	16212.1	44797	-1376.7	832075.6	15414.5	651731.1	-4444.2	935380.7	17375.1	1537351	2763.6	1310712	13510.4	722036	-4035.9	506278	15804.2	166800
218	151.9	#217	-2148.6	516843	-6205.7	634446	2681.3	46974.7	6435.4	621452.3	14929.6	567213	-448	1412723.6	16612.1	55488	-802.1	830462.7	15637.1	661937.2	-3774	931541.2	16161.6	1549760	2434.5	1313341	13806.6	730906	-2799.1	502670	16691.5	176996
219	152.6	#218	-1724.9	514898	-5138.4	629055	3856.4	47621.7	6122.2	626096.7	14397.1	577976	-837.6	1412796.9	17012.7	66631	-226.5	829500.5	15858.2	672390.4	-3102.3	928461.4	14948	1562169	2108.3	1315603	14102	740108	-1561.7	500216	17577.4	188016
220	153.3	#219	-1302.2	513807	-4074.2	625817	5029.1	50637.4	5808.9	630741.2	13864.7	588740	-1225.4	1412084.6	17414.5	78581	350.7	829701.7	16076.5	683285.1	-2428	926739.6	13734.5	1574577	1787.2	1317210	14396	749903	-323.2	499825	18461	200510
221	154	#220	-879.6	512716	-3010.1	622579	6201.8	53653	5495.7	635385.7	13332.2	599504	-1613.2	1411372.2	17816.3	90531	927.9	829902.9	16294.8	694179.9	-1753.7	925017.8	12520.9	1586986	1466.1	1318818	14690.1	759699	915.2	499434	19344.6	213003
222	154.7	#221	-513.3	512101	-2003.7	620569	7317.3	58024.2	5125.6	638908.7	12740.9	608375	-2055.5	1410032.2	18163.2	1E+05	1450.6	830945.3	16455.2	705363.3	-1133.2	924286	11253.3	1594685	1093	1319902	14927.2	769899	2098.6	500480	20170.8	226512

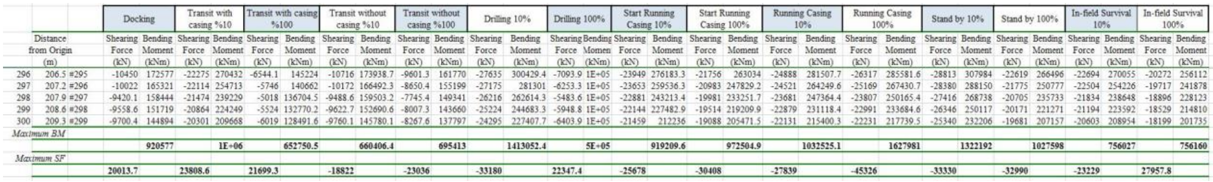
Appendix 14 Maximum Shear Force and Bending Moments C



			Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
	Distance from Origin (m)		Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Momen (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)
223	155.4	#222	-157.7	511739	-1008.6	619262	8421.7	63174.5	4745.1	642166.1	12138.7	616823	-2497.8	1408688.2	18510	1E+05	1973.3	831992.4	16615.6	716548	-512.6	923559.7	9985.8	1602371	719.9	1320983	15164.4	780102	3177.3	502336	20890.9	240577
224	156.1	#223	197.6	511654	-14.7	618731	9525.2	69185.1	4364.3	645034	11535.7	624656	-2939.1	1406846.4	18857.5	1E+05	2496.9	833629.9	16774.4	727910.5	109.4	923534.7	8718.9	1608323	349.7	1321646	15400.8	790571	4185.3	504989	21538.7	255158
225	156.8	#224	552.6	511765	978.3	618735	10627.9	75790.1	3983.5	647856.8	10932.7	632417	-3379.9	1404761.7	19205.3	1E+05	3020.9	835550.3	16932.5	739357.2	732	923846	7452.1	1614125	-19.1	1322107	15636.7	801166	5193.6	508186	22185.7	270087
226	157.5	#225	906.7	512371	1970	619575	11729.7	83324.4	3602.3	650008	10328.2	639114	-3819.7	1402061.2	19553.6	2E+05	3545.6	837971.7	17089.2	750952.1	1355.9	924752.8	6186.3	1617701	-384.6	1322056	15872	811984	6202.4	512347	22831.3	285631
227	158.2	#226	1260.7	513110	2937.4	621019	12807.2	91528.6	3221.1	652159.3	9723.7	645811	-4259.2	1399195.3	19902.1	2E+05	4070.7	840730.8	17244.8	762646	1980.5	926061.3	4920.4	1621276	-749.2	1321867	16106.7	822953	7211.5	517156	23475.9	301588
228	158.9	#227	1614.7	513849	3845.1	623132	13825.3	100481.6	2839.8	654310.5	9119.2	652508	-4698.8	1396329.4	20250.7	2E+05	4596.1	843664.9	17399.9	774390.8	2605.4	927578	3654.6	1624851	-1113.8	1321679	16341	833999	8220.7	522302	24120	317760
229	159.6	#228	1968.2	514891	4751.8	625862	14842.4	110125.5	2458.4	655867.4	8513.6	658263	-5137.8	1393087.1	20599.6	2E+05	5121.9	847086.3	17553.6	786276.9	3231.3	929674.7	2389.6	1626460	-1476.5	1321181	16574.5	845260	9230.3	528383	24762.6	334526
230	160.3	#229	2320.8	516416	5656.8	629448	15858.1	120730.4	2076.7	657104.6	7907.3	663510	-5575.9	1389243.4	20948.8	2E+05	5648.3	851006.5	17705.6	798305.5	3858.2	932365.5	1125.2	1627011	-1836	1320188	16807.1	856741	10240.1	535421	25403.5	351898
231	161	#230	2673.5	517942	6561.3	633365	16873.3	131705.9	1695.1	658341.9	7301.1	668757	-6014	1385399.8	21298.1	2E+05	6174.9	855119.3	17857.1	810389	4485.5	935285.7	-139.2	1627561	-2195.5	1319194	17039.4	868307	11250.1	542828	26043.9	369504
232	161.7	#231	3025.9	519612	7464.7	637847	17887.5	143315.3	1313.4	659399.4	6694.6	673719	-6451.9	1381375.9	21647.6	2E+05	6701.8	859562	18007.5	822565.6	5113.4	938599.1	-1403.3	1627518	-2554.1	1318054	17271	880016	12260.3	550868	26683.2	387509
233	162.4	#232	3377.5	521842	8366.7	643165	18900.4	155862.7	931.8	659881.1	6087.1	677765	-6888.7	1376657.7	21997.4	3E+05	7229.3	864493.8	18156.4	834879.1	5742.3	942495.6	-2666.2	1625573	-2909	1316348	17501.8	891939	13270.9	559845	27321	406104
234	163.1	#233	3729	524073	9267.7	649023	19912.5	169016.4	550	660358.7	5479.7	681805	-7326.4	1371934.6	22347.4	3E+05	7757.1	869742.4	18304.3	847280.3	6371.9	946770	-3929.2	1623614	-3264.8	1314639	17732	903999	14281.7	569428	27957.8	425081
235	163.8	#234	3412.3	526437	9499.8	655322	20174.6	182666.3	156.1	660399.6	4859.3	685152	-7911.6	1366710.7	21948.8	3E+05	7536.5	875125.8	17702.2	859525.4	6253.4	951256.6	-5203.6	1620223	-3766.4	1312518	17212.7	915966	14544	579511	27844.6	444271
236	164.5	#235	3029.1	528544	9664.6	661746	20369.4	196457.9	-304.2	660125.9	4172.4	688024	-8588.3	1361034.8	21484.2	3E+05	7250	880326.5	17032.7	871309	6069.4	955633.2	-6543.7	1615902	-4358.3	1310013	16626.4	927533	14740.2	589748	27663.9	463342
237	165.2	#236	2673.2	530402	9855.5	668301	20590.4	210402.1	-736.7	659551	3512.7	690437	-9236.8	1354904.2	21046.9	3E+05	6991	885343.5	16389.2	882645	5913.2	959897	-7855.5	1610669	-4920.9	1307109	16066.7	938709	14963.8	600135	27509.3	482305
238	165.9	#237	2282.3	531984	10010.3	674976	20775.2	224487	-1204.3	658660	2817.7	692376	-9919.7	1348289.1	20574.8	3E+05	6697.4	890158.8	15709.4	893491	5722.8	964035	-9201.8	1604512	-5516.7	1303790	15471.2	949458	15152.6	610674	27318.4	501136
239	166.6	#238	1889.6	533311	10162.3	681746	20957.3	238684.7	-1673.8	657430.6	2120.3	693814	-10604	1341234.5	20101.2	3E+05	6402.3	894783.2	15026.8	903896.9	5531.2	968048.4	-10550	1597392	-6112.5	1300088	14873.3	959822	15339.8	621329	27124.7	519839
240	167.3	#239	1534	534367	10352.6	688647	21177.6	253038.3	-2104.2	655890.5	1461.6	694783	-11250	1333691.2	19667	4E+05	6147	899197.3	14382.2	913802.1	5379.6	971929.5	-11858	1589346	-6669.4	1295957	14313.9	969748	15566.6	632141	26968.9	538411
241	168	#240	1216.9	535186	10576.7	695694	21431.4	267559	-2496	654063.7	841.1	695303	-11857	1325701.1	19267.6	4E+05	5926.7	903450.2	13771.1	923283.6	5263.5	975719.8	-13127	1580393	-7185.9	1291439	13788.5	979309	15828.2	643120	26846.6	556893
242	168.7	#241	916	535799	10814.9	702892	21699.3	282250.3	-2871.2	651980.6	236.8	695413	-12448	1317307.6	18883.5	4E+05	5721.7	907566.2	13174	932375.8	5163	979440.6	-14378	1570590	-7684.7	1286577	13277.5	988535	16105.2	654275	26738.3	575302
243	169.4	#242	857	536194	10413.8	710043	21068.4	296825.5	-2926.7	649657.6	-49.1	694784	-13056	1308485.7	17784.2	4E+05	4801.9	911280.1	11860.3	940772.5	4165.6	982773.3	-15312	1560003	-8516.3	1281243	11868	997067	15484.6	665321	25731	593315
244	170.1	#243	798.1	536589	9909.5	716320	20335.2	310112.4	-2982.2	647334.6	-335	694155	-13764	1298423.3	16586	4E+05	3783.5	913192.8	10444.1	946651.2	3070.5	984166.3	-16345	1547588	-9432.1	1273155	10357.3	1002911	14765	675105	24621.1	609362
245	170.8	#244	739.2	536983	9405.3	722596	19602	323399.3	-3037.7	645011.7	-620.9	693526	-14471	1288360.9	15387.7	4E+05	2765.1	915105.6	9027.9	952529.8	1975.4	985559.2	-17378	1535172	-10348	1265068	8846.5	1008755	14045.5	684889	23511.2	625409
246	171.5	#245	680.3	537378	8901.1	728873	18868.9	336686.3	-3093.2	642688.7	-906.8	692897	-15178	1278298.5	14189.5	4E+05	1746.7	917018.3	7611.7	958408.5	880.3	986952.2	-18411	1522757	-11264	1256981	7335.8	1014598	13326	694673	22401.4	641455
247	172.2	#246	621.4	537773	8396.9	735149	18135.7	349973.2	-3148.7	640365.7	-1192.7	692268	-15885	1268236.1	12991.2	4E+05	728.3	918931	6195.5	964287.1	-214.8	988345.1	-19444	1510342	-12180	1248894	5825	1020442	12606.5	704457	21291.5	657502
248	172.9	#247	565	538028	7892.7	740368	17403.6	361723.1	-3201.3	637912	-1477	690954	-16587	1256566.8	11798.2	4E+05	-284.3	918525.5	4780	966928.2	-1303	987246.3	-20473	1495572	-13095	1240806	4316.6	1022835	11891.8	712740	20182.3	671223
249	173.6	#248	509.1	538261	7388.5	745406	16671.6	373211	-3253.4	635436	-1761.1	689524	-17287	1244623.5	10606	5E+05	-1296	917724.8	3364.7	969017.5	-2390.1	985722.7	-21500	1480400	-14011	1232719	2808.5	1024640	11178	720768	19073.1	684547
250	174.3	#249	453.1	538493	6884.4	750444	15939.6	384698.9	-3305.6	632960	-2045.2	688094	-17987	1232680.2	9413.8	5E+05	-2307.6	916924.1	1949.3	971106.7	-3477.2	984199.1	-22528	1465228	-14927	1224632	1300.4	1026446	10464.1	728796	17964	697872
251	175	#250	-255.2	538421	5726.5	754571	14554.6	394968.1	-4009.9	630184.5	-2982.1	686050	-18686	1220395.8	8222.8	5E+05	-3317.9	915630.3	534.3	972504.5	-4562.6	982145.7	-23555	1449555	-15836	1215624	-207	1027515	9099.6	735633	16201.5	709469
252	175.7	#251	-958.7	537771	4572.8	757753	13174.1	404105.7	-4709.3	626834.8	-3914.3	683242	-19378	1207097.1	7039.3	5E+05	-4320.5	912869.2	-876.3	971842.3	-5639.6	978516	-24574	1432390	-16719	1203947	-1708.9	1026390	7741.3	741356	14443.5	719625
253	176.4	#252	-1657.7	536635	3423.6	760135	11798.3	412286.3	-5404.1	623001.8	-4841.9	679788	-20064	1193320.8	5861.7	5E+05	-5316.8	909414.7	-2282.2	970202.1	-6710.2	974141.4	-25588	1414520	-17601	1192268	-3205.7	1024225	6388.9	746139	12690	728562
254	177.1	#253	-2354.3	535250	2276.6	762107	10425	419977.1	-6096.5	618921.3	-5767	676004	-20747	1179300	4687.1	5E+05	-6310.1	905605.4	-3685.7	968061.2	-7777.4	969385.6	-26599	1396288	-18484	1180588	-4699.9	1021526	5039.6	750441	10939	736874
255	177.8	#254	-3276.2	533131	904.3	762922	8826.8	426297.8	-7014.1	614110.7	-6917.2	671272	-21654	1164558	3289.4	5E+05	-7526.4	900784.2	-5314.3	964521.7	-9067.2	963548.4	-27833	1377028	-19577	1167414	-6418.5	1017345	3467.1	753396	8962.9	743462
256	178.5	#255	-4193.7	530382	-463.3	762798	7233.6	431524.7	-7927.1	608672.9	-8062.9	665752	-22556	1149196	1897.8	5E+05	-8736.4	895131.5	-6938	959867.5	-10351	956829.4	-29062	1356924	-20666	1153851	-8131.8	1011987	1900.9	755275	6991.6	748696
257	179.2	#256	-5105.4	526825	-1824.7	761468	5647.1	435346.6	-8834.2	602431.2	-9202.6	659223	-23451	1133040.3	514.5	5E+05	-9938.4	888413.1	-8555.1	953781.1	-11626	948979.8	-30284	1335737	-21736	1138802	-9837.7	1005118	342.9	755774	5027	752192
258	179.9	#257	-6014.4	522883	-3183.2	759565	4063.7	438499.7	-9738.6	595807.6	-10340	652214	-24342	1116508	-864.9	5E+05	-11137	881188.7	-10169	947013.1	-12897	940593.3	-31502	1314036	-22806	1123749	-11540	997531	-1211.2	755617	3065.5	754858
259	180.6	#258	-6918.8	518214	-4536.5	756571	2485.9	440382.6	-10638	588459.4	-11472	644293	-25227	1099261.4	-2237.3	5E+05	-12328	873004	-11777	938950.2	-14162	931187.7	-32714	1291359	-23867	1107995	-13237	988578	-2758.2	754214	1110	755951



			Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
	Distance from Origin (m)		Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Momen (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)
260	181.3	#259	-7819.7	512971	-5885.9	752720	912.4	441265.5	-11534	580541.4	-12600	635656	-26109	1081453.8	-3604.3	5E+05	-13514	864064.7	-13381	929868.1	-15421	920981.1	-33922	1267913	-24914	1091120	-14928	978549	-4299.8	751830	-840.9	755804
261	182	#260	-8716.5	507057	-7230.3	747863	-655.8	440975	-12426	571955.8	-13724	626176	-26985	1062989.6	-4964.8	5E+05	-14694	854241.7	-14979	919590	-16673	909836.2	-35124	1243568	-25955	1073860	-16614	967259	-5834.8	748297	-2786.1	754201
262	182.7	#261	-9608.9	500415	-8569.2	741913	-2217.8	439409.8	-13314	562645.9	-14843	615784	-27855	1043813.7	-6317.7	5E+05	-15866	843460.7	-16570	908012.9	-17918	897674	-36319	1218247	-26983	1055586	-18293	954599	-7362.3	743517	-4724.4	751017
263	183.4	#262	-10497	493303	-9903.1	735259	-3774.6	437022.7	-14197	552869.4	-15958	604803	-28721	1024179.8	-7664.6	5E+05	-17033	832062.8	-18156	895598.3	-19158	884856.7	-37510	1192297	-28001	1036738	-19966	941055	-8883.7	737933	-6656.9	746812
264	184.1	#263	-11369	485167	-11216	727063	-5309.4	432836.1	-15064	542074.7	-17054	592535	-29569	1003545.7	-8987.4	5E+05	-18176	819318.3	-19719	881350.3	-20374	870607	-38679	1164973	-28991	1016682	-21616	925577	-10381	730590	-8565.4	740370
265	184.8	#264	-12238	476857	-12524	718608	-6839.8	428345.4	-15928	531108.1	-18147	580051	-30414	982742.8	-10306	5E+05	-19316	806346.3	-21278	866792.5	-21587	856115.4	-39845	1137417	-29982	996626	-23261	909771	-11874	722949	-10469	733550
266	185.5	#265	-13098	468081	-13821	709449	-8358.4	423031.9	-16782	519678.5	-19230	566979	-31249	961485.7	-11611	4E+05	-20443	792761.9	-22824	851396.7	-22788	840971.3	-40999	1109236	-30950	975731	-24894	893079	-13354	714504	-12360	725704
267	186.2	#266	-13939	458294	-15094	698763	-9851.7	415928.7	-17618	507244.6	-20291	552634	-32064	939244.3	-12890	4E+05	-21545	777849.2	-24343	834178.6	-23964	824410.6	-42130	1079695	-31891	953862	-26499	874462	-14807	704312	-14224	715626
268	186.9	#267	-14776	448329	-16362	687808	-11341	408510.2	-18450	494634.3	-21349	538064	-32875	916830	-14163	4E+05	-22642	762703.2	-25858	816639.6	-25135	807601	-43257	1049915	-32827	931774	-28101	855505	-16255	693813	-16082	705155
269	187.6	#268	-14968	437780	-16980	675849	-12178	399871.6	-18637	481446.3	-21760	522696	-33040	893855.1	-14784	4E+05	-23088	746718.2	-26720	797855.1	-25656	789878.5	-43735	1019269	-33104	909003	-29049	835217	-17051	682131	-17288	693099
270	188.3	#269	-15100	427127	-17534	663507	-12952	390710.4	-18763	468161.2	-22109	507085	-33144	870778.3	-15341	4E+05	-23469	730450.9	-27517	778529.5	-26113	771822.1	-44150	988330.9	-33276	886049	-29933	814327	-17782	669936	-18427	680273
271	189	#270	-15163	416415	-18016	650807	-13653	381036.9	-18821	454827.5	-22388	491267	-33178	847649.3	-15823	4E+05	-23778	713935.8	-28240	758672.5	-26497	753461.1	-44493	957133.1	-33327	863002	-30742	792839	-18438	657243	-19492	666666
272	189.7	#271	-15168	405681	-18432	637566	-14287	370550.1	-18820	441477.8	-22605	475158	-33152	824531.5	-16237	4E+05	-24021	697093.9	-28894	737975.8	-26816	734678	-44772	925565.9	-33307	839947	-31484	770402	-19027	643789	-20486	651792
273	190.4	#272	-15170	394945	-18846	624239	-14919	359932.2	-18817	428128.4	-22821	459005	-33124	801418.3	-16648	4E+05	-24260	680201.2	-29546	717143.7	-27132	715828.2	-45049	893940.8	-33286	816893	-32222	747811	-19613	630213	-21477	636714
274	191.1	#273	-15173	384209	-19259	610912	-15550	349314.3	-18814	414778.9	-23036	442851	-33096	778305.2	-17060	4E+05	-24500	663308.5	-30197	696311.6	-27448	696978.5	-45326	862315.7	-33265	793839	-32960	725220	-20199	616637	-22468	621635
275	191.8	#274	-15173	373460	-19662	597015	-15659	338011.8	-18624	401485.9	-22919	426508	-33065	755242.4	-17129	4E+05	-24727	646101.7	-30321	674774.2	-27570	677780.8	-44899	830563	-33304	770830	-32990	701878	-20588	602344	-22932	605393
276	192.5	#275	-15153	362719	-20042	582859	-15713	326658.6	-18418	388327	-22747	410263	-33013	732205.9	-17142	3E+05	-24933	628750	-30393	653174.5	-27671	658507.7	-44423	799112.9	-33320	747798	-32966	678537	-20954	587799	-23338	588865
277	193.2	#276	-15110	352003	-20395	568433	-15704	315294.1	-18193	375331.9	-22514	394174	-32937	709215.8	-17093	3E+05	-25113	611254.4	-30403	631549.3	-27748	639167.6	-43892	768041.5	-33310	724761	-32882	655239	-21291	572993	-23677	572063
278	193.9	#277	-15047	341324	-20725	553788	-15641	303957.4	-17950	362491.7	-22228	378258	-32841	686280.3	-16988	3E+05	-25269	593649.1	-30360	609938.7	-27802	619784.2	-43314	737333.8	-33275	701734	-32746	632017	-21603	557975	-23959	555062
279	194.6	#278	-14962	330698	-21029	538926	-15521	292689	-17690	349829.1	-21887	362562	-32723	663417.9	-16825	3E+05	-25400	575942.9	-30262	588381.1	-27832	600370.4	-42685	707048.6	-33217	678734	-32554	608911	-21889	542748	-24179	537891
280	195.3	#279	-14853	320148	-21304	523844	-15339	281542.7	-17409	337378	-21487	347157	-32580	640654.6	-16601	3E+05	-25504	558146.2	-30104	566927.9	-27836	580942.6	-42004	677270.6	-33131	655786	-32304	585980	-22145	527314	-24334	520580
281	196	#280	-14722	309687	-21553	508583	-15103	270551.3	-17110	325135.2	-21034	332059	-32416	617999.6	-16322	3E+05	-25583	540285.8	-29892	545612.2	-27816	561520.7	-41276	647995	-33019	632904	-32001	563250	-22373	511710	-24431	503188
282	196.7	#281	-14574	299302	-21782	493193	-14827	259701	-16796	313060	-20541	317222	-32234	595436.9	-16002	3E+05	-25642	522387	-29641	524424	-27778	542113.2	-40513	619124.6	-32889	610084	-31659	540696	-22581	495987	-24483	485756
283	197.4	#282	-14401	289046	-21981	477636	-14493	249098.3	-16462	301245.9	-19994	302795	-32027	573027	-15624	3E+05	-25673	504450.8	-29333	503462.2	-27712	522745.4	-39700	590884.8	-32731	587372	-31261	518440	-22758	480109	-24473	468311
284	198.1	#283	-14206	278924	-22153	461949	-14108	238759.4	-16109	289681.7	-19399	288793	-31797	550772.8	-15195	2E+05	-25677	486501.7	-28977	482744.2	-27621	503432.9	-38845	563247.5	-32548	564779	-30815	496490	-22906	464115	-24409	450897
285	198.8	#284	-13989	268945	-22299	446157	-13679	228703.9	-15738	278367.9	-18760	275223	-31546	528681.7	-14721	2E+05	-25657	468557.8	-28576	462290.1	-27508	484189.5	-37953	536210.2	-32341	542318	-30327	474864	-23028	448029	-24296	433548
286	199.5	#285	-13751	259124	-22420	430276	-13206	218962.9	-15349	267317.5	-18081	262076	-31273	506768.6	-14202	2E+05	-25612	450635.6	-28133	442129.7	-27370	465031.2	-37023	509800.5	-32111	519992	-29795	453591	-23123	431868	-24136	416297
287	200.2	#286	-13483	249552	-22501	414307	-12672	209722.5	-14935	256662.1	-17345	249645	-30971	485134.4	-13622	2E+05	-25531	432776.9	-27629	422440.2	-27199	446023.8	-36045	484322	-31848	497908	-29205	432871	-23178	415639	-23907	399247
288	200.9	#287	-13206	240062	-22569	398315	-12119	200644.9	-14512	246132.3	-16593	237435	-30659	463590.4	-13024	2E+05	-25437	414942.4	-27106	402904.1	-27016	427067.3	-35052	459138.2	-31575	475900	-28597	412329	-23219	399393	-23658	382268
289	201.6	#288	-12905	230793	-22605	382290	-11520	192008.8	-14069	235932	-15785	226039	-30323	442289.2	-12380	2E+05	-25314	397189.9	-26537	383786.3	-26806	408258.5	-34023	434719.2	-31266	454187	-27944	392268	-23228	383129	-23356	365504
290	202.3	#289	-12577	221770	-22606	366252	-10873	183863.8	-13603	226089.4	-14963	214831	-29961	421257.6	-11688	2E+05	-25159	379543.2	-25921	365135.7	-26566	389622.5	-32958	411121.5	-30949	432543	-27245	372738	-23200	366870	-22999	349000
291	203	#290	-12269	213083	-22613	350213	-10221	176417.3	-13162	216728.1	-14129	204741	-29619	400592.2	-10991	2E+05	-25014	362050.9	-25297	347152	-26339	371228.4	-31901	388653.2	-30641	411307	-26541	353959	-23180	350633	-22627	332891
292	203.7	#291	-11951	204485	-22608	334173	-9552.3	169160	-12712	207494.3	-13280	194892	-29267	380023.9	-10278	2E+05	-24858	344599.4	-24657	329349.1	-26102	352898.3	-30832	366489	-30323	390158	-25822	335383	-23145	334402	-22236	316890
293	204.4	#292	-11613	196085	-22576	318154	-8854.1	162315.2	-12246	198535.3	-12406	185557	-28896	359670.2	-9534.9	2E+05	-24678	327251.5	-23987	311941.8	-25842	334718.2	-29740	344964.8	-29984	369201	-25073	317247	-23085	318205	-21810	301142
294	205.1	#293	-11250	187959	-22509	302172	-8116.6	156037.5	-11756	189953.2	-11498	176924	-28500	339612.9	-8753.3	2E+05	-24465	310051.7	-23277	295079.1	-25551	316748.1	-28621	324312.8	-29619	348511	-24287	299715	-22988	302062	-21337	285746
295	205.8	#294	-10862	180121	-22409	286257	-7345	150340	-11246	181754.4	-10559	169061	-28079	319864.2	-7937.9	2E+05	-24222	293023.7	-22532	278775.6	-25233	299007.3	-27478	304524.6	-29226	328129	-23467	282798	-22858	286005	-20823	270731
296	206.5	#295	-10450	172577	-22275	270432	-6544.1	145224	-10716	173938.7	-9601.3	161770	-27635	300429.4	-7093.9	1E+05	-23949	276183.3	-21756	263034	-24888	281507.7	-26317	285581.6	-28813	307984	-22619	266496	-22694	270055	-20272	256112



			Docking		Transit with casing %10		Transit with casing %100		Transit without casing %10		Transit without casing %100		Drilling 10%		Drilling 100%		Start Running Casing 10%		Start Running Casing 100%		Running Casing 10%		Running Casing 100%		Stand by 10%		Stand by 100%		In-field Survival 10%		In-field Survival 100%	
	Distance from Origin (m)		Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Momen (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)	Shearing Force (kN)	Bending Moment (kNm)
296	206.5	#295	-10450	172577	-22275	270432	-6544.1	145224	-10716	173938.7	-9601.3	161770	-27635	300429.4	-7093.9	1E+05	-23949	276183.3	-21756	263034	-24888	281507.7	-26317	285581.6	-28813	307984	-22619	266496	-22694	270055	-20272	256112
297	207.2	#296	-10022	165321	-22114	254713	-5746	140662	-10172	166492.3	-8650.4	155199	-27175	281301	-6253.3	1E+05	-23653	259536.3	-20983	247829.2	-24521	264249.6	-25169	267430.7	-28380	288150	-21775	250777	-22504	254226	-19717	241878
298	207.9	#297	-9420.1	158444	-21474	239229	-5018	136704.5	-9488.6	159503.2	-7745.4	149341	-26216	262614.3	-5483.6	1E+05	-22881	243213.4	-19981	233251.7	-23681	247364.4	-23807	250165.4	-27416	268738	-20705	235733	-21834	238648	-18896	228123
299	208.6	#298	-9558.6	151719	-20864	224249	-5524	132770.2	-9622.7	152690.6	-8007.3	143660	-25224	244683.3	-5948.8	1E+05	-22144	227482.9	-19514	219209.9	-22879	231118.4	-22991	233684.6	-26346	250117	-20171	221271	-21194	223592	-18529	214810
300	209.3	#299	-9700.4	144894	-20301	209668	-6019	128491.6	-9760.1	145780.1	-8267.6	137797	-24295	227407.7	-6403.9	1E+05	-21459	212236	-19088	205471.5	-22131	215400.3	-22231	217739.5	-25340	232206	-19681	207157	-20603	208954	-18199	201735
Maximum BM																																
				920577		**1E+06**		**652750.5**		**660406.4**		**695413**		**1413052.4**		**5E+05**		**919209.6**		**972504.9**		**1032525.1**		**1627981**		**1322192**		**1027598**		**756027**		**756160**
Maximum SF																																
			20013.7		**23808.6**		**21699.3**		**-18822**		**-23036**		**-33180**		**22347.4**		**-25678**		**-30408**		**-27839**		**-45326**		**-33330**		**-32990**		**-23229**		**27957.8**	