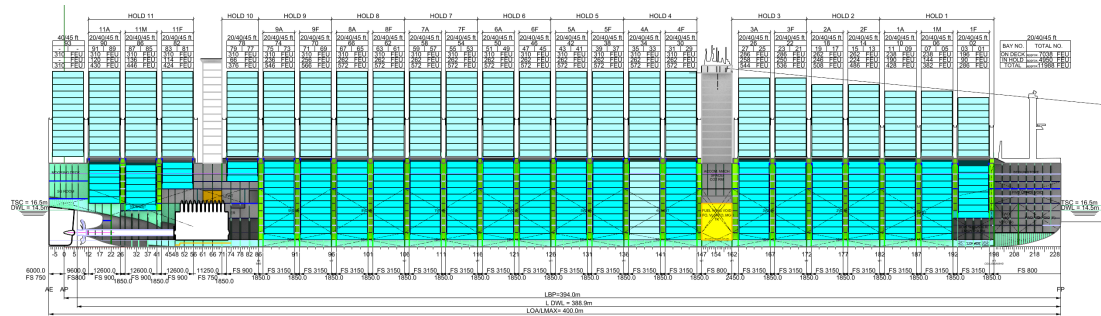


Impact of Alternative Fuels on Ultra-Large Container Ship Cargo Capacity and Emissions



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**The University of Strathclyde Department of Naval Architecture,
Ocean, and Marine Engineering**

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Signed:  Dale Pederson

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1. Abstract

One of the goals of the shipping industry is to achieve major reductions in carbon emissions by 2050. One way to achieve this is to utilize low-carbon fuels instead of the currently used Heavy Fuel Oil (HFO). Such alternative fuels include Liquefied Natural Gas (LNG), Ammonia, Methanol, and Hydrogen. These fuels have a lower volumetric energy density than HFO and may negatively impact the vessel cargo capacity depending on the arrangements required to accommodate the various alternative fuels. This research presents a method for evaluating and comparing the environmental performance of a vessel powered by conventional and alternative fuels from a lifecycle, fleet, and cargo demand perspective. A case study examining a 24,000 TEU containership was then performed using this methodology. It was found that for this vessel type, while the cargo capacity was negatively impacted for all alternative fuels compared to HFO from both a TEU and deliverable cargo weight standpoint, the losses in capacity were small and could be compensated by increasing either the number of ships in a given fleet or increasing the frequency of deliveries without a net gain in global warming impact associated with increased shipbuilding or operational emissions, if sourced renewably. This shows that alternative fuels should be beneficial in reducing global warming emissions from the shipping industry not only from an operational emissions standpoint but for the entire lifecycle and fleet perspective.

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3. Abbreviations

ABS	American Bureau of Shipping
AP	Aft Perpendicular
B	Beam
BC	Black Carbon
BHP	Brake Horsepower – Power at the engine
BOG	Boil-Off Gas
D	Depth
DNV	Det Nordske Veritas
CII	Carbon Intensity Indicator
CO ₂	Carbon Dioxide
CO _{2Eq} /CO _{2E}	Carbon Dioxide Equivalent
EEDI	Energy Efficiency Design Index
EEXI	Energy Efficiency EXisting Ship Index
EHP	Estimated Horsepower – Power Required to Move the Hull
EPA	Environmental Protection Agency
ETS	Emissions Trading Scheme
GWP	Global Warming Potential, Measured in CO _{2Eq}
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
ISO	International Organization for Standardization
km	Kilometre
kW	Kilo-Watt
kW-hr	Kilo-Watt hour
LBP	Length Between Perpendiculars
LCA	Lifecycle Assessment
LCI	Lifecycle Inventory
LCIA	Lifecycle Impact Assessment
LCV	Lower Calorific Value
LH	Liquified Hydrogen Gas
LNG	Liquified Natural Gas
LOA	Length Over All
LPG	Liquified Petroleum Gas
LWL	Length Waterline
MAN	Maschinen Fabrik Augsburg Nürnberg Diesel and Turbo
MCR	Maximum Continuous Rating
MDO	Medium Diesel Oil
MEPC	Marine Environmental Protection Committee
MGO	Medium Gas Oil
MJ	Megajoule
MMMCZCS	Maersk Mc-Kinney Møller Centre for Zero Carbon Shipping
MT	Metric Ton
NCR	Normal Continuous Rating
NO _x	Nitric Oxide and Nitrogen Dioxide
NMi	Nautical Mile
PM	Particulate matter, 10 or 2.5
SEP	Ship Evaluation Program – HEC Internal Tool
SFC	Specific Fuel Consumption

SLL	Summer Load Line
SO _x	Sulphur Oxides
SPOC	Specific Pilot Oil Consumption
T	Draft
TEU	Twenty-Foot-Equivalent Unit
TPC	Tons per Centimetre Immersion
TTW	Tank-to-Wake
ULCC	Ultra-Large Container Carrier (or Crude Carrier)
VLSFO	Very Low Sulphur Fuel Oil
VCG	Vertical Centre of Gravity
WTT	Well-to-Tank
WTW	Well-to-Wake

4. Background

The current international regulatory goals of substantially reducing the global warming impact from the shipping industry by 2050 have inspired unprecedented research and development efforts in the shipping industry. Classification societies, industry trade groups, think tanks, equipment manufacturers, ship owners, shipyards, and international organizations are all working towards achieving substantial reductions in the shipping industry's contribution to global warming by the adoption of new technologies and fuels (DNV, 2021b).

On an international level, emissions regulations for the shipping industry are governed by IMO regulations. The key regulations from this perspective are amendments to MARPOL Annex VI developed through the Marine Environment Protection Committee (MEPC) (ABS, 2019a) and focus on:

- Reduction of global-warming causing CO_{2e} (Carbon Dioxide-Equivalent) emissions through the Energy Efficiency Design Index (EEDI), Energy Efficiency Existing Ship Index (EEXI), and Carbon Intensity Indicator (CII). These regulations require ships to meet minimum requirements of carbon emitted per unit work-transport, measured in CO_{2e} emitted per deadweight-ton-Nautical Mile. These requirements can be met both through improving the efficiency of the vessel by reducing the energy required or reducing the CO_{2e} emissions through alternative fuels (Baker *et al.*, 2022).
- Reduction of other emissions such as NO_x, SO_x, Particulate Matter, and Black Carbon (Baker *et al.*, 2022). NO_x and SO_x emissions are handled by equipment modifications to the vessel, such as exhaust gas treatment systems. Particulate matter and black carbon emissions are not yet regulated directly.

There are also regional regulations that set emissions regulations for ships such as the US Environmental Protection Agency (EPA), or implement market measures to encourage reduction of harmful emissions such as the EU Emissions Trading Scheme (ETS) or the FuelEU regulations (European Commission). It is the need to meet these regulations that is driving interest in the adoption of alternative fuels in the shipping industry.

One of the primary ways a reduction in global warming emissions is planned is through the adoption of alternative fuels with a lower effective- or net-carbon emission when compared to the widely used types of diesel fuel such as VLSFO and MGO (Gilbert *et al.*, 2018; Brynolf, Fridell and Andersson, 2014). Such alternatives include LNG, Hydrogen, Ammonia, LPG, Methanol, or wider adoption of batteries (ABS, 2020).

The use of alternative fuels has major implications to the design of ships, since most proposed alternative fuels have a lower volumetric energy density than the industry standard fuel oils used today (ABS, 2020; DNV, 2021b; DNV, 2021a) as shown in Table 1.

Table 1: Summary of Volumetric Energy Densities for Prospective Alternative Fuels (Baker et al., 2022)

Fuel Type	Lower Calorific Value (LCV)	Density	Volumetric Energy Density	Energy Density Compared to HFO
-	MJ/kg	kg/m ³	GJ/m ³	%
HFO/VLSFO	40.2	980	39.4	100%
MGO	42.7	860	36.7	93%
LNG	48.0	462.5	22.2	56%
Methanol	19.9	784	15.6	40%
Ammonia	18.6	758	14.1	36%
Compressed Hydrogen	120.0	42	5.0	13%
Liquid Hydrogen	120.0	71	8.5	22%

This reduced volumetric energy density has implications on the design parameters of the vessel such as cargo capacity, speed, and bunkering frequency. As a result, the cargo throughput of any individual ship utilizing such alternative fuels will be decreased. For example, a 2-knot speed reduction results in an increased demand for capacity by 17.4% for containerhips (ABS, 2020). McKinlay *et. al.*(2021) also performed a comparative of alternative fuels looking at range for an LNG vessel assuming the replacement of a 2,700m³ Heavy Fuel Oil (HFO) tank with an equally sized tank utilizing alternative fuels, shown in Table 2. Their research indicated that substantial loss of range would occur when alternative fuels are used, which indicates that either larger fuel storage volumes are necessary to maintain operational ranges, or more frequent stops for bunkering will be required.

Table 2: Range of LNG transport vessel assuming direct replacement of 2,700m³ HFO fuel tank with alternative fuels (McKinlay, Turnock and Hudson, 2021)

Fuel	Range (NMi)	% of HFO Range
HFO	7155	100%
LNG	5764	81%
Compressed Hydrogen (700 Bar)	1284	18%
Liquid Hydrogen	2165	30%
Ammonia	3578	50%
Methanol	4579	64%

These limitations present a particular problem for long-range trading vessels, where endurance, speed, bunkering frequency, and cargo capacity are all critical factors in the viability of the vessel. For short-sea shipping applications, batteries and opportunities to bunker regularly alleviate some of the problems associated with the low volumetric energy density of alternative fuels.

4.1. Description of Research, Aims, and Objectives

The purpose of this research is to present a methodology for the environmental impact assessment of alternative fuels in the shipping industry. The methodology is intended to be applicable for designs in the basic and conceptual design stages. The methodology uses a model to examine the lifecycle emissions of a conventional ship design powered by HFO and compares it with the equivalent lifecycle emissions for derivative designs utilizing the following alternative fuels:

- Liquified Natural Gas (LNG)
- Ammonia
- Methanol
- Liquified Hydrogen (LH₂)
- Compressed Hydrogen

The various designs are compared based on the quantity of CO₂ equivalent (CO_{2eq}) emissions on a 100-year global warming impact time scale emitted over a given ship's life. The lifecycle emissions from each of the alternatively fuelled ship designs are then extended to examine the cargo throughput and lifecycle emissions from a fleet of such vessels. The objective is to examine and compare the emissions from a fleet of alternatively fuelled vessels with the requirement of delivering the same amount of cargo as a conventionally fuelled vessel. This allows the additional carbon impact of

ship building and breaking, or higher operating speeds, to be accounted for with the adoption of alternative fuels.

4.2. Research Gap

This research seeks to address whether the adoption of alternative fuels could potentially lead to an unintended increase in worldwide carbon emissions due to an increase in shipbuilding. To address this question, the presented methodology is an extension of existing research in three different ways:

- It looks at a larger variety of alternative fuels than other existing research, which typically compare one or two alternative fuels in a given design, such as what was done in Hua, Cheng and Hwang (Hua, Cheng and Hwang) (2019) where a conventional fuel and LNG powered post-Panamax containership is examined, or the study from the Maersk Mc-Kinney Møller Centre for Zero Carbon Shipping (MMMCZCS, Seaspan and Shipping, 2023), where an ammonia powered 15,000 TEU containership is compared to an HFO version.
- It examines the lifecycle emissions for each of the vessels. In the cases of research that does cover a wide variety of fuels, such as the Liquid Biofuel, LNG, Ammonia, and Hydrogen Ships investigated in (ABS, 2019a), the lifecycle emissions are not investigated
- Investigating the cargo throughput of a fleet of alternatively fuelled vessels while simultaneously considering lifecycle emissions and the implications of ship building emissions or slow steaming has not been investigated in other research.

It is at this intersection of alternative fuels, lifecycle analysis, and fleet assessment where the novelty of the research lies, even though each individual aspect may have been examined in the past.

5. Literature Review - Lifecycle Assessments

5.1. Lifecycle Assessment Literature Review – Goals and Overview

The proposed emissions model and associated methodology requires conducting a Life Cycle Assessment (LCA) of a vessel. This is because the objective of the model is to compare operational emissions associated with conventional and alternative fuels and

the incremental, unavoidable emissions associated with shipbuilding and ship breaking.

The aim of the literature review of Life cycle assessment of ships is to address the following key points:

- Identify the key steps of a life cycle assessment, as established by international standards
- Assess the methods used in existing life cycle assessments for ships, focusing on those utilizing basic and conceptual design stage data
- Determine well-to-tank emission factors for the various alternative fuels and associated production methods

5.2. Definition of Life Cycle Assessment

A lifecycle assessment is a cradle-to-grave assessment of the vessel's total environmental impact accounting for all aspects of the ship's life: design, construction, operations, maintenance, and disposal (Blanco-Davis and Zhou, 2016), while also accounting for the emissions resulting from acquiring and transporting the raw materials used in every step of a vessel's life (Mio, Fermeglia and Favi, 2022).

The key steps of a lifecycle assessment have been codified in a pair of ISO Standards: ISO 14040:2006 and ISO 14044:2006 (Blanco-Davis and Zhou, 2016; Favi *et al.*, 2018). ISO 14040 focuses primarily on the aims, objectives, and goals of a lifecycle assessment, while 14044 provides stricter sets of rules and requirements in order that the goals outlined in 14040 are obtained. These ISOs are not exclusive to the shipbuilding industry but instead are generalized to products which may be a service, software, hardware, or processed material (ISO 14044, 2006). The intent is to present a framework to “systematically assess the environmental impacts of product systems, from raw material acquisition to final disposal” (ISO 14040, 2006). Overall, the aim is to divide a single product into a series of component unit processes, where the inputs (such as raw materials, or the outputs from a previous process) and outputs (such as waste, or intermediate inputs for the next unit process) are linked.

This ISO standard specifies the steps that should be taken in a standardized lifecycle assessment, dividing it into the following major phases (ISO 14040, 2006):

- Goal and Scope definition Phase
- Inventory Analysis Phase
- Impact Assessment Phase
- Interpretation Phase

The following additional steps are recommended to be taken (ISO 14040, 2006):

- Reporting and review of the analyses
- Identifying limitations of the analyses
- Highlighting the relationships between the phases

5.2.1. Goal and Scope Definition Phase

The goal and scope definition phase consists of establishing the functional unit, reference flow, and system boundaries for the life cycle assessment. A functional unit defines the output of the assessed system, and there can be multiple functional units for a given system (ISO 14040, 2006). This functional unit should be a quantitative value against which the defined system's inputs and outputs can be normalized (ISO 14044, 2006). For example, the functional unit of a containership can be either the number of TEU's it can deliver or the total weight of cargo that can be delivered within those containers, normalized by the distance travelled to provide TEU-km or MT-km.

A reference flow is a measure of all the outputs required to deliver the functional unit (ISO 14044, 2006; MMMCZCS and Shipping, 2023). In the case of delivery of ocean-going cargo, the reference flow would be a ship, and an inventory of system inputs and outputs would be constructed for that ship.

The system boundary is defined to capture a set of steps called unit processes that are required to create the reference flow. Items such as elementary flows and product flows come into the system boundary, and waste, emissions and functional units exit the system boundary. Elementary flows are raw materials or energy extracted directly from the environment, such as iron ore. Product flows are finished products that cross the system boundary, and ideally would have their own associated lifecycle assessment data available (ISO 14044, 2006). An example of a product flow would be raw steel crossing the system boundary to be used in the shipbuilding unit process. The steel used in the hull construction would require extraction of the ore, transportation of the ore, smelting, transportation of the steel, cutting, welding, assembly, and painting (Jeong *et*

al., 2018). Figure 1 depicts a simplified representation of the individual lifecycle analysis that would need to be conducted for the product flow of steel.

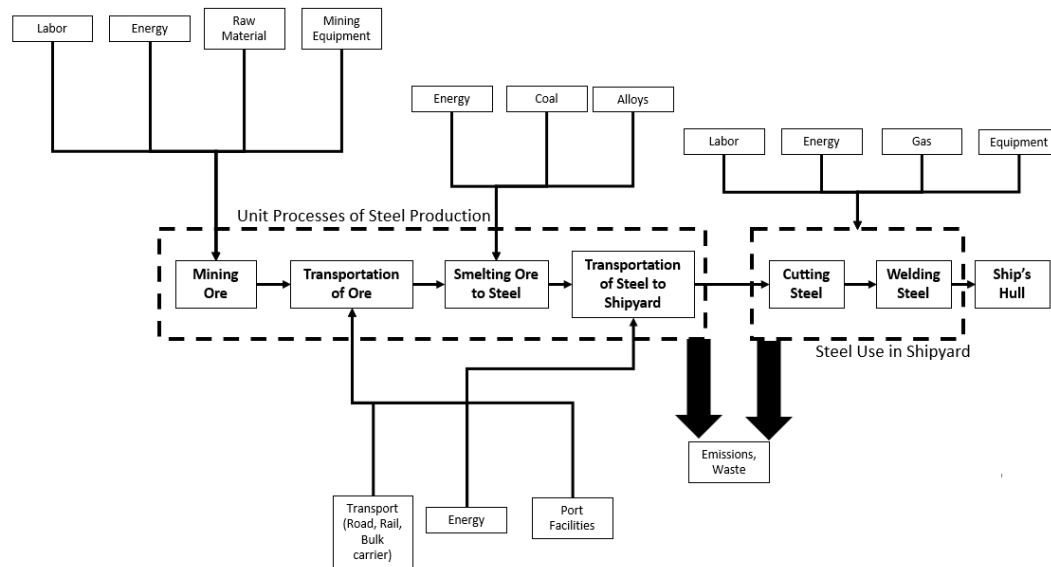


Figure 1: Simplified flow diagram showing components of the steel manufacturing process (Gratsos, Psaraftis and Zachariadis, 2010; Jeong *et al.*, 2018)

In establishing a system boundary, it is important to clearly state the cut-off criteria and explain why the boundary is positioned where it is in the overall process (ISO 14044, 2006). Cut-off criteria in this case refer to criteria used to ignore certain flows because their overall impact on the results is minor. A very common cutoff criteria used in shipbuilding lifecycle analyses is the assumption that steel is the primary component of hulls and thus other materials need not be investigated in detail (Gratsos, Psaraftis and Zachariadis, 2010; Hua, Cheng and Hwang, 2019; Gilbert *et al.*, 2017)

An example of a process flow and system boundary diagram for one ship designed for the transport of goods is provided in Figure 2 (Favi *et al.*, 2018; Nian and Yuan, 2017; Kjær *et al.*, 2015).

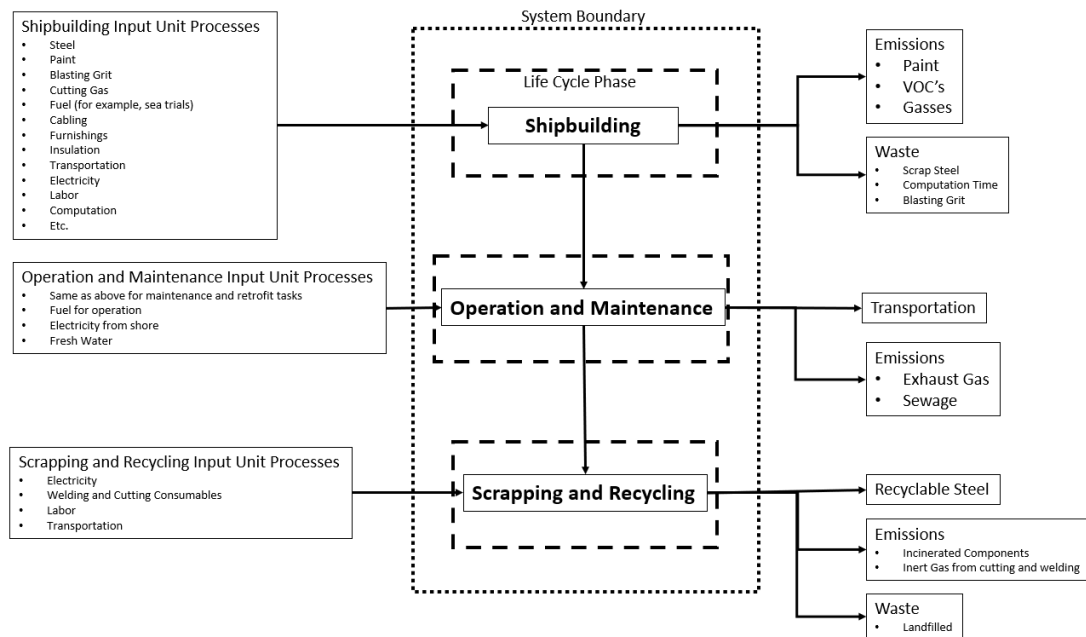


Figure 2: Example of a Process Flow and System Boundary Diagram for a Ship

Finally, the desired outputs are defined within the global scope definition phase. There are three basic types of outputs, an inventory output, a midpoint output, and finally an endpoint output (Blanco-Davis and Zhou, 2016). An example of an inventory output would be CO_2 or NO_x , which is a quantity of something released in the lifecycle of a product. These are then grouped and interpreted into midpoint outcomes, where a single emission from the inventory may have an impact in multiple areas such as global warming potential or human toxicity as reported by the CML 2001 method (Guinée, 2001). For example, the $\text{CO}_{2\text{Eq}}$ midpoint outcome consists of contributions from the inventory outputs of CO_2 , CH_4 , and N_2O multiplied by contribution factors based on a given time scale (typically 20, 100, and 1000 years) depending on the impact assessment methodology used. Finally, these midpoint indicators can be further interpreted into endpoint indicators, which are major aggregations of the midpoint indicators into categories such as damage to human health, damage to ecosystems, and resource availability, such as in the Eco-Indicator 99 method (Goedkoop and Spriensma, 2001).

5.2.2. Life Cycle Inventory Analysis

The lifecycle inventory analysis is considered one of the most challenging portions of the life cycle assessment (Favi *et al.*, 2018; Jeong *et al.*, 2018). It involves collection of all the inputs and outputs of a unit process, such as raw materials, energy, labour,

transportation, waste, and is an iterative process where the individual unit processes build up with the outputs of one leading directly to the inputs of another. The difficulty in this process is apparent, since it requires an immense amount of data collection. To simplify the inventory analysis, many lifecycle analyses conducted for ships leverage an existing commercial database such as GaBi (Dong and Cai, 2019), Ecolnvent (Favi *et al.*, 2018; Cucinotta *et al.*, 2021; Gilbert *et al.*, 2018), SimaPro (Bilgili, 2021; Kjær *et al.*, 2015; Bicer and Dincer, 2018) and the European Commission LCA Database (Gilbert *et al.*, 2018). It is also possible to build up a smaller inventory through research, control of system boundaries, and use of cut-off criteria (Chatzinikolaou and Ventikos, 2015; Dong and Cai, 2019; Brynolf, Fridell and Andersson, 2014; Gratsos, Psaraftis and Zachariadis, 2010). This is another reason why completing the lifecycle inventory is difficult – in addition to the large data requirements, if a commercial or standardized database isn't used, the end results of the entire lifecycle assessment is highly dependent on what factors are chosen to be included or excluded, which is a matter of judgement and experience from the researcher (Favi *et al.*, 2018; Jeong *et al.*, 2018).

A common approach to conducting the life cycle inventory analysis for a ship begins with subdividing the ship into major components and corresponding subsections for each of the major phases of use (Chatzinikolaou and Ventikos, 2015; Jeong *et al.*, 2018; Favi *et al.*, 2018). An example of an inventory grouping suitable for the ship building phase synthesized from these three sources is shown in Figure 3, while a similar inventory for the maintenance and operation is shown in Figure 4. Note that processes which consume materials such as cutting and blasting or shop testing are also included in these sorts of inventories.

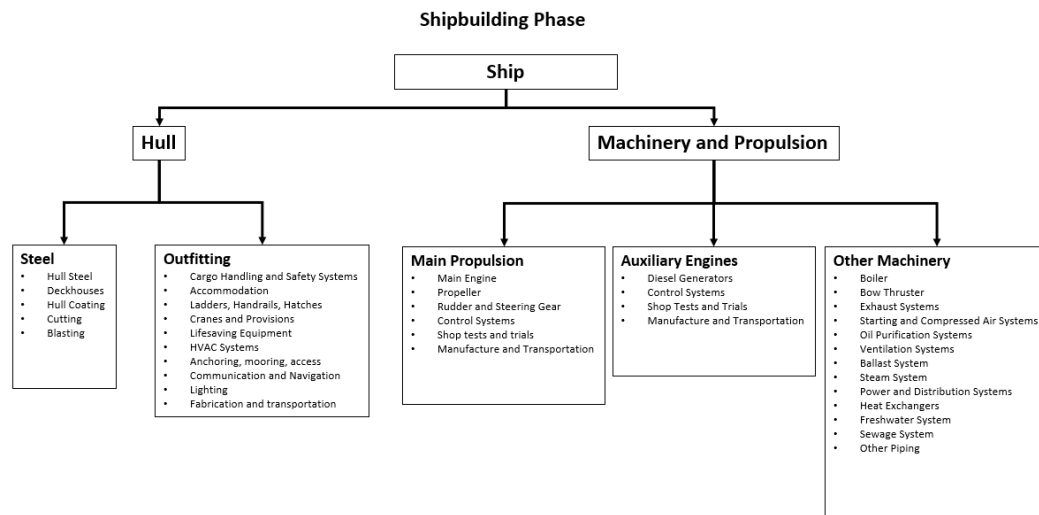


Figure 3: Example of a lifecycle inventory grouping scheme for the shipbuilding phase (Chatzinikolaou and Ventikos, 2015; Jeong *et al.*, 2018; Favi *et al.*, 2018)

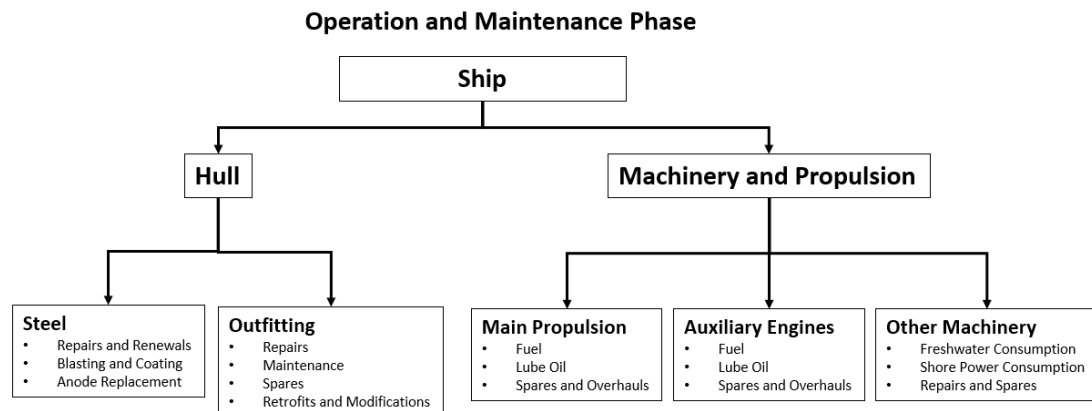


Figure 4: Example of a lifecycle inventory grouping scheme for the operations and maintenance phase (Chatzinikolaou and Ventikos, 2015; Jeong *et al.*, 2018; Favi *et al.*, 2018)

Dividing the lightweight and manufacturing process of a vessel into the components required for a detailed life cycle inventory is difficult unless the design has progressed to a stage where a reasonable lightship weight breakdown is available. For example, Favi *et al.* (2018) proposes the use of both a detailed lightweight breakdown, a 3D CAD model, a welding map, a manufacturing manual, and several technical datasheets to adequately generate input data for a lifecycle inventory during the shipbuilding and operation phases. This data is usually not available at early design stages, and so simplifying assumptions must be made that avoid development of detailed weight estimates.

An example of a simplifying assumption or cut-off criteria is presented in Hua, Cheng and Hwang (2019), where it is assumed that the entirety of the vessel's lightship weight

consists of steel, arguing that the minor items in the vessel are also made out of steel. While this isn't an entirely accurate assumption, since insulation, paneling and flooring, furniture, electronics, and composites associated with equipment housings and lifeboats are all not steel, the weight of these items is relatively small in comparison to the total lightweight of a vessel. A similar assumption was made in Lindstad, Asbjørnslett and Strømman (2011), where a simplified assumption of 4.3 kg/CO₂ per kg of lightweight steel is assumed for a panamax bulk carrier, who also argued that more than 95% of the weight of the vessel consisted of steel to justify this assumption. A competing figure for the amount of CO₂ released is 1.75 kg of CO₂ per 1 kg of steel based only on emissions from a steel mill and noting exclusion of contributions from mining and transportation, but including a further 0.216 kg of CO₂ per 1 kg of steel attributable to shipyard works, for a total of approximately 2 kg/CO₂ per kg steel (Gratsos, Psaraftis and Zachariadis, 2010). A similar approach is used in Gilbert *et. al.*, where (2017) the lightweight is assumed to be entirely composed of steel with an emission factor of 1.16 kg/CO₂ per kg of steel, but then proceeds to calculate additional carbon emissions associated with a specific steel transport route, cutting, welding, sandblasting, and coating. Despite these differences in emissions, a common approach amongst the literature appears to be assuming that steel and the processes involved in converting that steel into a usable vessel are the primary factors during the building phase of a vessel's life, and that a detailed weight breakdown may not be strictly necessary if the scope of the lifecycle analysis focuses on the entire vessel rather than a specific sub-system.

5.2.3. Impact Assessment Phase

At the completion of the inventory analysis, the entire set of process flows, emissions, and waste streams composing the lifecycle of the product/ship is available. The impact assessment is then the phase where these resource flows are aggregated and divided into environmental impact categories and category indicators (ISO 14040, 2006). Generally, the raw materials used as inputs and the associated waste streams can be examined for the various mid-point indicators such as "Abiotic Depletion" (resource use of non-biological things like minerals or oil, as opposed to biological resources like trees) or "Global Warming Potential" expressed in CO₂ equivalent as described in the CML2001 approach.

Examples of these impact categories and indicators are contained in standardized groups such as the aforementioned mid-point indicators contained in the EDIP97 or CML 2001 standards or the endpoint indicators contained in the Eco-Indicator 99 standard (Dreyer, Niemann and Hauschild, 2003). Further development of the CML 2001 and Eco-Indicator 99 standards have been carried out in the lifecycle model ReCiPe, which was sponsored by the Dutch Ministry of Infrastructure and Environment (Huijbregts *et al.*, 2017). It is not surprising that these impact categories have been standardized, as it greatly assists in comparing the results of lifecycle analysis across different studies. However, as defined in the global scope of the life cycle assessment, sometimes the entire set of possible impact indicators is not necessary or possible to extract, depending on the choice of system boundaries and the implementation of standardized inventories. An example of several of the impact indicators from the CML method are shown in Table 3.

Table 3: Example of CML Mid-point impact indicators (Dong and Cai, 2019; Tuan and Wei, 2018)

Abbreviation	Environmental Indicator	Units	Description
ADPe	Abiotic Depletion (ADP elements)	kg antimony equiv.	Use of non-renewable resources such as iron ore, rare earth metals, etc.
ADPf	Abiotic Depletion (ADP fossil)	MJ	Use of non-renewable fossil fuels like crude oil, natural gas
AP	Acidification Potential	kg SO _x equiv	Formation of Acid Rain from emissions
EP	Eutrophication Potential	kg phosphate equiv.	Emission of fertilizers that can yield undesirable population explosions (like algal blooms)
FAETP	Freshwater Aquatic Ecotoxicity Potential	kg dichlorobenzene equiv.	Emission of toxic chemicals into freshwater environments
GWP	Global Warming Potential (100-years)	kg CO ₂ equiv. (CO _{2e})	Emission of greenhouse gasses
GWPe	GWP excluding biotic carbon	kg CO ₂ equiv. (CO _{2e})	Emission of greenhouse gasses excluding carbon emitted from burning biomass
HTP	Human Toxicity Potential	kg dichlorobenzene equiv.	Emission of chemicals that may be harmful to human health (e.g. particulates)
MAETP	Marine Aquatic Ecotoxicity Potential	kg dichlorobenzene equiv.	Emission of chemicals that are harmful to marine life
ODP	Ozone Layer Depletion Potential	kg trichlorofluoromethane equiv.	Emission of gasses that deplete the ozone layer
POCP	Photochemical Ozone Creation Potential	kg ethene equiv.	Emission of chemicals such as Volatile Organic Compounds that produce ground-level ozone
TETP	Terrestrial Ecotoxicity Potential	kg dichlorobenzene equiv.	Emission of chemicals that are harmful to terrestrial life

An example of how the lifecycle inventory can be converted into midpoint indicators and endpoint indicators is shown in Figure 5, which is based on the ReCiPe 2016 model (Huijbregts *et al.*, 2017). As an output of the lifecycle inventory, an aggregate quantity of some input materials and output emissions, such as steel or CO₂ will be available. Each of the inputs or outputs will have some unit associated with them, most typically mass

as measured in kilograms, but can also include volumes in cubic meters for water use. These quantities are then multiplied by a “Characterization Factor” to convert them into midpoint indicators. For example, the midpoint environmental indicator Global Warming Potential is measured in kilograms of CO₂ equivalent, and so each kilogram of CO₂ from the lifecycle inventory would be added to the Global Warming Potential category. Similarly, for methane, each kilogram of methane from the inventory would be multiplied by a characterization factor (for example, 34 from a 100-year perspective) and then added to the previous contribution from CO₂ in the global warming potential category. Note that some of the characterization factors are time-dependent based on the natural rates of degradation for the chemicals in the air. For the methane example above, the characterization factor is 84 for a 20-year period, 34 for a 100-year period, and 4.8 for a 1,000-year period (Huijbregts *et al.*, 2017).

Endpoint indicators are similarly calculated from an aggregation of the midpoint indicators assumed to contribute to that endpoint indicator and an associated characterization factor. For example, items that contribute to midpoint indicators “particulate matter” and “human toxicity” will both ultimately contribute to the endpoint indicator “Damage to Human Health”. There are three major endpoint factors in the Eco-Indicator 99 and carried through in the ReCiPe model (Huijbregts *et al.*, 2017):

- Damage to Resource Availability, measured in surplus cost in 2013 dollars to extract fossil or mineral resources
- Damage to Human Health, measured in disability-adjusted years of life lost
- Damage to Ecosystems, measured in species lost per year

Endpoint indicators are time-dependent, with characterization factors used to convert the various midpoint indicators dependent on three options for relevant timescale defined:

- Individualist, over a 20-year time span
- Hierarchist, over a 100-year times span
- Egalitarian, over a very long time span, 1,000 years to infinite depending on the midpoint indicator.

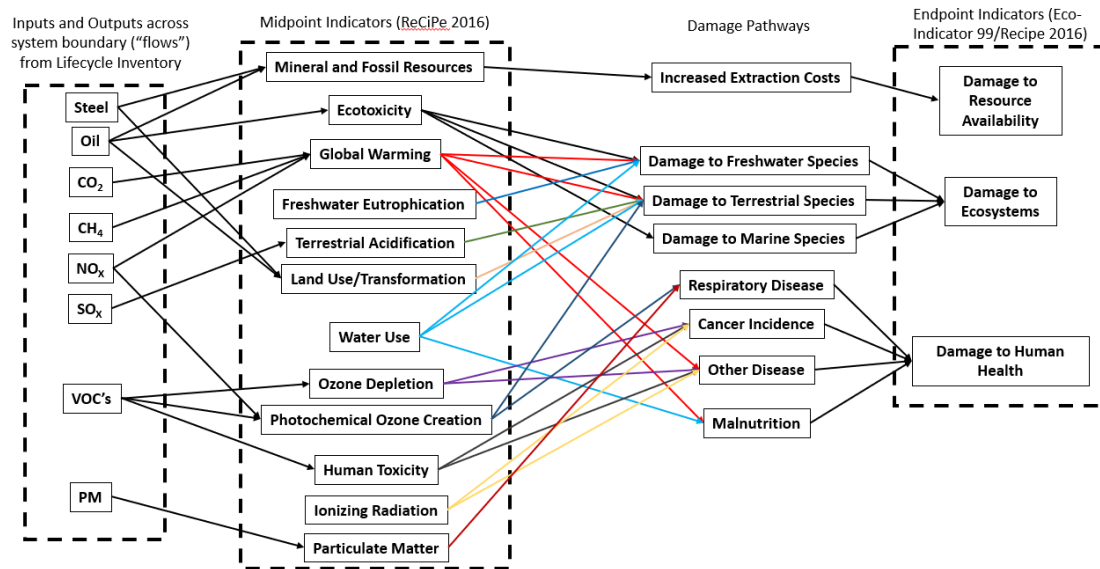


Figure 5: Simplified representation of the flow from outputs of lifecycle inventory to midpoint indicators through damage pathways to endpoint indicators (Huijbregts *et al.*, 2017)

During review of lifecycle assessments for ships, the following impact indicator methodologies were identified:

CML2001/CML2016:

- Dong and Cai's (2010; 2019) LCA of Panamax Bulk Carriers
- Jeong *et al.* (2018) recommend a modified version of the CML database (CML2016) in their proposed framework for LCA in selecting optimum propulsion systems
- Tuan and Wei's (2018) assessment of a Panamax Bulk Carrier uses the CML2001 method
- Quang *et al.* (2021) evaluation of a Panamax oil tanker

ECO-Indicator 99

- A portion of Chatzinikolaou and Ventikos's (2015) comparative study on Panamax oil tankers, specifically for the main engine

ReCiPe (based on CML and Eco-Indicator):

- Ko and Gantner's (2016) Assessment of Ship Scrapping
- Bilgili's (2021) comparative assessment of alternative marine fuels
- Favi *et al.*'s (2018) framework and tool for life cycle analysis of maritime vessels

Other:

- Cucinotta *et al.*'s (2021) Lifecycle Assessment of Sister Ferries with Diesel/LNG–ILCD 2018
- Gratsos, Psaraftis, and Zachariadis's (2010) study of CO₂ emissions from Bulk Carriers– uses no inventory database, rather derives CO₂ emissions from various processes and reports CO₂ emissions alone.
- Kameyama's (2007) study of Bulk Carrier Lifecycle inventory was based on data from the Japanese Environmental Management Association and uses the LIME life cycle impact assessment methodology
- Hua's (2019) study of post-panamax containerships utilizes a custom Total Life Cycle Emissions Model tracking the emission of various gasses and chemical individually without consolidation into CO_{2e} or assessment of their environmental impact
- MEPC's Annex 14 proposes Well-to-Wake emissions be measured on Greenhouse gas emissions (CO_{2Eq}), direct land use change, indirect land use change, water quality (use and eutrophication), soil, waste, and conservation (MEPC.376(80), 2017).

While the above survey of the life cycle impact assessments methodologies used in the literature is not exhaustive, it does indicate that the CML and ReCiPe (which is a derivative of the CML method) are more popular impact indicators to use for lifecycle assessments in the marine industry, specifically when coupled with a commercially available inventory databases that make extracting contributions from unit processes to these impact categories more streamlined. It also appears valid to derive or cull any of the existing sets down to focus on a specific impact indicator, as is done in Blanco-Davis and Zhou's (2016) focus on CO_{2e} or Gratsos's (2010) focus on CO₂, which depends on either the goal of the analysis or the choice for how the life cycle inventory is carried out.

This reduced set of mid-point indicators for the assessment of alternative fuels is precisely what the MEPC is proposing in its well-to-wake lifecycle guidelines. Adoption of the CO_{2Eq} measure in the shipping industry is an example of a midpoint indicator associated with the lifecycle impact assessment category "Global Warming Potential – 100 years" from the CML2001 standard, later adapted into the ReCiPe impact

assessment model (Huijbregts *et al.*, 2017). The CO_{2Eq} consists of three emission factors – CO₂ (Carbon Dioxide), CH₄ (Methane), and N₂O (Nitrous oxide, laughing gas) and a time scale. In the case of the MEPC guidance, the associated timescale is 100-years impact and the associated emission factors are 1 for CO₂, 28 for Methane, and 265 for Nitrous Oxide. The reporting units are kg CO_{2Eq}, and this means for every 1 kg of methane released to the atmosphere, the global warming impact is equivalent to 28 kilograms of CO₂ (MEPC.376(80), 2017). The emission factors in MEPC differ slightly from those in ReCiPe, where the contribution factors for Methane and Nitrous Oxide on a 100-year scale are 34 and 298 respectively.

According to the International Council on Clean Transportation (ICCT), black carbon also has a global warming impact, even if it is not accounted for in the MEPC guidance or included in the impact factors within the CML and ReCiPe LCA methods. Black carbon is a particulate emission on the order of or smaller than PM_{2.5} emissions which absorb and transfer heat from the sun. Black carbon is difficult to categorize in the same manner as other gaseous emissions because it persists for a much shorter time in the atmosphere (1-3 weeks) and will settle out of the atmosphere within a few thousand kilometres of its emissions source (depending on weather conditions). This means it has a much stronger local heating effect, but a reduced global effect compared to other, more persistent gas emissions. Black carbon has a very strong solar heat absorption effect and can deposit on snow and ice which reduces its reflectivity and increases its susceptibility to melting from sunlight, so despite its low time in the atmosphere, it has a very large impact even when this is averaged over longer time scales as typical for measure of GWP (ICCT *et al.*, 2009). The listed contribution factors for CO_{2Eq} from black carbon is 900 on a 100-year time scale and 3,200 on a 20-year timescale as per Comer and Oslpova (2021), and 460 on the 100-year time scale and 1,600 on the 20-year time scale as per the ICCT report itself citing a 2007 report from the Intergovernmental Panel on Climate Change (IPCC) (ICCT *et al.*, 2009). The discrepancy between the reported GWP figures is not clarified – Comer and Oslpova cite an earlier paper (Comer *et al.*, 2017) where the higher emission factor figures are presented without further citation.

5.3. Lifecycle Analysis for Ships – Literature Review

A literature review was conducted examining several of the existing lifecycle analyses that have been performed for various ship types to determine which methodologies

would be most suitable for the intended research. One of the key goals of this research is to assess the emissions associated with shipbuilding and ship breaking to compare them to those during the operational phase of the ship's life. This data was available from existing publications for differing ship types and combinations of alternative fuels.

Lifecycle assessments have grown in prominence since their origin in the 1990's, with their first application to shipbuilding found in Fet (1998). Following this initial study, lifecycle analysis has been identified as a useful way to analyse the environmental impact from the marine industry, which is an expansion over the typical IMO guidelines focusing primarily on the operational phase of a ship's life and utilizing such measures as EEDI, EEXI and CII (Blanco-Davis and Zhou, 2016). However, lifecycle analyses are also under-utilized in the marine industry due to their complexity, requirement for large databases of unit-emissions, and expertise to correctly set-up (Jeong *et al.*, 2018; Favi *et al.*, 2018).

The idea of using lifecycle assessments to gain a more complete understanding of shipping emissions is already being implemented by the IMO. Future regulations such as well-to-tank emission standards and the implementation of the CO₂ Equivalent measure of global warming potential, contained in (MEPC.376(80), 2017), are examples of aspects of lifecycle analysis being proposed for use as future standards. The MMMCZCS also has proposed a parallel framework for well-to-tank emissions following the standards of ISO 14040 and 14044 (MMMCZCS and Shipping, 2023). By capturing the well-to-wake emissions, the greatest source of emissions from the operational aspect of a ship's lifetime can be inventoried.

5.3.1. Lifecycle Analysis for Ships – Existing Methodologies

Mio, Fermeglia, and Favi (2022) have produced a critical literature review that compiles a range of lifecycle analyses for a variety of ships such as cruise and ferry boats, tankers, cargo vessels, fishing vessels, tug boats, and pleasure and sporting boats. This research topic is focused on long-distance transportation of goods and the sections pertaining to tankers and cargo vessels are of primary interest. The goal from investigating this paper was to both see the breadth of papers investigated as well as the critical analysis associated with the various life cycle assessments.

The key references for the tanker section were:

- Medium range tankers in Kjaer et al. (2015)
- Panamax tankers in Chatzinikolaou and Ventikos (2015), further studied by Quang et al. (2021)
- Eleven oil routes with 5 tanker types spanning from Panamax to ULCC in Nian and Yuan (2017).
- Bicer and Dincer (2018) studied alternative fuels for a freight vessel and a tanker

Ultimately, this consists of five papers dealing with the lifecycle assessment of oil tankers.

Cargo vessels as per Mio et al. are divided into four major groups (Mio, Fermeglia and Favi, 2022):

- General Freight
- Container ships
- Dry bulk
- RoRo

The following key references were identified:

- Panamax and Handymax Bulk carriers in Gratsos et al. (2010) and furthered by Dong and Cai (2019)
- Containership in Gilbert *et al.* (2017), focusing on the life cycle impact of the ship manufacturing process, maintenance and re-use of the hull steel but not the operational portion of the lifetime.
- Panamax Bulk carrier in Tuan and Wei (2018)(Construction to delivery only) and Kameyama (2007)

It is notable that Mio *et al.* did not present literature relating to lifecycle analyses of other cargo vessel types, specifically containerships which after bulk carriers and oil tankers represent approximately 13% of the world's trading capacity by deadweight tons (UNCTAD, 2022).

As a reference for containerships, Hua *et al.* (2019) performed a study of a series of 10 post-panamax containerships and comparing the lifecycle emissions reductions between HFO and LNG. The study also includes emissions associated with a VLCC and bunker barge transporting fuel to the refinery and containership respectively but does

not perform lifecycle analysis of these support vessels themselves. Notably, this study avoided changing the cargo capacity or bunkering frequency associated with the lower volumetric energy density of LNG as a fuel.

The above papers were collated into a table breaking down the key components of their lifecycle analysis, with a specific focus on necessary steps in shipbuilding, maintenance, and ship breaking. This list is shown in Table 4 through Table 6.

Table 4: Literature Review – Ship Lifecycle Part 1

Author	Dong and Cai	Tuan and Wei	Quang, Dong, Pham	Chatziniolaou, Ventikos	Favi
Year	2019	2018	2021	2015	2018
Title	A comparative study of life cycle assessment of a Panamax bulk carrier in consideration of lightship weight	Cradle to Gate life cycle assessment of Ships: A case study of Panamax Bulk Carrier	Evaluating Environmental Impacts of an Oil Tanker Using Life Cycle Assessment Method	Holistic Framework for Studying Ship Air Emissions in a Life Cycle Perspective	Using Design Information to Create a data framework and tool for life cycle analysis of complex maritime vessels
Ship Type	Bulk Carrier	Bulk Carrier	Oil Tanker	Oil Tanker	Luxury Yachts
Ship Sub-Type	Panamax	Panamax	Panamax	Panamax	
Database Inventory	GaBi	GaBi	Gabi	Ex-Tremis	
	National Pollutant Inventory, 1999				
	World Steel Association				
Impact Method	CML2001	CML2001	CML 2001	Eco-Indicator 99	ReCiPe Hierarchist, 2009
Building Phase	Steel extraction manufacture. LS Weight x 1.1 (10% Steel Lost). 95% lost steel recycled, 5% lost	Steel Manufacture (LS Weight x1.1). Breakdown of Structural Steel, Outfitting steel, and Machinery.	Steel Manufacture	Steel Production	
	Transportation of Steel to Shipyard	Transportation of Steel to Shipyard	Transportation of Steel to Shipyard	Transportation of Steel to Shipyard	
	Electricity Consumption - per ton of steel	Electricity - steel cutting and welding	Electricity from Steel Cutting	Electricity from Steel Cutting	
	Cutting and Welding, Metal Fume and NO _x from National Pollutant Inventory	Cutting Steel - PM and NO _x Welding CO and NO _x Welding Wire, GMAW	Cutting and Welding (Welding Wire)	Steel Cutting and Welding	Steel Cutting and Welding
	Sandblasting	Sandblasting	Sandblasting	Sandblasting	
	Painting (kg/m ² painting surface)	Painting	Painting	Painting	
		Anodes		Anodes	
	Sea Trials	Sea Trials	Sea Trials	Sea Trials	
Operational & Maintenance Phase		Shop Tests		Shop Tests	
	Fuel Production		Fuel Extraction/Production		
	Fuel Consumption		Fuel Combustion/Consumption	Fuel Consumption	
	Steel Replacement		Steel Replacement	Steel Replacement	
	Painting		Painting		
			Added Resistance from Marine Growth	Added Resistance from Marine Growth	
End of Life/Scrapping				Anodes	
				Material Transport	
	10-16% of steel is lost/solid waste			2.7x less emissions from recycled plate	
	90% Assumed Steel Recycling		88-90% Recycled	Steel Recovery in India, Alang, and is directly re-rolled	
Notes			Propane Consumption from Cutting	Emission Factors for Ship Breaking and Manufacturing from Scrap. Standard CO _{2e} factors + CFC	
			Transport of Scrapping steel to mill		
		Nickel-Al-Brass Propeller Individually Considered	Steel is the only considered construction material, remaining is neglected	Divided into Hull and Machinery	
			Weight of raw material is 2.66x higher than steel weight	For engines, assumed 125 km transport by road	
			Scrapping in Bangladesh	engines are separate steel	

Table 5: Literature Review – Ship Lifecycle Part 2

Author	Yongjoo	Popa and Florin	Cucinotta	Kameyama
Year	2017	2014	2021	2007
Title	Bottom-Up Analysis of GHG Emissions from Shipbuilding Processes for Low-Carbon Ship Production in Korea	Application of Life Cycle Assessment (LCA) in Shipping Industry	A comparative Life Cycle Assessment of two sister Cruise ferries with Diesel and Liquefied Natural Gas Machinery Systems	Study of Life Cycle Impact Assessment for Ships
Ship Type	N/A	Containership	Ferries	Bulk Carrier
Ship Sub-Type	N/A	Post-Panamax 157k Tons		Panamax
Database Inventory			Open LCA w/ EcolInvent	Lifecycle Assessment Society of Japan
				LIME
Impact Method			ILCD 2018	
Building Phase		Steel Production	Steel Production - Sheet Rolling	Steel Plates and Ship Parts
		Transportation of Steel to Shipyard		Transportation of raw materials
	Electricity for cranes and painting, steel forming			
	Steel Cutting and Welding, and Plate forming	Steel Cutting and Welding	Steel Cutting, Welding	Cutting, welding,
		Sandblasting	Sandblasting	
	Painting	Painting	Painting	Painting
			Separate items for engine, copper, bronze, insulation, zinc, based on detailed weight breakdown	
	Sea Trial			Sea trial
Operational & Maintenance Phase				
End of Life/Scrapping				
Notes			Same as Fet, Weight of steel hull + 10%	
			2.8m cutting length per tonne assumed (fet)	
			120 Ton of Electrode and 150 Tons of CO2 for	
			0.147 kg zinc per ton of hull steel	

Table 6: Literature Review – Ship Lifecycle Part 3

Author	Gratsos	Hua	Gilbert	Nian & Yuan
Year	2010	2019	2017	2017
Title	Life-Cycle CO ₂ emissions of Bulk Carriers: A Comparative Study	Total Life Cycle Emissions of Post-Panamax Containership Powered by Conventional Fuel or Natural Gas	The role of material efficiency to reduce CO ₂ emissions during ship manufacture: A life cycle approach	A method for analysis of maritime transportation systems in the life cycle approach - The Oil tanker example
Ship Type	Bulk Carriers	Containership	Containership	Oil Tankers
Ship Sub-Type	Panamax and x2 Handymax	Post-Panamax	Maersk triple E, 18,000 TEU	Panamax, Aframax, Suezmax, VLCC, ULCC
Database Inventory	Scaled from Kameyama 2007	REET	Custom, World Steel	Custom, from site info from a major chinese shipyard
		Custom methodologies - based on data from Taiwanese Shipyards	Based on Gratsos	Carbon Emissions purely from electricity Consumption
	World Steel		World Steel Association	
Impact Method	CO _{2e} emissions only	Inventory Only	CO _{2e} emissions only	CO ₂ only
Building Phase	1.75 MT CO ₂ per Ton steel at the steel mill. 3484 Nm for raw materials from Australia to Korea. 2.66 MT of iron/coal/limestone per ton steel	Steel Production - Emission factors for NO _x , SO _x , PM ₁₀ , VOC, and CO _{2e} are provided on a kg/Ton basis	Lightship weight + 10% (as per Fet), all Steel. 1.116 MT CO ₂ /Ton Raw Steel for total production	Electricity consumption in kWh/MT Lightweight for Production, Coating, Outfitting, Assembly, Production Support, and Logistics
	4 grams CO ₂ /ton-km for ships transporting steel.	Shipbuilding - Emission factors for NO _x , SO _x , PM ₁₀ , VOC, and CO _{2e} are provided on a kg/Ton basis	Steel transported to shipbuilding site China to Korea. 822 km travelled, 11.9 gCO ₂ /ton-km	
	0.216 MT CO ₂ /ton steel for shipyard activities		Welding - electricity consumption	
			Cutting based on 10% steel loss and hull surface area, electricity consumption	
			Sandblasting. Diesel Consumption during blasting	
			Basic estimates of paint per ton of hull	
Operational & Maintenance Phase	1MT cutting uses 60 kg liquid Propane, 0.18 MT CO ₂ /ton steel cut.	Oil Refinery - Emission factors for NO _x , SO _x , PM ₁₀ , VOC, and CO _{2e} are provided on a kg/Ton basis - Well to Tank	2.5 Year Maintenance Period. 5% weld reinforcement, Hull	33.89 days downtime per year
	0.303 MT CO ₂ /Ton replacement steel	Accounts for extraction, VLCC transport, Bunkering and Tank to Wake Emissions with provided emission factors	Sandblasted, 50% repainted, 10% hull steel weight growth over vessel lifetime	Shipyard energy consumptions the same for maintenance as building, calculated on an hourly basis
End of Life/Scrapping	Cutting of steel as per the maintenance	Stated to be immature with limited literature	Cutting area equal to total surface area. Same emission factors.	Energy use at scrapping - 753.62 MJ of Propane, 130.78 MJ of Diesel, and 0.9 MJ of Electricity per DWT
	Transport of steel - 4136 nmi for recycled steel from Bangladesh to China	Intentionally Excluded	Travel of steel by truck within India	Not a focus of the study
	0.18 MT CO ₂ /ton steel cut			
Notes	Assumes the entire lightweight of the vessel is steel	Assumes the entire lightweight of the vessel is steel		

From this assessment of the existing methodologies, several trends emerged:

- The lifecycle of ships is always divided into building, operations, and scrapping, where the operations can consist of normal operations and maintenance over the lifecycle of the vessel

- Data relating to the scrapping phase is much sparser and less well developed than in the building phase
- The maintenance phase tends to re-use factors from the shipbuilding phase
- Much of the shipbuilding phase use similar data sets and key steps and assumptions
 - Most assume steel is the major (or only) component in the lightweight of the vessel. Those that do not and look at more detailed weight breakdowns tend to involve smaller ship designs such as yachts, have such a breakdown available for an existing ship, or use completely different methodologies.
 - Most assume an extra 10% steel above lightweight is required as a raw material
 - Most account for some sort of transport from the steel from the fabrication facility to the shipyard
 - Most have factors covering cutting, welding, sandblasting and painting
 - Some specially consider the zinc required for anodes
 - Some include emissions from sea trials and shop tests.
 - Most are based on the same methodology or set of methodologies, originally proposed by Fet (1998) or Kameyama (2007) and then expanded on to use more modern inventories or impact assessment categories.
- The methodologies used by Hua (2019) and Nian and Yuan (2017) are somewhat unique, being based on local emissions factors directly from shipyards in Taiwan and China respectively. These are very simple to implement, and in the case of Hua, provide five emissions, not just CO_{2Eq}
- Similarly, the method employed by Gratsos (2010) is not complicated to implement, being directly derivable from the lightship weight and yielding a CO₂ emission inventory.

Normalization of Results and Design Metrics

The performance of individual ships are normalized by comparison of work-transport metrics (Gratsos, Psaraftis and Zachariadis, 2010) such as tonnes of cargo-kilometres transported in a year, or even further normalized from a life-cycle perspective as an

efficiency ratio comparing the ratio of environmental impacts from non-operational and operational life cycle phases with the vessel's overall power/lightweight ratio (Mio, Fermeglia and Favi, 2022). In the case of the efficiency ratio, the transport efficiency is folded into the environmental impacts of the operational phase for an individual ship.

The measurement of performance on a tonne (or TEU) of cargo-kilometres transported basis is a useful metric for comparison of the performance of differing ship designs. With this metric available for a given ship, the to calculate the number of ships required to service a given cargo demand. This is done in Gratsos *et al.* (2010) with the implementation of an “additional ships factor”. The idea of normalization on the work-transport basis would therefore permit the specific demand of cargo on a given route, which is a value with a high degree of uncertainty (ABS, 2020), to act as an independent variable that can be varied. This can then in turn be linked to outputs such as number of ships required and associated environmental impact.

Shipbuilding's Contribution to CO_{2e} Emissions

Mio *et al.* (2022) found in a critical literature review of four different lifecycle analyses (Chatzinikolaou and Ventikos, 2015; Quang, Dong and Hai, 2021; Kjær *et al.*, 2015; Nian and Yuan, 2017), focusing on oil tankers that GHG emissions from the operational phase account for between 79%-99% of emissions, followed by shipbuilding and then other operation, service and maintenance activities (Mio, Fermeglia and Favi, 2022). However, it is acknowledged that there is substantial deviation in methodology between these studies which makes them difficult to accurately compare.

Kameyama *et al.* (2007) made a similar finding, attributing 98% of the whole environmental impact of the analysed bulk carrier to the operational phase.

In conclusion, a large amount of ship building will be necessary to offset the potential gains from switching to alternative fuels, considering global warming potential alone, and assuming the fuel can be produced in a sustainable manner.

5.4. Alternative Fuels, Definitions, and the Color Scale

Alternative fuels can have their provenance described by a color scale as follows (ABS, 2021; BIMCO, 2023):

- Grey/Black/Brown: Fuel produced from fossil sources. This is the most typical form of fuel used currently. Grey typically refers to fossil-natural gas as the source, while black and brown would use coal as feedstock.
- Blue: Produced from fossil sources combined with carbon capture and storage. The carbon that would be emitted from their production is instead captured sequestered in the ground rather than being emitted to the atmosphere
- Green: Produced from renewable sources such as electrolysis via renewable energy (such as wind or solar). Green Hydrogen would be directly produced via electrolysis from renewable sources, while Methanol would involve combining green hydrogen with atmospheric CO₂ and Ammonia would require combining atmospheric Nitrogen. Biofuels are categorized separately and without an assigned color according to the BIMCO glossary.
- Orange: A blend of the above sources. For example hydrogen produced via electrolysis using power from the current European grid would have a blend of electricity supplied by renewables and fossil sources
- Turquoise: Hydrogen generated through pyrolysis of natural gas using renewable energy. The carbon in the natural gas turns into a solid from this technique and is not emitted to the atmosphere as CO₂.
- Pink: Nuclear energy is used to supply electricity for producing the fuel
- White: Extraction of natural hydrogen deposits through fracking
- Yellow: Solar power is used to supply electricity for producing the fuel

Additionally, some specific categories of renewable fuel are (BIMCO, 2023):

- Biofuels: The fuel is produced via processing biomass. Biomass absorbs CO₂ while growing and then this CO₂ is released when the fuel is consumed, which can be considered net-zero from a cyclic standpoint, assuming there are not substantial sources of other GHG emissions during production, transport, and distribution of the biofuel.
- E-Fuels: Fuels produced from renewable hydrogen and captured CO₂. Equivalent to green fuels by this definition.

5.5. Well-to-Tank and Tank-to-Wake Emission Factor Literature Review

Well-To-Tank (WTT) emissions involve performing a lifecycle analysis of the fuels themselves, prior to their use onboard the vessels. Existing IMO regulations investigate the performance of a ship from the Tank-to-Wake (TTW) perspective, which is a distinct process flow in a complete lifecycle inventory of ship emissions, but including the well-to-tank data completes the lifecycle inventory allowing the environmental impacts from the fuel entering the system boundary to be inventoried. Without a well-to-tank assessment of the fuels, the benefits or drawbacks from their use cannot be fully captured. For example if the carbon-intensive Haber-Bosch process is used for production of ammonia instead of steam hydrogen reforming utilizing renewably produced hydrogen, the carbon impact can be equivalent to the use of HFO (Wang and Wright, 2021).

Both the IMO through MEPC (MEPC.376(80), 2017) and the MMMCZCS (MMMCZCS, 2023) provide methodologies for calculating the well-to-tank and well-to-wake emissions from fuels in compliance with ISO 14040 and 14044, but these documents are aimed at fuel manufacturers and ship owners performing lifecycle assessment for a very specific trade and data produced using these methodologies is still currently scarce. It is expected that IMO will release the appropriate well-to-tank factors that can be utilized in the design stage to supplement EEDI/EEXI and CII calculations, but until then these factors have been retrieved through a literature review.

Ten sources were utilized to determine the well-to-tank emission factors for the various fuels, the most important of which was Wang and Wright's Comparative Review of Alternative Fuels for the Maritime Sector (2021). This paper was itself a literature review of the available information for well-to-tank and tank-to-wake emissions, so was an excellent compilation of internally self-consistent well-to-tank emission factors.

Table 7 through Table 13 show the emission factors for conventional and alternative fuels produced from fossil and renewable means on a MT-emission per MT-fuel basis. Note that the tables are colour coded with the final selected values used in this research highlighted in green. Values highlighted in orange come from reference 5 (Bilgili, 2021), and appear to be much greater in magnitude than the other sources so were not used.

Table 7: Well-to-Tank Emission Factor Literature Review – Source Key Table

Reference Index	Reference Title	Author and Year
1	Total life cycle emissions of post-Panamax containerhips powered by conventional fuel or natural gas	(Hua, Cheng and Hwang, 2019)
2	Assessment of Selected Alternative Fuels and Technologies	(DNV, 2019)
3	Well-to-tank carbon emissions from crude oil maritime transportation	(Greene, Jia and Rubio-Domingo, 2020)
4	Environmental assessment of marine fuels: liquefied natural gas, liquefied biogas, methanol and bio-methanol	(Brynolf, Fridell and Andersson, 2014)
5	Comparative assessment of alternative marine fuels in life cycle perspective	(Bilgili, 2021)
6	Comparative life cycle assessment of various ammonia production methods	(Bicer <i>et al.</i> , 2016)
7	A Comparative Review of Alternative Fuels for the Maritime Sector: Economic, Technology, and Policy Challenges for Clean Energy Implementation	(Wang and Wright, 2021)
8	Fuel Oil Bunkering to Linger Despite New GHG Rule	(Wechsler, 2023)

9	Accounting for Well-to-Wake Carbon Dioxide Equivalent Emissions in Maritime Transportation Climate Policies	(Comer and Oslpova, 2021)
10	Methanol as Marine Fuel: Environmental Benefits, Technology Readiness, and Economic Feasibility	(IMO, 2016)

Table 8: Well-to-Tank Emission Factors from Literature Review, HFO, VLSFO, and MGO

Fuel Type	HFO							VLSFO		MGO			
Production	Fossil							Fossil		Fossil			
Reference	1	2	3	4	8	9	10	8	9	2	8	9	10
MT/MT Fuel	HFO	HFO	HFO	HFO	HFO	HFO	HFO	VLSFO	VLSFO				
CO ₂ Emissions	0.124	0.394	0.255	0.269	0.599	0.431	0.342	0.675	0.546	0.542	0.756	0.575	0.408
Bio CO ₂ Emissions													
SO _x Emissions	6.54E-04			1.57E-03									
NO _x Emissions	1.42E-03			8.44E-04									
PM ₁₀ Emissions	1.52E-04			4.42E-05									
PM _{2.5} Emissions													
CH ₄ Emissions	5.73E-03			2.89E-03		3.99E-03			4.48E-03			4.60E-03	
CO Emissions	3.91E-04			3.70E-04									
N ₂ O Emissions	4.92E-04			6.43E-06		1.00E-05			1.00E-05			1.00E-05	
NM VOC Emissions	4.45E-04			3.30E-06									
GWP20	0.735	0.394	0.255	0.514	0.599	0.769	0.342	0.675	0.925	0.542	0.756	0.964	0.408
GWP100	0.465	0.394	0.255	0.370	0.599	0.570	0.342	0.675	0.701	0.542	0.756	0.734	0.408
MEPC	0.415	0.394	0.255	0.352	0.599	0.545	0.342	0.675	0.674	0.542	0.756	0.706	0.408

Table 9: Well-to-Tank Emission Factors from Literature Review, Bio-Diesel

Fuel Type	Bio-Diesel					
Production		Soy	Rapeseed	Palm	Rapeseed	Soy
Reference	2	5	5	5	7	7
MT/MT Fuel						
CO ₂ Emissions	0.427	1.500	1.800	1.600	0.811	0.641
Bio CO ₂ Emissions					2.861	2.861
SO _x Emissions		6.40E-03	7.70E-03	7.60E-03	1.71E-03	1.28E-03
NO _x Emissions		1.00E-02	1.00E-02	9.10E-03	2.56E-03	6.41E-03
PM ₁₀ Emissions					0.00E+00	0.00E+00
PM _{2.5} Emissions		2.80E-03	1.60E-03	2.30E-03	0.00E+00	0.00E+00
CH ₄ Emissions		4.20E-03	5.00E-03	4.80E-03	1.28E-03	8.54E-04
CO Emissions		4.80E-03	5.70E-03	5.30E-03	0.00E+00	0.00E+00
N ₂ O Emissions		2.60E-03	4.20E-03	3.60E-03	3.71E-03	4.27E-05
NM VOC Emissions		1.70E-03	1.70E-03	1.60E-03		
GWP20	0.427	2.539	3.329	2.954	1.900	0.724
GWP100	0.427	2.418	3.222	2.836	1.962	0.682
MEPC	0.427	2.307	3.053	2.688	1.832	0.676

Table 10: Well-to-Tank Emission Factors from Literature Review, LNG/Methane

Fuel Type	LNG										
Production	Fossil							Bio			
Reference	1	2	4	5	7	7	9	2	5	4	7
MT/MT Fuel					Low	High					
CO ₂ Emissions	0.574	0.514	0.398	2.700	0.398	1.283	0.530	0.970	0.900	1.296	1.296
Bio CO ₂ Emissions					0.000	0.000				4.656	4.656
SO _x Emissions	7.21E-04		3.98E-05	5.40E-02	3.98E-05	1.12E-03			2.20E-03	3.50E-03	3.50E-03
NO _x Emissions	1.54E-03		4.56E-04	3.20E-03	4.56E-04	4.37E-03			1.90E-03	2.54E-03	2.54E-03
PM ₁₀ Emissions	3.82E-05		1.54E-05		0.00E+00	0.00E+00				8.64E-04	0.00E+00
PM _{2.5} Emissions				7.00E-04	0.00E+00	0.00E+00			3.00E-04		0.00E+00
CH ₄ Emissions	8.50E-03		1.58E-03	4.40E-02	1.58E-03	1.58E-03	1.81E-02		2.50E-03	8.64E-03	8.64E-04
CO Emissions	4.58E-04		1.30E-04	4.40E-03	1.30E-04	1.30E-04			1.30E-03	4.61E-04	4.61E-04
N ₂ O Emissions	1.18E-05		8.16E-06	4.00E-05	7.68E-06	7.68E-06	1.00E-05		4.00E-04	1.58E-05	1.58E-05
NM VOC Emissions	7.90E-05		3.31E-05	3.60E-03					3.00E-04	4.18E-04	
GWP20	1.290	0.514	0.534	6.407	0.533	1.418	2.053	0.970	1.216	2.026	1.373
GWP100	0.866	0.514	0.455	4.208	0.455	1.339	1.148	0.970	1.104	1.594	1.330
MEPC	0.815	0.514	0.445	3.943	0.445	1.329	1.039	0.970	1.076	1.542	1.324

Table 11: Well-to-Tank Emission Factors from Literature Review, Ammonia

Fuel Type	Ammonia									
Production	Haber-Bosch				E-Ammonia				Bio	
Reference	5	6	7	7	6	6	6	6	7	7
MT/MT Fuel			Low	High					Low	High
CO ₂ Emissions	4.800	1.500	1.207	1.571	0.380	0.840	0.850	0.340	0.345	0.554
Bio CO ₂ Emissions			0.000	0.000					0.000	0.000
SO _x Emissions	2.30E-02		8.18E-06	8.18E-06					0.00E+00	0.00E+00
NO _x Emissions	5.50E-03		8.18E-04	8.18E-04					8.18E-04	8.18E-04
PM ₁₀ Emissions			0.00E+00	0.00E+00					0.00E+00	0.00E+00
PM _{2.5} Emissions	2.10E-03		0.00E+00	0.00E+00					0.00E+00	0.00E+00
CH ₄ Emissions	8.30E-03		9.86E-05	9.86E-05					0.00E+00	0.00E+00
CO Emissions	1.80E-03		6.88E-05	6.88E-05					0.00E+00	0.00E+00
N ₂ O Emissions	1.00E-04		8.37E-06	8.37E-06					8.37E-06	8.37E-06
NM VOC Emissions	3.10E-03									
GWP20	5.524	1.500	1.217	1.581	0.380	0.840	0.850	0.340	0.348	0.556
GWP100	5.112	1.500	1.213	1.576	0.380	0.840	0.850	0.340	0.348	0.556
MEPC	5.059	1.500	1.212	1.576	0.380	0.840	0.850	0.340	0.348	0.556

Table 12: Well-to-Tank Emission Factors from Literature Review, Methanol

Fuel Type	Methanol									
Production	From Methane				Bio					
Reference	2	4	7	10	2	4	5	7	10	10
MT/MT Fuel									Low	High
CO ₂ Emissions	0.425	0.398	0.398	0.498	0.160	0.338	1.500	0.338	0.498	1.353
Bio CO ₂ Emissions		0.000	0.000			2.388		2.388		
SO _x Emissions		4.18E-05	4.18E-05			9.55E-04	6.50E-03	9.55E-04		
NO _x Emissions		9.15E-04	9.15E-04			1.11E-03	9.90E-03	1.11E-03		
PM ₁₀ Emissions		1.13E-05	0.00E+00			2.19E-04		0.00E+00		
PM _{2.5} Emissions			0.00E+00				2.20E-03	0.00E+00		
CH ₄ Emissions		2.19E-04	2.19E-04			8.36E-04	3.90E-03	8.36E-04		
CO Emissions		1.25E-04	1.25E-04			4.98E-04	1.30E-02	4.98E-04		
N ₂ O Emissions		5.77E-06	5.77E-06			4.38E-06	2.00E-04	4.38E-06		
NM VOC Emissions		2.19E-04				2.79E-04	3.70E-03			
GWP20	0.425	0.418	0.418	0.498	0.160	0.410	1.880	0.410	0.498	1.353
GWP100	0.425	0.407	0.407	0.498	0.160	0.368	1.692	0.368	0.498	1.353
MEPC	0.425	0.406	0.406	0.498	0.160	0.363	1.662	0.363	0.498	1.353

Table 13: Well-to-Tank Emission Factors from Literature Review, Hydrogen

Fuel Type	Hydrogen					
	Cracking			Electrolysis		
Production	2	7	7	2	7	7
Reference	2	7	7	2	7	7
MT/MT Fuel		Low	High		Low	High
CO ₂ Emissions	10.792	9.358	10.099	0.144	0.948	1.159
Bio CO ₂ Emissions		0.000	0.000		0.000	0.000
SO _x Emissions		4.56E-03	8.40E-03		6.12E-03	7.68E-03
NO _x Emissions		4.08E-03	1.18E-02		3.60E-03	4.68E-03
PM ₁₀ Emissions		0.00E+00	0.00E+00		0.00E+00	0.00E+00
PM _{2.5} Emissions		0.00E+00	0.00E+00		0.00E+00	0.00E+00
CH ₄ Emissions		1.80E-02	5.88E-02		3.00E-04	3.72E-04
CO Emissions		1.20E-03	8.88E-03		9.00E-04	9.00E-04
N ₂ O Emissions		3.00E-05	3.00E-04		4.92E-05	4.92E-05
NM VOC Emissions						
GWP20	10.792	10.878	15.118	0.144	0.986	1.203
GWP100	10.792	9.979	12.188	0.144	0.973	1.187
MEPC	10.792	9.870	11.825	0.144	0.969	1.183

As can be seen from the highlighted cells, reference 7 (Wang and Wright, 2021) was used as far as practical to keep consistency in the data being used in the lifecycle assessment. It generally provided data that was within range of the other sources for a given fuel type, and seemed to be agree with or be based on the data from Brynolf (2014). For VLSFO and MGO reference 9 (Comer and Oslpova, 2021) values were because it was in the middle of the range of values obtained for MGO, and thus this selection led to the using the same source for VLSFO's emissions factor for consistency. For HFO, the value from reference 4 (Brynolf, Fridell and Andersson, 2014) was selected because it appears to be a similar dataset to what was used for reference 7, and therefore keeps the chosen dataset internally consistent.

It should be noted that while reference 5 (Bilgili, 2021) was highlighted as unusable because the data differed substantially from the other sources, the methodology to derive those values appears to be based on a bottom-up accounting of the lifecycle for those fuels using a modern inventory database (Ecolnvent). The reported functional unit is one MT of fuel, and the units for each of the emissions are provided, but the final CO₂ emission factor appears much higher than from the other data sources. This is disappointing because the use of a modern inventory database allowed for a detailed emissions inventory to be developed accounting for more than just CO₂ and the paper studied most of the alternative fuels excluding hydrogen. It cannot be judged whether the values presented in the paper are correct or not, indeed, the methodology used could potentially be superior to what was presented in the other papers. This does demonstrate the variability of lifecycle assessments and how the chosen methodology,

system boundaries, cutoff criteria, and inventories can have a large impact on the results.

5.6. Results and Conclusions from Lifecycle Analysis Literature Review

The overall conclusions from this literature review of lifecycle assessments are:

- A lifecycle assessment is difficult to carry out primarily due to the information required in the life cycle inventory phase. Most papers presenting life cycle assessment for ships look at 2 to 3 ships or variations at most. Simplifying assumptions reducing the scope of the inventory (i.e. the ship is composed entirely of steel) need to be made to make lifecycle assessment of ships feasible.
- The ship's lifecycle can be broken into three main phases – ship building, ship operation, and ship breaking
 - There are simplistic methods available for estimating the emissions from shipbuilding based primarily on the vessel's lightweight, and maybe some additional parameters such as surface area.
 - Operational emissions should be divided into cargo delivery phases, where primarily fuel is burnt and releases emissions, and maintenance phases, where a similar emissions inventory to the shipbuilding process can be used.
 - More industry and academic research needs to be done on ship scrapping to develop a more reliable and in-depth lifecycle inventory for this phase of the ship's life, however some simplistic methods such as those presented in Chatzinikolaou and Ventikos (2015) can be implemented in the absence of better methods
- The operation of a ship produces far more global warming potential than the ship building or ship scrapping phases
 - This implies a tremendous amount of shipbuilding will be necessary to offset the potential benefits from renewably sourced fuel with low environmental impact factors
- Evaluating and comparing the performance of vessels can be simplified by using normalized metrics based on their work-transport capabilities.

- Other types of environmental impacts, such as damage to human health, are more localized in nature and driven primarily from the ship building and ship dismantling phases of a ship's lifecycle. If shipbuilding increases, these may be more relevant than global warming effects
- Well-to-Wake emission data for various fuels are available in the literature, but there is wide variation in their methodologies and outputs. Since the operational phase is the most important, and this is driven by fuel consumption, this naturally introduces a large variability into any ship lifecycle assessment. However, excluding them obscures the benefits and drawbacks of the various alternative fuels, especially how they are sourced.

6. Literature Review – Global Trade

6.1. Literature Review Goals

The goal of this portion of the literature review is to examine the existing world fleet composition and trading routes and use that information to identify a candidate ship for a case study. The research questions aimed to be answered by this literature review are:

- What are the major global shipping routes?
- What types of ships use these major shipping routes, and how much percent of the world's cargo do they carry?
- What are the design and performance requirements for ships that trade on these shipping routes?

This literature review highlights a set of performance criteria (range, speed, cargo demand), ship types (bulk carrier, containership, oil tanker, etc.), ship sub-types (i.e. panamax containership, iron ore or general bulk carriers, QMax LNG ship etc.) that can be used to carry out a lifecycle assessment of vessels powered by conventional and alternative fuels so a “vertical” lifecycle assessment can be carried out (Mio, Fermeglia and Favi, 2022) accounting not only for the individual vessel's performance relative to each other, but also assess how many additional vessels may be required to meet a given cargo demand. From this set of ships, a candidate case study ship can be conducted, and additional recommendations for further future study can be made.

6.2. Major Ship Types

ABS has previously investigated global trade volumes in its 2020 issue of “Setting the course to low carbon shipping” publication. It identified five major vessel types that accounted for 68% of global emissions in 2008. These ship types were dry bulk carriers, oil and chemical tankers, containerships, LNG carriers, and LPG carriers (ABS, 2020). This also agrees with the fleet makeup assumed in the IMO Greenhouse Gas Studies (Study *et al.*, 2014; Study *et al.*, 2020).

The literature review for ship lifecycle assessments has identified that existing studies primarily concern primarily bulk carriers and oil tankers, with fewer studies carried out for containerships. As per the UNCTAD report on marine transportation (2022), Bulk carriers make up 43% of the world fleet’s capacity, followed by Oil Tankers at 29% and Containerships at 13% (UNCTAD, 2022). Between these three overall ship types, 84% of the global fleet as measured by deadweight is captured. This selection is supported by Lindstad (2011), who found that bulk carriers (including tankers), container vessels, and RoRo vessels above 15,000 DWT represented 80% of global sea transport.

Despite containerships making up a relatively small portion of the fleet by deadweight, which is not as useful a measure for containerships since their cargo capacity may be limited by other factors, they are noted to be one of the largest sources of maritime pollution due to their higher operational speed (Hua, Cheng and Hwang, 2019), with post-panamax containerships contributing 15% of CO₂ emissions amongst the various sizes of containerships. This same study also assumes a route of these post-Panamax containerships from western Europe through the Suez canal to China, with an assumed speed of 16 knots (slow steaming) and a total distance of 10,500 Nautical Miles and 13 port visits. Similarly, Gilbert (2017) elected to perform a cradle-to-gate lifecycle assessment of containerships on the order of the Maersk Triple-E class vessels carrying 18,000+ TEU, citing trends in the container shipping industry and the push to take advantage of economies of scale.

6.3. Oil Tanker Trade Routes and Vessel Sizes

11 major trade lanes (and 2 other categories) for oil tankers were identified by Greene *et al.* (2020) based on examining AIS data over the period from 2013-2016. This data set initially consisted of a set of approximately 70,000 oil shipments that were filtered down

to 28,000 shipments after eliminating short-haul, circular (same origin and destination), and other shipments deemed not useful by the author. These trade lanes and relevant statistics of the vessels are shown in Table 14.

Table 14: Trade Lanes and Average Values based on AIS Data 2013-2016 (Greene, Jia and Rubio-Domingo, 2020)

Index	Origin	Destination	Avg. Distance	Avg. Duration	Avg. Sailing Speed	Avg. Design Speed	Avg. Load Factor	Avg. Deadweight	Well-to-wake from oil
#	-	-	NMi	days	knots	knots	%	1k MT	g CO ₂ /t-NM
1	Arab Gulf	East Asia	3252	26	9.9	15.71	65	294	3.0889
2	Arab Gulf	Europe	2768	23	9.2	15.31	77	187	3.9024
3	Arab Gulf	North America	5216	43	9.3	15.54	57	263	3.3125
4	Arab Gulf	SE Asia	1212	11	8.4	15.19	66	204	3.8183
5	Russia	East Asia	689	7	7.3	15.1	87	19	4.8255
6	Russia	Europe	945	10	7.9	15.15	83	117	4.826
7	Latin America	North America	876	10	7.6	14.99	62	103	5.3269
8	Latin America	SE Asia	4833	40	9.4	15.73	82	277	3.5419
9	North Africa	Europe	695	7	8.1	15.11	77	125	4.4887
10	West Africa	Europe	2236	17	10.2	15.26	76	152	4.0596
11	West Africa	SE Asia	3927	30	10	15.39	64	232	3.4876
12	Intraregional		565	6	7.7	14.93	74	116	5.0191
13	Other International		1984	17	8.8	15.12	75	147	4.3602

This dataset provides a pre-filtered set of distances, durations, vessel speeds, and vessel deadweight tonnages, which allows for the derivation of performance criteria and selection of oil tanker sub-types.

Relevant tanker types can be extracted from the above table using a breakdown based on the average deadweight and a set of typical cargo deadweight ranges for various types of oil tankers. The assumed category breakdowns are (UNCTAD, 2022):

Aframax: 85-125k MT DWT
 Suezmax: 125-200k MT DWT
 VLCC: 200-320k MT DWT
 ULCC: 320+k MT DWT

Using these deadweight ranges, sorting by deadweight in increasing order and discarding the intraregional and other international categories where the deadweight averaging may cause misleading results leads to the following tanker sub-type assignments for each of the remaining 11 routes, as presented in Table 15:

Table 15: Tanker type associated with each major oil transport route. Candidate baseline vessels highlighted

Origin	Destination	Avg. Distance	Avg. Duration	Avg. Sailing Speed	Avg. Design Speed	Avg. Deadweight	Tanker Type
-	-	NMi	days	knots	knots	1k MT	-
Latin America	North America	876	10	7.6	14.99	103	Aframax
Russia	East Asia	689	7	7.3	15.1	109	Aframax
Russia	Europe	945	10	7.9	15.15	117	Aframax
North Africa	Europe	695	7	8.1	15.11	125	Suezmax
West Africa	Europe	2236	17	10.2	15.26	152	Suezmax
Arab Gulf	Europe	2768	23	9.2	15.31	187	Suezmax
Arab Gulf	SE Asia	1212	11	8.4	15.19	204	VLCC
West Africa	SE Asia	3927	30	10	15.39	232	VLCC
Arab Gulf	North America	5216	43	9.3	15.54	263	VLCC
Latin America	SE Asia	4833	40	9.4	15.73	277	VLCC
Arab Gulf	East Asia	3252	26	9.9	15.71	294	VLCC-ULCC

It is noted that the Arab Gulf to East Asia trade route is on the upper end of the average deadweight scale for VLCC's, and it is likely that ULCC's would be present in that trading mix but are eliminated due to averaging. This indicates that analysing a typical Aframax, a Suezmax, and a VLCC would be sufficient to capture most of the major international oil trade volume.

It is expected that adoption of alternative fuels will have a larger impact on vessels engaged in long-range trading where endurance is essential, and so the maximum length trade routes have been isolated for each of the tanker sub-types. Based on Table 15, the maximum sailing range for an Aframax tanker is associated with the Russia-Europe route, the maximum sailing range for a Suezmax is associated with the Arabian Gulf to Europe route, and the maximum sailing range for VLCC's is the Arabian Gulf to North American route.

6.4. Bulk Carrier Trade Routes and Vessel Sizes

Information for the worldwide bulk carrier trade is retrieved from the Baltic Exchange, which is an organization intended to provide market information such as charter rates and operating expenses to customers looking to charter bulk carriers or other types of vessels. The Baltic Exchange is composed of Capesize, Panamax, and Supramax indices, which have a basic standard ship size and several routes associated with them (Baltic Exchange, 2023). For reference, the bulk carrier size categories are divided by deadweight tonnage as follows (UNCTAD, 2022):

Handysize:	10-40k MT DWT
Handymax/Supramax:	40-65k MT DWT
Panamax:	65-100k MT DWT
Capesize:	100k+ MT DWT

The Capesize, Panamax, and Handymax bulk carrier categories represent 68% of the world's bulk carrier fleet by gross number of ships and 88% of the bulk capacity by deadweight, with 39% of the world's bulk carrier capacity attributable to capesize vessels alone (Faber *et al.*, 2020), shown in Table 16.

Table 16: Summary of number of ships and capacity for bulk carriers, from IMO 4th GHG Study

Size Type	% by # of Ships	% by Capacity
Handysize	32%	12%
Handymax	31%	24%
Panamax	22%	25%
Capesize	15%	39%

Note that the routing data from the Baltic Exchange sometimes represent a region for pick-up and delivery rather than a specific pair of ports. Therefore, distances presented in the following tables are approximate and extracted from Searoutes.com based on the listed port pairs which are in the region indicated by the route information available through Baltic exchange.

6.4.1. Supramax/Handymax Bulk Carriers

The Baltic index standard Supramax bulk carrier has the following basic parameters:

Deadweight:	58,328 DWT (40-65k)
Draft:	12.8 m
LOA:	189.99 m
Beam:	32.26 m
TPC:	57.5 MT/cm
Carrying Capacity (Volumetric):	72,300 m ³ (Grain)/5 holds + 4 grabs
Design Speed:	14 knots laden/14 knots ballasted

This deadweight tonnage would otherwise classify the Supramax tankers as Handymax size based on the UNCTAD breakdown of bulk carrier sizes.

As per the Baltic exchange index, this nominal vessel services 10 routes, presented in Table 17.

Table 17: Supramax Bulker Trading Routes, from (Baltic Exchange, 2023), Distances calculated with Searoutes.com

Route Index	Origin	Destination	Distance (Nmi)
S1B_58	Istanbul	Hong Kong	7373
S1C_58	New Orleans	Shanghai	10092
S2_58	Brisbane	Qingdao	4377
	Qingdao	Vancouver	5087
	Vancouver	Brisbane	6596
S3_58	Kribi	Shanghai	10043
S4A_58	Houston	Rotterdam	5051
S4B_58	Same as above		
S5_58	Kribi	Rio de Janeiro	3497
	Rio de Janeiro	Shanghai	10927
S8_58	Fangcheng	Chennai	2959
S9_58	Kribi	Rio de Janeiro	3497
	Rio de Janeiro	Rotterdam	5297
S10_58	Hong Kong	Balikpapan	1612

Several routes for the supramax size of tankers are quite long, on the order of 10-11,000 Nmi. The longest is from South America to China, with similar lengths from the US Gulf Coast to China and West Africa to China. The longest route is shown in

Figure 6, and like the Panamax vessels, indicates that a successful supramax bulk carrier should have a range on the order of 11,000 Nmi to offer a wider variety of potential routes to charterers.

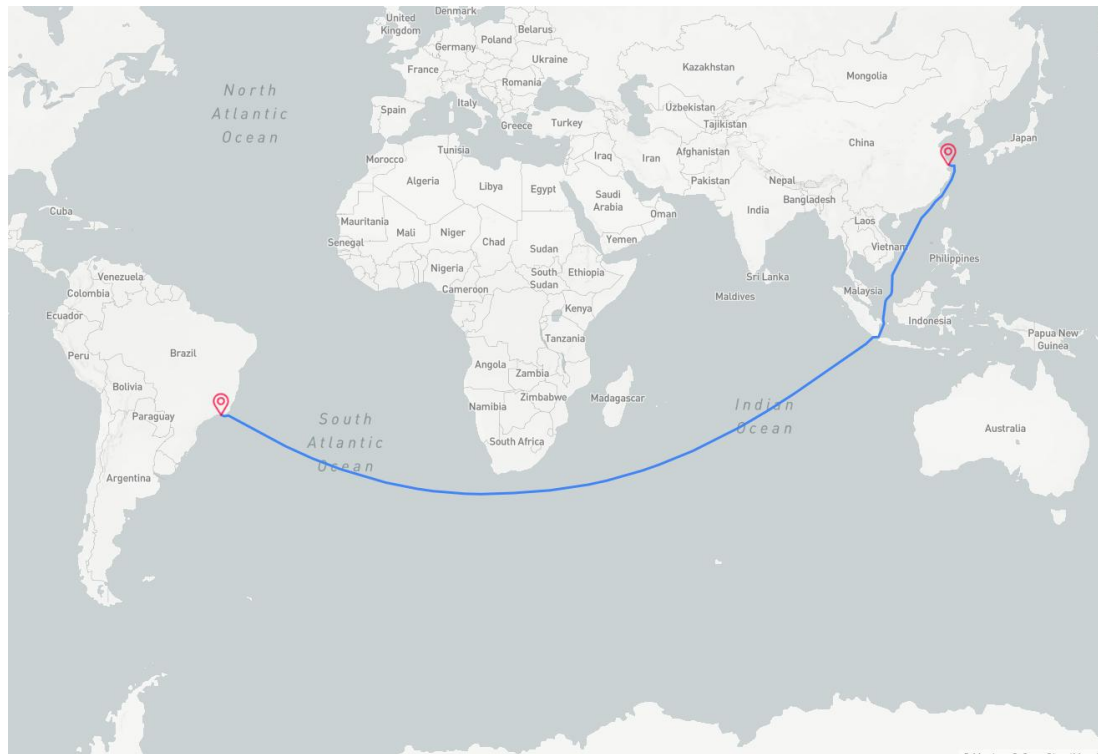


Figure 6: Longest Distance Supramax Baltic Index Route S5_58 from South America to China, Route Data from Searoutes.com, Map Data from OpenStreetMap (<https://openstreetmap.org/copyright>)

6.4.2. Panamax Bulk Carriers

The Baltic index standard Panamax bulk carrier has the following basic parameters:

Deadweight: 82,500 DWT
 Draft: 14.43 m
 LOA: 229 m
 Beam: 32.25 m
 TPC: 70.5 MT/cm
 Carrying Capacity (Volumetric): 97,000 m³ (Grain)
 Design Speed: 13.5 knots laden/14 knots ballasted

As per the Baltic exchange index, this nominal vessel services eight routes, presented in Table 18.

Table 18: Panamax Bulker Trading Routes, from (Baltic Exchange, 2023), Distances calculated with Searoutes.com

Route Index	Origin	Destination	Distance (Nmi)
P1A_82	New Orleans	Rotterdam	4856
P2A_82	New Orleans	Qingdao	10134
P3A_82	Yokohama	Vancouver	4208
P4_82	Incheon	Brisbane	4354
	Brisbane	Rotterdam	12252
P5_82	Hong Kong	Balikpapan	1612
P6_82	Singapore	Rio de Janeiro	8905
P7	New Orleans	Qingdao	10134
P8	Santos	Qingdao	11319

The routing for Panamax bulk carriers includes one of the longest legs seen in the Baltic index trade routing – from Brisbane to Rotterdam at 12,252 Nmi as part of a two-legged-trade route also involving the far east northern ports like Incheon in South Korea. This route is shown in

Figure 7.

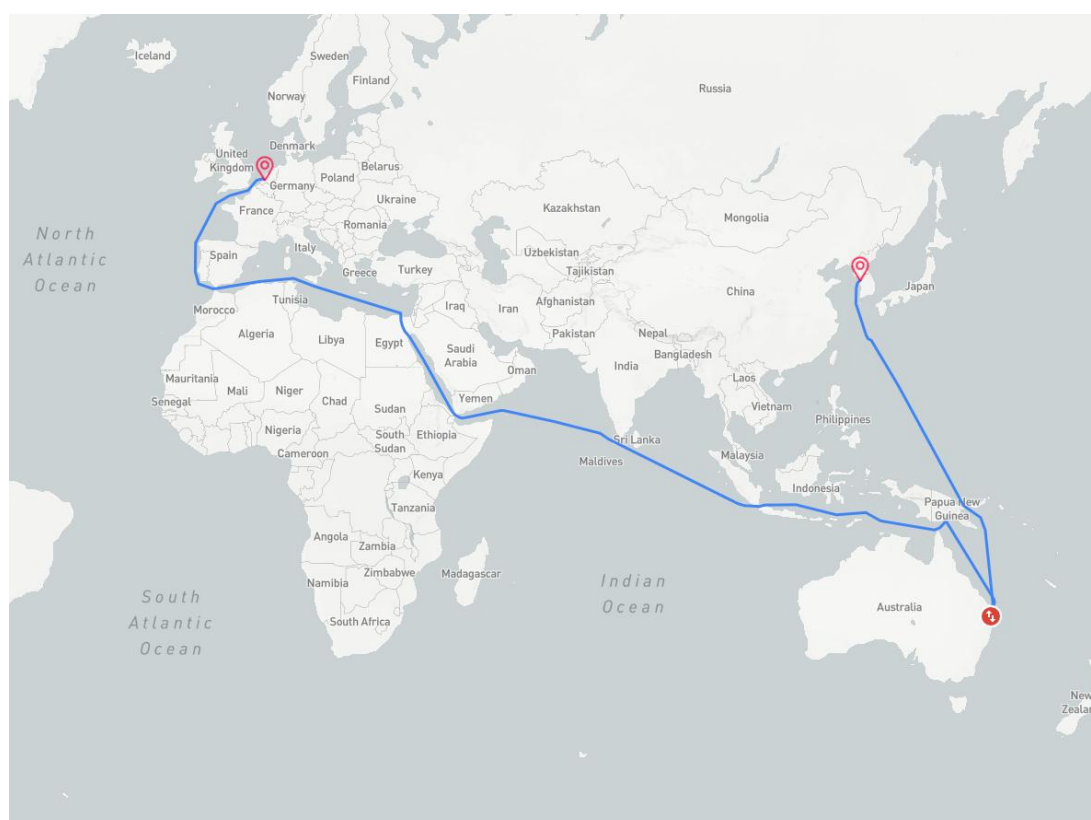


Figure 7: Longest Distance Panamax Baltic Index Route P4_82 from Asia to Australia East Coast and Rotterdam, Route Data from Searoutes.com, Map Data from OpenStreetMap (<https://openstreetmap.org/copyright>)

In addition to this long route, several of the key routes are also over 10,000 Nmi, such as US Gulf Coast to China and South America to China. This indicates that a successful

Panamax bulk carrier should have a range on the order of 10,000 NMi, even when powered by alternative fuels, in order to potentially serve a wider range of charters.

6.4.3. Capesize Bulk Carriers

The Baltic index standard capsize bulk carrier has the following basic parameters:

Deadweight: 180,000 DWT
 Draft: 18.2 m
 LOA: 290 m
 Beam: 45 m
 TPC: 121 MT/cm
 Carrying Capacity (Volumetric): 198,000 m³ (Grain)
 Design Speed: 14 knots laden/15 knots ballasted

As per the Baltic exchange index, this nominal vessel services 11 routes, of which seven were identified as unique as presented in Table 19.

Table 19: Capesize Bulker Trading Routes, from (Baltic Exchange, 2023), Distances calculated with Searoutes.com

Route Index	Origin	Destination	Commodity	Distance (Nmi)
C2	Tubarao	Rotterdam	160,000 MT Iron Ore	5024
C3	Tubarao	Qingdao	160,000 MT Iron Ore	11127
C5	West Australia (Port Hedland)	Qingdao	160,000 MT Iron Ore	3507
C7	Puerto Bolivar	Rotterdam	150-160,000 MT Coal	4385
C8_14	Puerto Bolivar	Hamburg	Not Stated	4679
C9_14	Rotterdam	Florianopolis	Not Stated	5677
	Florianopolis	Qingdao	Not Stated	11318
C16	Hamburg	Saldanha Bay	Not Stated	6439
	Saldanha Bay	Qingdao	Not Stated	8056

Based on this data, the longest haul routes are delivery of iron ore from Tubarao and Florianopolis (approximate port) in Brazil to Qingdao, and the expected cargo is iron ore, shown in

Figure 8. This represents a journey of approximately 11,300 Nautical miles, and so an appropriately designed alternatively fuelled vessel would ideally be able to sail this distance without requiring bunkering, though an option for bunkering in Singapore is present.

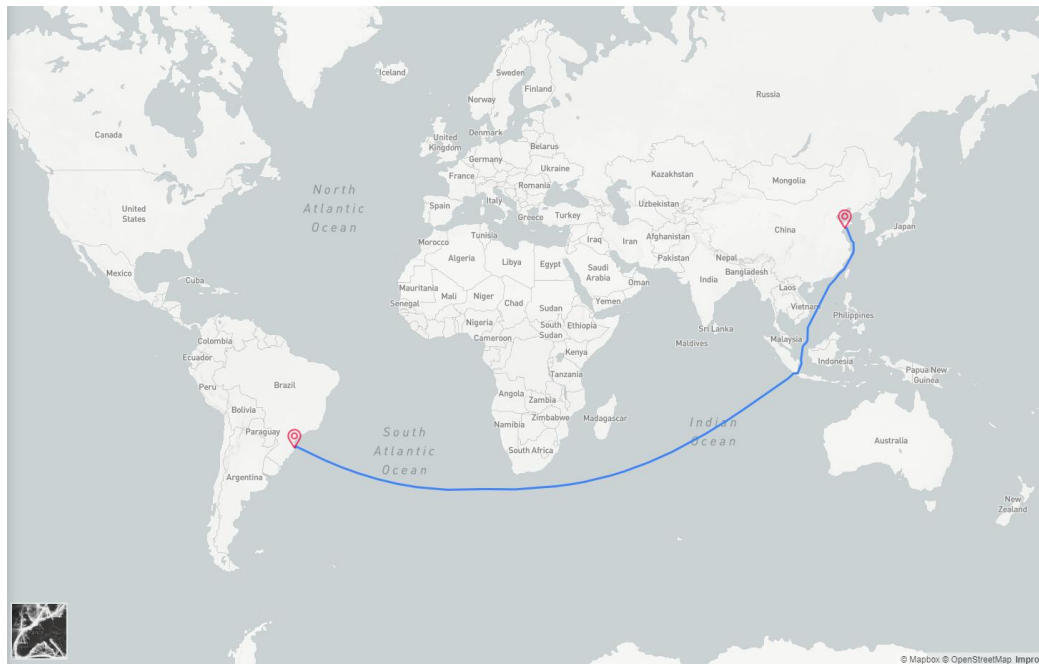


Figure 8: Longest distance Capesize Bulk Carrier Route C9_14, Florianopolis (Approximate departure port) to Qingdao, Route Data from Searoutes.com, Map Data from OpenStreetMap (<https://openstreetmap.org/copyright>)

Alternatively, the much shorter route from West Australia (Port Hedland) to China is considered to be one of the most important iron-ore and coal bulk transit routes (UNCTAD, 2022). If a Capesize bulker design were to be seriously compromised by adoption of alternative fuels, this route would represent a minimum endurance limit, and the resulting vessel would likely not be suitable for spot trading.

6.4.4. Discussion of Baltic Indices and Comparison to Other Bulker Trade Data

Precise information on what is carried by the various types of bulk carriers is not available from the Baltic index outside of a few specific routes serviced by Capesize bulk carriers, where iron ore is specifically highlighted for trade from South America to China and Australia to China, and coal is highlighted from South America to Europe (Baltic Exchange, 2023). Other types of cargo that can be carried are bulk foodstuffs such as grain, rice, soybeans, and animal feed, other types of ores such as bauxite, manganese, and nickel ore, and biomass or other raw materials such as forestry products (Walsh *et al.*, 2019; Getting to Zero Coalition, 2021). Currently, the iron ore trade dominates as the commodity most commonly carried by bulk carriers, as shown in Table 20 (Getting to Zero Coalition, 2021). However, the model of future trade of iron ore as presented by Walsh *et al.* (2017) indicates that the demand of iron ore will ultimately vary heavily depending on whether a 2°C global temperature goal is aggressively pursued, with

demand expecting to decrease in this case, or increase substantially if business as usual is pursued.

Table 20: Extract of Trade Corridors from Green Corridors Study (Getting to Zero Coalition, 2021), showing common bulk commodities, typical trade routes, and the percentage that commodity represents of the total presented

Bulk Cargo	Routes	Volume (Mega-MT, 2019 data)	Total Cargo Volume	% Total Cargo Volume
Iron Ore	Australia-China	689	1086	83%
	Brazil-China	212		
	Australia-Japan	62		
	Australia-South Korea	53		
	Brazil-Malaysia	29		
	South Africa-China	17		
	Brazil-Japan	13		
	Brazil-Netherlands	11		
Soybeans	Brazil-China	58	81	6%
	United States-China	23		
Bauxite	Guinea-China	38	69	5%
	Australia-China	31		
Manganese	South Africa-China	11	11	1%
Nickel Ore	Philippines-China	25	43	3%
	Indonesia-China	18		
Forestry Products	New Zealand-China	14	14	1%

Lifecycle analysis data is available for Panamax and Handymax bulk carriers, which were analysed by Gratsos et. al. (2010), with the nominal ships having deadweight tonnages of approximately 71,000 DWT for the Panamax size vessels and 45,000 DWT for the handymax vessels. These sizes are slightly smaller than the Baltic Index's nominal ship. Surprisingly, lifecycle studies have not been performed for capesize bulk carriers, which are primarily employed in the busy iron ore trade and represent the largest share of bulk cargo when measured by deadweight (Faber *et al.*, 2020).

6.5. Containership Trade Routes and Vessel Sizes

Containerships are one of the most important categories of trading vessels from a world emissions standpoint, because they as a category of ship types currently burn the most fuel (Faber *et al.*, 2020). This is because they typically operate at higher speeds than bulk carriers and oil tankers, and correspondingly higher power requirements.

6.5.1. Trade Routes and Required Sailing Distances

The most significant trade routes are highlighted in DHL's ocean freight market update (DHL, 2023), also presented in Table 21. Discounting the shorter-range Intra-Asia trade

(which is also partially handled by stopovers in multi-leg container delivery routes), the most significant international long-distance routes are Far-east to North America, Far-East to Europe, Far-East to the Middle-East and North Africa, and Far-East to Latin America. These top five routes represent a total container flow of 65 million TEU out of a potential total of 85.7 million TEU when disregarding the intra-Asia trade.

Table 21: Major Container Trade Routes and Volumes, from DHL (2023; 2024)

Trade Route	2023				2024			
	Delivery	Backhaul	Sum	Rank	Delivery	Backhaul	Sum	Rank
Intra Asia	42.1	42.1	-	1	39.2	39.2	-	1
Far-East to North America	23.8	3.6	27.4	2	24	6.8	30.8	2
Far-East to Europe	15.6	4.9	20.5	3	14.9	5.8	20.7	3
Far-East to Middle East and North Africa	6.7	2.6	9.3	4	8.3	2.5	10.8	4
Far-East to Latin America	6.3	1.5	7.8	5	4.6	1.7	6.3	7
Europe to Middle East and North Africa	3.3	3.2	6.5	6	3.8	3	6.8	5
North America to Europe	1.6	4.6	6.2	7	1.8	4.6	6.4	6
North America to Latin America	1.6	3	4.6	8	1.8	2.6	4.4	8
Europe to Latin America	1.7	1.7	3.4	9	1.1	1.8	2.9	9
Intra Middle East and North Africa	2.7	2.7	-	10	3.2	3.2	-	10

*Values in Million of TEU, sum is Delivery + Backhaul

The largest of trade flows are associated with the Far-East to North America, which in itself can be considered to consist of two sub-routes, Far-East to West Coast North America, and Far-East to East Coast North America via the Panama Canal. A good example of a far-east to west coast north America trade route would be Shanghai to Los Angeles (Drewry, 2023) shown in Figure 9, or the port of Yantian to Vancouver (CMA-CGM, 2023). In this case, the leg length is approximately 5,800 Nautical Miles.

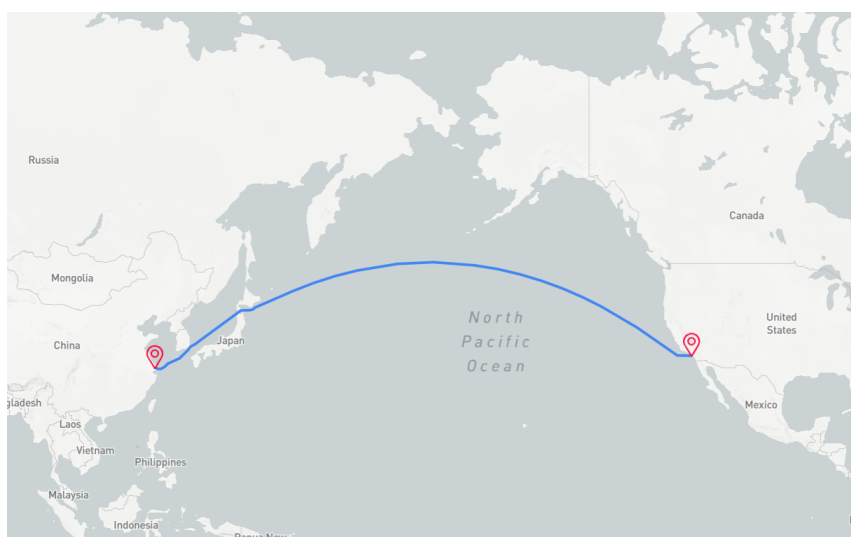


Figure 9: Typical Leg of a Far-East/US-West Coast Container Shipping Route – Shanghai to Long Beach (Los Angeles). Route Data from Searoutes.com, Map Data from OpenStreetMap (<https://openstreetmap.org/copyright>)

An example of a trade route from the Far-East to the US-West coast is the CMA-CGM Chesapeake Bay Express, which runs from several countries in Asia, starting at Singapore and then working up the east Asian coast stopping at Vietnam, China, South Korea, and Japan, before transiting the Panama Canal to Norfolk, trading along the south of the US East coast before departing to Singapore via the Suez Canal (CMA-CGM, 2023), shown in Figure 10. This is a good example of a very long trading route, with the Japan to US-East route requiring transiting approximately 9,600 Nautical Miles and the route from US-East to Singapore via the Suez spanning 10,900 Nautical Miles, circumnavigating the globe and representing the furthest sailing distance on CMA-CGM's routes.

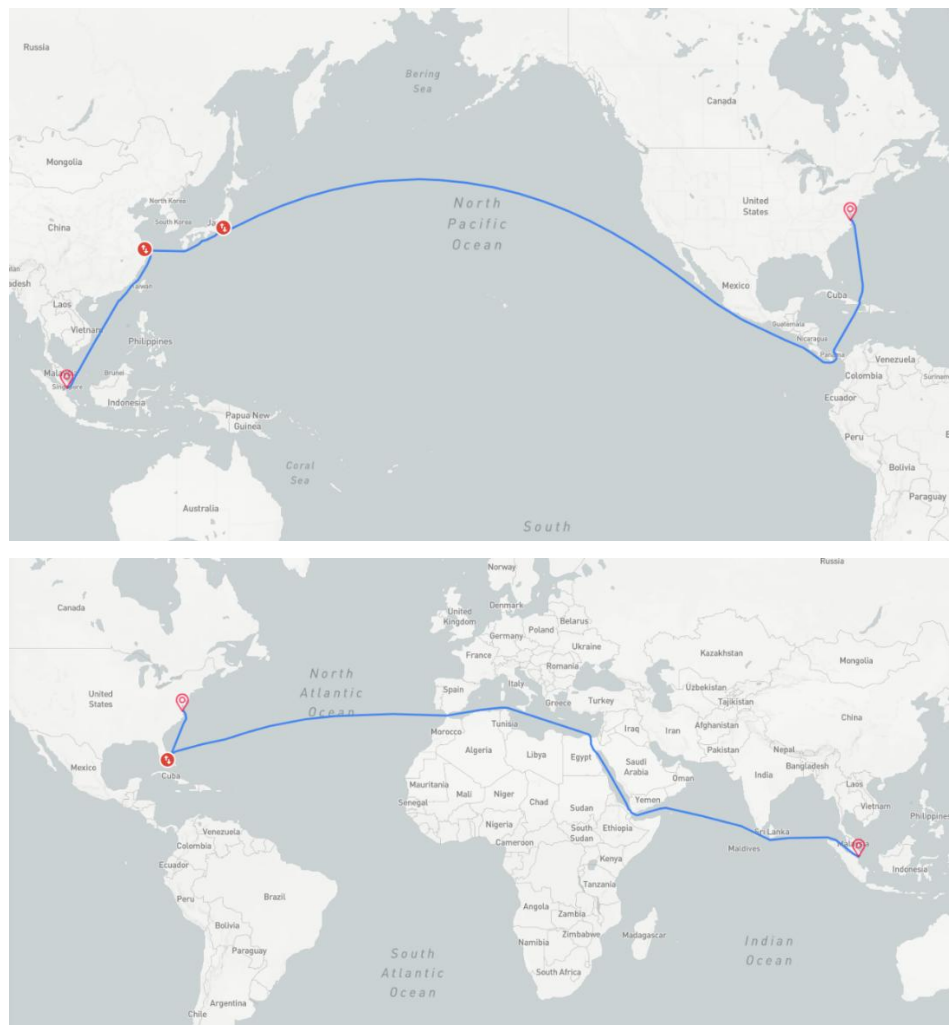


Figure 10: Abbreviated Example of the CMA-CGM Chesapeake Bay Express, a global circumnavigation route servicing the Far-East/US Trade. Route Data from Searoutes.com, Map Data from OpenStreetMap (<https://openstreetmap.org/copyright>)

The container trade volumes from the Far-East to Europe are also one of the most significant in the world, with the second highest trade volumes per the DHL report

(2023), and the highest weighting as per the World Container Index (Drewry, 2023). This route is known for utilizing the largest containerships (Ducruet and Berli, 2018), serviced by vessels too large for even the expanded Panama canal and with capacities of 20,000 TEU or greater. For example, the CMA-CGM Louvre, which is a 23,000 TEU LNG-powered containership, trades on CMA-CGM's FAL-1 Asia-North Europe line (CMA-CGM, 2023; ShipmentLink, 2023).

A good example of the Asia-Europe container route is presented in the Green Corridors report (Getting to Zero Coalition, 2021), with the longest leg in the presented route being between the ports of Colombo in Sri Lanka to Felixstowe in the UK via the Suez Canal, at 6850 NMi. However, there is naturally a large variability in the precise routing based on the shipping company. The longest route on the Asia-Europe trade was found to be 9,900 NMi between Hong Kong and Rotterdam based on Hanjin/Evergreen's CUS/CEM route (Wiegmans and Janic, 2019), shown in Figure 11.

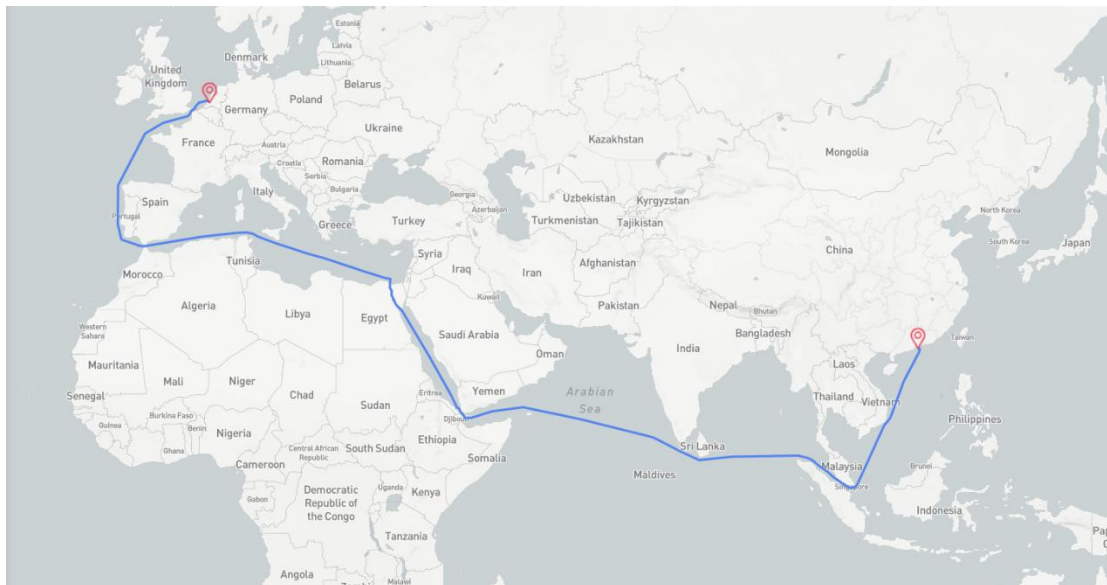


Figure 11: Example of a long-haul East-Asia to Europe container route via Suez Canal. Route Data from Searoutes.com, Map Data from OpenStreetMap (<https://openstreetmap.org/copyright>)

An example of modern ultra-large container carrier route is CMA-CGM's FAL3 line, running between China and Europe. This route employs some of the largest container vessels at between 17,000-23,000 TEU, and utilizes some alternatively powered vessels such as the LNG-powered CMA CGM *Jaques Saade* (CMA-CGM, 2023; M, 2020).

6.5.2. Container Vessel Sizing and Route Association

The fourth IMO GHG (2020) study divided containerships into size categories based on their TEU capacities, as shown in Table 22. This was also accompanied by data relating to the number of ships in each category as well as the total fleet capacity associated with that category.

Table 22: Containership Size Categorization based on 2018 data, from IMO 4th GHG Study (Annex Table 24)

Bin Size (TEU)	Size Category	Distribution by # Ships	Distribution by Capacity
100-2999	Feeder	56%	19%
3000-5999	Intermediate - Old Panamax	21%	23%
6000-7999	Intermediate	5%	9%
8000-11999	Neo-Panamax	12%	27%
12000-14999	Neo-Panamax	4%	14%
15000+	Post-Panamax	2%	9%

While feeder containerships (100-2999 TEU) are the most numerous by number, their total capacity is outstripped by the capacities of the old panamax (3000-5999) type vessels and the 8,000-12,000 TEU previous post-panamax vessels, now reclassified as neo-panamax type vessels. It is also interesting that while the Post-Panamax ultra-large containerships of 15,000+ TEU make up only 2% of the fleet by number, they manage to carry 9% of the cargo capacity.

Current trends outlined in the IMO 4th GHG study also indicate that the fleet composition is likely to change in the future (Faber *et al.*, 2020). Smaller vessels are expected to be phased out because of future port development, while Panamax vessels in the 3,000-5,000 TEU range are expected to be gradually replaced by neo-panamax vessels up to around 15,000 TEU. It is predicted that the very large containership fleet will also continue to grow to serve the Asia-Europe trade routes. However, for these very large containerships, it is also expected that they're both approaching their maximum feasible size due to technical limitations of the Suez canal (Jean-Paul *et al.*, 2020) as well as speculation that they are falling into disfavour by shipping companies due to issues with filling rates, logistical inflexibility, port waiting times, and insurance costs (Container-XChange).

Based on the most common types of containerships, the projected trends in containership sizes, and the associated routes, the following three containership types

are representative of the world fleet and good candidates for further examination of alternative fuels:

- Post-Panamax containership, 6,000-6,500 TEU capacity, servicing the Asia-US East trade route (minimum range of 6,000 NMi)
- Neo-Panamax containership, 14,000-14,500 TEU capacity, servicing the Asia-US West trade route (minimum range of 11,000 NMi)
- Ultra-large containership, 20,000 TEU+ capacity, servicing the Asia-Europe trade route (minimum range of 15,100 NMi)

The selection of a post-panamax size of between 6,000-6,500 TEU agrees with the 4th IMO GHG study (Faber *et al.*, 2020), which states that the average containership in 2050 is expected to be approximately 5,800 TEU in size. Containerships in the 5,500-6,500 TEU range are also noted to be quite flexible with regards to port and market access (Jean-Paul *et al.*, 2020), and so are likely to remain in demand into the future. These types of vessels establish a lower bound on the most likely containership size for future international trade.

Neo-Panamax containerships transiting the expanded Panama canal are expected to meet the very high demand of the Asia-US container market, while also being of sufficient size to be competitive on the Asia-Europe market, especially where access to ports not capable of handling ultra-large containerships is required. These represent a good mid-size containership for examination of performance with alternative fuels, with also long endurance requirements.

The Ultra-large containerships also serve as an interesting design study for the implementation of alternative fuels. They represent the upper bound of containership sizes, have a long endurance requirement, move large volumes of cargo, and are expected to continue to be relevant in the future. The example of the LNG-powered 23,000 TEU CMA CGM *Louver* or the 17,000 TEU Methanol powered vessels ordered by Maersk (Rasmussen, 2022) indicates that container shipping companies are already experimenting with alternative fuels for containerships above the neo-panamax size.

6.6. Case Study Selection

Based on the literature review assessing the world international trading fleet and associated routes, the ultra-large container carrier was selected for use as the case

study vessel in this research. There are several reasons this vessel is the most interesting to examine:

- Largest endurance requirements: The volumetric energy density penalty of alternative fuels would pose a larger challenge because bunkering facilities are not easily accessible.
- Cargo Capacity Impact: Unlike bulk carriers or oil tankers, fitting type-C tanks on deck is not feasible. This means cargo capacity will be negatively impacted if fuel tanks need to be much larger than for conventional fuel
- Growing relevance: It is expected that the fleet of ultra-large container vessels will continue to grow to meet projected cargo demands between the EU and Asia, and thus they will take up a larger portion of the fleet by TEU capacity, but will similarly need to meet the more stringent environmental requirements being phased in by IMO

The other vessel types highlighted in this literature review are all good candidates for study with the methodology presented in this research, especially the smaller container vessels, but the ultra large container vessel type has some unique interactions with the drawbacks of alternative fuels that make it the most interesting to study in-depth. If this methodology is applied to the rest of the vessel types identified in this literature review, it would allow for an assessment of the impacts of alternative fuel adoption on a sizable and representative cross section of the world fleet.

7. Alternative Fuels

7.1. Types of Fuels

The case study investigated the following different fuel types and sub-types:

- HFO – Primarily the VLSFO variant to meet sulphur emissions requirements without the use of a scrubber. Considered a “grey” fuel in all cases.
- MGO – Primarily as pilot fuel for alternative primary fuels. Considered a “grey” fuel in all cases.
- Biodiesel – Primarily as a pilot fuel for alternative primary fuels. Considered as “green” or “biogenic” fuel to be used in conjunction with alternative fuels.
- LNG – Both Fossil (“grey”) and Bio-Methane (“biogenic” or “green”)

- Ammonia – Both Fossil (“grey”) and Bio-Ammonia (“biogenic” or “green”)
- Methanol – Both Fossil (“grey”) and Bio-Methanol (“biogenic” or “green”)
- Hydrogen – Both Fossil Hydrogen (“grey”, as produced from methane) and E-hydrogen from electrolysis (“green”)

The properties of the fuels are presented in Table 23.

Table 23: Primary Characteristics of Alternative Fuels (Baker *et al.*, 2022; MEPC.376(80), 2017)

Fuel Type	Lower Calorific Value (LCV)	Density	Volumetric Energy Density	CO ₂ Emissions Factor	Carbon Mass
-	MJ/kg	kg/m ³	GJ/m ³	g-CO ₂ /g-fuel	g-C/g-fuel
HFO/VLSFO	40.2	980	39.4	3.11	-
MGO/Bio Diesel	42.7	860	36.7	3.21	2.83
LNG	48.0	462.5	22.2	2.75	2.75
Methanol	19.9	784	15.6	1.38	1.38
Ammonia	18.6	758	14.1	0.00	0.00
Compressed Hydrogen	120.0	42	5.0	0.00	0.00
Liquid Hydrogen	120.0	71	8.5	0.00	0.00

7.2. Fuel Storage and Bunkering Requirements

The various fuels have unique storage requirements that have a large impact on how they can be carried onboard a vessel. The critical parameters of the various fuels from an arrangement standpoint are summarized in Table 24.

Table 24: Summary of Critical Parameters of Fuels from an Arrangement and Storage Perspective (Baker *et al.*, 2022; ABS, 2024; ABS, 2019a; IMO, 2015)

Fuel Type	Pressure	Temperature	IGF Requirements?	Low Flashpoint Fuel?	Suitable Tank Types
-	bar	°C	-	-	-
HFO/VLSFO	Atmospheric	Ambient - Heating for Pumping	No	No	Hull/Standard
MGO/Bio Diesel	Atmospheric	Ambient	No	No	Hull/Standard
LNG	0.25 (Membrane) 0.7 (Type A and B) 10 bar (type C)	-163 °C	Yes	Yes	Membrane, Type-A, Type-B, Type-C
Methanol	Atmospheric	Ambient	Yes	Yes	Hull/Stainless Steel w/ Cofferdams and if at shell below WL
Ammonia	8 Bar/Ambient Temp.	-33 °C/Atmospheric Press.	Yes	No	Membrane, Type-A, Type-B, Type-C
Compressed Hydrogen	700 bar	Ambient	Yes	Yes	Type-C - Extremely High Pressure
Liquid Hydrogen	<1 bar	-253 °C	Yes	Yes	Type-C - Special Insulation

7.2.1. Hull Tanks

Standard hull tanks with appropriate arrangements to comply with MARPOL 12A requirements are used to store HFO/VLSFO, MGO/MDO, and Biodiesel. These are the types of tanks typically used in ships today, as shown in Figure 12.

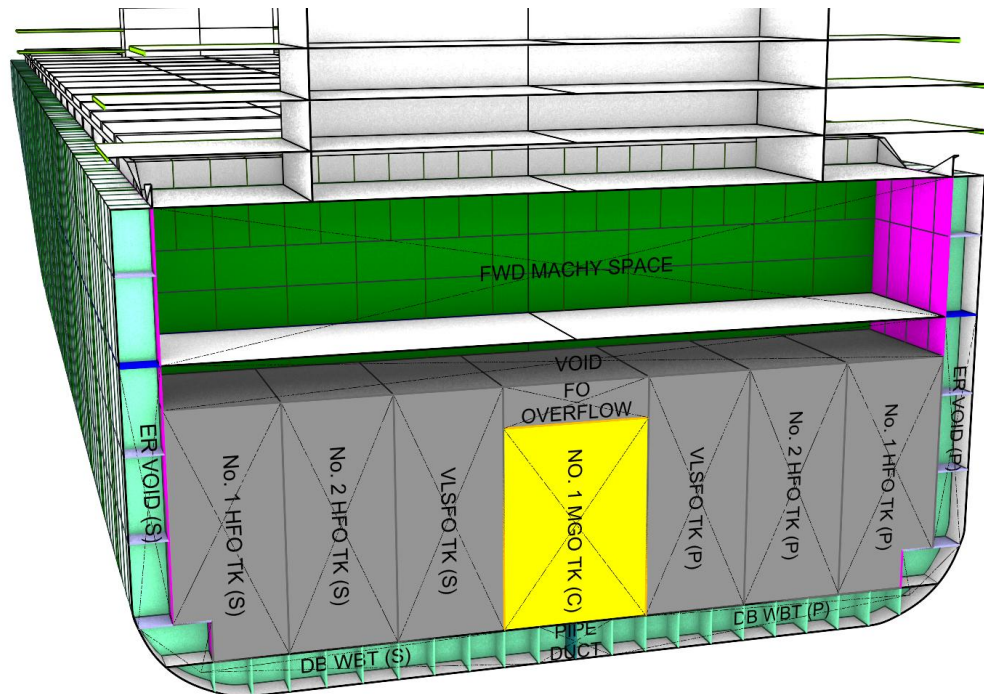


Figure 12: Conventional Hull Tanks for Fuel Oil

Methanol, unique amongst the alternative fuels, can also be stored in conventional hull tanks. However, these tanks should be made of stainless steel or require special coating (Baker *et al.*, 2022), must not be in accommodation or engine spaces, and should be separated from all spaces except the fuel preparation room or adjacent methanol tanks by a 600mm cofferdam. Methanol can also be stored in hull tanks adjacent to the shell so long as their maximum fill level is below the lowest possible waterline of the vessel and the fore- and aft- ends are separated with the appropriate cofferdams (ABS, 2024). Methanol could be stored in any of the other tank types described, but there is usually a loadable volume penalty associated with doing so.

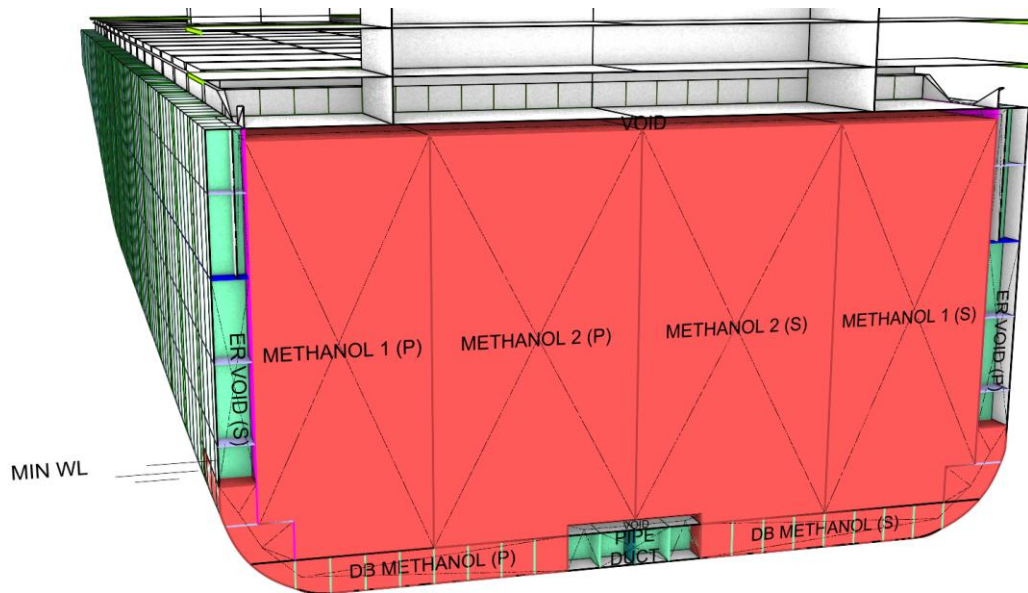


Figure 13: Hull Tanks arranged for Methanol Fuel

7.2.2. Membrane Tanks

Membrane tanks are commonly used for LNG storage and are potentially useful for the storage of Ammonia as well (Chambers, 2021). Membrane tanks are built into the hull of a vessel with layers of insulation and thin membranes of steel or other material containing the fluid (IMO, 1975). Membrane tanks are suitable for pressures up to 0.25 bar, which means that measures must be taken to handle boil-off gases such as reliquification, venting, flaring, or use.

LNG stored within membrane tanks is typically kept at $-163\text{ }^{\circ}\text{C}$, while ammonia can be stored at $-33\text{ }^{\circ}\text{C}$.

Figure 14 shows a cross section through a representative LNG membrane cargo tank.

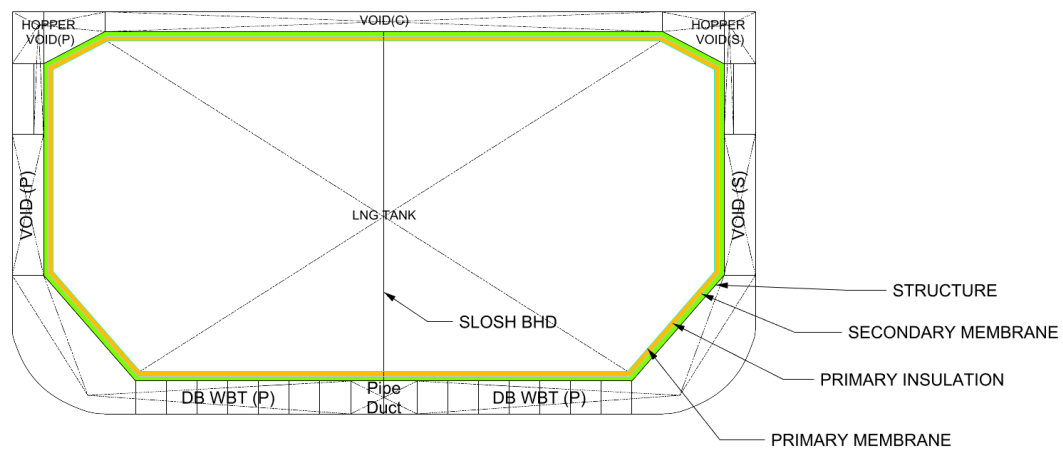


Figure 14: Example of a Membrane LNG Cargo Tank (Chakraborty, 2019)

7.2.3. Type A and B Tanks

Type A and B tanks are structurally independent tanks surrounded by insulation that are connected to the adjacent hull structure through a set of support chocks and keys that permit thermal expansion and contraction while arresting all degrees of freedom. The difference between the two types is the rule set used for construction, with type-A tanks utilizing normal ship design rules and type B tanks utilize more advanced analysis techniques (IMO, 1975). The most recognizable type-B tanks are the spherical “Moss Type” LNG storage tanks, but in practice they can also be made in prismatic shapes. The secondary barrier has different requirements between the two types of tanks as well, where type A tanks require a complete secondary barrier and type B require a partial secondary barrier. The secondary barrier means the compartment surrounding the tanks must be capable of containing the leakage from the tanks for a minimum of 15 days (IMO, 2015).

Type A and B tanks are typically limited to a maximum pressure of 0.7 bar (IMO, 2015), which means they can handle more internal pressure and accumulation of boil-off gases than a membrane tank but still must address boil off gasses regularly.

Similar to membrane tanks, Type A and B tanks are suitable for the storage of LNG or Ammonia at low temperatures.

Figure 15 shows a typical ship cross section of a type A or B fuel tank with associated pilot oil.

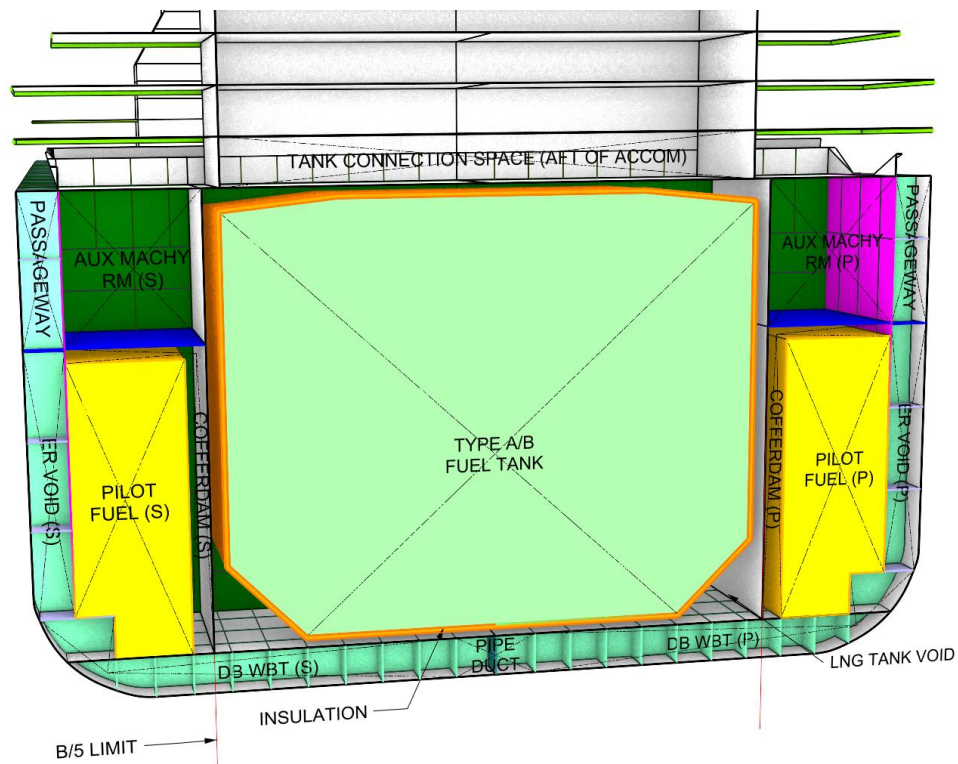


Figure 15: Cross-Section Showing Type A/B Prismatic Type Fuel Tank and Pilot Oil Tanks

7.2.4. Type C Tanks

Type C Tanks are structurally independent tanks typically in a cylindrical shape but meeting pressure vessel regulations (IMO, 1975). Type C tanks do not require a secondary barrier. Type C tanks can be used for LNG, Ammonia, Compressed Hydrogen, and Liquid Hydrogen with the correct insulation.

For LNG, type C tanks still require the methane to be kept at low temperatures, but have a much higher tolerance for pressure build up, typically 10 bar (Baker *et al.*, 2022). This allows for a longer period before reliquefaction or use/venting of the boil off gas is necessary, which in turn allows for greater operational flexibility, for example the ability to finish cargo operations at pier while on shore power without the added power demand from reliquefaction. However, type C tanks are less volumetrically efficient than either membrane or type A/B tanks.

For Ammonia, it is possible to design the type C tank to withstand a pressure of 8 bar, which would allow the ammonia to be stored in a liquid form without any cooling (Baker

et al., 2022). This makes type C tanks very useful for dual fuel ammonia/LNG vessels, and ammonia stored in such a manner will have no issues associated with boil-off gas.

Hydrogen can only be stored in type C pressure vessel tanks, and this provides two options: liquified hydrogen or compressed hydrogen. Compressed hydrogen is stored at pressures up to 700 bar, which poses substantial challenges to the tank design. Typically a combination of steel, aluminium, and carbon fibre will be required to hold the compressed hydrogen at such extreme pressures. The tanks will also necessarily need to be small and numerous to keep stress levels within acceptable limits with existing technology (Baker *et al.*, 2022). Alternatively, hydrogen can be stored in liquid form at temperatures of -253 °C and pressure less than 1 bar. A double-walled tank with a vacuum or glass bead insulation coupled with a multi-stage helium cooling unit is required to reach such low temperatures (ABS, 2022).

Type C tanks can have several different shapes aside from the classic cylinder pressure vessel to maximize usable volume within the hull. Such alternative type C tank designs include the bi-lob and tri-lobe design (Kalyanaraman, 2020) or elongated pressure vessel design (as described by an LNG system supplier), shown in Figure 16 and

Figure 17.

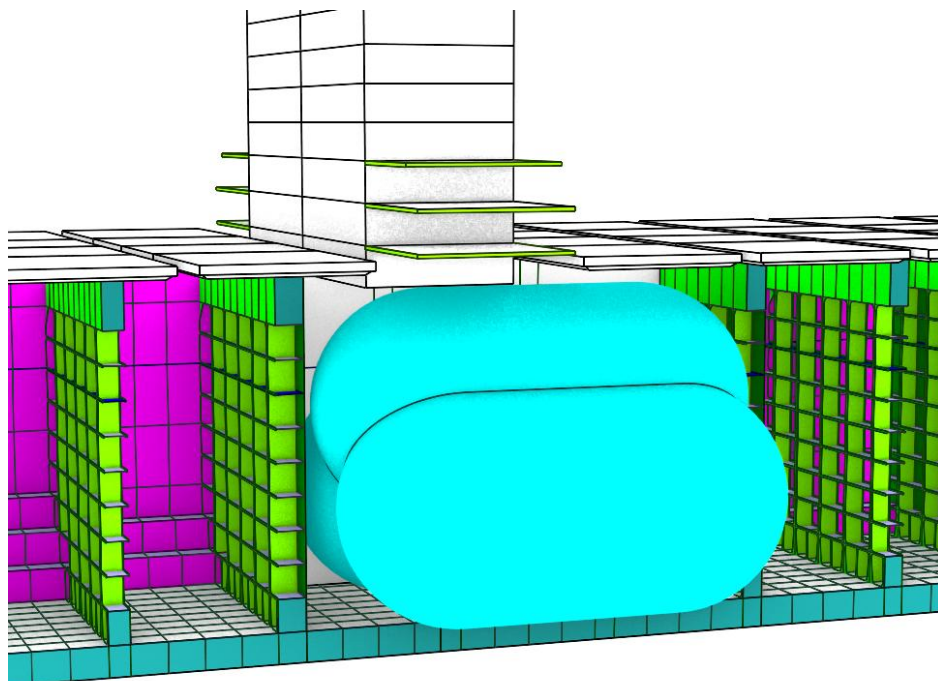


Figure 16: Example of Tri-Lobe Type C Tanks

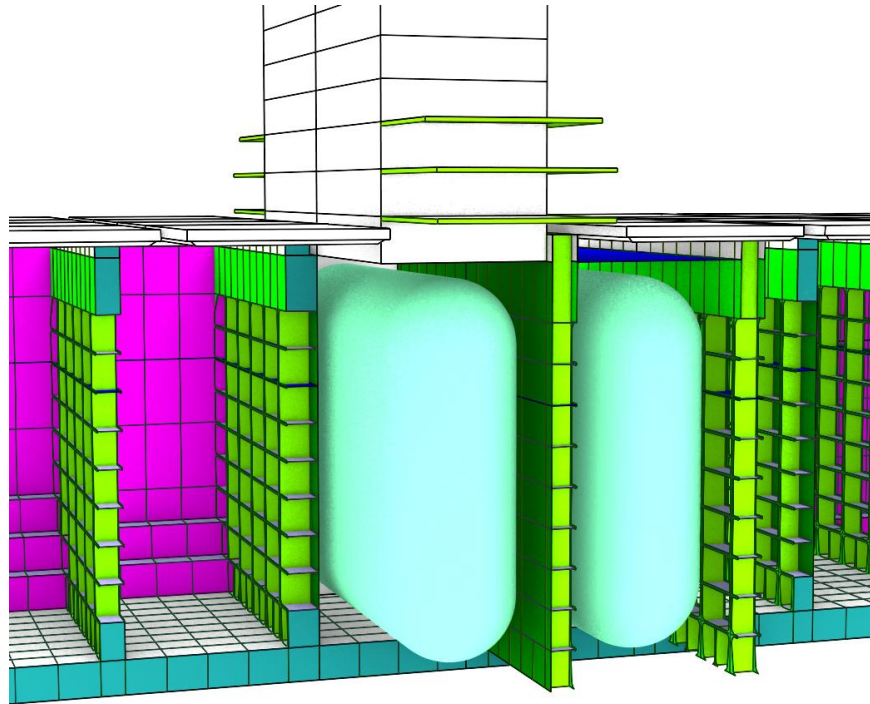


Figure 17: Example of Elongated Type C Tanks, stored transversely in the vessel

7.2.5. Tank Location Requirements

The requirements for location of tanks, machinery, and piping are outlined in detail in the IGF code. From the perspective of overall arrangements, the key requirements are that the fuel tanks must be located to minimize the possibility of damage from collision and grounding. To accomplish this, the IGF code requires the tanks to be within $B/5$ inboard from the shell, or 11.5m whichever is lesser. The tanks must also be aft of the collision bulkhead and above $B/15$ or 2m whichever is less. As alternative to the above prescriptive requirements, the required boundaries of the tank can be set such that the probability of breach from any direction in the event of an impact is less than 4%, using a similar method to calculate the probability as from the SOLAS probabilistic damage stability calculations (IMO, 2015).

Since all vessels using alternative fuels are required to comply with the IGF code, these arrangement limitations are applicable to all of the alternative fuel storage with the exception of Methanol, which has its own set of requirements (ABS, 2024). These

requirements for the safe storage compounded with the special tank designs and the lower volumetric energy density make it challenging to carry enough alternative fuel to match the range of HFO powered vessels.

7.2.6. *Bunkering Requirements*

Bunkering requirements for the various alternative fuels are also outlined in the IGF code and various classification society rules. The general requirements are that the bunkering station should be on open deck, but the associated piping should be protected from damage. Spills must be capable of being contained and not damage the surrounding structure. The bunkering system should avoid releasing gas to the atmosphere and inert gas is also typically required for most alternative fuels (IMO, 2015).

There are also special considerations for transferring the different types of fuels themselves, typically requiring a dedicated bunkering equipment skids and davits to be installed near the bunkering station. The result is that the bunkering station for alternative fuels tends to take up more deck space than for traditional fuels. For oil tankers and bulk carriers where there is spare deck space, this is usually not an issue, but for containerhips it is more challenging to meet these requirements and results in the loss of some cargo capacity, usually around 4 containers slots on each side from the outboard most stack plus a full stack on each side in the hold below. The bunkering station also counts as a hazardous area and generally needs to be away from the accommodation and engine room spaces. This can be an issue if the fuel tanks are underneath the accommodation, as would be typical for a large containerhip with a forward deckhouse. (MMMCZCS and Seaspan, 2023).

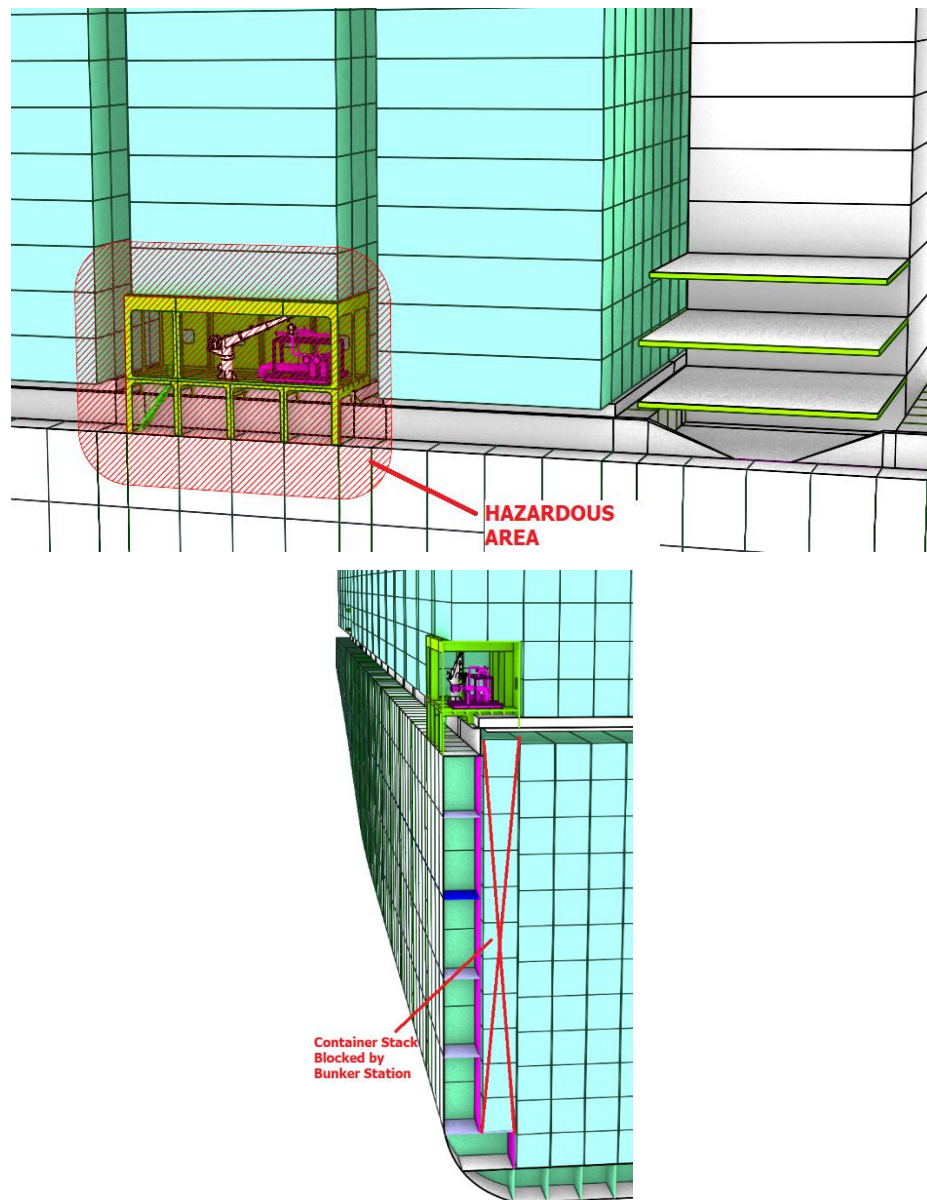


Figure 18: Example of Bunkering Station for Alternative Fuels on Container Carrier, showing Slot Losses

8. Methodology

8.1. Overview

The methodology developed in this research allows for normalized, parallel performance and comparative lifecycle emissions assessments focusing on CO_{2Eq} to be carried out for a given ship design and derivative designs. This methodology is then applied to a case-study vessel to examine some of the implications of adopting alternative fuels and scaled to a fleet of such vessels. The methodology is applicable to the basic or conceptual design level depending on the available data.

The methodology consists of the following general steps, also shown in Figure 19:

1. Establish critical parameters for the lifecycle assessments such as functional unit, reference flow, system boundaries, and cutoff criteria. This methodology will advise what parameters were implemented in the case study and why.
2. Selection of a parent conventionally powered vessel with defined operating parameters at a minimum.
 - a. Calculation of lightweight, speed-power, stability, and cargo capacity for the conventionally fuelled baseline ship.
 - b. Collation of fuel consumption data for prime movers, auxiliary engines, and auxiliary equipment for all conventional and alternative fuels that are being investigated.
3. Alternative fuel consumption data must now be collected so fuel consumption quantities can be calculated. Fuel consumption data for the chosen prime mover, auxiliary power generation plants, and boilers (if applicable) should be gathered or estimated.
4. Development of a set of design operating conditions for the purposes of tank sizing. This consists of the calculations associated with fuel consumption such as transit speed, transit distance, auxiliary engine load, boiler load, minimum and maximum tank filling levels, and bunkering frequency. Fuel consumption for each of the consumers and alternative fuels should be tabulated so the required tank sizes can be determined for multiple scenarios.

5. Selection of tank sizes for each of the alternative fuels, matched with an appropriate operating scenario that provides the required endurance without unduly limiting the operating profile of the vessel.
6. Creation of alternatively fuelled derivative designs based on the parent vessel and storage requirements for the relevant alternative fuel.
 - a. Calculation of change in lightship weight, cargo capacity and any other operating parameters (such as bunkering frequency or speed) for the alternative fuelled vessels relative to the baseline vessel.
7. Conduct a lifecycle inventory for the shipbuilding phase for the parent and derivative designs, recommending using the lightweight of the vessel as the primary input, surface area, welding weight/length are the three required inputs
8. Conduct a lifecycle inventory for the maintenance phase, utilizing the same approach as for the shipbuilding phase with reduced values for renewed steel, painting area, and additional welding/cutting. Aggregate each of the expected maintenance periods into one single maintenance value.
9. Conducting a lifecycle inventory for the operational phase.
 - a. First identify a representative route that the vessel will be trading. Identify the distance, average speed, time in port, and idle/waiting time for this route.
 - b. Identify the power required from the main engine, auxiliary engines, boilers, and shore power, and cargo re-liquefaction (if necessary).
 - c. Using the required power and the associated specific consumptions inventory the required input fuel, pilot fuel, lube oil, urea, NaOH.
 - d. Utilizing emissions factors taken from the 4th IMO GHG study, inventory the emissions from the combustion of the fuel and methane slip.
 - e. If desired, at this stage the tank-to-wake CO_{2Eq} work transport ratio can be calculated for the operational phase of the ship, representative of one journey.
10. Using the inventory of required inputs for the operational phase, utilize tank-to-wake emissions factors to inventory the emissions associated with the required input fuels and electricity.
 - a. These are then added to the tank-to-wake factors to yield the well-to-wake inventory of emissions.

- b. The $\text{CO}_{2\text{Eq}}$ work-transport ratio of a single trip from a well-to-wake standpoint can be calculated now if desired.
11. Conduct a lifecycle inventory for the shipbreaking phase. The methodology proposed in this research is very simplistic and involves simply the lightweight of the vessel.
 12. Combine the lifecycle inventories from each of the phases. Note that the Operational emissions values should be multiplied by the total number of round trips expected in the vessel's lifetime based on the assumed operational profile and schedule.
 13. The lifecycle inventory is now complete, and the lifecycle impact assessment and fleet assessments can be carried out.
 14. For each design, determine an "additional ships factor" on the basis of the ratio of the cargo carried multiplied by the kilometres travelled for the conventional ship relative to the alternatively fuelled ship. If the ratio is greater than 1, that indicates more ships are necessary to convey the same amount of cargo the same distance utilizing alternative fuels, and vice versa.
 15. Multiply the lifetime $\text{CO}_{2\text{Eq}}$ work-transport derived from the lifecycle analysis by the additional ship factor and compare against the conventional ship. This will highlight if a given alternatively fuelled design will have a larger global warming impact than a conventionally powered ship on a fleet basis.
 16. Additional variations can be explored, such as normalizing the amount of cargo delivered between the designs by increasing the number of deliveries a vessel can make in a lifetime by travelling faster, instead of constructing additional ships.

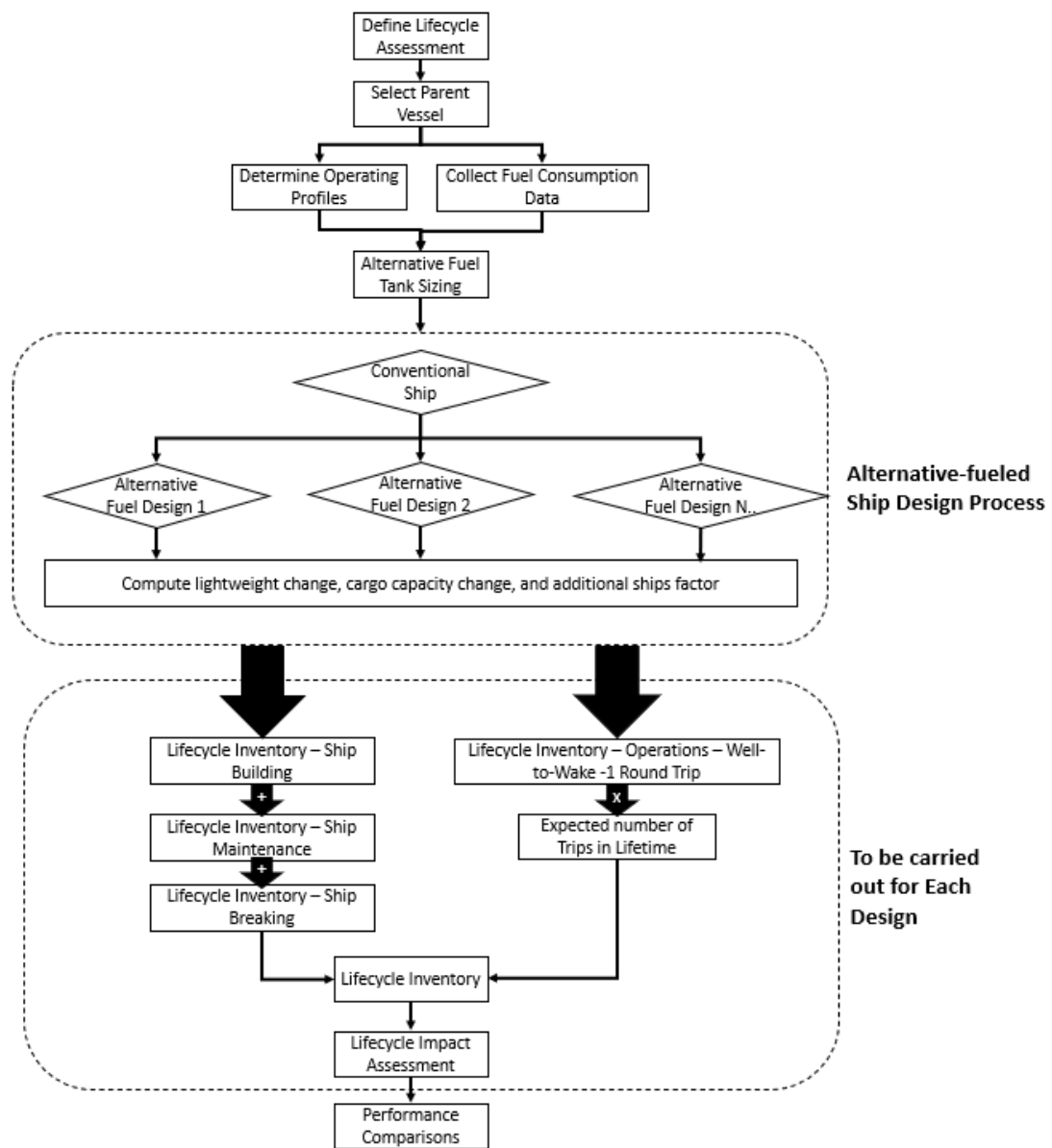


Figure 19: Overview of Methodology Steps

8.2. Lifecycle Goal and Scope Definition

As per ISO 14040 and 14044, the critical parameters to establish in this step are defining the goals of the lifecycle assessment, assessment criteria, the functional unit, the reference flow, and the system boundary. Exclusion criteria should also be discussed. For this methodology, the following guidance is provided:

- **Goals:** This methodology presents a comparative lifecycle assessment where the lifecycle emission and work-transport performance of a conventionally powered vessel is compared to derivative designs utilizing alternative fuel. The

result is several parallel lifecycle assessments that are directly comparable with one another, which are normalized on the basis of transported cargo.

- **Assessment Criteria:** The lifecycle assessments focus on CO_{2Eq} emissions, though additional data is inventoried if available and can be used for the calculation of other impact categories if desired. The CO_{2Eq} is both reported on its own and normalized by work-transport factors.
- **Functional Unit:** The functional unit for this analysis is cargo, typically measured in metric tons. More than one functional unit is permitted, and cargo as measured in deadweight tons for the vessel, delivered cargo in MT, or TEU in the case of containerhips are all valid functional units. The functional unit is frequently normalized by the distance travelled by the vessel, to MT-km or TEU-km.
- **Reference Flow:** A ship is the reference flow for each of these lifecycle analyses, and the “additional ships factor” is what is used to scale the functional unit for the various designs. The presented methodology results in the generation of several similar ships powered by differing fuels, which allows their output with reference to the functional unit to be consistent.
- **System boundary:** The proposed system boundary is shown in
- Figure 20.

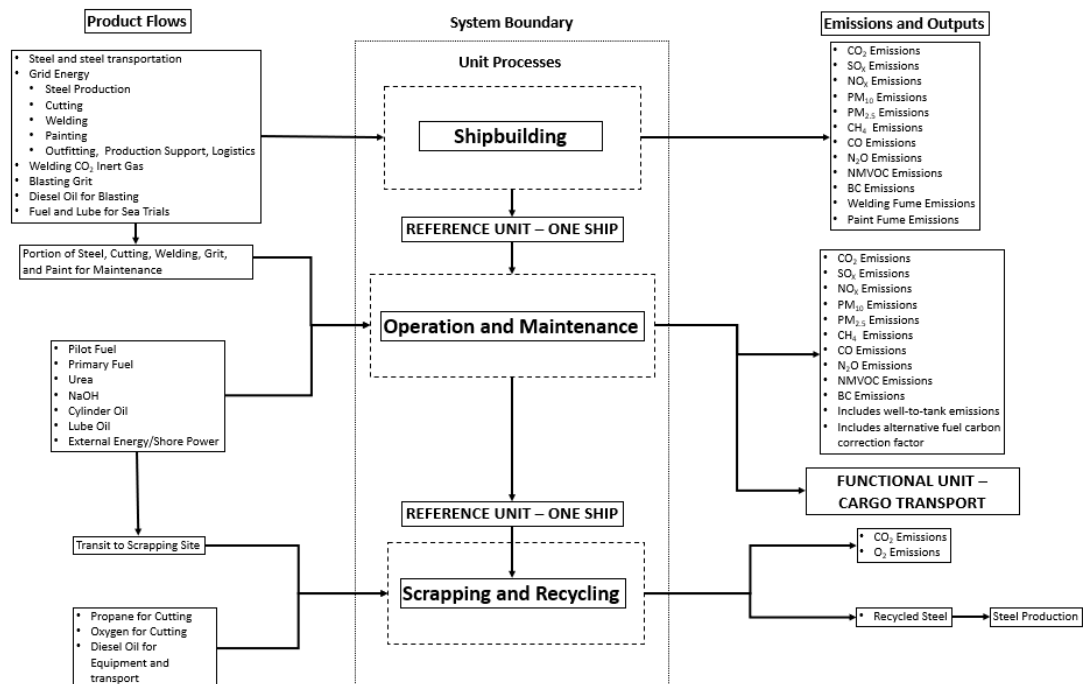


Figure 20: System boundary of lifecycle analysis from the method developed in this research

- **Exclusion criteria:** This analysis is intended to be applicable to the basic and conceptual design stages, therefore the available data is limited. The following exclusion criteria are applied to allow the assessment to be carried out in the early stages of the design:
 - The lightweight of the vessel is assumed to be composed entirely of steel. As described in the literature review, a much more detailed breakdown of the vessel's lightweight, typically available at a more advanced stage of the design, is required to formally inventory a ship, since it is composed of so many differing product flows. For other components that are available, such as the main engine and machinery, these are still mostly composed of steel, but it is acknowledged that by assuming they are just steel, all of the additional emissions associated with those product flows are neglected.
 - Scrap steel produced in the shipyard is ignored. It can be assumed to be reused or re-cycled nearby. The quantity of scrap steel is also an estimate at +10% of the lightweight of the vessel (Fet, 1998), minus losses from cutting.

- Crewing product flows such as food, transportation, and freshwater consumption is ignored. Freshwater is both consumed by the crew, used by machinery, and used for washing purposes. Freshwater generated onboard is inherently captured in the base energy demand of the vessel while at sea.
- The scrapping phase implements the method from Rahman, Handler and Mayer (2016) which primarily tabulates CO₂ emissions. While substantial other local emissions are expected from the scrapping process, they are neglected because of the early design stages and simplification of the lightweight into steel. This is justified due to the dearth of data and regional specific nature of ship scrapping (Favi *et al.*, 2018).

8.3. Selection of the Parent Ship and Trade Route

The next step in applying this methodology is to select a ship to serve as the baseline or parent ship, from which the derivative designs can be produced. The steps for the lifecycle assessment are generic enough to be applied to any relatively similar ships and the baseline ship need not necessarily be conventionally fuelled. However, for the goals of this research and the case study, an HFO powered ship was selected with a low-speed diesel and its principal parameters and hull form were not varied for any of the derivative designs.

At a minimum, the selection of the baseline ship should be made so that the lightweight, speed-power, and cargo capacities can be determined. Stability is an optional assessment parameter, but it should be included in case stability concerns limit the cargo capacity. Strength and hull girder bending concerns can be neglected unless essential for establishing the lightweight.

The prime mover, auxiliary engines, and auxiliary equipment such as boilers must also have consumptions that are known or can be estimated. It is recommended to use values from manufacturers where available, such as MAN project guides for low-speed diesels and auxiliary diesel generators. The consumptions of the boiler can be estimated using data from the IMO 4th GHG study (IMO 4th GHG Study *et al.*, 2020).

A nominal trade route must also be established for the baseline ship that the alternative fuelled ships would also be capable of sailing.

8.4. Collation of Alternative Fuel Consumption Data

Prior to sizing the tanks and calculating the consumption of the various alternative fuels, data on the fuel consumption for the prime mover, auxiliary engines, and boiler must be obtained. This will allow the energy demand from the vessel's operational conditions derived in either MJ or kW-hrs to be converted into a quantity of fuel necessary to be stored on board the vessel. These can collectively be referred to as energy converters, as they convert the energy stored in the fuel into usable energy such as motive power or electricity, with varying levels of efficiency. In the modern international fleet, the most common forms of energy converters are low-speed diesel, auxiliary diesel generators, and boilers (IMO 4th GHG Study *et al.*, 2020), but in practice any form of energy converter such as fuel cells or boilers and steam turbines can be used with this methodology so long as their energy conversion efficiency is known.

Note that if the impact of speed variation is intended to be investigated, the fuel consumption needs to be calculated at a range of power levels for at least the prime mover.

The case study used in this research investigated low speed diesels, which are suitable for the combustion of all alternative fuels, even hydrogen (Serrano, Jiménez-Espadafor and López, 2021), though they may require pilot fuel. MAN already has fuel consumption data available for a range of low- and medium-speed diesel engines powered by traditional fuels, methane, and methanol. As of 2024, data for ammonia powered engines is imminent but has not yet been published. However per a webinar discussion, MAN has indicated that the pilot oil heat rate for the low speed diesels is approximately 5%, similar to methanol (MAN, Hansen and Bidstrup, 2024). The concept of heat rate allows for the fuel consumptions of alternatively fuelled engines to be estimated for ammonia and hydrogen, which do not have manufacturer data available.

Heat rate is defined as:

$$\text{Heat Rate} = \text{SFC} * \text{LCV}_{\text{Fuel}} + \text{SPOC} * \text{LCV}_{\text{Pilot oil}}$$

Where SFC is the specific consumption of the primary fuel in g/kW-hr, LCV_{Fuel} is the lower calorific value of the fuel in MJ/kg, SPOC is the specific pilot oil consumption, and $LCV_{Pilot\ oil}$ is the associated lower calorific value of the pilot oil used.

The heat rate for an engine is either directly provided by the manufacturer or can be calculated based on the fuel and pilot oil consumption. It was noted that the heat rates for a low-speed diesel powered by HFO, LNG, and Methanol were similar, as shown in Table 25. Furthermore, the fraction of the heat rate supplied by the pilot fuel could be determined by the following equation:

$$Pilot\ Heat\ Rate\ Fraction = \frac{SPOC * LCV_{Pilot\ oil}}{Heat\ Rate}$$

Table 25: Fuel Consumption and Heat Rate for HFO, LNG, and Methanol for MAN 11G95ME-C10.6, from MAN project guides

			Pure HFO Engine		LNG Engine				Methanol Engine			
% SMCR	Power	RPM	SFOC	Heat Rate	SPOC	SGC	Heat Rate	SPOC HR Fraction	SPOC	SGC	Heat Rate	SPOC HR Fraction
%	kW	r/min	g/kW-hr	kJ/kW-hr	g/kW-hr	g/kW-hr	kJ/kW-hr	%	g/kW-hr	g/kW-hr	kJ/kW-hr	%
100	65,500	77.9	158.8	24900	2.79	132.0	6,719	1.77%	9.29	324.1	6,847	5.79%
95	62,225	76.6	157.7	24727	2.88	131.0	6,673	1.84%	9.61	319.7	6,772	6.06%
90	58,950	75.2	156.8	24586	2.99	130.2	6,637	1.92%	9.96	315.6	6,706	6.34%
85	55,675	73.8	156.2	24492	3.11	129.5	6,609	2.01%	10.35	312.0	6,652	6.64%
80	52,400	72.3	156	24461	3.23	129.3	6,602	2.09%	10.78	309.7	6,623	6.95%
75	49,125	70.8	156	24461	3.38	129.1	6,600	2.19%	11.25	307.5	6,600	7.28%
70	45,850	69.2	153.9	24132	3.53	127.3	6,514	2.31%	11.78	305.8	6,588	7.64%
65	42,575	67.5	151.9	23818	3.71	125.4	6,426	2.47%	12.38	303.9	6,576	8.04%
60	39,300	65.7	152.4	23896	3.92	125.7	6,452	2.59%	13.06	303.4	6,594	8.46%
55	36,025	63.8	153.2	24022	4.15	126.2	6,486	2.73%	13.83	303.1	6,622	8.92%
50	32,750	61.8	154.1	24163	4.42	126.8	6,528	2.89%	14.74	302.8	6,656	9.46%
45	29,475	59.7	155.3	24351	4.74	127.5	6,578	3.08%	15.81	302.2	6,689	10.09%
40	26,200	57.4	156.6	24555	5.13	128.3	6,634	3.30%	17.10	301.4	6,728	10.85%
35	22,925	54.9	158	24774	5.61	129.1	6,695	3.58%	18.71	300.2	6,772	11.80%
30	19,650	52.1	159.5	25010	6.22	129.9	6,761	3.93%	20.74	298.2	6,821	12.98%
25	16,375	49.1	161.2	25276	7.02	130.6	6,831	4.39%	23.40	295.2	6,874	14.54%

Based on the statement from MAN's presentation that they were achieving approximately 5% pilot oil heat rate for ammonia and noting that this was similar to what was achieved for Methanol, the fuel consumption data for an ammonia powered low-speed diesel was calculated assuming the same heat rate and pilot oil heat rate fraction as for a methanol powered engine.

The hydrogen engine's consumption data was also based on the heat rate and pilot oil fraction of methanol, based on the studies done by Liu *et al.* (2022) where an engine was tested to 90% hydrogen by energy fraction and Serrano, Jiménez-Espadafor and López (2021), which created a validated computer simulation of a low-speed diesel utilizing hydrogen at heat rates up to 80%. Since hydrogen low-speed diesels are still maturing technology, and the benefits of utilizing hydrogen as a fuel lie in minimizing the amount

of carbon emissions and thus pilot fuel, it is expected some improvements are achievable by main engine manufacturers when they begin development, and so it was considered justifiable to use the SPOC fraction associated with Methanol for a hydrogen powered low-speed diesel as well.

The estimated fuel and pilot oil consumption values for ammonia and hydrogen low-speed diesel scaled by heat rate are presented in Table 26.

Table 26: Estimated Pilot Oil and Fuel Consumption Values for Ammonia and Hydrogen Low-Speed Diesels

% SMCR	Power	RPM	Ammonia Engine				Hydrogen Engine			
			Heat Rate	SPOC HR Fraction	SPOC	SGC	Heat Rate	SPOC HR Fraction	SPOC	SGC
			kJ/kW-hr	%	g/kW-hr	g/kW-hr	kJ/kW-hr	%	g/kW-hr	g/kW-hr
100	65,500	77.9	6,847	5.79%	9.29	346.8	6,847	5.79%	9.29	53.8
95	62,225	76.6	6,772	6.06%	9.61	342.0	6,772	6.06%	9.61	53.0
90	58,950	75.2	6,706	6.34%	9.96	337.7	6,706	6.34%	9.96	52.3
85	55,675	73.8	6,652	6.64%	10.35	333.9	6,652	6.64%	10.35	51.8
80	52,400	72.3	6,623	6.95%	10.78	331.3	6,623	6.95%	10.78	51.4
75	49,125	70.8	6,600	7.28%	11.25	329.0	6,600	7.28%	11.25	51.0
70	45,850	69.2	6,588	7.64%	11.78	327.2	6,588	7.64%	11.78	50.7
65	42,575	67.5	6,576	8.04%	12.38	325.1	6,576	8.04%	12.38	50.4
60	39,300	65.7	6,594	8.46%	13.06	324.5	6,594	8.46%	13.06	50.3
55	36,025	63.8	6,622	8.92%	13.83	324.3	6,622	8.92%	13.83	50.3
50	32,750	61.8	6,656	9.46%	14.74	324.0	6,656	9.46%	14.74	50.2
45	29,475	59.7	6,689	10.09%	15.81	323.3	6,689	10.09%	15.81	50.1
40	26,200	57.4	6,728	10.85%	17.10	322.5	6,728	10.85%	17.10	50.0
35	22,925	54.9	6,772	11.80%	18.71	321.1	6,772	11.80%	18.71	49.8
30	19,650	52.1	6,821	12.98%	20.74	319.1	6,821	12.98%	20.74	49.5
25	16,375	49.1	6,874	14.54%	23.40	315.9	6,874	14.54%	23.40	49.0

A similar method can be used for medium speed diesel generators, where data is available for conventional, HFO, and methanol fuelled engines. Note that the pilot oil heat rate fraction is typically much larger in a medium speed diesel, on the order of 30% based on MAN's project guide for the L2131DF-M engine.

For boiler fuel consumption figures, a similar heat-rate scaling methodology was utilized. The baseline HFO power output and fuel oil consumption for the ship's boiler was calculated based on the IMO 4th GHG study (2020). The heat rate for the HFO powered boiler was then determined by multiplying the HFO specific fuel oil consumption with the associated lower calorific value of HFO. The specific consumption of the boiler utilizing alternative fuels is then calculated by dividing the heat rate by the lower calorific values of the various alternative fuels.

$$HR_{Boiler} = SFOC_{Boiler} * LCV_{HFO}$$

$$SFC_{Boiler-Alternate\ Fuel} = HR_{Boiler}/LCV_{Alternate\ Fuel}$$

8.5. Development of Design Endurance Conditions

A set of operating conditions should be developed to establish the maximum reasonable endurance requirements of the ship, based on the selected route from the previous step. This design operating condition should be realistic while not limiting the operational profile of the vessel. The traditional range calculations are not considered appropriate because they do not consider auxiliary loads, which may be substantial.

For example, a ship may slow steam in operation to save fuel, but the endurance requirements should be set such that the vessel can travel the entire route at its design speed with the appropriate auxiliary engine power demands (including refrigerated container loads if applicable). If this is not done, it may not be possible for the vessel to utilize its design speed on the specified trade route, which represents an operational limitation that must be acknowledged.

During this step, the sailing distance, assumed sailing speed, main engine, auxiliary engine, and boiler required energy in kW-hrs or MJ should be calculated (depending on the available consumption data). The power required to sail at the design speed should be calculated using a speed-power curve developed from any reliable method, such as the Holtrop formula for basic level designs, and CFD or model test data for more advanced designs or if the data is available. A 15% sea margin and 7% hull fouling factor (IMO 4th GHG Study *et al.*, 2020) is added to the calm-water speed-power curves to correct the power required to expected operational levels. The sailing distance from the route data should also be increased by a small margin, typically 10% to provide a small factor of safety for operational purposes. Using the collected specific fuel consumptions from the previous step, the quantities of fuel and other consumables can then be calculated and used for the tank sizing step.

Next, the tanks should be sized larger such that filling level restrictions are not exceeded. General filling restrictions are 98% maximum for fuel oil tanks, 95% for methanol to provide room for thermal expansion (Baker *et al.*, 2022), and 85% with a 5% cooling reserve as a minimum fill level for liquefied gasses such as ammonia, LNG, and LH₂, which is based on previous experience with LNG project specifications. Compressed hydrogen can be assumed to have an 85% max filling level to provide

margin for pressure build up. Higher maximum filling limits can be used based on the tank design pressure and pressure relief set points, but doing so will require more detailed analysis of the tank and fuel system supply and is outlined in the IGF rules, which does allow a fill limit of up to 98% maximum (IMO, 2015).

It is also standard practice to assume a permeability for tanks to account for unusable volume related to structure. Hull tanks and type A/B tanks will have internal structure, and a standard permeability of 0.98 should be assumed. For type C and membrane tanks, it may be acceptable to assume no permeability losses depending on the expected internal structure of the tank.

One parameter that is considered acceptable to relax is bunkering frequency. It is acknowledged that alternative fuels may require a vessel to bunker at both ends of a route instead of being able to make a full round trip without refuelling. The necessity for this will be determined during the tank sizing step, but during this step it is important to also construct scenarios allowing for bunkering operations at either end.

Please refer to section 9.4 for an example from the case study of how these endurance conditions can be developed and some key variables.

8.6. Selection of Tank Sizes and Creation of Alternative-Fuelled Designs

8.6.1. Tank Sizing

The next stage of the procedure is to generate derivative designs utilizing alternative fuels based on the design requirements for endurance established in the previous step. This is a very labour-intensive task, and detailed guidance cannot be provided since the required work relies on the application of naval architecture principles. However, general guidance will be provided in this section relating to key aspects for consideration.

Once the total tank volume including margins associated with usable volumes is determined, the tanks can be designed and arranged within the vessel. See section 7.2 for more details relating to the types of tanks suitable for the various alternative fuels and considerations relating to arrangement and bunkering. It is recommended that sizing studies be carried out investigating several different tank sizes and arrangements for comparison purposes, as shown in Figure 21. Pilot fuel tanks can typically be arranged outside the B/5 boundaries and still provide sufficient volume.

For each tank arrangement, the associated cargo impact should also be determined to aid in the final selection of the tank arrangements. For oil tankers and bulk carriers, this may either be a loss of cargo hold volume or deadweight associated with lightweight weight growth. For container ships, this will be a loss of container slots and potentially deadweight limitations also associated with lightweight growth. However, since lightweight changes are more difficult to determine, it is recommended to focus on losses associated with volume or slot losses depending on the ship type at this stage, and then proceed to estimate the modified lightweight once a tank design is finalized.

By following this method, a range of tank sizes and offered volumes can be compared against the operating profiles, required volume, and potential cargo loss, allowing the designer to choose the final appropriate tank design. An example of this decision matrix from the case study is presented in section 9.5.

Note that one major limitation of this method is that the impact of boil-off gas is not accounted for. The higher allowable pressures due to boil-off gas accumulation are one of the main benefits of type-C tanks, which are otherwise not as volumetrically efficient as membrane or type A/B tanks. Their higher allowable pressures provide more

operational flexibility that may be worth the volume/cargo losses to ship owners and operators. This means there is typically little reason to choose a type C tank over the alternatives when using this method. Boil off gas can be handled by using it directly for auxiliary power, as is the case for the LNG powered Ultra Large Containership CMA CGM *Jacques Saade* (Kalyanaraman, 2020), so this may not always be a problem, but if shore power/cold ironing is a port requirement, the boil off gasses will likely need to be reliquefied with a membrane or type A/B tank which will increase the power use at port and could be avoided entirely with a type C tank.

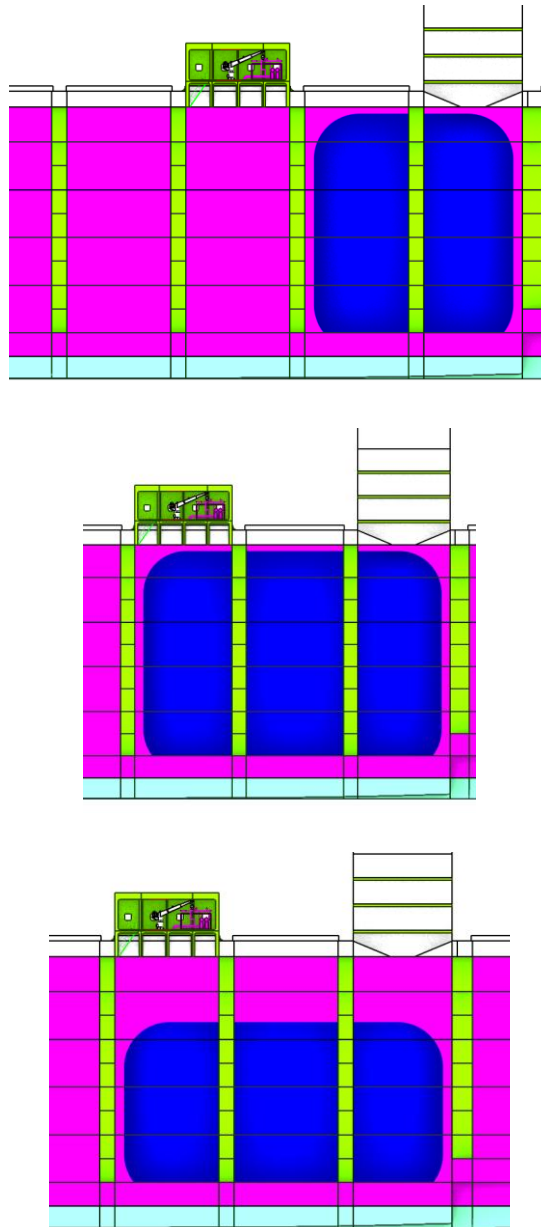


Figure 21: Example of Tank Sizing Study for Elongated Type C Tanks
Top: Tanks Beneath Accommodation + 1 Hold
Middle: Tanks Beneath Accommodation + 2 Holds
Bottom: Tanks Beneath Accommodation + 2 Holds Lower Height

8.6.2. *Lightship Weight Impact*

The modifications for alternative fuel will also have an associated lightweight impact. Because detailed plant and sizing design is not being carried out, it is more difficult to estimate the total impact on the lightweight from the alternative fuel system. The final

tank arrangement should be chosen before the lightweight is calculated to simplify the process.

The methodology used for the case study vessel involved estimating the weight of steel removals associated with the conventional HFO tanks, equipment spaces, and cargo hold bulkheads. Additional weight for secondary barrier bulkheads, pilot fuel tank bulkheads, cofferdam bulkheads, alternative fuel tanks, insulation, bunkering stations, and the fuel gas supply system is also estimated.

For plane bulkheads and decks used for example hull tanks or additional longitudinal bulkheads, the weight of the additions and removals was estimated by extracting the plane area from a 3D model of the vessel, multiplying by a thickness of 12 mm for watertight bulkheads and 10mm for non-tight or low-pressure head structure, and calculating the weight assuming a density of 8000 kg/m^3 . An additional 15% of the weight was added to account for stiffeners and girders. For structure with lesser stiffening such as stringers or vertical girders, a factor of 5% was used, and for structure without girders but with stiffeners, a 10% factor was used.

Based on previous industry project data, a regression was created to estimate the structural weight of type B and C tanks based on their volume, shown in Figure 22 and Figure 23. The data set was very limited, but it provides a baseline reference weight that allows for order of magnitude weight estimation. An additional weight for insulation was added to the tank assuming a 300mm thick layer of polyurethane with a density of 130 kg/m^3 (Kalyanaraman, 2020).

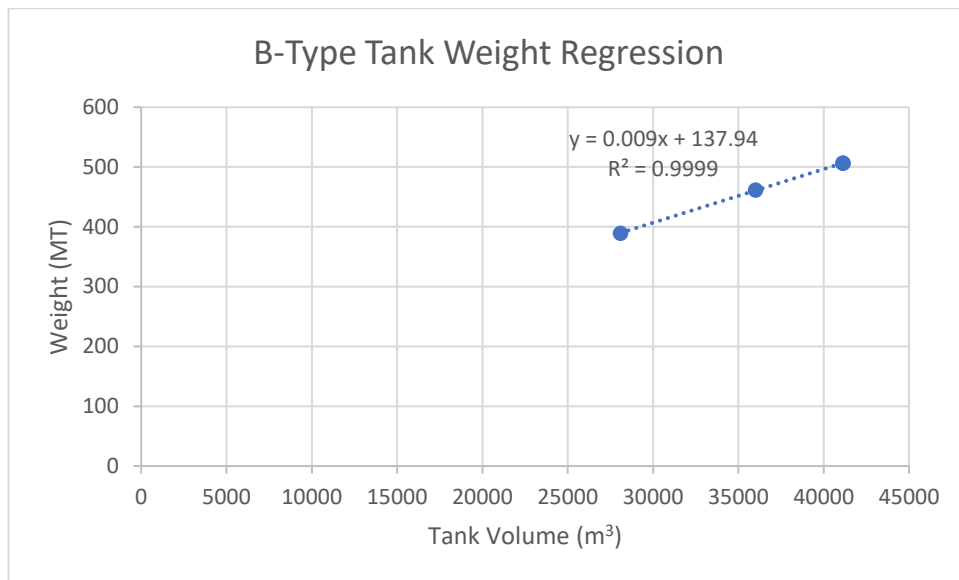


Figure 22: B-type tank weight regression

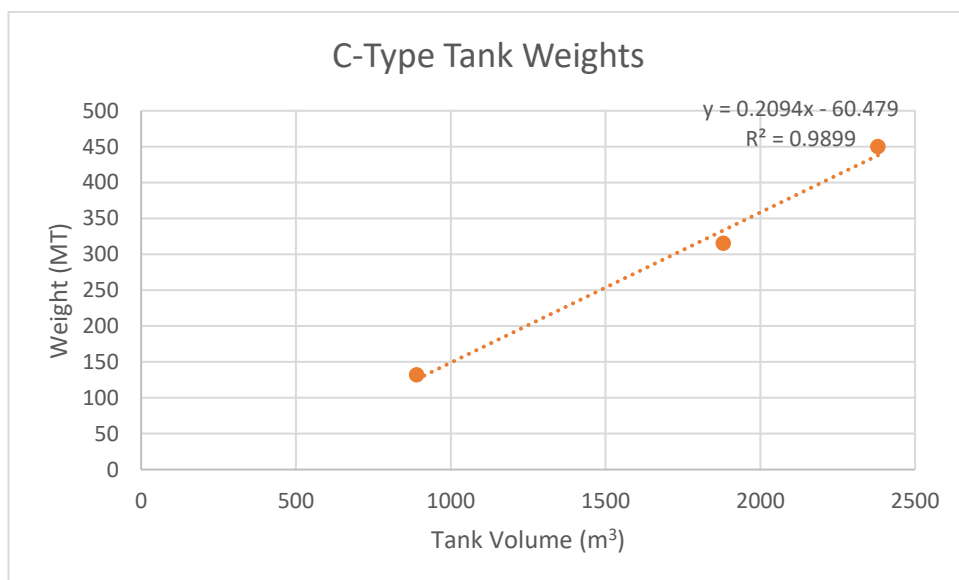


Figure 23: C-type (cylindrical) type tank weight regression

Very little data was available for the assumed hydrogen tanks, which were elongated type-C tanks to meet the required volume demands. The LH₂ tank was assumed to be a double-skinned tank with a glass bubble insulation (ABS, 2022). The inner skin was assumed to be 6.5mm thick and the outer skin 8mm thick plate, with their associated areas extracted from a 3D model of the tanks. The insulation was assumed to be 800mm thick, and the volume of this space was multiplied by the glass bead density of 125 kg/m³

(White, 2021). An extra 30% margin was added for support structure and outfitting for the tanks.

Compressed hydrogen tanks of the size required for fuelling large oceangoing vessels on international trading routes do not exist today, and substantial research and development will need to be carried out before they become feasible. As a rough order of magnitude estimate, the compressed hydrogen tanks were assumed to be made of a combination of 25mm thick stainless steel wrapped in a 75mm thick carbon fibre composite shell with a density of 2200 kg/m³. An additional 30% margin was also added, similar to what was done for the LH₂ tanks.

Based on previous projects, a bunker station weight of 11 MT was assumed for each bunker station port and starboard. This is based on 4.5 MT steel weight, 4.5 MT weight for the bunkering station equipment skid, and 2 MT for the bunkering davit.

Finally, the weight for the equipment for the fuel gas supply system was estimated based on scaling the equipment weight tabulated from a previous LNG conversion projected by the installed power on a vessel. The implemented scale factor was 0.001188 MT/kW main engine power. In practice there should be a lower limit to this value as the glycol, buffer tank, and vaporizer skids would have a minimum size, but this should yield an approximate weight for ships with power requirements greater than 20,000 kW. A minimum value of 15 MT is recommended for lower powered vessels, based on some of the outfitting and equipment weights from other projects.

Centres of gravity for all the modifications can be estimated based on their centre of area/volume extracted from a 3D model or a rough estimation of where the equipment would be located.

8.6.3. Speed-Power and Stability

It is recommended to not change the principal characteristics or hullform of the vessel below the waterline so that the original speed-power curves can be used for the baseline hull and all derivative designs. This greatly simplifies the fuel consumption calculations during the operational lifecycle inventory because the energy required to move the hull remains constant.

By keeping the hullform constant, the stability data will also not substantially change. For tanks complying with the IGF code B/5 requirement, the damaged stability performance will remain the same or improve from the extra subdivision because the probability of a collision penetrating that depth per SOLAS regulations is zero. This means that only the methanol fuelled alternative design (if utilizing hull tanks) will require re-assessment from a damaged stability standpoint. If the probabilistic method is used to locate the tanks, then it is possible for the tank space to become damaged, which may have a negative impact on the damaged stability performance of the vessel, and the damaged stability check should be re-run if there is not a large margin from the parent ship. If there is more than 4% attained vs.. required probability margin in the parent ship, this step can be skipped because the probabilistic rules for locating the tanks will at most increase the attained index by 4%, assuming every case damaging a tank space results in loss of the vessel.

Intact stability will primarily be influenced by the lightweight, arrangement, and fuel tank changes. Sample conditions representative of the typical operating profile should be assessed to make sure the vessel still meets the required intact and damaged stability requirements and to calculate the loadable cargo capacity for the various designs, which is later used as the functional unit for comparison purposes in the lifecycle assessment.

8.7. Lifecycle Inventory – General

At this step, several ship designs are available – the conventionally fuelled design and several derivative designs utilizing the chosen alternative fuels. A lifecycle inventory will need to be completed for each design. The inventory is composed of the following three steps:

- Ship Building and Maintenance
- Operations
- Ship Breaking

The shipbuilding and maintenance inventories will need to be carried out for each design because the lightweight is different between the designs. The operational emissions will change substantially because of the different fuels used.

It is recommended to set up the calculation such that the inventories for each of the designs can be completed in parallel, because much of the data is common between the various phases and designs. For example, the power required for the vessel to complete one round trip can be assumed not to change if the hullform is the same for all the derivative designs, and there is no practical difference in the tank-to-wake emissions between a compressed hydrogen or liquid hydrogen design (except for reliquification energy). An example of the inventory model and which phases apply to which aspect of the design is shown in Figure 24.

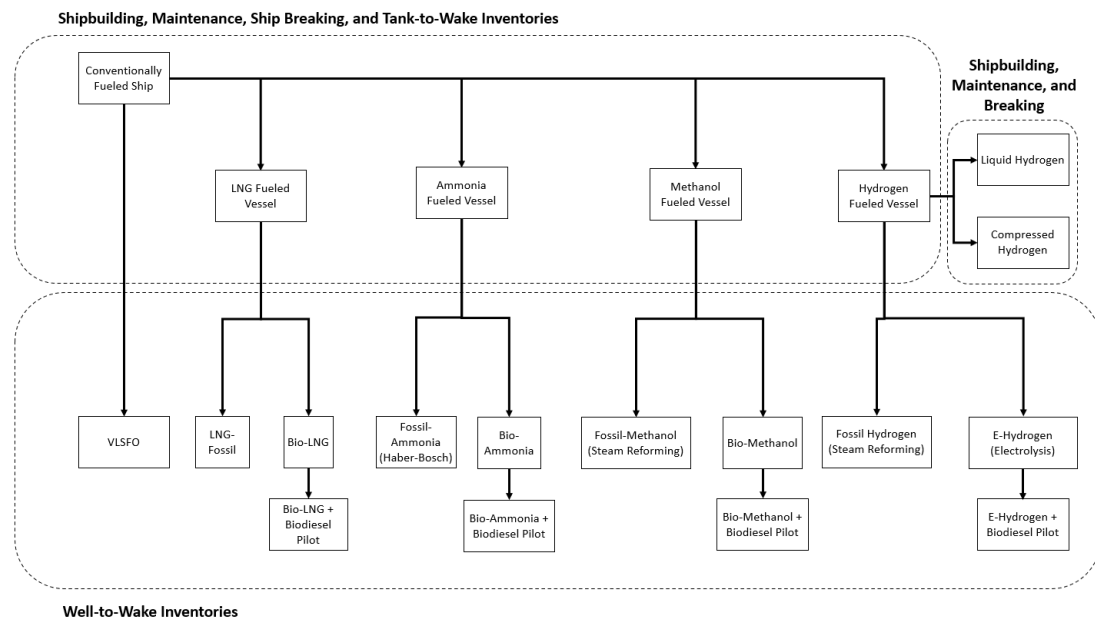


Figure 24: Lifecycle inventory steps and applicability

8.8. Lifecycle Inventory – Ship Building and Maintenance

Three methodologies were investigated and compared for the shipbuilding and maintenance phase: the simplified method presented in Hua's (2019) study of post-panamax containerships, the method presented by Gratsos (2010), and finally a composite shipbuilding inventory created for this research as a composite of methods from various sources (Fet, 1998; Worldsteel, 2021; Gilbert *et al.*, 2017; Cucinotta *et al.*, 2021; Nian and Yuan, 2017).

For Hua's method, the vessel's lightweight is the only required input. Emission factors for CO₂, PM₁₀, NO_x, and VOC's are provided on a kg-emission per ton lightweight basis for the steel factory and shipbuilding processes, as shown in Table 27. The input

lightweight was increased by 10% to account for the quantity of raw steel used in the shipbuilding process (Fet, 1998).

Table 27: Emission Factors from shipbuilding in kg-emission per ton of ship lightweight (Hua, Cheng and Hwang, 2019)

Emission (kg/ton)	Emission Factor	
	Steel Factory	Shipbuilding
CO ₂	2331.2	239.6
PM ₁₀	0.3749	0.0209
NO _x	0.9787	0.0029
VOC	0.0724	5.2925

The method proposed by Gratsos (2010) requires the lightweight of the vessel as an input and makes assumptions regarding the location of the raw material extraction site, the steel mill, and the shipyard to account for additional emissions associated with material transport. First, it is assumed that the total amount of steel required for the construction of the vessel is 10% more than the lightweight of the vessel, citing Fet (1998). Then it is estimated that for every ton of steel, 2.66 MT of raw material such as coal and iron ore is required. This material must be transported by a bulk carrier from a mine in Australia to a steel mill in China, with a total distance travelled of 6452 km and a raw material transport emission factor of 4 grams of CO₂ per MT-kilometre. 1.75 MT of CO₂ is then assumed to be emitted per ton of steel produced, and in the shipyard, 0.216 MT of CO₂ is emitted per ton of steel used in the construction of the vessel. A flowchart of the procedure proposed by Gratsos is shown in Figure 25.

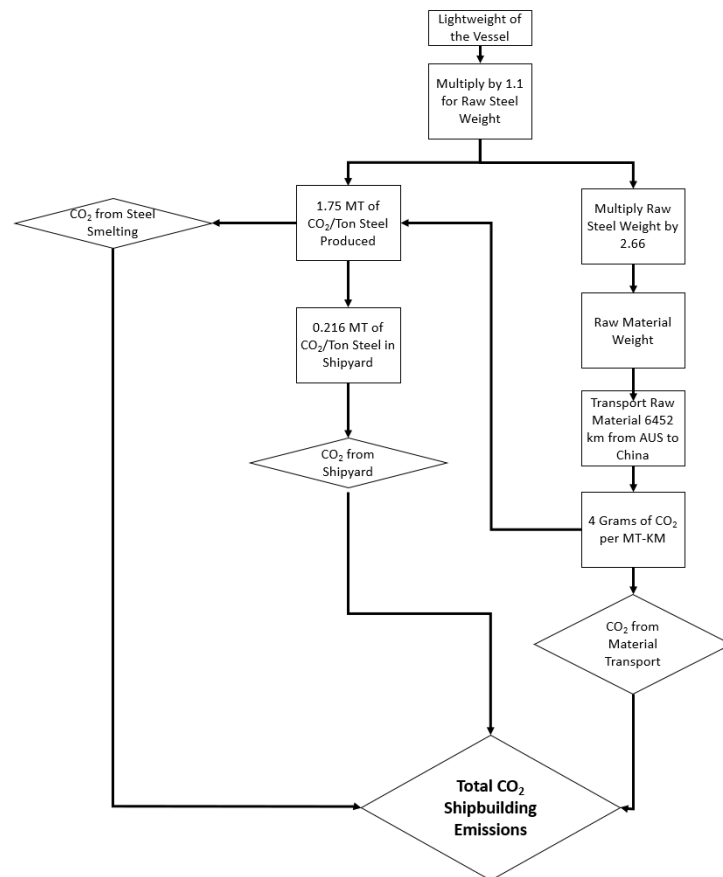


Figure 25: Simplified Method of Estimating Shipbuilding Emissions (Gratsos, Psaraftis and Zachariadis, 2010)

A unique method for calculating the shipbuilding emissions was also developed for this research by combining several methodologies from literature, but primarily following the procedure laid out by Gilbert (2017), which in itself was an extension of the work of Fet (1998). $\text{CO}_{2\text{Eq}}$ is the main output, but other emissions are inventoried where available from this method. The main phases in this method are follows:

- Steel Production and Transport to Shipyard
- Steel Cutting
- Welding
- Blasting
- Painting
- Other Electricity consumption
- Sea Trials

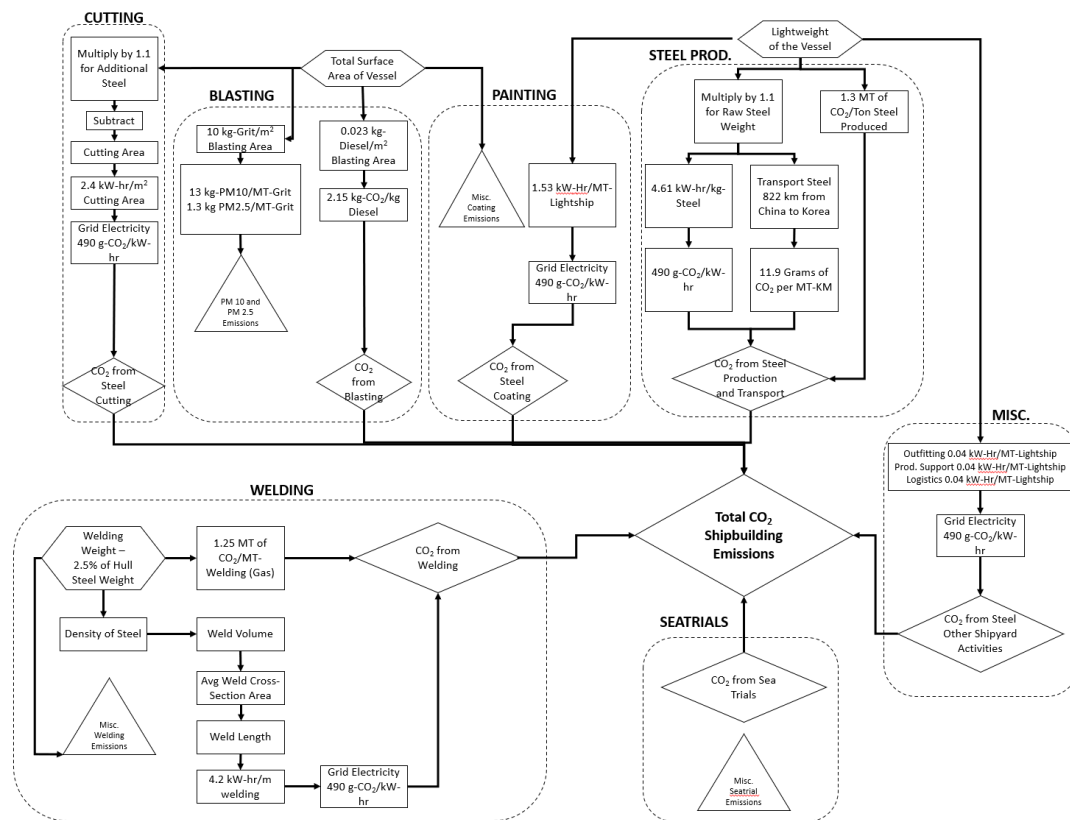


Figure 26: Proposed Method for Calculating CO₂Eq Emissions from Shipbuilding Activities

The primary inputs for this method are the lightship weight of the vessel, the total surface area of the vessel, and an estimate of the welding weight and average weld throat thickness. Sea trial emissions are estimated based on an abbreviated operating profile using the same methodology as the operational phase.

8.8.1. Steel Production and Transport

Steel production and transport involves the processes for producing the steel and transporting it to the shipyard for use. As per the other methodologies, the entire lightship weight is assumed to be composed of steel and an extra 10% of raw steel is assumed necessary to fabricate the vessel. A raw steel CO₂Eq emissions factor of 1.3 MT CO₂Eq per MT of steel is taken from the Worldsteel Organization publication (2021), consistent with the “sections” category of steel. This value represents a lifecycle product flow for the steel production process including extraction of raw materials, transportation to the foundry, and production of the steel. It also includes a component of recycling: 1.58 MT CO₂Eq per MT of steel is the cradle-to-gate value of the raw steel production and a recycling credit of -2.6 MT CO₂Eq per MT of steel is applied in the publication. There is also an associated primary energy demand of 16.6 MJ per kg of

steel, which equates to 4.61 kW-hrs/kg of steel. A grid power emissions factor of 490 g-CO₂/kW-hr is assumed based on linear interpolation of projected power demands (Gilbert *et al.*, 2018), shown in Table 28.

Table 28: Estimated Grid Electricity CO₂ Emissions Factors, 2 Deg C energy scenario, global electricity

Year	2020	2030	2040	2050
CO ₂ Avg Grid EF (g CO ₂ /kW-Hr)	530	430	240	90

Steel transportation follows the method from Gilbert (2017) assuming that the steel produced from the factory is shipped 822 km from Shanghai in China to South Korea by barge, with an emission factor of 11.9 g-CO₂ per MT-kilometre.

8.8.2. Steel Cutting

Estimates for the steel cutting emissions also directly follow the work of Gilbert (2017), where the total surface area of the vessel is determined, that surface area is increased by 10% accounting for the steel losses, and the difference between the increased surface area and the original surface area represents the cutting surface area. An energy demand of 2.4 kW-hr/m² of cutting is taken, and using the same grid energy emission factor, allows for the CO₂ emissions from the cutting process to be calculated.

One notable departure from the method proposed by Gilbert is that the total surface area is estimated based on a 3D model of the ship that was produced. Gilbert's calculations rely on paint area estimation calculations from a paint manufacturer (Transocean Coatings, 2022), and while it does provide a good estimate of the exterior paint areas, it does not correctly tabulate interior and stiffener painting areas. For the case study, the estimate using the Transocean coating method was less than half that extracted from the 3D model, so it is recommended that a different technique be used to estimate the paint areas.

8.8.3. Welding

Emissions due to welding is probably the least well-defined section of this methodology, because it is difficult to get a good estimate of the quantity and length of welding required in the basic design stage.

Based on a survey of preliminary lightweight estimates from various design firms for other projects, a welding weight of 2.5% of the hull steel (not the entire lightweight) was

found to be an appropriate estimate of the welding weight. From the welding weight and the density of steel, the volume of weld could be calculated. An average weld cross-section was assumed using a leg length of 5mm and double continuous fillet welding, which allowed an estimate of the welding length to be produced. A welding energy factor of 4.2 kW-hr/meter of weld (Gilbert *et al.*, 2017) was then used with the grid electricity emission factor to derive a CO₂ emissions factor from the welding process itself. An additional 1.25 MT-CO₂ per MT of weld for direct use of CO₂ gas for displacing the air in way of the weld, as well as a set of emissions factor for Chromium, Cobalt, Manganese, Nickel, and PM₁₀, shown in Table 29, were taken from Cucinotta *et al.* (2021), citing the national pollutant inventory of the Australian government.

Table 29: Non-CO₂ welding emission factors (Cucinotta *et al.*, 2021)

Welding Additional Emission Factors		
Chromium III EF	g/kg weld	0.01
Cobalt EF	g/kg weld	0.001
Manganese EF	g/kg weld	3.18
Nickel EF	g/kg weld	0.01
PM ₁₀ EF	g/kg weld	5.20

8.8.4. Sandblasting

Sandblasting emissions follow directly from the method implemented by Gilbert (2017). The total surface area of the vessel is multiplied by a grit use factor of 10 kg of grit per m² of area to be blasted. The grit directly contributes to PM₁₀ and PM_{2.5} emissions at the rate of 13 and 1.3 kg of particulate matter per MT of grit used. Additionally, diesel is required to run the sandblasting equipment at rate of 0.023 kg of diesel per m² blasted. This diesel oil has an emissions factor of 2.15 kg of CO₂ per kilogram of diesel consumed.

8.8.5. Painting

The emissions from painting also follow the method by Gilbert (2017) with an additional energy use factor taken from Nian and Yuan (2017). The primary emissions from painting are chemicals and volatile organic compounds to the atmosphere, as shown in Table 30. This is supplemented with an energy use factor of 1.53 kW-hr/MT of vessel lightweight, which can then be converted using the grid electricity CO₂ emission factor.

Table 30: Non-CO₂ painting emission factors

Painting Non-CO ₂ Emission Factors		
Trimethylbenzene EF	kg/m ²	0.0003
Xylene EF	kg/m ²	0.250
4-methyl 2-pentanone EF	kg/m ²	0.020
5-methyl 2-hexane EF	kg/m ²	0.060
Methyl isobutylene EF	kg/m ²	0.006
TBT (tributyltin) to Water EF	kg/m ²	0.022
Tar vinyl to Water EF	kg/m ²	0.003
Copper oxide to Water EF	kg/m ²	0.022
White spirit to Waste EF	kg/m ²	0.010
Xylene to Waste EF	kg/m ²	0.010
VOC	kg/m ²	0.240

8.8.6. Other Shipyard Activities

Emission factors for other shipyard activities are taken from Nian and Yuan (2017), and are reported as electricity use per MT of vessel lightweight, shown in Table 31. This is again then converted to a CO₂ emission using the grid electricity emission factor.

Table 31: Other Shipyard Energy Use Factors

Other Shipyard Activity Emission Factors		
Outfitting	kW-Hr/MT Ship	0.04
Production Support	kW-Hr/MT Ship	0.96
Logistics	kW-Hr/MT Ship	17.46

These factors were included because they are not accounted for in any of the other methodologies examined. The outfitting accounts for detailed work associated with outfitting the vessel such as joinery, cleaning, and electrical systems installation. Production support is assumed to be related to engineering support and scaffolding type activities. Logistics, which has the highest emission factors, is assumed to be associated with cranes, drydocking, tugs, and procurement/warehousing related activities.

8.8.7. Sea Trials

Emissions from sea trials are calculated the same way as for the operation of the vessel, except a special sea trial speed-power curve representative of the ballast condition without sea margin or fouling factor is applied. The vessel is assumed to motor at slow

speed (30% of MCR) to and from the trial position over a total distance of 250 NMi, and then operate at 100% MCR for 250 NMi. The baseline auxiliary power is used with no extra consumers such as refrigerated containers. The boiler is assumed to be in operation during the motoring phase for testing purposes but is otherwise off during the speed trials.

8.8.8. Evaluation of Method

This methodology results in about 1.5 times more CO_{2eq} emissions compared to Hua's method and 1.85 times more CO_{2Eq} emissions compared to Gratsos's method. A breakdown of the percentage of CO_{2Eq} emissions from each phase, computed from the case study for an HFO-powered ship, is presented in Table 32.

Table 32: Percent Contribution to CO_{2eq} emissions from each phase

Steel Production and Transport	%	94.65%
Cutting	%	0.03%
Welding	%	4.84%
Blasting	%	0.01%
Painting	%	0.02%
Other Shipyard Activity	%	0.22%
Sea Trials	%	0.22%

Steel production has the largest contributor to CO_{2eq} emissions, followed by the welding process. Cutting, blasting, and painting are all nearly negligible in their CO₂ emission contributions, however blasting and painting result in other pollutants such as particulate matter and volatile organic compounds. Similarly, the sea trials may not result in large quantities of CO₂, but especially if conducted with HFO, would release substantial quantities of particulate matter and volatile organic compounds. These percentage contributions indicate that the cutting and other shipyard activity steps could be ignored to simplify the method, but the other steps should be retained if a more in-depth impact analysis focusing on other environmental impact categories is carried out.

8.8.9. Maintenance

Calculation of the maintenance phase emissions utilizes a similar procedure as for the shipbuilding phase with the sea trial phase eliminated and some modifications to the cutting and welding phases.

Instead of utilizing the lightweight of the vessel, it is assumed that the shipyard will replace 7 MT of steel per day in the shipyard (Gratsos, Psaraftis and Zachariadis, 2010). This allows the emissions from the steel production and transport, steel cutting, and other shipyard activity phases to be estimated if a length of time in the shipyard is known.

For the steel cutting phase, it is assumed that the removed steel weight is equal to the additional steel weight, and that propane is used to cut away the steel, at 0.06 MT of propane used per MT of steel cut. The emission factor of propane is 3 MT of CO₂ released per MT of propane (Dong and Cai, 2019).

For the welding phase, it is assumed the weight of welding is 2.5% of the replaced steel weight, and all other steps are otherwise the same as described in section 8.8.3.

The surface area for the blasting and painting phases is assumed to be the shell exterior area for hull cleaning and re-coating purposes and 5% of the remaining area of the vessel for touch-ups and repairs.

The emissions are inventoried for a single shipyard period and multiplied by the total number of shipyard periods expected in the life of the vessel. If the vessel's expected lifetime is 25 years and a shipyard period occurs every five years, then this would result in four maintenance periods.

Implementation of alternative fuels may have an impact on the time out of service for a given ship due to additional time required for such activities as:

- Vaporizing and discharging spare cryogenic fuel prior to entering the shipyard
- Cooling down tanks prior to loading fuel after departing a shipyard
- Less capability to do repairs underway due to more hazardous area zones preventing hotwork
- Additional compartment and tanks that require gas-freeing, entry, and inspection
- Additional system complexity:
 - Additional vents and fans to meet the required air changes per hour in fuel gas spaces and maintain positive pressure in annular pipes
 - Additional compressors, vaporizers, and fuel handling skids associated with the fuel gas supply system

- Additional sensors for tank fill level, gas detection
 - Additional safety systems
 - Additional tie-ins to the control and monitoring systems
- Specialist materials and equipment necessary to deal with cryogenic, explosive, and/or poisonous fuels
 - Low temperature steels, stainless steels, and super duplex steels, including workers trained to work with them
 - Procurement of explosion-proof equipment
 - Increased use of carbon fibre, especially for the compressed hydrogen tanks
 - Insulation and wooden tank support blocks

While the environmental impact effects of the above cannot be handled directly by the simplified emissions model in this methodology, the impact on operations and total achievable lifetime cargo throughput should be considered in relation to the ship's schedule.

8.9. Lifecycle Inventory – Operations

Calculation of the operational lifecycle emission are similar to the tank sizing calculations in that a representative operational profile should be developed so that the fuel consumption and carbon emissions from combustion of the fuel can be calculated. The operational lifecycle can be partitioned into the three following phases:

- Calculation of operational energy and fuel requirements
- Summation of the tank-to-wake emissions
- Summation of the well-to-tank emissions

8.9.1. Operational Energy Requirements

A series of operational conditions representative of the trading patterns of the vessel needs to be established to calculate the operational fuel consumption of the vessel. The route should be a typical round-trip journey of the trade the vessel is expected to carry out over its lifetime so that the emissions can be scaled up to yield a lifetime operational emissions inventory. The desired outputs from this assessment are the quantities of fuel consumed by the prime mover, the auxiliary engines, and the boiler (if fitted). The required inputs are the typical number of days per round trip, the sailing distance for

each leg of the journey, the associated drafts for each leg of the journey and corresponding speed-power curves for those drafts, along with an estimate of the time spent in port during the trip. As per the tank sizing calculations, a 10% margin should be added to the sail distances to account for weather routing or other manoeuvring. A 15% sea margin and 7% hull fouling factor (IMO 4th GHG Study *et al.*, 2020) should also be applied to the speed-power curves. The speed-power calculation can also assume slow steaming at this stage if that is how the vessel will typically be operated. The chosen speed and power levels should be an average value to simplify the calculation, rather than broken down into detailed manoeuvring steps.

The total number of round trips achievable in the lifetime of the vessel should also be calculated at this stage. This can be determined based on an assumed operating lifetime (typically 20-25 years), a given shipyard interval (typically 5 years), and a typical time in shipyard. The number of operating and non-operating days can then be determined, with the number of potential round trips based on the total operating days and the average round trip scheduled (or achievable) time.

Auxiliary power demands should include the basic sea load as determined either through the EEDI calculation or the IMO 4th GHG study (2020), as well as additional power loads such as refrigerated containers. Power required while in port or idle, as well as the boiler fuel demand, can also be determined from data in the 4th IMO GHG study, as shown in Table 33. It should be noted that unlike the main engine, the auxiliary engines will be operating when the vessel is at berth or idle/anchored, unless the vessel is connected to shore power. This means if a vessel has higher auxiliary power demand, slow steams, and has a schedule with substantial idle or port time, the auxiliary engine consumptions and emissions can be substantial.

Table 33: Boiler and Auxiliary Engine Power Requirements by Ship Type, Size, and Operational Phase (IMO 4th GHG Study *et al.*, 2020)

Ship Type	Size Unit	Size Bin	Aux Boiler Output (kW)				Aux Engine Power Output (kW)			
			At Berth	Anchored	Manoeuvring	At-Sea	At Berth	Anchored	Manoeuvring	At-Sea
Container Ship	TEU	0-999	250	250	240	0	370	450	790	410
		1,000-1,999	340	340	310	0	820	910	1,750	900
		2,000-2,999	460	450	430	0	610	910	1,900	920
		3,000-4,999	480	480	430	0	1,100	1,350	2,500	1,400
		5,000-7,999	590	580	550	0	1,100	1,400	2,800	1,450
		8,000-11,999	620	620	540	0	1,150	1,600	2,900	1,800
		12,000-14,499	630	630	630	0	1,300	1,800	3,250	2,050
		14,500-19,999	630	630	630	0	1,400	1,950	3,600	2,300
Oil tanker	DWT	20,000+	700	700	700	0	1,400	1,950	3,600	2,300
		0-4,999	500	100	100	0	250	250	375	250
		5,000-9,999	750	150	150	0	375	375	560	375
		10,000-19,999	1,250	250	250	0	690	500	580	490
		20,000-59,999	2,700	270	270	270	720	520	600	510
		60,000-79,999	3,250	360	360	280	620	490	770	560
		80,000-119,999	4,000	400	400	280	800	640	910	690
		120,000-199,999	6,500	500	500	300	2,500	770	1,300	860
Bulk carrier	DWT	200,000+	7,000	600	600	300	2,500	770	1,300	860
		0-9,999	70	70	60	0	110	180	500	190
		10,000-34,999	70	70	60	0	110	180	500	190
		35,000-59,999	130	130	120	0	150	250	680	260
		60,000-99,999	260	260	240	0	240	400	1,100	410
		100,000-199,999	260	260	240	0	240	400	1,100	410
		200,000+	260	260	240	0	240	400	1,100	410

This methodology assumes that the boiler demand taken from the IMO 4th GHG study is applicable to alternatively fuelled vessels, but this may not be the case. A large demand of steam during the manoeuvring and port times is associated with heating HFO to a usable viscosity, and therefore the demand for steam may be substantially lower in an alternatively fuelled vessel. However, if the boiler use is reduced or eliminated, it also poses an issue with utilizing boil-off gas while the vessel is in port. A refinement to this analysis would be to investigate if the boiler use should be reduced for alternatively fuelled vessels.

Note that if the hullform has not changed between the various designs, this step need only be completed once and the data can be used for all of the derivative alternatively fuelled designs.

Boil-Off Gas Rate

If using LNG, ammonia, or liquified hydrogen as fuel, reliquification energy should also be considered if the vessel will be calling in EU ports and burning of the boil off gas is not permitted. For LNG and ammonia this is expected to be necessary only if membrane or type A/B tanks are used, and the stay is not excessively long (about 14 days) for a type C tank to handle the pressure build up. For liquid hydrogen, it is expected that boil-off gas will always need to be reliquified if it is not used.

To calculate the boil-off gas liquefaction energy required, the fuel boil-off gas rate needs to be determined. First, the storage temperature of the liquified fuel needs to be known. Typical rates for LNG are -163 °C, for Ammonia -33 °C, and for liquified Hydrogen -253°C. The rate of heat transfer is dependent on the radiative and convective heat ingress. The radiative heat ingress can be determined by the following equations:

$$Energy\ Ingress_{Radiative} = \sigma * \epsilon * A * t * \Delta T^4$$

$$Heat\ Ingress_{Radiative} = Energy\ Ingress / (24 \frac{hours}{day} * 3600 \frac{seconds}{hour})$$

Where:

- σ = Stefan-Boltzmann constant of 5.67E-8 J/(sec*m²*K⁴)
- ϵ = the emissivity of the paint of the decks and tanks taken as 20% for white paint (Hanlu *et al.*, 2010)
- A = the exposed surface area of the tanks
- t = the time exposed to sunlight, taken as 30,600 seconds (8.5 hours/day)
- ΔT^4 = Ambient Temperature⁴ (25°C for Europe, 45°C for gulf routes)-Fuel Temperature⁴

The convective heat ingress is:

$$Heat\ Ingress_{Convective} = \Delta T * \frac{A}{t} * k$$

Where:

- ΔT = Ambient Temperature (25°C for Europe, 45°C for gulf routes)-Fuel Temperature⁴
- A = Tank surface area
- t = insulation thickness
- k = Coefficient of thermal conductivity, 0.03 for LNG and 0.025 for ammonia (polyurethane insulation, (ToolBox, 2007)), 0.000035 for liquified hydrogen with glass bead insulation (White, 2021)

The heat ingress rates from the radiative and convective sources can be added together, and the total daily energy ingress is calculated by multiplying the heat ingress by the number of seconds per day. The daily boil-off rate can then be calculated by dividing the

energy ingress by the enthalpy of vaporization for each of the fuels, as shown in Table 34.

Table 34: Properties of Liquified fuels for Boil-Off calculations

	Enthalpy of vaporization	Molar mass	Enthalpy of vaporization	Liquid density	Liquid temp.
	kJ/mol	g/mol	kJ/g	kg/m ³	C
H ₂	0.899	2.016	0.446	71.11	-253
CH ₄ /LNG	8.170	16.042	0.509	463	-163
NH ₃ /Ammonia	23.350	17.030	1.371	784	-33

The boil off rate is typically normalized into a percentage of the total tank volume per day by dividing the boil off volume per day by the total tank capacity when full.

Once the daily boil-off rate is known, the energy required for liquefaction can be estimated. The reliquification energy consumption for LNG was given as 2719 kW per kilogram of boil off gas per second (Romero Gómez *et al.*, 2015). This reliquification energy was then scaled based on the enthalpy of vaporization for Ammonia and Liquified Hydrogen, yielding a power required of 1010 kW per kilogram of boiloff gas per second for ammonia and 3104 kW per kilogram of boiloff gas per second for liquified hydrogen.

The power required from the EU grid for reliquification of the boil-off gas can then be estimated from the boil off per second multiplied by this power requirement factor. Finally, this is converted to a CO_{2Eq} emission by multiplying by the grid power emissions factor.

8.9.2. Calculation of Required Fuel Quantities and Tank-to-Wake Emissions

Using the energy requirements determined from the previous step, the quantities of fuel and other liquids consumed can be calculated for the main engine, auxiliary engines, and the boilers. This calculation must be carried out for the parent and derivative designs but can be done in parallel. This calculation is agnostic of the source of the fuel since it only considers tank-to-wake emissions, so there is no need for a specific assessment of, for example, bio methanol vs.. regular methanol at this stage. The well-to-tank emissions are handled in the next step.

Main Engine Consumption

If the main engine is a low-speed diesel, then fuel and other consumable consumptions are readily available from the MAN project guides or the estimation technique for ammonia and hydrogen described in section 8.4. The appropriate consumption figures

corresponding with the main engine operating load should be selected. Typically available consumption data for low speed diesels are:

- Specific Fuel Consumption (SFC), g/kW-hr
- Specific Pilot Oil Consumption (SPOC), g/kW-hr
- Urea consumption, Liters/hr (For IMO NO_x emissions compliance)
- NaOH consumption, Liters/hr (for Methanol fuelled engines)
- Cylinder Oil Consumption, g/kW-hr
- Lube Oil Consumption, g/kW-hr
- Methane Slip, g/kW-hr (for LNG fuelled engines)

Note that the specific fuel and pilot oil consumption values should be increased by 5% to account for performance margins, as specified in the project guides.

These specific consumption or hourly consumption figures can be multiplied by the main engine operating kW-hrs or operational hours from the previous step to yield the quantities of consumables needed for the route.

The portion of the energy delivered by the pilot oil should also be calculated at this step, as it is required for some of the emissions factors. This can be calculated by first multiplying the quantity of fuel and pilot oil consumed by their corresponding lower calorific values, then taking the ratio of those two figures and multiplying this ratio by the total kilowatt hours of the main engine.

$$Pilot\ Fuel\ kW - Hrs = \frac{Pilot\ Fuel\ Used * LCV_{Pilot}}{Main\ Fuel\ Used * LCV_{Main\ Fuel}} * Main\ Engine\ kW - hrs$$

Auxiliary Engine Consumption

Similar to the main engine, specific fuel consumption data should be available from MAN project guides for auxiliary engines. The listed fuel consumption values should be increased by 5%, and the lube oil consumption figures should be increased by 20% as per the project guide tolerances.

Auxiliary engines tend to have very poor fuel consumption properties at lower loads, especially for alternatively fuelled engines, and so the number of operating diesel engines should be chosen such that they can be assumed to be operating above 50% of capacity. Typically available consumption figures for auxiliary engines are:

- Specific Fuel Consumption (SFC), g/kW-hr
- Specific Pilot Oil Consumption (SPOC), g/kW-hr
- Urea consumption, g/kW-hr (For IMO NO_x emissions compliance) -Note not L/hr like for the main engine
- Lube Oil Consumption, g/kW-hr
- Methane Slip, g/kW-hr (for LNG fuelled engines)

Unlike the main engines, the auxiliary engines will be operating while the vessel is at port and idle, and will have different power demands for the different phases. If possible, based on the energy demands and generator sizing and number a simplifying assumption can be made at this step that the number of active generators will be varied instead of the loading, which allows for a single set of consumption rate figures to be used. Otherwise, if the loading on the generators is substantially different for the different phases, then different consumption rates need to be used for each phase.

Similar to the main engine, the pilot fuel kW-hr fraction also needs to be determined for use with several of the emission factors.

Boiler Consumption

The boiler required fuels can be directly calculated from the established boiler specific fuel consumption and the boiler operating kW-hrs. It is assumed that the boilers can burn any of the alternative fuels directly.

Shore Power

If the operational profile of the vessel requires shore power to be used instead of the auxiliary engines, this should be tabulated in this phase. The shore power requirements can be assumed to be equal to the in port auxiliary power demand, plus any reliquification energy. Note that if shore power is used in port, the auxiliary engine power demand while in port should be zero.

8.9.3. Tank-to-Wake Emissions

Once the quantity of consumables is known for the main engine, the auxiliary engines, the boiler, and shore power, the emissions associated with using the fuel can be calculated by using emissions factors. These emission factors are taken from the IMO 4th GHG study (2020). The emissions inventoried are:

- CO₂
- SO_x
- NO_x
- Particulate Matter (10 and 2.5)
- Methane
- Carbon Monoxide
- N₂O
- Volatile Organic Compounds
- Black Carbon

Emission factors are provided either in terms of a mass of emission per mass of fuel or as a specific emission factor reporting the mass of emission per kW-hr. The emissions can therefore be calculated by multiplying the mass of fuel consumed by the emission factor, or by kilowatt hours of the respective engine.

Except for CO₂, there are varying emission factors for the main engine, auxiliary engines, and boilers. The CO₂ emission factors for the different fuels are shown in Table 35.

Table 35: CO₂ Emission Factors for Conventional and Alternative Fuels

Fuel	CO ₂
-	g-CO ₂ /g Fuel
HFO	3.114
LSHFO	3.114
MDO	3.206
Methane/LNG	2.75
Methanol	1.375
Ammonia	0
Hydrogen	0

Methanol, Ammonia, and Hydrogen do not have non-CO₂ emission factors associated with them. The IMO 4th GHG study assumed that methanol engines would have 10% of the emissions of an HFO powered vessel. Rather than following that assumption, for these fuels the non-CO₂ emissions are assumed to be associated with the combustion of the pilot oil, MDO. For this reason, emissions from the pilot oil are tracked separately from the primary fuel and aggregated at the end.

The consumed quantities of lube and cylinder oil are assumed to be combusted with the same properties as MDO.

PM_{2.5} is taken as 92% of the PM₁₀ emissions.

Main Engine non-CO₂ Emission Factors

The main engine non-CO₂ emission factors are presented in Table 36.

Table 36: Main Engine Non-CO₂ Emission Factors

Fuel	SO _x	NO _x	CH ₄	CO	N ₂ O	NM VOC
-	g-SO _x /g-fuel	g-NO _x /kw-hr	g-CH ₄ /kW-hr	g-CO/kw-hr	g-N ₂ O/kW-hr	g-NM VOC/kW-hr
HFO	0.051	3.4	0.01	0.54	0.031	0.632
LSHFO	0.020	3.4	0.01	0.54	0.031	0.632
MDO	1.56E-03	3.4	0.01	0.044	0.03	0.632
Methane/LNG	3.17E-05	3.4	from Engine Data	1.04	0.03	0.4
Methanol	Pilot Fuel	3.4	Pilot Fuel	Pilot Fuel	Pilot Fuel	Pilot Fuel
Ammonia	Pilot Fuel	3.4	Pilot Fuel	Pilot Fuel	Pilot Fuel	Pilot Fuel
Hydrogen	Pilot Fuel	3.4	Pilot Fuel	Pilot Fuel	Pilot Fuel	Pilot Fuel

SO_x emissions are calculated using the following formula:

$$SO_x = 2 * 0.97753 * S \text{ (IMO 4th GHG Study et al., 2020)}$$

Where S is the sulphur content in the fuel, assumed to be 2.6% for HFO, 1% for LSHFO, and 0.08 for MDO. For Methane, an SO_x emission factor is directly available and this is added to the SO_x emissions associated with combustion of the pilot fuel.

NO_x emissions are limited by IMO Tier III regulations, and the limit of 3.4 g/kW-hr is applied to all fuels.

Methane emissions (CH₄) are directly available for conventional fuels, and the methane slip for an LNG powered low-speed diesel is reported in the main engine project guide.

Calculation of PM₁₀ is more complicated, being dependent on the specific fuel consumption of an engine and the sulphur content of the fuel. The equations for calculating the PM₁₀ emission factors is shown in Table 37 (IMO 4th GHG Study et al., 2020).

Table 37: PM₁₀ emission Factors for Main Engine

Fuel	Sulphur Content S	PM10
-	%	g-PM10/kW-hr
HFO	2.60%	$1.35 + \text{SFC} * 7 * 0.02247 * (S - 0.0246)$
LSHFO	1%	$1.35 + \text{SFC} * 7 * 0.02247 * (S - 0.0246)$
MDO	0.08%	$0.23 + \text{SFC} * 7 * 0.02247 * (S - 0.0024)$
Methane/LNG	0	0.01
Methanol	0	Pilot Fuel
Ammonia	0	Pilot Fuel
Hydrogen	0	Pilot Fuel

Black Carbon emissions for HFO and MDO are dependent on the engine load, with more black carbon being emitted at lower engine loads. Therefore, the emission factor for black carbon varies with the route main engine load, as shown in Table 38. For methane, a fixed value of 0.002 g-Black Carbon per kilowatt-hour is provided. For the other alternative fuels, the black carbon production is assumed to come from the combustion of the pilot fuels.

Table 38: Black Carbon Emission Factors for Main Engine, in Mass BC/Mass Fuel

	HFO	MDO
5%	4.40E-04	1.00E-04
10%	3.40E-04	8.00E-05
20%	2.70E-03	6.00E-05
30%	2.30E-04	5.00E-05
40%	2.10E-04	4.00E-05
50%	1.90E-04	4.00E-05
60%	1.80E-04	4.00E-05
70%	1.70E-04	4.00E-05
80%	1.60E-04	3.00E-05
90%	1.60E-04	3.00E-05
100%	1.50E-04	3.00E-05

Auxiliary Engine non-CO₂ Emission Factors

Auxiliary Engine non-CO₂ emission factors are presented in Table 39, taken from the IMO 4th GHG study.

Table 39: Aux Engine Non-CO₂ Emission Factors

Fuel	SO _x	NO _x	CH ₄	CO	N ₂ O	NM VOC	PM10
-	g-SO _x /g-fuel	g-NO _x /kw-hr	g-CH ₄ /kw-hr	g-CO/kw-hr	g-N ₂ O/kw-hr	g-NM VOC/kw-hr	g-PM10/kw-hr
LSHFO	0.0196	2.414	0.01	0.54	0.04	0.421	1.39
MDO	0.0016	2.414	0.01	0.54	0.036	0.421	0.18
Methane/LNG	3.17E-05	3.400	0.2	1.3	0.03	0.4	0.02
Methanol	2.64E-03	2.414	Pilot Fuel	Pilot Fuel	Pilot Fuel	Pilot Fuel	0.14
Ammonia	Pilot Fuel	2.414	Pilot Fuel	Pilot Fuel	Pilot Fuel	Pilot Fuel	Pilot Fuel
Hydrogen	Pilot Fuel	2.414	Pilot Fuel	Pilot Fuel	Pilot Fuel	Pilot Fuel	Pilot Fuel

The NO_x emission factors is calculated for all fuels except LNG by the following formula:

$$EF_{NO_x} = 9 * RPM^{-0.2}$$

Where the RPM for the medium speed auxiliary diesel generators is taken as 720.

Unlike for the main engines, particulate matter emissions are directly available.

Similar to the main engine, the black carbon emission factor is dependent on the engine load, as shown in Table 40. For methane, a fixed value of 0.002 g-Black Carbon per kilowatt-hour is provided. For the other alternative fuels, the black carbon production is assumed to come from the combustion of the pilot fuels.

Table 40: Black Carbon Emission Factors for Aux Engine, in Mass BC/Mass Fuel

	HFO	MDO
5%	4.52E-03	3.48E-03
10%	2.31E-03	1.60E-03
20%	1.18E-03	7.30E-04
30%	8.00E-04	4.60E-04
40%	6.00E-04	3.40E-04
50%	4.90E-04	2.60E-04
60%	4.10E-04	2.10E-04
70%	3.50E-04	1.80E-04
80%	1.60E-04	1.50E-04
90%	1.60E-04	1.40E-04
100%	1.50E-04	1.20E-04

Boiler Emission Factors

The boiler non-CO₂ emission factors are presented in Table 41 (IMO 4th GHG Study *et al.*, 2020).

Table 41: Boiler Non-CO₂ Emission Factors

Fuel	SO _x	NO _x	CH ₄	CO	N ₂ O	NM VOC	PM ₁₀	Black Carbon
-	g-SO _x /g-fuel	g-NO _x /kw-hr	g-CH ₄ /kW-hr	g-CO/kw-hr	g-N ₂ O/kW-hr	g-NM VOC/kW-hr	g-PM ₁₀ /kW-hr	g-BC/kW-hr
LSHFO	0.0196	2.100	0.002	0.2	0.04	0.421	1.42	0.08
MDO	0.0016	2.100	0.002	0.2	0.049	0.421	0.14	0.06
Methane/LNG	3.17E-05	1.300	0.04	0.2	0.02	0.105	0.03	0.003
Methanol	2.64E-03	0.000	0	0	0	0	0	0
Ammonia	0	0.000	0	0	0	0	0	0
Hydrogen	0	0.000	0	0	0	0	0	0

Summary Data

At the end of the tank-to-wake inventory phase, a series of system inputs and outputs should be available, as shown in Table 42. The system inputs, specifically Pilot Oil, Fuel,

Cylinder Oil, Lube Oil, and External Energy are then brought to the next phase for calculation of the well-to-tank emissions.

Table 42: List of System Inputs and Outputs from Tank-to-Wake Inventory

System Input Summary	
Pilot Oil (MDO)	MT
Fuel (Varies)	MT
Urea	MT
NaOH	MT
Cylinder Oil	MT
Lube Oil	MT
External Energy	kW-Hr
System Output Summary	
CO ₂ Emissions	MT
SO _x Emissions	MT
NO _x Emissions	MT
PM ₁₀ Emissions	MT
PM _{2.5} Emissions	MT
CH ₄ Emissions	MT
CO Emissions	MT
N ₂ O Emissions	MT
NMVOC Emissions	MT
BC Emissions	MT

Note that Urea and NaOH consumptions are listed, but well-to-tank emissions for these chemicals are not examined further.

8.9.4. Well-to-Tank Emissions

Well-to-tank emission factors were extracted from literature as discussed in section 5.4, and the final emission factors, given as MT of Emission per MT of fuel, are presented in Table 43.

Table 43: Well-to-Tank Emission Factors for Various Fuels and Fuel Production Methods

Well-to-Tank Emission Factors												
MT Emission/MT Fuel	HFO	VLSFO	MGO	Bio-Diesel	LNG	Bio-LNG	Ammonia	Bio-Ammonia	Methanol	Bio-Methanol	Hydrogen	E-Hydrogen
CO ₂ Emission Factor	0.269	0.546	0.575	0.641	0.398	1.296	1.571	0.554	0.398	0.338	9.358	0.948
Bio CO ₂ Uptake Factor				2.861	0.000	4.656	0.000	0.000	0.000	2.388	0.000	0.000
Carbon Offset Factor	0.000	0.000	0.000	2.829	0.000	2.750	0.000	0.000	0.000	1.380	0.000	0.000
SO _x Emission Factor	1.57E-03			1.28E-03	3.98E-05	3.50E-03	8.18E-06	0.00E+00	4.18E-05	9.55E-04	4.56E-03	6.12E-03
NO _x Emission Factor	8.44E-04			6.41E-03	4.56E-04	2.54E-03	8.18E-04	8.18E-04	9.15E-04	1.11E-03	4.08E-03	3.60E-03
PM ₁₀ Emission Factor	4.42E-05			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CH ₄ Emission Factor	2.89E-03	4.48E-03	4.60E-03	8.54E-04	1.58E-03	8.64E-04	9.86E-05	0.00E+00	2.19E-04	8.36E-04	1.80E-02	3.00E-04
CO Emission Factor	3.70E-04			0.00E+00	1.30E-04	4.61E-04	6.88E-05	0.00E+00	1.25E-04	4.98E-04	1.20E-03	9.00E-04
N ₂ O Emission Factor	6.43E-06	1.00E-05	1.00E-05	4.27E-05	7.68E-06	1.58E-05	8.37E-06	8.37E-06	5.77E-06	4.38E-06	3.00E-05	4.92E-05
NMVOC Emission Factor	3.30E-06											

It should be noted that depending on the source of the data, different emission factors are available. As far as practical emissions factors matching those available for the tank-to-wake study were extracted and reported, but in some cases only CO₂ or CO_{2Eq} are reported directly from the sources. Since this report focuses on CO_{2Eq}, the available values for CO₂ (or CO_{2Eq} if directly reported), CH₄, and N₂O are the most critical.

The associated well-to-tank emissions can be calculated by multiplying the mass of fuel by the corresponding emissions factor. This is carried out for the pilot fuel, main fuel, lube oil and cylinder oil (assuming the emissions factors of MGO), and external energy (for shore power).

The grid electricity CO₂ emission factor is assumed to be 334 g-CO₂/kW-hr, taken from the average predicted grid emissions over the period from 2020-2050 from Gilbert (2017).

Note that the emission factors are not consistently available for all the different possible fuels and fuel sources due to the varied nature of the input data.

It is assumed that fugitive emissions associated with bunkering are included in these well-to-tank emission factors.

When considering the well-to-wake emissions, a distinction can be made on the source of both the pilot fuel and the primary fuel. The pilot fuel can be taken as either fossil-derived MDO, or assumed to be biodiesel, which will allow the pilot fuel's CO₂ emissions to be offset. The alternative fuels can also be assumed to come from fossil sources ("Grey") or biogenic/renewable sources ("Green") based on the chosen well-to-wake emission factors. The examined combination of fuels is presented in Table 44. Blue, Purple, Pink, etc. emission factors are not investigated in this research.

Table 44: Combination of Fuels in this Research, per Fuel Category

Fuel Combinations																
Ship Fuel Design	Base	LNG			Ammonia			Methanol			LH ₂			Comp. H ₂		
Pilot Fuel	N/A	MDO	MDO	Bio diesel	MDO	MDO	Bio diesel	MDO	MDO	Bio diesel	MDO	MDO	Bio diesel	MDO	MDO	Bio diesel
Main Fuel	VLSFO	LNG	Bio LNG	Bio LNG	Ammonia	Bio Ammonia	Bio Ammonia	Methanol	Bio-Methanol	Bio-Methanol	Hydrogen	E-Hydrogen	E-Hydrogen	Hydrogen	E-Hydrogen	E-Hydrogen

8.9.5. Total Operational Emissions

The total operational emissions can be calculated by summing the well-to-tank with the tank-to-wake data to produce the final well-to-wake emissions inventory.

At this stage, some assessment steps can be performed, such as calculating the global warming impact from the CO₂, CH₄, and N₂O emissions. The work-transport of the vessel from a well-to-wake perspective can also be calculated. Finally, comparisons can be made between the portions of the emissions that are associated with the well-to-tank and tank-to-wake phases.

8.10. Lifecycle Inventory – Ship Breaking

As described in the literature review, the ship breaking process was one of the more difficult steps to inventory. Ultimately, the method from Rahman, Handler and Mayer (2016) was implemented to provide an estimation of the CO₂ Emissions associated with ship breaking. A diagram summarizing the steps in this process is shown in Figure 27.

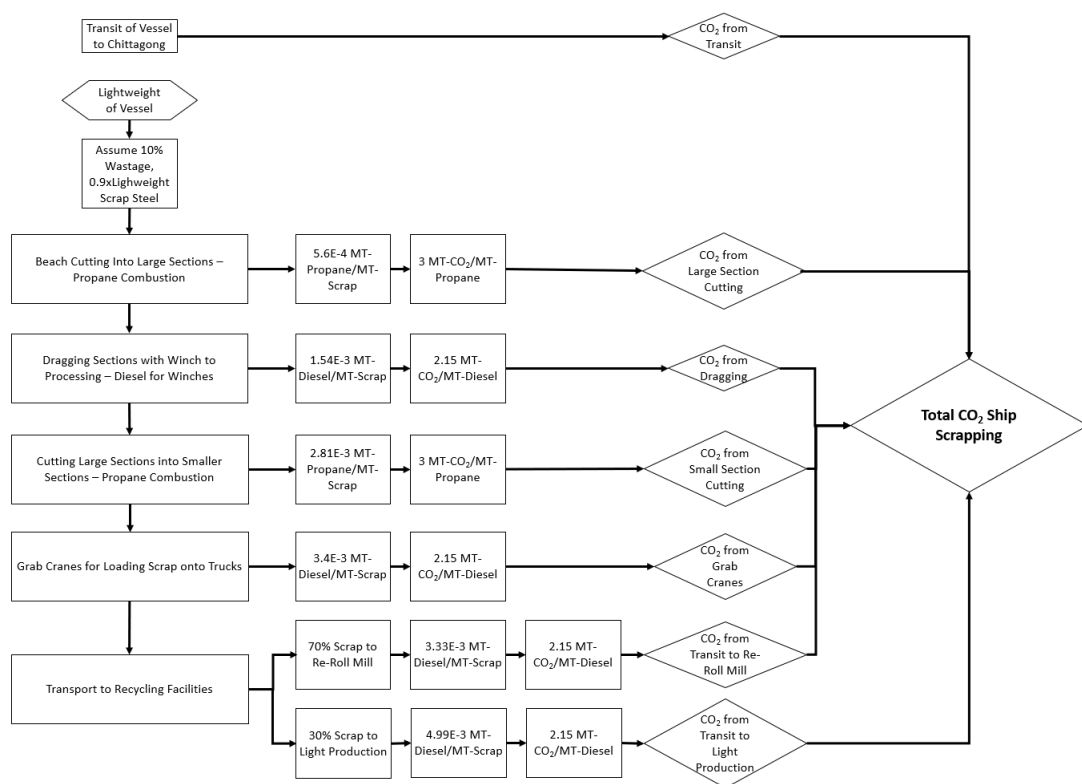


Figure 27: Ship Breaking Emissions Calculation Procedure (Rahman, Handler and Mayer, 2016)

The first step in the process is to calculate the emissions from sailing the vessel to Chittagong, Bangladesh where the ship breaking is assumed to take place. The transit emissions are calculated using the same methodology as the operating emissions with the vessel assumed to slow-steam in a ballast draft condition and have the usual 1.15

sea margin and 1.07 hull fouling factor applied. The auxiliary loads are the baseline for at-sea operations, and the boiler isn't used.

Following sailing to Chittagong, the vessel is assumed to be beached where it will proceed to be cut into larger chunks, approximately 350 MT each. This cutting is done with gas torches using propane, and a use factor of 0.56 kg of propane per MT of scrap recovered is applied. 5.73 kg of oxygen gas per MT of recovered scrap is also consumed with the torches. The emissions factor of propane to CO₂ is taken as 3 MT-CO₂/MT-propane, as from the repair phase.

After the vessel is cut into chunks, the chunks are winched further inland to a processing facility. These winches are assumed to consume 1.54 kg of diesel oil per ton of scrap, and a diesel CO₂ emission factor of 2.15 MT-CO₂/MT-diesel is applied as per the shipbuilding and maintenance phases.

Next, the larger chunks are cut into smaller pieces that can be fit onto a truck and transported further inland. This cutting process requires 2.81 kg of propane and 28.67 kg of oxygen per MT of scrap recovered, more than in the first stage of cutting primarily due to much more cutting being required.

Grab cranes are then used to load the steel pieces onto trucks for transport toward reclamation facilities. The grab cranes were estimated to consume 3.4 kg of diesel per MT of scrap loaded.

Finally, the steel is trucked to reclamation facilities, either re-rolling plants or "light engineering" where the steel is machined and re-purposed. It is assumed 70% of the steel goes to re-rolling plants and 30% goes to light engineering facilities (Chatzinikolaou and Ventikos, 2015), and the associated diesel consumption for this transit is 3.33 kg/MT of scrap and 4.99 kg/MT of scrap respectively.

At this stage, the scrapping process is considered finished. The Worldsteel organization (2021) lifecycle data for steel includes a reduction factor associated with recycling steel, and so at the gate of the steel foundry the secondary steel lifecycle is considered closed.

This methodology provides primarily CO₂ and O₂ emissions, with minor other emissions tabulated from the transit to scrapping site.

8.11. Additional Ships Factor

Using the quantities of cargo and total distance sailed over the lifetime of the vessel from the lifecycle operational inventory, calculate, the “additional ships factor” as per Gratsos (2010). This factor is useful for normalizing the reference flow because alternatively fuelled ship design may have a different cargo capacity, which would require construction of additional ships to deliver the same amount of cargo from a fleet perspective. The additional ships factor is calculated as follows:

Additional Ships Factor

$$= \text{Cargo Cap}_{HFO} * \text{Dist}_{HFO} / (\text{Cargo Cap}_{Alt Fuel} * \text{Dist}_{Alt Fuel})$$

Where cargo capacity is the functional unit, either a measure of delivered cargo in terms of MT or TEU, and the distance is the sailed distance to deliver the cargo in kilometres. The additional ships factor can be fractional, though in practice a full ship would be required to make up a fractional difference.

8.12. Total Lifecycle Inventory, Impact Assessment and Normalization

All stages of the lifecycle inventory are now complete, and the complete lifecycle emissions of the vessel can be determined by summing up the values from the shipbuilding, operational, maintenance, and ship breaking inventories. The operational emissions are for a single round trip and should be multiplied by the number of round trips the vessel will complete in its lifetime. Similarly, the maintenance emissions should be multiplied by the number of shipyard periods if it has not already been done so.

Since this analysis intends to focus primarily on CO_{2Eq}, the CO_{2Eq} is calculated from the CO₂, CH₄, and N₂O emissions from the MEPC emissions factors of 1, 28, and 265 respectively (MEPC.376(80), 2017). The breakdown of emissions associated with Shipbuilding, Maintenance, and operations is now available at this stage.

Using the CO_{2Eq} values for the lifetime of the vessel, the work-transport metrics should be calculated on the basis of CO_{2Eq} per ton-km or TEU-km (for container ships). This work-transport efficiency can then be multiplied by the additional ships factor calculated in section 8.11 to yield a normalized work-transport figure that can be used to directly compare the performance of the derivative designs against the baseline

design and against each other, with due consideration of the different cargo capacities of the designs and the potential need for additional shipbuilding.

The lifecycle assessment model is linear with respect to the number of ships, so the relative performance of the designs is independent of the number of ships, though the absolute emissions natural increase with increasing numbers of vessels. However, the model is non-linear with respect to sailing speed, and therefore, with route distance (if speeding up is required to cover a larger distance to maintain a schedule). This is because the main engine power requirements increase roughly with the cube of the travel speed, and similarly the specific fuel and pilot oil consumptions are variable with relation to the delivered power. Longer routes/higher speeds would emphasize the operational emissions.

9. Case Study – Ultra Large Containership

Based on the results of the literature review, a case study was carried out implementing the proposed comparative lifecycle methodology for an Ultra Large Container Carrier (ULCC) with an approximate capacity of 24,000 TEU sailing between Europe and Asia.

9.1. Case Study Lifecycle Goal and Scope Definition

The goal of the case study is to perform a comparative evaluation of the CO_{2Eq} emissions from a series of ultra-large containerships powered by conventional and alternative fuels. The assessment metric will be the CO_{2Eq} per work transport over the lifetime of the vessel, measured in both TEU carried per kilometre and MT delivered with those TEU per kilometre. The performance of the alternatively fuelled designs will be normalized by the additional ships factor so the lifetime cargo delivered by each design is equivalized by assuming changes in the number of respective ship designs. The functional unit is MT-km and TEU-km delivered by the vessel, and the reference flow is a ship for the carriage of containerized cargo from Asia to Europe and back. The system boundary described in methodology section 8.2 is implemented.

9.2. Selection of Case Study Parent Ship and Trade Route

The purpose of this section is to outline the critical parameters of the case study vessel required as inputs to the life cycle analysis methodology. The required inputs are:

- Basic Ship Information/Principal Particulars
- Distance and Time Sailed (Routing Information)
- Lightship Weight
- Cargo Capacity
 - Requires build-up of representative loading conditions, which requires:
 - Lightweight
 - Container Loads
 - Tank Loads
 - Constant Loads
 - Requires stability assessment of loading conditions
- Speed-Power Characteristics
 - Requires drafts and displacements from loading conditions
- Main and Auxiliary Engines

- Painting Areas

9.2.1. *Principal Particulars, Arrangement and Nominal Cargo Capacity*

Three candidate ultra large containerships were identified from Significant Ships publications which were in the 20,000+ TEU range:

- MOL *Triumph* (RINA, 2018)
- CMA-CGM *Jacques Saade* (RINA, 2021)
- HMM *Algeciras* (RINA, 2021)
- HMM *Oslo* (RINA, 2021)

These ships were used as the basis for designing a new ultra large containership with a capacity of approximately 24,000 TEU for this case study. The basic properties of these four reference ships and the values used for the case study ship are shown in Table 45.

Table 45: Principal Particulars of Ultra Large Container Vessels (RINA, 2018; RINA, 2021)

Particular	unit	MOL Triumph	CMA CGM Jacques Saade	HMM Algeciras	HMM Oslo	CASE STUDY VESSEL
LOA	m	400.00	399.90	399.90	399.90	400.00
LBP	m	383.00	393.90	383.30	383.00	394.00
B	m	58.80	61.30	61.00	61.50	61.00
D	m	32.80	33.50	33.20	33.20	33.00
Design Draft	m	14.50	14.50	14.50	14.50	14.50
Scantling Draft	m	16.00	16.00	16.50	16.50	16.50
Design Draft Displacement	MT	225,824	256,365	254,614	252,655	256,320
Scantling Draft Displacement	MT	255,224	288,355	298,114	294,455	299,729
Lightship Weight	MT	62,524	67,105	65,414	65,855	67,000
Estimated Lightship Weight 1	MT	55,830	60,197	58,176	58,533	-
Estimated Lightship Weight 2	MT	69,219	75,632	72,652	73,177	-
Design Deadweight	MT	163,300	189,261	189,200	186,800	189,320
Scantling Deadweight	MT	192,700	221,251	232,700	228,600	232,729
Block Coefficient Design Draft	-	0.67	0.71	0.73	0.72	0.74
Block Coefficient Scantling Draft	-	0.69	0.73	0.75	0.74	0.77
Design Speed	knots	22.50	21.97	22.40	22.25	22.4
Main Engine Installed Power	kW	59,250	63,840	60,380	59,600	65,500
Fuel Oil Capacity	m ³	15,000	1+18,762	12,000	13,500	11,844
Propeller Diameter	m	10.4	10.1	10.3	10.4	10.4
TEU Capacity on Deck	TEU	11,080	13,328	14,032	14,032	14,076
TEU Capacity in Holds	TEU	9,066	9,784	9,932	9,788	9,900
Total TEU Capacity	TEU	20,146	23,112	23,964	23,820	23,976
TEU Capacity at 14 MT/TEU	TEU		14,810	15,450	15,056	14,398
Reefer Capacity	FEU		2,200	1,500	1,500	2,200
Tiers on Deck	#		12	13	13	13
Rows on Deck	#		24	24	24	24
Tiers in Hold	#		11	12	12	12
Rows in Hold	#		22	22	22	22

*Values in blue are estimated/calculated from regression formulae

The case study vessel is a combination of the CMA CGM *Jacques Saade* and the HMM *Algeciras*, resembling the *Jacques Saade* externally but primarily using the internal configuration of the *Algeciras*, based on the available data.

A 3D model of the case study vessel was made in Rhino 3D in order to:

- lay out the cargo holds, tanks and compute the total number of container slots
- verify visibility requirements with regards to the conning position and the forward stack heights
- carry out design studies for alternative fuel tank arrangements
- estimate areas, weights, and centres of gravity

The designed vessel has a maximum slot capacity of 23,976 TEU, with 2,200 FEU of reefer plugs and an estimated lightship weight of 67,000 MT developed through regressions and comparison to the CMA-CGM *Jaques Saade*.

Some key drawings of the design vessel are shown in Figure 28 through Figure 31, Table 46, and more details of the case study vessel and its design parameters can be found in Appendix A – Case Study Detailed Parent Ship Design Data.

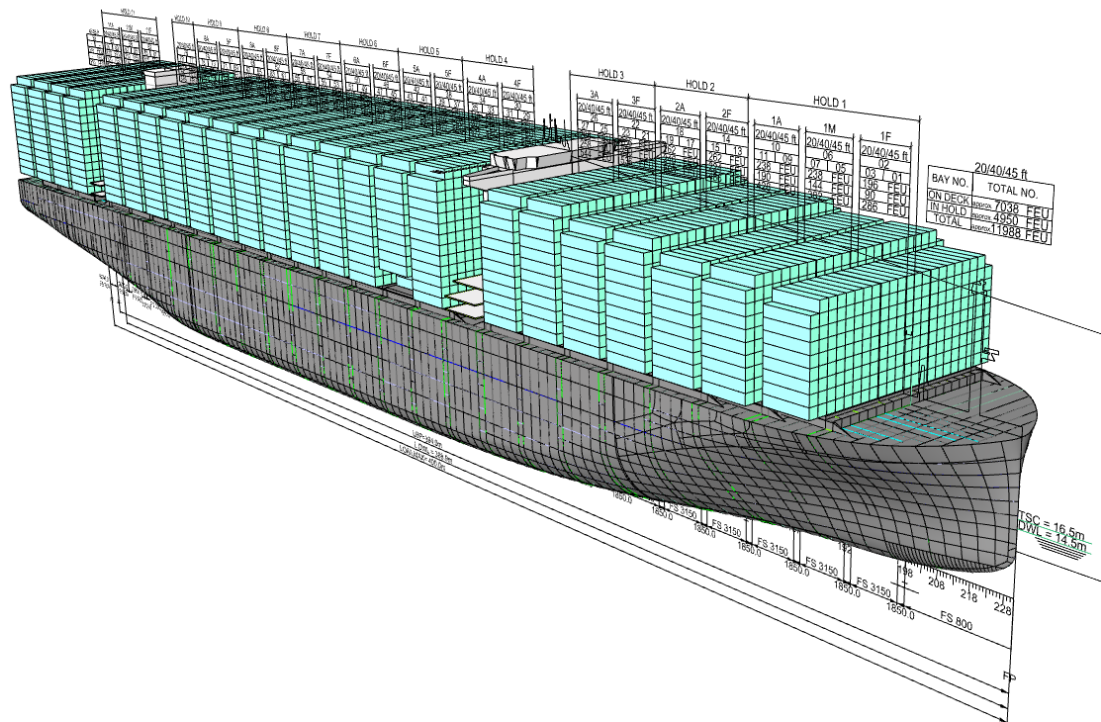


Figure 28: 3D model of Case Study ULCC (Bow View)

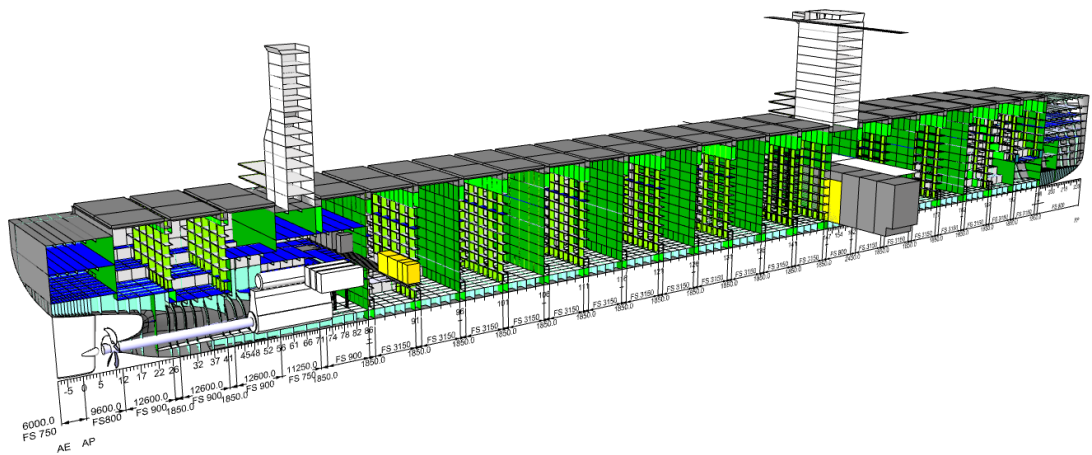


Figure 29: 3D model of Case Study ULCC (Cutaway View)

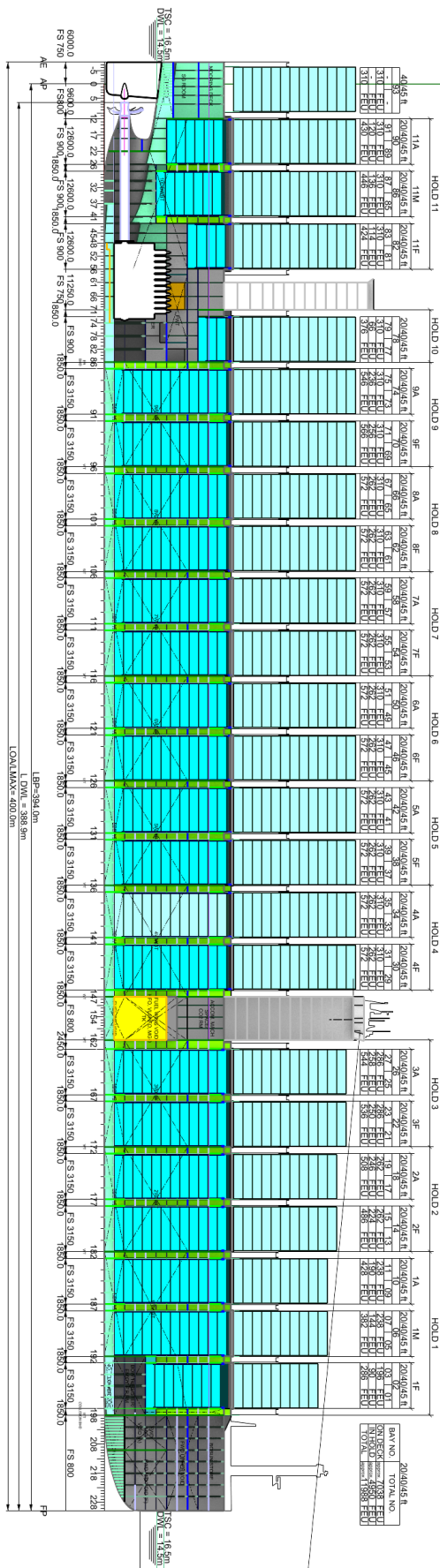


Figure 30: Side Profile of Case Study Vessel

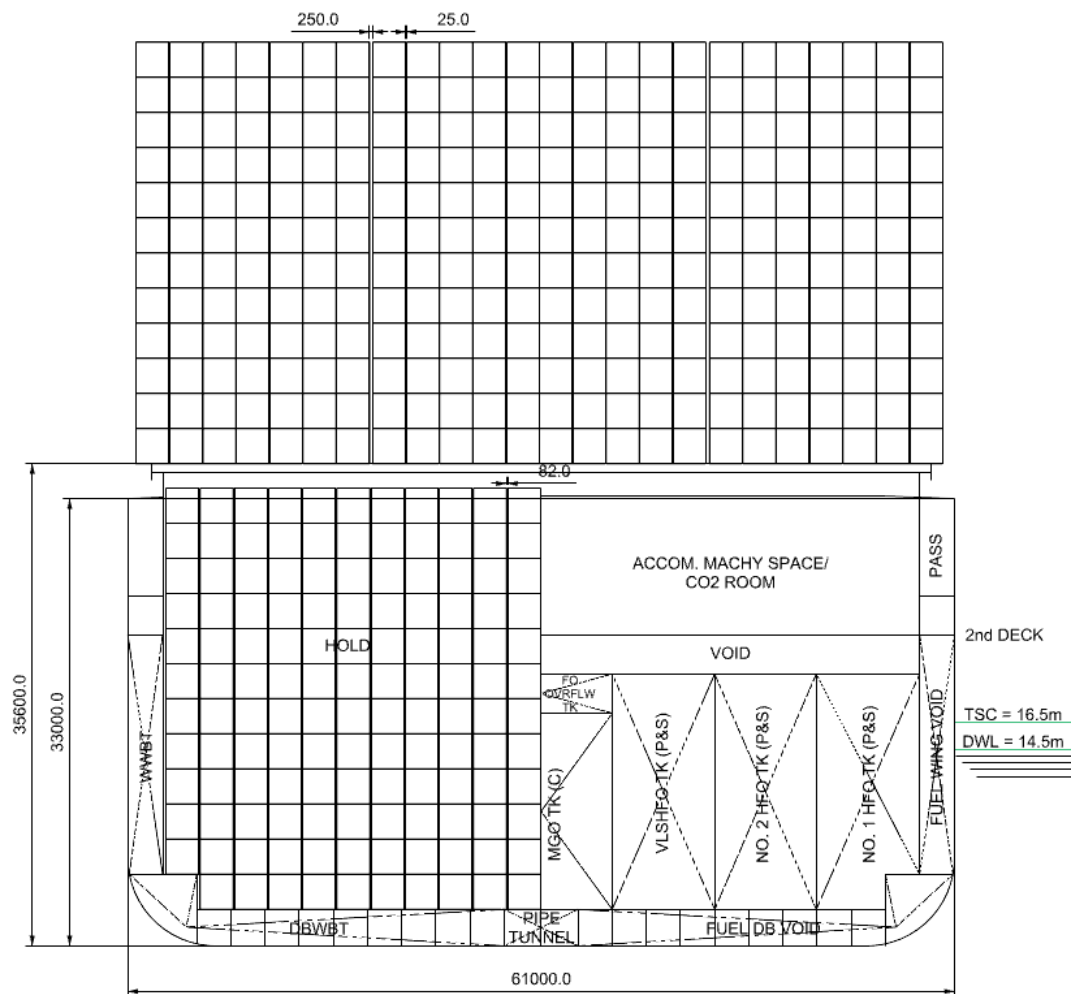


Figure 31: Case Study Vessel, Midships Section

Table 46: Container Count Summaries by Bay

	40' Bay	94	90	86	82	78	74	70	66	62	58	54	50	46	42	38	34	30	26	22	18	14	10	6	2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
Tiers	20' Bay		91	89	87	85	83	81	79	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	27	25	23	21	19	17	15	13	11	9	7	5	3	1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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9.2.2. Trade Route

The vessel is similar in size and properties to the CMA CGM *Jaques Saade*, so was assumed to be employed in the same trade between Europe and Asia, namely the FAL3 line. There are two versions of this route available, one utilizing the Suez canal shown in Table 47, and one routed around the Cape of Africa, shown in Table 48. In either case, the scheduled round trip time is 98 days for a complete journey. The change from the Suez to the Cape route was a response to geopolitical issues near the Red Sea making the route potentially hazardous, but there have been other incidences such as the grounding of the *Ever Given* in the Suez Canal which makes it advantageous for vessels on the Asia to Europe trade to have the flexibility to handle the extra ~3,500 Nautical miles added to each leg of the journey should re-routing around the Cape be necessary.

Table 47: CMA-CGM FAL 3 Line, Via Suez Canal between Singapore and Dunkerque and Le Havre to Singapore

Origin->Destination	Schedule Time	Schedulal Interval	Sailing Distance
-	day	-	Nmi
Qingdao->Shanghai	1	1	357
Shanghai->Ningbo	4	3	109
Ningbo->Yantian	8	4	759
Yantian->Singapore	13	5	1,457
Singapore->Dunkerque	42	29	8,334
Dunkerque->Rotterdam	44	2	117
Rotterdam->Southampton	48	4	255
Southampton->Antwerp	51	3	266
Antwerp->Le Havre	55	4	236
Le Havre->Singapore	88	33	8,239
Singapore->Qingdao	95	7	2,483

Total Distance, Asia to Europe: 11016 Nautical Miles

Total Distance, Europe to Asia: 11596 Nautical Miles

Total Round Trip Distance: 22612 Nautical Miles

Table 48: CMA-CGM FAL 3 Line, Via the Cape Route between Singapore and Dunkerque and Le Havre to Port Klang

Origin->Destination	Schedule Time	Schedulal Interval	Sailing Distance
-	day	day	Nmi
Qingdao->Shanghai	2	1	357
Shanghai->Ningbo	5	3	109
Ningbo->Yantian	9	4	759
Yantian->Singapore	14	5	1,457
Singapore->Dunkerque	42	28	11,722
Dunkerque->Rotterdam	45	3	117
Rotterdam->Southampton	49	4	255
Southampton->Antwerp	52	3	266
Antwerp->Le Havre	56	4	236
Le Havre->Port Klang	86	30	11,456
Port Klang->Qingdao	96	10	2,681

Total Distance, Asia to Europe: 14404 Nautical Miles

Total Distance, Europe to Asia: 15011 Nautical Miles

Total Round Trip Distance: 29415 Nautical Miles



Figure 32: CMA-CGM FAL 3, Using the Cape of Africa Route (CMA-CGM, 2023)

This case study simplifies the route into two legs, one from Asia to Europe and a backhaul from Europe to Asia in a lighter draft condition. The vessel is assumed to be in the design draft condition until Dunkerque, and then assumed to be in a light draft

condition until returning to Qingdao. The vessel visits 5 ports in the EU and 6 ports in Asia. The vessel is assumed to stay 1.5 days in every port during normal operations (taken as 1.36 or 15 days in port total during endurance operations) and is assumed to be able to bunker while loading containers or during the idle time in the schedule.

9.2.3. Cargo Demand Projections and Nominal Fleet Sizes

The expected cargo demand was estimated based on a set of four trade scenarios based on 2024 trade volumes, where the demand of cargo from Asia to Europe was listed as 14.9 Million TEU/Year and the demand of cargo from Europe to Asia was 5.8 Million TEU (DHL, 2024). The four scenarios included a 2% decrease in trade volumes per year, 0% growth, 2% growth, and 4% growth, the maximum of which roughly follows the trends outlined in the UNCTAD 2022 report (2022). Assuming the vessels were trading for 25 years starting now until 2049, the total cargo demand for a 25-year service between Asia and Europe under these four scenarios was calculated.

The entire trade volume between Europe and Asia is not covered by vessel's with 20,000+ TEU capacity. Using data from the IMO 4th GHG study relating to container fleet sizes in 2018 and projected to 2050, and assuming that the Asia/Europe trade route would be serviced by vessels of 12,000 TEU+ size, the share of cargo carried by ultra-large container ships was estimated using a weighted average based on the median capacity and percentage fleet composition, shown in Table 49. The total calculated cargo demand and the portion expected to be carried by Ultra-Large Container Carriers is shown in Table 50.

Table 49: Estimation of Portion of Europe-Asia Trade carried by 20,000+ TEU container vessels

Ship Size	TEU Range	Assumed Capacity*	2018			2050		
			% of Ships	Capacity x % Ships	% of Capacity	% of Ships	Capacity x % Ships	% of Capacity
Neo-Panamax	12000-14499	13249.5	4.3%	564	53%	9.0%	1192.455	52%
Very Large Container Vessel	14500-19999	17249.5	1.9%	326	31%	4.0%	689.98	30%
Ultra Large Container Vessel	20000+	20000	0.8%	165	16%	2.0%	400	18%

Table 50: Calculation of Trade Volumes 2024-2050 between EU and Asia, and Portion Carried by Case Study Vessel

Year	Container Trade Demand, Million TEU's							
	-2%		0%		2%		4%	
	To EU	To Asia	To EU	To Asia	To EU	To Asia	To EU	To Asia
2024	14.90	5.80	14.90	5.80	14.90	5.80	14.90	5.80
2025	14.60	5.68	14.90	5.80	15.20	5.92	15.50	6.03
2026	14.31	5.57	14.90	5.80	15.50	6.03	16.12	6.27
2027	14.02	5.46	14.90	5.80	15.81	6.16	16.76	6.52
2028	13.74	5.35	14.90	5.80	16.13	6.28	17.43	6.79
2029	13.47	5.24	14.90	5.80	16.45	6.40	18.13	7.06
2030	13.20	5.14	14.90	5.80	16.78	6.53	18.85	7.34
2031	12.94	5.04	14.90	5.80	17.12	6.66	19.61	7.63
2032	12.68	4.93	14.90	5.80	17.46	6.80	20.39	7.94
2033	12.42	4.84	14.90	5.80	17.81	6.93	21.21	8.26
2034	12.17	4.74	14.90	5.80	18.16	7.07	22.06	8.59
2035	11.93	4.64	14.90	5.80	18.53	7.21	22.94	8.93
2036	11.69	4.55	14.90	5.80	18.90	7.36	23.86	9.29
2037	11.46	4.46	14.90	5.80	19.27	7.50	24.81	9.66
2038	11.23	4.37	14.90	5.80	19.66	7.65	25.80	10.04
2039	11.00	4.28	14.90	5.80	20.05	7.81	26.83	10.45
2040	10.78	4.20	14.90	5.80	20.45	7.96	27.91	10.86
2041	10.57	4.11	14.90	5.80	20.86	8.12	29.02	11.30
2042	10.36	4.03	14.90	5.80	21.28	8.28	30.18	11.75
2043	10.15	3.95	14.90	5.80	21.71	8.45	31.39	12.22
2044	9.95	3.87	14.90	5.80	22.14	8.62	32.65	12.71
2045	9.75	3.79	14.90	5.80	22.58	8.79	33.95	13.22
2046	9.55	3.72	14.90	5.80	23.04	8.97	35.31	13.75
2047	9.36	3.64	14.90	5.80	23.50	9.15	36.72	14.30
2048	9.18	3.57	14.90	5.80	23.97	9.33	38.19	14.87
2049	8.99	3.50	14.90	5.80	24.45	9.52	39.72	15.46
2050	8.81	3.43	14.90	5.80	24.93	9.71	41.31	16.08
At 25 Years from 2024	304.41	118.50	387.40	150.80	501.70	195.29	660.24	257.01
Proportion carried by 20,000 TEU+ Vessels	53.35	20.77	67.89	26.43	87.92	34.23	115.71	45.04

Based on these trade volumes, a nominal fleet size of the case-study vessels required to meet this demand was estimated, shown in Table 51.

Table 51: Expected Fleet Size of Case Study Sized Containerships to Meet Europe-Asia Projected Trade Volumes

Assumed Growth - TEU Demand			# of Ships Req'd to Meet EU Demand			
			-2%	0%	2%	4%
Fuel Type	Lifetime TEU Delivery, MTEU	MTEU Demand	53.35	67.89	87.92	115.71
	HFO	# Ships	27.9	35.4	45.9	60.4

Assumed Growth - MT Demand			# of Ships Req'd to Meet EU Demand			
			-2%	0%	2%	4%
Fuel Type	Lifetime MegaTon Delivery, MT	MegaTon Demand	445	566	733	965
	HFO	# Ships	27.7	35.2	45.6	60.0

Note that while fractional ships are reported in this table, it would be expected that the required number of ships would be rounded up. Also note that since the Asia to Europe demand was much larger, it was considered to dominate, and fleet sizes were set based on that demand, rather than the backhaul.

9.2.4. Loading Conditions

A HECSTAB stability model was developed using the 3D arrangement model to assess the vessel for compliance with intact and damaged stability requirements. To assess the stability, the lightship weight, compartmentation, cargo capacity, and other loads needed to be developed.

Lightship Weight and Centre of Gravity

The lightweight and centre of gravity was determined through a weight estimation procedure, with the total lightweight estimated by regression and comparison to similar ships and a more detailed breakdown produced using estimates and regression formula from Papanikolaou (2014) and similar ship data, regressions, or direct 3D modelling. This reverse-weight breakdown from a total lightship weight was necessary to determine the longitudinal and vertical centres of gravity, as well as the portion of the lightweight attributable to hull steel, itself needed to determine the welding weight. The Transverse centre of gravity is assumed to be located at centreline. A high-level breakdown of the lightship weight items is shown in Table 52, and the implemented lightship weight distribution is shown in Figure 33. More details of how the lightweight items are estimated and a detailed breakdown of the lightship weight distribution can be found in Appendix A.

Table 52: Lightship Weight Breakdown for Case Study ULCC

Item	Weight	LCG	Aft Extent	Fwd Extent	VCG
-	MT	m-AP	m-AP	m-FP	m-ABL
Hull Steel	45,940	188.2901			19.7
Main Engine	2,273	54.332	43.9	64.2	8.132
Engine Foundation	67	54.332	43.9	64.2	2.7
Aux DG	503	69.6	66	73.2	18.8
Machinery Misc.	1,623	59.35	36.65	73.2	18.8
Prop Shaft	244	26.08	8.245	43	5.6
Propeller	152	7.2448	6.245	8.245	5.6
Hatch Coaming Aft	323	30.35	9.6	51.1	34.5
Hatch Coaming Mid	1,548	157.2	62.35	252.05	34.5
Hatch Coaming Fwd	864	315.1	264.05	367.65	34.5
Casing Aft	499	58.6	54.85	62.35	50
Accommodation Fwd	1,046	258	252.05	264.05	50.5
Accommodation Outfit	632	258	252.05	264.05	40
Mooring aft	300	1.8	-6	9.6	26.8
Mooring and Anchors Fwd	1,242	377.8	367.65	400	29
Paint	793	190	-6	400	21
Hatch Covers	4,359	187.4	Varies	Varies	35
Lashing Bridges	2,632	173.7	Varies	Varies	42.4
Cell Guides	1,961	192.3	Varies	Varies	21.0
Total	67,000	181.713			22.826

Groups	Weight	% Of total
-	MT	%
Steel Weight	51,080	76%
Hull Outfit	1,542	2%
Accom. Outfit	632	1%
Cargo Outfit	8,951	13%
Machinery	4,795	7%
Total	67,000	

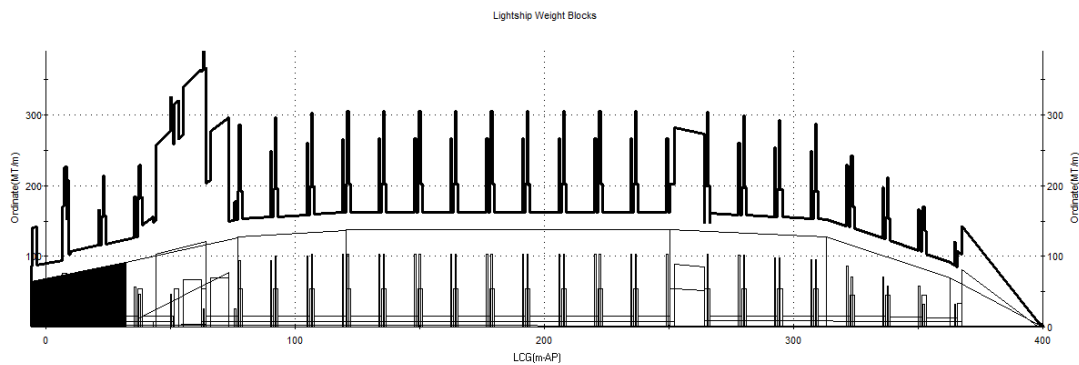


Figure 33: Lightship Weight Distribution for Case Study ULCC

Tank Loadings and Capacities

The internal arrangement and compartmentation used in the stability model was based on the drawings of the HMM *Algeciras* (RINA, 2021) and design experience with other

containerships. The internal compartmentation is shown in Figure 34. More detailed information pertaining to the tank capacities can be found in Appendix A.

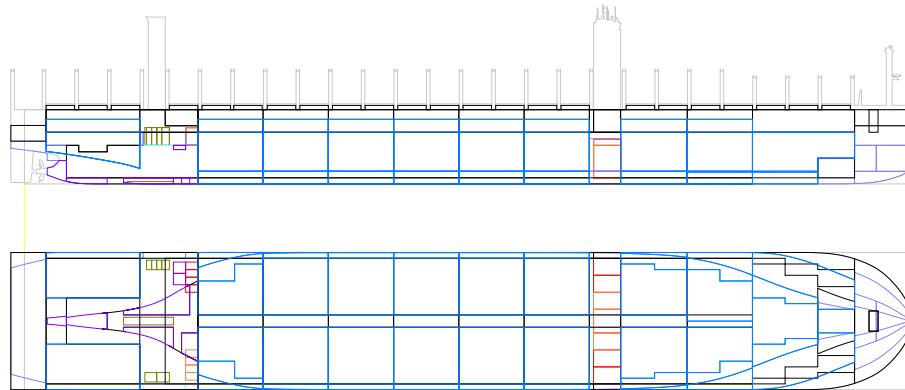


Figure 34: Stability Model for Case Study ULCC showing Internal Compartmentation

Container Loads

The following container loading scenarios were investigated:

- Max TEU Capacity, Scantling Draft Departure Condition
- Max TEU Capacity, Design Draft Departure Condition
- 10-Tier Deck Scantling Draft Departure Condition
- 10-Tier Deck Design Draft Departure Condition
- 14 MT/TEU Homogenous Scantling Draft Departure Condition
- Backhaul Max TEU Condition Departure Condition
- Ballast Arrival Condition (no TEU)

The max TEU scantling and design draft conditions assumed the vessel would be using all of its 11,988 container slots (23,976 TEU) for carrying cargo. The 10-tier deck conditions were more representative of “realistic” conditions, because in practice it is very difficult to load anything but empty containers in stacks up to 13 high across the deck due to concerns with acceleration and stability. The total loadable cargo weight was found to increase when the deck stacks were limited to 10 tiers, even if the number of containers transported decreased. The 10-tier deck condition allowed for the transport of 10,524 FEU (21,048 TEU) and was considered the operational condition from Asia to Europe. The 14 MT/TEU homogenous condition is a standard assessment condition, and was used for comparison purposes with the existing vessels but otherwise not further investigated. The backhaul condition is representative of carrying light containers from

Europe to Asia and was assumed to carry the maximum possible TEU. The ballast arrival condition was included to verify that the vessel had sufficient ballast capacity to immerse the propeller and was also used in the sea trials and transit to ship-breaking lifecycle phases.

Container loads were developed from arranging containers in the 3D model and utilizing a spreadsheet to compute their associated centres of gravity, which were subsequently applied as loads to the stability model. An example of the container loads applied to the stability model is shown in Table 53 and Table 54, while an example of a container bay VCG and count calculation is shown in Figure 35, with the corresponding 3D model of how the bay would look on the vessel shown in Figure 36.

Table 53: Max Design Draft Departure Container Weight Summaries by Bay

Condition: Max Design Departure			
Container Assume VCG:	1.16586 m-Bottom (45% of container height) See DNV Rule Ships Part 5 Chapter 2 Section 8/4.1.3		
Container Heights:	2.591 m	Hi-Cube Height	2.8956 m
Container Weight Hold:	18 MT	9 MT/TEU	Hatch Height: 35.6 m-BL
Container Weight Deck:	11.5 MT	5.75 MT/TEU	

	Hold Wt	LCG	VCG	TCG	Deck Wt	LCG	VCG	TCG
Bay	MT	m-AP	m-BL	m-CL	MT	m-AP	m-BL	m-CL
2	1,620	359.500	24.782	0	2,254	359.500	47.023	0
6	2,592	345.050	21.828	0	2,737	345.050	48.326	0
10	3,420	330.600	20.848	0	2,737	330.600	48.326	0
14	4,032	316.150	19.655	0	3,013	316.150	49.621	0
18	4,428	301.700	18.952	0	3,013	301.700	49.621	0
22	4,500	287.250	18.736	0	3,289	287.250	50.916	0
26	4,644	272.800	18.500	0	3,289	272.800	50.916	0
30	4,716	243.900	18.250	0	3,565	243.900	52.210	0
34	4,716	229.450	18.250	0	3,565	229.450	52.210	0
38	4,716	215.000	18.250	0	3,565	215.000	52.210	0
42	4,716	200.550	18.250	0	3,565	200.550	52.210	0
46	4,716	186.100	18.250	0	3,565	186.100	52.210	0
50	4,716	171.650	18.250	0	3,565	171.650	52.210	0
54	4,716	157.200	18.250	0	3,565	157.200	52.210	0
58	4,716	142.750	18.250	0	3,565	142.750	52.210	0
62	4,716	128.300	18.250	0	3,565	128.300	52.210	0
66	4,716	113.850	18.250	0	3,565	113.850	52.210	0
70	4,608	99.400	18.640	0	3,565	99.400	52.210	0
74	4,248	84.950	19.431	0	3,565	84.950	52.210	0
78	1,188	70.500	29.617	0	3,565	70.500	52.210	0
82	2,052	44.800	25.856	0	3,565	44.800	52.210	0
86	2,448	30.350	24.394	0	3,565	30.350	52.210	0
90	2,160	15.900	25.564	0	3,565	15.900	52.210	0
94					3,565	1.450	52.210	0
Total Hold	89,100 MT				Total Deck	80,937 MT		
Total Cargo	170,037 MT							

Table 54: Container Count Summary by Bay, Deck and Hold Containers

Tiers	40' Bay	94	90	86	82	78	74	70	66	62	58	54	50	46	42	38	34	30	26	22	18	14	10	6	2
13	374	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	0	0	0	0	0	0	0
12	452	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0	0	0	0
11	500	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0	0
10	548	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0
9	572	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20
8	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
7	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
6	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
5	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
4	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
3	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
2	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
1	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
Deck Total	7038	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310	286	286	262	262	238	238	196
12	446	22	22	22	22	18	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	16	12	8
11	500	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	18
10	500	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	18
9	472	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	18	14
8	456	20	22	14	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	16	12
7	436	12	18	12	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	18	14	10
6	396	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	16	12	8
5	382	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	16	10	6
4	372	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	16	8	4
3	358	18	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	16	12	8
2	338	14	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	18	14	8	6
1	294	10	16	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	18	16	14	10	6	4	
Hold Total	4950		120	136	114	66	236	256	262	262	262	262	262	262	262	262	262	262	258	250	246	224	190	144	90
Grand Total	11988	FEU	430	446	424	376	546	566	572	572	572	572	572	572	572	572	572	572	544	536	508	486	428	382	286
	23976	TEU																							

Bay 6																									
Height Check	1.425	33.94	33.63	33.33	33.02	32.72	32.42	34.4	34.09	33.79	33.79	33.79	33.79	34.09	34.4	32.42	32.72	33.02	33.33	33.63	33.94	1.425			
Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG- Bot	Count Rows	
12								32.97	32.67	32.36	32.36	32.36	32.36	32.67	32.97										8
11		32.51	32.21	31.90	31.60	31.29	30.99	30.38	30.08	29.77	29.77	29.77	29.77	30.08	30.38	30.99	31.29	31.60	31.90	32.21	32.51			31.65	20
10		29.92	29.62	29.31	29.01	28.70	28.40	27.79	27.49	27.18	27.18	27.18	27.18	27.49	27.79	28.40	28.70	29.01	29.31	29.62	29.92			28.755	20
9			27.03	26.72	26.42	26.11	25.81	25.20	24.90	24.59	24.59	24.59	24.59	24.90	25.20	25.81	26.11	26.42	26.72	27.03				25.86	18
8				24.13	23.83	23.52	23.22	22.61	22.31	22.00	22.00	22.00	22.00	22.31	22.61	23.22	23.52	23.83	24.13					22.965	16
7					21.24	20.93	20.63	20.02	19.71	19.41	19.41	19.41	19.41	19.71	20.02	20.63	20.93	21.24						20.07	14
6						18.34	18.04	17.43	17.12	16.82	16.82	16.82	16.82	17.12	17.43	18.04	18.34							17.175	12
5							15.45	14.84	14.53	14.23	14.23	14.23	14.23	14.53	14.84	15.45								14.28	10
4								12.25	11.94	11.64	11.64	11.64	11.64	11.94	12.25									11.385	8
3								9.66	9.35	9.05	9.05	9.05	9.05	9.35	9.66									8.49	8
2									6.76	6.46	6.46	6.46	6.46	6.76										5.595	6
1											3.87	3.87	3.87	3.87										2.7	4
	0	2	3	4	5	6	7	10	11	12	12	12	12	11	10	7	6	5	4	3	2	0			
Stack Wt	0	36	54	72	90	108	126	180	198	216	216	216	216	198	180	126	108	90	72	54	36	0			
Count	144	#																							
Sum VCG	3143	m																							
Sum Mass	2592	MT																							
VCG	21.83	m-BL																							
198																									

Figure 35: Bay 6 (Hold 1 middle bay) Container VCG, Count, and Weight summary

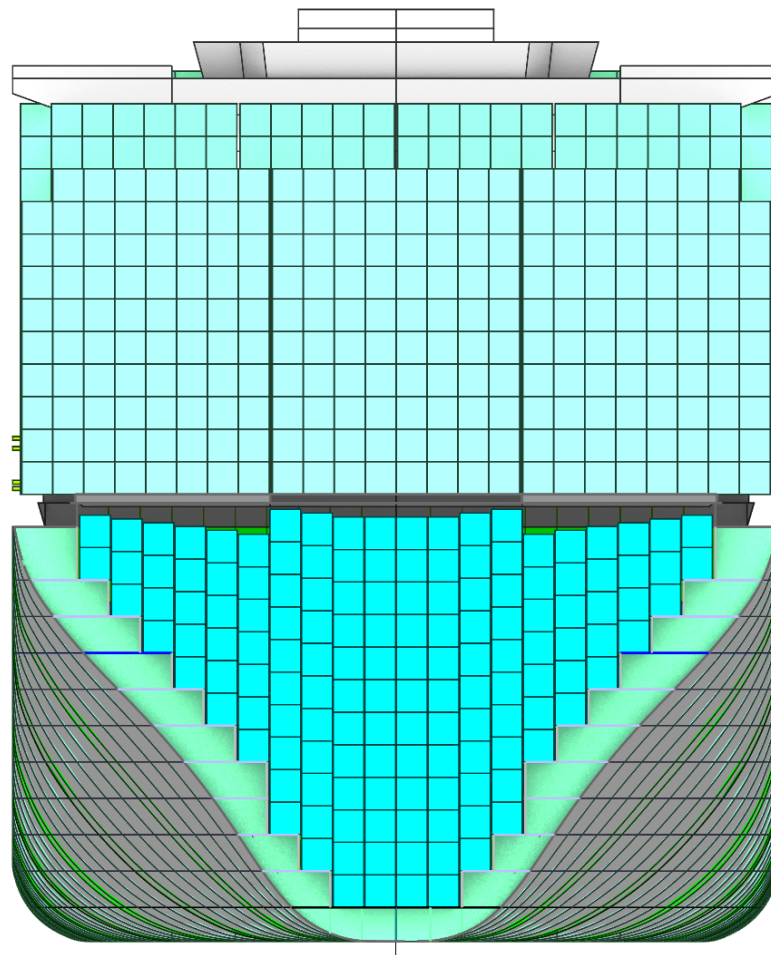


Figure 36: 3D Model Section through Bay 6 showing Container Stowage in Bay

Container loads were assumed to be homogenous within the hold and deck container groups, i.e., every deck container was assumed to have the same weight, and every hold container was assumed to have the same weight, which could be different between the two groups. The vertical centre of gravity of each container was assumed to be at 45% of the container height, consistent with DNV rules for ships part 5 Chapter 2 Section 8/4.1. Containers were assumed to be standard height 2.591 m tall and 40' long (though the stepped cargo hold bulkheads were designed to permit hi-cubes to be loaded), and only 40' containers were carried.

The stacks within the hold were limited to a maximum height at the top of the uppermost container of 35.6 m above base line, corresponding to the bottom of the hatch cover structure. For containers on deck, the maximum stack height of 13 was implemented except forward of the accommodation, where the stack heights were limited by the IMO visibility requirements.

The maximum stack weight was assumed to be 216 MT in holds, based on (Shipping *et al.*, 2019), corresponding to a weight above the bottommost container of 198 MT at 9 MT/TEU, and 196 MT on deck corresponding to a weight above the lowest container of 168 MT (ABS, 2019b; IMO). The allowable stack weight for deck containers is lower because lashing arrangements provide less support than cell guides, and higher accelerations are expected from rolling for the deck containers.

The outboard-most container stack (weather stack) on deck was assumed to have one less tier in the maximum TEU condition. In the realistic 10-high condition, the weather stack had two tiers less and the stack immediately inboard had one tier less than the maximum 10-tier limit. This is illustrated in Figure 37.

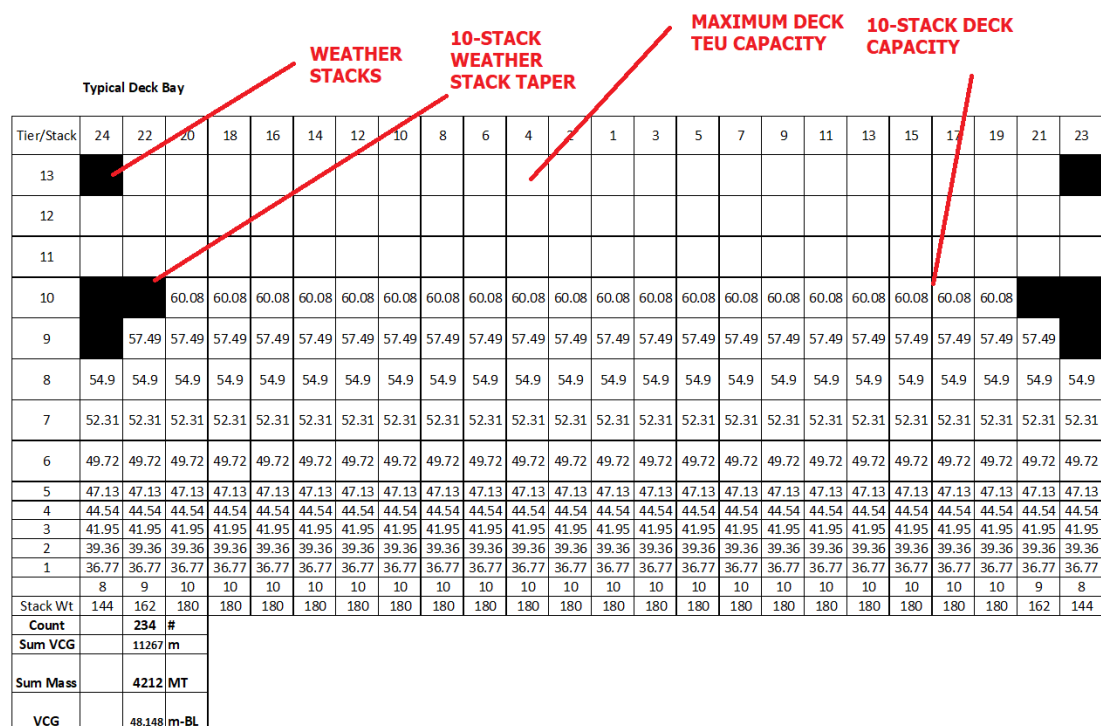


Figure 37: Typical and 10-Tier Deck Stack, showing Arrangement of Weather Stacks and Stack Taper

In the development of the loading conditions, the maximum possible weight was assumed loaded into the containers while still meeting stability, deadweight, and stack weight requirements. In general, this capped the hold containers to a maximum of 9 MT/TEU due to stack weight limitations. The deck container weight was then the primary variable and was varied within the stability and deadweight limits. In the 14 MT/TEU condition, the stack weight was the primary limiting variable. In the 10-tier deck conditions, heavier weights could be loaded on deck than without this limitation, and

this resulted in the MT delivered to be higher than in the full TEU conditions, even if the total TEU carried was lower.

Finally, the backhaul condition was set to 3.5 MT/TEU in the hold and 3 MT/TEU on the deck, which is based on the ratio of cargo demand from Asia to EU and from the EU to Asia. The cargo demand from Asia to Europe was 14.9 million TEU, and the cargo demand from Europe to Asia was 5.8 million TEU (DHL, 2024), with a ratio of 2.6:1. The respective deck weight/TEU and hold weight/TEU from the 10-tier deck containers, design draft condition was scaled by this factor to achieve this backhaul condition weight. Note that the empty weight of 40' containers is 3.7 MT (Hapah-Lloyd, 2024; Hapag-Lloyd, 2024), which means the deck containers are only loaded with 2.3 MT of Cargo.

Consumable Loads (Departure/Arrival)

Consumable tank fill levels for the departure and arrival conditions were taken as shown in Table 55 and Table 56. Oil tanks were filled to 95% capacity and drawn down to 10% capacity, excluding service/settling/sump/working tanks which were assumed to be filled and emptied regularly so on average stayed at 50%. The stern tube cooling water tank is maintained at 100% regardless of the condition, and Sludge/Waste/Holding tanks increased from near empty (10%) at departure to 50% at arrival.

Table 55: Fuel Tank Fill Levels Departure/Arrival

Fuel Oil Tanks				
Tank Name	Density	Capacity	Departure	Arrival
-	MT/m ³	m ³	% Full	% Full
ULHFO 1 P	0.98	1,201	95	10
ULHFO 1 S	0.98	1,201	95	10
ULHFO 2P	0.98	1,544	95	10
ULHFO 2S	0.98	1,544	95	10
HFO OVERFLOW TANK	0.98	357	10	50
NO 1 HFO SETT TK	0.98	140	50	50
NO 2 HFO SETT TK	0.98	140	50	50
NO 1 HFO SERV TK	0.98	140	50	50
NO 2 HFO SERV TK	0.98	140	50	50

MGO Tanks				
Tank Name	Density	Capacity	Departure	Arrival
-	MT/m ³	m ³	% Full	% Full
MGO 3P	0.86	1,544	95	10
MGO 3S	0.86	1,544	95	10
MGO 4C	0.86	1,786	95	10
NO 1 MGO SETT TK	0.86	140	50	50
NO 2 MGO SETT TK	0.86	140	50	50
NO 1 MGO SERV TK	0.86	140	50	50
NO 2 MGO SERV TK	0.86	140	50	50

Table 56: Lube and Other Tank Fill Levels Departure/Arrival

LO Tanks				
Tank Name	Density	Capacity	Departure	Arrival
-	MT/m ³	m ³	% Full	% Full
ME LO SUMP	0.9	117	50	50
ME LO STOR TK	0.9	110	95	10
ME LO SETT TK	0.9	74	50	50
SSDG LO STOR TK	0.9	74	95	10
SSDG LO SETT TK	0.9	74	50	50
NO 1 CYL OIL STOR TK	0.9	183	95	20
NO 2 CYL OIL STOR TK	0.9	170	95	0

Fresh Water Tanks				
Tank Name	Density	Capacity	Departure	Arrival
-	MT/m ³	m ³	% Full	% Full
FWT P	1	275	100	0
FWT S	1	275	100	10

Misc. Tanks				
Tank Name	Density	Capacity	Departure	Arrival
-	MT/m ³	m ³	% Full	% Full
ST CWT	1	140	100	100
LO SLUDGE TANK	1	51	10	50
HFO SLUDGE TANK	1	51	10	50
WASTE OIL TANK	1	138	10	50
EGR BLEED WATER TK	1	331	50	50
GRAY WATER HOLDING TANK	1	177	10	50
BILGE HOLDING TANK	1	158	10	50

Constant Loads

Constant non-cargo and non-tank weight items were assumed to be similar to other containerhips and are presented Table 57.

Table 57: Misc. Constant Weights for ULCC Case Study

Item	Weight	LCG	VCG	TCG	Aft Bound	Fwd Bound
-	MT	m-AP	m-BL	m-CL	m-AP	m-AP
Provisions	7	258.45	40	0	252.05	264.05
Crew & Effects	6	258.45	55	0	252.05	264.05
Water in Piping	50	160	1.35	0	33.05	375.65
Bosun Stores	40	385	28.755	0	367.65	394
ER Misc Tanks	50	62.35	25	0	33.05	76.8
Loose Fitting, Gear, Spares	200	180	40	0	-6	370
Stores Distributed	120	160	27.2	0	-6	394
Total	473	179.868	30.321	0.000		

Stability Criteria

The vessel's loading conditions were checked for compliance with the following stability criteria:

- 2008 IS Code 2.2: General Criteria (IMO, 2008)
- 2008 IS Code 2.3: Weather Criteria (IMO, 2008)
- IMO IS Code 4.9 Containerships (IMO, 1993)
- SOLAS Chapter II-1 Part B-1 (Cargo ships) (IMO, 1974)

A required input for stability assessment with these regulations is inclusion of downflooding points in the stability model. These points were established around the periphery of the vessel representing the openings in way of hatch cover corners (weathertight), tank and space vents (weathertight), and ER accessways and vents (Unprotected). Vents along the midbody were located at the fore and aft ends of the tanks, near the hatch coaming as is standard practice for container ships. Vents for tanks, compartments, and void spaces in the aft mooring deck and foc'sle deck were located around their periphery as appropriate for the space. In total, 230 downflooding points were considered in the stability model. The overall arrangement of downflooding points is shown in Figure 38, with additional details provided in Appendix A.

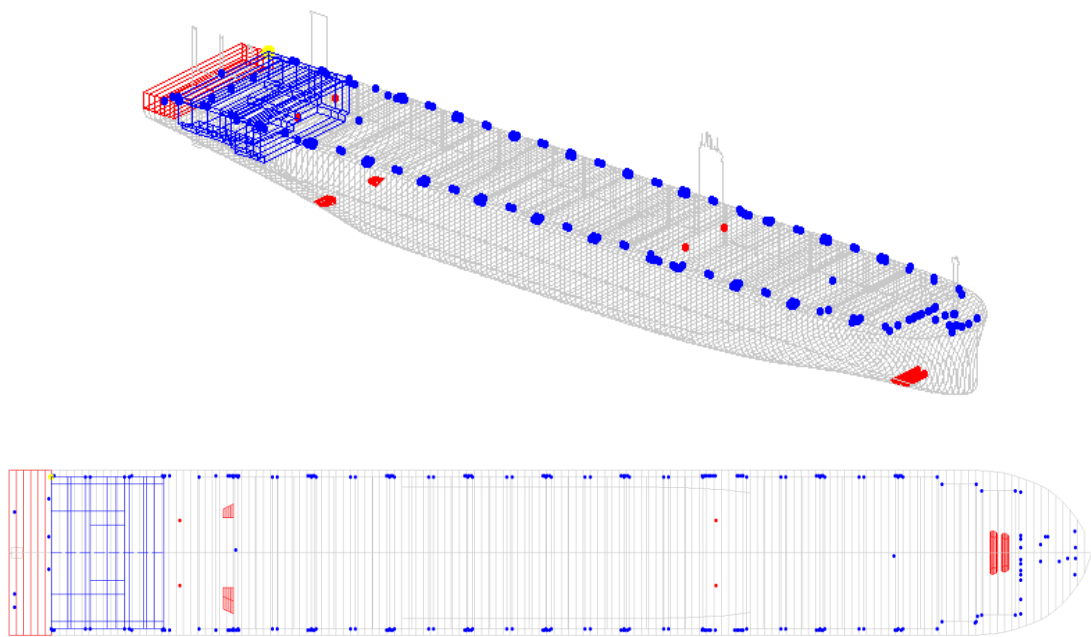


Figure 38: Downflooding Points for Case Study ULCC

The loading conditions were developed and checked for compliance with the stability criteria utilizing the software HECSTAB, see Appendix D – Loading Condition Printouts for details.

For the probabilistic damaged stability check required by SOLAS Chapter II-1, the minimum GM at the light draft (7.698 Fore/10.971 Aft) was set to 4m, the minimum GM at the partial subdivision draft (12.979 Fore/14.288 Aft) was set to 0.8, and the minimum GM at the deep subdivision draft (scantling draft, 16.5m F/A) was set to 0.8. A total of 1237 damage cases were generated, and an attained index of 0.789 was achieved with these minimum GM limits in compared to a required index of 0.768, shown below in Table 58. The defined zone boundaries are shown in Figure 39.

Table 58: Summary of Damaged Stability Input Drafts, GM's and Attained Values

SOLAS Chapter II-1 Part B-1									
Reg 7 Attained Subdivision Index, Trim Range									
Trim Range = 0.5%L									
L=		394 m							
Trim Range =		1.97 m							
		Draft		Min GM					
DS=	FP	16.5	m	0.8	(Scantling Draft, Even Keel)				
	AP	16.5	m		Trim Range = +/- 1.97 m				
DP=	FP	12.979	m	0.8	(Partial Draft, 1.309m trim aft)				
	AP	14.288	m		Trim Range = -0.661 m-bow 3.279 m-stern				
DL=	FP	7.698	m	4	(Light/Ballast Draft, 3.273m trim aft)				
	AP	10.971	m		Trim Range = 1.303 m-stern 5.243 m-stern				
Draft		Cases	P	A	W	Attained Index			
Deepest Subdivision Draft (ds)		449	0.997212	0.744344	0.4	0.297738			
Light Service Draft (dl)		316	0.996173	0.764893	0.2	0.152979			
Partial Subdivision Draft (dp)		472	0.997212	0.84635	0.4	0.33854			
TOTAL		1237			1	0.789256			
REQUIRED						0.768116			

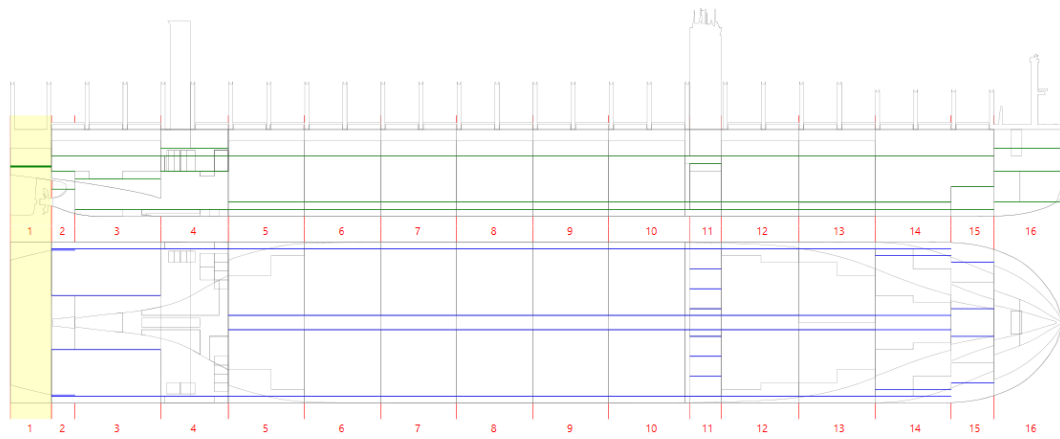


Figure 39: Defined Zone Boundaries for Probabilistic Damaged Stability Assessment

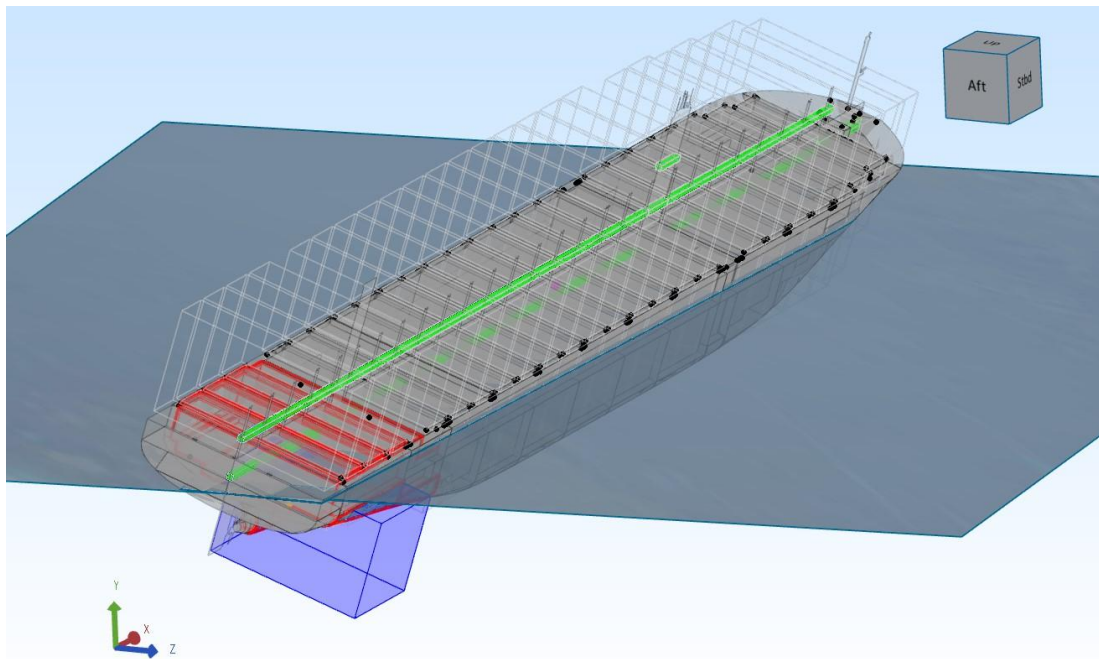


Figure 40: Example of a Failing Damage Condition from Probabilistic Damaged Stability Assessment

During the development of the loading conditions, it was found that the IS 4.9 Containership code governed over the IS 2008 2.2 and 2.3 criteria, and so an intact max KG/min GM curve was also developed for the vessel's 0 trim condition for comparison purposes with the damaged stability curve, shown in Figure 41.

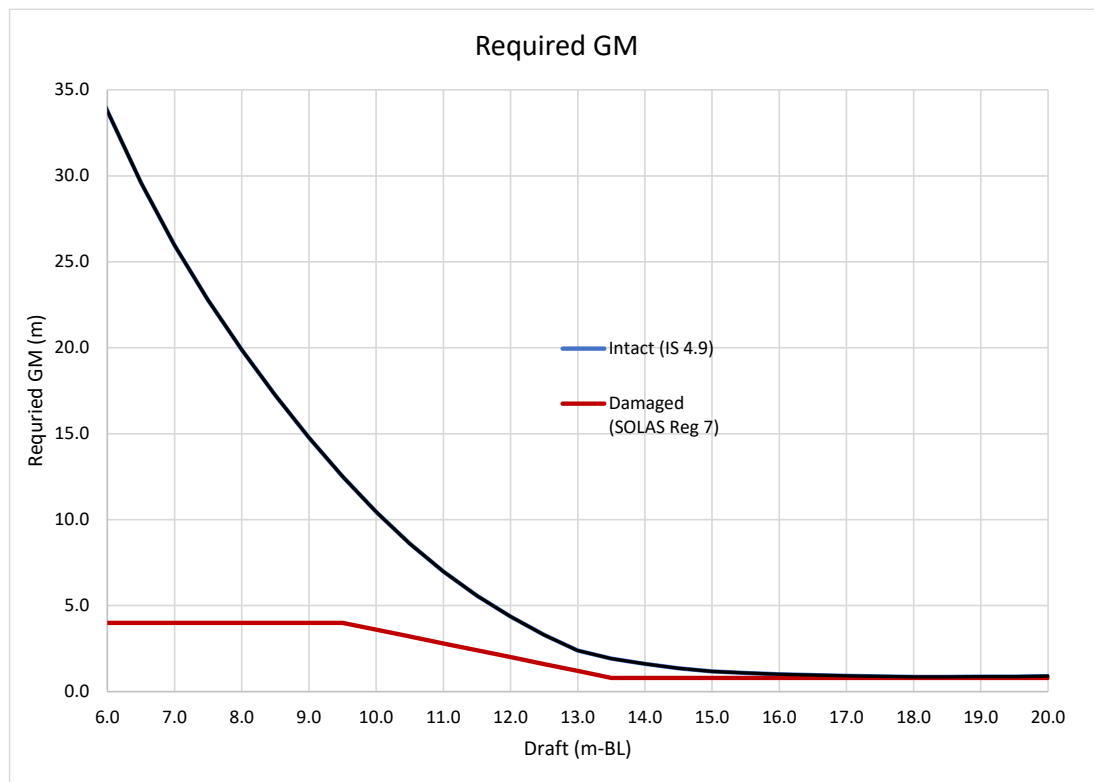


Figure 41: Required GM Curve, Damaged and Intact (IS 4.9)

For all drafts, the Intact IS code 4.9 was found to require a higher GM than that retrieved from the damaged stability analysis.

Maximum Loadable Capacity

The maximum loadable containers for the baseline ship in each of the investigated conditions, with account for maximum stack weight, stability requirements, and deadweight requirements is shown in Table 59.

Table 59: Maximum Allowable Containers for HFO Case Study ULCC

		Max Containers, Scantling Draft	Max Containers, Design Draft	10-Tier Deck Containers, Scantling Draft	10-Tier Deck Containers, Design Draft	14 MT/TEU Homogenous Scantling Draft	Backhaul to Asia
Deck Weight/TEU	MT	7.20	5.75	9.60	7.85	14.00	3.00
Deck FEU	# FEU	7,038	7,038	5,574	5,574	3,970	7,038
Deck TEU	# TEU	14,076	14,076	11,148	11,148	7,940	14,076
Hold Weight/TEU	MT	9.00	9.00	9.00	9.00	14.00	3.50
Hold FEU	# FEU	4,950	4,950	4,950	4,950	3,230	4,950
Hold TEU	# TEU	9,900	9,900	9,900	9,900	6,460	9,900
Total Cargo Weight	MT	190,447	170,037	196,121	176,612	201,600	76,878
Total TEU	# TEU	23,976	23,976	21,048	21,048	14,400	23,976

9.2.5. Speed-Power Curves

Speed-power curves are calculated for the design draft, the light load/backhaul draft, and the ballast draft for use in determining the required engine power. The design draft is used for the Asia->Europe leg of the route, while the light load/backhaul draft is used for the return Europe->Asia leg to complete the round trip. The ballast draft speed-power data is used for calculations of the emissions associated with the sea trials and travel of the ship to the breaking yard in Bangladesh.

The speed-power calculations were performed using Herbert Engineering's internal tool SEP (Ship Evaluation Program), which employs the Holtrop method for determining the hull estimated horsepower (EHP) and the B-series propeller data for propulsive coefficients. The final EHP in SEP can be scaled if a speed-power point is known. To determine this scale factor, a vessel with the properties of the *Jacques Saade* at its design draft was entered into SEP with the design speed of 22.4 knots and a BHP 63,840 kW. The scale factor was iterated until the vessel was capable of attaining the design speed at a normal continuous rating (NCR) of 90% MCR. A scale factor of 0.76 was found to be appropriate. This was then applied to the case study vessel's speed-power calculations as a correction factor.

Table 60: Draft, Displacement, and Coefficients used for Holtrop Calculation

	T _{FP}	T _{AP}	T _{MS}	LWL	Displ.	CB	CM	CW	WSA
Loading Condition	m	m	m	m	MT	-	-	-	m ²
Design Draft Condition	14.50	14.50	14.50	400	256,387	0.716	0.991	0.843	27,829
Light Draft Condition	10.57	10.90	11.22	399.98	183,528	0.703	0.972	0.787	24,297
Ballast Draft Condition	7.75	10.88	9.38	379.3	154,113	0.693	0.967	0.769	22,856

Table 61: Propeller Properties for Speed-Power Calculation

B-Series Propeller Properties		
Diameter	m	10.4
Number of Blades	#	5
P/D Ratio	-	0.94
EBAR	-	0.87
Bow Thruster Diameter	m	2.7

SEP outputs the speed-power curve as a polynomial equation with 4 coefficients, as shown below:

$$Trial\ Power\ (kW) = A * V^8 + B * V^6 + C * V^4 + D * V^2$$

Where A, B, C, and D are coefficients and V is the ship speed in knots. The calculated coefficients for the trial power (no sea margin or fouling assumed) from SEP are shown in Table 62

Table 62: SEP Coefficients for Speed-Power Curves (Trial Speed)

Coefficient			A	B	C	D
Design Draft	14.5	m	-3.642E-08	1.97E-04	-0.0767	87.4385
Light Load Draft	10.90	m	-5.020E-08	1.76E-04	-0.0599	75.8462
Ballast Draft	9.38	m	-1.109E-08	1.14E-04	0.0301	24.1013

The resulting speed-power curve data is shown in Table 63 and Figure 42.

Table 63: Speed-Power Data for Case Study ULCC

Loading Condition	Design Draft	Light Load Draft	Ballast Draft
Speed	Power	Power	Power
Knots	kW	kW	kW
12	13,312	11,713	5,094
13	15,538	13,706	6,293
14	17,970	15,893	7,728
15	20,641	18,302	9,445
16	23,594	20,972	11,503
17	26,886	23,951	13,968
18	30,587	27,296	16,921
19	34,783	31,078	20,452
20	39,577	35,378	24,668
21	45,091	40,290	29,690
22	51,464	45,920	35,653
23	58,859	52,384	42,713
24	67,456	59,810	51,042
25	77,458	68,337	60,833

including 15% Sea Margin

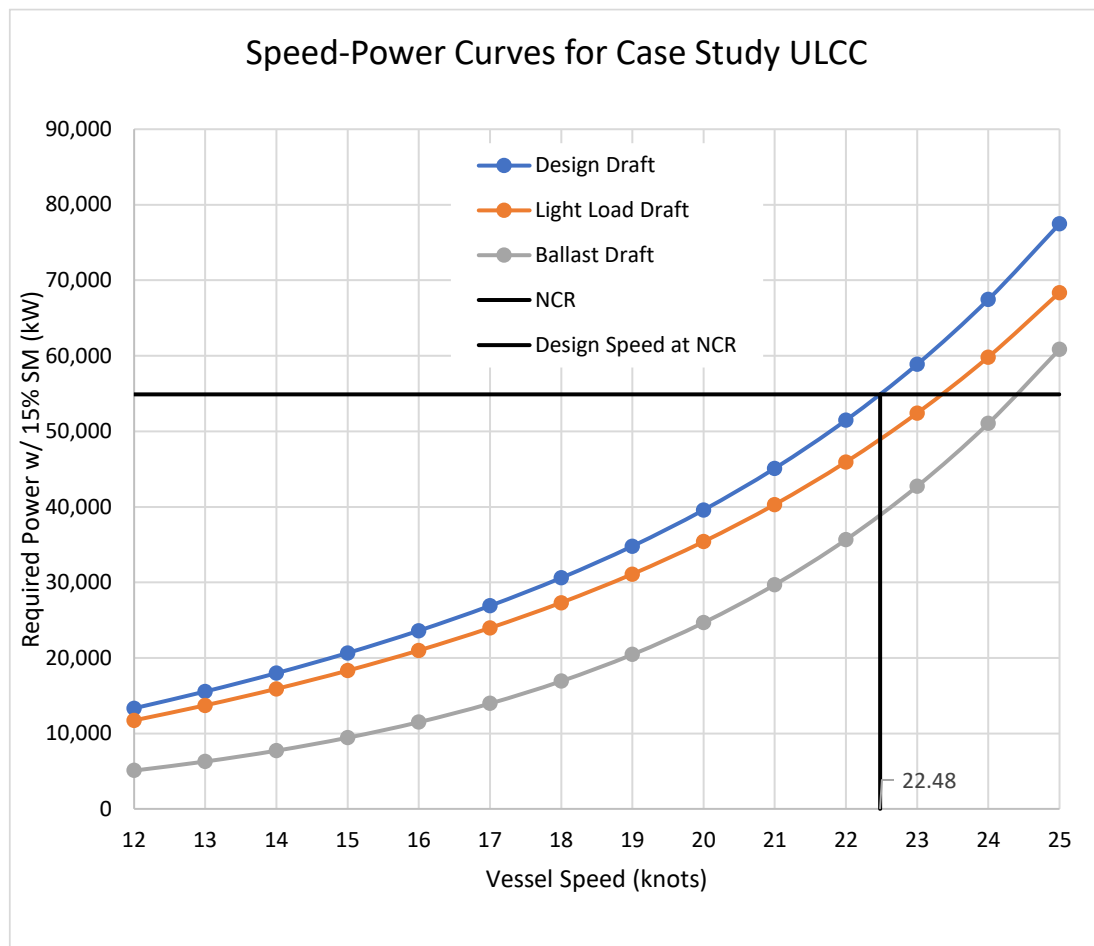


Figure 42: Speed-Power Curves for Case Study ULCC

9.2.6. Main and Auxiliary Engine Sizing

Based on the required speed-power data, an engine with a brake power of 54,900 kW at 90% MCR was required to make the design speed of approximately 22.4 knots. This means the specified MCR would need to be at least 61,000 kW to meet the desired speed. A main engine was chosen with a specified MCR of 65,500 kW, which would allow a 4,500 kW shaft generator to be installed to reduce the at-sea loads on the diesel generators.

As per the IMO 4th GHG study (IMO 4th GHG Study *et al.*, 2020), the average at-sea power load for a 20,000+ TEU container vessel is 2,300 kW at sea, 3,600 kW when manoeuvring, and 1,675 kW while at port/anchored (the average value of 1,400 kW at berth and 1,950 kW at anchor was taken as a simplification). Additionally, this vessel has 2,200 reefer slots. At maximum power, these reefer containers can draw up to 7 kW each, for a maximum total power for refrigerated containers of 15,400 kW. This means the absolute

maximum demand while manoeuvring could be up to 19,000 kW, with a potential maximum continuous at-sea load of 17,700 kW. Six medium-speed diesel generators were chosen to satisfy these load requirements: x2 at 4,480 kW and x4 at 3,920 kW, for a total maximum power of 24,60 kW. This installed auxiliary power allows for one generator of each type to be kept on standby or out of service while the shaft generator is being used to meet the normal seagoing needs while keeping the loading below 90%, and all the generators can be one for manoeuvring without exceeding 80% load while the shaft generator is off.

The final selected engines are a MAN 11G95ME-C10.6 for the main engine with a specified MCR of 65,500 kW and MAN L35/44DFCD 7- and 8-Cylinder diesel generators with a rated output of 3,920 kW and 4,480 kW respectively.

9.2.7. *Paint Areas*

Paint areas are a required input for the shipbuilding and maintenances phases of the lifecycle inventory. The paint areas were extracted from the 3D model and are shown in Table 64 and Table 65. Several coefficients were used to correct the paint areas. First, except for structure on centreline and the cell guides, surface areas were extracted from a half-model of the ship, so a half-ship multiple of 2 was applied to account for the whole ship. Next a double sided multiplier was applied if the structure could be assumed to be painted on both sides the same amount. In most cases, the surfaces representing the structure were divided into a “flat side” and “stiffener side”, and on the stiffener side an extra factor of 1.15, 1.1, 1.075, or 1.05 was applied to account for stiffener surface area. 1.15 represented a large number of stiffeners an/or girders requiring painting, with the decreasing values applied to structure with fewer and/or smaller stiffeners such as non-tight girders.

An example of how the structural model was used to extract paint areas is shown in Figure 43.

Table 64: Painting Areas – Full Ship

Item	Area (m ²)	Half-Ship Multiple	Double-Sided Multiplier	Stiffener Multiplier	Total Area (m ²)
Shell Exterior	26,639	2	1	1	53,278
Shell Interior	26,639	2	1	1.15	61,269
Centerline T-Girders	417	1	2	1	834
Centerline Plate Girders	1,586	1	2	1.05	3,330
Inner Bottom Plate Lower	7,689	2	1	1.15	17,685
Inner Bottom Plate Upper	7,689	2	1	1	15,379
Bottom Girders	8,799	2	2	1.05	36,955
Cell Guides	29,662	1	1	1	29,662
Longitudinal Bulkhead Stiffener Side	10,011	2	1	1.15	23,025
Longitudinal Bulkhead Flat Side	10,011	2	1	1	20,022
Non-Tight Web Frames	13,964	2	2	1.075	60,045
Transverse T-Girders	1,282	2	1	1	2,565
Non-Tight Support Bulkheads	12,542	2	2	1.05	52,676
Watertight Bulkheads - Stiffener Side	11,815	2	1	1.15	27,175
Watertight Bulkheads - Flat Side	11,815	2	1	1	23,630
Midcell Bulkhead Vertical Girders	7,629	2	2	1.05	32,040
Deckhouse Plating and Decks	8,137	2	2	1.075	34,991
Watertight Decks - Stiffener Side	7,533	2	1	1.15	17,325
Watertight Decks - Flat Side	7,533	2	1	1	15,066
Side Stringers - Stiffener Side	16,629	2	1	1.1	36,583
Side Stringers - Flat Side	16,629	2	1	1	33,257
FWT Fore/Aft Bulkheads	30	2	2	1.1	131
Hatch Coaming	4,753	2	2	1.05	19,965
Hatch Covers	18,481	2	2	1.05	77,622
Rudder	311	1	2	1.1	683
Total Modeled					695,192
20% Margin for Outfitting, Lashing Bridges					1.2
Total Paint Area (m²)					834,230

Table 65: Painting Areas, Maintenance

Item	Area (m ²)	Factor	Total Area (m ²)
Shell Exterior	53,277.77	1	53,277.77
Other Locations	780,952.48	0.05	39,047.62
Total Maintenance Paint Area			92,325.40

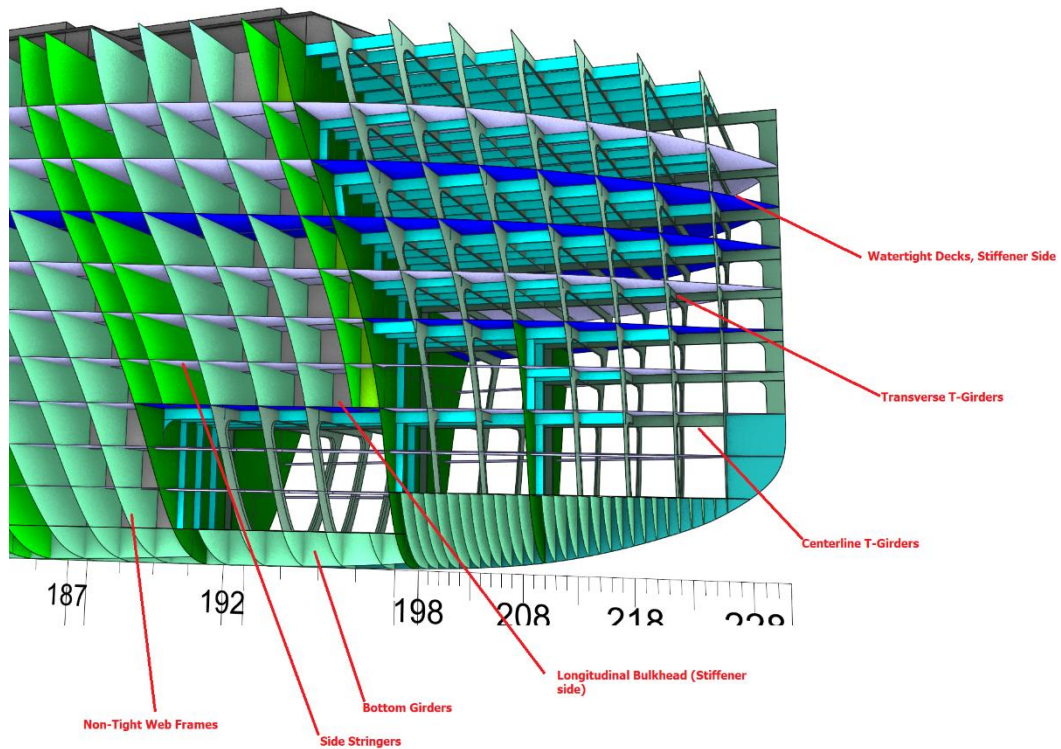


Figure 43: Example of Structure in 3D Model used to Extract Paint Areas

9.3. Collation of Fuel Consumption Data for Case Study Designs

Data for HFO, LNG, and Methanol was directly available from MAN project guides for the fuel consumptions of the main engine and auxiliary engines. For Ammonia and Hydrogen, the consumptions were scaled by heat rate as described in section 8.4. The utilized fuel consumption values are presented in Table 66 through Table 71. Fuel consumption data for the boiler is shown in Table 72.

Note that the fuel consumption values for the main and auxiliary engines should be increased by 5% to account for the testing condition tolerance, as specified in the MAN project guides.

Table 66: Main Engine Fuel Consumption – HFO and LNG

% SMCR	Power	Pure HFO Engine				LNG Engine Using LNG					
		RPM	SFOC	Heat Rate	Urea	SPOC	SGC	Heat Rate	SPOC HR Fraction	Urea	Methane Slip
%	kW	r/min	g/kW-hr	kJ/kW-hr	l/hr	g/kW-hr	g/kW-hr	kJ/kW-hr	%	l/hr	g/kW-hr
100	65500	77.9	158.8	6384	1090	2.79	132.0	6,719	1.77%	1230	0.2
95	62225	76.6	157.7	6340	1110	2.88	131.0	6,673	1.84%	1240	0.21
90	58950	75.2	156.8	6303	1110	2.99	130.2	6,637	1.92%	1250	0.21
85	55675	73.8	156.2	6279	1110	3.11	129.5	6,609	2.01%	1250	0.22
80	52400	72.3	156	6271	1110	3.23	129.3	6,602	2.09%	1240	0.22
75	49125	70.8	156	6271	1090	3.38	129.1	6,600	2.19%	1220	0.23
70	45850	69.2	153.9	6187	1070	3.53	127.3	6,514	2.31%	1170	0.23
65	42575	67.5	151.9	6106	1040	3.71	125.4	6,426	2.47%	1110	0.24
60	39300	65.7	152.4	6126	1010	3.92	125.7	6,452	2.59%	1050	0.24
55	36025	63.8	153.2	6159	960	4.15	126.2	6,486	2.73%	980	0.25
50	32750	61.8	154.1	6195	910	4.42	126.8	6,528	2.89%	910	0.25
45	29475	59.7	155.3	6243	860	4.74	127.5	6,578	3.08%	860	0.26
40	26200	57.4	156.6	6295	810	5.13	128.3	6,634	3.30%	810	0.26
35	22925	54.9	158	6352	740	5.61	129.1	6,695	3.58%	740	0.27
30	19650	52.1	159.5	6412	660	6.22	129.9	6,761	3.93%	660	0.27
25	16375	49.1	161.2	6480	580	7.02	130.6	6,831	4.39%	580	0.28

Table 67: Main Engine Fuel Consumption - Methanol

% SMCR	Power	Methanol Engine using Methanol						
		RPM	SPOC	SGC	Heat Rate	SPOC HR Fraction	Sludge Accumulation	NaOH Consumption
%	kW	r/min	g/kW-hr	g/kW-hr	kJ/kW-hr	%	l/hr	l/hr
100	65500	80	9.3	324.1	6,847	5.79%	13.9	12.8
95	62225	78.6	9.6	319.7	6,772	6.06%	13.6	12.6
90	58950	77.2	10.0	315.6	6,706	6.34%	13.3	12.4
85	55675	75.8	10.4	312.0	6,652	6.64%	12.8	12.1
80	52400	74.3	10.8	309.7	6,623	6.95%	12.3	11.6
75	49125	72.7	11.3	307.5	6,600	7.28%	11.7	11.1
70	45850	71	11.8	305.8	6,588	7.64%	10.9	10.5
65	42575	69.3	12.4	303.9	6,576	8.04%	10	9.8
60	39300	67.5	13.1	303.4	6,594	8.46%	9.1	9.1
55	36025	65.5	13.8	303.1	6,622	8.92%	8.1	8.3
50	32750	63.5	14.7	302.8	6,656	9.46%	7.2	7.6
45	29475	61.3	15.8	302.2	6,689	10.09%	6.4	7
40	26200	58.9	17.1	301.4	6,728	10.85%	5.6	6.4
35	22925	56.4	18.7	300.2	6,772	11.80%	5.4	6.5
30	19650	53.6	20.7	298.2	6,821	12.98%	4.5	5.7
25	16375	50.4	23.4	295.2	6,874	14.54%	3.6	5

Table 68: Main Engine Fuel Consumption – Ammonia and Hydrogen

% SMCR	Power	Ammonia Engine					Hydrogen Engine			
		Heat Rate	SPOC HR Fraction	SPOC	SGC	Urea	Heat Rate	SPOC HR Fraction	SPOC	SGC
	kW	kJ/kW-hr	%	g/kW-hr	g/kW-hr	l/hr	kJ/kW-hr	%	g/kW-hr	g/kW-hr
100	65500	6,847	5.79%	9.3	346.8	1230	6,847	5.79%	9.3	53.8
95	62225	6,772	6.06%	9.6	342.0	1240	6,772	6.06%	9.6	53.0
90	58950	6,706	6.34%	10.0	337.7	1250	6,706	6.34%	10.0	52.3
85	55675	6,652	6.64%	10.4	333.9	1250	6,652	6.64%	10.4	51.8
80	52400	6,623	6.95%	10.8	331.3	1240	6,623	6.95%	10.8	51.4
75	49125	6,600	7.28%	11.3	329.0	1220	6,600	7.28%	11.3	51.0
70	45850	6,588	7.64%	11.8	327.2	1170	6,588	7.64%	11.8	50.7
65	42575	6,576	8.04%	12.4	325.1	1110	6,576	8.04%	12.4	50.4
60	39300	6,594	8.46%	13.1	324.5	1050	6,594	8.46%	13.1	50.3
55	36025	6,622	8.92%	13.8	324.3	980	6,622	8.92%	13.8	50.3
50	32750	6,656	9.46%	14.7	324.0	910	6,656	9.46%	14.7	50.2
45	29475	6,689	10.09%	15.8	323.3	860	6,689	10.09%	15.8	50.1
40	26200	6,728	10.85%	17.1	322.5	810	6,728	10.85%	17.1	50.0
35	22925	6,772	11.80%	18.7	321.1	740	6,772	11.80%	18.7	49.8
30	19650	6,821	12.98%	20.7	319.1	660	6,821	12.98%	20.7	49.5
25	16375	6,874	14.54%	23.4	315.9	580	6,874	14.54%	23.4	49.0

Table 69: Auxiliary Engine Fuel Consumption – HFO and LNG

% Output	HFO & MDO	HFO and MDO			LNG			
		SFC With Pumps and 5% Margin	Heat Rate Total	Heat Rate With Pumps and Margin	Pilot Oil	Pilot Oil HR %	SPOC w/ Pumps and Margin	SGC w/ Pumps and Margin
	g/kW-hr	g/kW-hr	kJ/kW-hr	kJ/kW-hr	kJ/kW-hr	%	g/kW-hr	g/kW-hr
100	189	201	7500	7995	105	1.40%	2.6	164.2
85	185	198	7620	8144	130	1.71%	3.3	166.8
75	185	198	7750	8302	163	2.10%	4.1	169.3
50	189	204	8530	9229	300	3.52%	7.6	185.5
25	208	232	9700	10804	1150	11.86%	30.0	198.4

Table 70: Auxiliary Engine Fuel Consumption – Methanol, Ammonia, and Hydrogen

% Output	HFO & MDO	Methanol			Ammonia			Hydrogen		
		Pilot Oil HR %	SPOC w/ Pumps and Margin	SGC w/ Pumps and Margin	Pilot Oil HR %	SPOC w/ Pumps and Margin	SGC w/ Pumps and Margin	Pilot Oil HR %	SPOC w/ Pumps and Margin	SGC w/ Pumps and Margin
	g/kW-hr	%	g/kW-hr	g/kW-hr	%	g/kW-hr	g/kW-hr	%	g/kW-hr	g/kW-hr
100	189	30%	56.2	281.2	30%	56.2	300.9	30.00%	56.2	46.6
85	185	33%	62.9	274.2	33%	62.9	293.4	33.00%	62.9	45.5
75	185	37%	71.9	262.8	37%	71.9	281.2	37.00%	71.9	43.6
50	189	93%	201.0	32.5	93%	201.0	34.7	93.00%	201.0	5.4
25	208	70%	177.1	162.9	70%	177.1	174.3	70.00%	177.1	27.0

Table 71: Misc. Consumption Data and Pump Efficiency Factors for Auxiliary Diesel Generators

Correction Factors and Other Consumption Data- per MAN Project Guides								
% Output	LO Consumption	Urea Consumption	i_{HT} pump	i_{LT} pump	f_{HTpump}	f_{LTpump}	f_{LOpump}	f_{pumps}
%	g/kW-hr	g/kW-hr	#	#				
100	0.48	13.00	1	1	0.0021	0.0029	0.0102	1.0152
85	0.56	13.00	1	1	0.002471	0.003412	0.012	1.017882
75	0.64	13.00	1	1	0.0028	0.003867	0.0136	1.020267
50	0.96	13.00	1	1	0.0042	0.0058	0.0204	1.0304
25	1.92	13.00	1	1	0.0084	0.0116	0.0408	1.0608

Table 72: Boiler Fuel Consumption – All Fuels

Boiler Fuel	Heat Rate	LCV	SFOC
-	kJ/kW-hr	MJ/kg	g/kW-hr
HFO	13,668	40.2	340
LNG	13,668	48	285
Ammonia	13,668	18.6	735
Methanol	13,668	19.9	687
Hydrogen	13,668	120	114

9.4. Case Study Design Endurance Conditions

A total of eight endurance conditions were examined for the purposes of range comparison and alternative tank sizing. The conditions developed were as follows:

- 2A – Max Power (90% MCR), 100% Reefer Load, 1 Bunker per Round Trip, Travel Around Cape of Africa
- 2B – Max Power (90% MCR), 100% Reefer Load, 1 Bunker per Round Trip, Travel Through Suez Canal
- 2C – Slow Steaming (57% MCR), 50% Reefer Load, 1 Bunker per Round Trip, Travel Around Cape of Africa
- 2D – Slow Steaming (57% MCR), 50% Reefer Load, 1 Bunker per Round Trip, Travel Through Suez Canal
- 1A – Max Power (90% MCR), 100% Reefer Load, 2 Bunkers per Round Trip, Travel Around Cape of Africa
- 1B – Max Power (90% MCR), 100% Reefer Load, 2 Bunkers per Round Trip, Travel Through Suez Canal

- 1C – Slow Steaming (57% MCR), 50% Reefer Load, 2 Bunkers per Round Trip, Travel Around Cape of Africa
- 1D – Slow Steaming (57% MCR), 50% Reefer Load, 2 Bunkers per Round Trip, Travel Through Suez Canal

There are 6 key variables that are varied between the eight loading conditions:

- One bunker per round trip (prefix 2) or two bunkers per round trip (prefix 1). The prefix is intended to represent the number of legs that can be completed without refuelling.
 - Design range with round trip is 32,500 NMi around the Cape of Africa, and 25,000 NMi through the Suez Canal
 - Design range with two bunkers per round trip is 16,500 NMi around the Cape of Africa and 12,500 NMi through the Suez Canal
- Sailing through the Suez Canal or sailing around the Cape of Africa (A and C for Africa, B and D for Suez)
- Main Engine Power – 90% MCR for propulsion and the shaft generator for cases A and B, with 50% for propulsion (and an additional 7% for the shaft generator) for C and D. Fuel consumptions are adjusted for the main engine to account for the load.
- Refrigerated container load – 100% for cases A and B, 50% for cases C and D.
 - Note that refrigerated container power draw is assumed at 6 kW for the 1/3 of containers in the hold and 4.5 kW for the 2/3 stored on deck, for an average of 5 kW/reefer (MMMCZCS and Seaspan, 2023).
 - This differs from the 7 kW/reefer assumed for the electrical plant sizing calculations, which are worst-case values.
- 15 days of port or idle time for cases A and B assuming a round trip, with the rest of the time spent sailing as fast as possible. 8 Days of port or idle time for a one-way trip. Total schedule time is dependent on the amount of time required to finish the route with the above constraints.
- Scheduled 98-day round trip for cases C and D, with idle/port time considered as the remaining non-sailing time. 49-day one-way trip, with associated idle/port time for cases C and D.

The main engine required power is increased by 15% accounting for a Sea Margin and an additional 7% accounting for hull fouling as described in section 8.5.

The auxiliary engines are assumed to have to support the refrigerated container load the entire travel time, plus either the 2,300 kW baseline sea power when sailing or 1,675 kW anchored/at berth power when at port/idle. While at sea, it is assumed that the shaft generator is operated at maximum power, reducing the demand on the diesel generators by 4,500 kW. This is not possible while at berth/idle. The specific fuel consumption values for the generators are assumed to stay at the 85% load level, and it is assumed that the number of generators or the contribution from the shaft generator will be varied to keep them operating at this load level.

The boiler is assumed to be operating during the at-berth/idle time, and off while sailing.

A summary of the design endurance conditions is shown in Table 73, and details of the design endurance condition calculations can be found in Appendix B – Case Study Alternatively Fuelled Ship Design Data.

Table 73: Endurance Parameters and Required Tank Sizing from Design Endurance Conditions

			Round Trip Endurance				1-Way Endurance			
			2A	2B	2C	2D	1A	1B	1C	1D
	Condition		Max Power Full Reefers Cape	Max Power Full Reefers w/ Suez	Slow Steaming 50% Reefers Cape	Slow Steaming 50% Reefers w/ Suez	Max Power Full Reefers Cape 1-Way	Max Power Full Reefers w/ Suez 1-Way	Slow Steaming 50% Reefers Cape 1-Way	Slow Steaming 50% Reefers w/ Suez 1-Way
Route and Operation	Sail Range	NMi	32500	25000	32500	25000	16500	12500	16500	12500
	Vessel Speed	knots	21.9	21.9	18	18	21.9	21.9	18	18
	Engine Power	% MCR	90%	90%	57%	57%	90%	90%	57%	57%
	Time Between Bunkering	days	77	63	98	98	39	32	49	49
	Bunkering Frequency	-	1 per RT	1 per RT	1 per RT	1 per RT	Each end	Each end	Each end	Each end
	Reefer % Utilized	%	100%	100%	50%	50%	100%	100%	50%	50%
Required Volume	HFO	m ³	18,542	14,500	13,419	11,241	9,441	7,284	6,782	5,621
	LNG	m ³	32,788	25,644	23,619	19,807	16,695	12,882	11,936	9,903
	Methanol	m ³	42,805	33,353	30,646	25,269	21,781	16,737	15,502	12,635
	Ammonia	m ³	47,509	37,018	34,046	28,065	24,175	18,576	17,222	14,032
	Compressed Hydrogen	m ³	133,898	104,331	96,502	79,523	68,134	52,354	48,817	39,762
	Liquid Hydrogen	m ³	78,764	61,371	56,766	46,778	40,079	30,797	28,716	23,389
Tank Volume	HFO Tank Size (98% Full)	m ³	18,920	14,796	13,693	11,470	9,634	7,433	6,920	5,736
	LNG Tank Size (85% Full)*	m ³	40,604	31,757	29,250	24,529	20,675	15,953	14,781	12,264
	Methanol Tank Size (95% Full)	m ³	45,058	35,108	32,259	26,599	22,927	17,618	16,318	13,300
	Ammonia Tank Size (85% Full)*	m ³	58,835	45,843	42,162	34,755	29,938	23,004	21,328	17,377
	Compressed Hydrogen Tank Size (85% Full)**	m ³	157,527	122,742	113,532	93,556	80,158	61,593	57,432	46,779
	Liquid Hydrogen Tank Size (85% Full)*	m ³	97,541	76,001	70,298	57,929	49,633	38,139	35,562	28,965

*For LNG, Ammonia, and Liquid Hydrogen, max fill level of 85% with a 5% cooling reserve assumed

**For Compressed Hydrogen, max fill level of 85% assumed

For reference, total MDO+HFO on current vessel is

11754 m³

9.5. Case Study Tank Sizing and Alternative-Fuelled Ship Design

The case-study fuel storage layouts were designed to satisfy the following design requirements:

- A minimum volume of fuel to satisfy the “1B” operating condition, corresponding to being able to make it to Europe from China or China from Europe at maximum speed accounting for the shortened sailing distance associated with using the Suez canal.
- Minimum loss of cargo as far as practical.
- Satisfying IGF code with relation to the placement of the tanks (for LNG, Ammonia, Hydrogen). This means at least a B/15 or 2 m double bottom height and within B/5 or 11.5 m inboard from the side shell. If the tank space is placed within the B/5 limit, it also has the benefit of eliminating side damage cases penetrating this space during damaged stability assessments.

- Satisfy the safety requirements for carriage of Methanol including minimum 600 mm cofferdams between the Methanol tanks and other space, and if within the double bottom, below the lowest operational waterline.
- Sufficient space around the tanks for the requisite amount of insulation and additionally additional space for access and inspection (generally 800 mm from the nearest decks and bulkheads to the insulation).

9.5.1. Tank Sizing

Tank Volume Requirements

From the set of design endurance conditions, the minimum required tank volumes were calculated, shown in Figure 44.

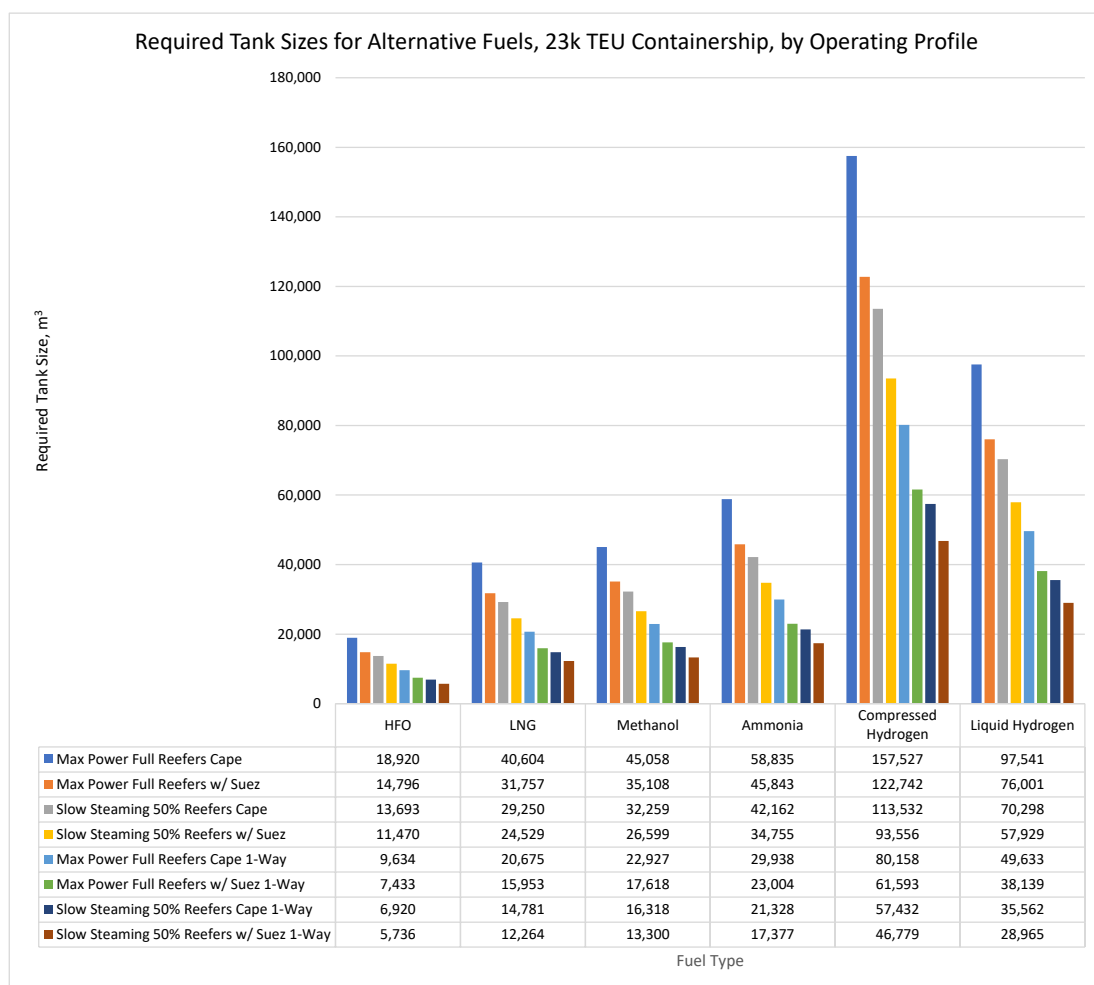


Figure 44: Required Tank Sizes for Each Fuel and Route

The baseline HFO design could at best achieve condition 2D – Slow Steaming with 50% reefers and utilizing the Suez Canal (required HFO tank capacity of 11,470 m³ vs.

baseline ship capacity of 11,754 m³). Therefore, this set the maximum level of performance that should be expected from the alternatively fuelled vessels. Similarly, endurance conditions 1C and 1D involving a one-way trip with slow steaming were not considered viable options, as they would force the ship to slow steam to meet the required travel range. Therefore, only three of the original eight conditions were considered to provide viable target volumes for the alternatively fuelled vessels.

Tank Sizing Study - General

The types of tanks and arrangements investigated were:

- Hull conforming/double bottom below lowest waterline for Methanol
- B-type independent for LNG and Ammonia
- C-Type Trilobe for LNG, Ammonia, and Hydrogen
- C-Type Elongated (longitudinally arranged) for LNG, Ammonia, and Hydrogen
- C-Type Elongated (transversely arranged) for LNG, Ammonia, and Hydrogen

Tank sizes were iterated based on the number of container holds they would eliminate, if any. The tanks were assumed to be located underneath the accommodation, as per the reference ship design, and were extended aft a set number of holds. Keeping the tanks beneath the accommodation as far as practical minimizes the cargo loss associated with a given design, so this was chosen as the default starting location for all alternative-fuel designs. Since the containerized cargo is discrete longitudinally, there is no advantage to taking up a partial hold, since it was not desired to dedicate a hold to the carriage of 20' containers. However, if a tank was found to offer too much volume after an incremental increase in the number of holds used longitudinally, the tank's height could be reduced to allow partial depth holds above the tank, with suitable cofferdams above. Figure 45 shows how the different tank extents are defined. Please refer to section 7.2 for more details relating to the types of tanks examined.



Figure 45: Tank Size Designation defining Different Tank Extents

Methanol Tank Study

The required Methanol tank volumes from the design endurance conditions are presented in Table 74.

Table 74: Required Methanol Tank Volumes for Design Endurance Conditions

		Round Trip Endurance				1-Way Endurance			
		2A	2B	2C	2D	1A	1B	1C*	1D*
Condition		Max Power Full Reefers Cape	Max Power Full Reefers w/ Suez	Slow Steaming 50% Reefers Cape	Slow Steaming 50% Reefers w/ Suez	Max Power Full Reefers Cape 1-Way	Max Power Full Reefers w/ Suez 1-Way	Slow Steaming 50% Reefers Cape 1-Way	Slow Steaming 50% Reefers w/ Suez 1-Way
Methanol Tank Size	m ³	45,058	35,108	32,259	26,599	22,927	17,618	16,318	13,300

Five different configurations of Methanol tanks were examined in this sizing study to meet these volumes:

1. Methanol tank beneath the accommodation (including double-bottom tanks)

2. Methanol tanks beneath the accommodation + 1 cargo hold aft (including double-bottom tanks)
3. Methanol tanks beneath the accommodation + 1 cargo hold aft (excluding double-bottom tanks)
4. Methanol tanks beneath the accommodation + 1 partial cargo hold aft (including double-bottom tanks)
5. Methanol tanks beneath the accommodation + 1 partial cargo hold aft (excluding double bottom tanks).

As required by the ABS guide for methanol storage (ABS, 2024), cofferdams of 800 mm were located above, fore, and aft of the methanol tanks where they would otherwise bound a cargo hold (fore and aft), or machinery space/accommodation space (above). It was assumed that in way of the ballast tanks and side passageway on the port and starboard side of the tanks, a 600 mm wide cofferdam could be deducted from the volumes of those spaces rather than extending inboard and reducing the total methanol capacity. The arrangement of the methanol tanks is shown in Figure 46 and Figure 47.

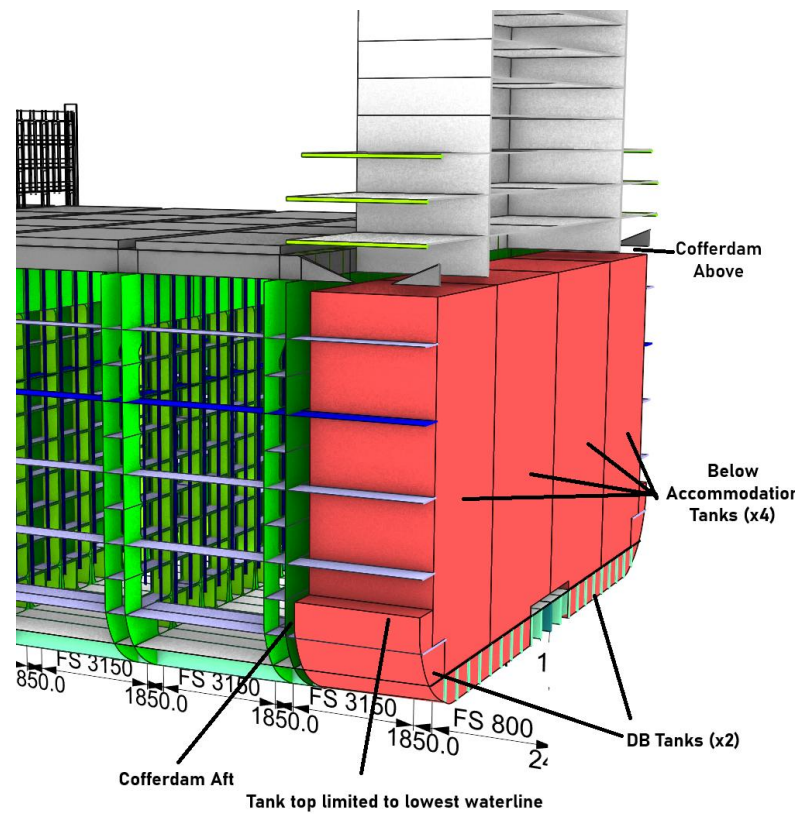


Figure 46: Section Showing Methanol Tank Arrangement – Below Accommodation

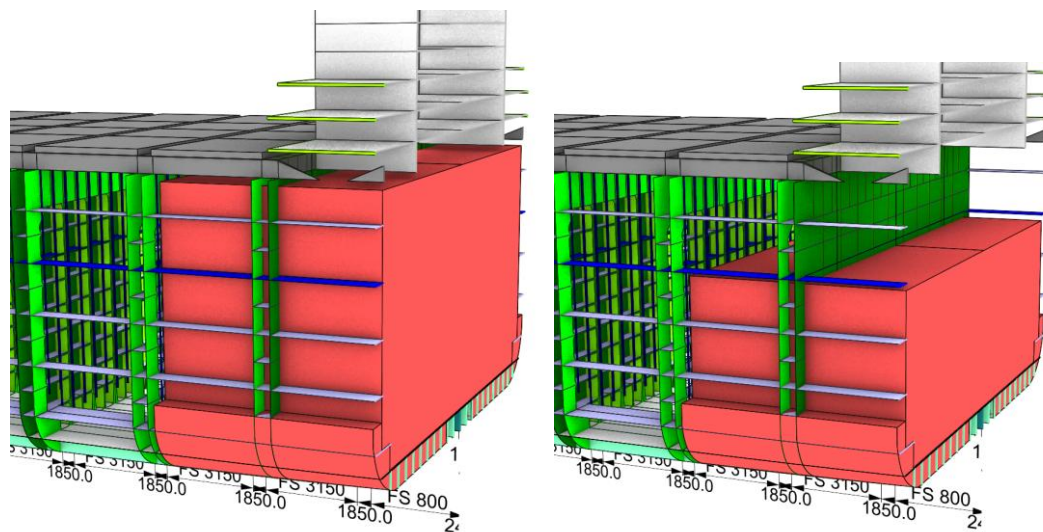


Figure 47: Methanol Tanks Arrangements, Accommodation + 1 Hold (Left) and Accommodation + 1 Hold (Right)

During the study of the Methanol tank sizing, it was found that sufficient volume for a one-way trip using Methanol and assuming the Suez Canal (1B) would be achievable using just the space below the accommodation and supplemented with double bottom tanks, without any cargo impact. Too much volume was offered by extending the entire

arrangement to include one cargo hold aft, both with and without the double bottom tanks. The configuration extending one cargo hold aft but only using the partial depth of the vessel was found to be able to minimize cargo losses while also allowing the vessel to run a round-trip without refueling under typical operating conditions (2D). However, ultimately it was decided that being able to avoid any cargo losses was worthwhile at the cost of requiring bunkering at either end of the route.

The lightship weight change associated with the inclusion of the methanol tanks involves the inclusion of the three subdivision bulkheads in way of the main tanks and some additional structure related to the cofferdams. This is partially offset by removal of the existing HFO tank bulkheads and the partial machinery deck that was located below the deckhouse in the baseline ship, shown in Figure 48 and typical for all designs where the HFO tanks are removed.

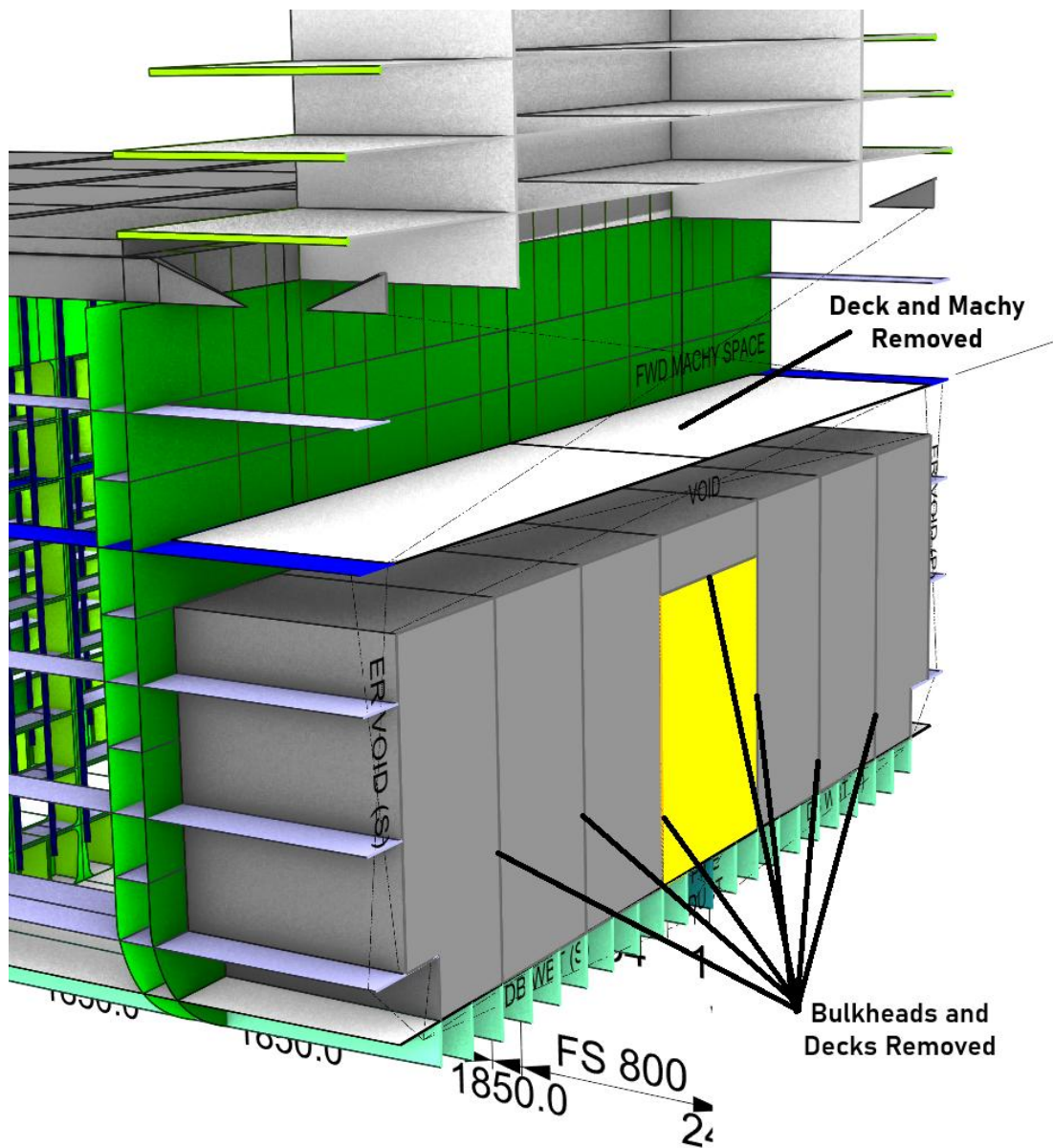


Figure 48: Typical Removals in way of Alternative Fuel Tanks below Accommodation

Type B Tank Size Study

Type-B prismatic tanks were selected as candidates for storing LNG and Ammonia, and the required volumes from the design endurance conditions for these fuels are presented in Table 75.

Table 75: Required LNG and Ammonia Tank Volumes for Design Endurance Conditions

		Round Trip Endurance				1-Way Endurance			
		2A	2B	2C	2D	1A	1B	1C*	1D*
Condition		Max Power Full Reefers Cape	Max Power Full Reefers w/ Suez	Slow Steaming 50% Reefers Cape	Slow Steaming 50% Reefers w/ Suez	Max Power Full Reefers Cape 1-Way	Max Power Full Reefers w/ Suez 1-Way	Slow Steaming 50% Reefers Cape 1-Way	Slow Steaming 50% Reefers w/ Suez 1-Way
LNG Tank Size	m ³	40,604	31,757	29,250	24,529	20,675	15,953	14,781	12,264
Ammonia Tank Size	m ³	58,835	45,843	42,162	34,755	29,938	23,004	21,328	17,377

While the free-standing type-B tanks are not as volumetrically efficient as a built-in membrane tank, they do provide an additional degree of protection, modularity, and are better candidates in the case of a retrofit. The tank locations are dictated by the requirements of the IGF code (IMO, 2015), specifically inboard 11.5m from the shell and 2m above the baseline. The distance minimums were governing as opposed to the B/5 and B/15 limits for side and bottom location limits due to the beam of the vessel. In this design, the secondary barrier (a plane structural bulkhead) was placed at the 11.5m location and the tank's shell is located 1.150m inboard of this bulkhead to provide space for insulation and associated inspection walkways. The lower extent limits were already satisfied due to the double bottom of the vessel, but a gap of 800 mm was left below and above the tank for supports, access, and insulation. The tank connection space is assumed to be located above the tank at the lowest level of the accommodation block. The prismatic tanks were assumed to have a hopper approximately 5x5 m (at a 45 degree angle) on the bottom of the tank but a very moderate 800 mm hopper at the top of the tank. The tank is assumed to have one internal non-tight longitudinal bulkhead to limit sloshing. Pilot fuel is assumed to be stored outboard of the tank in the space created by the 11.5 m plane bulkhead. A typical cross section in way of the type-B prismatic tanks and pilot fuel is shown in Figure 49.

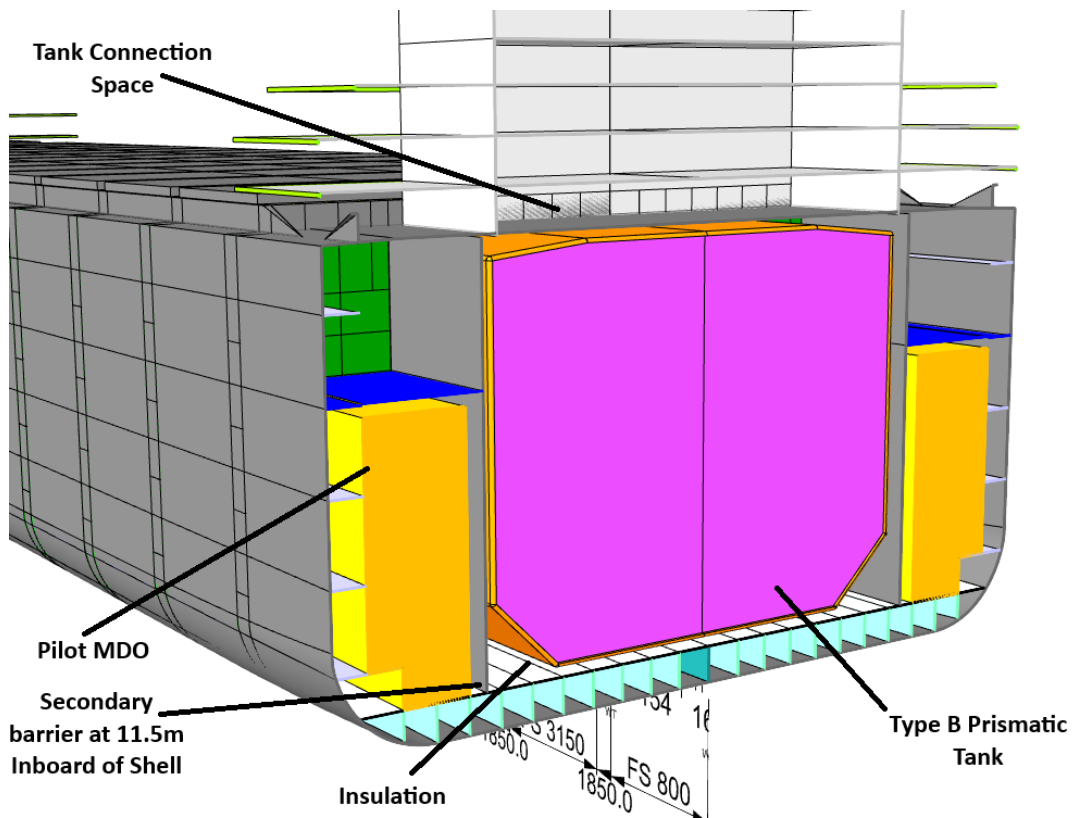


Figure 49: Typical Type-B Prismatic Tank Cross-Section (Beneath Accommodation)

Four configurations of the type-B tanks were considered:

1. Tank beneath the accommodation
2. Tank beneath the accommodation + 1 cargo hold aft
3. Tank beneath the accommodation + 2 cargo holds aft
4. Tank beneath the accommodation + 2 cargo holds aft with reduced height

The prismatic type-B tank configurations considered in this study are shown in Figure 50.

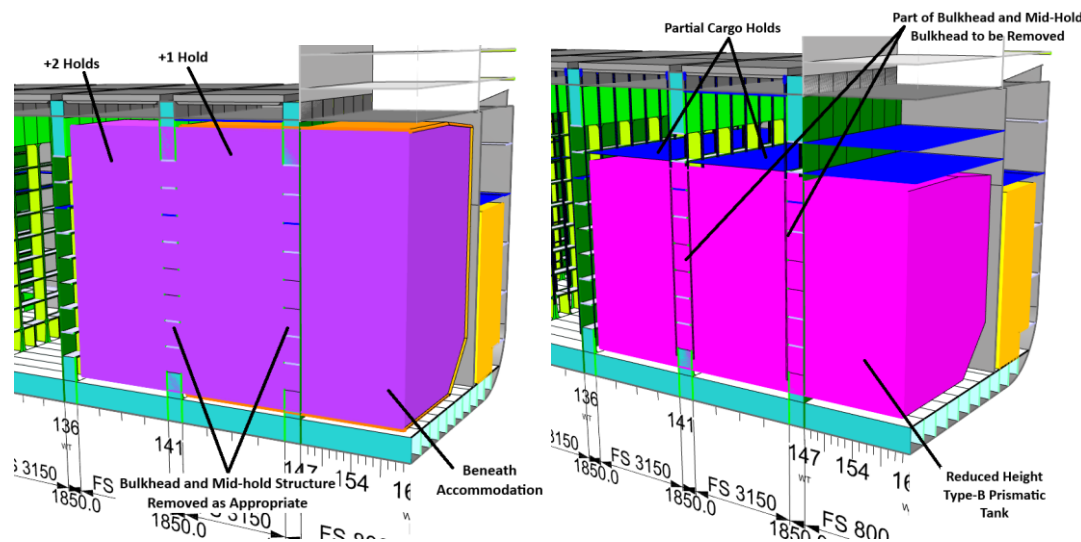


Figure 50: Arrangements for Type-B Tank Sizing Study

During the sizing study for the LNG and Ammonia configurations, it was determined that a tank located entirely below the accommodation offered insufficient endurance. By extending the fuel tank one hold aft, it was possible to complete a typical round trip using LNG and meet the minimum endurance requirements with ammonia. To complete a round trip with ammonia, the tank would need to be extended two holds aft, but this resulted in too much cargo capacity loss. The accommodation + two-hold tank reduced height configuration did not offer enough volume for a round trip with ammonia and resulted in more cargo loss than the loss of a single hold, so was considered ineffective. Ultimately the accommodation + 1 cargo hold full-depth tanks offered the best compromise between endurance and cargo capacity and was selected as the configuration from LNG and Ammonia powered designs.

Type C Tank Size Study

Type C tanks are proven for the carriage of LNG and ammonia. They would be the most likely candidates for storing compressed and liquid hydrogen fuel with some special considerations. One of the primary advantages of type C tanks is their higher design pressure, which allows for boil off gas to be accumulated in the tank for a limited time rather than spending energy for reliquification (if the gas is not needed as a fuel), but the extra volume offered by the type-B tank configuration was determined to be more important for the LNG and ammonia fuelled designs. For liquid hydrogen, it was assumed that a double-walled type-C tank with glass bead insulation and an appropriate reliquification plant would be suitable. For compressed hydrogen, it was

assumed that a type-C tank made of steel reinforced with carbon fibre would be capable of withstanding the 700 bar pressures. In practice such large compressed hydrogen tanks are not well-developed technology but are the only feasible way to carry the requisite quantity of compressed hydrogen fuel. The required tank sizes for compressed and liquid hydrogen from the endurance study are shown in Table 76.

Table 76: Required Hydrogen Tank Volumes for Design Endurance Conditions

		Round Trip Endurance				1-Way Endurance			
		2A	2B	2C	2D	1A	1B	1C*	1D*
Condition		Max Power Full Reefers Cape	Max Power Full Reefers w/ Suez	Slow Steaming 50% Reefers Cape	Slow Steaming 50% Reefers w/ Suez	Max Power Full Reefers Cape 1-Way	Max Power Full Reefers w/ Suez 1-Way	Slow Steaming 50% Reefers Cape 1-Way	Slow Steaming 50% Reefers w/ Suez 1-Way
Compressed Hydrogen Tank Size	m ³	157,527	122,742	113,532	93,556	80,158	61,593	57,432	46,779
Liquid Hydrogen Tank Size	m ³	97,541	76,001	70,298	57,929	49,633	38,139	35,562	28,965

There are numerous configurations of type-C tanks – from the standard cylinder with hemispherical ends to tri-lobe style designs and elongated designs. It was quickly determined that the typical cylindrical style tank would make very poor use of the available volume in the vessel, so the sizing study focused on tri-lobe and elongated designs. The tri-lobe design, while performing better than individual C-type tanks, was did not make effective use of the available space and was found inefficient compared to the elongated type C tanks. Finally, two separate configurations of elongated type C tanks were investigated – one storing them transversely in the vessel and the other lengthwise. The final sizing study ultimately determined that a set of three longitudinally arranged elongated C-type tanks was moderately more efficient than a single transverse elongated C-type tank beneath the accommodation and within the cargo holds, though as a retrofit option the transverse elongated C-type tank is attractive as it would allow much of the existing hold arrangement to be preserved. This is because proportionally, the elongated longitudinally arranged type-C tanks could not use just the space beneath the accommodation but required one or two of the holds to also be incorporated into the tank space to fit their lengths.

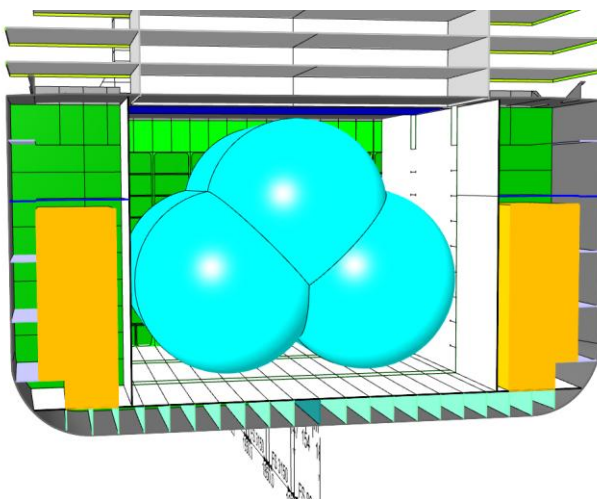


Figure 51: Example Arrangement of Tri-Lobe Tank in Tank Space

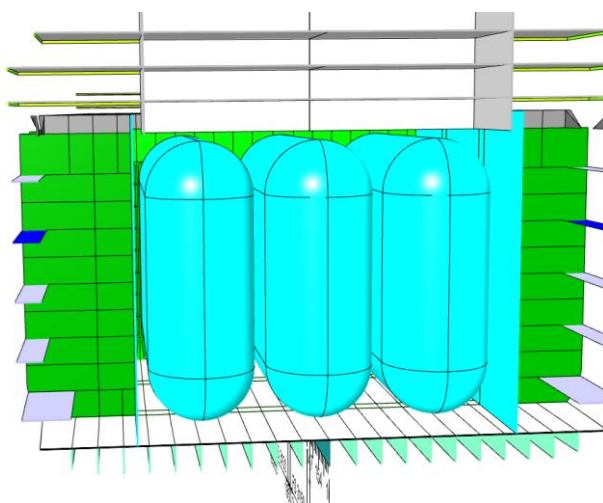


Figure 52: Example Arrangement of Longitudinal Elongated C-type Tanks

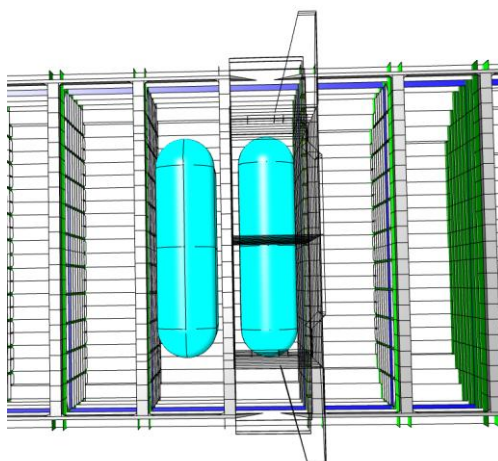


Figure 53: Example Arrangement of Transverse Elongated Type-C Tanks

The arrangement of the type-C tanks follows the IGF code. This means at a minimum the outer shell of the tanks is to be 11.5 m or further inboard from the side shell and at least 2 m above the baseline. The longitudinal bulkhead secondary barrier dividing the tank space from the rest of the vessel remains at 11.5 m from the shell and the tanks are 1.3 m inboard of this bulkhead. The tanks are 1.2 m away from each other transversely, and 800mm from the inner bottom and main deck level.

Six configurations of the type-C elongated tanks stored longitudinally were considered:

1. Tank beneath the accommodation + 1 cargo hold aft
2. Tank beneath the accommodation + 2 cargo holds aft
3. Tank beneath the accommodation + 2 cargo holds aft (Reduced height)
4. 2 cargo holds
5. Tank beneath the accommodation + 2 cargo holds aft + 2 cargo holds
6. Tank beneath the accommodation + 2 cargo holds aft + 2x2 cargo holds

This range of sizes were investigated because initially the type-C tanks were considered for LNG and Ammonia as well as the hydrogen. In practice, only options 5 and 6 offer the requisite volume for a hydrogen fuelled vessel and are shown in Figure 54.

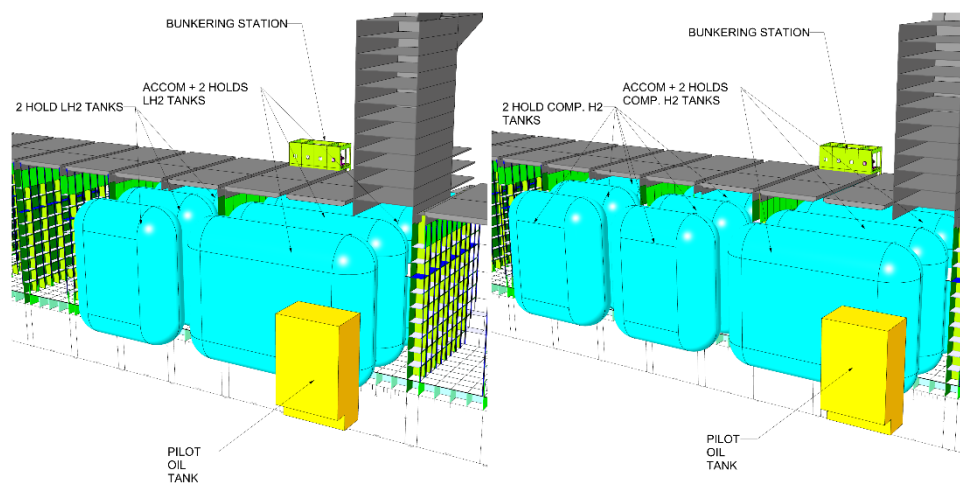


Figure 54: Arrangements for Type-C Tank Sizing Study

Calculation of Cargo Impact

Cargo loss was calculated based on the number of holds required for fuel tanks and the presence/absence of bunkering stations. The bunkering stations would each remove four containers from the deck stacks as well as entire stack in the hold below, for a total

of 30 slots lost (30 FEU, 60 TEU), shown in Figure 55. Bunkering stations were assumed to be required for LNG, Ammonia, and Hydrogen powered arrangements.

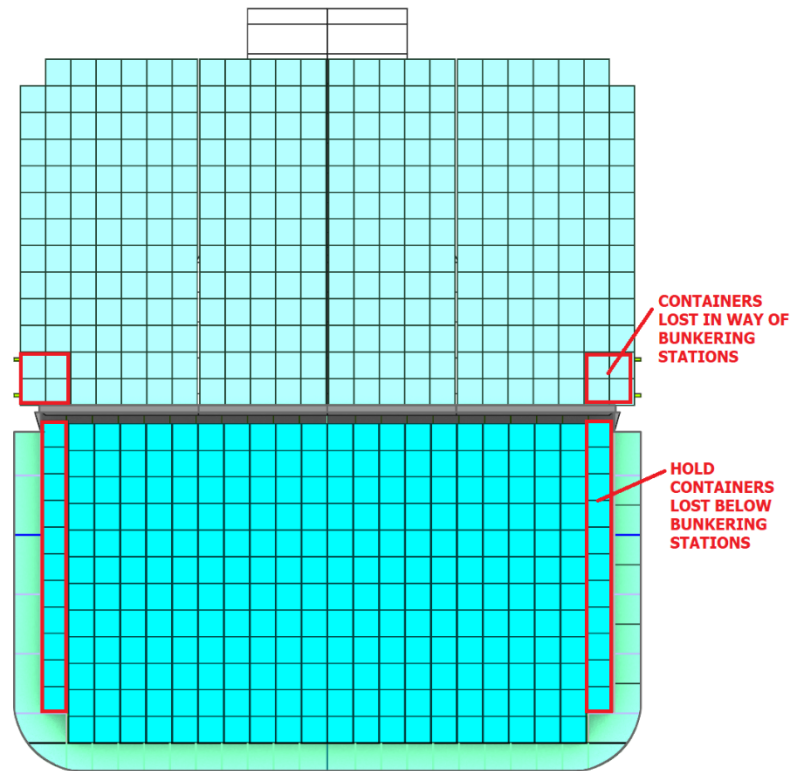


Figure 55: Container Losses in way of Bunkering Stations

A full container hold at midships has 262 slots, but the alternative fuels were only stored within the B/5 limits to comply with the IGF code (2015). This meant that two partial holds could be retained on either side of the fuel tank, reducing the losses to only 192 FEU slots per hold dedicated to fuel, shown in Figure 56.

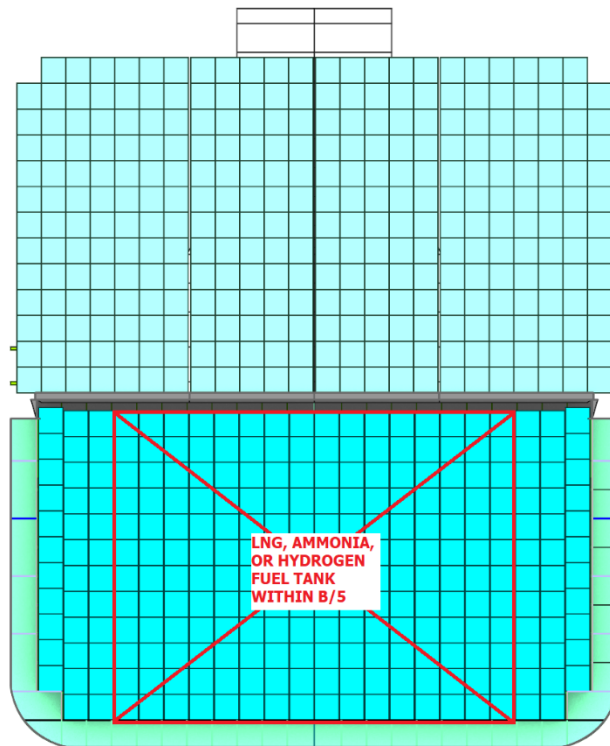


Figure 56: Container Losses in way of Alternative Fuel Tank located withing B/5

For Hydrogen designs, the holds lost in way of the fuel tanks were sufficiently aft of the accommodation space such that the bunker stations would also be above them, making the container losses cumulative and resulting in small but deep holds (four across, 12 tall). In practice, such a hold may be impractical and eliminated.

Two reduced height tanks were also examined. These permutations were investigated when removing two entire container holds was found to yield excessive range and so allowed a compromise between endurance and cargo capacity. For the type-B tank with reduced height, this would have resulted in the loss of 144 slots per hold for two holds. For the methanol tank with reduced height, this resulted in a loss of 174 slots for one hold. These reduced height designs are shown in Figure 57. Ultimately, they were not chosen as the final configurations.

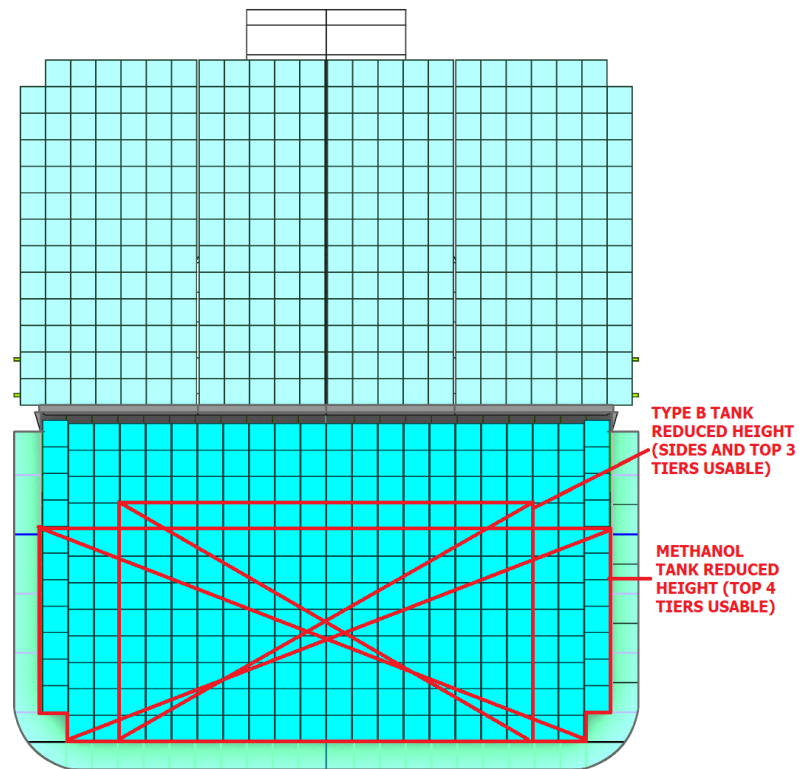


Figure 57: Reduced Height Tanks, allowing some Containers to be Stored Over Tanks

Tank Sizing Study - Results

The above designs were used to create a decision matrix, shown in Table 77, which allows the final tank type, size, and arrangement to be selected for each type of fuel. The selected tank for each fuel is highlighted in green, which also signifies the maximum route type that can be completed with that quantity of fuel. An arrangement with a tank sized for a 1B route (through Suez with max power, the minimum acceptable endurance condition), will be limited to slow steaming if it must go around the Cape of Africa, but would still have sufficient endurance to complete that route.

Table 77: Summary of Tank Sizing Study and Associated Slot Losses

		Round Trip Endurance				1-Way Endurance					
		2A	2B	2C	2D	1A	1B	1C*	1D*		
		Max Power Full Reefers Cape	Max Power Full Reefers w/ Suez	Slow Steaming 50% Reefers Cape	Slow Steaming 50% Reefers w/ Suez	Max Power Full Reefers Cape 1-Way	Max Power Full Reefers w/ Suez 1-Way	Slow Steaming 50% Reefers Cape 1-Way	Slow Steaming 50% Reefers w/ Suez 1-Way		
Condition											

Tank Type	Size	Base Volume	Perm.	Tank 100% Volume	HFO	LNG	Ammonia	Methanol	Comp. H ₂	LH ₂	Slots Lost
		m ³	-	m ³							FEU
HFO / Standard		12,025	0.98	11,784	2D	N/A	N/A	N/A	N/A	N/A	0
B-Type - No Top Hopper	Accommodation Only	10,209	0.98	10,005	N/A	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	30
	Accommodation + 1 Hold	24,560	0.98	24,068	N/A	2D	1B	1A	N/A	N/A	222
	Accommodation + 2 Hold	38,910	0.98	38,132	N/A	2B	2D	2B	N/A	N/A	414
	Accommodation + 2 Hold Prismatic Reduced Height	28,926	0.98	28,347	N/A	2C	1A	2D	N/A	N/A	318
C-Type Trilobe	Accommodation + 1 Hold	13,690	1	13,690	N/A	1D	1D	1D	Not Viable	Not Viable	222
	2 Hold	14,122	1	14,122	N/A	1C	1C	1D	Not Viable	Not Viable	414
	Accommodation + 2 Hold	24,068	1	24,068	N/A	2D	1B	1A	Not Viable	Not Viable	414
	3 Hold	24,499	1	24,499	N/A	2D	1B	1A	Not Viable	Not Viable	606
	Accommodation + 2 +1x3	48,567	1	48,567	N/A	2A	2B	2A	1D	1A	990
	Accommodation + 1 + 2x3	62,688	1	62,688	N/A	2A	2A	2A	1B	2D	1374
	Accommodation + 2 + 2x3	73,067	1	73,067	N/A	2A	2A	2A	1B	2C	1566
	Accommodation + 2 + 3x3	97,566	1	97,566	N/A	2A	2A	2A	2D	2A	2142
C-Type Elongated (Longitudinal)	Accommodation + 1 Hold	18,654	1	18,654	N/A	1B	1D	1B	Not Viable	Not Viable	222
	Accommodation + 2 Hold	31,214	1	31,214	N/A	2B	1A	2C	Not Viable	1D	414
	Accommodation + 2 Hold Reduced Height	22,652	1	22,652	N/A	1A	1C	1A	Not Viable	Not Viable	318
	2 Hold	19,175	1	19,175	N/A	1A	1D	1B	Not Viable	Not Viable	414
	Accommodation + 2 + 1x2 Hold	50,389	1	50,389	N/A	2A	2B	2A	1D	1A	798
	Accommodation + 2 + 2x2 Hold	69,565	1	69,565	N/A	2A	2A	2A	1B	2D	1182
C-Type Elongated (Transverse)	Accommodation	8,694	1	8,694	N/A	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	30
	Accommodation + 1 Hold	17,840	1	17,840	N/A	1B	1D	1B	Not Viable	Not Viable	222
	Accommodation + 2 Hold	26,987	1	26,987	N/A	2D	1B	2D	Not Viable	Not Viable	414
	Accommodation + 3 Hold	36,133	1	36,133	N/A	2B	2D	2B	Not Viable	1C	606
	Accommodation + 4 Hold	45,280	1	45,280	N/A	2A	2B	2A	Not Viable	1B	798
	Accommodation + 6 Hold	63,573	1	63,573	N/A	2A	2A	2A	1B	2D	1182
Hull Conforming	Accommodation Only	18,607	0.98	18,235	N/A	N/A	N/A	1B	N/A	N/A	0
	Accommodation +1 Hold	44,514	0.98	43,623	N/A	N/A	N/A	2A	N/A	N/A	262
	Accommodation +1 Hold no DB	40,580	0.98	39,768	N/A	N/A	N/A	2B	N/A	N/A	262
	Accommodation + 1 hold Reduced Height	30,586	0.98	29,975	N/A	N/A	N/A	2D	N/A	N/A	174
	Accommodation + 1 hold Reduced Height no DB	26,652	0.98	26,119	N/A	N/A	N/A	2D	N/A	N/A	174

The final arrangements chosen were:

- LNG: Accommodation + 1 Hold, Full Depth, 24,068 m³ tank volume, can achieve endurance case 2D (same as HFO). Container Losses = 222 Slots
- Ammonia: Same as LNG Tank. Achievable endurance case 1B (Max power through Suez, bunkering on both sides)

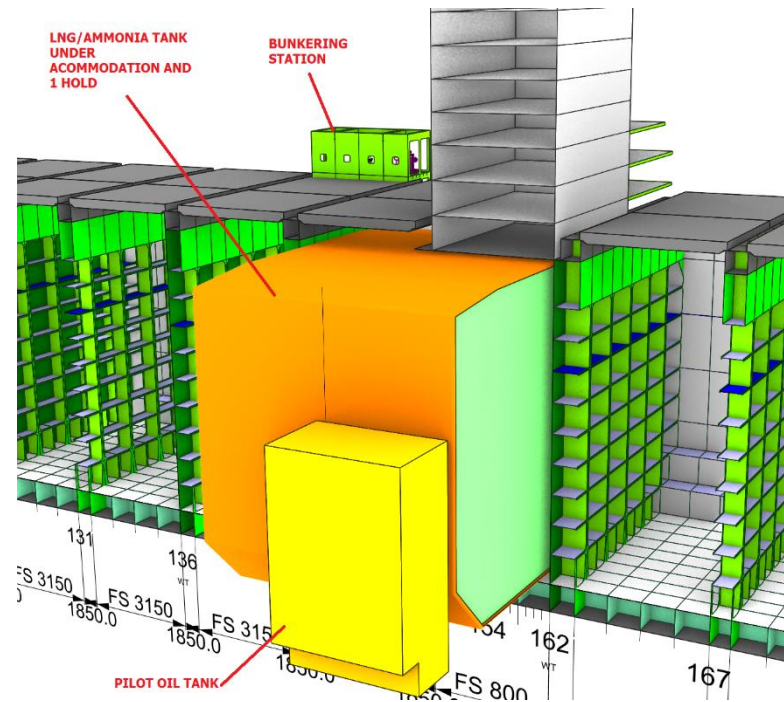
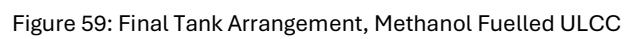


Figure 58: Final Tank Arrangement, LNG and Ammonia Fuelled ULCC

- Methanol: Hull conforming tank including double bottom tanks below waterline. 18,235 m³ total tank volume, can achieve endurance case 1B (Max power through Suez, bunkering on both sides). Container losses = 0 slots



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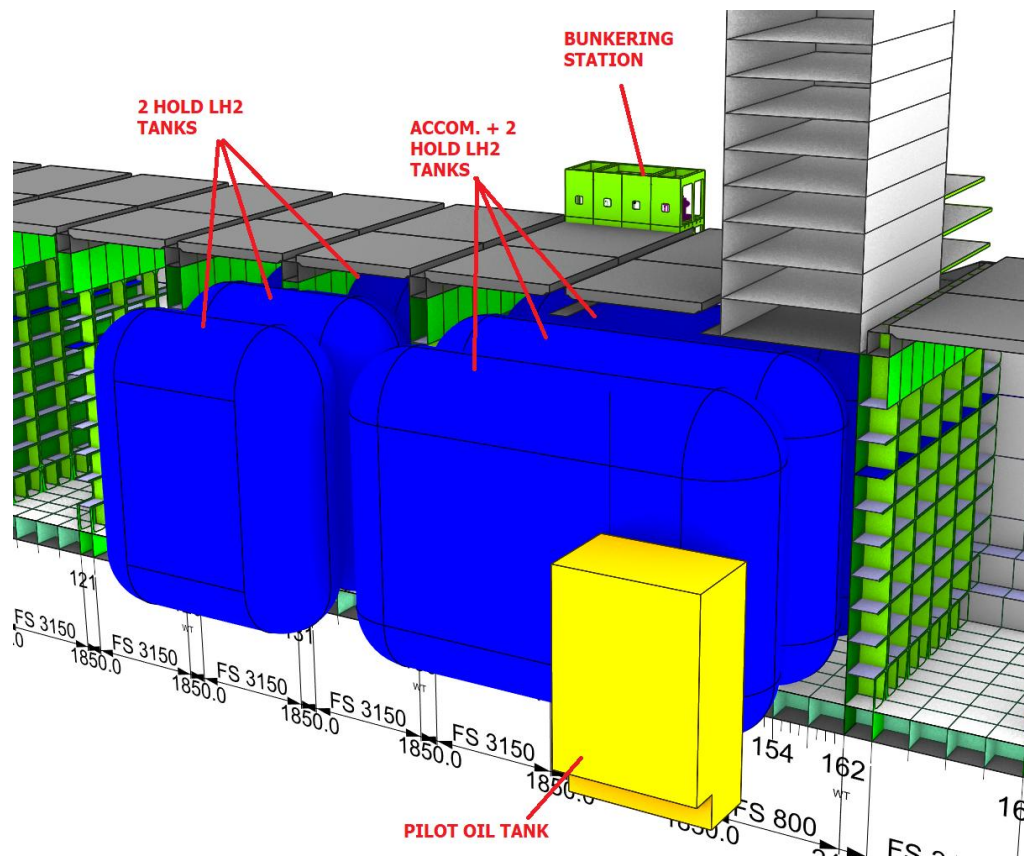


Figure 60: Final Tank Arrangement, Liquefied Hydrogen Fuelled ULCC

- Compressed Hydrogen: Type C tanks in longitudinal configuration, Accommodation + 2 holds + 2 sets of 2 hold tanks, x 9 tanks in total. 69,585 m³ total tank volume, can achieve endurance case 1B (Max power through Suez, bunkering on both sides). Container losses = 1182 slots.

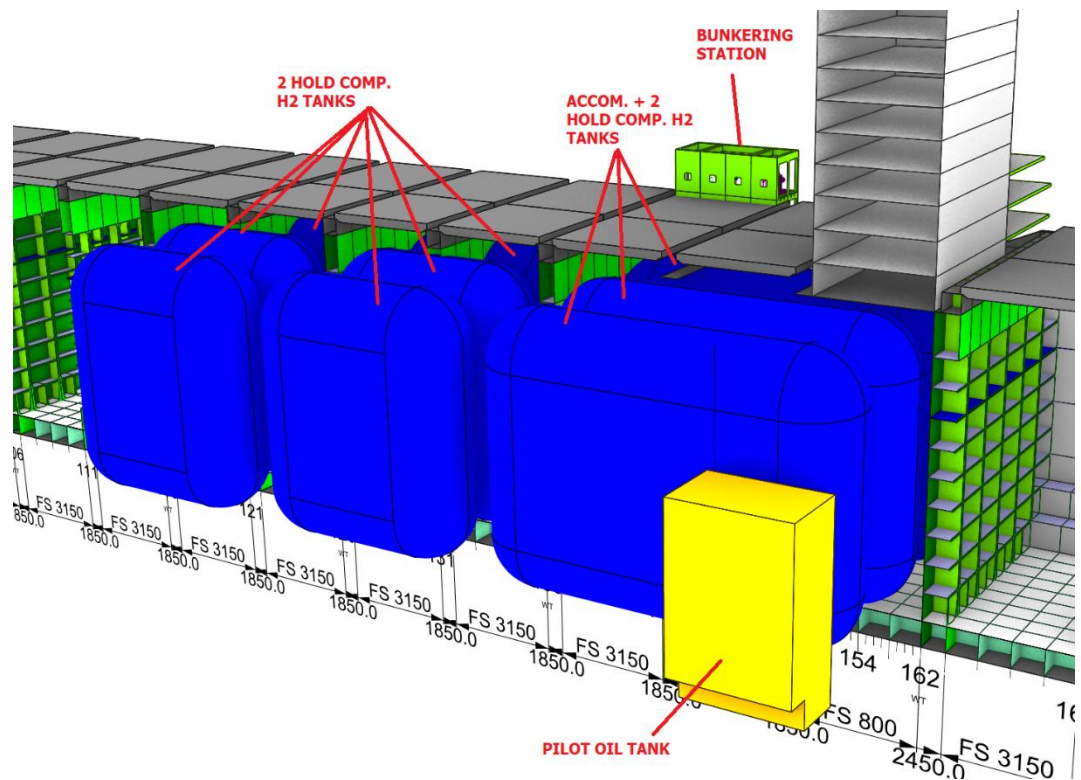


Figure 61: Final Tank Arrangement, Compressed Hydrogen Fuelled ULCC

9.5.2. Lightship Weight Changes

The lightweight for each of the baseline and alternatively fuelled designs is shown in Table 78.

Table 78: Lightweight Summary of Alternatively Fuelled Designs

Lightship Weight Summary			
	Weight	LCG	VCG
	MT	m-AP	m-BL
HFO	67,000	181.713	22.826
LNG	67,407	181.878	22.830
Ammonia	67,485	181.958	22.824
Methanol	67,270	181.915	22.810
LH ₂	71,247	184.232	22.571
Comp. H ₂	76,653	185.679	22.241

Detailed lightweight buildups were developed by extracting areas from structure removed and added using the 3D model and applying plate thicknesses and assumed stiffener weights. Tank weights were estimated by assuming a plating thickness, insulation thickness, and insulation density, along with a factor accounting for the tank supporting saddles, motion restraint keys, anti-flotation brackets, additional structural

reinforcement in way of double bottom floors and girders, web frames, and fuel gas preparation room structure. Refer to section 8.6.2 for more details on the estimation procedure, and Appendix B – Case Study Alternatively Fuelled Ship Design Data, section 15.3 for detailed information of how the lightship weight changes were calculated.

9.5.3. Speed-power, Stability, and Loading Conditions

The speed-power performance of the alternatively fuelled vessels was assumed to be the same as that of the parent vessel, since the hullform was not modified. This also greatly simplified the consumption calculation step, since the energy required for the vessel to complete its scheduled route remained constant regardless of the fuel type used.

Stability models were created for all the alternative fuel designs accounting for the new tanks, compartmentation and modified lightship weight for each vessel. An example of the modified stability model for the compressed hydrogen ULCC is shown in Figure 62, with similar modifications being carried out for all the alternatively fuelled vessels.

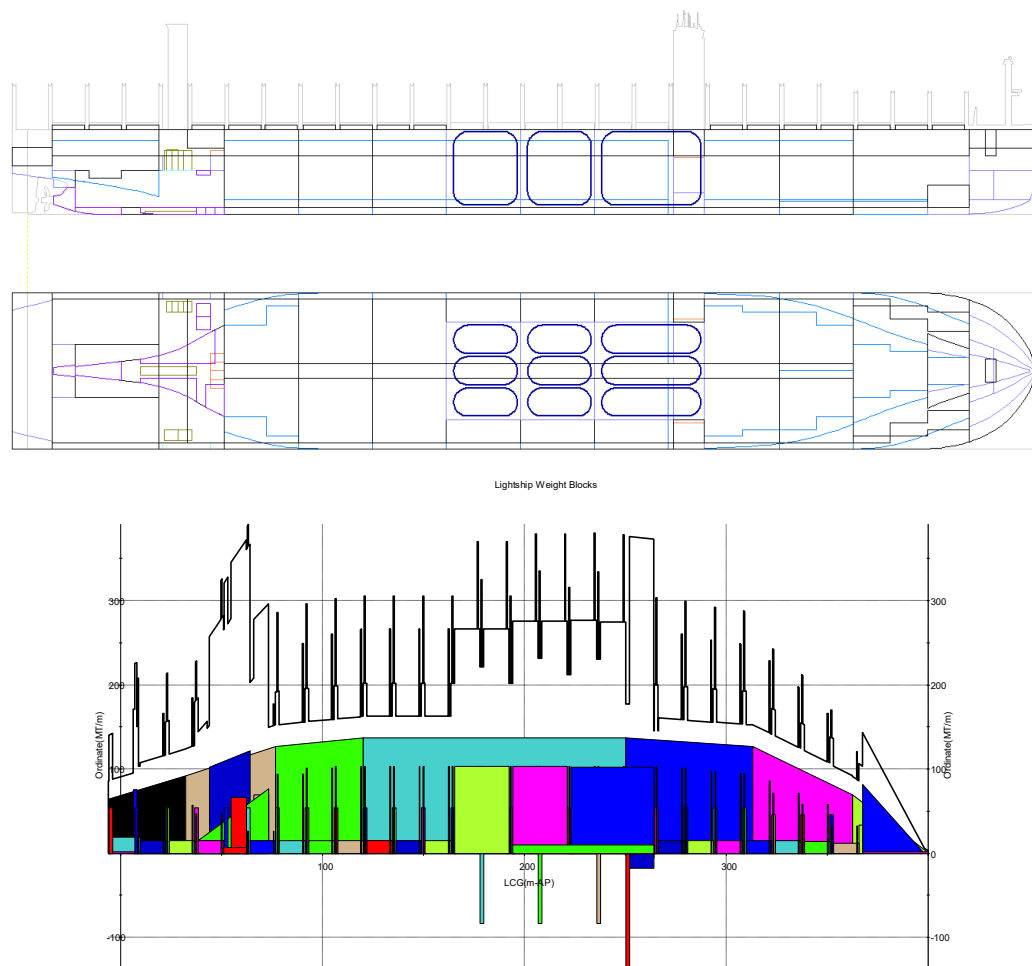


Figure 62: Updated Stability Model, Compressed Hydrogen Powered Design shown

Damaged stability was only re-assessed for the methanol fuelled vessel because its compartmentation beneath the accommodation had changed substantially. It was found to have sufficient damaged stability with the same specified GM minimum requirements as the HFO ship, shown in Figure 63. For the LNG, Ammonia, and Hydrogen powered vessels, the new compartmentation remained within the B/5 damage extents, which means they would not be damaged during the probabilistic damaged assessment.

Draft	Cases	P	A	W	Attained Index
Deepest Subdivision Draft (ds)	508	0.997212	0.745476	0.4	0.298191
Light Service Draft (dl)	345	0.996173	0.753638	0.2	0.150728
Partial Subdivision Draft (dp)	531	0.997212	0.840857	0.4	0.336343
TOTAL	1384			1	0.785261
REQUIRED					0.768116

Figure 63: Required and Attained Index from Methanol Fuelled Design Damaged Stability Assessment

Similar to the baseline HFO condition, loading conditions were created to determine the maximum loadable cargo capacity considering the new lightship weight, fuel densities, and internal arrangement. The weight of the homogenously loaded deck and hold cargo was varied, along with the ballast, in order to meet stability and deadweight criteria. Details of the loading conditions generated for all of the alternative fuel configurations can be found in Appendix D – Loading Condition Printouts.

With the differences in loadable TEU and cargo weight known, the functional unit for each of the alternative designs is available and one of the key variables for calculating the $\text{CO}_{2\text{Eq}}/\text{TEU-km}$ and $\text{CO}_{2\text{Eq}}/\text{MT-km}$ is known.

9.6. Case Study Lifecycle Inventory – Ship Building, Maintenance, and Scrapping

The lifecycle inventory of for the conventionally powered case-study vessel and the alternatively fuelled versions were carried out in parallel. The assumptions and inputs for the ship building, maintenance, and scrapping phases are presented together since they utilize similar input data. Detailed calculation data for these life cycle inventories can be found in Appendix C – Case Study Lifecycle Inventory Data.

9.6.1. Ship Building Lifecycle Inventory

Calculation of the ship building lifecycle inventory followed the procedure outlined in section 8.8, involving calculation of the steel $\text{CO}_{2\text{eq}}$ emissions based on the lightweight of the alternatively fuelled designs. The cutting, blasting, and painting emissions are based on the surface area of the vessel, which was assumed to remain constant for all designs since it's variation would be small relative to the total area. The welding emissions were calculated based on the welding weight, which was taken as 2.5% of the structural lightweight change, which was the total lightweight change minus the weight of equipment and outfitting such as the fuel gas supply system, tanks, and bunkering stations if fitted. In some cases, the structural lightweight change was negative if

substantial structure would be removed from the baseline design, for example in the case with the hydrogen designs where several mid-hold bulkheads were removed. The input parameters used in the shipbuilding phase of the lifecycle inventory are shown in Table 79.

Table 79: Input Parameters of Shipbuilding Phase of Lifecycle Inventory

		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Lightship Weight	MT	67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
Structural Lightweight Change	MT	0.0	112.4	190.7	269.7	-247.7	-196.9
Production Steel Factor	%	10%	10%	10%	10%	10%	10%
Raw Steel Weight	MT	73,700.0	74,147.4	74,233.6	73,996.7	78,371.8	84,318.2
Total Surface Area	m ²	834230	834230	834230	834230	834230	834230
Welding Weight	MT	1,148.0	1,150.8	1,152.8	1,154.7	1,141.8	1,143.1

Sea trial emissions were estimated in the same manner as the operational emissions, using an abbreviated operational profile (see section 8.8.7 for more details) and were assumed to be carried out using the corresponding design fuel mix for each of the vessels, with the fossil version of the alternative fuel being tested, assuming the shipyards would try to save costs. Since the sea trials were calculated to make up 0.22% of the CO_{2Eq} emissions associated with the shipbuilding process as calculated by this method, this would be a fair cost-saving measure with minimal global warming impact on the shipyard's part.

9.6.2. Ship Maintenance Lifecycle Inventory

The calculation procedure for the ship maintenance lifecycle inventory is similar to the ship building inventory, as described in section 8.8.9. The required inputs change slightly and for this case study they are:

- Number of Yard Periods: A 25-year vessel life was assumed with yard periods every 5 years. This corresponds to 4 shipyard periods in the life of the vessel.
- Time in Shipyard: The vessel was assumed to stay in the shipyard on average 45 days per maintenance period. In practice it is expected the early periods may be shorter than this for simple hull cleaning and minor repairs, while later periods may involve longer periods with more extensive repairs or retrofits.
 - The time in the shipyard is used directly to calculate the quantity of replaced steel, at 7 MT/day (315 MT/yard period). This substitutes in for the lightweight of the vessel for the purposes of determining the steel

production, cutting, welding emissions (where the welding amount is assumed to be 2.5% of the replaced steel weight), and other shipyard emissions

- An extension of the maintenance period was considered for the alternatively fuelled designs but was ultimately found to have little impact because of the unique trading conditions of these vessels. The round-trip schedule for these vessels includes substantial idle or waiting time, even considering slow steaming. This means that there is a pool of surplus days in the lifetime of the vessel that could be apportioned instead to additional maintenance time and would not meaningfully reduce the number of round trips the vessel can complete in its lifetime, if the operators were willing to compress the sailing schedule on a few trips. Additionally, while it is expected the maintenance of the alternatively fuelled vessels could take longer from a time perspective, it is not expected that it would increase the emissions in an impactful manner using this LCA methodology.
- **Painting Area:** The exterior shell was assumed to be blasted and re-coated to remove hull fouling each yard period. Additionally, 5% of the remaining area of the ship was assumed to be blasted and re-coated in way of steel replacements or to repair degraded coating elsewhere.

9.6.3. *Ship Breaking Lifecycle Inventory*

The case study vessels were assumed to go through the ship breaking process described in section 8.10, where the primary input is the lightship weight. An estimate of the emissions released from the transit to the breakers was also calculated in the same manner as operational emissions and from sea trials.

The vessel was assumed to sail from Shanghai to Chittagong for ship breaking, 3,710 Nautical Miles, shown in Figure 64. The vessel would travel at ballast draft, at a speed of 18.5 knots, representing a slow-steaming condition at 30% MCR. A sea margin of 15% and a fouling factor of 7% were applied to the power requirements. Auxiliary loads were maintained at the baseline at-sea power of 2,300 kW, and the boiler was assumed to remain off during the entire trip.

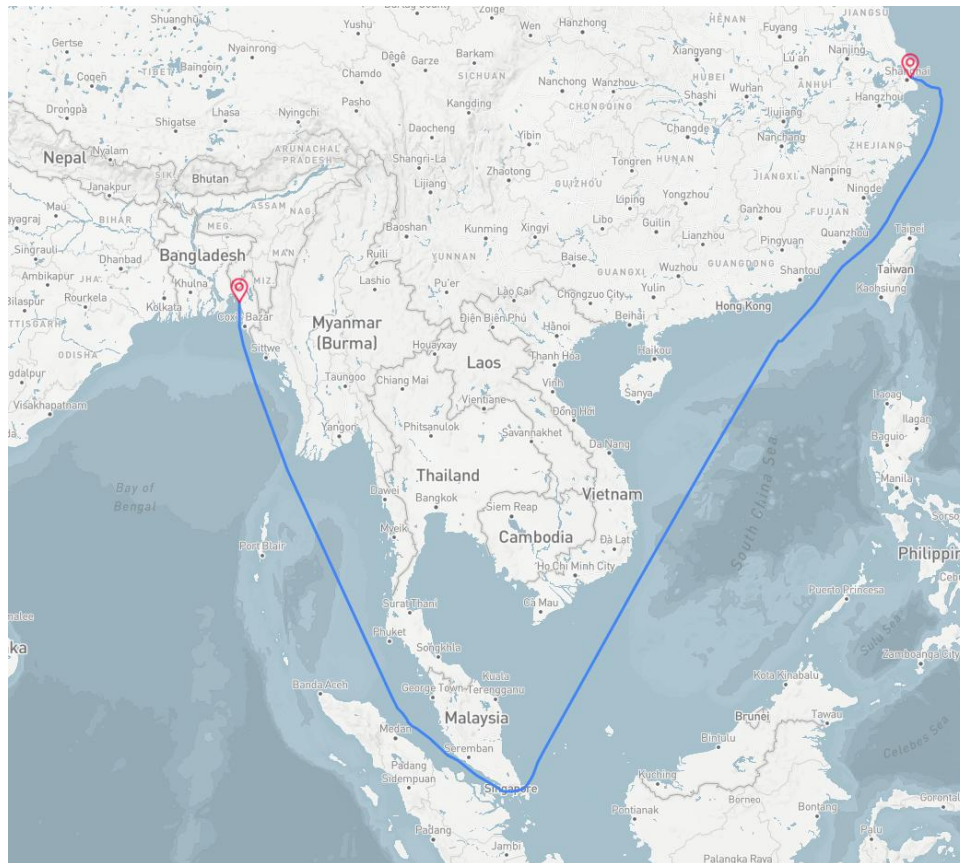


Figure 64: Transit from Shanghai to Chittagong, Bangladesh, for Ship Breaking. Route Data from Searoutes.com, Map Data from OpenStreetMap (<https://openstreetmap.org/copyright>)

9.7. Case Study Lifecycle Inventory – Ship Operations

The operational emissions are the most important part of the ship's lifecycle inventory. The procedure outline in section 8.9 was followed to develop the operational lifecycle inventory. Please refer to Appendix C – Case Study Lifecycle Inventory Data, section 16.4 for more details on the calculations carried out for this inventory.

9.7.1. Operational Energy Requirements

The operational energy and fuel requirements were calculated based on the route described in section 9.2.2 representing a round-trip trade route from Asia to Europe and back calling at eleven ports total. Two variations of the route were examined, one utilizing the Suez Canal and one sailing around the Cape of Africa. Each round trip was assumed to take 98 days as per the published schedule (CMA-CGM, 2023). The vessel was assumed to spend 1.5 days per port on average, with a total port time of 16.5 days for the entire round-trip journey. The remaining time not spent sailing was classified as

Idle/waiting days, which could be used by the vessel to bunker, allow for extra time in port, manoeuvre, or wait for a slot at a container terminal.

The vessel was assumed to sail 12,118 nautical miles in the design draft condition representing transit from Asia to Europe, and sail 12,756 nautical miles in the light draft condition representing the backhaul from Europe to Asia while utilizing the Suez Canal. While travelling around the Cape of Africa, the vessel was assumed to travel 15,844 nautical miles at the design draft condition from Asia to Europe, and 16,512 nautical miles in the backhaul light draft condition from Europe to Asia. These sail distances are the calculated sail distance from Searoutes.com between each of the ports with an extra 10% margin.

Main Engine Power Requirements and Sailing Speed

The vessels were assumed to slow steam as per common practice (Hua, Cheng and Hwang, 2019), and the speeds were reduced as slow as practical to meet the schedule while minimizing the idle/waiting days, though a minimum idle/waiting time of 7 days was targeted. In general, the vessel utilized 35% of MCR for propulsion when sailing via the Suez canal, and 50% MCR for propulsion when sailing around the Cape of Africa. These power usages may seem unusually low, but are supported by data from Hua, Cheng, and Hwang (2019) and the IMO 4th GHG study (2020), shown in Table 80. The shaft generator was assumed to be used at 100% capacity when sailing to Europe and at a reduced power when sailing back from Europe to Asia accounting for reduced reefer loads and to keep the Auxiliary engines near their best fuel consumption efficiency point.

Table 80: Containership Average Main Engine Load at Sea, as % of MCR (IMO 4th GHG Study *et al.*, 2020)

Ship Type	Size Unit	Size Bin	Average ME Loads at sea - Table 36 (Page 105 133/524)						
			2012	2013	2014	2015	2016	2017	2018
Container Ship	TEU	0-999	55%	54%	52%	51%	51%	50%	48%
		1,000-1,999	50%	48%	46%	46%	47%	46%	46%
		2,000-2,999	42%	37%	35%	35%	37%	39%	39%
		3,000-4,999	41%	36%	33%	32%	33%	33%	33%
		5,000-7,999	37%	34%	32%	31%	31%	34%	34%
		8,000-11,999	35%	34%	34%	33%	38%	40%	40%
		12,000-14,499	36%	34%	35%	36%	40%	42%	41%
		14,500-19,999	26%	29%	35%	54%	60%	60%	56%
		20,000+	N/A	N/A	N/A	N/A	N/A	34%	51%

The speed, required engine power, shaft generator power, % of MCR used, and sailing time for the operational condition is summarized in Table 81.

Table 81: Main Engine Utilization, Vessel Sail Speed, and Time Spent Sailing per Round Trip

<i>Speed-Power</i>		Suez		Cape	
		Design Draft	Light Draft	Design Draft	Light Draft
Speed at Design Draft	knots	15.25	16.0	18.0	18.7
Required Trial Power	kW	18566	18237	26597	25994
Sea Margin		1.15	1.15	1.15	1.15
Fouling Factor		1.07	1.07	1.07	1.07
Total Required Propulsive Power	kW	22845	22441	32728	31986
Shaft Generator	kW	4500	1750	4500	1750
Total ME Power Req'd while Sailing	kW	27345	24191	37228	33736
ME Installed MCR	kW	65500	65500	65500	65500
% MCR	%	42%	37%	57%	52%
% of Propulsive MCR	%	35%	34%	50%	49%

Route Sailing Time	Hours	795	797	880	883
	Days	33	33	37	37
Combined Route Sail Time	Days	66		73	

For the Suez Canal route, with a sail time of 66 days and a port time of 16.5 days, this left 15.2 days as idle/waiting time. For the Cape route with substantially longer sailing distances and higher speed required to meet the schedule, completing the sailing portion in 73 days left 8 days as idle/waiting time, near the lower limit of the acceptable margin.

Auxiliary Engine and Boiler Power Requirements

The baseline at-sea auxiliary power load of 2,300 kW was added to the reefer loads during each leg of the journey. It was assumed that 50% of the total reefer slots would be used on the trip from Asia to Europe, and 25% would be used for the backhaul, with the average refrigerated container load taken as 5 kW/container (MMMCZCS and Seaspan, 2023). The reefer loads were thus 5,500 kW while travelling to Europe and 2,750 kW while travelling back to Asia. This total auxiliary power demand was met by the auxiliary generators the shaft generator.

While the vessel was at port or idle, the auxiliary power demand was reduced to 1,675 kW as per the value from the 4th IMO GHG study (2020), while the reefer load remained unchanged. Since the route is a fixed length of time, this implies that even if the vessel travelled at a higher speed to visit the ports quicker, the auxiliary power burnt while idle would grow as the idle time increases.

While in European ports, it was assumed that the vessels would be required to operate on shore power (European Commission), which set their auxiliary consumption to zero

but required the input of external grid electricity. While at port in Asia, the vessel was assumed to utilize its diesel generators.

The vessel was assumed to be idle 40% of the apportioned idle time in the European port phase of the journey and 60% of the time in the Asian port phase of the journey. This bias is an attempt to account for the increased waiting times associated with the port of Singapore (UNCTAD, 2022), and is relevant because of the differing reefer loads associated with each leg of the Journey.

The auxiliary boiler was assumed to be operational only during the port and idle days, and not operational while sailing (IMO 4th GHG Study *et al.*, 2020). Despite the requirements for shore power, the boilers were still assumed to be operational even while in EU ports, rather than utilize electrical steam generators.

It is assumed that the boiler and auxiliary engine loads are burning the boil-off-gas while the main engine is off in port or idle. Based on the boil off gas rates, this is possible for all of the cryogenic fuels except liquid hydrogen. For simplification, liquid hydrogen was also assumed to not require reliquification while the auxiliary engines and boilers were running as well. However, while on shore power in Europe, burning the boil off gas would not be possible. Therefore, the energy consumption from the grid was increased by the estimated energy consumption of the reliquification plants for LNG, Ammonia, and Hydrogen fuels.

9.7.2. *Tank-to-Wake Inventory*

The tank-to-wake inventory is a combination of the energy requirements from the trading route, the specific fuel consumption for the main engine, auxiliary engines, and boilers, and the emissions that result from burning that fuel in the various energy conversion devices. The energy requirements are established in the previous section, and are combined with the fuel consumption data compiled in section 9.3. The required quantities of fuel and emissions released by burning that fuel were calculated as per the procedure outlined in section 8.9.3. The resulting inventories for the case study vessel designs are shown in Table 82 and Table 83.

Table 82: Tank-to-Wake Inventory, Suez Route

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Suez		Suez		Suez		Suez		Suez	
		To EU	To Asia	To EU	To Asia	To EU	To Asia	To EU	To Asia	To EU	To Asia
System Input Summary											
Pilot Oil (MDO)	MT	0.0	0.0	125.9	124.7	610.7	652.9	610.7	652.9	610.7	652.9
Fuel (Varies)	MT	4,365.0	4,192.2	3,597.3	3,454.1	8,658.3	8,121.8	8,044.9	7,545.8	1,342.0	1,258.9
Urea	MT	777.5	738.0	777.5	738.0	777.5	738.0	47.7	59.2	777.5	738.0
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	8.0	7.8	0.0	0.0
Cylinder Oil	MT	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Lube Oil	MT	2.3	2.0	2.3	2.0	2.3	2.0	2.3	2.0	2.3	2.0
External Energy	kW-Hr	1.3E+06	0.0E+00	1.5E+06	0.0E+00	1.3E+06	0.0E+00	1.3E+06	0.0E+00	1.4E+06	0.0E+00
System Output Summary											
CO ₂ Emissions	MT	13,641.5	13,097.9	10,345.0	9,941.6	2,006.6	2,136.4	13,068.3	12,511.9	2,006.6	2,136.4
SO _x Emissions	MT	85.3	82.0	0.3	0.3	1.0	1.0	4.0	4.9	1.0	1.0
NO _x Emissions	MT	83.2	77.2	78.9	71.9	82.7	76.6	82.7	76.6	82.7	76.6
PM ₁₀ Emissions	MT	581.3	522.0	0.3	0.3	1.5	1.5	1.7	1.8	1.5	1.5
PM _{2.5} Emissions	MT	534.8	480.2	0.3	0.3	1.3	1.4	1.5	1.6	1.3	1.4
CH ₄ Emissions	MT	0.3	0.2	6.4	6.0	0.0	0.0	0.0	0.0	0.0	0.0
CO Emissions	MT	13.8	12.9	27.4	26.0	1.1	1.3	1.1	1.3	1.1	1.3
N ₂ O Emissions	MT	0.8	0.8	0.8	0.7	0.1	0.2	0.1	0.2	0.1	0.2
NM VOC Emissions	MT	15.4	14.2	10.2	9.6	2.4	2.5	2.4	2.5	2.4	2.5
BC Emissions	MT	0.9	0.9	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.1

Table 83: Tank-to-Wake Inventory, Cape Route

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Cape		Cape		Cape		Cape		Cape	
		To EU	To Asia	To EU	To Asia	To EU	To Asia	To EU	To Asia	To EU	To Asia
System Input Summary											
Pilot Oil (MDO)	MT	0.0	0.0	151.1	150.0	683.8	728.2	683.8	728.2	683.8	728.2
Fuel (Varies)	MT	6,006.1	5,756.7	4,964.0	4,757.3	12,370.2	11,653.7	11,504.6	10,834.7	1,917.4	1,806.3
Urea	MT	1,000.9	963.6	1,000.9	963.6	1,000.9	963.6	45.0	57.0	1,000.9	963.6
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	11.5	10.5	0.0	0.0
Cylinder Oil	MT	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Lube Oil	MT	3.4	3.1	3.4	3.1	3.4	3.1	3.4	3.1	3.4	3.1
External Energy	kW-Hr	1.3E+06	0.0E+00	1.5E+06	0.0E+00	1.3E+06	0.0E+00	1.3E+06	0.0E+00	1.4E+06	0.0E+00
System Output Summary											
CO ₂ Emissions	MT	18,776.6	17,993.3	14,209.0	13,630.2	2,265.7	2,401.6	18,084.6	17,299.3	2,265.7	2,401.6
SO _x Emissions	MT	117.4	112.5	0.4	0.4	1.1	1.1	3.9	4.7	1.1	1.1
NO _x Emissions	MT	120.1	112.3	116.1	107.3	119.8	111.9	119.8	111.9	119.8	111.9
PM ₁₀ Emissions	MT	856.5	784.8	0.3	0.4	1.6	1.6	1.8	1.9	1.6	1.6
PM _{2.5} Emissions	MT	788.0	722.0	0.3	0.3	1.4	1.5	1.6	1.7	1.4	1.5
CH ₄ Emissions	MT	0.4	0.3	8.7	8.3	0.0	0.1	0.0	0.1	0.0	0.1
CO Emissions	MT	19.6	18.5	38.6	36.7	1.1	1.3	1.1	1.3	1.1	1.3
N ₂ O Emissions	MT	1.2	1.1	1.1	1.0	0.2	0.2	0.2	0.2	0.2	0.2
NM VOC Emissions	MT	22.2	20.8	14.5	13.7	2.7	2.8	2.7	2.8	2.7	2.8
BC Emissions	MT	1.1	1.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

9.7.3. Well-to-Tank and Total Operational Inventory

With the tank-to-wake inventory completed, the quantity of the required input fuels is known, and well-to-tank emission factors provided in section 8.9.4 can be used to yield the well-to-tank emissions.

For each alternative fuel, three fuel origins were considered:

- Fossil source, which are how the majority of alternative fuels are produced today
- A renewable source for the primary fuel, generally extracted from biomass or, or in the case of hydrogen, E-hydrogen made from electrolysis using renewable energy. In the case of bio-sourced fuels, a carbon emissions offset was applied to the tank-to-wake carbon emissions based on the carbon content of the fuel (MMMCZCS, 2023). This is paired with fossil-sourced MDO for the pilot fuel.
- A renewable source for both primary fuel and pilot fuel (bio diesel), targeting minimizing net operating CO₂ emissions.

The well-to-tank emissions were added to the tank-to-wake emissions to provide the total well-to-wake operational emissions of the case study vessel and derivative designs.

9.8. Case Study Lifecycle Inventory – Total Inventory

The total emissions inventory from all phases of the lifecycle inventory are aggregated in Table 84 and Table 85.

Table 84: Total Emissions Inventory, All Phases, 91 Round Trips (Full Lifecycle), Suez Canal

		Suez Canal Route															
		HFO / Baseline Ship	LNG Ship			Ammonia Ship			Methanol Ship			LH ₂ Ship			Compressed Hydrogen Ship		
		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ Bio Diesel	Methanol	Bio- Methanol	Bio- Methanol w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel
CO ₂ Emissions	MT	3.19E+06	2.45E+06	1.26E+06	1.20E+06	3.17E+06	1.62E+06	1.30E+06	3.29E+06	1.24E+06	9.27E+05	3.01E+06	1.02E+06	6.97E+05	4.04E+06	1.19E+06	8.33E+05
SO _x Emissions	MT	15,243.2	81.6	2,304.4	2,333.6	192.1	179.6	326.9	868.7	2,164.6	2,311.9	1,260.1	1,629.4	1,776.7	1,747.1	2,275.7	2,440.3
NO _x Emissions	MT	14,616.0	14,035.3	15,375.1	15,521.1	15,764.7	15,764.7	16,501.1	15,813.8	16,096.1	16,832.6	15,480.3	15,366.7	16,103.2	22,479.2	22,316.6	23,139.6
PM ₁₀ Emissions	MT	100,693	219	219	219	436	436	436	476	476	476	436	436	436	456	456	456
PM _{2.5} Emissions	MT	92,504	67	67	67	267	267	267	304	304	304	267	267	267	285	285	285
CH ₄ Emissions	MT	3,538.6	2,258.0	1,796.0	1,710.6	690.8	540.3	109.6	851.1	1,726.3	1,295.6	4,805.5	616.2	185.5	6,708.5	710.8	229.4
CO Emissions	MT	2,432.3	4,952.7	5,165.3	5,165.3	324.5	219.4	219.4	397.5	925.5	925.5	503.6	432.6	432.6	621.5	519.9	519.9
N ₂ O Emissions	MT	244.2	229.3	234.6	235.3	129.6	129.6	133.4	125.1	123.1	126.9	123.9	128.5	132.2	129.6	136.1	140.3
NM VOC Emissions	MT	2,897.6	1,999.6	1,999.6	1,999.6	644.9	644.9	644.9	647.0	647.0	647.0	644.9	644.9	644.9	702.9	702.9	702.9
BC Emissions	MT	157.4	9.1	9.1	9.1	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.9	9.9	9.9
Chromium III Emissions	kg	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Cobalt Emissions	kg	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Manganese Emissions	kg	3,751	3,760	3,760	3,760	3,766	3,766	3,766	3,772	3,772	3,772	3,731	3,731	3,731	3,735	3,735	3,735
Nickel Emissions	kg	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Trimethylben- zene	kg	361	361	361	361	361	361	361	361	361	361	361	361	361	361	361	361
Xylene	kg	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883
4-methyl 2- pentanon	kg	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071
5-methyl 2- hexane	kg	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212
Methyl isobutylene	kg	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221
TBT (tributyltin)	kg	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478
Tar vinyl	kg	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611
Copper oxide	kg	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478
White spirit	kg	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035

Table 85: Total Emissions Inventory, All Phases, 91 Round Trips (Full Lifecycle), Cape

		Cape of Africa Route															
		HFO / Baseline Ship	LNG Ship			Ammonia Ship			Methanol Ship			LH ₂ Ship			Compressed Hydrogen Ship		
		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ Bio Diesel	Methanol	Bio- Methanol	Bio- Methanol w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel
CO ₂ Emissions	MT	4.26E+06	3.23E+06	1.60E+06	1.52E+06	4.26E+06	2.04E+06	1.68E+06	4.43E+06	1.50E+06	1.15E+06	4.02E+06	1.17E+06	8.12E+05	1.04E+06	7.19E+05	4.04E+06
SO _x Emissions	MT	20,946.0	106.1	3,170.6	3,205.7	218.6	200.7	365.3	870.5	2,727.3	2,891.9	1,747.1	2,275.7	2,440.3	1,629.4	1,776.7	1,747.1
NO _x Emissions	MT	21,175.1	20,752.6	22,599.7	22,775.2	22,886.2	22,886.2	23,709.2	22,958.0	23,362.5	24,185.5	22,479.2	22,316.6	23,139.6	15,366.7	16,103.2	22,479.2
PM ₁₀ Emissions	MT	149,652	226	226	226	456	456	456	494	494	494	456	456	456	436	436	456
PM _{2.5} Emissions	MT	137,546	74	74	74	285	285	285	320	320	320	285	285	285	267	267	285
CH ₄ Emissions	MT	4,865.5	3,081.1	2,444.1	2,341.5	819.7	604.2	122.9	1,049.4	2,303.5	1,822.2	6,708.5	710.8	229.4	616.2	185.5	6,708.5
CO Emissions	MT	3,470.1	6,975.9	7,268.9	7,268.9	365.1	214.7	214.7	469.8	1,226.3	1,226.3	621.5	519.9	519.9	432.6	432.6	621.5
N ₂ O Emissions	MT	306.0	288.8	296.0	296.9	137.7	137.7	141.9	131.3	128.4	132.6	129.6	136.1	140.3	128.5	132.2	129.6
NM VOC Emissions	MT	4,117.5	2,768.8	2,768.8	2,768.8	702.9	702.9	702.9	704.9	704.9	704.9	702.9	702.9	702.9	644.9	644.9	702.9
BC Emissions	MT	196.0	12.9	12.9	12.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.7	9.7	9.9
Chromium III Emissions	kg	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Cobalt Emissions	kg	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Manganese Emissions	kg	3,751	3,760	3,760	3,760	3,766	3,766	3,766	3,772	3,772	3,772	3,731	3,731	3,731	3,735	3,735	3,735
Nickel Emissions	kg	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Trimethylbenzene	kg	361	361	361	361	361	361	361	361	361	361	361	361	361	361	361	361
Xylene	kg	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883
4-methyl 2-pentanone	kg	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071
5-methyl 2-hexane	kg	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212
Methyl isobutylene	kg	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221
TBT (tributyltin)	kg	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478
Tar vinyl	kg	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611
Copper oxide	kg	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478
White spirit	kg	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035

9.9. Case Study Additional Ships Factor

With the route and cargo capacities established, the additional ships factor for each type of vessel is calculated based on the methodology presented in section 8.11. The associated additional ships factor for each alternatively fuelled design is shown in Table 86.

The calculated additional ships factors range from 1-1.12. For example, with a methanol fuelled vessel, the additional ships factor is 1.02 based on MT of cargo delivered. That means a fleet of 102 methanol powered vessels would be required to deliver the same amount of cargo on a MT basis as compared to a fleet of 100 HFO fuelled vessels, and so the additional emissions associated with building and operating two additional

vessels would be accounted for by multiplying the lifecycle impact analysis results by the additional ships factor.

Table 86: Calculation of Additional Ships Factor for Alternately Fuelled Designs

Suez Route		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Travel Distance	NMi	24,873	24,873	24,873	24,873	24,873	24,873
	km	46,065	46,065	46,065	46,065	46,065	46,065
Cargo Delivered	TEU	45,024	44,136	44,136	45,024	41,832	40,296
	MT-Loaded	253,490	246,853	242,957	249,588	236,906	228,308
Add. Ships Fac.	TEU Basis	1.00	1.02	1.02	1.00	1.08	1.12
	MT Basis	1.00	1.03	1.04	1.02	1.07	1.11
Cape Route		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Travel Distance	NMi	32,357	32,357	32,357	32,357	32,357	32,357
	km	59,924	59,924	59,924	59,924	59,924	59,924
Cargo Delivered	TEU	45,024	44,136	44,136	45,024	41,832	40,296
	MT-Loaded	253,490	246,853	242,957	249,588	236,906	228,308
Add. Ships Fac.	TEU Basis	1.00	1.02	1.02	1.00	1.08	1.12
	MT Basis	1.00	1.03	1.04	1.02	1.07	1.11

9.10. Case Study Lifecycle Impact Analysis and Evaluation

As described in section 8.12, the case study designs are compared to each other based on CO_{2Eq} emissions per work-transport, both considering TEU and MT of cargo delivered over the lifetime of the vessel. This work-transport factor is normalized by the additional ships factor to inherently capture the impact of additional ship building required to meet a fixed cargo demand with a fleet of alternatively fuelled vessel with lower cargo capacity.

Since CO_{2Eq} is used as the evaluation metric, the only relevant emissions are CO₂, CH₄, and N₂O, and the other emissions are reported but not evaluated further with midpoint or endpoint indicators.

9.11. Additional Ships vs. Additional Round Trips

The outlined methodology provided a means of evaluating the relative performance of alternatively fuelled vessels vs. a baseline HFO vessel assuming that additional ships would be added to a fleet to make up for the difference in cargo capacity. However, since the vessels are operating at such a low range of their installed power, an alternative method of making up the cargo shortfall is available by increasing the number of round trips in the vessel's lifetime without building additional ships. The goal of this portion of

the analysis is to determine under what circumstances speeding up vs. building additional ships and continuing to slow steam would yield the lowest global warming impact.

The number of additional trips required was calculated by multiplying the ratio of the cargo carried by the HFO design to the cargo carried by an alternatively fuelled design by the number of round trips. The number of additional trips required by each fuel type is shown in Table 87.

Table 87: Additional Lifetime Round Trips required for Equivalent Lifetime Cargo Delivery

Fuel Type	TEU/Trip	MT/Trip	TEU Basis		MT Basis	
			Lifetime RT	Extra Trips	Lifetime RT	Extra Trips
HFO	21048	176,612	91	0	91	0
LNG	20604	171,521	93	2	94	3
Ammonia	20604	167,625	93	2	96	5
Methanol	21048	172,710	91	0	94	3
LH ₂	19452	165,606	99	8	97	6
Compressed H ₂	18684	159,696	103	12	101	10

The operational lifecycle emissions were recalculated based on increasing the number of round trips in a vessel lifetime through reducing the scheduled round trip time and increasing the vessel's speed (if required) to keep a minimum of 7 days idle/anchor time as a margin. The changes to the operating profile with regards to the total round trip scheduled time, the speed at each draft, and the distribution of sailing/port/idle days is shown in Table 88.

Table 88: Operational Changes Required to Increase Number of Round Trips in Vessel's Lifetime for Equivalent Cargo Delivery

	Extra Trips	Number of RT	Days Scheduled	Suez					Cape Speed Knots				
				Design Draft	Light Draft	Sail Days	Port Days	Idle Days	Design Draft	Light Draft	Sail Days	Port Days	Idle Days
				knots	knots	days	days	days	knots	knots	days	days	days
TEU Equivalence	0	91	98	15.25	16.0	66.3	16.5	15.2	18.0	18.7	73.5	16.5	8
	2	93	96	15.25	16.0	66.3	16.5	13.2	18.3	19	72.3	16.5	7.2
	8	99	90	15.25	16	66.3	16.5	7.2	20	20.65	66.3	16.5	7.2
	12	103	87	16	16.7	63.4	16.5	7.1	20.9	21.6	63.4	16.5	7.1
MT Cargo Equivalence	3	94	95	15.25	16	66.3	16.5	12.2	18.6	19.2	71.3	16.5	7.2
	5	96	93	15.25	16	66.3	16.5	10.2	19.1	19.7	69.5	16.5	7
	6	97	92	15.25	16	66.3	16.5	9.2	19.4	20	68.4	16.5	7.1
	10	101	89	15.5	16.2	65.4	16.5	7.1	20.3	20.9	65.4	16.5	7.1

For the Suez route, there was already substantial margin in the number of idle days which allowed for a decrease in the scheduled round trip time of up to 8 days before the vessel was required to speed up to meet the schedule. Therefore, round trips could be added to Suez Canal route without incurring an emissions penalty for LNG, Ammonia, and Methanol fuels. In fact, reducing the scheduled round trip time reduces the

emissions slightly, since there are no longer as many idle days where the generators and boiler would be running. In this case, it was almost always more worthwhile to have the ships in the fleet run a compressed schedule than to build extra ships. However, for the Cape route, there was already very little margin in the schedule and so increasing the number of round trips required increases in speed. In this case, emissions were increased in the operational phase of the vessel due to higher fuel demand while sailing, and there is a breakpoint where it would result in less carbon emissions to build a new ship rather than to run the vessel faster. The associated one round-trip operational emissions for each derivative design and fuel type is shown in Table 89.

Table 89: Operational kg-CO₂Eq Emissions from 1 Round Trip, Cargo Throughput Matching through Increased Lifetime Round Trips

	HFO/Baseline Ship		LNG Ship								Ammonia Ship					
	HFO/VLSFO		LNG - Fossil		Bio LNG		Bio LNG - w/ Bio				Ammonia		Bio-Ammonia		Bio-Ammonia w/ Bio	
	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape			Suez	Cape	Suez	Cape	Suez	Cape
# RT - TEU	91	91	93	93	93	93	93	93	93	93	93	93	93	93	93	93
# RT - MT	91	91	94	94	94	94	94	94	94	96	96	96	96	96	96	96
To Use - For TEU Scaling	3.34E+07	4.58E+07	2.48E+07	3.46E+07	1.17E+07	1.61E+07	1.10E+07	1.52E+07	3.19E+07	4.49E+07	1.48E+07	1.98E+07	1.13E+07	1.58E+07	1.58E+07	1.58E+07
To Use - For MT Scaling	3.34E+07	4.58E+07	2.47E+07	3.49E+07	1.16E+07	1.62E+07	1.09E+07	1.54E+07	3.16E+07	4.65E+07	1.46E+07	2.03E+07	1.11E+07	1.64E+07	1.64E+07	1.64E+07

	HFO/Baseline Ship		Methanol Ship								LH ₂ Ship					
	HFO/VLSFO		Methanol		Bio-Methanol		Bio-Methanol w/ Bio				Hydrogen		E-Hydrogen		E-Hydrogen w/ Bio	
	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape			Suez	Cape	Suez	Cape	Suez	Cape
# RT - TEU	91	91	91	91	91	91	91	91	99	99	99	99	99	99	99	99
# RT - MT	91	91	94	94	94	94	94	94	97	97	97	97	97	97	97	97
To Use - For TEU Scaling	3.34E+07	4.58E+07	3.33E+07	4.60E+07	1.11E+07	1.42E+07	7.52E+06	1.01E+07	3.05E+07	4.79E+07	7.80E+06	1.01E+07	4.37E+06	6.25E+06	6.25E+06	6.25E+06
To Use - For MT Scaling	3.34E+07	4.58E+07	3.31E+07	4.74E+07	1.11E+07	1.46E+07	7.57E+06	1.06E+07	3.07E+07	4.61E+07	7.88E+06	9.99E+06	4.41E+06	6.09E+06	6.09E+06	6.09E+06

	HFO/Baseline Ship		Compressed Hydrogen Ship							
	HFO/VLSFO		Hydrogen		E-Hydrogen		E-Hydrogen w/ Bio			
	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape		
# RT - TEU	91	91	103	103	103	103	103	103	103	103
# RT - MT	91	91	101	101	101	101	101	101	101	101
To Use - For TEU Scaling	3.34E+07	4.58E+07	3.12E+07	5.09E+07	7.77E+06	1.03E+07	4.42E+06	6.54E+06	6.54E+06	6.54E+06
To Use - For MT Scaling	3.34E+07	4.58E+07	3.07E+07	4.87E+07	7.79E+06	1.02E+07	4.39E+06	6.33E+06	6.33E+06	6.33E+06

10. Case Study Results

10.1. Baseline HFO Design

10.1.1. Stack Weight, Stability, and Slot Capacity

Some interesting observations were made when producing the baseline HFO design loading conditions. The loading conditions were typically limited by three concerns – stability, deadweight, and stack weight. Stack weight limitations were particularly difficult to meet with 12-high stacks in the hold and 13-high stacks on deck. It was found impractical to carry heavy containers because of the stack weight limitations, and a penalty to the VCG and stability was identified with heavy deck containers. More ballast was required to compensate for the higher VCG and to meet the stability regulations, and thus deadweight limitations started limiting the loadable capacity, especially at the design draft.

Ultimately, it was found that the optimum arrangement was to carry the maximum stack weight of 9MT/TEU in the holds as this provided some stability benefits, while reducing the deck stack weights until the deadweight and stability criteria could be satisfied. The difference in loaded weight per TEU in the deck vs. hold containers is particularly noticeable in the design draft condition, where the deck containers were limited to 5.75 MT/TEU, while the hold containers remained at the optimum 9 MT/TEU. It also explains why when limiting the deck containers to 10 tiers, the total cargo weight that could be carried by the vessel increased even if the total number of TEU delivered decreased. In this circumstance, the deck containers could be loaded to 9.6 MT/TEU (which would be the maximum allowed based on stack weight), while the hold containers remained at 9 MT/TEU due to stack weight limitations. These are still light container weights however, with the maximum container weight approaching 14 MT/TEU.

This indicates that the tall stack sizes impose limitations on the ability of Ultra-Large Container Vessels to utilize their maximum slot capacity. It seems more practical to carry fewer but heavier loaded containers to maximize the weight of cargo that can be carried, rather than numerous lightly loaded or empty boxes, if cargo throughput rather than box throughput is the goal.

It is acknowledged that homogenous cargo loading is a very approximate representation of how the container vessel would be loaded in reality, and that cargo stratification and

logistic concerns mean that real container loads are quite different than design conditions, but these findings do lend credibility to the idea that these ultra large containerships either carry mostly empty containers or advertise more slot capacity than is practically usable.

10.1.2. Endurance Considerations

One of the surprising results from the endurance calculation was that the baseline HFO-fuelled vessel only had capacity to make the designed round-trip while slow steaming. While this is the likely operating profile of the vessel, it does mean that if the vessel does travel faster than the assumed slow-steaming profile, it will also need to bunker on either end of the journey rather than being able to complete a round trip. A calculation of the nominal cruising range of the HFO and alternatively fuelled derivative designs is shown in Table 90.

Table 90: Nominal Cruising Range at Maximum Speed, No Auxiliary Loads (Typical for Specifications)

Nominal Range							
Fuel Type		HFO	LNG	Methanol	NH ₃	Comp. H ₂	LH ₂
Design Service Speed	Knots	22.4					
Primary Fuel Tank Capacity	m ³	11,754	24,068	18,235	24,068	69,565	50,389
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
Usable Volume	m ³	11519	19435	17323	19435	59130	40689
Primary Fuel Density	MT/m ³	0.98	0.46	0.78	0.76	0.04	0.07
Primary Fuel Consumption	MT/day	232	193	468	503	78	78
Cruising Range	NMi	26,103	25,031	15,602	15,758	17,015	19,905
Attainable Journey	Max Power	Suez RT	Suez RT	Suez 1 Way	Suez 1 Way	Cape 1-way	Cape 1-way

This shows that the “specified” endurance would meet the requirements for completing a Europe-Asia round trip through the Suez Canal at the design speed of the vessel with the available bunker capacity, and this is likely how the tanks were sized. However, this calculation ignores the energy required for refrigerated containers and the auxiliary sea loads, which can be substantial for containerships. Examining the endurance conditions in this case study, the fraction of the energy required for non-motive power was between 20-30% of the total, shown in Table 91. This indicates that the basic specification range calculation is inappropriate for vessels with high auxiliary loads, and this should be appropriately considered when designing tankage for alternatively fuelled vessels.

Table 91: Comparison of Energy Demand, Main Engine vs. Auxiliary Engine

		Round Trip Endurance				1-Way Endurance			
		2A	2B	2C	2D	1A	1B	1C	1D
Condition		Max Power Full Reefers Cape	Max Power Full Reefers w/ Suez	Slow Steaming 50% Reefers Cape	Slow Steaming 50% Reefers w/ Suez	Max Power Full Reefers Cape 1-Way	Max Power Full Reefers w/ Suez 1-Way	Slow Steaming 50% Reefers Cape 1-Way	Slow Steaming 50% Reefers w/ Suez 1-Way
Sail Distance	NMi	32500	25000	32500	25000	16500	12500	16500	12500
ME MCR	%	90%	90%	57%	57%	90%	90%	57%	57%
Reefers Carried	FEU	2200	2200	1100	1100	2200	2200	1100	1100
ME Energy	MJ	2.90E+08	2.23E+08	2.13E+08	1.64E+08	1.47E+08	1.12E+08	1.08E+08	8.18E+07
Aux Energy	MJ	8.74E+07	7.11E+07	6.48E+07	6.39E+07	4.48E+07	3.61E+07	3.24E+07	3.19E+07
Total Energy	MJ	3.77E+08	2.94E+08	2.78E+08	2.28E+08	1.92E+08	1.48E+08	1.40E+08	1.14E+08
Fraction Aux-ME	%	23%	24%	23%	28%	23%	24%	23%	28%

10.2. Alternative Design Loadable Capacities

In addition to slot losses associated with the alternative fuel tanks and bunkering stations, the loadable capacity per container in terms of MT/TEU was also impacted. Similar to with the baseline HFO ship, the weight/TEU in the hold was kept constant at 9 MT/TEU, while the weight/TEU for the deck cargo was varied.

The achieved cargo loadings for all the designs and the six evaluated loading conditions are shown in Table 92. None of the alternative fuel designs offered an improvement over or even parity with the cargo capacity of an HFO fuelled vessel from a MT deliverable standpoint. Only the Methanol fuelled vessel could equal the number of TEU of the HFO vessel, but this came at the penalty of deliverable cargo weight.

Table 92: Container Capacities and Total Loadable Weight, by Alternative Fuel Type and Loading Condition

		Fuel	HFO	LNG	Ammonia	Methanol	LH ₂	Comp H ₂
Max Containers, Scantling Draft	Deck Weight/TEU	MT	7.20	7.24	7.00	7.00	7.39	7.48
	Deck FEU	# FEU	7,038	7,030	7,030	7,038	7,030	7,030
	Deck TEU	# TEU	14,076	14,060	14,060	14,076	14,060	14,060
	Hold Weight/TEU	MT	9.00	9.00	9.00	9.00	9.00	9.00
	Hold FEU	# FEU	4,950	4,736	4,736	4,950	4,160	3,776
	Hold TEU	# TEU	9,900	9,472	9,472	9,900	8,320	7,552
	Total Cargo Weight	MT	190,447	187,042	183,668	187,632	178,783	173,137
	Total TEU	# TEU	23,976	23,532	23,532	23,976	22,380	21,612
	Cargo Weight Delta	MT	0	-3,405	-6,779	-2,815	-11,664	-17,310
	TEU Delta		0	-444	-444	0	-1,596	-2,364
Max Containers, Design Draft	Deck Weight/TEU	MT	5.75	5.74	5.63	5.63	6.00	6.10
	Deck FEU	# FEU	7,038	7,030	7,030	7,038	7,030	7,030
	Deck TEU	# TEU	14,076	14,060	14,060	14,076	14,060	14,060
	Hold Weight/TEU	MT	9.00	9.00	9.00	9.00	9.00	9.00
	Hold FEU	# FEU	4,950	4,736	4,736	4,950	4,160	3,776
	Hold TEU	# TEU	9,900	9,472	9,472	9,900	8,320	7,552
	Total Cargo Weight	MT	170,037	165,952	164,406	168,348	159,240	153,734
	Total TEU	# TEU	23,976	23,532	23,532	23,976	22,380	21,612
	Cargo Weight Delta	MT	0	-4,085	-5,631	-1,689	-10,797	-16,303
	TEU Delta		0	-444	-444	0	-1,596	-2,364
10-Tier Deck Containers, Scantling Draft	Deck Weight/TEU	MT	9.60	9.60	9.40	9.51	9.60	9.60
	Deck FEU	# FEU	5,574	5,566	5,566	5,574	5,566	5,566
	Deck TEU	# TEU	11,148	11,132	11,132	11,148	11,132	11,132
	Hold Weight/TEU	MT	9.00	9.00	9.00	9.00	9.00	9.00
	Hold FEU	# FEU	4,950	4,736	4,736	4,950	4,160	3,776
	Hold TEU	# TEU	9,900	9,472	9,472	9,900	8,320	7,552
	Total Cargo Weight	MT	196,121	192,115	189,889	195,117	181,747	174,835
	Total TEU	# TEU	21,048	20,604	20,604	21,048	19,452	18,684
	Cargo Weight Delta	MT	0	-4,006	-6,232	-1,003	-14,374	-21,286
	TEU Delta		0	-444	-444	0	-1,596	-2,364
10-Tier Deck Containers, Design Draft	Deck Weight/TEU	MT	7.85	7.75	7.40	7.50	8.15	8.24
	Deck FEU	# FEU	5,574	5,566	5,566	5,574	5,566	5,566
	Deck TEU	# TEU	11,148	11,132	11,132	11,148	11,132	11,132
	Hold Weight/TEU	MT	9.00	9.00	9.00	9.00	9.00	9.00
	Hold FEU	# FEU	4,950	4,736	4,736	4,950	4,160	3,776
	Hold TEU	# TEU	9,900	9,472	9,472	9,900	8,320	7,552
	Total Cargo Weight	MT	176,612	171,521	167,625	172,710	165,606	159,696
	Total TEU	# TEU	21,048	20,604	20,604	21,048	19,452	18,684
	Cargo Weight Delta	MT	0	-5,091	-8,987	-3,902	-11,006	-16,916
	TEU Delta		0	-444	-444	0	-1,596	-2,364
14 MT/TEU Homogenous Scantling Draft	Deck Weight/TEU	MT	14.00	14.00	14.00	14.00	14.00	14.00
	Deck FEU	# FEU	3,970	3,964	3,964	3,970	3,962	4,002
	Deck TEU	# TEU	7,940	7,928	7,928	7,940	7,924	8,004
	Hold Weight/TEU	MT	14.00	14.00	14.00	14.00	14.00	14.00
	Hold FEU	# FEU	3,230	3,104	3,104	3,230	2,770	2,544
	Hold TEU	# TEU	6,460	6,208	6,208	6,460	5,540	5,088
	Total Cargo Weight	MT	201,600	197,904	197,904	201,600	188,496	183,288
	Total TEU	# TEU	14,400	14,136	14,136	14,400	13,464	13,092
	Cargo Weight Delta	MT	0	-3,696	-3,696	0	-13,104	-18,312
	TEU Delta		0	-264	-264	0	-936	-1,308
Backhaul to Asia	Deck Weight/TEU	MT	3.00	3.00	3.00	3.00	3.00	3.00
	Deck FEU	# FEU	7,038	7,030	7,030	7,038	7,030	7,030
	Deck TEU	# TEU	14,076	14,060	14,060	14,076	14,060	14,060
	Hold Weight/TEU	MT	3.50	3.50	3.50	3.50	3.50	3.50
	Hold FEU	# FEU	4,950	4,736	4,736	4,950	4,160	3,776
	Hold TEU	# TEU	9,900	9,472	9,472	9,900	8,320	7,552
	Total Cargo Weight	MT	76,878	75,332	75,332	76,878	71,300	68,612
	Total TEU	# TEU	23,976	23,532	23,532	23,976	22,380	21,612
	Cargo Weight Delta	MT	0	-1,546	-1,546	0	-5,578	-8,266
	TEU Delta		0	-444	-444	0	-1,596	-2,364

For five of the six loading conditions, the TEU differential between the baseline and the alternatively fuelled ships is equal to the predicted loss in slots. The only exception is the 14 MT/TEU homogenous scantling draft condition, where the container losses are less than the slot losses due to limited stack heights in the hold limiting the losses associated with the fuel tanks in the cargo hold.

For all the alternatively loaded ships, the loadable cargo weight decreases. The methanol fuelled ship loses the least loadable cargo weight, while the hydrogen ship loses the most loadable cargo weight, shown in Figure 65.

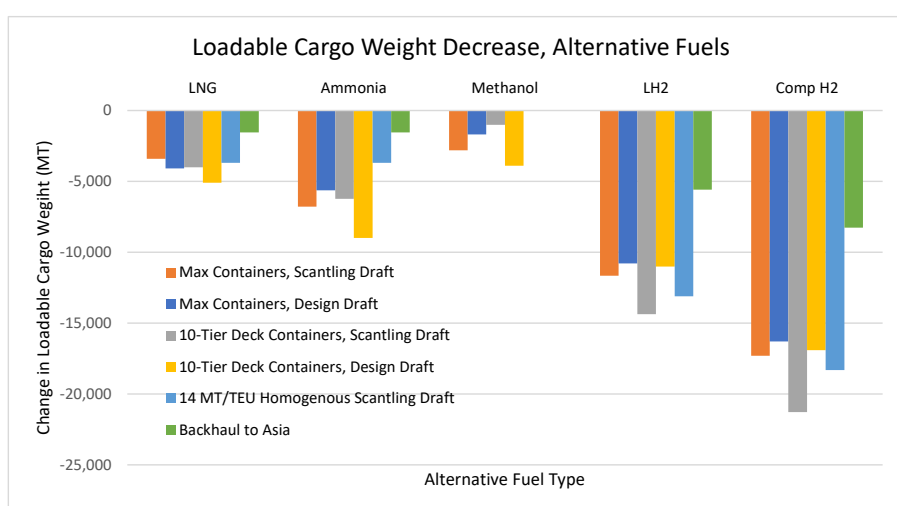


Figure 65: Loadable Cargo Weight Decrease from Alternative Fuels

The average weight per TEU for each of the designs and conditions is summarized in Table 93.

Table 93: Average Weight per Container, Per Design and Loading Condition

Loading Condition	HFO	LNG	Ammonia	Methanol	LH ₂	Comp H ₂
Max Containers, Scantling Draft	7.94	7.95	7.81	7.83	7.99	8.01
Max Containers, Design Draft	7.09	7.05	6.99	7.02	7.12	7.11
10-Tier Deck Containers, Scantling Draft	9.32	9.32	9.22	9.27	9.34	9.36
10-Tier Deck Containers, Design Draft	8.39	8.32	8.14	8.21	8.51	8.55
14 MT/TEU Homogenous Scantling Draft	14.00	14.00	14.00	14.00	14.00	14.00
Backhaul to Asia	3.21	3.20	3.20	3.21	3.19	3.17

The LNG vessel had a slightly reduced deck loading in the design draft and heavier at the scantling draft when compared to the HFO design.

The hydrogen ships allowed for heavier containers on average to be loaded on the deck, while the ammonia and methanol required lighter average deck container loads. The

hydrogen design allowed for heavier containers to be loaded on the deck because the total fuel weight was lighter than for HFO, even accounting for the extra tank weight in the lightship. This allowed for more ballast to be carried and thus offset the VCG impact from heavier deck cargoes.

The Ammonia and Methanol designs suffered from the opposite problem, where the increased fuel mass carried and higher tank VCG's both negatively impacted stability performance and prevented extra ballast from being carried in the double bottom to offset this.

Despite the ability to load more cargo into the deck containers for the hydrogen designs, it was not sufficient to compensate for the number of slots lost and so their overall weight of cargo delivered was substantially less than any of the alternative designs.

The average deliverable weight lost per TEU lost is shown in Table 94, which highlights how important stability and deadweight constraints were for each fuel type and loading condition.

Table 94: Average Decrease in Deliverable MT per Container Slot Loss

Loading Condition	LNG	Ammonia	Methanol*	LH ₂	Comp H ₂
Max Containers, Scantling Draft	7.67	15.27	2815.20	7.31	7.32
Max Containers, Design Draft	9.20	12.68	1689.12	6.77	6.90
10-Tier Deck Containers, Scantling Draft	9.02	14.04	1003.32	9.01	9.00
10-Tier Deck Containers, Design Draft	11.47	20.24	3901.80	6.90	7.16
14 MT/TEU Homogenous Scantling Draft	14.00	14.00	0.00	14.00	14.00
Backhaul to Asia	3.48	3.48	0.00	3.49	3.50

*Total weight lost is reported for Methanol because no container slots were lost

Ammonia, and especially methanol, perform poorly by this metric because the maximum weight per TEU dropped more than with other fuels. Methanol in particular didn't lose any container slots but still lost 1000-4000 MT of loadable cargo weight because of stability and deadweight issues.

10.3. Ship Building Emissions

A breakdown of the CO_{2eq} emissions from each step of the shipbuilding process and the contribution to the total shipbuilding emissions is presented in Table 95. Particulate matter and VOC emissions from the shipbuilding process are presented in Table 96.

Table 95: Shipbuilding Emissions Inventory and Portion of Total Shipbuilding Emissions

		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Steel Production and Transport	kg-CO_{2eq}	2.63E+08	2.65E+08	2.65E+08	2.64E+08	2.80E+08	3.01E+08
Cutting	kg-CO_{2eq}	9.65E+04	9.65E+04	9.65E+04	9.65E+04	9.65E+04	9.65E+04
Welding	kg-CO_{2eq}	1.35E+07	1.35E+07	1.35E+07	1.35E+07	1.34E+07	1.34E+07
Blasting	kg-CO_{2eq}	4.13E+04	4.13E+04	4.13E+04	4.13E+04	4.13E+04	4.13E+04
Painting	kg-CO_{2eq}	5.02E+04	5.05E+04	5.06E+04	5.04E+04	5.34E+04	5.75E+04
Other Shipyard Activity	kg-CO_{2eq}	6.06E+05	6.10E+05	6.10E+05	6.08E+05	6.44E+05	6.93E+05
Sea Trials	kg-CO_{2eq}	6.05E+05	4.50E+05	5.86E+05	6.13E+05	5.71E+05	5.71E+05
Total	kg-CO_{2eq}	2.78E+08	2.79E+08	2.80E+08	2.79E+08	2.95E+08	3.16E+08
Steel Production and Transport	%	94.65%	94.72%	94.68%	94.64%	94.98%	95.29%
Cutting	%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%
Welding	%	4.84%	4.83%	4.83%	4.85%	4.54%	4.24%
Blasting	%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Painting	%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
Other Shipyard Activity	%	0.22%	0.22%	0.22%	0.22%	0.22%	0.22%
Sea Trials	%	0.22%	0.16%	0.21%	0.22%	0.19%	0.18%

Table 96: Particulate Matter and Volatile Organic Compound Emissions from Shipbuilding, Primarily from Blasting and Painting

PM10	kg	137,983	114,442	114,481	114,494	114,424	114,430
PM2.5	kg	32,524	10,852	10,879	10,881	10,879	10,879
VOC	kg	200,791	200,585	200,274	200,274	200,274	200,274

The steel production process has the largest contribution to the CO_{2eq} emissions, varying between 94-96% of the total, followed by Welding at approximately 5% of the total. The remaining activities contribute a negligible amount of carbon emissions, though the particulate matter and VOC emissions from blasting, painting, and sea trials are appreciable. Since the emissions from steel production are linearly related to the lightweight of the vessel, the higher lightweight associated with the hydrogen fuelled vessels contributes directly to the increased shipbuilding emissions.

10.4. Maintenance Emissions

The CO_{2eq} emissions from a single maintenance phase are presented in Table 97, and the particulate matter and VOC emissions are provided in Table 98.

Table 97: Maintenance Emissions Inventory and Portion of Total Maintenance Emissions – Single Maintenance Period

		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Steel Production and Transport	kg-CO _{2eq}	1.12E+06	1.12E+06	1.12E+06	1.12E+06	1.12E+06	1.12E+06
Cutting	kg-CO _{2eq}	5.67E+04	5.67E+04	5.67E+04	5.67E+04	5.67E+04	5.67E+04
Welding	kg-CO _{2eq}	9.23E+04	9.23E+04	9.23E+04	9.23E+04	9.23E+04	9.23E+04
Blasting	kg-CO _{2eq}	4.57E+03	4.57E+03	4.57E+03	4.57E+03	4.57E+03	4.57E+03
Painting	kg-CO _{2eq}	5.02E+04	5.05E+04	5.06E+04	5.04E+04	5.34E+04	5.75E+04
Other Shipyard Activity	kg-CO _{2eq}	2.85E+03	2.85E+03	2.85E+03	2.85E+03	2.85E+03	2.85E+03
Total	kg-CO _{2eq}	1.33E+06	1.33E+06	1.33E+06	1.33E+06	1.33E+06	1.34E+06
Steel Production and Transport	%	84.47%	84.45%	84.45%	84.46%	84.27%	84.02%
Cutting	%	4.26%	4.26%	4.26%	4.26%	4.25%	4.24%
Welding	%	6.94%	6.93%	6.93%	6.93%	6.92%	6.90%
Blasting	%	0.34%	0.34%	0.34%	0.34%	0.34%	0.34%
Painting	%	3.77%	3.80%	3.80%	3.79%	4.00%	4.29%
Other Shipyard Activity	%	0.21%	0.21%	0.21%	0.21%	0.21%	0.21%

Table 98: CO_{2eq}, Particulate Matter and Volatile Organic Compound Emissions from Maintenance, Primarily from Blasting and Painting - Lifetime

CO _{2eq} Repair Emissions	kg-CO _{2eq}	5.32E+06	5.33E+06	5.33E+06	5.32E+06	5.34E+06	5.35E+06
PM10	kg	48,173	48,173	48,173	48,173	48,173	48,173
PM2.5	kg	4,801	4,801	4,801	4,801	4,801	4,801
VOC	kg	88,632	88,632	88,632	88,632	88,632	88,632

It is interesting to note that the CO_{2eq} emissions from the maintenance phase is about 2% of the CO_{2eq} emitted from the shipbuilding, indicating that the CO_{2eq} contribution from the maintenance phase is minor. The Particulate matter and VOC emissions are more significant in the maintenance phase, with VOC's from maintenance being 44% of those emitted from the shipbuilding process. This disagrees with the findings in some of the literature (Quang, Dong and Hai, 2021; Chatzinikolaou and Ventikos, 2015), and is assumed to be primarily related to both the estimation procedure for painting areas and the amount of re-painting assumed necessary for a vessel during maintenance.

As in the shipbuilding phase, the steel production dominates the emissions in the maintenance phase, but welding and, cutting, and painting become more relevant in the total CO_{2eq} emissions profile.

10.5. Ship Breaking Emissions

A summary of the CO_{2eq} emissions from the various stages of the shipbreaking process as well as a breakdown of the stage's contribution to the total is shown in Table 99.

Table 99: Ship Breaking Emissions Inventory and Portion of Total Breaking Emissions

Stage	Unit	Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Transit To Breakers	kg-CO _{2eq}	2,895,115	2,173,659	2,812,603	2,924,945	2,744,515	2,744,515
Beach Cutting to Large Blocks	kg-CO _{2eq}	101,304	101,919	102,037	101,712	107,726	115,899
Winch Dragging	kg-CO _{2eq}	199,653	200,865	201,099	200,457	212,309	228,418
Small Steel Cutting	kg-CO _{2eq}	508,329	511,415	512,009	510,375	540,552	581,566
Loading/Unloading with Cranes	kg-CO _{2eq}	440,793	443,469	443,984	442,567	468,735	504,299
Transport to Reclamation Facilities	kg-CO _{2eq}	496,281	499,294	499,874	498,279	527,740	567,782
Total	kg-CO_{2eq}	4,641,476	3,930,621	4,571,607	4,678,335	4,601,577	4,742,479
Transit To Breakers	%	62%	55%	62%	63%	60%	58%
Beach Cutting to Large Blocks	%	2%	3%	2%	2%	2%	2%
Winch Dragging	%	4%	5%	4%	4%	5%	5%
Small Steel Cutting	%	11%	13%	11%	11%	12%	12%
Loading/Unloading with Cranes	%	9%	11%	10%	9%	10%	11%
Transport to Reclamation Facilities	%	11%	13%	11%	11%	11%	12%

The transit distance accounts for a little more than half of the CO_{2eq} emissions from the ship breaking process, followed in importance by the cutting of the steel into truck-sized loads and transportation of the steel by those trucks to the reclamation facilities. The emissions associated with cutting the ship into large steel chunks contributes the least to the total scrapping emissions.

10.6. Operational Emissions: Tank-to-Wake and Well-to-Tank Breakdown

10.6.1. Tank-to-Wake Results

Based on the tank-to-wake inventories collected in section 9.7.2, the work-Transport efficiencies based on CO_{2eq}, and relative performance of the alternatively fuelled designs compared to the baseline HFO design were determined and are shown in Table 100 and Table 101.

Table 100: Tank-to-Wake Work Transport Efficiencies, by TEU and MT, Suez Route

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Liquid Hydrogen Fueled Ship		Comp. Hydrogen Fueled Ship	
Transport Efficiencies		Suez		Suez		Suez		Suez		Suez		Suez	
Travel Distance	NMi	12118	12756	12118	12756	12118	12756	12118	12756	12118	12756	12118	12756
TEU Delivered	TEU	21,048	23,976	20,604	23,532	20,604	23,532	21,048	23,976	19,452	22,380	18,684	21,612
MT Delivered	MT-Loaded	176,612	76,878	171,521	75,332	167,625	75,332	172,710	76,878	165,606	71,300	159,696	68,612
CO _{2eq} Work-Transport Eff. (TEU)	kg-CO _{2e} /TEU-NMi	0.0544	0.0435	0.0430	0.0343	0.0082	0.0073	0.0514	0.0411	0.0087	0.0076	0.0090	0.0079
TEU Work-Transport Difference	% Difference			-21%	-21%	-85%	-83%	-5%	-6%	-84%	-82%	-83%	-82%
CO _{2eq} Work-Transport Eff. (MT)	kg-CO _{2e} /MT-NMi	0.0065	0.0136	0.0052	0.0107	0.0010	0.0023	0.0063	0.0128	0.0010	0.0024	0.0011	0.0025
MT Work-Transport Difference	%			-20%	-21%	-84%	-83%	-3%	-6%	-84%	-82%	-84%	-82%

Table 101: Tank-to-Wake Work Transport Efficiencies, by TEU and MT, Cape Route

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Liquid Hydrogen Fueled Ship		Comp. Hydrogen Fueled Ship	
Transport Efficiencies		Cape		Cape		Cape		Cape		Cape		Cape	
Travel Distance	NMi	15844	16512	15844	16512	15844	16512	15844	16512	15844	16512	15844	16512
TEU Delivered	TEU	21,048	23,976	20,604	23,532	20,604	23,532	21,048	23,976	19,452	22,380	18,684	21,612
MT Delivered	MT-Loaded	176,612	76,878	171,521	75,332	167,625	75,332	172,710	76,878	165,606	71,300	159,696	68,612
CO _{2eq} Work-Transport Eff. (TEU)	kg-CO _{2e} /TEU-NMi	0.0573	0.0462	0.0452	0.0364	0.0071	0.0063	0.0544	0.0438	0.0075	0.0066	0.0078	0.0069
TEU Work-Transport Difference	% Difference	5%	6%	-22%	-23%	-92%	-92%	-5%	-6%	-92%	-91%	-91%	-90%
CO _{2eq} Work-Transport Eff. (MT)	kg-CO _{2e} /MT-NMi	0.0068	0.0144	0.0054	0.0114	0.0009	0.0020	0.0066	0.0137	0.0009	0.0021	0.0009	0.0022
MT Work-Transport Difference	%	5%	6%	-22%	-22%	-92%	-92%	-3%	-6%	-92%	-91%	-91%	-90%

The Cape route is approximately 5-6% less efficient than the Suez Canal route due to the increased sail distance and higher required speed for the HFO powered design.

Ammonia and Hydrogen (carbon free fuels) have a tank-to-wake emission reduction of 82-92% when compared to HFO, with the longer routes enjoying a more pronounced decrease in global warming potential. The CO_{2Eq} emissions from these fuels are not completely abated because of the use of pilot fuel and a small emission of N₂O.

From a tank-to-wake standpoint, Methanol does not offer substantial emissions abatement, between 3-6%. Because the methanol design can also carry less cargo by weight than the HFO design despite having the same number of TEU slots, it also has a slightly worse performance when measured by MT work-transport efficiency when compared to the TEU work-transport efficiency.

An assessment of the achieved tank-to-wake emission factors based on MT-CO_{2Eq} emitted per MT of fuel (both primary and pilot) was also conducted, with the results shown in Table 102 and Figure 66.

Table 102: TTW Emission Factors from Inventory

		Suez Canal Route												
		HFO	LNG			Ammonia			Methanol			LH ₂ and Compressed Hydrogen		
Main Fuel Source		Fossil	Fossil	Bio	Bio	Fossil	Bio	Bio	Fossil	Bio	Bio	Fossil	E	E
Pilot Fuel		N/A	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel
Main Fuel	MT	8,557	7,051	7,051	7,051	16,780	16,780	16,780	15,591	15,591	15,591	2,601	2,601	2,601
Pilot Fuel and LO	MT	6	256	256	256	1,269	1,269	1,269	1,269	1,269	1,269	1,269	1,269	1,269
Pilot Oil Mass %	%	0	4%	4%	4%	8%	8%	8%	8%	8%	8%	49%	49%	49%
CO _{2eq}	MT	27,183	21,029	21,029	21,029	4,224	4,224	4,224	25,662	25,662	25,662	4,224	4,224	4,224
CO ₂ Offset	MT	0	0	-19,391	-20,100	0	0	-3,575	0	-21,515	-25,090	0	0	-3,575
TTW EF - No Offset	MT CO _{2eq} /MT Fuel	3.175	2.878	2.878	2.878	0.234	0.234	0.234	1.522	1.522	1.522	1.092	1.092	1.092
TTW EF - Offset	MT CO _{2eq} /MT Fuel	3.175	2.878	0.224	0.127	0.234	0.234	0.036	1.522	0.246	0.034	1.092	1.092	0.168
Nominal TTW EF	MT CO ₂ /MT Fuel	3.114	2.750	2.750	2.750	0.000	0.000	0.000	1.375	1.375	1.375	0.000	0.000	0.000

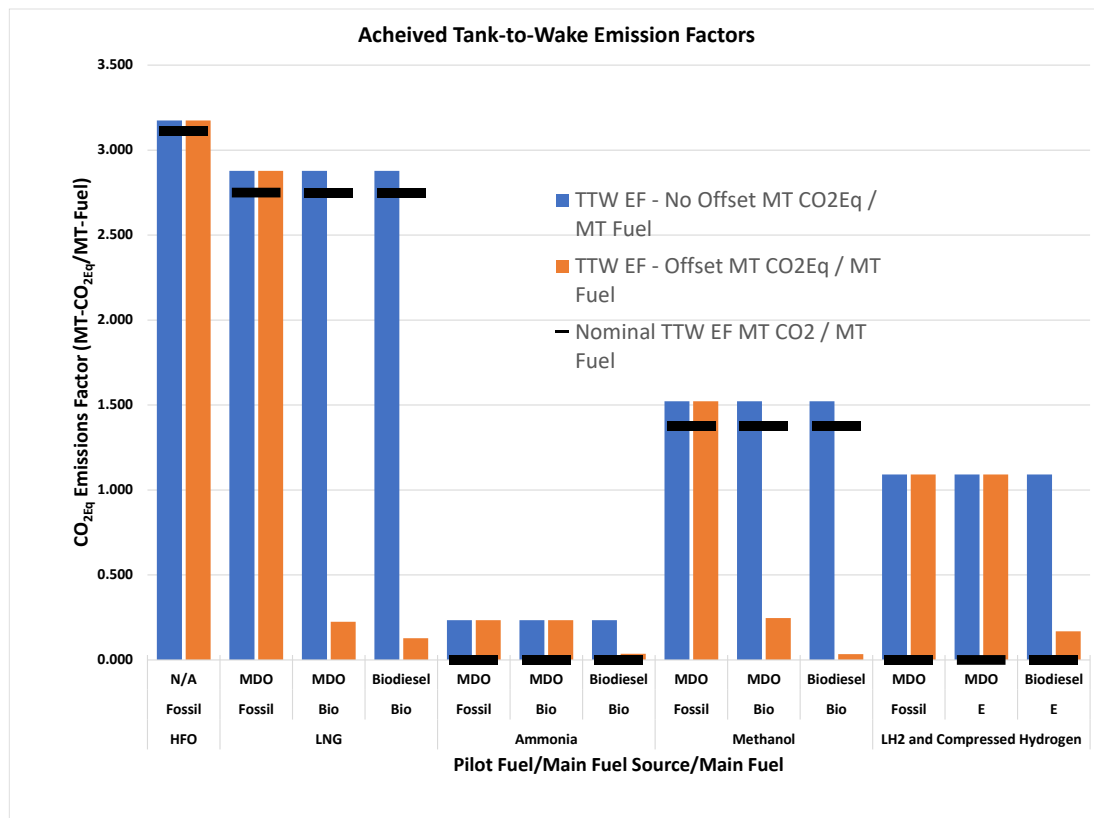


Figure 66: Achieved Tank-to-Wake Emission Factors from Inventory, Including CO₂ Offset from Biogenic Sources

The tank-to-wake emission factors are close to nominal value of the primary fuel but are always higher because the CO₂_{Eq} also considers contributions from methane and N₂O. To highlight the difference in grey vs. green fuels, the results of the emission factor with and without the CO₂ offset from biogenic sources is also presented. The pilot oil's contribution to the emissions factor is included, which accounts for some of the “zero carbon” fuels such as ammonia and hydrogen having non-zero TTW emissions factors. It is interesting to note that hydrogen has a worse TTW emissions factor than ammonia. This is because so little mass of hydrogen is combusted and pilot oil makes up just under half of the combusted mass, so on a ton-for-ton basis hydrogen does release more emissions. If the CO₂_{Eq} tank-to-wake emissions factor is instead examined on the basis of the energy content of the fuel in MJ, as shown in Figure 67, zero-carbon fuels ammonia and hydrogen perform the same as expected, and interestingly enough LNG performs better than methanol, which is partially due to the better combustion and lower pilot fuel consumption and the relatively high energy density of methane compared to methanol.

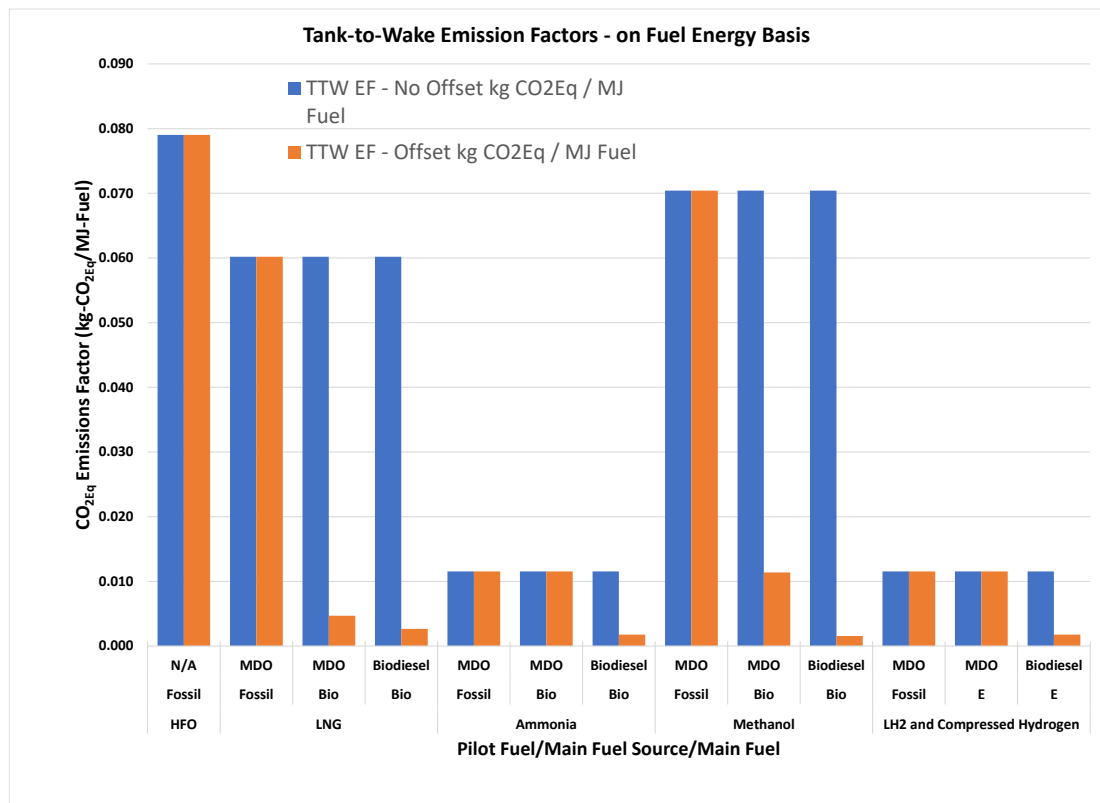


Figure 67: Achieved Tank-to-Wake Emissions Factors, based on Fuel Energy in MJ

10.6.2. Well-to-Wake Results

The tank-to-wake emissions and input inventory is combined with well-to-tank emissions factors to yield the complete well-to-wake emissions factors, summarized in Table 103 and Table 104.

Table 103: Well-to-Tank and Total Operational Emissions Inventory, Suez Route

		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ BD	Methanol	Bio- Methanol	Bio- Methanol w/ BD	Hydrogen	E- Hydrogen	E- Hydrogen w/ BD
Required Consumables		Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez
Pilot Oil	MT	0.0	250.5	250.5	250.5	1,263.5	1,263.5	1,263.5	1,263.5	1,263.5	1,263.5	1,263.5	1,263.5	1,263.5
Fuel	MT	8,557.3	7,051.4	7,051.4	7,051.4	16,780.1	16,780.1	16,780.1	15,590.8	15,590.8	15,590.8	2,600.9	2,600.9	2,600.9
Urea	MT	1,515.5	1,515.5	1,515.5	1,515.5	1,515.5	1,515.5	1,515.5	106.9	106.9	106.9	1,515.5	1,515.5	1,515.5
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.8	15.8	15.8	0.0	0.0	0.0
Cylinder Oil	MT	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Lube Oil	MT	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
External Energy	kW-Hr	1.29E+06	1.50E+06	1.50E+06	1.50E+06	1.30E+06	1.30E+06	1.30E+06	1.29E+06	1.29E+06	1.29E+06	1.41E+06	1.41E+06	1.41E+06
Well-to-Tank Emissions														
CO ₂ Emissions	MT	5,104.2	3,458.6	9,788.0	9,804.4	27,519.0	10,459.0	10,541.7	7,366.2	6,435.4	6,518.2	25,539.8	3,667.2	3,750.0
SO _x Emissions	MT	0.0	0.3	24.7	25.0	0.1	0.0	1.6	0.7	14.9	16.5	11.9	15.9	17.5
NO _x Emissions	MT	0.0	3.2	17.9	19.5	13.7	13.7	21.8	14.3	17.4	25.5	10.6	9.4	17.5
CH ₄ Emissions	MT	38.4	12.3	7.3	6.3	7.5	5.8	1.1	9.3	18.9	14.1	52.7	6.6	1.9
CO Emissions	MT	0.0	0.9	3.2	3.2	1.2	0.0	0.0	2.0	7.8	7.8	3.1	2.3	2.3
N ₂ O Emissions	MT	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2
Tank-to-Wake Emissions														
CO ₂ Emissions	MT	26,739.4	20,286.5	20,286.5	20,286.5	4,142.9	4,142.9	4,142.9	25,580.3	25,580.3	25,580.3	4,142.9	4,142.9	4,142.9
CO ₂ Emissions Offset	MT	0.0	0.0	-19,391.3	-20,100.1	0.0	0.0	-3,574.9	0.0	-21,515.3	-25,090.2	0.0	0.0	-3,574.9
SO _x Emissions	MT	167.3	0.6	0.6	0.6	2.0	2.0	2.0	8.9	8.9	8.9	2.0	2.0	2.0
NO _x Emissions	MT	160.4	150.8	150.8	150.8	159.3	159.3	159.3	159.3	159.3	159.3	159.3	159.3	159.3
PM ₁₀ Emissions	MT	1,103.3	0.6	0.6	0.6	3.0	3.0	3.0	3.4	3.4	3.4	3.0	3.0	3.0
PM _{2.5} Emissions	MT	1,015.0	0.6	0.6	0.6	2.8	2.8	2.8	3.2	3.2	3.2	2.8	2.8	2.8
CH ₄ Emissions	MT	0.5	12.4	12.4	12.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CO Emissions	MT	26.7	53.4	53.4	53.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
N ₂ O Emissions	MT	1.6	1.5	1.5	1.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
NM VOC Emissions	MT	29.6	19.7	19.7	19.7	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
BC Emissions	MT	1.7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Operational Emissions														
CO ₂ Emissions	MT	31,843.7	23,745.2	10,683.2	9,990.8	31,661.9	14,601.9	11,109.8	32,946.4	10,500.4	7,008.3	29,682.8	7,810.2	4,318.0
SO _x Emissions	MT	167.3	0.9	25.3	25.6	2.1	2.0	3.6	9.5	23.8	25.4	13.8	17.9	19.5
NO _x Emissions	MT	160.4	154.0	168.8	170.4	173.0	173.0	181.1	173.6	176.7	184.8	169.9	168.7	176.7
PM ₁₀ Emissions	MT	1,103.3	0.6	0.6	0.6	3.0	3.0	3.0	3.4	3.4	3.4	3.0	3.0	3.0
PM _{2.5} Emissions	MT	1,015.0	0.6	0.6	0.6	2.8	2.8	2.8	3.2	3.2	3.2	2.8	2.8	2.8
CH ₄ Emissions	MT	38.9	24.8	19.7	18.8	7.6	5.9	1.2	9.3	19.0	14.2	52.7	6.7	2.0
CO Emissions	MT	26.7	54.4	56.7	56.7	3.6	2.4	2.4	4.4	10.2	10.2	5.5	4.7	4.7
N ₂ O Emissions	MT	1.7	1.5	1.6	1.6	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.5
NM VOC Emissions	MT	29.6	19.7	19.7	19.7	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
BC Emissions	MT	1.7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table 104: Well-to-Tank and Total Operational Emissions Inventory, Cape Route

		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ BD	Methanol	Bio- Methanol	Bio- Methanol w/ BD	Hydrogen	E-Hydrogen	E-Hydrogen w/ BD
Required Consumables		Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape
Pilot Oil	MT	0.0	301.1	301.1	301.1	1,412.0	1,412.0	1,412.0	1,412.0	1,412.0	1,412.0	1,412.0	1,412.0	1,412.0
Fuel	MT	11,762.8	9,721.2	9,721.2	9,721.2	24,023.9	24,023.9	24,023.9	22,339.4	22,339.4	22,339.4	3,723.7	3,723.7	3,723.7
Urea	MT	1,964.5	1,964.5	1,964.5	1,964.5	1,964.5	1,964.5	1,964.5	101.9	101.9	101.9	1,964.5	1,964.5	1,964.5
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.0	22.0	22.0	0.0	0.0	0.0
Cylinder Oil	MT	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Lube Oil	MT	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
External Energy	kW-Hr	1.29E+06	1.46E+06	1.46E+06	1.46E+06	1.30E+06	1.30E+06	1.30E+06	1.29E+06	1.29E+06	1.29E+06	1.39E+06	1.39E+06	1.39E+06
Well-to-Tank Emissions														
CO ₂ Emissions	MT	6,854.7	4,537.7	13,263.5	13,283.2	38,981.8	14,557.3	14,649.8	10,138.7	8,805.1	8,897.6	36,124.5	4,809.7	4,902.2
SO _x Emissions	MT	0.0	0.4	34.1	34.4	0.2	0.0	1.8	0.9	21.3	23.1	17.0	22.8	24.6
NO _x Emissions	MT	0.0	4.4	24.7	26.7	19.7	19.7	28.7	20.4	24.9	33.9	15.2	13.4	22.4
CH ₄ Emissions	MT	52.7	16.8	9.8	8.7	8.9	6.5	1.2	11.4	25.2	19.9	73.6	7.6	2.4
CO Emissions	MT	0.0	1.3	4.5	4.5	1.7	0.0	0.0	2.8	11.1	11.1	4.5	3.4	3.4
N ₂ O Emissions	MT	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.1	0.1	0.2	0.1	0.2	0.2
Tank-to-Wake Emissions														
CO ₂ Emissions	MT	36,769.9	27,839.2	27,839.2	27,839.2	4,667.3	4,667.3	4,667.3	35,384.0	35,384.0	35,384.0	4,667.3	4,667.3	4,667.3
CO ₂ Emissions Offset	MT	0.0	0.0	-26,733.4	-27,585.3	0.0	0.0	-3,995.0	0.0	-30,828.3	-34,823.3	0.0	0.0	-3,995.0
SO _x Emissions	MT	230.0	0.8	0.8	0.8	2.2	2.2	2.2	8.6	8.6	8.6	2.2	2.2	2.2
NO _x Emissions	MT	232.5	223.4	223.4	223.4	231.6	231.6	231.6	231.6	231.6	231.6	231.6	231.6	231.6
PM ₁₀ Emissions	MT	1,641.3	0.7	0.7	0.7	3.2	3.2	3.2	3.6	3.6	3.6	3.2	3.2	3.2
PM _{2.5} Emissions	MT	1,510.0	0.6	0.6	0.6	3.0	3.0	3.0	3.3	3.3	3.3	3.0	3.0	3.0
CH ₄ Emissions	MT	0.7	17.0	17.0	17.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CO Emissions	MT	38.1	75.3	75.3	75.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
N ₂ O Emissions	MT	2.3	2.1	2.1	2.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
NMVOE Emissions	MT	43.0	28.2	28.2	28.2	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
BC Emissions	MT	2.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Operational Emissions														
CO ₂ Emissions	MT	43,624.6	32,376.9	14,369.2	13,537.1	43,649.2	19,224.6	15,322.1	45,522.7	13,360.7	9,458.2	40,791.8	9,477.0	5,574.5
SO _x Emissions	MT	230.0	1.2	34.8	35.2	2.4	2.2	4.0	9.6	30.0	31.8	19.2	25.0	26.8
NO _x Emissions	MT	232.5	227.9	248.2	250.1	251.3	251.3	260.3	252.1	256.5	265.6	246.8	245.0	254.1
PM ₁₀ Emissions	MT	1,641.3	0.7	0.7	0.7	3.2	3.2	3.2	3.6	3.6	3.6	3.2	3.2	3.2
PM _{2.5} Emissions	MT	1,510.0	0.6	0.6	0.6	3.0	3.0	3.0	3.3	3.3	3.3	3.0	3.0	3.0
CH ₄ Emissions	MT	53.4	33.8	26.8	25.7	9.0	6.6	1.3	11.5	25.3	20.0	73.7	7.7	2.5
CO Emissions	MT	38.1	76.6	79.8	79.8	4.0	2.4	2.4	5.2	13.5	13.5	6.8	5.7	5.7
N ₂ O Emissions	MT	2.4	2.2	2.3	2.3	0.5	0.5	0.6	0.5	0.4	0.5	0.4	0.5	0.6
NMVOE Emissions	MT	43.0	28.2	28.2	28.2	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
BC Emissions	MT	2.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Summaries of the CO₂_{Eq} well-to-wake emissions, broken down by contributions from the well-to-tank, tank-to-wake, and carbon credits for all of the investigated fuel mixes are shown in Figure 68 and Figure 69.

		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ BD	Methanol	Bio- Methanol	Bio- Methanol w/ BD	Hydrogen	E- Hydrogen	E- Hydrogen w/ BD	Hydrogen	E-Hydrogen	E-Hydrogen w/ BD
Total GWP																	
Eq. GWP MEPC (100yr)	kg-CO _{2e}	3.34E+07	2.48E+07	1.17E+07	1.09E+07	3.20E+07	1.49E+07	1.13E+07	3.33E+07	1.11E+07	7.52E+06	3.13E+07	8.11E+06	4.50E+06	3.13E+07	8.11E+06	4.50E+06
Reduction	%		-26%	-65%	-67%	-4%	-55%	-66%	0%	-67%	-77%	-6%	-76%	-87%	-6%	-76%	-87%

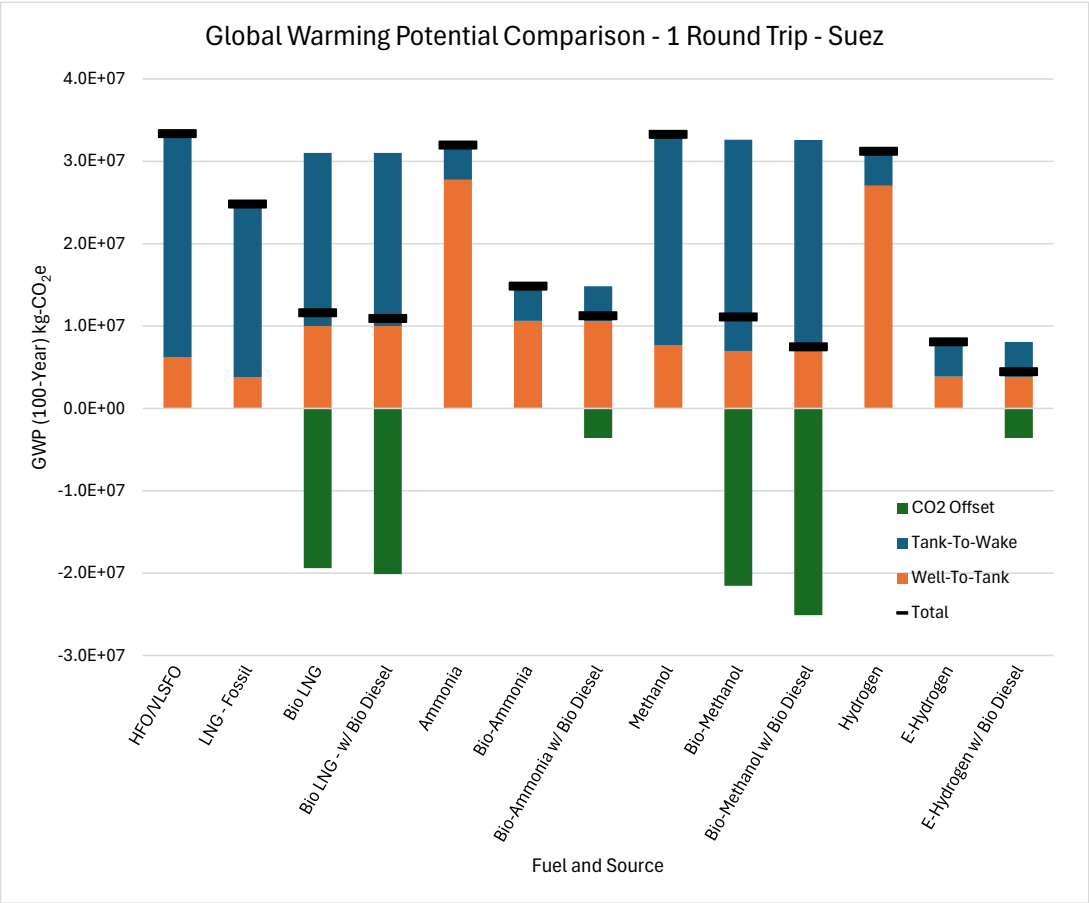


Figure 68: Total Operational Emissions Showing Contributions from Well-to-Tank, Tank-to-Wake, and CO₂ Offset, Suez Route

		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio-Ammonia	Bio-Ammonia w/ BD	Methanol	Bio-Methanol	Bio-Methanol w/ BD	Hydrogen	E-Hydrogen	E-Hydrogen w/ BD	Hydrogen	E-Hydrogen	E-Hydrogen w/ BD
Total GWP																	
Eq. GWP MEPC (100yr)	kg-CO _{2e}	4.58E+07	3.39E+07	1.57E+07	1.49E+07	4.40E+07	1.96E+07	1.55E+07	4.60E+07	1.42E+07	1.01E+07	4.30E+07	9.83E+06	5.79E+06	4.30E+07	9.83E+06	5.79E+06
Reduction	%		-26%	-66%	-68%	-4%	-57%	-66%	0%	-69%	-78%	-6%	-79%	-87%	-6%	-79%	-87%

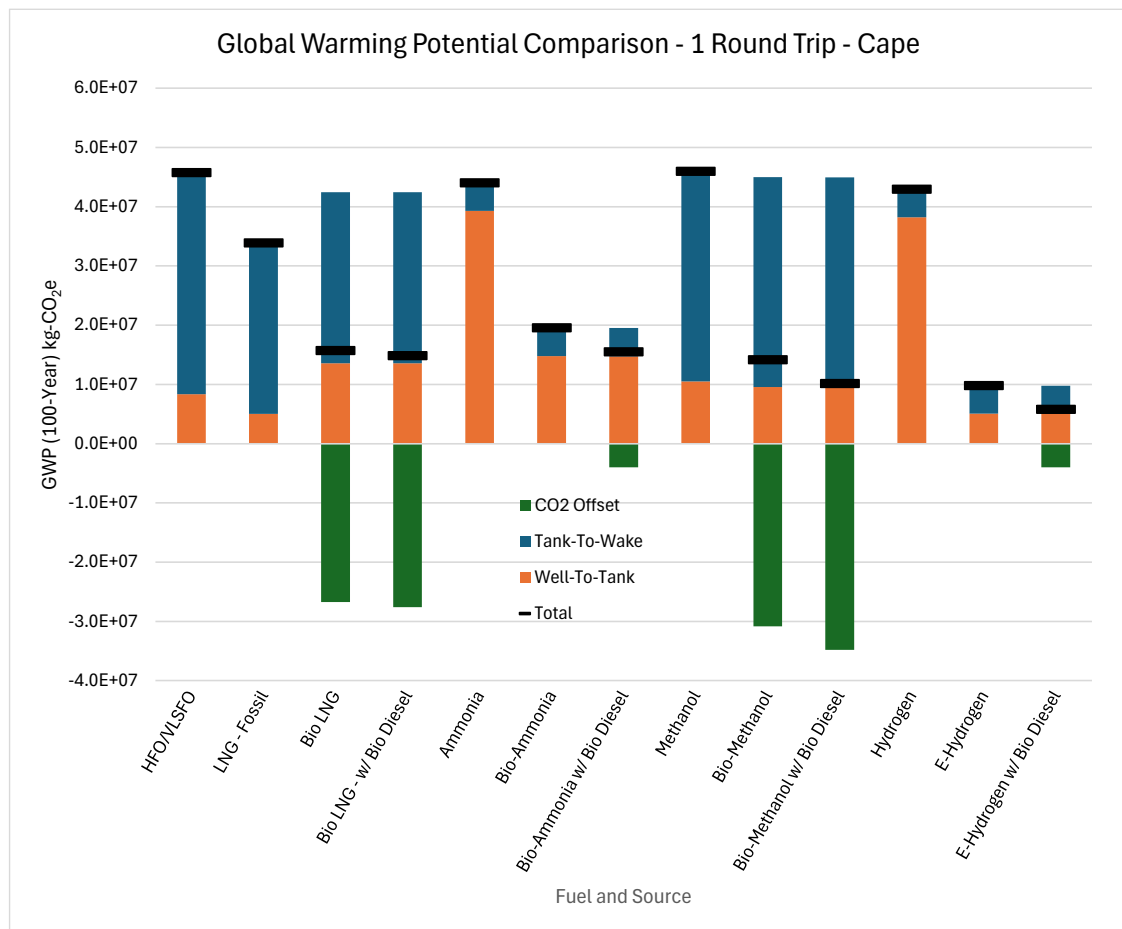


Figure 69: Total Operational Emissions Showing Contributions from Well-to-Tank, Tank-to-Wake, and CO₂ Offset, Cape Route

This total operational GWP data shows some interesting trends. LNG is the only fuel that when derived from fossil sources still offers a substantial reduction in global warming potential, on the order of 23%. Ammonia, Methanol and Hydrogen, when derived from fossil sources, provide very little savings, on the order of 0-6%. Methanol performs particularly badly, with fossil-derived methanol predicted to provide no savings whatsoever compared to HFO. Hydrogen provides the greatest potential reduction in CO_{2e}, followed by Bio-Methanol with bio diesel as a pilot fuel. This implies that Methanol is one of the fuels with the highest risk to reward ratio. If it can be renewably sourced, it offers very good carbon reduction without substantially negatively impacting the cargo capacity of the vessel, but if it is sourced from current carbon-intensive production techniques, will not be any better than HFO.

LNG offers the opposite characteristics to Methanol, with immediate reductions in GWP available even from fossil sources with more potential reductions if it can be sourced from biogenic sources in sufficient quantities. It also benefits from being a mature technology compared to the other alternative fuels. Note that unlike the other fuels where the tank-to-wake emissions are nearly eliminated by CO₂ offsetting from the biogenic sources, Methane will always have some global warming potential due to the methane slip.

Ammonia is one of the poorer choices amongst alternative fuels due to its higher well-to-tank emissions. It doesn't offer the potential savings of Methanol or Hydrogen, performing about equivalent to Bio-Methane, while also having a higher impact on the loadable cargo capacity from a MT delivered standpoint.

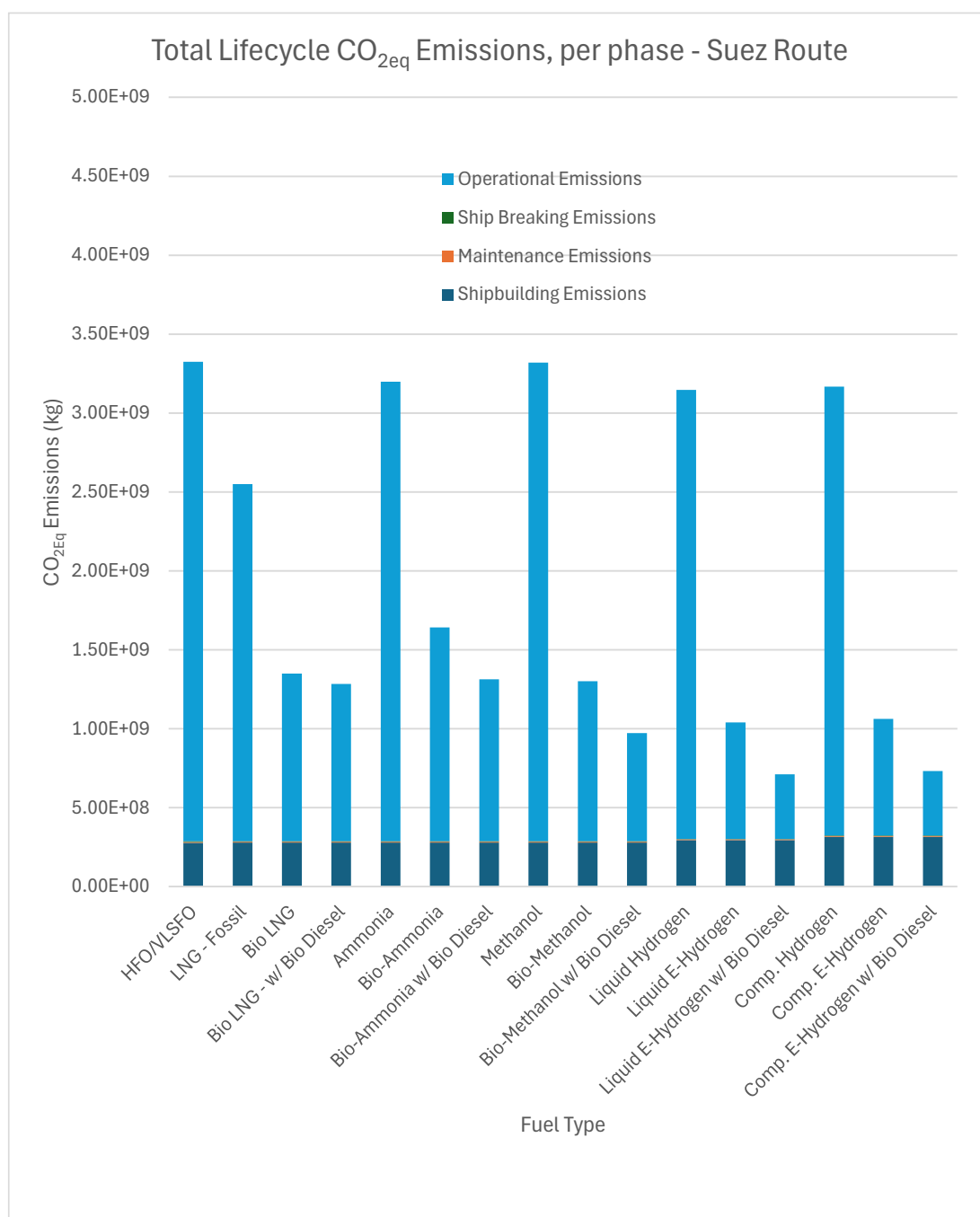
Another finding of this assessment is due primarily to well-to-tank emissions, it is not possible to eliminate the carbon emissions from a ship's operation. The tank-to-wake emissions can be nearly eliminated through CO₂ offsetting with biogenically sourced fuels, but unless the shore-based supply side can also decarbonize, shipping cannot on a well-to-wake basis.

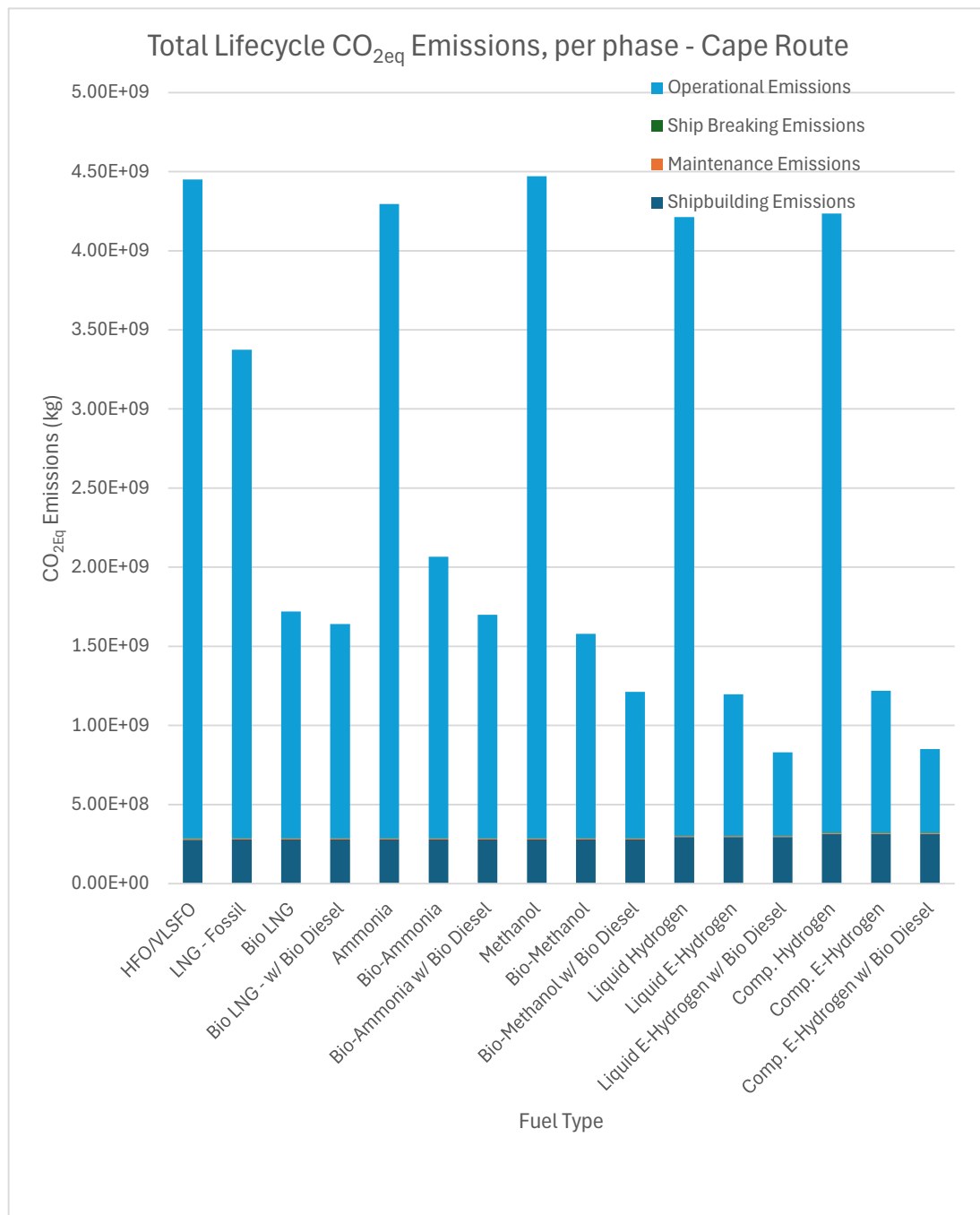
10.7. CO_{2Eq} from Each Phase of Ship's Lifecycle

The total lifecycle CO_{2Eq} plots for the Suez and Cape routes are shown in Figure 70 and Figure 71 respectively.

The operational phase emissions are shown to dominate the total lifecycle emissions of the vessel and that the scrapping and maintenance phases are almost negligible in their contribution to global warming (<1% for all fuel options and ship design types). Even ship building represents a small, though appreciable portion of the total emissions, varying from approximately 6% for carbon-intensive operational phase/fuel combinations such as HFO use around the cape to up to 43% for a compressed e-hydrogen fuelled ship where the shipbuilding emissions are largest due to the high lightship weight and the operational emissions are minimized.

The cape scenario emphasizes the operational phase emissions, since the sailing route is longer and the travel speed is higher.

Figure 70: CO_{2eq} Lifecycle Emissions, Suez Trading Route

Figure 71: CO_{2eq} Lifecycle Emissions, Cape of Africa Trading Route

Since the shipbuilding emissions are mostly associated with steel production, and the operational emissions consist of the well-to-tank, tank-to-wake, and CO₂ offsets, the categories can be re-arranged to show the importance of these four components in the total global warming impact of the case study designs, shown in Table 105 and Figure 72.

Table 105: Breakdown of % Lifetime Contributions to GWP from Steel Production, WTT, TTW, and CO₂ Offset

		Baseline	LNG Ship				Ammonia Ship			Methanol Ship			LH ₂ Ship		
		VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio-Ammonia	Bio-Ammonia w/ BD	Methanol	Bio-Methanol	Bio-Methanol w/ BD	Hydrogen	E-Hydrogen	E-Hydrogen w/ BD	
		Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	
Steel Production	%	7.9%	10.4%	8.5%	8.5%	8.3%	16.1%	16.1%	8.0%	8.1%	8.1%	8.9%	26.8%	26.9%	
Well-to-Tank Emissions	%	17.0%	13.6%	29.3%	29.3%	78.9%	59.0%	58.9%	21.0%	19.5%	19.4%	78.1%	33.9%	33.7%	
Tank-to-Wake Emissions	%	74.4%	75.0%	61.4%	61.5%	12.0%	23.4%	23.4%	70.3%	71.6%	71.7%	12.2%	36.9%	37.0%	
Other Lifecycle Emissions	%	0.7%	0.9%	0.8%	0.8%	0.8%	1.5%	1.5%	0.8%	0.8%	0.8%	0.8%	2.4%	2.4%	
CO ₂ Offset	%	0.0%	0.0%	-56.7%	-58.7%	0.0%	0.0%	-19.8%	0.0%	-60.1%	-70.1%	0.0%	0.0%	-31.3%	

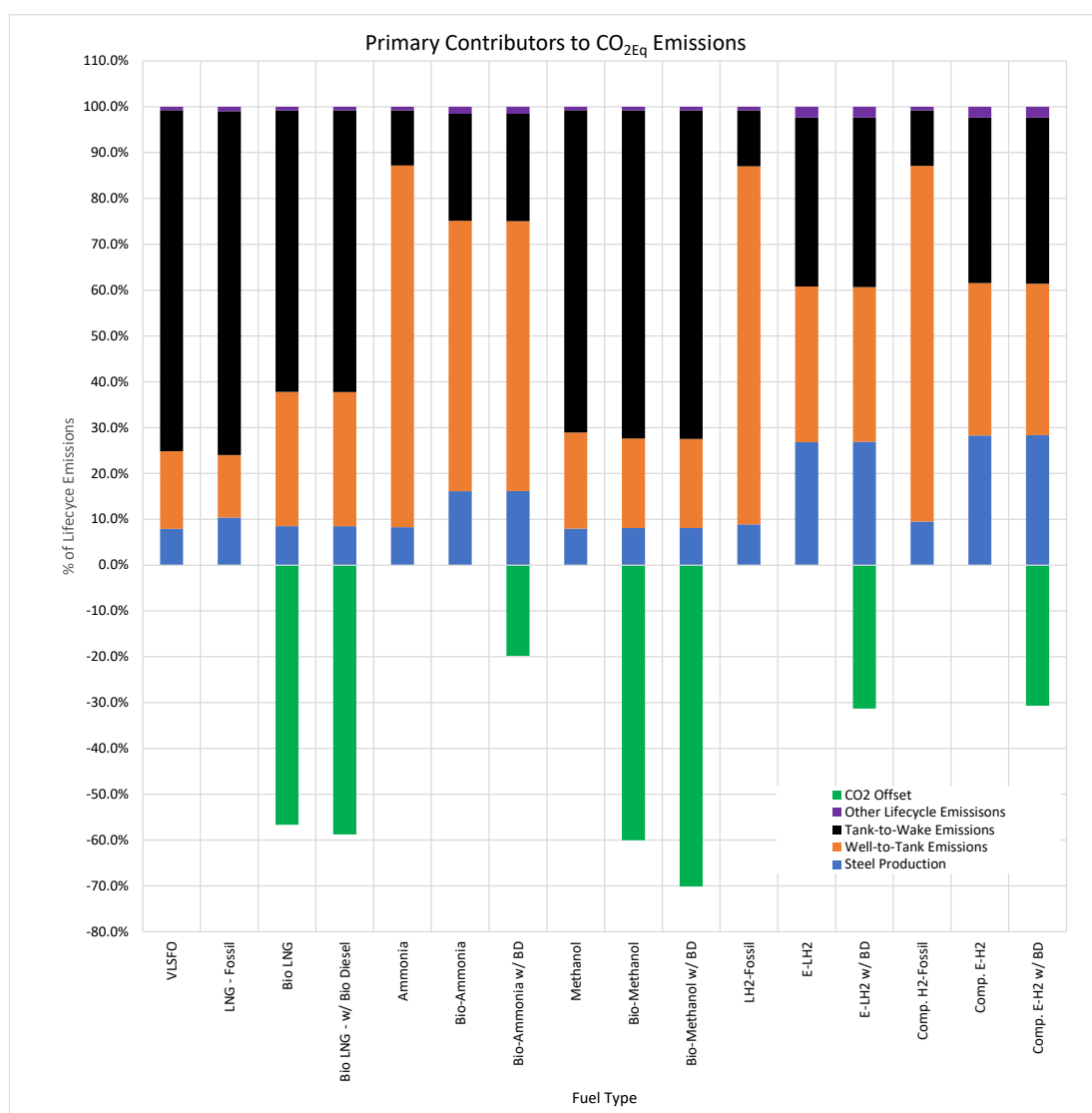


Figure 72: Contributions to GWP from four Key Emissions Sources in Ship's Lifecycle

This chart shows that these four categories are the most important components of a ship's lifecycle inventory as per the developed ship lifecycle inventory methodology.

10.8. Work-Transport Efficiency Comparison

The primary metric of comparison from this study is the CO_{2Eq} emitted per TEU or MT-km for each of the case study designs and alternative fuels. The direct and normalized (by the additional ship factor) results are shown in Table 106 for the Suez Canal route and Table 107 for the Cape of Africa route.

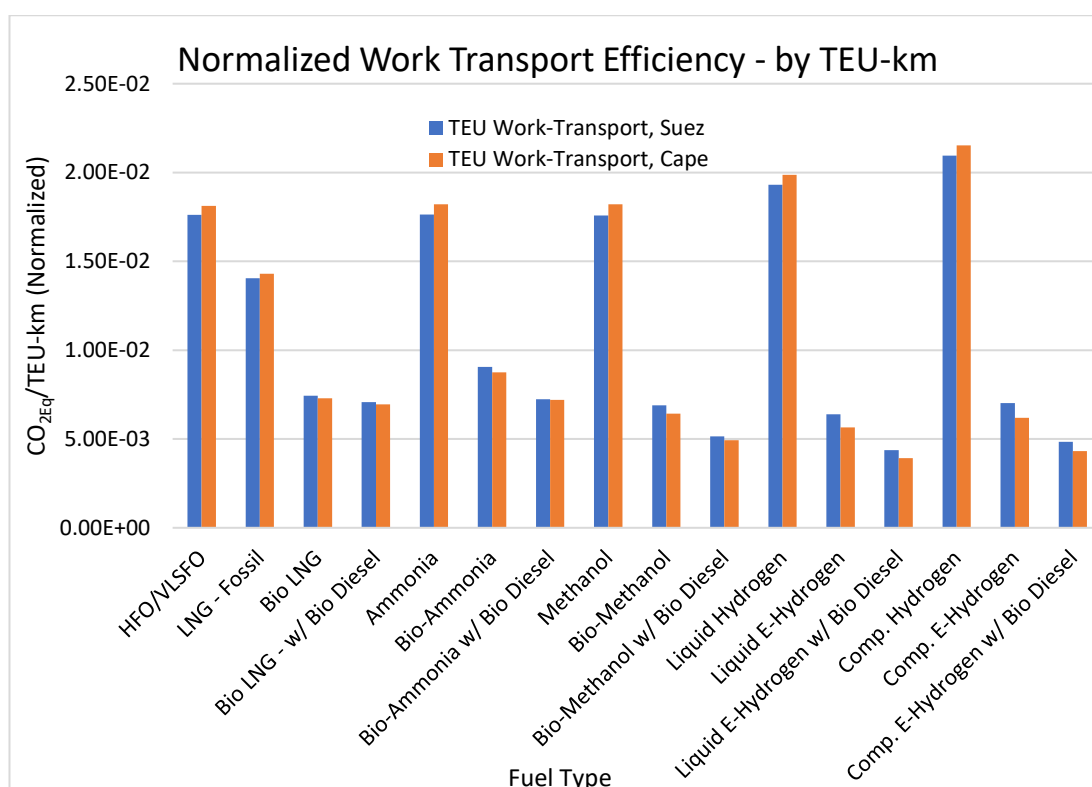
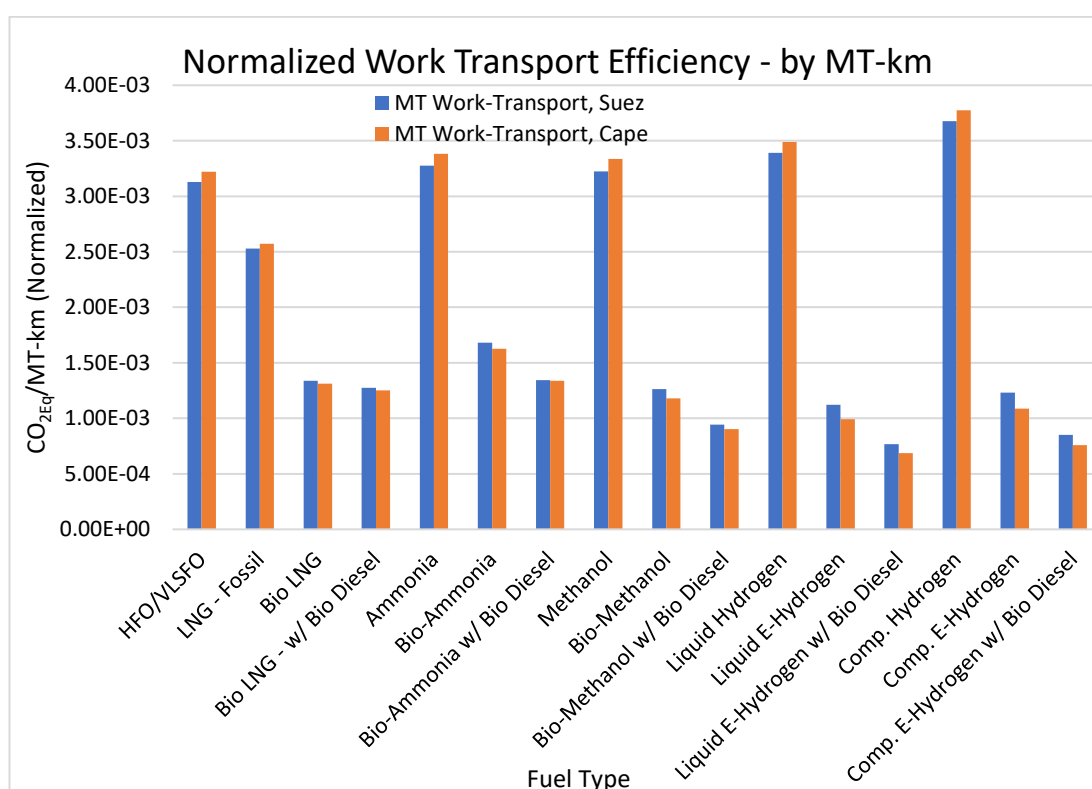
Table 106: CO_{2Eq} Work-Transport/Ship, reduction compared to baseline, and impact of Additional Ships Factor, Suez Route

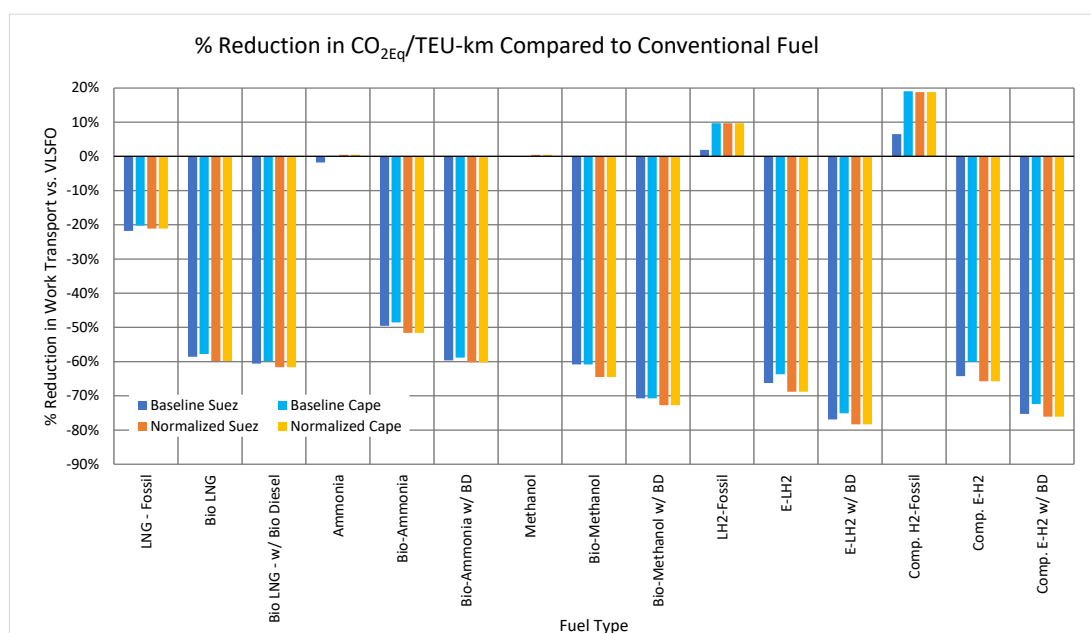
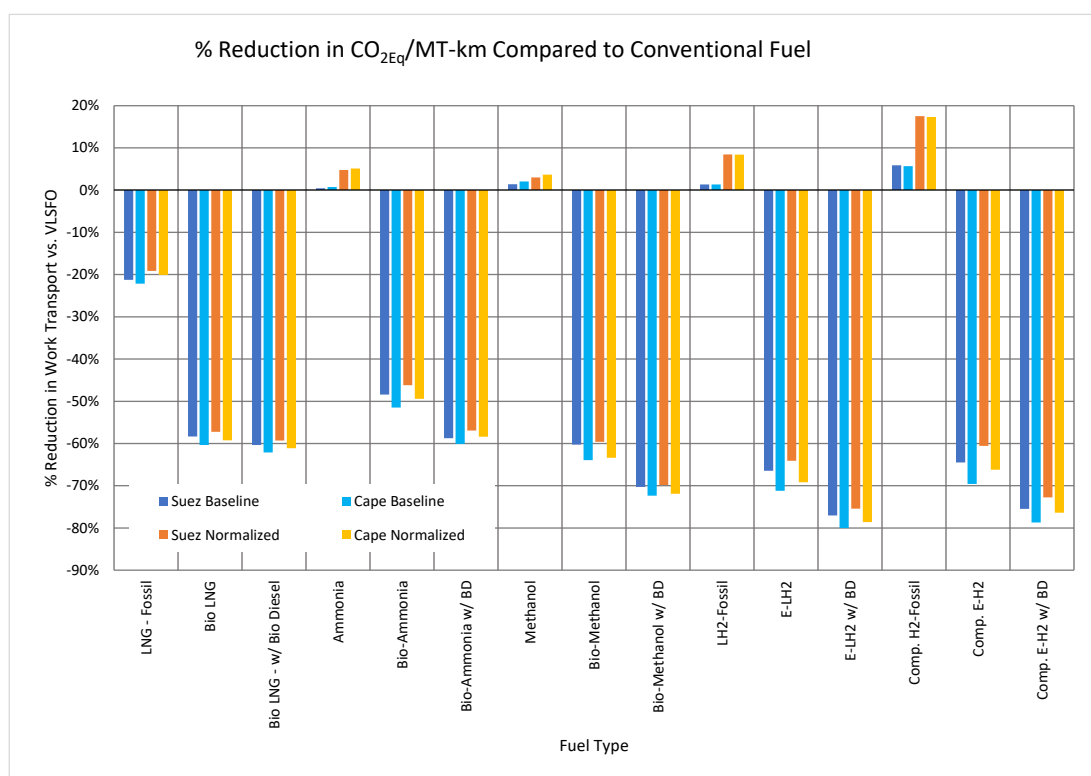
		Baseline	LNG Ship			Ammonia Ship			Methanol Ship			LH ₂ Ship			Comp. Hydrogen Ship		
		VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio-Ammonia	Bio-Ammonia w/ BD	Methanol	Bio-Methanol	Bio-Methanol w/ BD	Hydrogen	E-Hydrogen	E-Hydrogen w/ BD	Hydrogen	E-Hydrogen	E-Hydrogen w/ BD
		Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez
CO _{2eq} Wrk-Trans. Eff. (TEU)	kg-CO _{2e} /TEU-km	1.76E-02	1.38E-02	7.29E-03	6.94E-03	1.73E-02	8.89E-03	7.11E-03	1.76E-02	6.90E-03	5.16E-03	1.80E-02	5.95E-03	4.07E-03	1.88E-02	6.30E-03	4.35E-03
CO _{2eq} Wrk-Trans. Eff. (MT)	kg-CO _{2e} /MT-km	3.13E-03	2.46E-03	1.30E-03	1.24E-03	3.14E-03	1.61E-03	1.29E-03	3.17E-03	1.24E-03	9.30E-04	3.17E-03	1.05E-03	7.19E-04	3.31E-03	1.11E-03	7.68E-04
% Reduction Wrk-Trans. (TEU)	%	0%	-22%	-59%	-61%	-2%	-50%	-60%	0%	-61%	-71%	2%	-66%	-77%	7%	-64%	-75%
% Reduction Wrk-Trans. (MT)	%	0%	-21%	-58%	-60%	0%	-48%	-59%	1%	-60%	-70%	1%	-66%	-77%	6%	-64%	-75%
Additional Ships Factor	TEU Basis	1.00	1.02	1.02	1.02	1.02	1.02	1.02	1.00	1.00	1.00	1.08	1.08	1.08	1.12	1.12	1.12
	MT Basis	1.00	1.03	1.03	1.03	1.04	1.04	1.04	1.02	1.02	1.02	1.07	1.07	1.07	1.11	1.11	1.11
Eq. CO _{2eq} Wrk-Trans. Eff. (TEU)	kg-CO _{2e} /TEU-km	1.76E-02	1.41E-02	7.44E-03	7.08E-03	1.77E-02	9.07E-03	7.25E-03	1.76E-02	6.90E-03	5.16E-03	1.93E-02	6.40E-03	4.38E-03	2.10E-02	7.04E-03	4.86E-03
Eq. CO _{2eq} Wrk-Trans. Eff. (MT)	kg-CO _{2e} /MT-km	3.13E-03	2.53E-03	1.34E-03	1.27E-03	3.28E-03	1.68E-03	1.35E-03	3.22E-03	1.26E-03	9.45E-04	3.39E-03	1.12E-03	7.69E-04	3.68E-03	1.23E-03	8.53E-04
% Reduction Wrk-Trans. (TEU)	%	0%	-20%	-58%	-60%	0%	-49%	-59%	0%	-61%	-71%	10%	-64%	-75%	19%	-60%	-72%
% Reduction Wrk-Trans. (MT)	%	0%	-19%	-57%	-59%	5%	-46%	-57%	3%	-60%	-70%	8%	-64%	-75%	18%	-61%	-73%

Table 107: CO_{2Eq} Work-Transport/Ship, reduction compared to baseline, and impact of Additional Ships Factor, Cape Route

		Baseline	LNG Ship			Ammonia Ship			Methanol Ship			LH ₂ Ship			Comp. Hydrogen Ship		
		VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio-Ammonia	Bio-Ammonia w/ BD	Methanol	Bio-Methanol	Bio-Methanol w/ BD	Hydrogen	E-Hydrogen	E-Hydrogen w/ BD	Hydrogen	E-Hydrogen	E-Hydrogen w/ BD
		Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape
CO _{2eq} Wrk-Trans. Eff. (TEU)	kg-CO _{2e} /TEU-km	1.81E-02	1.40E-02	7.14E-03	6.82E-03	1.79E-02	8.60E-03	7.07E-03	1.82E-02	6.43E-03	4.94E-03	1.85E-02	5.26E-03	3.65E-03	1.93E-02	5.55E-03	3.88E-03
CO _{2eq} Wrk-Trans. Eff. (MT)	kg-CO _{2e} /MT-km	3.22E-03	2.51E-03	1.28E-03	1.22E-03	3.24E-03	1.56E-03	1.28E-03	3.29E-03	1.16E-03	8.91E-04	3.26E-03	9.28E-04	6.44E-04	3.40E-03	9.80E-04	6.85E-04
% Reduction Wrk-Trans. (TEU)	%	0%	-23%	-61%	-62%	-2%	-53%	-61%	0%	-65%	-73%	2%	-71%	-80%	6%	-69%	-79%
% Reduction Wrk-Trans. (MT)	%	0%	-22%	-60%	-62%	1%	-52%	-60%	2%	-64%	-72%	1%	-71%	-80%	6%	-70%	-79%
Additional Ships Factor	TEU Basis	1.00	1.02	1.02	1.02	1.02	1.02	1.02	1.00	1.00	1.00	1.08	1.08	1.08	1.12	1.12	1.12
	MT Basis	1.00	1.03	1.03	1.03	1.04	1.04	1.04	1.02	1.02	1.02	1.07	1.07	1.07	1.11	1.11	1.11
Eq. CO _{2eq} Wrk-Trans. Eff. (TEU)	kg-CO _{2e} /TEU-km	1.81E-02	1.43E-02	7.29E-03	6.96E-03	1.82E-02	8.77E-03	7.21E-03	1.82E-02	6.43E-03	4.94E-03	1.99E-02	5.66E-03	3.92E-03	2.15E-02	6.21E-03	4.34E-03
Eq. CO _{2eq} Wrk-Trans. Eff. (MT)	kg-CO _{2e} /MT-km	3.22E-03	2.57E-03	1.31E-03	1.25E-03	3.38E-03	1.63E-03	1.34E-03	3.34E-03	1.18E-03	9.05E-04	3.49E-03	9.93E-04	6.89E-04	3.78E-03	1.09E-03	7.61E-04
% Reduction Wrk-Trans. (TEU)	%	0%	-21%	-60%	-62%	0%	-52%	-60%	0%	-65%	-73%	10%	-69%	-78%	19%	-66%	-76%
% Reduction Wrk-Trans. (MT)	%	0%	-20%	-59%	-61%	5%	-49%	-58%	4%	-63%	-72%	8%	-69%	-79%	17%	-66%	-76%

Plots of the normalized CO_{2Eq}/TEU-km and CO_{2Eq}/MT-km are presented in Figure 73 and Figure 74. Finally, the percentage reduction in CO_{2Eq} released per TEU-km and MT-km for the alternative fuels compared to conventional fuel for both routes is shown in Figure 75 and Figure 76.

Figure 73: CO_{2Eq}/TEU-KM, Normalized by Additional Ships Factor, All Fuels, both RoutesFigure 74: CO_{2Eq}/TEU-KM, Normalized by Additional Ships Factor, All Fuels, both Routes

Figure 75: % Reduction in CO_{2Eq}/TEU-km for all Fuels Relative to Conventional FuelFigure 76: % Reduction in CO_{2Eq}/MT-km for all Fuels Relative to Conventional Fuel

These results show that if not derived from renewable sources, all alternative fuels except LNG have worse performance compared to HFO from a CO_{2Eq}/MT-km standpoint, and only for the non-normalized data does Ammonia and Methanol offer very slight

potential reductions in $\text{CO}_{2\text{Eq}}$ /TEU-km over the baseline HFO ship. When extrapolated to a fleet of ships fuelled by such vessels, it does not make sense to use any alternative fuel except LNG if the alternative fuel cannot be sourced renewably.

However, it is also evident that all alternative fuels, if sourced in a manner which minimizes net carbon emissions, can offer substantial improvements in the work-transport efficiency of seagoing vessels. The approximate reductions (or increase) in $\text{CO}_{2\text{Eq}}$ transport efficiency from the various fuel types for a fleet of vessels are:

- LNG: 20-60% reduction in emissions
- Ammonia: +5% increase to 60% reduction in emissions
- Methanol: +5% increase to 70% reduction in emissions
- Liquid Hydrogen: +10% increase to 80% reduction in emissions
- Compressed Hydrogen: +20% increase to 75% reduction in emissions

These results favour LNG, which does not suffer from potentially increasing emissions even if used from fossil sources. However, it is understood that sourcing enough bio-methane remains challenging, and global warming potential cannot be fully abated because of the presence of methane slip.

Ammonia and Methanol are roughly equivalent, but Methanol does offer some advantages in that it offers potentially higher total emissions reductions when renewably sourced. Methanol also has benefits in flexibility of ship arrangement, but as can be seen when normalized for work-transport on a weight of cargo delivered basis, does not offer substantial improvement over ammonia. Ammonia also has potential interchangeability with LNG, since the tanks and fuel preparation equipment can be designed to be used with either fuel. This would allow a ship to be designed with the goal of recognizing immediate carbon reductions using fossil LNG and then either adopt bio-LNG or Bio/E-Ammonia depending on availability in the future.

Hydrogen's primary benefit is the potential for the most reduction in $\text{CO}_{2\text{Eq}}$ /cargo-mile, but it is considered a poor choice because if the hydrogen is not renewably sourced, then it will have more global warming impact than using fuel oil. The technology for using hydrogen as a fuel in a low-speed diesel is not yet fully mature, and there remain issues associated with bunkering, reliquification, and fuel tank design for use with LH_2 . While compressed hydrogen is more mature from a bunkering storage, and use standpoint,

the extremely large tanks used in this case study may not be practical to build. An arrangement employing numerous smaller cylindrical compressed hydrogen tanks would require more volume, weight, and result in a very complicated fuelling and distribution system with numerous points of failure. This technological risk coupled with the potential of performing worse than HFO from a GWP perspective make it difficult to recommend hydrogen as a primary fuel, at least as determined by this case study.

10.9. Fleet Analysis - More Ships vs. Increase in Ship Speed

An additional variation of the case study was carried out where rather than assuming additional ship building is carried out to compensate for the decrease in cargo capacity associated with the alternatively fuelled ship designs, a given vessel was assumed to complete more round trips in its lifetime to deliver an equivalent amount of cargo. This study examines the interaction between the marginal increased emissions associated with the shipbuilding, maintenance, and breaking phases as well as emissions from operating additional ships, vs. the higher per-ship operating emissions expected from travelling faster, and the associated cubic increase in power demand.

The fleet size estimates developed in section 9.2.3 were used to provide a reference number of vessels, which would remain constant and equivalent to the HFO fleet size for the increased speed scenario. The additional shipbuilding required on a fleet of a given size for the base speed scenario is calculated by multiplying the base number of HFO ships in a fleet by the additional ships factor, rounded up. The lifecycle emissions per ship were calculated for both scenarios, and this was multiplied by the number of ships in each fleet to yield the total fleet lifecycle emissions for both scenarios. The lifecycle emissions from additional shipbuilding or increased speed were then compared, and the scenario yielding the least overall CO_{2Eq} was determined to be the most effective option. The results of this study are shown in Table 108 through Table 110 for a TEU delivered equivalence basis and Table 111 through Table 113 for a MT delivered equivalence basis.

10.9.1.Speed vs. Shipbuilding Tables: TEU Basis

Table 108: Comparison of Shipbuilding vs. Increased Speed Lifecycle Emissions, TEU-Basis, LNG and Ammonia

		HFO/Baseline Ship		LNG Ship								Ammonia Ship							
		HFO/VLSFO		LNG - Fossil		Bio LNG		Bio LNG - w/ Bio		Ammonia		Bio-Ammonia		Bio-Ammonia w/ Bio					
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape
Shipbuilding Emissions	kg-CO ₂ /TEU	2.78E+08	2.78E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Operational Emissions 1-RT	kg-CO ₂ /TEU	3.34E+07	4.58E+07	2.48E+07	3.46E+07	1.17E+07	1.61E+07	1.10E+07	1.52E+07	3.19E+07	4.49E+07	1.48E+07	1.98E+07	1.13E+07	1.58E+07				
Number of Round Trips	#	91	91	93	93	93	93	93	93	93	93	93	93	93	93				
Operational Emissions Lifetime	kg-CO ₂ /TEU	3.04E+09	4.16E+09	2.31E+09	3.21E+09	1.09E+09	1.49E+09	1.02E+09	1.41E+09	2.97E+09	4.18E+09	1.38E+09	1.84E+09	1.05E+09	1.47E+09				
Maintenance Emissions	kg-CO ₂ /TEU	5.32E+06	5.32E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06				
Ship Breaking Emissions	kg-CO ₂ /TEU	4.64E+06	4.64E+06	3.93E+06	3.93E+06	3.93E+06	3.93E+06	3.93E+06	3.93E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06				
Total Emissions - More RT	kg-CO ₂ /TEU	3.33E+09	4.45E+09	2.59E+09	3.50E+09	1.37E+09	1.78E+09	1.31E+09	1.70E+09	3.26E+09	4.47E+09	1.67E+09	2.13E+09	1.34E+09	1.76E+09				
Original Emissions (91 RT)	kg-CO ₂ /TEU	3.33E+09	4.45E+09	2.55E+09	3.37E+09	1.35E+09	1.72E+09	1.28E+09	1.64E+09	3.20E+09	4.30E+09	1.64E+09	2.07E+09	1.32E+09	1.70E+09				
Emissions Change - Per Ship	%	0.00%	0.00%	1.74%	3.80%	1.86%	3.70%	1.85%	3.79%	1.81%	3.94%	1.47%	3.13%	1.58%	3.55%				
Base Fleet Size -2% Growth	#	28	28	28	28	28	28	28	28	28	28	28	28	28	28				
Additional Ship Fleet Size	#	28	28	29	29	29	29	29	29	29	29	29	29	29	29				
Total Fleet Emissions - More RT	kg-CO ₂ /TEU	9.31E+10	1.25E+11	7.26E+10	9.81E+10	3.85E+10	4.99E+10	3.66E+10	4.77E+10	9.13E+10	1.25E+11	4.67E+10	5.97E+10	3.74E+10	4.93E+10				
Total Fleet Emissions - More Ships	kg-CO ₂ /TEU	9.31E+10	1.25E+11	7.39E+10	9.78E+10	3.91E+10	4.99E+10	3.72E+10	4.76E+10	9.28E+10	1.25E+11	4.77E+10	6.00E+10	3.82E+10	4.93E+10				
Emissions - More v.s. Faster	%	0.00%	0.00%	-1.77%	0.22%	-1.65%	0.13%	-1.66%	0.21%	-1.70%	0.36%	-2.03%	-0.42%	-1.92%	-0.02%				
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships				
Base Fleet Size 0% Growth	#	36	36	36	36	36	36	36	36	36	36	36	36	36	36				
Additional Ship Fleet Size	#	36	36	37	37	37	37	37	37	37	37	37	37	37	37				
Total Fleet Emissions - More RT	kg-CO ₂ /TEU	1.20E+11	1.60E+11	9.34E+10	1.26E+11	4.95E+10	6.42E+10	4.71E+10	6.13E+10	1.17E+11	1.61E+11	6.01E+10	7.68E+10	4.81E+10	6.34E+10				
Total Fleet Emissions - More Ships	kg-CO ₂ /TEU	1.20E+11	1.60E+11	9.43E+10	1.25E+11	4.99E+10	6.38E+10	4.75E+10	6.07E+10	1.18E+11	1.59E+11	6.08E+10	7.66E+10	4.87E+10	6.30E+10				
Emissions - More v.s. Faster	%	0.00%	0.00%	-1.01%	1.00%	-0.89%	0.90%	-0.90%	0.99%	-0.94%	1.13%	-1.28%	0.34%	-1.16%	0.75%				
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships				
Base Fleet Size +2% Growth	#	46	46	46	46	46	46	46	46	46	46	46	46	46	46				
Additional Ship Fleet Size	#	46	46	47	47	47	47	47	47	47	47	47	47	47	47				
Total Fleet Emissions - More RT	kg-CO ₂ /TEU	1.53E+11	2.05E+11	1.19E+11	1.61E+11	6.32E+10	8.20E+10	6.02E+10	7.84E+10	1.50E+11	2.05E+11	7.68E+10	9.82E+10	6.15E+10	8.11E+10				
Total Fleet Emissions - More Ships	kg-CO ₂ /TEU	1.53E+11	2.05E+11	1.20E+11	1.59E+11	6.34E+10	8.08E+10	6.04E+10	7.71E+10	1.50E+11	2.02E+11	7.73E+10	9.72E+10	6.18E+10	8.00E+10				
Emissions - More v.s. Faster	%	0.00%	0.00%	-0.42%	1.59%	-0.30%	1.50%	-0.31%	1.58%	-0.35%	1.73%	-0.69%	0.94%	-0.58%	1.34%				
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships				
Base Fleet Size +4% Growth	#	61	61	61	61	61	61	61	61	61	61	61	61	61	61				
Additional Ship Fleet Size	#	61	61	63	63	63	63	63	63	63	63	63	63	63	63				
Total Fleet Emissions - More RT	kg-CO ₂ /TEU	2.03E+11	2.72E+11	1.58E+11	2.14E+11	8.39E+10	1.09E+11	7.98E+10	1.04E+11	1.99E+11	2.73E+11	1.02E+11	1.30E+11	8.00E+10	1.07E+11				
Total Fleet Emissions - More Ships	kg-CO ₂ /TEU	2.03E+11	2.72E+11	1.61E+11	2.13E+11	8.50E+10	1.08E+11	8.09E+10	1.03E+11	2.02E+11	2.71E+11	1.04E+11	1.30E+11	8.29E+10	1.07E+11				
Emissions - More v.s. Faster	%	0.00%	0.00%	-1.49%	0.51%	-1.37%	0.41%	-1.38%	0.50%	-1.42%	0.64%	-1.76%	-0.14%	-1.64%	0.26%				
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships				

Table 109: Comparison of Shipbuilding vs. Increased Speed Lifecycle Emissions, TEU-Basis, Methanol and Liquid Hydrogen

		HFO/Baseline Ship		Methanol Ship								LH ₂ Ship							
				HFO/VLSFO		Methanol		Bio-Methanol		Bio-Methanol w/ Bio		Hydrogen		E-Hydrogen		E-Hydrogen w/ Bio			
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape		
Shipbuilding Emissions	kg-CO ₂ _{Eq}	2.78E+08	2.78E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.95E+08	2.95E+08	2.95E+08	2.95E+08	2.95E+08	2.95E+08	2.95E+08			
Operational Emissions 1-RT	kg-CO ₂ _{Eq}	3.34E+07	4.58E+07	3.33E+07	4.60E+07	1.11E+07	1.42E+07	7.52E+06	1.01E+07	3.05E+07	4.79E+07	7.80E+06	1.01E+07	4.37E+06	6.25E+06				
Number of Round Trips	#	91	91	91	91	91	91	91	91	99	99	99	99	99	99				
Operational Emissions Lifetime	kg-CO ₂ _{Eq}	3.04E+09	4.16E+09	3.03E+09	4.18E+09	1.01E+09	1.29E+09	6.84E+08	9.23E+08	3.02E+09	4.74E+09	7.72E+08	1.00E+09	4.33E+08	6.19E+08				
Maintenance Emissions	kg-CO ₂ _{Eq}	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.34E+06	5.34E+06	5.34E+06	5.34E+06	5.34E+06	5.34E+06				
Ship Breaking Emissions	kg-CO ₂ _{Eq}	4.64E+06	4.64E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.60E+06	4.60E+06	4.60E+06	4.60E+06	4.60E+06	4.60E+06				
Total Emissions - More RT	kg-CO ₂ _{Eq}	3.33E+09	4.45E+09	3.32E+09	4.47E+09	1.30E+09	1.58E+09	9.73E+08	1.21E+09	3.33E+09	5.05E+09	1.08E+09	1.31E+09	7.37E+08	9.23E+08				
Original Emissions (91 RT)	kg-CO ₂ _{Eq}	3.33E+09	4.45E+09	3.32E+09	4.47E+09	1.30E+09	1.58E+09	9.73E+08	1.21E+09	3.15E+09	4.22E+09	1.04E+09	1.20E+09	7.14E+08	8.32E+08				
Emissions Change - Per Ship	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.60%	19.69%	3.24%	8.91%	3.25%	11.02%				
Base Fleet Size -2% Growth	#	28	28	28	28	28	28	28	28	28	28	28	28	28	28				
Additional Ship Fleet Size	#	28	28	28	28	28	28	28	28	31	31	31	31	31	31				
Total Fleet Emissions - More RT	kg-CO ₂ _{Eq}	9.31E+10	1.25E+11	9.30E+10	1.25E+11	3.65E+10	4.42E+10	2.72E+10	3.39E+10	9.31E+10	1.41E+11	3.01E+10	3.66E+10	2.06E+10	2.59E+10				
Total Fleet Emissions - More Ships	kg-CO ₂ _{Eq}	9.31E+10	1.25E+11	9.30E+10	1.25E+11	3.65E+10	4.42E+10	2.72E+10	3.39E+10	9.76E+10	1.31E+11	3.23E+10	3.72E+10	2.21E+10	2.58E+10				
Emissions - More v.s. Faster	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-4.62%	8.11%	-6.76%	-1.63%	-6.74%	0.28%				
				+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Ships	+ Trips	+ Trips	+ Trips	+ Ships				
Base Fleet Size 0% Growth	#	36	36	36	36	36	36	36	36	36	36	36	36	36	36				
Additional Ship Fleet Size	#	36	36	36	36	36	36	36	36	39	39	39	39	39	39				
Total Fleet Emissions - More RT	kg-CO ₂ _{Eq}	1.20E+11	1.60E+11	1.20E+11	1.61E+11	4.69E+10	5.69E+10	3.50E+10	4.36E+10	1.20E+11	1.82E+11	3.88E+10	4.70E+10	2.65E+10	3.32E+10				
Total Fleet Emissions - More Ships	kg-CO ₂ _{Eq}	1.20E+11	1.60E+11	1.20E+11	1.61E+11	4.69E+10	5.69E+10	3.50E+10	4.36E+10	1.23E+11	1.64E+11	4.07E+10	4.68E+10	2.78E+10	3.24E+10				
Emissions - More v.s. Faster	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-2.52%	10.49%	-4.71%	0.54%	-4.69%	2.48%				
				+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships				
Base Fleet Size +2% Growth	#	46	46	46	46	46	46	46	46	46	46	46	46	46	46				
Additional Ship Fleet Size	#	46	46	46	46	46	46	46	46	50	50	50	50	50	50				
Total Fleet Emissions - More RT	kg-CO ₂ _{Eq}	1.53E+11	2.05E+11	1.53E+11	2.06E+11	5.99E+10	7.27E+10	4.48E+10	5.58E+10	1.53E+11	2.32E+11	4.95E+10	6.01E+10	3.39E+10	4.25E+10				
Total Fleet Emissions - More Ships	kg-CO ₂ _{Eq}	1.53E+11	2.05E+11	1.53E+11	2.06E+11	5.99E+10	7.27E+10	4.48E+10	5.58E+10	1.57E+11	2.11E+11	5.21E+10	6.00E+10	3.57E+10	4.16E+10				
Emissions - More v.s. Faster	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-2.85%	10.12%	-5.02%	0.20%	-5.01%	2.14%				
				+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships				
Base Fleet Size +4% Growth	#	61	61	61	61	61	61	61	61	61	61	61	61	61	61				
Additional Ship Fleet Size	#	61	61	61	61	61	61	61	61	66	66	66	66	66	66				
Total Fleet Emissions - More RT	kg-CO ₂ _{Eq}	2.03E+11	2.72E+11	2.03E+11	2.73E+11	7.94E+10	9.64E+10	5.94E+10	7.40E+10	2.03E+11	3.08E+11	6.57E+10	7.97E+10	4.50E+10	5.63E+10				
Total Fleet Emissions - More Ships	kg-CO ₂ _{Eq}	2.03E+11	2.72E+11	2.03E+11	2.73E+11	7.94E+10	9.64E+10	5.94E+10	7.40E+10	2.08E+11	2.78E+11	6.88E+10	7.91E+10	4.71E+10	5.49E+10				
Emissions - More v.s. Faster	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-2.40%	10.63%	-4.59%	0.66%	-4.57%	2.61%				
				+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships				

Table 110: Comparison of Shipbuilding vs. Increased Speed Lifecycle Emissions, TEU-Basis, Compressed Hydrogen

		HFO/Baseline Ship		Compressed Hydrogen Ship							
		HFO/VLSFO		Hydrogen				E-Hydrogen			
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape
Shipbuilding Emissions	kg-CO _{2eq}	2.78E+08	2.78E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08
Operational Emissions 1-RT	kg-CO _{2eq}	3.34E+07	4.58E+07	3.12E+07	5.09E+07	7.77E+06	1.03E+07	4.42E+06	6.54E+06	6.54E+06	6.54E+06
Number of Round Trips	#	91	91	103	103	103	103	103	103	103	103
Operational Emissions Lifetime	kg-CO _{2eq}	3.04E+09	4.16E+09	3.22E+09	5.24E+09	8.00E+08	1.07E+09	4.56E+08	6.74E+08	6.74E+08	6.74E+08
Maintenance Emissions	kg-CO _{2eq}	5.32E+06	5.32E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06
Ship Breaking Emissions	kg-CO _{2eq}	4.64E+06	4.64E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06
Total Emissions - More RT	kg-CO _{2eq}	3.33E+09	4.45E+09	3.54E+09	5.57E+09	1.13E+09	1.39E+09	7.82E+08	1.00E+09	1.00E+09	1.00E+09
Original Emissions (91 RT)	kg-CO _{2eq}	3.33E+09	4.45E+09	3.17E+09	4.24E+09	1.06E+09	1.22E+09	7.35E+08	8.53E+08	8.53E+08	8.53E+08
Emissions Change - Per Ship	%	0.00%	0.00%	11.73%	31.40%	5.82%	14.00%	6.27%	17.17%	17.17%	17.17%
Base Fleet Size -2% Growth	#	28	28	28	28	28	28	28	28	28	28
Additional Ship Fleet Size	kg-CO _{2eq}	28	28	32	32	32	32	32	32	32	32
Total Fleet Emissions - More RT	kg-CO _{2eq}	9.31E+10	1.25E+11	9.92E+10	1.56E+11	3.15E+10	3.90E+10	2.19E+10	2.80E+10	2.80E+10	2.80E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	9.31E+10	1.25E+11	1.01E+11	1.36E+11	3.41E+10	3.91E+10	2.35E+10	2.73E+10	2.73E+10	2.73E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-2.24%	14.98%	-7.41%	-0.25%	-7.01%	2.52%	2.52%	2.52%
				+ Trips	+ Ships	+ Trips	+ Trips	+ Trips	+ Ships	+ Ships	+ Ships
Base Fleet Size 0% Growth	#	36	36	36	36	36	36	36	36	36	36
Additional Ship Fleet Size	#	36	36	41	41	41	41	41	41	41	41
Total Fleet Emissions - More RT	kg-CO _{2eq}	1.20E+11	1.60E+11	1.28E+11	2.00E+11	4.05E+10	5.01E+10	2.81E+10	3.60E+10	3.60E+10	3.60E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	1.20E+11	1.60E+11	1.30E+11	1.74E+11	4.36E+10	5.00E+10	3.02E+10	3.50E+10	3.50E+10	3.50E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-1.90%	15.38%	-7.09%	0.10%	-6.69%	2.88%	2.88%	2.88%
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Ships	+ Ships
Base Fleet Size +2% Growth	#	46	46	46	46	46	46	46	46	46	46
Additional Ship Fleet Size	#	46	46	52	52	52	52	52	52	52	52
Total Fleet Emissions - More RT	kg-CO _{2eq}	1.53E+11	2.05E+11	1.63E+11	2.56E+11	5.18E+10	6.40E+10	3.60E+10	4.60E+10	4.60E+10	4.60E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	1.53E+11	2.05E+11	1.65E+11	2.20E+11	5.53E+10	6.35E+10	3.82E+10	4.44E+10	4.44E+10	4.44E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-1.16%	16.24%	-6.39%	0.85%	-5.99%	3.65%	3.65%	3.65%
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Ships	+ Ships
Base Fleet Size +4% Growth	#	61	61	61	61	61	61	61	61	61	61
Additional Ship Fleet Size	#	61	61	69	69	69	69	69	69	69	69
Total Fleet Emissions - More RT	kg-CO _{2eq}	2.03E+11	2.72E+11	2.16E+11	3.40E+11	6.87E+10	8.49E+10	4.77E+10	6.10E+10	6.10E+10	6.10E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	2.03E+11	2.72E+11	2.19E+11	2.92E+11	7.34E+10	8.42E+10	5.07E+10	5.89E+10	5.89E+10	5.89E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-1.22%	16.17%	-6.45%	0.78%	-6.05%	3.58%	3.58%	3.58%
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Ships	+ Ships

10.9.2. Speed vs. Shipbuilding Tables: Metric Ton Basis

Table 111: Comparison of Shipbuilding vs. Increased Speed Lifecycle Emissions, MT-Basis, LNG and Ammonia

		HFO/Baseline Ship		LNG Ship								Ammonia Ship					
		HFO/VLSFO		LNG - Fossil				Bio LNG				Ammonia					
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape
Shipbuilding Emissions	kg-CO _{2eq}	2.78E+08	2.78E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Operational Emissions 1-RT	kg-CO _{2eq}	3.34E+07	4.58E+07	2.47E+07	3.49E+07	1.16E+07	1.62E+07	1.09E+07	1.54E+07	3.16E+07	4.65E+07	1.46E+07	2.03E+07	1.11E+07	1.11E+07	1.11E+07	1.64E+07
Number of Round Trips	#	91	91	94	94	94	94	94	94	96	96	96	96	96	96	96	96
Operational Emissions Lifetime	kg-CO _{2eq}	3.04E+09	4.16E+09	2.32E+09	3.28E+09	1.09E+09	1.53E+09	1.03E+09	1.45E+09	3.03E+09	4.47E+09	1.41E+09	1.95E+09	1.07E+09	1.07E+09	1.58E+09	1.58E+09
Maintenance Emissions	kg-CO _{2eq}	5.32E+06	5.32E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06
Ship Breaking Emissions	kg-CO _{2eq}	4.64E+06	4.64E+06	3.93E+06	3.93E+06	3.93E+06	3.93E+06	3.93E+06	3.93E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06
Total Emissions - More RT	kg-CO _{2eq}	3.33E+09	4.45E+09	2.61E+09	3.57E+09	1.38E+09	1.81E+09	1.32E+09	1.73E+09	3.32E+09	4.76E+09	1.70E+09	2.24E+09	1.36E+09	1.36E+09	1.87E+09	1.87E+09
Original Emissions (91 RT)	kg-CO _{2eq}	3.33E+09	4.45E+09	2.55E+09	3.37E+09	1.35E+09	1.72E+09	1.28E+09	1.64E+09	3.20E+09	4.30E+09	1.64E+09	2.07E+09	1.32E+09	1.32E+09	1.70E+09	1.70E+09
Emissions Change - Per Ship	%	0.00%	0.00%	2.38%	5.89%	2.44%	5.54%	2.41%	5.68%	3.78%	10.72%	3.09%	8.41%	3.32%	3.32%	9.65%	9.65%
Base Fleet Size -2% Growth	#	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Additional Ship Fleet Size	#	28	28	29	29	29	29	29	29	30	30	30	30	30	30	30	30
Total Fleet Emissions - More RT	kg-CO _{2eq}	9.31E+10	1.25E+11	7.31E+10	1.00E+11	3.87E+10	5.08E+10	3.68E+10	4.86E+10	9.30E+10	1.33E+11	4.75E+10	6.28E+10	3.81E+10	5.22E+10	5.22E+10	5.22E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	9.31E+10	1.25E+11	7.39E+10	9.78E+10	3.91E+10	4.99E+10	3.72E+10	4.76E+10	9.60E+10	1.29E+11	4.93E+10	6.21E+10	3.95E+10	5.10E+10	5.10E+10	5.10E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-1.15%	2.24%	-1.09%	1.90%	-1.12%	2.04%	-3.14%	3.34%	-3.79%	1.18%	-3.57%	2.34%	2.34%	2.34%
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships
Base Fleet Size 0% Growth	#	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
Additional Ship Fleet Size	#	36	36	37	37	37	37	37	37	38	38	38	38	38	38	38	38
Total Fleet Emissions - More RT	kg-CO _{2eq}	1.20E+11	1.60E+11	9.40E+10	1.29E+11	4.98E+10	6.53E+10	4.74E+10	6.24E+10	1.20E+11	1.71E+11	6.10E+10	8.08E+10	4.89E+10	6.72E+10	6.72E+10	6.72E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	1.20E+11	1.60E+11	9.43E+10	1.25E+11	4.99E+10	6.36E+10	4.75E+10	6.07E+10	1.22E+11	1.63E+11	6.25E+10	7.86E+10	5.00E+10	6.47E+10	6.47E+10	6.47E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-0.39%	3.03%	-0.33%	2.69%	-0.36%	2.82%	-1.69%	4.89%	-2.34%	2.70%	-2.12%	3.88%	3.88%	3.88%
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships
Base Fleet Size +2% Growth	#	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Additional Ship Fleet Size	#	46	46	48	48	48	48	48	48	48	48	48	48	48	48	48	48
Total Fleet Emissions - More RT	kg-CO _{2eq}	1.53E+11	2.05E+11	1.20E+11	1.64E+11	6.36E+10	8.35E+10	6.05E+10	7.98E+10	1.53E+11	2.19E+11	7.80E+10	1.03E+11	6.25E+10	8.58E+10	8.58E+10	8.58E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	1.53E+11	2.05E+11	1.22E+11	1.62E+11	6.48E+10	8.25E+10	6.17E+10	7.88E+10	1.54E+11	2.06E+11	7.89E+10	9.93E+10	6.32E+10	8.17E+10	8.17E+10	8.17E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-1.89%	1.48%	-1.83%	1.14%	-1.86%	1.28%	-0.55%	6.11%	-1.21%	3.89%	-0.99%	5.08%	5.08%	5.08%
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships
Base Fleet Size +4% Growth	#	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Additional Ship Fleet Size	#	60	60	62	62	62	62	62	62	63	63	63	63	63	63	63	63
Total Fleet Emissions - More RT	kg-CO _{2eq}	2.00E+11	2.67E+11	1.57E+11	2.14E+11	8.30E+10	1.09E+11	7.89E+10	1.04E+11	1.99E+11	2.86E+11	1.02E+11	1.35E+11	8.16E+10	1.12E+11	1.12E+11	1.12E+11
Total Fleet Emissions - More Ships	kg-CO _{2eq}	2.00E+11	2.67E+11	1.58E+11	2.09E+11	8.37E+10	1.07E+11	7.96E+10	1.02E+11	2.02E+11	2.71E+11	1.04E+11	1.30E+11	8.29E+10	1.07E+11	1.07E+11	1.07E+11
Emissions - More v.s. Faster	%	0.00%	0.00%	-0.93%	2.47%	-0.86%	2.13%	-0.89%	2.27%	-1.16%	5.45%	-1.82%	3.25%	-1.60%	4.43%	4.43%	4.43%
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships

Table 112: Comparison of Shipbuilding vs. Increased Speed Lifecycle Emissions, MT-Basis, Methanol and Liquid Hydrogen

		HFO/Baseline Ship		Methanol Ship						LH ₂ Ship					
		HFO/VLSFO		Methanol		Bio-Methanol		Bio-Methanol w/ Bio		Hydrogen		E-Hydrogen		E-Hydrogen w/ Bio	
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape
Shipbuilding Emissions	kg-CO _{2eq}	2.78E+08	2.78E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.95E+08	2.95E+08	2.95E+08	2.95E+08	2.95E+08	2.95E+08
Operational Emissions 1-RT	kg-CO _{2eq}	3.34E+07	4.58E+07	3.31E+07	4.74E+07	1.11E+07	1.46E+07	7.57E+06	1.06E+07	3.07E+07	4.61E+07	7.88E+06	9.99E+06	4.41E+06	6.09E+06
Number of Round Trips	#	91	91	94	94	94	94	94	94	97	97	97	97	97	97
Operational Emissions Lifetime	kg-CO _{2eq}	3.04E+09	4.16E+09	3.11E+09	4.46E+09	1.05E+09	1.37E+09	7.12E+08	9.96E+08	2.98E+09	4.48E+09	7.65E+08	9.69E+08	4.28E+08	5.90E+08
Maintenance Emissions	kg-CO _{2eq}	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.34E+06	5.34E+06	5.34E+06	5.34E+06	5.34E+06	5.34E+06
Ship Breaking Emissions	kg-CO _{2eq}	4.64E+06	4.64E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.60E+06	4.60E+06	4.60E+06	4.60E+06	4.60E+06	4.60E+06
Total Emissions - More RT	kg-CO _{2eq}	3.33E+09	4.45E+09	3.40E+09	4.75E+09	1.33E+09	1.66E+09	1.00E+09	1.28E+09	3.29E+09	4.78E+09	1.07E+09	1.27E+09	7.32E+08	8.95E+08
Original Emissions (91 RT)	kg-CO _{2eq}	3.33E+09	4.45E+09	3.32E+09	4.47E+09	1.30E+09	1.58E+09	9.73E+08	1.21E+09	3.15E+09	4.22E+09	1.04E+09	1.20E+09	7.14E+08	8.32E+08
Emissions Change - Per Ship	%	0.00%	0.00%	2.49%	6.19%	2.50%	4.98%	2.87%	5.97%	4.36%	13.42%	2.52%	6.23%	2.53%	7.58%
Base Fleet Size -2% Growth	#	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Additional Ship Fleet Size	#	28	28	29	29	29	29	29	29	30	30	30	30	30	30
Total Fleet Emissions - More RT	kg-CO _{2eq}	9.31E+10	1.25E+11	9.53E+10	1.33E+11	3.74E+10	4.64E+10	2.80E+10	3.60E+10	9.20E+10	1.34E+11	2.99E+10	3.57E+10	2.05E+10	2.51E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	9.31E+10	1.25E+11	9.63E+10	1.30E+11	3.78E+10	4.58E+10	2.82E+10	3.52E+10	9.45E+10	1.26E+11	3.13E+10	3.60E+10	2.14E+10	2.50E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-1.04%	2.53%	-1.04%	1.36%	-0.68%	2.32%	-2.60%	5.86%	-4.31%	-0.85%	-4.31%	0.41%
				+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Ships	+ Trips	+ Trips	+ Trips	+ Ships
Base Fleet Size 0% Growth	#	36	36	36	36	36	36	36	36	36	36	36	36	36	36
Additional Ship Fleet Size	#	36	36	37	37	37	37	37	37	39	39	39	39	39	39
Total Fleet Emissions - More RT	kg-CO _{2eq}	1.20E+11	1.60E+11	1.23E+11	1.71E+11	4.80E+10	5.97E+10	3.60E+10	4.63E+10	1.18E+11	1.72E+11	3.85E+10	4.59E+10	2.64E+10	3.22E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	1.20E+11	1.60E+11	1.23E+11	1.65E+11	4.82E+10	5.85E+10	3.60E+10	4.49E+10	1.23E+11	1.64E+11	4.07E+10	4.68E+10	2.78E+10	3.24E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-0.28%	3.32%	-0.27%	2.14%	0.09%	3.11%	-3.67%	4.70%	-5.36%	-1.94%	-5.36%	-0.70%
				+ Trips	+ Ships	+ Trips	+ Ships	+ Ships	+ Ships	+ Trips	+ Ships	+ Trips	+ Trips	+ Trips	+ Trips
Base Fleet Size +2% Growth	#	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Additional Ship Fleet Size	#	46	46	47	47	47	47	47	47	50	50	50	50	50	50
Total Fleet Emissions - More RT	kg-CO _{2eq}	1.53E+11	2.05E+11	1.57E+11	2.18E+11	6.14E+10	7.63E+10	4.61E+10	5.91E+10	1.51E+11	2.20E+11	4.92E+10	5.86E+10	3.37E+10	4.12E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	1.53E+11	2.05E+11	1.56E+11	2.10E+11	6.12E+10	7.43E+10	4.57E+10	5.70E+10	1.57E+11	2.11E+11	5.21E+10	6.00E+10	3.57E+10	4.16E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	0.31%	3.93%	0.32%	2.75%	0.68%	3.72%	-3.99%	4.35%	-5.68%	-2.27%	-5.68%	-1.03%
				+ Ships	+ Ships	+ Ships	+ Ships	+ Ships	+ Ships	+ Trips	+ Ships	+ Trips	+ Trips	+ Trips	+ Trips
Base Fleet Size +4% Growth	#	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Additional Ship Fleet Size	#	60	60	61	61	61	61	61	61	65	65	65	65	65	65
Total Fleet Emissions - More RT	kg-CO _{2eq}	2.00E+11	2.67E+11	2.04E+11	2.85E+11	8.01E+10	9.95E+10	6.01E+10	7.71E+10	1.97E+11	2.87E+11	6.41E+10	7.64E+10	4.39E+10	5.37E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	2.00E+11	2.67E+11	2.03E+11	2.73E+11	7.94E+10	9.64E+10	5.94E+10	7.40E+10	2.05E+11	2.74E+11	6.78E+10	7.79E+10	4.64E+10	5.41E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	0.81%	4.45%	0.82%	3.26%	1.18%	4.24%	-3.67%	4.70%	-5.36%	-1.94%	-5.36%	-0.70%
				+ Ships	+ Ships	+ Ships	+ Ships	+ Ships	+ Ships	+ Trips	+ Ships	+ Trips	+ Trips	+ Trips	+ Trips

Table 113: Comparison of Shipbuilding vs. Increased Speed Lifecycle Emissions, MT-Basis, Compressed Hydrogen

		HFO/Baseline Ship		Compressed Hydrogen Ship					
		HFO/VLSFO		Hydrogen		E-Hydrogen		E-Hydrogen w/ Bio	
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape
Shipbuilding Emissions	kg-CO _{2eq}	2.78E+08	2.78E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08
Operational Emissions 1-RT	kg-CO _{2eq}	3.34E+07	4.58E+07	3.07E+07	4.87E+07	7.79E+06	1.02E+07	4.39E+06	6.33E+06
Number of Round Trips	#	91	91	101	101	101	101	101	101
Operational Emissions Lifetime	kg-CO _{2eq}	3.04E+09	4.16E+09	3.10E+09	4.92E+09	7.86E+08	1.03E+09	4.43E+08	6.39E+08
Maintenance Emissions	kg-CO _{2eq}	5.32E+06	5.32E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06
Ship Breaking Emissions	kg-CO _{2eq}	4.64E+06	4.64E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06
Total Emissions - More RT	kg-CO _{2eq}	3.33E+09	4.45E+09	3.43E+09	5.25E+09	1.11E+09	1.35E+09	7.69E+08	9.65E+08
Original Emissions (91 RT)	kg-CO _{2eq}	3.33E+09	4.45E+09	3.17E+09	4.24E+09	1.06E+09	1.22E+09	7.35E+08	8.53E+08
Emissions Change - Per Ship	%	0.00%	0.00%	8.14%	23.81%	4.52%	10.87%	4.54%	13.13%
Base Fleet Size -2% Growth	#	28	28	28	28	28	28	28	28
Additional Ship Fleet Size	#	28	28	32	32	32	32	32	32
Total Fleet Emissions - More RT	kg-CO _{2eq}	9.31E+10	1.25E+11	9.60E+10	1.47E+11	3.11E+10	3.79E+10	2.15E+10	2.70E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	9.31E+10	1.25E+11	1.01E+11	1.36E+11	3.41E+10	3.91E+10	2.35E+10	2.73E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-5.37%	8.33%	-8.55%	-2.99%	-8.52%	-1.01%
				+ Trips	+ Ships	+ Trips	+ Trips	+ Trips	+ Trips
Base Fleet Size 0% Growth	#	36	36	36	36	36	36	36	36
Additional Ship Fleet Size	#	36	36	40	40	40	40	40	40
Total Fleet Emissions - More RT	kg-CO _{2eq}	1.20E+11	1.60E+11	1.23E+11	1.89E+11	4.00E+10	4.87E+10	2.77E+10	3.47E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	1.20E+11	1.60E+11	1.27E+11	1.69E+11	4.26E+10	4.88E+10	2.94E+10	3.41E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-2.67%	11.43%	-5.94%	-0.21%	-5.91%	1.82%
				+ Trips	+ Ships	+ Trips	+ Trips	+ Trips	+ Ships
Base Fleet Size +2% Growth	#	46	46	46	46	46	46	46	46
Additional Ship Fleet Size	#	46	46	52	52	52	52	52	52
Total Fleet Emissions - More RT	kg-CO _{2eq}	1.53E+11	2.05E+11	1.58E+11	2.41E+11	5.12E+10	6.23E+10	3.54E+10	4.44E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	1.53E+11	2.05E+11	1.65E+11	2.20E+11	5.53E+10	6.35E+10	3.82E+10	4.44E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-4.33%	9.52%	-7.54%	-1.92%	-7.52%	0.08%
				+ Trips	+ Ships	+ Trips	+ Trips	+ Trips	+ Ships
Base Fleet Size +4% Growth	#	60	60	60	60	60	60	60	60
Additional Ship Fleet Size	#	60	60	67	67	67	67	67	67
Total Fleet Emissions - More RT	kg-CO _{2eq}	2.00E+11	2.67E+11	2.06E+11	3.15E+11	6.67E+10	8.12E+10	4.61E+10	5.79E+10
Total Fleet Emissions - More Ships	kg-CO _{2eq}	2.00E+11	2.67E+11	2.12E+11	2.84E+11	7.13E+10	8.18E+10	4.93E+10	5.72E+10
Emissions - More v.s. Faster	%	0.00%	0.00%	-3.15%	10.87%	-6.40%	-0.71%	-6.38%	1.31%
				+ Trips	+ Ships	+ Trips	+ Trips	+ Trips	+ Ships

10.9.3. Results from the Fleet Analysis

These results are condensed into the ships/trips decision matrix in Table 114.

Table 114: Ships/Trips Decision Matrix for TEU and MT delivered

Baseline - For One Ship in Fleet - Speed Variations - TEU Carried Equivalence

Assumed Growth	Base Ships	LNG Ship						Ammonia Ship						Methanol Ship						LH ₂ Ship						Comp. Hydrogen Ship					
		F		B+P		B+BP		F		B+P		B+BP		F		B+P		B+BP		F		B+P		B+BP		F		E+P		E+BP	
		SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP
-2%	28	T	S	T	S	T	S	T	S	T	T	T	T	T	T	T	T	T	T	S	T	T	T	T	S	T	S	T	T	T	S
0%	36	T	S	T	S	T	S	T	S	T	S	T	S	T	T	T	T	T	T	T	S	T	S	T	S	T	S	T	S	T	S
2%	46	T	S	T	S	T	S	T	S	T	S	T	S	T	T	T	T	T	T	T	S	T	S	T	S	T	S	T	S	T	S
4%	61	T	S	T	S	T	S	T	S	T	T	T	S	T	T	T	T	T	T	T	S	T	S	T	S	T	S	T	S	T	S

Baseline - For One Ship in Fleet - Speed Variations - MT Carried Equivalence

Assumed Growth	Base Ships	LNG Ship						Ammonia Ship						Methanol Ship						LH ₂ Ship						Comp. Hydrogen Ship					
		F		B+P		B+BP		F		B+P		B+BP		F		B+P		B+BP		F		B+P		B+BP		F		E+P		E+BP	
		SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP	SC	CP
-2%	28	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	T	T	S	T	S	T	T	T	T
0%	36	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	T	T	T	T	S	T	T	T	S
2%	46	T	S	T	S	T	S	T	S	T	S	T	S	T	S	S	S	S	S	S	T	S	T	T	T	T	T	S	T	T	S
4%	60	T	S	T	S	T	S	T	S	T	S	T	S	S	S	S	S	S	S	S	T	S	T	T	T	T	T	S	T	T	S

F = Fossil Origin Fuel

SC = Suez Canal

T = More Trips/Ship will result in less overall GWP

B = Bio Origin Fuel

CP = Cape of Africa Route

S = More Ships being built will result in less overall GWP

P = Fossil Origin Pilot Fuel

BP = Bio Origin Pilot Fuel

The results of this assessment are mixed and highly dependent on the fuel type and route. In general, adding trips to the Suez Canal route was the best option because, for most of the designs, the additional trips could be accomplished without speeding the vessel up. Instead, reducing the scheduled round trip time by reducing the idle/anchor time allowed more lifetime round trips to be completed and the cargo deficit to be filled. This does indicate that minimizing container ship idle or waiting time at ports is an important step in reducing CO_{2Eq} emissions. In the case of the cape route, the extra carbon emissions from the ships going faster ended up being worse than the emissions from building and operating additional ships, which shows how beneficial slow steaming is toward reducing global warming impact. Even a modest increase in speed for these routes resulted in an increase in operational emissions sufficient to offset the emissions from building and operating one or two additional ships, which was a surprising finding.

Finally, the results were found to be somewhat unpredictable, because of the impact of rounding up to meet cargo demand. Nominally the results would be linear per ship required, and a comparison can be made between the additional ships factor and the ratio of the increased speed total lifecycle CO_{2Eq} vs. the baseline speed lifecycle CO_{2Eq} to determine if it would make more sense to build more ships or speed up. However, because of rounding up to meet cargo demand, there exists a certain range where the

impact from building an additional ship will result in more lifetime fleet emissions than speeding up with a slightly smaller fleet.

Looking at individual fuels, when using LNG-fuelled vessels, it was better to complete additional trips on the Suez route, taking advantage of the reduced round-trip time without a speed-power penalty. The exact opposite was found on the Cape route, where it made more sense to build more ships rather than increase the speed and number of lifetime round trips.

Ammonia exhibited a similar pattern when considered on a MT cargo delivered basis, but there were a few situations in the cape route where it made more sense to go faster, due to an incremental ships factor, where the emissions were otherwise very close between the two scenarios. However, in these borderline cases the extra emissions associated with non-operational phases of the lifecycle were enough to give a slight advantage to increased sailing speeds.

For the methanol fuelled design, it didn't matter which option was chosen, because there was no TEU deficit. This is because methanol suffered no TEU penalty and so the additional ships factor was 1. However, the methanol design did have a reduced MT delivery capacity, and it was found that building ships was the better option for reducing fleet emissions. In this case, the ratio of the $\text{CO}_{2\text{Eq}}$ emitted from speeding up was unfavourable compared to the $\text{CO}_{2\text{Eq}}$ emitted from operating additional ships, so it became beneficial to build more ships in every circumstance.

Liquid hydrogen and compressed hydrogen followed the same pattern as LNG for fossil-derived hydrogen. There was one exception on the TEU equivalent basis for the cape route where an incremental penalty from rounding up the number of ships built caused a faster route time to be the best option. It should be noted that hydrogen vessels were required to speed up the most to compensate for the cargo losses on both a TEU and MT basis. Despite this, speeding up was advantageous when utilizing liquified E-hydrogen, mostly because shipbuilding represents a substantial portion of the lifecycle emissions of hydrogen vessels. The compressed hydrogen vessel was on the other side of the breakpoint at larger fleet sizes. In this case, the vessel was travelling so much faster that the large emissions from shipbuilding relative to the total lifecycle emissions was not enough to offset the increase in emissions from travelling faster.

10.9.4. Impacts of Additional Shipbuilding

Special consideration should be given to situations where additional shipbuilding is required to meet the projected fleet cargo demands. While the lifecycle emissions model and fleet analysis compare the CO_{2EQ} impact of speeding up vs. building additional ships, there are other emissions that are inventoried but not directly considered. Table 115 lists the emissions as a percentage of the total lifecycle emissions associated with shipbuilding, maintenance, and ship breaking, which represent the marginal emissions that are generated for every additional ship built.

Table 115: Shipbuilding/Maintenance/Breaking Lifecycle Emissions % for a Single Ship

	Main Fuel Source	Pilot Fuel	HFO / Baseline Ship	LNG Ship			Ammonia Ship			Methanol Ship			LH ₂ Ship			Compressed Hydrogen Ship		
			Fossil	Fossil	Bio	Bio	Fossil	Bio	Bio	Fossil	Bio	Bio	Fossil	E	E	Fossil	E	E
			N/A	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel
Shipbuilding + Maintenance + Ship Breaking	CO ₂ Emissions	%	7%	9%	18%	19%	7%	14%	17%	7%	19%	25%	8%	26%	37%	31%	45%	8%
	SO _x Emissions	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	NO _x Emissions	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	PM ₁₀ Emissions	%	0%	72%	72%	72%	36%	36%	36%	33%	33%	33%	36%	36%	36%	37%	37%	36%
	PM _{2.5} Emissions	%	0%	21%	21%	21%	6%	6%	6%	5%	5%	5%	6%	6%	6%	6%	6%	6%
	CH ₄ Emissions	%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	2%	1%	3%	0%
	CO Emissions	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	N ₂ O Emissions	%	29%	31%	30%	30%	64%	64%	62%	68%	69%	67%	68%	65%	63%	69%	67%	68%
	NM VOC Emissions	%	5%	7%	7%	7%	29%	29%	29%	28%	28%	28%	29%	29%	29%	31%	31%	29%
	BC Emissions	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Discounting CO₂, CH₄, and N₂O which are included in the measure of global warming potential used in the fleet analysis, we can see that the most relevant emissions are particulate matter and volatile organic compounds. Though it is noteworthy that the N₂O emissions from the non-operational portions of the lifecycle are substantial for the alternatively fuelled vessels. This is because HFO and LNG are expected to produce a N₂O during their combustion process as per the emissions factors in the IMO 4th GHG study, while the alternative fuels do not have an associated emissions factor and the only N₂O contributions come from either the pilot fuel combustion or the non-operational lifecycle phases.

A chart focusing on the emissions of PM₁₀, PM_{2.5}, and NMVOC's for each of the designs and fuel combinations is shown in Figure 77.

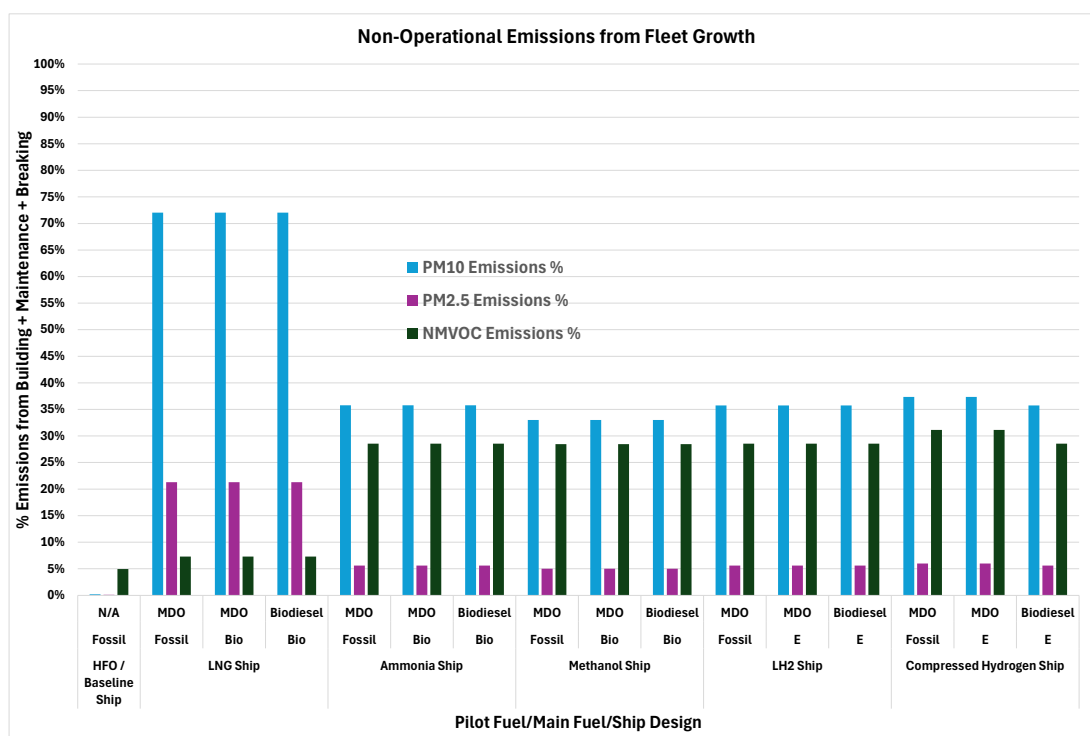


Figure 77: Particulate Matter and Volatile Organic Compound Emissions Associated with Additional Ship Building

Note that the values presented in Figure 77 represent the percentage of lifecycle emissions from non-operational sources. This means that it represents the ratio of the operational emissions to the building/maintenance/scrapping emissions. Indeed, the actual quantities by mass of PM and VOC's do not vary substantially between designs. This is part of the reason why LNG exhibits a higher proportion of PM10 and PM2.5 from shipbuilding than the other designs – the LNG fueled engines burn less pilot oil than the other alternatively fueled engines, and so form less particulate matter in operation, which means the particulate matter they do form during the construction and maintenance phases are more prominent.

The emissions inventory indicates that for HFO fueled vessels, the NMVOC emissions from shipbuilding make up approximately 5% of the total lifecycle emissions, and almost none of the other emission types are substantial when compared to the operational phase. Essentially, running a ship on HFO creates a broad enough spectrum of pollutants to substantially mute the impact of the shipbuilding. However, this pattern does not hold with alternative fuels, where the PM and VOC emissions from burning fuel decrease substantially. For these fuels, the non-operational emissions begin to become relevant. Particulate matter and NMVOC's contribute to environmental impact

indicators related to damage to human health and ozone formation (smog) respectively (Huijbregts *et al.*, 2017), which are more localized problems but important to consider from a complete environmental protection perspective. There are other issues associated with deploying additional ships such as increased crewing requirements and logistical support networks to handle each additional vessel. Finally, the lifecycle model implemented in this research is focused on tracking emissions related to GWP as defined by the MEPC characterization factors, and numerous ancillary emissions are only touched on or omitted entirely. A more comprehensive model would allow better tracking of the complete spectrum of emissions associated with building, maintaining, and disposing of vessels. Together, these considerations indicate that a more nuanced approach than simply considering global warming potential is necessary when considering the benefits of increasing the fleet size vs. increasing the fleet speed, and as the operational environmental impacts of shipping decreases by alternative fuel, the hard-to-abate environmental impacts of increasing fleet size begin to be more prominent.

10.10. Well-to-Tank Sensitivity Study

The literature review in section 5.4 identified a substantial variability in the well-to-tank emission factors, especially those identified as particularly high from Bilgili (2021). The well-to-wake component of the emissions was found to be responsible for between 14% to 83% of the operational emissions in the case study, depending on the fuel, source, and route. Therefore, a sensitivity study was carried out examining how the CO_{2EQ}/TEU-km would vary when different well-to-tank emission factors were used. From the literature review data, the high and low values for each investigated fuel were identified, shown in Figure 78.

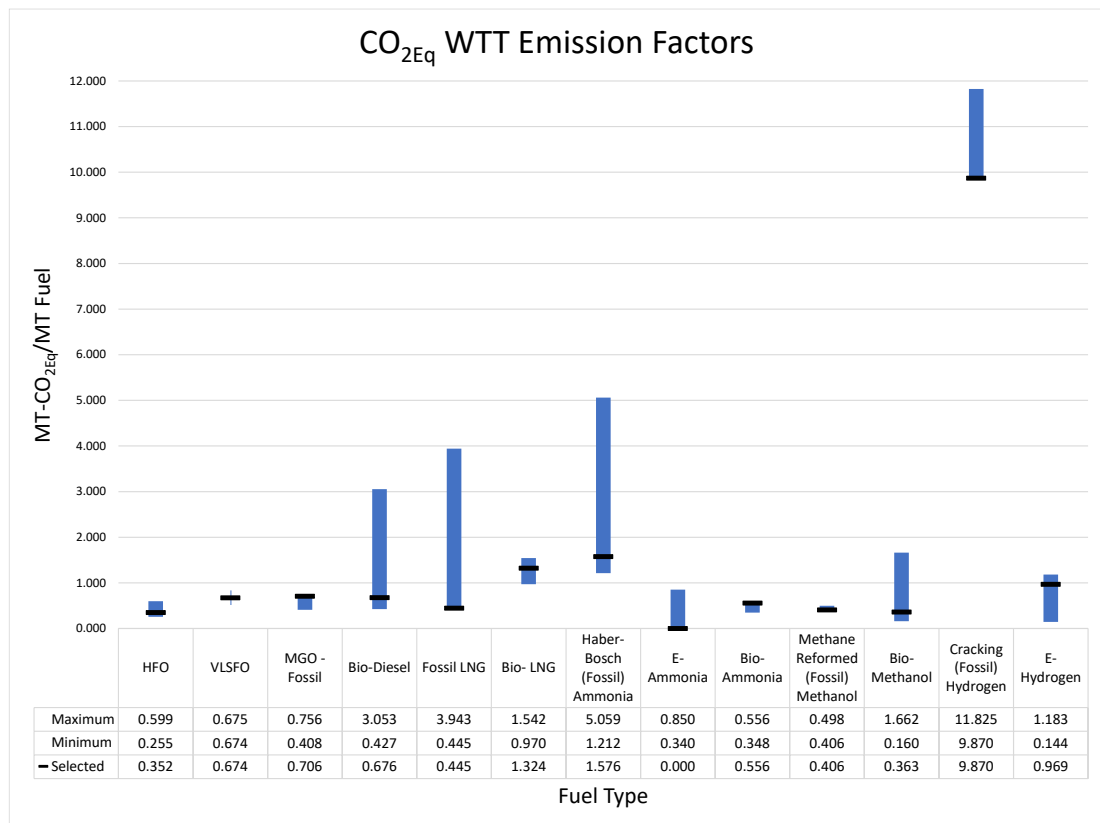


Figure 78: CO_{2Eq} Well-to-Tank Emission Factors, Variance, and Analysis Selected Value for Each Fuel

These emissions factors were then substituted for the selected well-to-tank emissions factors in the case study, and the CO_{2Eq} emissions from the lifecycle were recalculated. The results of this sensitivity analysis are shown in Figure 79.

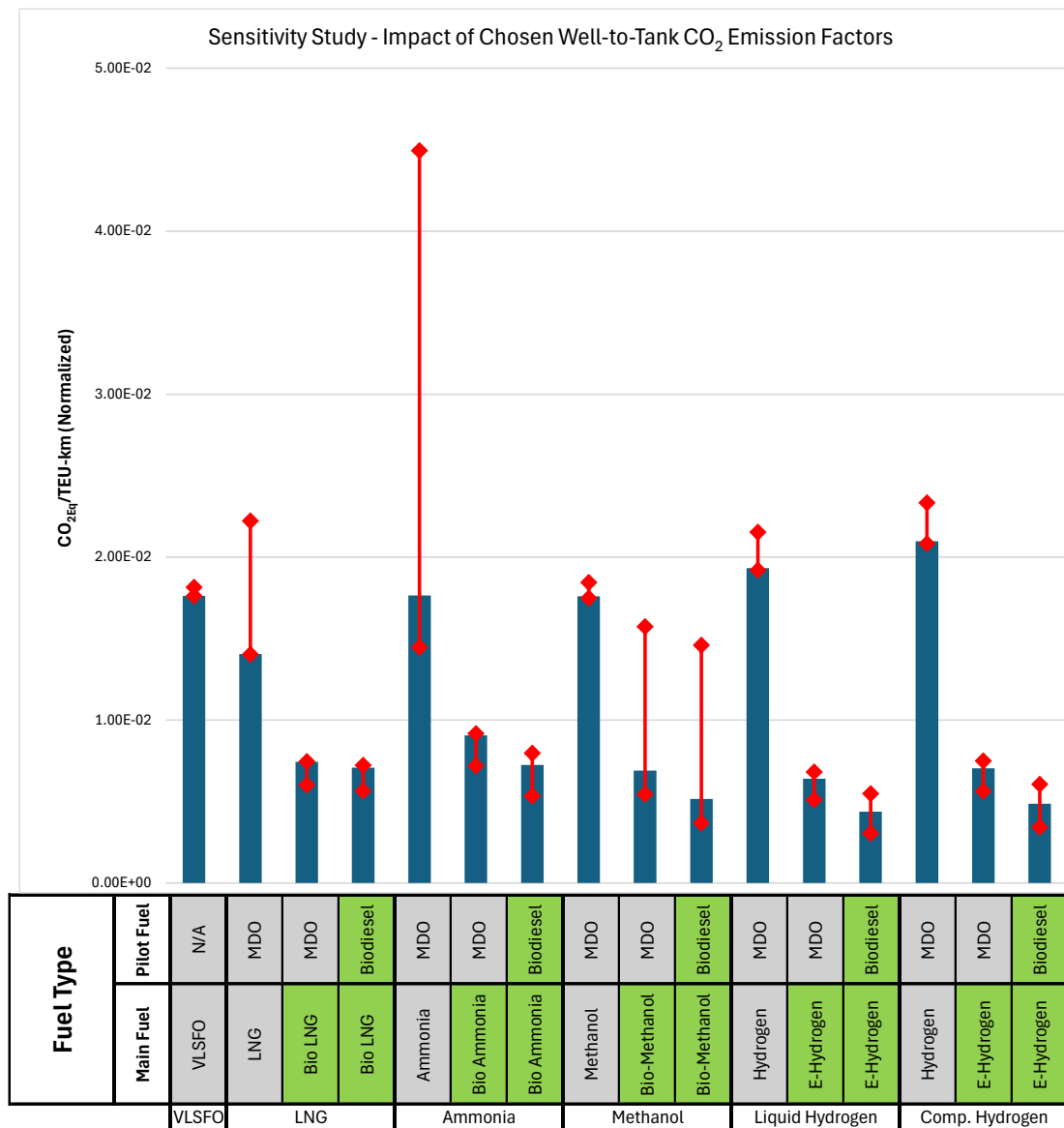


Figure 79: Potential Variability in Work-Transport Efficiency Associated with Well-to-Tank Emission Factors

Figure 79 presents the work-transport and additional ship factor normalized CO₂eq emissions from the entire set of fuel combinations investigated in this research. The blue bar represents the “chosen” Well-to-Tank emission factors presented elsewhere in this report, while the red bounds represent the potential low-high variance depending on if the minimum or maximum Well-to-Tank emission factors are selected for both the main and pilot fuel. The fuels are divided into the main and pilot fuel and shaded by their respective “fuel colour” with grey denoting fossil-derived fuels and green denoting biogenic or renewable fuels. This demonstrates how an alternative fuel can be

combined with either fossil fuel pilot oil or renewable pilot oil and the impact on emissions.

These results indicate that the variability in well-to-tank emissions factors have the largest impact on fossil LNG, Haber-Bosch produced Ammonia, and Bio Methanol. The other alternative fuels have a moderate potential variation that would not substantially change the results of the case study. This analysis has been found to be particularly sensitive to well-to-wake emission factors and should be re-evaluated if standard values are derived and published by the IMO.

10.10.1. Conventional Fuel WTT Factors

The conventional fuels can be considered HFO, VLSFO, MGO, and to a lesser extent, Biodiesel. These are all “drop-in” fuels that can be used by current marine engines with minimal modification, and whose properties are broadly similar.

HFO is not directly investigated in this study (though the ship would be capable of and is “designed” for HFO use), with the WTT factors of VLSFO being used instead. This is because in the absence of a scrubber, traditional HFO is not permitted to be used to comply with sulfur emissions requirements. There are a wide range of emission factors available for HFO, varying from 0.255-0.599 MT CO_{2Eq}/MT Fuel. Nominally this variance would be related to extraction methods, refining methods, storage, and transportation.

There are two published figures for VLSFO from different sources but roughly the same value, shown in Table 116. Since VLSFO is refined from HFO, the emission factors are always higher than HFO.

Table 116: VLSFO WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

VLSFO	
MT CO _{2Eq} /MT Fuel	Reference
0.675	Wechsler 2023 (Article)
0.674	Comer 2021 ICCT, Table 2

The two data sources being roughly in agreement results in very little variation in the expected lifecycle emissions for the baseline ship design.

MGO is relevant as pilot fuel for the alternatively fueled designs, so the variance in the MGO WTT emission factors is additive to the variance inherent in the alternative fuel.

Since MGO is a common fuel and the supply chains are well established, it is expected these figures are accurate within the limitations of the applied lifecycle analysis methodologies. The high and low CO_{2Eq} emission factors for fossil MGO are shown in Table 117.

Table 117: Fossil MGO WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

MGO - Fossil	
MT CO _{2Eq} /MT Fuel	Reference
0.542	DNV 2019
0.756	Wechsler 2023 (Article)
0.706	Comer 2021 ICCT, Table 2
0.408	IMO 2016 Methanol as Marine Fuel

Biodiesel has a much larger variance in WTT factors because of the variety in production methods, its relatively new supply chains, and the natural variance in how WTT factors are calculated. The feedstock for biodiesel is particularly important for the ultimate WTT emission factor, so it is expected that even if methodologies are unified and supply chains stabilize, there will be variance in this figure. The biodiesel WTT emission factors are presented in Table 118.

Table 118: Biodiesel WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

Bio-Diesel	
MT CO _{2Eq} /MT Fuel	Reference
0.427	DNV 2019
2.307	Bilgili 2021 Soy
3.053	Bilgili 2021 Rapeseed
2.688	Bilgili 2021 Palm
1.832	Wang Wright 2021 Rapeseed
0.676	Wang Wright 2021 Soy

Despite the variability of biodiesel WTT emission factors, the impact is relatively muted because of the proportionally smaller quantity of biodiesel consumed. The impact of biodiesel on lifecycle emissions can be seen by comparing the alternative fuel with fossil MDO to alternative fuel with biodiesel columns in Figure 79.

10.10.2. LNG/Methane WTT Factor

For fossil LNG/Methane, the highest potential emissions factor is up to 3.94 MT-CO_{2Eq} per MT of CH₄ (Bilgili, 2021). This is eight times higher than the low-end estimate (which was what was used in this analysis), but more than twice as high as the next highest estimate. Most mid-range estimates are on the order of 0.8-1.3 MT-CO_{2Eq} per MT of methane. However, using the mid-range well-to-tank emissions factor of 0.815 from Hua (2019) does not fundamentally change the results, with the benefit of fossil LNG compared to HFO on a CO_{2Eq}/work-transport basis dropping from 19-20% to 16-17%. At the higher end emission factor of 1.33 estimated from Wang and Wright (2021), the benefits from fossil LNG use start to approach that of HFO, but remain slightly under at a 1 to 3% reduction in CO_{2Eq}/Work Transport. This level of well-to-tank emissions would bring fossil-derived LNG more in line with the other fossil-derived alternative fuels. The well-to-tank CO_{2Eq} emissions factors from the literature review for Methane are shown in Table 119, which demonstrates that the high end value from Bilgili (2021) is an outlier. Potentially, the high WTT emission factor from Bilgili's research is driven by a larger amount of assumed fugitive methane emissions in the lifecycle of LNG production, which would consequently increase the global warming potential.

Table 119: Fossil LNG WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

Fossil LNG	
MT CO _{2Eq} /MT Fuel	Reference
0.815	Hua 2019
0.514	DNV 2019
0.445	Brynnolf 2014
3.943	Bilgili 2021
0.445	Wang Wright 2021
1.329	Wang Wright 2021
1.039	Comer 2021 ICCT, Table 2

If the highest end WTT emission factor for fossil LNG is implemented, LNG performs worse than VLSFO, methanol, and liquid hydrogen in terms on a CO_{2Eq}/Work Transport basis.

The variance associated with Bio-LNG is substantially smaller than with fossil LNG, as shown in Table 120. The Bio-LNG WTT emission factors vary between 0.97-1.542 MT-

CO_{2Eq}/MT Fuel, which is generally higher than the WTT emission factors for fossil LNG discounting the high-end estimate from Bilgili (2021).

Table 120: Bio-LNG WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

Bio- LNG	
MT CO _{2Eq} /MT Fuel	Reference
0.970	DNV 2019
1.076	Bilgili 2021
1.542	Brynolf 2014
1.324	Wang Wright 2021

This substantially reduces the uncertainty associated with bio-LNG, which indicates it could remain competitive with bio-ammonia and bio-methanol.

10.10.3. Ammonia WTT Factors

Fossil ammonia was also noted to have an extremely high potential variance, again driven by a large emissions factor of 5.1 MT-CO_{2Eq}/MT-Ammonia well-to-tank emissions factor as reported from Bilgili (2021), especially when compared to the emission factors on the range of 1.2-1.6 MT-CO_{2E}/MT-Ammonia from other sources, as shown in Table 121.

Table 121: Fossil Ammonia WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

Haber-Bosch (Fossil) Ammonia	
MT CO _{2Eq} /MT Fuel	Reference
5.059	Bilgili 2021
1.500	Bicer and Dincer 2016
1.212	Wang Wright 2021
1.576	Wang Wright 2021

Such a high emissions factor would make a Fossil-ammonia fuelled vessel more than twice as inefficient as a conventionally fuelled vessel, while even with the implemented and low-bound fossil ammonia WTT factors yield a work-transport efficiency roughly equivalent to fossil HFO and LNG. .

When considering Bio-Ammonia, the variance decreases substantially because only a single source listed bio-ammonia WTT emission factors. However, the single source is based on a broader literature review (Wang and Wright, 2021). The WTT values for bio-

ammonia are shown in Table 122. This reduced variance is clearly shown in the results of the sensitivity analysis.

Table 122: Bio Ammonia WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

Bio-Ammonia	
MT CO _{2Eq} /MT Fuel	Reference
0.348	Wang Wright 2021
0.556	Wang Wright 2021

WTT figures for E-Ammonia are also available, but from a single source (Bicer *et al.*, 2016) which provided only CO_{2Eq} emission factors, shown in Table 123. While the E-ammonia data was not used in this analysis, it's WTT values are comparable to that of Bio-Ammonia and substantially less than the WTT factors for fossil ammonia, so it is assumed that this E-ammonia is produced with renewable energy. Since the WTT factors fit within the bounds of bio-ammonia, it can be assumed that the overall results with E-ammonia would be similar to those of Bio-Ammonia.

Table 123: E-Ammonia WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

E-Ammonia	
MT CO _{2Eq} /MT Fuel	Reference
0.380	Bicer and Dincer 2016
0.840	Bicer and Dincer 2016
0.850	Bicer and Dincer 2016
0.340	Bicer and Dincer 2016

10.10.4. Methanol WTT Factors

Fossil Methanol WTT factors varied between 0.43 and 0.5, as shown in Table 124.

Table 124: Fossil Methanol WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

Methane Reformed (Fossil) Methanol	
MT CO _{2Eq} /MT Fuel	Reference
0.425	DNV 2019
0.406	Brynolf 2014
0.406	Wang Wright 2021
0.498	IMO 2016 Methanol as Marine Fuel

This small variance is reflected in the sensitivity study, where there is relatively little variance in the potential fossil methanol results. However, it should be noted that the emissions factors for the fossil-derived methanol are lower than or similar to fossil-derived methane, which is surprising considering the methanol is produced from the methane. This may be due to differences in how the well-to-tank lifecycle analyses are conducted or associated with fewer opportunities for fugitive methane emissions on the well-to-tank pathway.

Bio-methanol has a very large range in the available well-to-wake emission factors, and at the high end would make it an unattractive fuel to use for reducing global warming potential. In this case, the value presented by Bilgili (2021) of 1.662 MT-CO_{2Eq}/MT-Methanol is the highest, but a second source establishes an upper range value on the order of 1.353 MT-CO_{2Eq}/MT-Methanol (IMO, 2016). The bio-methanol well-to-tank emission factors are provided in Table 125, showing that an emissions factor of 1.662 does not diverge substantially from the higher end of expected by the IMO for bio-methanol production, but other sources do estimate substantially lower emissions factors.

Table 125: Bio-Methanol WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

Bio-Methanol	
MT CO _{2Eq} /MT Fuel	Reference
0.160	DNV 2019
0.363	Brynolf 2014
1.662	Bilgili 2021
0.363	Wang Wright 2021
0.498	IMO 2016 Methanol as Marine Fuel
1.353	IMO 2016 Methanol as Marine Fuel

In this case, even the high end well-to-tank emissions factor for bio-methanol would not cause bio-methanol to perform worse than conventional fuels but would make it the least beneficial option amongst the alternative fuels.

10.10.5. Hydrogen WTT Factors

Hydrogen produced through steam methane reformation of fossil methane is similarly considered fossil hydrogen and has some of the highest well-to-tank emission factors of all the fuels, varying between 9.87-11.825 MT-CO_{2Eq}/MT-Fuel as shown in Table 126.

Table 126: Fossil Hydrogen WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

Cracking (Fossil) Hydrogen	
MT CO _{2Eq} /MT Fuel	Reference
10.792	DNV 2019
9.870	Wang Wright 2021
11.825	Wang Wright 2021

As a result of this high WTT factor, the hydrogen fueled configuration using fossil-derived hydrogen offers less transport efficiency than a conventionally fueled vessel or any of the alternative fuels, with the potential exception of fossil-derived ammonia and methane at the higher WTT emission ranges.

E-hydrogen produced through electrolysis using renewable energy is the opposite, offering the lowest potential WTT emission factor of 0.144 MT-COT_{2Eq}/MT-Fuel. However, at the maximum range the WTT emission factor is up to 1.183 MT-COT_{2Eq}/MT-Fuel, shown in Table 127, which is worse than the upper limit reported for any of the conventional fuels – HFO (0.6), VLSFO (0.675), and MDO (0.756).

Table 127: E-Hydrogen WTT Emission Factors, on CO_{2Eq} Basis. Red denotes upper bound value, and blue denotes lower bound value

Electrolysis Produced Hydrogen	
MT CO _{2Eq} /MT Fuel	Reference
0.144	DNV 2019
0.969	Wang Wright 2021
1.183	Wang Wright 2021

Despite the potential for higher well-to-tank emission factors from hydrogen production, emitting no carbon on the tank-to-wake portion of the lifecycle is sufficient to make hydrogen perform substantially better with regards to CO_{2Eq} work transport efficiency compared to any fossil derived fuel and be competitive with most of the biogenically sourced alternatives.

10.11. Impact of Black Carbon on GWP

As per the ICCT, Black Carbon has a nominal GWP impact of 460 MT-CO_{2Eq}/MT-black carbon on the 100-year timescale (ICCT *et al.*, 2009), which is an equivalent timescale used for the MEPC emission factors. From the emissions inventory for the case study, it was determined that negligible quantities of black carbon are emitted in the ship

building, maintenance, and breaking phases. However, even in the operational phases where most of the black carbon is generated, it was found to account for between 0-2% of the total GWP as shown in Table 128, indicating that its impact is relatively small. With the adoption of alternative fuels, the expected generation of black carbon is also expected to decrease.

Table 128: Impact of Black Carbon on GWP

		HFO / Baseline Ship	LNG Ship				Ammonia Ship			Methanol Ship			LH ₂ Ship			Compressed Hydrogen Ship		
Main Fuel Source		Fossil	Fossil	Bio	Bio	Fossil	Bio	Bio	Fossil	Bio	Bio	Fossil	E	E	Fossil	E	E	
Pilot Fuel		N/A	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel	MDO	MDO	Biodiesel	
Operations (91 Round Trips)	CO ₂ Emissions	MT	2.90E+06	2.16E+06	9.72E+05	9.09E+05	2.88E+06	1.33E+06	1.01E+06	3.00E+06	9.56E+05	6.38E+05	2.70E+06	7.11E+05	3.93E+05	3.71E+06	8.62E+05	5.07E+05
	CH ₄ Emissions	MT	3,535.8	2,255.3	1,793.3	1,707.9	690.0	539.5	108.8	850.1	1,725.3	1,294.6	4,799.8	610.5	179.8	6,702.8	705.1	223.7
	N ₂ O Emissions	MT	155.4	140.5	145.8	146.5	40.9	40.9	44.7	36.4	34.5	38.2	35.2	39.8	43.5	40.9	47.4	51.6
	BC Emissions	MT	157.2	9.1	9.1	9.1	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.9	9.9	9.9
	CO _{2EQ} MEPC (Excluding BC)	MT	3,037,945	2,260,946	1,061,012	995,811	2,911,397	1,354,725	1,025,877	3,031,582	1,012,975	684,128	2,844,864	738,361	409,513	3,910,581	894,720	527,228
	CO _{2EQ} BC	MT	72,311	4,189	4,189	4,189	4,437	4,437	4,437	4,437	4,437	4,437	4,437	4,437	4,437	4,533	4,533	4,533
	Total CO _{2EQ}	MT	3,110,255	2,265,135	1,065,201	1,000,000	2,915,834	1,359,162	1,030,314	3,036,019	1,017,412	688,565	2,849,301	742,798	413,950	3,915,114	899,253	531,761
	Black Carbon Fraction	%	2%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	1%	1%	0%	1%	1%

11. Discussion and Conclusions

The main conclusion from this research is that without improvement in the well-to-tank emissions factors of alternative fuels, using them in most cases will result in a negligible improvement or even a slight increase in the CO_{2EQ} emissions when considering lifecycle emissions, impacts on cargo capacity, and resulting fleet growth to keep an equivalent amount of cargo delivered. The notable exception to this is LNG, which should offer savings unless the well-to-wake emission factors are at the highest end of what is published.

However, adoption of alternative fuels does offer the potential for very large reductions in the lifecycle CO_{2EQ} emissions from the operation of vessels. While net-zero could not be achieved with the available emissions factors, reductions in emissions between 50-80% were achievable depending on the alternative fuel and sailing route, even including the additional emissions from shipbuilding, maintenance, and scrapping. This means the pursuit of alternative fuels is still a worthwhile, and necessary goal for reducing the overall global warming impact from the shipping industry.

11.1. Main Components of Lifecycle Emissions

The three main components of the lifecycle emissions of the vessel from a global warming perspective were the steel production, the tank-to-wake emissions, and the well-to-tank emissions. The rest of the processes were found to contribute very little to the lifecycle emissions of the vessel, on the order of 0.5-2%. While it is acknowledged

that some of these phases have other emissions that may be critical in other environmental impact categories so are worth retaining if the study was to include them, if the goal is to look at CO_{2Eq} emissions, they can safely be omitted. Despite this, as emissions from ship operations decrease, this also means that emissions from ship building, maintenance, and breaking will continue to increase in importance relative to the entire lifecycle emissions inventory of a vessel. The importance of well-to-tank emissions also means that a large part of the burden of decarbonizing shipping lies with shore-side improvements. Reduction of well-to-tank emissions factors for biofuels or other green fuel pathways is essential for reducing two of the main parts of the lifecycle emissions. Vessels need to be capable of utilizing these alternative fuels but utilizing them without having the well-to-tank emission factors reduced will not result in substantial benefits to the environment.

Similarly, improvements in reducing the CO_{2Eq} impact of steel production processes will help reduce the lifecycle emissions of the shipping industry. While it is generally a smaller category than the operational emissions, it is still an appreciable portion of the lifecycle emissions of a vessel (6-28%) and will increase in importance as well-to-wake emissions decrease.

The high emphasis on the operational emissions also means that efforts to reduce emissions from this lifecycle phase are the most effective at reducing the carbon impact from shipping. This means the application of existing energy savings devices and development of new technologies to reduce the power requirements of vessels is still important even with the adoption of alternative fuels.

11.2. Economic Considerations of Alternative Fuel Adoption

This research focuses on the reduction in global warming potential from alternative fuels and economic considerations are excluded. However, the economic challenges of implementation of alternative fuels in the shipping industry are substantial.

The first economic barrier is equipment and system complexity. The equipment must be capable of effectively converting the energy in the fuel into motive force and/or electricity. This has been largely solved as discussed in this research – both medium and low speed diesels can be used with alternative fuel, but other technologies both old and new such as boilers with steam turbines and fuel cells with motors can also be used as

energy converters with alternative fuels (ABS, 2019a). However, equipment for conventional fuel has the benefit of economies of scale and familiarity supporting it, keeping costs down for now. There are additional complexities associated with the storage and processing requirements of the fuels themselves. High pressure, cryogenic containment systems made of special materials or coatings are needed for such items as tanks or membranes, as well as low temperature and stainless steels for secondary barriers and drip trays. Frequently, compressors, reliquification units, chemical support skids, and vaporizers are needed to keep the fuel cool or heat it up so that it can be used in the engines. This results in the need for specialist equipment and trained workers to build, install, and maintain it, adding to the cost above what would be needed for an installation. Finally, the cost of safety is not insubstantial. HFO and conventional fuels are relatively safe and easy to store when compared to alternative fuels which are either stored at high pressure, cryogenic temperatures, or are toxic to humans. This leads to a substantial amount of additional safety equipment being necessary – numerous gas detectors, enhanced ventilation, specialized bunkering stations, double-walled leak detecting piping, and explosion-proof equipment (IMO, 2015), all of which adds to the equipment costs for using alternative fuel. The equipment and associated system design also need to be specially approved by classification societies and flag state administrations, which add to the cost.

The above equipment challenges and costs are present whether the vessel is designed from the keel-out to use alternative fuels or if it is a retrofit, however retrofits present an even larger challenge. In many cases, the existing prime mover is not suitable for use with alternative fuels and will require reengining which typically involves substantially cutting the ship to remove the old engine and bring in the new engine. All the piping, electrical equipment, and support systems will need to be disconnected and re-connected during this process at a minimum, which also requires substantial time in drydock. Installation of the alternative fuel tanks is likewise challenging. If these can be mounted on the deck, this will still involve substantial re-routing of existing piping and outfitting, plus new piping and possibly deckhouses for equipment. If the retrofit is for a containership, one or more container holds will need to be converted into a tank space. The next challenge is fitting in the new equipment into an existing ship, where frequently there is not enough space, not enough electrical capacity, not enough spare switchboard capacity, not enough firefighting capacity, not enough seawater cooling

capacity, and challenging arrangements of vent masts and hazardous area zones. All of these lead to substantial retrofit costs. From my company's recent projects, conversions carried out in China of "LNG Ready" containerships where space was retained for LNG tanks and the engine was already LNG capable, the cost to the owner was approximately \$30 million. For a complete retrofit project of a containership involving replacing the main engine and converting a hold into LNG tank space, the final cost to the owner was on the order of \$50 million. This was only economical because the vessels were US Jones Act vessels, and their replacement costs were consequently very high. For most internationally built vessels, this retrofit cost would represent an unacceptably high portion of their initial acquisition costs, and it would likely be more economical to build new purpose-built alternative fuel capable vessels.

Another inescapable economic burden of alternative fuel adoption is the cost of the fuel itself, shown in Table 129, retrieved from Wang and Wright (2021) and supplemented with current data for VLSFO and MGO from Ship & Bunker (2025).

Table 129: Comparative Costs of Alternative Fuels (Wang and Wright, 2021; Ship & Bunker, 2025)

Fuel Type and Source	Cost (US\$/MJ)		Cost-Multiplier HFO		LCV (MJ/kg)	Cost (US\$/MT)	
	Low	High	Low	High		Low	High
Liquid Fossil Fuel (HFO, VLSFO)	0.012	0.015	1.0	1.0	40.2	\$ 478.00	\$ 595.00
MGO	0.015	0.018	1.3	1.2	42.7	\$ 640.00	\$ 770.00
Bio-Diesel	0.013	0.027	1.1	1.8	42.7	\$ 555.10	\$ 1,152.90
Fossil LNG	0.0022	0.0092	0.2	0.6	48	\$ 105.60	\$ 441.60
Bio-LNG	0.0081	0.032	0.7	2.2	48	\$ 388.80	\$ 1,536.00
Haber-Bosch (Fossil) Ammonia	0.0093	0.036	0.8	2.4	18.6	\$ 172.98	\$ 669.60
E-Ammonia	0.021	0.037	1.8	2.5	18.6	\$ 390.60	\$ 688.20
Methane Reformed (Fossil) Methanol	0.006	0.022	0.5	1.5	19.9	\$ 119.40	\$ 437.80
Bio-Methanol	0.021	0.037	1.8	2.5	19.9	\$ 417.90	\$ 736.30
Cracking (Fossil) Hydrogen	0.0063	0.035	0.5	2.4	120	\$ 756.00	\$ 4,200.00
E-Hydrogen	0.025	0.08	2.1	5.4	120	\$ 3,000.00	\$ 9,600.00

From this data, at the low end of the price range only bio-LNG has the potential to be cheaper than current fuels, while at the high end of the price range all green fuels would be 2-5x more expensive, based on US\$/MJ. Note that prices are also presented in terms of US\$/MT, but this is a very misleading figure because fuels with a lower LCV such as Ammonia and Methanol would require more tons of fuel to be consumed for the same energy output.

The final negative economic pressure associated with adoption of alternative fuels is reduction in cargo capacity, as demonstrated in this research. The space requirements for alternative fuel tanks and supporting equipment typically require a sacrifice in loadable capacity. Even for the best performing design utilizing methanol, while no TEU

slots needed to be sacrificed, the loadable capacity of the vessel on a MT/TEU basis decreased. It is expected for other ship types where volume is less of a concern that a reduction in loadable deadweight can still be expected for an alternatively fueled vessel.

Overall, the economics of alternative fuel do remain a substantial barrier. While it is expected that aspects related to the machinery and equipment costs will decrease, the systems are fundamentally more complicated, and thus more expensive than traditional HFO. There have been years of investment in the oil production and transport infrastructure, and HFO is essentially a byproduct of the oil refinement process, which means it will be difficult for the costs of alternative fuel to reach the low prices of HFO. Additionally, the alternative fuel market is suffering from choice paralysis, with at least four potential fuel pathways and ship owners and fuel suppliers hesitating to commit and risk wasting money. Finally, there is a negative impact on the cargo capacity of ships utilizing alternative fuel, which means a potential reduction in revenues.

11.3. Fuel Availability and Infrastructure Challenges

There are at least three challenges associated with alternative fuels from an availability and infrastructural standpoint which also contribute to their cost penalty. These challenges are a result of the physical properties of the fuels, and can be described as production challenges, storage challenges, and distribution challenges.

Production issues relate primarily to difficulties in producing large quantities of a given fuel in a sustainable manner. LNG is readily available from fossil sources, and it or other fossil sources such as coal can be used to produce ammonia, methanol, and hydrogen readily and in many cases already at industrial scales. However, the fuel demand of the shipping industry is very large, and even the existing industrial production capacity for methanol and hydrogen will require substantial expansion of the world's production capacities even using fossil based sources (DNV, 2021b). Ammonia is already produced in vast quantities, but this current supply is needed as fertilizer and so even that industry would need to expand to meet the demands of the shipping industry. The remaining issue is producing the fuels in a renewable manner. As demonstrated in this research, the well-to-tank emission factors associated with fossil-derived alternative fuels mean the net benefit from using such fossil alternative fuels is equivalent to or more harmful to the environment than using traditional fuel oil. The proposed green pathways for bio-

LNG are quite challenging, typically involving schemes such as collection of livestock emissions, large composting centers for food waste, or industrial level farming and decomposition of willows or other plant materials (Brynolf, Fridell and Andersson, 2014; Bilgili, 2021). However, it is difficult to see how such a process would be scaled up to produce enough fuel without excessive land use, freshwater use, and ammonia for fertilizers in the case of willow farming. Hydrogen is probably one of the most straightforward green fuels to produce via electrolysis of water using renewable energy. However, the energy demand for electrolysis of hydrogen at the scales needed is expected to be massive and requires substantial investment in both the renewable energy sector and national grids. This renewable hydrogen could then be used to create ammonia and methanol, but this process would add to the cost and energy requirements of producing those fuels. Bio-methanol would similarly be produced from plant matter (Brynolf, Fridell and Andersson, 2014), and bio-ammonia could be produced through biomass powerplants and biomass derived methane with the Haber-Bosch process (Bicer *et al.*, 2016), but both of these methodologies suffer from the scaling problems of bio-methane.

Storage of alternative fuels is less of a problem for land-based systems where volume is not as important as on board a ship. Many of the gases that would need to be stored cryogenically or under pressure on board a vessel to reach acceptable energy density levels can be stored as a gas on-land. For example, methane is already widely used, stored, and distributed on land, so does not pose much of an infrastructure challenge. Similarly, ammonia is regularly stored and distributed, and from a physical standpoint is easier to store than methane except for its safety concerns. Similarly, methanol is not a challenge to store in vast quantities so long as the appropriate safety precautions are taken. Hydrogen storage remains an issue, as the molecule tends to leak out of tanks and the energy density of it is such that even on land the footprint of storage facilities remains unacceptable large. Hydrogen as a gas at atmospheric pressure is also less dense than air, which typically results in it being stored as compressed hydrogen in relatively small pressure vessels. Hydrogen is also extremely flammable, which means safety precautions need to be taken near any storage facility to prevent explosions.

Finally, transport is a challenge for most alternative fuels. The fuels need to be transported to their point-of-use, which for vessels typically means either pier-side or

with a bunkering vessel. With a bunkering vessel all the aforementioned storage requirements for the alternative fuels need to be met as outlined in the IGC code (IMO, 1975), and if the bunkering vessel is going to be also using its cargo as a fuel source adds the extra complications of fuel gas supply systems and the associated IGF code (IMO, 2015). Land transportation of methane is well established within existing distribution pipelines, but it is currently more difficult to get it to vessels. Early adopters of LNG fuel had to rely on fleets of trucks carrying the fuel to piers, but more recently there is a relative boom in the construction and deployment of LNG bunkering vessels and barges which handle the last leg of the distribution of LNG from shore to ship. Ammonia does not have as well established a distribution network as methane, and so substantial efforts will need to be made to build the associated pipelines to bring them to piers and vessels, and current distribution networks would rely on trucks. There are currently no ammonia bunkering vessels in operation, only a recent approval in principle (Sumitomo Corp. *et al.*, 2024). Similarly, methanol does not have a well-established distribution network like fuel oil or natural gas, but does have bunkering vessels already in service (Port of Amsterdam, 2025), and is somewhat easier to transport due to it being a liquid at ambient temperatures and pressures. Finally, hydrogen remains one of the most challenging fuels to distribute for similar reasons it is difficult to store, and again, widespread distribution networks for hydrogen do not yet exist.

The infrastructure and availability barriers of alternative fuels remain a substantial challenge for decarbonizing the world fleet. The world's energy production will need to be substantially improved to produce alternative fuels with low well-to-tank emission factors. Substantial investment will be required in production facilities for alternative fuels, and associated distribution networks will need to be put into place. All of this adds to the economic penalties associated with alternative fuels.

12. Recommendations for Future Work

While quite a large amount of research was conducted in the execution of this project, there were several areas where extra research would be beneficial.

The initial intent of the project was to investigate a representative cross-section of the world fleet using the proposed methodology, rather than just carrying out a single case study. The study could be expanded to look at additional containership sizes and ship

types. It was noted that the ultra-large container carrier used as the case study vessel ended up being limited in its total loadable capacity by a few factors, and though adoption of alternative fuels did negatively impact its carrying capacity, this was muted by the sheer size of the vessel. Losing ~1,000 TEU on a 24,000 TEU vessel represents a much smaller portion of its maximum cargo capacity than on a smaller containership, and a portion of the container slot capacity was identified as situationally useful due to stack weight or stability concerns anyway. Similarly, it would be interesting to see if similar trends and impacts apply to bulk carriers and oil tankers, with completely different internal hull layouts and considerations with regards to where the alternative fuel tanks could be located and the associated cargo impacts.

The research also initially intended to use the ReCiPe midpoint and endpoint indicators coupled with the Ecolnvent database to perform the lifecycle assessment. This would allow for more emissions to be inventoried and a more environmental impacts to be assessed. Limitations of the methodologies implemented and time constraints required a focus on CO_{2Eq} emissions as a measure of Global Warming Potential Instead. However, there is no reason the model can't be expanded to include some additional emissions and impact indicators, which are likely to emphasize the shipbuilding, maintenance, and scrapping phases, especially with regards to the impact of local pollutants such as particulate matter and volatile organic compounds.

It is noted that some limitations in the shipbuilding, maintenance, and scrapping methodologies prevented detailed inventories from being developed. Some additional research into the existing methodologies could be carried out to refine these such that a more in-depth emissions inventory could be generated. For example, it is acknowledged that assuming the entire lightweight of the vessel is steel excludes a large number of potential process flows from crossing the system boundary, such as those associated with the manufacture and testing of machinery, the propeller, and the electrical system. Assuming the hull is entirely steel is underestimating the total emissions, because the raw steel is in reality used as the input into a different process flow that is ultimately converted into a piece of machinery, with potentially substantial associated emissions over and above the production of raw steel. Similarly, painting emissions are only tallied from the application process, but the entire lifecycle of the paint production and transport should also be considered.

There are also some weaknesses in the methodologies used to estimate welding length and painting area. The welding length estimate is approximate, and confidence in the figure presented in the case study is only possible because the final valued could be calibrated based on a corresponding estimate from Gilbert (2017) for a similar sized vessel. The calculation of the total area for painting and blasting was extremely time-intensive, requiring a 3D model of the ship's primary and secondary structure to be produced so areas could be extracted. A much simpler method for estimating these areas should be developed, but one that is more accurate than the Transocean coatings (2022) method which is believed to have been misapplied by Gilbert (2017) and Dong and Cai (2019). Furthermore, it is technically assumed that only one layer of paint is applied, when in reality several layers of paint would be applied depending on the vessel's painting specification.

One of the other major weaknesses in the proposed methodology is in the handling of boil-off-gas from the cryogenic alternative fuels. The current method favours tanks based on volume and does not consider pressure build-up. The methodology can be expanded during the tank sizing phase to consider the expected amount of time near port and associated pressure build-up from boil off gas. This would allow a decision to be made regarding reliquification energy vs. being able to let the pressure build, which in turn would allow type C tanks to be viable options for LNG and Ammonia.

Finally, it is expected that some data sources will improve in the near future. IMO is developing standardized Well-to-Tank emission factors, and these should be implemented when they are available. Additional sources of fuel and associated Well-to-Tank emission factors can also be investigated over and above what was examined in this report. For example, the Well-to-Tank emissions factors of blue hydrogen, ammonia, and methanol can be considered, as well as E-methanol and E-ammonia as green or orange fuels (i.e. derived either wholly or partially from electricity produced from renewables). This would provide a more complete spectrum of emission abatement options available and their associated impact, and if coupled with an economic analysis considering the cost of the fuels, their GWP abatement potential, and scenarios considering the increasing use of renewable energy in the world's electricity supply, may yield interesting optimal solutions for the future development and implementation of green fuels.

Similarly, engine manufacturers are working on Ammonia fuelled low speed diesels and will be publishing the relevant fuel and pilot oil consumption data. The fuel consumption data in this methodology should be refined once that data is available.

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14. Appendix A – Case Study Detailed Parent Ship Design Data

14.1. Lightship Weight Breakdown

14.1.1. Total Lightship Weight and Weight Block List

Table 130: Lightweight Breakdown by Group

Groups	Weight	% Of total
-	MT	%
Steel Weight	51,080	76%
Hull Outfit	1,542	2%
Accom. Outfit	632	1%
Cargo Outfit	8,951	13%
Machinery	4,795	7%
Total	67,000	

Table 131: Lightweight Blocks

Item	Weight	LCG	TCG	VCG	Aft Extent	Fwd Extent
-	MT	m-AP	m-CL	m-BL	m-AP	m-AP
Stern-ER Aft	2,973.0	14.15	0	19.7	-6	32.11
ER Aft to ER Fwd	4,879.0	55.65	0	19.7	32.11	76.8
ER-Fwd to Midships	5,724.0	98.75	0	19.7	76.8	120.15
Midships	17,874.0	185.175	0	19.7	120.15	250.2
Midships-Fwd 1	8,304.0	281.18	0	19.7	250.2	313
Fwd 1-Fwd 2	4,884.0	335.4	0	19.7	313	362.65
Fwd 2-Bow	1,302.0	375.2	0	19.7	362.65	400
Main Engine	2,273.1	54.332	0	8.132	43.9	64.2
Engine Foundation	67.0	54.332	0	2.7	43.9	64.2
Aux DG	503.2	69.6	0	18.8	66	73.2
Machinery Misc.	1,623.0	59.35	0	18.8	36.65	73.2
Prop Shaft	243.6	26.08	0	5.6	8.245	43
Propeller	152.0	7.2448	0	5.6	6.245	8.245
Hatch Coaming Aft	323.0	30.35	0	34.5	9.6	51.1
Hatch Coaming Mid	1,548.0	157.2	0	34.5	62.35	252.05
Hatch Coaming Fwd	864.0	315.1	0	34.5	264.05	367.65
Casing Aft	499.0	58.6	0	50	54.85	62.35
Accommodation Fwd	1,046.0	258	0	50.5	252.05	264.05
Accommodation Outfitting	632.0	258	0	40	252.05	264.05
Mooring Aft	300.0	1.8	0	26.8	-6	9.6
Mooring And Anchors Fwd	1,242.0	377.8	0	29	367.65	400
Paint	793.1	190	0	21	-6	400
LB1	61.6	366.725	0	42.4	365.8	367.65
LB2	84.0	352.275	0	42.4	351.35	353.2
LB3	84.0	337.825	0	42.4	336.9	338.75
LB4	84.0	323.375	0	42.4	322.45	324.3
LB5	100.8	308.925	0	42.4	308	309.85
LB6	100.8	294.475	0	42.4	293.55	295.4
LB7	100.8	280.025	0	42.4	279.1	280.95
LB8	100.8	265.275	0	42.4	264.35	266.2
LB9	100.8	251.125	0	42.4	250.2	252.05
LB10	100.8	236.675	0	42.4	235.75	237.6
LB11	100.8	222.225	0	42.4	221.3	223.15
LB12	100.8	207.775	0	42.4	206.85	208.7
LB13	100.8	193.325	0	42.4	192.4	194.25
LB14	100.8	178.875	0	42.4	177.95	179.8
LB15	100.8	164.425	0	42.4	163.5	165.35
LB16	100.8	149.975	0	42.4	149.05	150.9
LB17	100.8	135.525	0	42.4	134.6	136.45
LB18	100.8	121.075	0	42.4	120.15	122

Item	Weight	LCG	TCG	VCG	Aft Extent	Fwd Extent
-	MT	m-AP	m-CL	m-BL	m-AP	m-AP
LB19	100.8	106.625	0	42.4	105.7	107.55
LB20	100.8	92.175	0	42.4	91.25	93.1
LB21	100.8	77.725	0	42.4	76.8	78.65
LB22	100.8	63.275	0	42.4	62.35	64.2
LB23	100.8	52.225	0	42.4	51.3	53.15
LB24	100.8	37.575	0	42.4	36.65	38.5
LB25	100.8	23.125	0	42.4	22.2	24.05
LB26	100.8	8	0	42.4	7.075	8.925
LB27	100.8	-4.875	0	42.4	-5.8	-3.95
H1F	156.6	359.5	0	35	353.2	365.8
H1M	182.7	345.05	0	35	338.75	351.35
H1A	191.4	330.6	0	35	324.3	336.9
H2F	191.4	316.15	0	35	309.85	322.45
H2A	191.4	301.7	0	35	295.4	308
H3F	191.4	287.25	0	35	280.95	293.55
H3A	191.4	272.8	0	35	266.5	279.1
H4F	191.4	243.9	0	35	237.6	250.2
H4A	191.4	229.45	0	35	223.15	235.75
H5F	191.4	215	0	35	208.7	221.3
H5A	191.4	200.55	0	35	194.25	206.85
H6F	191.4	186.1	0	35	179.8	192.4
H6A	191.4	171.65	0	35	165.35	177.95
H7F	191.4	157.2	0	35	150.9	163.5
H7A	191.4	142.75	0	35	136.45	149.05
H8F	191.4	128.3	0	35	122	134.6
H8A	191.4	113.85	0	35	107.55	120.15
H9F	191.4	99.4	0	35	93.1	105.7
H9A	191.4	84.95	0	35	78.65	91.25
H10	191.4	70.5	0	35	64.2	76.8
H11F	191.4	44.8	0	35	38.5	51.1
H11M	191.4	30.35	0	35	24.05	36.65
H11A	191.4	15.9	0	35	9.6	22.2
CG Bay 2F	16.4	364.8	0	26.03	364.55	365.05
CG Bay 2A	16.4	352.2	0	26.03	351.95	352.45
CG Bay 6F	28.8	350.35	0	21.97	350.1	350.6
CG Bay 6A	28.8	337.75	0	21.97	337.5	338
CG Bay 10F	35.6	335.9	0	21.41	335.65	336.15
CG Bay 10A	35.6	323.3	0	21.41	323.05	323.55
CG Bay 14F	42.9	321.45	0	20.145	321.2	321.7
CG Bay 14A	47.5	308.85	0	19.248	308.6	309.1
CG Bay 18F	47.5	307	0	19.248	306.75	307.25
CG Bay 18A	48.7	294.4	0	18.993	294.15	294.65
CG Bay 22F	48.7	292.55	0	18.993	292.3	292.8
CG Bay 22A	50.6	279.95	0	18.6	279.7	280.2
CG Bay 26F	50.6	278.1	0	18.6	277.85	278.35
CG Bay 26A	51.8	265.5	0	20.197	265.25	265.75
CG Bay 30F	51.8	249.2	0	20.197	248.95	249.45
CG Bay 30A	51.8	236.6	0	20.197	236.35	236.85
CG Bay 34F	51.8	234.75	0	20.197	234.5	235

Item	Weight	LCG	TCG	VCG	Aft Extent	Fwd Extent
-	MT	m-AP	m-CL	m-BL	m-AP	m-AP
CG Bay 34A	51.8	222.15	0	20.197	221.9	222.4
CG Bay 38F	51.8	220.3	0	20.197	220.05	220.55
CG Bay 38A	51.8	207.7	0	20.197	207.45	207.95
CG Bay 42F	51.8	205.85	0	20.197	205.6	206.1
CG Bay 42A	51.8	193.25	0	20.197	193	193.5
CG Bay 46F	51.8	191.4	0	20.197	191.15	191.65
CG Bay 46A	51.8	178.8	0	20.197	178.55	179.05
CG Bay 50F	51.8	176.95	0	20.197	176.7	177.2
CG Bay 50A	51.8	164.35	0	20.197	164.1	164.6
CG Bay 54F	51.8	162.5	0	20.197	162.25	162.75
CG Bay 54A	51.8	149.9	0	20.197	149.65	150.15
CG Bay 58F	51.8	148.05	0	20.197	147.8	148.3
CG Bay 58A	51.8	135.45	0	20.197	135.2	135.7
CG Bay 62F	51.8	133.6	0	20.197	133.35	133.85
CG Bay 62A	51.8	121	0	20.197	120.75	121.25
CG Bay 66F	51.8	119.15	0	20.197	118.9	119.4
CG Bay 66A	51.8	106.55	0	20.197	106.3	106.8
CG Bay 70F	50.5	104.7	0	20.544	104.45	104.95
CG Bay 70A	50.5	92.1	0	20.544	91.85	92.35
CG Bay 74F	46.8	90.25	0	21.471	90	90.5
CG Bay 74A	46.8	77.65	0	21.471	77.4	77.9
CG Bay 78F	12.9	75.8	0	31.622	75.55	76.05
CG Bay 78A	12.9	63.2	0	31.622	62.95	63.45
CG Bay 82F	23.4	50.1	0	28.425	49.85	50.35
CG Bay 82A	23.4	37.5	0	28.425	37.25	37.75
CG Bay 86F	28.6	35.65	0	26.914	35.4	35.9
CG Bay 86A	28.6	23.05	0	26.914	22.8	23.3
CG Bay 90F	25.0	21.2	0	27.969	20.95	21.45
CG Bay 90A	25.0	8.6	0	27.969	8.35	8.85
Totals	67,000	181.714	0	22.826		

14.1.2. Estimation of Specific Weight Block Items

Methods from Papanikolaou (2014) were used for the estimation of the following weight block items:

- Hull Steel Vertical Centre of Gravity
- Engine Foundation
- Hatch Coaming Weight
- Accommodation Outfitting Weight
- Mooring and Anchoring Weights (divided fore- and aft-)
- Miscellaneous Engine Room Machinery
- Propeller Shaft Weight
- Propeller Weight
- Accommodation Forward Structure
- Accommodation Aft Structure

Approximation of Outfitting Weight

2.15.5/B

$$W_{OT} = K_{OT} \cdot L \cdot B$$

$$K_{OT} (t/m^2) \quad 0.34$$

$$W_{OT} = 8171.56$$

Approximation of Paint Weight

2.15.5/Table 2.32

Group II₂, Cargo Weight Coefficient (4-7)

4

Based on Strohnbusch

$$\text{Weight Paint} = 3172.488$$

Not used - too high

Approximation of Accommodation Outfitting Weight

2.15.5/III Page 229

$$W_{accom} = 40 \text{ kg/m}^3$$

$$\text{Accommodation Volume (m}^3\text{)} \quad 15798.4$$

$$W_{accom} \text{ (MT)} \quad 632$$

CG Located at center of accommodation block forward

Anchors, Mooring, Misc. Outfitting

2.15.5/IV Page 229

$$W_{out} = (LBD)^{2/3} C_1$$

$$C_1 = 0.18 - 0.26$$

$$W_{out} \text{ (MT)} \quad 1542$$

Weight is divided with 300 MT aft and remaining forward. Extra weight forward for anchors and chains

Machinery, Overall Estimate

2.15.6

Watson-Gilfillan Method

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$$W_M = C_{MD} \cdot P_B^{0.89}$$

$$C_{MD} = 0.3 - 0.5 \quad 0.5$$

$$W_M \text{ (MT)} \quad 9670$$

$$W_{MM} = 12 \cdot \text{MCR/RPM}$$

2.15.6/D

$$W_{MM} \text{ (MT)} \quad 9825$$

Too high! Larger than total machinery weight

$$W_{MRest} = C_M (\text{MCR})^{0.70}$$

$$C_M = 0.69$$

Containerships

$$W_{MRest} \text{ (MT)} \quad 1623$$

Used as Machinery Misc. Weight, located in aft ER area

Schneecluth Method

2.15.6/E

Propeller Shaft Weight

$$d_s = 0.115 \cdot (0.99 \cdot \text{MCR/N})^{1/3}$$

$$d_s \text{ (m)} \quad 1.07$$

$$W_{SH} = 0.081 \cdot (0.99 \cdot \text{MCR/N})^{2/3} \cdot L_{SH}$$

$$L_{SH} \text{ (m)} \quad 34.6$$

$$W_{SH} = 243.64$$

Located at CG of propeller Shaft from model

Propeller Weight

$$W_{PR} = K_P D_P^3$$

$$K_P = d_s / D_P \cdot (1.85 \cdot A_E / A_O - (z-2)/10)$$

$$D_P \text{ (m)} \quad 10.4$$

$$A_E / A_O \quad 0.87$$

$$Z \quad 5$$

$$K_P \quad 0.14$$

$$W_{PR} \text{ (MT)} \quad 152$$

Located at CG of propeller from model

$$W_{PR} = D_P^2 \cdot d_s (A_E / A_O + 0.2) K_P'$$

E. Strohnbusch 1971

$$K_P' (1.2-1.3) \quad 1.2$$

$$W_{PR} \text{ (MT)} \quad 149$$

From 3D Model

$$\text{Rho Mn-Bz} = 7.7 \text{ MT/m}^3$$

$$\text{Volume} = 18.60909 \text{ m}^3$$

$$\text{Weight} = 143.29$$

Other Weights

$$W_{mach, Other} = 40 \text{ to } 70 \text{ kg} \cdot \text{MCR} \quad 0.04$$

$$W_{mach, Other} \text{ (MT)} \quad 2620$$

Propeller Shaft by IACS UR M68.4

$$d_{min} = F \cdot K \cdot ((P/N_O) \cdot 1 / (1 - (d_i^4 / d_o^4) \cdot 560 / (\sigma_{g8} + 160)))^{1/3}$$

$$F \quad 100$$

$$K \quad 1.22$$

Table 5 Keyless Taper fitted propellers

$$\sigma_{g8} \text{ (MPa)} \quad 760$$

IACS UR M68.3

$$d_i \text{ (mm)} \quad 1.918$$

$$d_o \text{ (mm)} \quad 2.318$$

$$d_i / d_o \quad 0.83$$

$$1 - d_i^4 / d_o^4 \quad 0.53$$

$$d_{min} \text{ (mm)} \quad 1190$$

Papanikolaou 2014 Ship Design Methodologies of Preliminary Design

Weight of Superstructure and Deckhouses by Mueller Koester 1973, Journal Hansa, Schneekluth 1985

For weight of Accommodation/Wheelhouse Forward

 C_{DH} Factor, kg/m³

Layer	1	2	3	4	Wheelhouse
A_u/A_u					
1	57	55	52	53	40
1.25	64	63	59	60	45
1.5	71	70	65	66	50
1.75	78	77	72	73	55
2	86	84	78	80	60
2.25	93	91	85	86	65
2.5	100	98	91	93	70

Layer	A_u	A_v	A_u/A_u	A_m	h	l_{dk}	w_{dk}	l_i	k_1	k_2	k_3	C_{DH}	W_{DH}	Layer	Ao/Au lookup
1	428.28	732	1.709162	580.14	3.2	12	35.69	54	1.012	1	1	78	146541	1	1.75
2	732	732	1	732	3.2	12	35.69	54	1.012	1	1	55	130378	2	1
3	732	670.2	0.915574	701.1	3.2	12	35.69	54	1.012	1	1	52	118063	3	1
4	670.2	428.28	0.639033	549.24	2.9	12	35.69	54	1.006	1	1	53	84925	4	1
5	428.28	428.28	1	428.28	2.9	12	35.69	54	1.006	1	1	53	66222	4	1
6	428.28	428.28	1	428.28	2.9	12	35.69	54	1.006	1	1	53	66222	4	1
7	428.28	428.28	1	428.28	2.9	12	35.69	54	1.006	1	1	53	66222	4	1
8	428.28	428.28	1	428.28	2.9	12	35.69	54	1.006	1	1	53	66222	4	1
9	428.28	428.28	1	428.28	2.9	12	35.69	54	1.006	1	1	53	66222	4	1
10	428.28	428.28	1	428.28	2.9	12	35.69	54	1.006	1	1	53	66222	4	1
11	428.28	428.28	1	428.28	2.9	12	35.69	54	1.006	1	1	53	66222	4	1
12	428.28	428.28	1	428.28	2.9	12	35.69	54	1.006	1	1	53	66222	4	1
WH	428.28	189.78	0.443121	309.03	2.9	12	35.69	54	1.006	1	1	40	36063	#wheelhouse	1
Total					38.6									1046	

 Z_{DH} = 29.336 m-deck (0.76*total height) A_u = Area at deckhouse deck A_v = Area at deckhouse deckhead including platforms A_m = 0.5*(A_u + A_v)

h = deck height

 l_{dk} = deck length w_{dk} = width of deck enclosed l_i = internal length of structural bulkheads, considered standard 4.5 * L_{DH} k_1 = 1+0.02*(h-2.6) k_2 = 1+0.05*(4.5- l_i/l_{dk}) k_3 = 1

Unusual configuration, but split deckhouse means deckhouse isn't too long

 W_{DH} = C_{DH} * A_m *h* k_1 * k_2 * k_3

Papanikolaou 2014 Ship Design Methodologies of Preliminary Design

Weight of Superstructure and Deckhouses by Mueller Koester 1973, Journal Hansa, Schneekluth 1985

For Weight of Aft Machinery Casing

 C_{DH} Factor, kg/m³

Layer	1	2	3	4	Wheelhouse
A_u/A_u					
1	57	55	52	53	40
1.25	64	63	59	60	45
1.5	71	70	65	66	50
1.75	78	77	72	73	55
2	86	84	78	80	60
2.25	93	91	85	86	65
2.5	100	98	91	93	70

Layer	A_u	A_o	A_u/A_u	A_m	h	l_{dk}	w_{dk}	l_i	k_1	k_2	k_3	C_{DH}	W_{DH}	Layer	Ao/Au lookup
1	190	475.5	2.502632	332.75	3.7	7.5	25.405	33.75	1.022	1	1	100	125826	1	2.5
2	475.5	475.5	1	475.5	3.5	7.5	25.405	33.75	1.018	1	1	55	93181	2	1
3	475.5	190	0.399579	332.75	3.5	7.5	25.405	33.75	1.018	1	1	52	61651	3	1
4	190	190	1	190	2.9	7.5	25.405	33.75	1.006	1	1	53	29378	4	1
5	190	190	1	190	2.9	7.5	25.405	33.75	1.006	1	1	53	29378	4	1
6	190	165.3	0.87	177.65	2.9	7.5	25.405	33.75	1.006	1	1	53	27469	4	1
7	165.3	140.1	0.84755	152.7	2.9	7.5	22.045	33.75	1.006	1	1	53	23611	4	1
8	140.1	114.9	0.820128	127.5	2.9	7.5	18.685	33.75	1.006	1	1	53	19714	4	1
9	114.9	114.9	1	114.9	2.9	7.5	15.325	33.75	1.006	1	1	53	17766	4	1
10	114.9	114.9	1	114.9	2.9	7.5	15.325	33.75	1.006	1	1	53	17766	4	1
11	114.9	114.9	1	114.9	2.9	7.5	15.325	33.75	1.006	1	1	53	17766	4	1
12	114.9	114.9	1	114.9	2.9	7.5	15.325	33.75	1.006	1	1	53	17766	4	1
13	114.9	114.9	1	114.9	2.9	7.5	15.325	33.75	1.006	1	1	53	17766	4	1
Total					39.7								499		

 Z_{DH} = 30.172 m-deck (0.76*total height) A_u = Area at deckhouse deck A_o = Area at deckhouse deckhead including platforms A_m = $0.5 \cdot (A_o + A_u)$

h = deck height

 l_{dh} = deck length w_{dk} = width of deck enclosed l_i = internal length of structural bulkheads, considered standard $4.5 \cdot L_{DH}$ $k_1 = 1 + 0.02 \cdot (h - 2.6)$ $k_2 = 1 + 0.05 \cdot (4.5 - l_i / l_{dh})$ $k_3 = 1$

Unusual configuration, but split deckhouse means deckhouse isn't too long

 $W_{DH} = C_{DH} \cdot A_m \cdot h \cdot k_1 \cdot k_2 \cdot k_3$ *Paint Weight*

The weight of paint was estimated by multiplying the length, beam, and depth of the vessel by a coefficient of 0.001. This is similar to the Strohbush method (2.15.5/Table 2.32 (Papanikolaou, 2014)) but with a much lower coefficient. The Strohbush method yielded a paint weight of approximately 3,200 MT which was judged too high. This method yielded a paint weight of 793 MT, which is approximately 1.2% of the total lightweight. Examination of other industry lightweight estimates showed that a paint/LBD ratio of between 0.0008-0.0013 was not uncommon in first-stage estimates.

Main and Auxiliary Engines

Main and auxiliary engine weights are taken directly from the MAN project guides.

Table 132: Main Engine Weights

11G95ME-C10.6		65500	kW
Mass of Engine		2246	MT
Mass of Working Fluids		27.1	MT

Table 133: Auxiliary Engine Weights

Power	Number	Model	Weight
kW	#	-	MT
4320	2	MAN 9L32/40	85.8
3840	4	MAN 8L32/40	81.8

Hatch Covers

The weight of the containership hatch covers was determined by examining the hatch cover weights from several containerships where hatch cover weight vendor data was available. The weights of the hatch covers were normalized by a weight of hatch per container stack carried. Ultimately, a weight per stack of 8.7 MT hatch cover weight per stack supported was selected based on scaling the vendor data by the increase in expected stack weights from a higher number of tiers.

Table 134: Hatch Cover Weights – by Size

8.7 MT/Stack

Hatch Designation	Number	Rows	Tiers	Weight	Weight/Cover
-	#	#	#	MT	MT
HC1FP&S	2	6	9	104.4	52.2
HC1FC	1	6	9	52.2	52.2
HC1MP&S	2	6	10	104.4	52.2
HC1MC	1	9	10	78.3	78.3
OTHER P&S	42	6	13	2192.4	52.2
OTHER CP&S	42	5	13	1827	43.5
Total				4358.7	MT

Table 135: Hatch Cover Weights – by Hold and Location

Name	Weight	LCG	Aft	Fwd
-	MT	m-AP	m-AP	m-AP
H1F	156.6	359.50	353.2	365.8
H1M	182.7	345.05	338.75	351.35
H1A	191.4	330.60	324.3	336.9
H2F	191.4	316.15	309.85	322.45
H2A	191.4	301.70	295.4	308
H3F	191.4	287.25	280.95	293.55
H3A	191.4	272.80	266.5	279.1
H4F	191.4	243.90	237.6	250.2
H4A	191.4	229.45	223.15	235.75
H5F	191.4	215.00	208.7	221.3
H5A	191.4	200.55	194.25	206.85
H6F	191.4	186.10	179.8	192.4
H6A	191.4	171.65	165.35	177.95
H7F	191.4	157.20	150.9	163.5
H7A	191.4	142.75	136.45	149.05
H8F	191.4	128.30	122	134.6
H8A	191.4	113.85	107.55	120.15
H9F	191.4	99.40	93.1	105.7
H9A	191.4	84.95	78.65	91.25
H10	191.4	70.50	64.2	76.8
H11F	191.4	44.80	38.5	51.1
H11M	191.4	30.35	24.05	36.65
H11A	191.4	15.90	9.6	22.2
	4358.7	187.36		

Lashing Bridges

Similar to the hatch covers, lashing bridge weights were estimated based on vendor data for existing containerhips and scaled by a factor related to the number of tiers and rows of containers high and wide the bridges were. From the vendor data, the weight of the lashing bridges per row-tier varied between 700-890 kg/row-tier, with higher lashing bridges tending toward the lighter end of the range. Therefore, a weight of 700 kg/Row-Tier was assumed to be applicable to the lashing bridge weights.

Table 136: Lashing Bridge Weights

Lashing Bridges

700 kg/(Row-Tier)

Name	Rows	Tiers	Weight	LCG	Aft	Fwd
-	#	#	MT	m-AP	m-AP	m-AP
LB1	22	4	61.6	366.725	365.8	367.65
LB2	24	5	84	352.275	351.35	353.2
LB3	24	5	84	337.825	336.9	338.75
LB4	24	5	84	323.375	322.45	324.3
LB5	24	6	100.8	308.925	308	309.85
LB6	24	6	100.8	294.475	293.55	295.4
LB7	24	6	100.8	280.025	279.1	280.95
LB8	24	6	100.8	265.275	264.35	266.2
LB9	24	6	100.8	251.125	250.2	252.05
LB10	24	6	100.8	236.675	235.75	237.6
LB11	24	6	100.8	222.225	221.3	223.15
LB12	24	6	100.8	207.775	206.85	208.7
LB13	24	6	100.8	193.325	192.4	194.25
LB14	24	6	100.8	178.875	177.95	179.8
LB15	24	6	100.8	164.425	163.5	165.35
LB16	24	6	100.8	149.975	149.05	150.9
LB17	24	6	100.8	135.525	134.6	136.45
LB18	24	6	100.8	121.075	120.15	122
LB19	24	6	100.8	106.625	105.7	107.55
LB20	24	6	100.8	92.175	91.25	93.1
LB21	24	6	100.8	77.725	76.8	78.65
LB22	24	6	100.8	63.275	62.35	64.2
LB23	24	6	100.8	52.225	51.3	53.15
LB24	24	6	100.8	37.575	36.65	38.5
LB25	24	6	100.8	23.125	22.2	24.05
LB26	24	6	100.8	8.000	7.075	8.925
LB27	24	6	100.8	-4.875	-5.8	-3.95
Total			2632	173.651		

Cell Guides

Two methods were used to estimate the weight of the cell guides. First, an estimated weight of 0.45 MT/hold slot was taken based on Papanikolaou (2014) table 2.26. With 4950 hold slots in this design, the estimated weight for cell guides came out to 2227.5 MT. However, cell guides are simple repeating structure, and so they were added to the 3D model, shown in Figure 80 and Figure 81. The weight and centre of gravity for the cell guides was then extracted from the 3D model directly, which provided an advantage over the Papanikolaou method in that their fore-aft extents and precise centre of gravity could be determined. The total weight was found to be 1961 MT when modelled directly, indicating that the Papanikolaou method is quite close. The connections from the cell guides to the bulkhead/mid-hold structure were not explicitly modelled, so this could potentially account for the weight difference, though such structure is also minor.

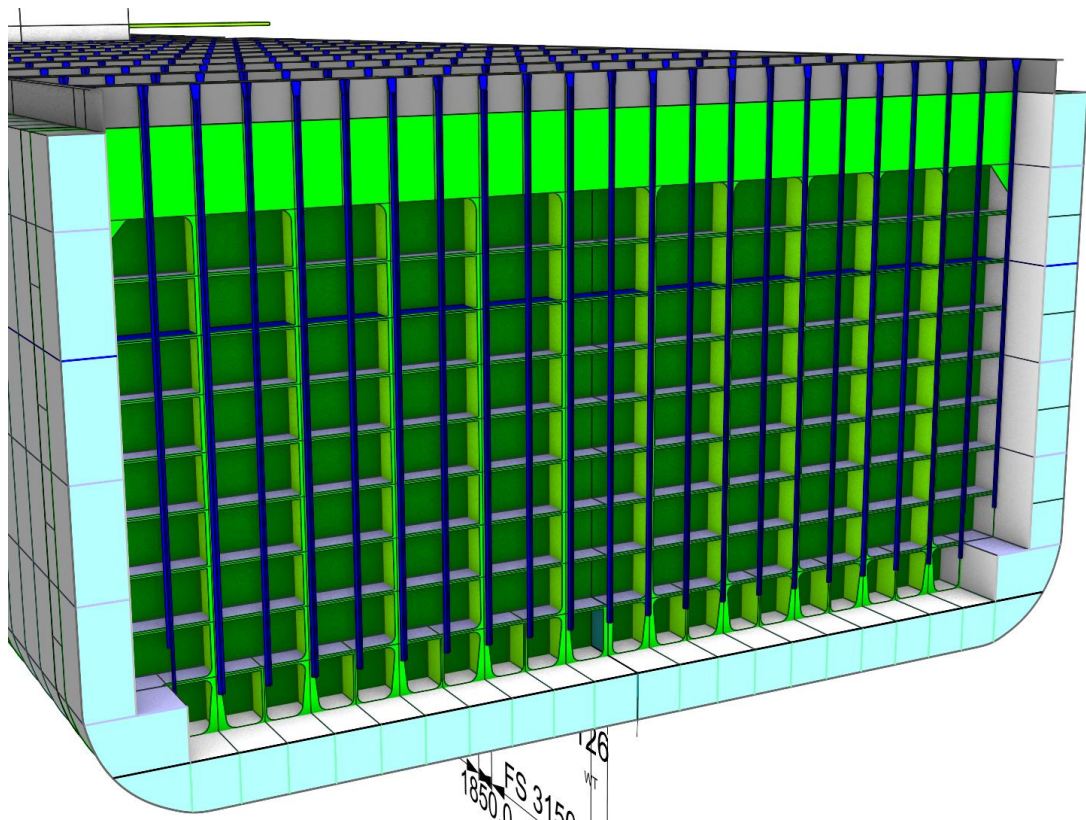


Figure 80: 3D Model showing Typical Hold Cell Guides

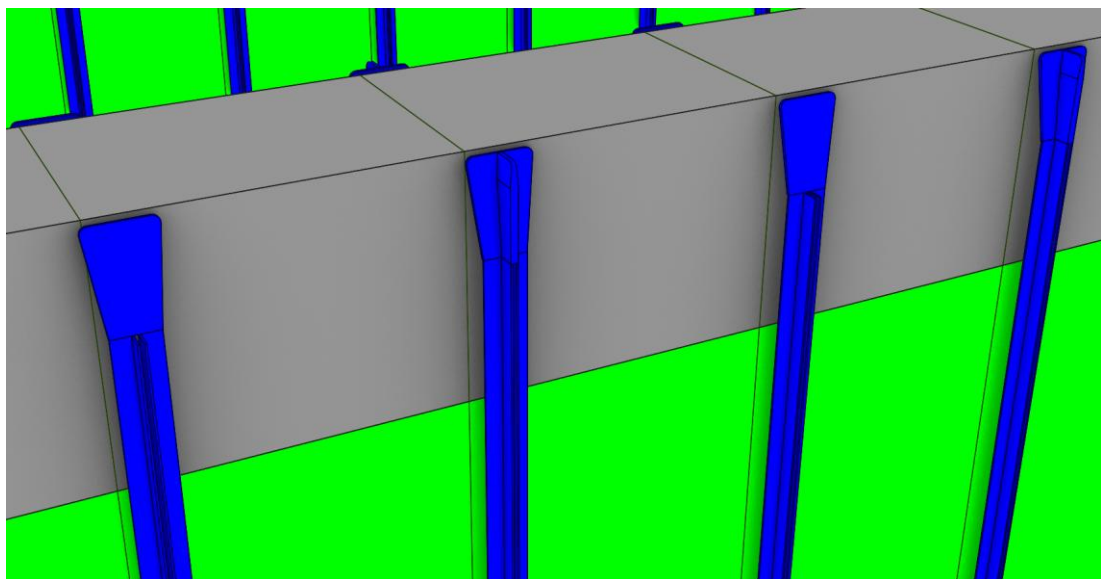


Figure 81: Close-Up Detail of Modelled Cell Guides

Table 137: Cell Guide Weight and Centre of Gravity Extracted from 3D Model

Cell Guides	Volume	Weight	LCG	Aft	Fwd	VCG	Slots
-	m ³	MT	m-AP	m-AP	m-AP	m-BL	
CG Bay 2F	1.822	16.4	364.8	364.55	365.05	26.03	90
CG Bay 2A	1.822	16.4	352.2	351.95	352.45	26.03	90
CG Bay 6F	3.19110577	28.8	350.35	350.1	350.6	21.97	144
CG Bay 6A	3.19110577	28.8	337.75	337.5	338	21.97	144
CG Bay 10F	3.945	35.6	335.9	335.65	336.15	21.41	190
CG Bay 10A	3.945	35.6	323.3	323.05	323.55	21.41	190
CG Bay 14F	4.7525	42.9	321.45	321.2	321.7	20.145	224
CG Bay 14A	5.263	47.5	308.85	308.6	309.1	19.248	224
CG Bay 18F	5.263	47.5	307	306.75	307.25	19.248	246
CG Bay 18A	5.3945	48.7	294.4	294.15	294.65	18.993	246
CG Bay 22F	5.3945	48.7	292.55	292.3	292.8	18.993	250
CG Bay 22A	5.6	50.6	279.95	279.7	280.2	18.6	250
CG Bay 26F	5.6	50.6	278.1	277.85	278.35	18.6	258
CG Bay 26A	5.7395	51.8	265.5	265.25	265.75	20.197	258
CG Bay 30F	5.7395	51.8	249.2	248.95	249.45	20.197	262
CG Bay 30A	5.7395	51.8	236.6	236.35	236.85	20.197	262
CG Bay 34F	5.7395	51.8	234.75	234.5	235	20.197	262
CG Bay 34A	5.7395	51.8	222.15	221.9	222.4	20.197	262
CG Bay 38F	5.7395	51.8	220.3	220.05	220.55	20.197	262
CG Bay 38A	5.7395	51.8	207.7	207.45	207.95	20.197	262
CG Bay 42F	5.7395	51.8	205.85	205.6	206.1	20.197	262
CG Bay 42A	5.7395	51.8	193.25	193	193.5	20.197	262
CG Bay 46F	5.7395	51.8	191.4	191.15	191.65	20.197	262
CG Bay 46A	5.7395	51.8	178.8	178.55	179.05	20.197	262
CG Bay 50F	5.7395	51.8	176.95	176.7	177.2	20.197	262
CG Bay 50A	5.7395	51.8	164.35	164.1	164.6	20.197	262
CG Bay 54F	5.7395	51.8	162.5	162.25	162.75	20.197	262
CG Bay 54A	5.7395	51.8	149.9	149.65	150.15	20.197	262
CG Bay 58F	5.7395	51.8	148.05	147.8	148.3	20.197	262
CG Bay 58A	5.7395	51.8	135.45	135.2	135.7	20.197	262
CG Bay 62F	5.7395	51.8	133.6	133.35	133.85	20.197	262
CG Bay 62A	5.7395	51.8	121	120.75	121.25	20.197	262
CG Bay 66F	5.7395	51.8	119.15	118.9	119.4	20.197	262
CG Bay 66A	5.7395	51.8	106.55	106.3	106.8	20.197	262
CG Bay 70F	5.591	50.5	104.7	104.45	104.95	20.544	256
CG Bay 70A	5.591	50.5	92.1	91.85	92.35	20.544	256
CG Bay 74F	5.1825	46.8	90.25	90	90.5	21.471	236
CG Bay 74A	5.1825	46.8	77.65	77.4	77.9	21.471	236
CG Bay 78F	1.4325	12.9	75.8	75.55	76.05	31.622	66
CG Bay 78A	1.4325	12.9	63.2	62.95	63.45	31.622	66
CG Bay 82F	2.596	23.4	50.1	49.85	50.35	28.425	114
CG Bay 82A	2.596	23.4	37.5	37.25	37.75	28.425	114
CG Bay 86F	3.16525	28.6	35.65	35.4	35.9	26.914	136
CG Bay 86A	3.16525	28.6	23.05	22.8	23.3	26.914	136
CG Bay 90F	2.769235	25.0	21.2	20.95	21.45	27.969	120
CG Bay 90A	2.769235	25.0	8.6	8.35	8.85	27.969	120
Total		1961	192.325			21.022	

Hull Steel Weight

The hull steel weight was calculated by subtracting each of the components explicitly calculated above from the total lightship weight which was determined through a regression. The hull steel weight was therefore 45,940 MT. This hull steel weight was then broken into 7 blocks. The weight per meter at the fore and aft end of block was assumed to be a fraction of the midships section weight per meter based on the hull-cross

sectional area of that section relative to midships. Trapezoidal integration was then carried out based on the start and end weight per meter values and the length of the block. This created a system where the total hull weight was dependent on the chosen midship weight per meter, which was then set so that the desired hull weight of 45,940 MT was obtained, at 137.4 MT per meter. The LCG of each weight block was chosen such that the weight blocks would smoothly transition. The weight blocks are shown in Table 138 and Figure 82

Table 138: Hull Steel Weight Blocks

Section Location	Area m ²	Fraction of MS	Location m-AP	Length m	Weight/m MT/m	Weight of Block MT	LCG m-AP
Stern	932.542	0.47	-6		64.4		
ER Aft	1328	0.67	32.11	38.11	91.7	2,973	14.150
ER Fwd	1835	0.92	76.8	44.69	126.7	4,879	55.650
Midships Start	1991	1.00	120.15	43.35	137.4	5,724	98.750
Midships End	1991	1.00	250.2	130.05	137.4	17,874	185.175
Fwd 1	1840	0.92	313	62.8	127.0	8,304	281.180
Fwd 2	1010	0.51	362.65	49.65	69.7	4,884	335.400
Forward End	0	0.00	400	37.35	0.0	1,302	375.200
Totals						45,940	188.290

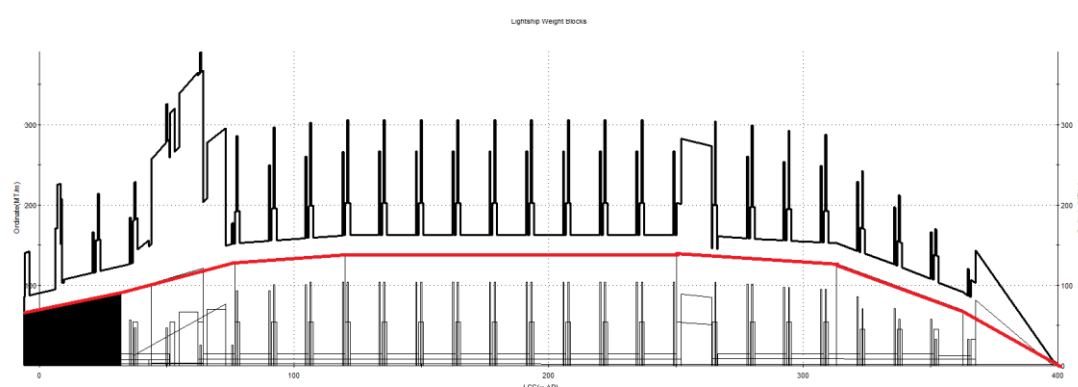


Figure 82: Lightweight Distribution with Hull Steel Blocks Highlighted

14.2. Compartmentation/ Tank List

Sea Water Ballast Tanks							
Tank Name	Density	Perm	Capacity	LCG	VCG	TCG	Slack FST
-	MT/m ³	-	m ³	m-AP	m-BL	m-CL	MT-m
1DBWBT	1.025	0.98	2,693	334.983	2.73	0.007P	54,908
1 WWBT P	1.025	0.98	4,837	342.216	15.128	17.292P	12,603
1 WWBT S	1.025	0.98	4,837	342.216	15.128	17.292S	12,603
2DBWBT P	1.025	0.98	1,918	307.118	2.446	14.123P	20,165
2DBWBTS	1.025	0.98	1,918	307.118	2.446	14.123S	20,165
2WWBT P	1.025	0.98	2,173	308.802	12.992	26.288P	1,899
2WWBT S	1.025	0.98	2,173	308.802	12.992	26.288S	1,899
3DBWBT P	1.025	0.98	2,316	278.621	2.112	16.734P	38,040
3DBWBT S	1.025	0.98	2,316	278.621	2.112	16.734S	38,040
3WWBT P	1.025	0.98	1,668	279.567	12.831	28.397P	760
3WWBT S	1.025	0.98	1,668	279.567	12.831	28.397S	760
4DBWBT P	1.025	0.98	2,406	236.619	1.847	17.178P	47,553
4DBWBT S	1.025	0.98	2,406	236.619	1.847	17.178S	47,553
4WWBT P	1.025	0.98	1,346	236.676	14.285	29.211P	45
4WWBT S	1.025	0.98	1,346	236.676	14.285	29.211S	45
5DBWBT P	1.025	0.98	2,278	206.849	1.848	17.258P	45,266
5DBWBT S	1.025	0.98	2,278	206.849	1.848	17.258S	45,266
5WWBT S	1.025	0.98	1,265	206.85	14.284	29.210S	42
5WWBT P	1.025	0.98	1,265	206.85	14.284	29.210P	42
6DBWBT P	1.025	0.98	2,279	177.95	1.848	17.259P	45,271
6DBWBT S	1.025	0.98	2,279	177.95	1.848	17.259S	45,271
6WWBT HEEL P	1.025	0.98	1,265	177.95	14.284	29.210P	42
6WWBT HEEL S	1.025	0.98	1,265	177.95	14.284	29.210S	42
7DBWBT P	1.025	0.98	2,277	149.057	1.848	17.251P	45,214
7DBWBT S	1.025	0.98	2,277	149.057	1.848	17.251S	45,214
7WWBT P	1.025	0.98	1,265	149.05	14.284	29.210P	42
7WWBT S	1.025	0.98	1,265	149.05	14.284	29.210S	42
8DBWBT P	1.025	0.98	2,216	120.317	1.846	16.971P	43,199
8DBWBT S	1.025	0.98	2,216	120.317	1.846	16.971S	43,199
8WWBT P	1.025	0.98	1,263	120.163	14.296	29.209P	42
8WWBT S	1.025	0.98	1,263	120.163	14.296	29.209S	42
9DBWBT P	1.025	0.98	2,199	92.012	2.464	15.367P	27,701
9DBWBT S	1.025	0.98	2,199	92.012	2.464	15.367S	27,701
9WWBT P	1.025	0.98	1,887	89.909	12.247	27.067P	3,126
9WWBT S	1.025	0.98	1,887	89.909	12.247	27.067S	3,126
10DBWBT P	1.025	0.98	4,871	32.84	16.254	20.288P	22,967
10DBWBT S	1.025	0.98	4,871	32.84	16.254	20.288S	22,967

Fuel Oil Tanks							
Tank Name	Density	Perm	Capacity	LCG	VCG	TCG	Slack FST
-	MT/m ³	-	m ³	m-AP	m-BL	m-CL	MT-m
ULHFO 1 P	0.98	0.98	1,201	258.05	13.246	23.965P	425
ULHFO 1 S	0.98	0.98	1,201	258.05	13.246	23.965S	425
ULHFO 2P	0.98	0.98	1,544	258.05	11.385	16.585P	425
ULHFO 2S	0.98	0.98	1,544	258.05	11.385	16.585S	425
HFO OVERFLOW TANK	0.98	0.98	357	258.05	18.623	0.000S	1,136
NO 1 HFO SETT TK	0.98	0.98	140	74.1	21.118	14.485P	11
NO 2 HFO SETT TK	0.98	0.98	140	74.1	21.118	24.565P	11
NO 1 HFO SERV TK	0.98	0.98	140	74.1	21.118	17.845P	11
NO 2 HFO SERV TK	0.98	0.98	140	74.1	21.118	21.205P	11

MGO Tanks							
Tank Name	Density	Perm	Capacity	LCG	VCG	TCG	Slack FST
-	MT/m ³	-	m ³	m-AP	m-BL	m-CL	MT-m
MGO 3P	0.86	0.98	1,544	258.05	11.385	9.025P	373
MGO 3S	0.86	0.98	1,544	258.05	11.385	9.025S	373
MGO 4C	0.86	0.98	1,786	258.05	9.938	0.000S	997
NO 1 MGO SETT TK	0.86	0.98	140	74.1	21.118	14.485S	9
NO 2 MGO SETT TK	0.86	0.98	140	74.1	21.118	17.845S	10
NO 1 MGO SERV TK	0.86	0.98	140	74.1	21.118	21.205S	10
NO 2 MGO SERV TK	0.86	0.98	140	74.1	21.118	24.565S	10

LO Tanks							
Tank Name	Density	Perm	Capacity	LCG	VCG	TCG	Slack FST
-	MT/m ³	-	m ³	m-AP	m-BL	m-CL	MT-m
ME LO SUMP	0.9	0.95	117	54.747	1.88	0.000P	66
ME LO STOR TK	0.9	0.98	110	62.525	21.118	24.968P	35
ME LO SETT TK	0.9	0.98	74	59.725	21.118	24.968P	35
SSDG LO STOR TK	0.9	0.98	74	57.475	21.133	24.968P	5
SSDG LO SETT TK	0.9	0.98	74	55.225	21.133	24.968P	5
NO 1 CYL OIL STOR TK	0.9	0.98	183	61.4	21.118	24.968S	22
NO 2 CYL OIL STOR TK	0.9	0.98	170	55.975	21.118	24.985S	21

Fresh Water Tanks							
Tank Name	Density	Perm	Capacity	LCG	VCG	TCG	Slack FST
-	MT/m ³	-	m ³	m-AP	m-BL	m-CL	MT-m
FWT P	1	0.98	275	62.003	20.07	29.212P	27
FWT S	1	0.98	275	62.003	20.07	29.212S	27

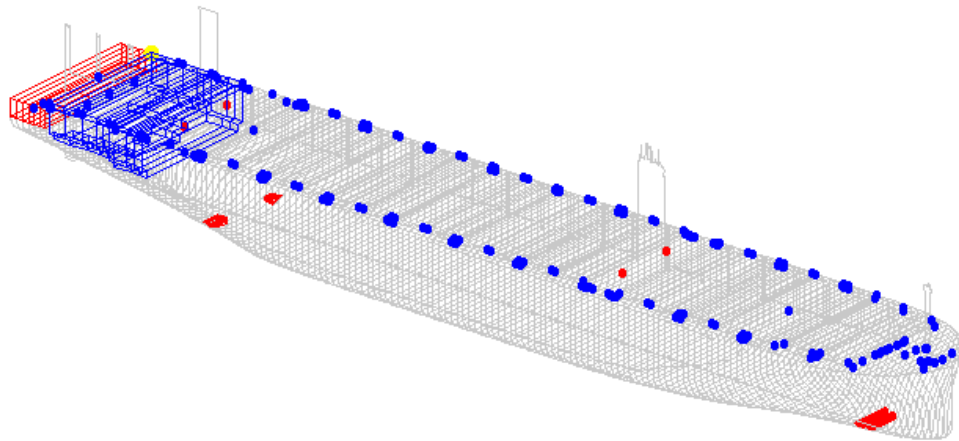
Misc. Tanks							
Tank Name	Density	Perm	Capacity	LCG	VCG	TCG	Slack FST
-	MT/m ³	-	m ³	m-AP	m-BL	m-CL	MT-m
ST CWT	1	0.98	140	15.463	5.548	0.000S	32
LO SLUDGE TANK	1	0.98	51	68.7	16.225	23.725P	58
HFO SLUDGE TANK	1	0.98	51	68.7	16.225	18.686P	58
WASTE OIL TANK	1	0.98	138	73.489	1.598	9.305S	691
EGR BLEED WATER TK	1	0.98	331	63.63	1.588	5.893P	1,459
GRAY WATER HOLDING TANK	1	0.98	177	58.227	1.623	4.856S	374
BILGE HOLDING TANK	1	0.98	158	29.403	1.71	0.000S	244

Cargo Holds						
Tank Name	Density	Perm	Capacity	LCG	VCG	TCG
-	MT/m ³	-	m ³	m-AP	m-BL	m-CL
HOLD 1	1.025	0.98	43,562	341.723	22.939	0.000P
HOLD 2	1.025	0.98	45,383	307.757	19.918	0.000S
HOLD 3	1.025	0.98	49,658	278.771	19.159	0.000P
HOLD 4	1.025	0.98	53,177	236.675	18.757	0.000P
HOLD 5	1.025	0.98	50,135	206.898	18.805	0.000P
HOLD 6	1.025	0.98	50,135	177.998	18.805	0.000P
HOLD 7	1.025	0.98	50,135	149.098	18.805	0.000P
HOLD 8	1.025	0.98	50,135	120.198	18.805	0.000P
HOLD 9	1.025	0.98	47,031	91.539	19.646	0.000S
HOLD 10	1.025	0.98	6,957	69.749	30.281	0.000S
HOLD 11	1.025	0.98	38,084	30.717	26.221	0.000P

Voids							
Tank Name	Density	Perm	Capacity	LCG	VCG	TCG	Slack FST
-	MT/m ³	-	m ³	m-AP	m-BL	m-CL	MT-m
FWD LOWER VOID	1.025	0.98	560	374.732	3.603	0.000S	1,242
FWD MID VOID F	1.025	0.98	1,173	382.706	12.1	0.000P	1,916
FWD MID VOID A	1.025	0.98	1,654	372.16	11.997	0.000S	6,652
FWD UPPER VOID	1.025	0.98	4,436	377.217	22.017	0.000P	52,464
1 LOWER VOID	1.025	0.98	362	358.575	1.431	0.000S	1,976
FUEL DB VOID P	1.025	0.98	1,082	258.023	2.206	17.800P	18,604
FUEL DB VOID S	1.025	0.98	1,082	258.023	2.206	17.800S	18,604
FUEL UPPER VOID	1.025	0.98	1,901	258.05	21.518	0.000P	140,559
FUEL WING VOID P	1.025	0.98	610	258.047	13.278	28.851P	135
FUEL WING VOID S	1.025	0.98	610	258.047	13.278	28.851S	135
AFT VOID	1.025	0.98	3,017	5.305	16.801	0.002P	104,863
ER VOID P	1.025	0.98	101	69.271	20.07	29.212P	10
ER VOID S	1.025	0.98	101	69.271	20.07	29.212S	10

Spaces							
Tank Name	Density	Perm	Capacity	LCG	VCG	TCG	Slack FST
-	MT/m ³	-	m ³	m-AP	m-BL	m-CL	MT-m
BOSUN STORE	1	0.7	4,053	377.886	29.727	0.001S	136,183
CHAIN LOCKERS	1	0.98	354	376.05	27.983	0.000S	244
BOW THRUSTER / EMRGY FP ROOM	1	0.6	1,509	358.8	7.536	0.000S	14,966
PIPE TUNNEL	1	0.98	3,539	199.595	1.351	0.000P	3,326
ACCOM MACHY	1	0.98	6,591	258.05	27.983	0.000P	174,875
SG ROOM	1	0.98	6,252	1.864	22.588	0.000S	280,410
ER	1	0.6	23,256	59.177	16.005	0.020S	485,872
ER DB	1	0.95	652	61.587	1.329	0.009P	5,369
PASSAGEWAY FWD P	1	0.98	4,211	322.162	27.722	26.726P	9,708
PASSAGEWAY FWD S	1	0.98	4,211	322.162	27.722	26.726S	9,708
PASSAGEWAY MID P	1	0.98	4,436	164.425	27.983	29.212P	250
PASSAGEWAY MID S	1	0.98	4,436	164.425	27.983	29.212S	250
PASSAGEWAY AFT P	1	0.98	1,701	43.205	27.984	29.212P	96
PASSAGEWAY AFT S	1	0.98	1,701	43.205	27.984	29.212S	96

14.3. Downflooding Points



No.	Name	Type	Comp	Long.	Vert.	Trans.
#	-	-	-	m-AP	m-BL	m-CL
1	HOLD 11 Hatch Aft Corner Aft-P	Weathertight	HOLD 11	9.6	34.9	27.925P
2	HOLD 11 Hatch Aft Corner Aft-S	Weathertight	HOLD 11	9.6	34.9	27.925S
3	HOLD 11 Hatch Aft Corner Fwd-P	Weathertight	HOLD 11	22.2	34.9	27.925P
4	HOLD 11 Hatch Aft Corner Fwd-S	Weathertight	HOLD 11	22.2	34.9	27.925S
5	HOLD 11 Hatch Mid Corner Aft-P	Weathertight	HOLD 11	24.05	34.9	27.925P
6	HOLD 11 Hatch Mid Corner Aft-S	Weathertight	HOLD 11	24.05	34.9	27.925S
7	HOLD 11 Hatch Mid Corner Fwd-P	Weathertight	HOLD 11	36.65	34.9	27.925P
8	HOLD 11 Hatch Mid Corner Fwd-S	Weathertight	HOLD 11	36.65	34.9	27.925S
9	HOLD 11 Hatch Fwd Corner Aft-P	Weathertight	HOLD 11	38.5	34.9	27.925P
10	HOLD 11 Hatch Fwd Corner Aft-S	Weathertight	HOLD 11	38.5	34.9	27.925S
11	HOLD 11 Hatch Fwd Corner Fwd-P	Weathertight	HOLD 11	51.1	34.9	27.925P
12	HOLD 11 Hatch Fwd Corner Fwd-S	Weathertight	HOLD 11	51.1	34.9	27.925S
13	HOLD 10 Hatch Corner Aft-P	Weathertight	HOLD 10	64.2	34.9	27.925P
14	HOLD 10 Hatch Corner Aft-S	Weathertight	HOLD 10	64.2	34.9	27.925S
15	HOLD 10 Hatch Corner Fwd-P	Weathertight	HOLD 10	76.8	34.9	27.925P
16	HOLD 10 Hatch Corner Fwd-S	Weathertight	HOLD 10	76.8	34.9	27.925S
17	HOLD 9 Hatch Aft Corner Aft-P	Weathertight	HOLD 9	78.65	34.9	27.925P
18	HOLD 9 Hatch Aft Corner Aft-S	Weathertight	HOLD 9	78.65	34.9	27.925S
19	HOLD 9 Hatch Aft Corner Fwd-P	Weathertight	HOLD 9	91.25	34.9	27.925P

No.	Name	Type	Comp	Long.	Vert.	Trans.
#	-	-	-	m-AP	m-BL	m-CL
20	HOLD 9 Hatch Aft Corner Fwd-S	Weathertight	HOLD 9	91.25	34.9	27.925S
21	HOLD 9 Hatch Fwd Corner Aft-P	Weathertight	HOLD 9	93.1	34.9	27.925P
22	HOLD 9 Hatch Fwd Corner Aft-S	Weathertight	HOLD 9	93.1	34.9	27.925S
23	HOLD 9 Hatch Fwd Corner Fwd-P	Weathertight	HOLD 9	105.7	34.9	27.925P
24	HOLD 9 Hatch Fwd Corner Fwd-S	Weathertight	HOLD 9	105.7	34.9	27.925S
25	HOLD 8 Hatch Aft Corner Aft-P	Weathertight	HOLD 8	107.55	34.9	27.925P
26	HOLD 8 Hatch Aft Corner Aft-S	Weathertight	HOLD 8	107.55	34.9	27.925S
27	HOLD 8 Hatch Aft Corner Fwd-P	Weathertight	HOLD 8	120.15	34.9	27.925P
28	HOLD 8 Hatch Aft Corner Fwd-S	Weathertight	HOLD 8	120.15	34.9	27.925S
29	HOLD 8 Hatch Fwd Corner Aft-P	Weathertight	HOLD 8	122	34.9	27.925P
30	HOLD 8 Hatch Fwd Corner Aft-S	Weathertight	HOLD 8	122	34.9	27.925S
31	HOLD 8 Hatch Fwd Corner Fwd-P	Weathertight	HOLD 8	134.6	34.9	27.925P
32	HOLD 8 Hatch Fwd Corner Fwd-S	Weathertight	HOLD 8	134.6	34.9	27.925S
33	HOLD 7 Hatch Aft Corner Aft-P	Weathertight	HOLD 7	136.45	34.9	27.925P
34	HOLD 7 Hatch Aft Corner Aft-S	Weathertight	HOLD 7	136.45	34.9	27.925S
35	HOLD 7 Hatch Aft Corner Fwd-P	Weathertight	HOLD 7	149.05	34.9	27.925P
36	HOLD 7 Hatch Aft Corner Fwd-S	Weathertight	HOLD 7	149.05	34.9	27.925S
37	HOLD 7 Hatch Fwd Corner Aft-P	Weathertight	HOLD 7	150.9	34.9	27.925P
38	HOLD 7 Hatch Fwd Corner Aft-S	Weathertight	HOLD 7	150.9	34.9	27.925S
39	HOLD 7 Hatch Fwd Corner Fwd-P	Weathertight	HOLD 7	163.5	34.9	27.925P
40	HOLD 7 Hatch Fwd Corner Fwd-S	Weathertight	HOLD 7	163.5	34.9	27.925S
41	HOLD 6 Hatch Aft Corner Aft-P	Weathertight	HOLD 6	165.35	34.9	27.925P
42	HOLD 6 Hatch Aft Corner Aft-S	Weathertight	HOLD 6	165.35	34.9	27.925S
43	HOLD 6 Hatch Aft Corner Fwd-P	Weathertight	HOLD 6	177.95	34.9	27.925P
44	HOLD 6 Hatch Aft Corner Fwd-S	Weathertight	HOLD 6	177.95	34.9	27.925S
45	HOLD 6 Hatch Fwd Corner Aft-P	Weathertight	HOLD 6	179.8	34.9	27.925P
46	HOLD 6 Hatch Fwd Corner Aft-S	Weathertight	HOLD 6	179.8	34.9	27.925S
47	HOLD 6 Hatch Fwd Corner Fwd-P	Weathertight	HOLD 6	192.4	34.9	27.925P
48	HOLD 6 Hatch Fwd Corner Fwd-S	Weathertight	HOLD 6	192.4	34.9	27.925S
49	HOLD 5 Hatch Aft Corner Aft-P	Weathertight	HOLD 5	194.25	34.9	27.925P
50	HOLD 5 Hatch Aft Corner Aft-S	Weathertight	HOLD 5	194.25	34.9	27.925S

No.	Name	Type	Comp	Long.	Vert.	Trans.
#	-	-	-	m-AP	m-BL	m-CL
51	HOLD 5 Hatch Aft Corner Fwd-P	Weathertight	HOLD 5	206.85	34.9	27.925P
52	HOLD 5 Hatch Aft Corner Fwd-S	Weathertight	HOLD 5	206.85	34.9	27.925S
53	HOLD 5 Hatch Fwd Corner Aft-P	Weathertight	HOLD 5	208.7	34.9	27.925P
54	HOLD 5 Hatch Fwd Corner Aft-S	Weathertight	HOLD 5	208.7	34.9	27.925S
55	HOLD 5 Hatch Fwd Corner Fwd-P	Weathertight	HOLD 5	221.3	34.9	27.925P
56	HOLD 5 Hatch Fwd Corner Fwd-S	Weathertight	HOLD 5	221.3	34.9	27.925S
57	HOLD 4 Hatch Aft Corner Aft-P	Weathertight	HOLD 4	223.15	34.9	27.925P
58	HOLD 4 Hatch Aft Corner Aft-S	Weathertight	HOLD 4	223.15	34.9	27.925S
59	HOLD 4 Hatch Aft Corner Fwd-P	Weathertight	HOLD 4	235.75	34.9	27.925P
60	HOLD 4 Hatch Aft Corner Fwd-S	Weathertight	HOLD 4	235.75	34.9	27.925S
61	HOLD 4 Hatch Fwd Corner Aft-P	Weathertight	HOLD 4	237.6	34.9	27.925P
62	HOLD 4 Hatch Fwd Corner Aft-S	Weathertight	HOLD 4	237.6	34.9	27.925S
63	HOLD 4 Hatch Fwd Corner Fwd-P	Weathertight	HOLD 4	250.2	34.9	27.925P
64	HOLD 4 Hatch Fwd Corner Fwd-S	Weathertight	HOLD 4	250.2	34.9	27.925S
65	HOLD 3 Hatch Aft Corner Aft-P	Weathertight	HOLD 3	266.5	34.9	27.925P
66	HOLD 3 Hatch Aft Corner Aft-S	Weathertight	HOLD 3	266.5	34.9	27.925S
67	HOLD 3 Hatch Aft Corner Fwd-P	Weathertight	HOLD 3	279.1	34.9	27.925P
68	HOLD 3 Hatch Aft Corner Fwd-S	Weathertight	HOLD 3	279.1	34.9	27.925S
69	HOLD 3 Hatch Fwd Corner Aft-P	Weathertight	HOLD 3	280.95	34.9	27.925P
70	HOLD 3 Hatch Fwd Corner Aft-S	Weathertight	HOLD 3	280.95	34.9	27.925S
71	HOLD 3 Hatch Fwd Corner Fwd-P	Weathertight	HOLD 3	293.55	34.9	27.925P
72	HOLD 3 Hatch Fwd Corner Fwd-S	Weathertight	HOLD 3	293.55	34.9	27.925S
73	HOLD 2 Hatch Aft Corner Aft-P	Weathertight	HOLD 2	295.4	34.9	27.925P
74	HOLD 2 Hatch Aft Corner Aft-S	Weathertight	HOLD 2	295.4	34.9	27.925S
75	HOLD 2 Hatch Aft Corner Fwd-P	Weathertight	HOLD 2	308	34.9	27.925P
76	HOLD 2 Hatch Aft Corner Fwd-S	Weathertight	HOLD 2	308	34.9	27.925S
77	HOLD 2 Hatch Fwd Corner Aft-P	Weathertight	HOLD 2	309.85	34.9	27.925P
78	HOLD 2 Hatch Fwd Corner Aft-S	Weathertight	HOLD 2	309.85	34.9	27.925S
79	HOLD 2 Hatch Fwd Corner Fwd-P	Weathertight	HOLD 2	322.45	34.9	27.925P
80	HOLD 2 Hatch Fwd Corner Fwd-S	Weathertight	HOLD 2	322.45	34.9	27.925S
81	HOLD 1 Hatch Aft Corner Aft-P	Weathertight	HOLD 1	324.3	34.9	27.925P

No.	Name	Type	Comp	Long.	Vert.	Trans.
#	-	-	-	m-AP	m-BL	m-CL
82	HOLD 1 Hatch Aft Corner Aft-S	Weathertight	HOLD 1	324.3	34.9	27.925S
83	HOLD 1 Hatch Aft Corner Fwd-P	Weathertight	HOLD 1	336.9	34.9	27.925P
84	HOLD 1 Hatch Aft Corner Fwd-S	Weathertight	HOLD 1	336.9	34.9	27.925S
85	HOLD 1 Hatch Mid Corner Aft-P	Weathertight	HOLD 1	338.75	34.9	25.405P
86	HOLD 1 Hatch Mid Corner Aft-S	Weathertight	HOLD 1	338.75	34.9	25.405S
87	HOLD 1 Hatch Mid Corner Fwd-P	Weathertight	HOLD 1	351.35	34.9	25.405P
88	HOLD 1 Hatch Mid Corner Fwd-S	Weathertight	HOLD 1	351.35	34.9	25.405S
89	HOLD 1 Hatch Fwd Corner Aft-P	Weathertight	HOLD 1	353.2	34.9	22.885P
90	HOLD 1 Hatch Fwd Corner Aft-S	Weathertight	HOLD 1	353.2	34.9	22.885S
91	HOLD 1 Hatch Fwd Corner Fwd-P	Weathertight	HOLD 1	365.8	34.9	22.885P
92	HOLD 1 Hatch Fwd Corner Fwd-S	Weathertight	HOLD 1	365.8	34.9	22.885S
93	1DBWBT F	Weathertight	1DBWBT	350.95	33.513	25.805S
94	1DBWBT A	Weathertight	1DBWBT	322.85	33.513	28.425P
95	2WWBT P F	Weathertight	2WWBT P	322.05	33.513	28.425P
96	2WWBT S F	Weathertight	2WWBT S	322.05	33.513	28.425S
97	2DBWBT P F	Weathertight	2DBWBT P	321.25	33.513	28.425P
98	2DBWBTS F	Weathertight	2DBWBTS	321.25	33.513	28.425S
99	2DBWBT P A	Weathertight	2DBWBT P	294.75	33.513	28.425P
100	2DBWBTS A	Weathertight	2DBWBTS	294.75	33.513	28.425S
101	2WWBT P A	Weathertight	2WWBT P	293.95	33.513	28.425P
102	2WWBT S A	Weathertight	2WWBT S	293.95	33.513	28.425S
103	3WWBT P F	Weathertight	3WWBT P	293.15	33.513	28.425P
104	3WWBT S F	Weathertight	3WWBT S	293.15	33.513	28.425S
105	3DBWBT P F	Weathertight	3DBWBT P	292.35	33.513	28.425P
106	3DBWBT S F	Weathertight	3DBWBT S	292.35	33.513	28.425S
107	3DBWBT P A	Weathertight	3DBWBT P	265.25	33.513	28.425P
108	3DBWBT S A	Weathertight	3DBWBT S	265.25	33.513	28.425S
109	3WWBT P A	Weathertight	3WWBT P	264.45	33.513	28.425P
110	3WWBT S A	Weathertight	3WWBT S	264.45	33.513	28.425S
111	FUEL WING VOID P F	Weathertight	FUEL WING VOID P	263.65	33.513	28.425P
112	FUEL WING VOID S F	Weathertight	FUEL WING VOID S	263.65	33.513	28.425S
113	FUEL DB VOID P F	Weathertight	FUEL DB VOID P	262.85	33.513	28.425P
114	FUEL DB VOID S F	Weathertight	FUEL DB VOID S	262.85	33.513	28.425S
115	FUEL UPPER VOID F	Weathertight	FUEL UPPER VOID	262.05	33.513	28.425S
116	FUEL UPPER VOID A	Weathertight	FUEL UPPER VOID	254.05	33.513	28.425P
117	FUEL DB VOID P A	Weathertight	FUEL DB VOID P	253.25	33.513	28.425P
118	FUEL DB VOID S A	Weathertight	FUEL DB VOID S	253.25	33.513	28.425S

No.	Name	Type	Comp	Long.	Vert.	Trans.
#	-	-	-	m-AP	m-BL	m-CL
119	FUEL WING VOID P A	Weathertight	FUEL WING VOID P	252.45	33.513	28.425P
120	FUEL WING VOID S A	Weathertight	FUEL WING VOID S	252.45	33.513	28.425S
121	4WWBT P F	Weathertight	4WWBT P	251.65	33.513	28.425P
122	4WWBT S F	Weathertight	4WWBT S	251.65	33.513	28.425S
123	4DBWBT P F	Weathertight	4DBWBT P	250.85	33.513	28.425P
124	4DBWBT S F	Weathertight	4DBWBT S	250.85	33.513	28.425S
125	4DBWBT P A	Weathertight	4DBWBT P	222.5	33.513	28.425P
126	4DBWBT S A	Weathertight	4DBWBT S	222.5	33.513	28.425S
127	4WWBT P A	Weathertight	4WWBT P	221.7	33.513	28.425P
128	4WWBT S A	Weathertight	4WWBT S	221.7	33.513	28.425S
129	5WWBT P F	Weathertight	5WWBT P	220.9	33.513	28.425P
130	5WWBT S F	Weathertight	5WWBT S	220.9	33.513	28.425S
131	5DBWBT P F	Weathertight	5DBWBT P	220.1	33.513	28.425P
132	5DBWBT S F	Weathertight	5DBWBT S	220.1	33.513	28.425S
133	5DBWBT P A	Weathertight	5DBWBT P	193.6	33.513	28.425P
134	5DBWBT S A	Weathertight	5DBWBT S	193.6	33.513	28.425S
135	5WWBT P A	Weathertight	5WWBT P	192.8	33.513	28.425P
136	5WWBT S A	Weathertight	5WWBT S	192.8	33.513	28.425S
137	6WWBT HEEL P F	Weathertight	6WWBT HEEL P	192	33.513	28.425P
138	6WWBT HEEL S F	Weathertight	6WWBT HEEL S	192	33.513	28.425S
139	6DBWBT P F	Weathertight	6DBWBT P	191.2	33.513	28.425P
140	6DBWBT S F	Weathertight	6DBWBT S	191.2	33.513	28.425S
141	6DBWBT P A	Weathertight	6DBWBT P	164.7	33.513	28.425P
142	6DBWBT S A	Weathertight	6DBWBT S	164.7	33.513	28.425S
143	6WWBT HEEL P A	Weathertight	6WWBT HEEL P	163.9	33.513	28.425P
144	6WWBT HEEL S A	Weathertight	6WWBT HEEL S	163.9	33.513	28.425S
145	7WWBT P F	Weathertight	7WWBT P	163.1	33.513	28.425P
146	7WWBT S F	Weathertight	7WWBT S	163.1	33.513	28.425S
147	7DBWBT P F	Weathertight	7DBWBT P	162.3	33.513	28.425P
148	7DBWBT S F	Weathertight	7DBWBT S	162.3	33.513	28.425S
149	7DBWBT P A	Weathertight	7DBWBT P	135.8	33.513	28.425P
150	7DBWBT S A	Weathertight	7DBWBT S	135.8	33.513	28.425S
151	7WWBT P A	Weathertight	7WWBT P	135	33.513	28.425P
152	7WWBT S A	Weathertight	7WWBT S	135	33.513	28.425S
153	8WWBT P F	Weathertight	8WWBT P	134.2	33.513	28.425P
154	8WWBT S F	Weathertight	8WWBT S	134.2	33.513	28.425S
155	8DBWBT P F	Weathertight	8DBWBT P	133.4	33.513	28.425P
156	8DBWBT S F	Weathertight	8DBWBT S	133.4	33.513	28.425S
157	8DBWBT P A	Weathertight	8DBWBT P	106.9	33.513	28.425P
158	8DBWBT S A	Weathertight	8DBWBT S	106.9	33.513	28.425S

No.	Name	Type	Comp	Long.	Vert.	Trans.
#	-	-	-	m-AP	m-BL	m-CL
159	8WWBT P A	Weathertight	8WWBT P	106.1	33.513	28.425P
160	8WWBT S A	Weathertight	8WWBT S	106.1	33.513	28.425S
161	9WWBT P F	Weathertight	9WWBT P	105.3	33.513	28.425P
162	9WWBT S F	Weathertight	9WWBT S	105.3	33.513	28.425S
163	9DBWBT P F	Weathertight	9DBWBT P	104.5	33.513	28.425P
164	9DBWBT S F	Weathertight	9DBWBT S	104.5	33.513	28.425S
165	9DBWBT P A	Weathertight	9DBWBT P	78	33.513	28.425P
166	9DBWBT S A	Weathertight	9DBWBT S	78	33.513	28.425S
167	9WWBT P A	Weathertight	9WWBT P	77.2	33.513	28.425P
168	9WWBT S A	Weathertight	9WWBT S	77.2	33.513	28.425S
169	ER VOID P F	Weathertight	ER VOID P	76.4	33.513	28.425P
170	ER VOID S F	Weathertight	ER VOID S	76.4	33.513	28.425S
171	ER DB F P	Weathertight	ER DB	75.6	33.513	28.425P
172	ER DB F S	Weathertight	ER DB	75.6	33.513	28.425S
173	ER DB A P	Weathertight	ER DB	39.3	33.513	28.425P
174	ER DB A S	Weathertight	ER DB	39.3	33.513	28.425S
175	ER VOID P A	Weathertight	ER VOID P	51.5	33.513	28.425P
176	ER VOID S A	Weathertight	ER VOID S	51.5	33.513	28.425S
177	10DBWBT P F	Weathertight	10DBWBT P	50.7	33.513	28.425P
178	10DBWBT S F	Weathertight	10DBWBT S	50.7	33.513	28.425S
179	10DBWBT P A	Weathertight	10DBWBT P	10	33.513	28.425P
180	10DBWBT S A	Weathertight	10DBWBT S	10	33.513	28.425S
181	FWT P F	Weathertight	FWT P	70.4	33.513	28.425P
182	FWT P A	Weathertight	FWT P	53.4	33.513	28.425P
183	FWT S F	Weathertight	FWT S	70.4	33.513	28.425S
184	FWT S A	Weathertight	FWT S	53.4	33.513	28.425S
185	BOSUN AFT	Weathertight	BOSUN STORE	367.65	33.513	2.400S
186	BOSUN FWD P	Weathertight	BOSUN STORE	387.65	33.513	8.000P
187	BOSUN FWD S	Weathertight	BOSUN STORE	387.65	33.513	8.000S
188	ROPE HATCH	Weathertight	BOSUN STORE	382	33.3	3.000S
189	CHAIN LOCKER P	Weathertight	CHAIN LOCKERS	375	33.3	3.000P
190	CHAIN LOCKER S	Weathertight	CHAIN LOCKERS	375	33.3	3.000S
191	FP ROOM SUPP	Weathertight	BOW THRUSTER/EMERGENCY FP ROOM	367.65	33.513	8.000S
192	FP ROOM EXH	Weathertight	BOW THRUSTER/EMERGENCY FP ROOM	367.65	33.513	4.000S
193	PIPE TUNNEL F	Weathertight	PIPE TUNNEL	320.875	34	1.000S
194	PIPE TUNNEL A	Weathertight	PIPE TUNNEL	77.725	34	1.000P
195	FWD ER ACCESS P	Unprotected	ACCOM MACHY	255.25	34	12.000P
196	FWD ER ACCESS S	Unprotected	ACCOM MACHY	255.25	34	12.000S
197	AFT ER ACCESS P	Unprotected	ER	57.1	34	12.000P
198	AFT ER ACCESS S	Unprotected	ER	57.1	34	12.000S

No.	Name	Type	Comp	Long.	Vert.	Trans.
#	-	-	-	m-AP	m-BL	m-CL
199	SG FWD P	Weathertight	SG ROOM	8.8	26.513	6.000S
200	SG FWDS	Weathertight	SG ROOM	8.8	26.513	6.000P
201	SG AFT P	Weathertight	SG ROOM	-4	26.513	15.000P
202	SG AFT S	Weathertight	SG ROOM	-4	26.513	15.000S
203	AFT VOID F	Weathertight	AFT VOID	8.8	26.513	20.000P
204	AFT VOID A	Weathertight	AFT VOID	-4	26.513	20.000S
205	FWD LOWER VOID FWD	Weathertight	FWD LOWER VOID	385	33.513	2.000S
206	FWD LOWER VOID AFT	Weathertight	FWD LOWER VOID	367.65	33.513	5.000P
207	FWD MID VOID F F	Weathertight	FWD MID VOID F	388	33.513	2.000S
208	FWD MID VOID F A	Weathertight	FWD MID VOID F	377.65	33.513	6.000P
209	FWD MID VOID A F	Weathertight	FWD MID VOID A	376.85	33.513	6.000P
210	FWD MID VOID A A	Weathertight	FWD MID VOID A	367.65	33.513	10.000S
211	FWD UPPER VOID F	Weathertight	FWD UPPER VOID	388	33.513	2.000P
212	FWD UPPER VOID A	Weathertight	FWD UPPER VOID	367.65	33.513	17.000S
213	1 LOWER VOID F	Weathertight	1 LOWER VOID	367.65	33.513	2.000P
214	1 LOWER VOID A	Weathertight	1 LOWER VOID	351.7	33.513	23.285S
215	1 WING VOID P F	Weathertight	1 W VOID P	367.65	33.513	6.500P
216	1 WING VOID P A	Weathertight	1 W VOID P	323.65	33.513	28.425P
217	1 WING VOID S F	Weathertight	1 W VOID S	367.65	33.513	6.500S
218	1 WING VOID S A	Weathertight	1 W VOID S	323.65	33.513	28.425S
219	PASSAGEWAY FWD P F	Weathertight	PASSAGEWAY FWD P	367.65	33.513	22.445P
220	PASSAGEWAY FWD P A	Weathertight	PASSAGEWAY FWD P	254.85	33.513	28.425P
221	PASSAGEWAY FWD S F	Weathertight	PASSAGEWAY FWD S	367.65	33.513	22.445S
222	PASSAGEWAY FWD S A	Weathertight	PASSAGEWAY FWD S	254.85	33.513	28.425S
223	PASSAGEWAY MID P F	Weathertight	PASSAGEWAY MID P	250.05	33.513	28.425P
224	PASSAGEWAY MID P A	Weathertight	PASSAGEWAY MID P	78.8	33.513	28.425P
225	PASSAGEWAY MID S F	Weathertight	PASSAGEWAY MID S	250.05	33.513	28.425S
226	PASSAGEWAY MID S A	Weathertight	PASSAGEWAY MID S	78.8	33.513	28.425S
227	PASSAGEWAY AFT P F	Weathertight	PASSAGEWAY AFT P	74.8	33.513	28.425P
228	PASSAGEWAY AFT P A	Weathertight	PASSAGEWAY AFT P	10.8	33.513	28.425P
229	PASSAGEWAY AFT S F	Weathertight	PASSAGEWAY AFT S	74.8	33.513	28.425S
230	PASSAGEWAY AFT S A	Weathertight	PASSAGEWAY AFT S	10.8	33.513	28.425S

14.4. Container Counts and Centres of Gravity

14.4.1. Maximum Container Capacity

Tiers	40' Bay	94	90	86	82	78	74	70	66	62	58	54	50	46	42	38	34	30	26	22	18	14	10	6	2
13	374	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	0	0	0	0	0	0	0
12	452	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0	0	0	0
11	500	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0	0	0
10	548	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0
9	572	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20
8	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
7	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
6	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
5	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
4	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
3	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
2	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
1	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
Deck Total	7038	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310	286	286	262	262	238	238	196
12	446		22	22	22	22	18	22	22	22	22	22	22	22	22	22	22	22	22	20	20	16	12	8	
11	500		22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	20	18
10	500		22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	20	18
9	472		22	22	22		22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	18	14
8	456		20	22	14		22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	16	12
7	436		12	18	12		22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	18	14	10
6	396			8			22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	18	12	8
5	382						22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	16	10	6	
4	372						22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	18	14	8	4
3	358						18	22	22	22	22	22	22	22	22	22	22	22	22	20	20	16	12	8	
2	338						14	20	22	22	22	22	22	22	22	22	22	22	22	20	18	14	8	6	
1	294						10	16	20	20	20	20	20	20	20	20	20	20	18	16	14	10	6	4	
Hold Total	4950		120	136	114	66	236	256	262	262	262	262	262	262	262	262	262	258	250	246	224	190	144	90	
Grand Total	11988	FEU	430	446	424	376	546	566	572	572	572	572	572	572	572	572	572	572	544	536	508	486	428	382	286
	23976	TEU		11988																					

Containers In Holds

Bay 2

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows	
8			32.51	32.51	32.21	31.9	31.6	31.29	30.99	30.69	30.69	30.69	30.69	30.99	31.29	31.6	31.9	32.21	32.51	32.51				18	
7			29.92	29.92	29.62	29.31	29.01	28.7	28.4	28.1	28.1	28.1	28.1	28.4	28.7	29.01	29.31	29.62	29.92	29.92			28.76	18	
6					27.03	26.72	26.42	26.11	25.81	25.5	25.5	25.5	25.5	25.81	26.11	26.42	26.72	27.03					25.86	14	
5						24.13	23.83	23.52	23.22	22.91	22.91	22.91	22.91	23.22	23.52	23.83	24.13						22.97	12	
4							21.24	20.93	20.63	20.32	20.32	20.32	20.32	20.63	20.93	21.24							20.07	10	
3								18.34	18.04	17.73	17.73	17.73	17.73	18.04	18.34								17.18	8	
2									15.45	15.14	15.14	15.14	15.14	15.45										14.28	6
1										12.55	12.55	12.55	12.55											11.39	4
	0	0	2	2	3	4	5	6	7	8	8	8	8	7	6	5	4	3	2	2	0	0		90	
Stack Wt	0	0	36	36	54	72	90	108	126	144	144	144	144	126	108	90	72	54	36	36	0	0		1620	
Count			90	#																					
Sum VCG			2230.4	m																					
Sum Mass			1620	MT																					
VCG			24.782	m-BL																					

Bay 6

Max Height 1.425 33.94 33.63 33.33 33.02 32.72 32.42 34.4 34.09 33.79 33.79 33.79 33.79 34.09 34.4 32.42 32.72 33.02 33.33 33.63 33.94 1.425

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows	
12								32.97	32.67	32.36	32.36	32.36	32.36	32.67	32.97									8	
11			32.51	32.21	31.9	31.6	31.29	30.99	30.38	30.08	29.77	29.77	29.77	29.77	30.08	30.38	30.99	31.29	31.6	31.9	32.21	32.51		31.65	20
10			29.92	29.62	29.31	29.01	28.7	28.4	27.79	27.49	27.18	27.18	27.18	27.49	27.79	28.4	28.7	29.01	29.31	29.62	29.92		28.76	20	
9				27.03	26.72	26.42	26.11	25.81	25.2	24.9	24.59	24.59	24.59	24.9	25.2	25.81	26.11	26.42	26.72	27.03			25.86	18	
8					24.13	23.83	23.52	23.22	22.61	22.31	22	22	22	22	22.31	22.61	23.22	23.52	23.83	24.13				22.97	16
7						21.24	20.93	20.63	20.02	19.71	19.41	19.41	19.41	19.41	19.71	20.02	20.63	20.93	21.24					20.07	14
6							18.34	18.04	17.43	17.12	16.82	16.82	16.82	16.82	17.12	17.43	18.04	18.34						17.18	12
5								15.45	14.84	14.53	14.23	14.23	14.23	14.23	14.53	14.84	15.45							14.28	10
4									12.25	11.94	11.64	11.64	11.64	11.64	11.94	12.25								11.39	8
3										9.656	9.352	9.047	9.047	9.047	9.047	9.352	9.656							8.49	8
2											6.761	6.457	6.457	6.457	6.457	6.761								5.595	6
1												3.866	3.866	3.866	3.866									2.7	4
	0	2	3	4	5	6	7	10	11	12	12	12	12	11	10	7	6	5	4	3	2	0			
Stack Wt	0	36	54	72	90	108	126	180	198	216	216	216	216	198	180	126	108	90	72	54	36	0			
Count	144			#																					
Sum VCG	3143			m																					
Sum Mass	2592			MT																					
VCG	21.828			m-BL																					

Bay 10

Max Height 33.63 33.33 32.72 32.42 32.11 34.4 34.4 34.09 33.79 33.79 33.79 33.79 33.79 33.79 34.09 34.4 34.4 32.11 32.42 32.72 33.33 33.63

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12						32.97	32.97	32.67	32.36	32.36	32.36	32.36	32.36	32.36	32.67	32.97	32.97							12
11	32.21	31.9	31.29	30.99	30.69	30.38	30.38	30.08	29.77	29.77	29.77	29.77	29.77	29.77	30.08	30.38	30.38	30.69	30.99	31.29	31.9	32.21	31.65	22
10	29.62	29.31	28.7	28.4	28.1	27.79	27.79	27.49	27.18	27.18	27.18	27.18	27.18	27.18	27.49	27.79	27.79	28.1	28.4	28.7	29.31	29.62	28.76	22
9	27.03	26.72	26.11	25.81	25.5	25.2	25.2	24.9	24.59	24.59	24.59	24.59	24.59	24.59	24.9	25.2	25.2	25.5	25.81	26.11	26.72	27.03	25.86	22
8		24.13	23.52	23.22	22.91	22.61	22.61	22.31	22	22	22	22	22	22	22.31	22.61	22.61	22.91	23.22	23.52	24.13		22.97	20
7			20.93	20.63	20.32	20.02	20.02	19.71	19.41	19.41	19.41	19.41	19.41	19.41	19.71	20.02	20.02	20.32	20.63	20.93			20.07	18
6			18.34	18.04	17.73	17.43	17.43	17.12	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.43	17.43	17.73	18.04	18.34			17.18	18
5				15.45	15.14	14.84	14.84	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.84	14.84	15.14	15.45				14.28	16
4					12.55	12.25	12.25	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.94	12.25	12.25	12.55					11.39	14
3						9.656	9.656	9.352	9.047	9.047	9.047	9.047	9.047	9.047	9.352	9.656	9.656						8.49	12
2								6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.761								5.595	8
1									3.866	3.866	3.866	3.866	3.866	3.866									2.7	6
	3	4	6	7	8	10	10	11	12	12	12	12	12	12	11	10	10	8	7	6	4	3		
Stack Wt	54	72	108	126	144	180	180	198	216	216	216	216	216	216	198	180	180	144	126	108	72	54		
Count	190		#																					
Sum VCG	3961		m																					
Sum Mass	3420		MT																					
VCG	20.848		m-BL																					

Bay 14

Max Height 33.02 32.42 32.11 34.4 34.09 34.09 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 34.09 34.09 34.4 32.11 32.42 33.02

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12				32.97	32.67	32.67	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.67	32.67	32.97					16
11	31.6	30.99	30.69	30.38	30.08	30.08	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	30.08	30.08	30.38	30.69	30.99	31.6	31.65	22
10	29.01	28.4	28.1	27.79	27.49	27.49	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.49	27.49	27.79	28.1	28.4	29.01	28.76	22
9	26.42	25.81	25.5	25.2	24.9	24.9	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.9	24.9	25.2	25.5	25.81	26.42	25.86	22
8	23.83	23.22	22.91	22.61	22.31	22	22	22	22	22	22	22	22	22	22	22	22.31	22.31	22.61	22.91	23.22	23.83	22.97	22
7	21.24	20.63	20.32	20.02	19.71	19.71	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.71	19.71	20.02	20.32	20.63	21.24	20.07	22
6		18.04	17.73	17.43	17.12	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.12	17.43	17.73	18.04		17.18	20
5		15.45	15.14	14.84	14.53	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.53	14.84	15.14	15.45		14.28	20
4			12.55	12.25	11.94	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	11.94	12.25	12.55			11.39	18
3				9.656	9.352	9.352	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.352	9.352	9.656				8.49	16
2					6.761	6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761	6.761					5.595	14
1							3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866							2.7	10
	5	7	8	10	11	11	12	12	12	12	12	12	12	12	12	12	11	11	10	8	7	5		
Stack Wt	90	126	144	180	198	198	216	216	216	216	216	216	216	216	216	216	198	198	180	144	126	90		
Count	224			#																				
Sum VCG	4403			m																				
Sum Mass	4032			MT																				
VCG	19.65			m-BL																				

Bay 18

Max Height 32.42 34.4 34.09 34.09 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 33.79 34.09 34.09 34.4 32.42

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12		32.97	32.67	32.67	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.67	32.67	32.97			20
11	30.99	30.38	30.08	30.08	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	30.08	30.08	30.38	30.99	31.65	22
10	28.4	27.79	27.49	27.49	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.49	27.49	27.79	28.4	28.76	22
9	25.81	25.2	24.9	24.9	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.9	24.9	25.2	25.81	25.86	22
8	23.22	22.61	22.31	22.31	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22.31	22.31	22.61	23.22	22.97	22
7	20.63	20.02	19.71	19.71	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.71	19.71	20.02	20.63	20.07	22
6	18.04	17.43	17.12	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.12	17.43	18.04	17.18	22
5	15.45	14.84	14.53	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.53	14.84	15.45	14.28	22
4		12.25	11.94	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	11.94	12.25		11.39	20
3		9.656	9.352	9.352	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.352	9.352	9.656		8.49	20
2			6.761	6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761	6.761			5.595	18
1					3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866					2.7	14
	7	10	11	11	12	12	12	12	12	12	12	12	12	12	12	12	12	12	11	11	10	7		
Stack Wt	126	180	198	198	216	216	216	216	216	216	216	216	216	216	216	216	216	216	198	198	180	126		
Count	246			#																				
Sum VCG	4662			m																				
Sum Mass	4428			MT																				
VCG	18.95			m-BL																				

Bay 22

Max Height	32.11	34.4	34.09	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	34.09	34.4	32.11		
Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12		32.97	32.67	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.67	32.97			20	
11	30.69	30.38	30.08	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	30.08	30.38	30.69	31.65	22	
10	28.1	27.79	27.49	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.49	27.79	28.1	28.76	22	
9	25.5	25.2	24.9	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.9	25.2	25.5	25.86	22	
8	22.91	22.61	22.31	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22.31	22.61	22.91	22.97	22	
7	20.32	20.02	19.71	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.71	20.02	20.32	20.07	22	
6	17.73	17.43	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.43	17.73	17.18	22	
5	15.14	14.84	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.84	15.14	14.28	22	
4	12.55	12.25	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	12.25	12.55	11.39	22	
3		9.656	9.352	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.352	9.656		8.49	20	
2			6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761			5.595	18	
1				3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866				2.7	16	
	8	10	11	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	11	10	8		
Stack Wt	144	180	198	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	198	180	144			
Count	250		#																					
Sum VCG	4684		m																					
Sum Mass	4500		MT																					
VCG	18.74		m-BL																					

Bay 26

Max Height	34.4	34.09	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	34.09	34.4		
Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12	32.97	32.67	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.67	32.97		22
11	30.38	30.08	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	30.08	30.38	31.65	22
10	27.79	27.49	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.49	27.79	28.76	22
9	25.2	24.9	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.9	25.2	25.86	22
8	22.61	22.31	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22.31	22.61	22.97	22
7	20.02	19.71	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.71	20.02	20.07	22
6	17.43	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.43	17.18	22
5	14.84	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.84	14.28	22
4	12.25	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	12.25	11.39	22
3	9.656	9.352	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.352	9.656	8.49	22
2		6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761		5.595	20
1			3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866			2.7	18
	10	11	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	11	10		
Stack Wt	180	198	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	198	180		
Count	258		#																					
Sum VCG	4773		m																					
Sum Mass	4644		MT																					
VCG	18.50		m-BL																					

Bay 30-66																								
Max Height	34.09	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	34.09	
Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12	32.67	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.67		22
11	30.08	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	30.08	31.65	22
10	27.49	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.49	28.76	22
9	24.9	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.9	25.86	22
8	22.31	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22.31	22.97	22
7	19.71	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.71	20.07	22
6	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.18	22
5	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.28	22
4	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	11.39	22
3	9.352	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.352	8.49	22
2	6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761	5.595	22
1		3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866		2.7	20
	11	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	11		
Stack Wt	198	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	198		
Count	262		#																					
Sum VCG	4781		m																					
Sum Mass	4716		MT																					
VCG	18.25		m-BL																					

Bay 70																								
Max Height	34.4	34.09	34.09	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	34.09	34.09	34.4	
Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12	32.97	32.67	32.67	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.36	32.67	32.67	32.97		22
11	30.38	30.08	30.08	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	29.77	30.08	30.08	30.38	31.65	22
10	27.79	27.49	27.49	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.18	27.49	27.49	27.79	28.76	22
9	25.2	24.9	24.9	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.59	24.9	24.9	25.2	25.86	22
8	22.61	22.31	22.31	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22.31	22.31	22.61	22.97	22
7	20.02	19.71	19.71	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.71	19.71	20.02	20.07	22
6	17.43	17.12	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.12	17.43	17.18	22
5	14.84	14.53	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.53	14.84	14.28	22
4	12.25	11.94	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	11.94	12.25	11.39	22
3	9.656	9.352	9.352	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.047	9.352	9.352	9.656	8.49	22
2		6.761	6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761	6.761		5.595	20
1					3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866				2.7	16
	10	11	11	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	11	11	10		
Stack Wt	180	198	198	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	198	198	180		
Count		256		#																				
Sum VCG		4772		m																				
Sum Mass		4608		MT																				
VCG		18.64		m-BL																				

Max Height	32.11	32.11	34.4	34.4	34.09	34.09	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	33.79	34.09	34.09	34.4	34.4	32.11	32.11

Bay 78																								
Max Height	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63
Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21		22
11	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	28.76	22
10	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	25.86	22
	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
Stack Wt	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54		
Count	66			#																				
Sum VCG	1955			m																				
Sum Mass	1188			MT																				
VCG	29.62			m-BL																				

[illegible]

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21		22
11	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	28.76	22
10	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	25.86	22
	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
Stack Wt	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54		
Count		66		#																				
Sum VCG		1955		m																				
Sum Mass		1188		MT																				
VCG		29.62		m-BL																				

Bay 82

Max Height33.0232.7232.7232.7232.7232.7232.7233.3333.3333.3333.3333.3333.3333.3332.7232.7232.7232.7232.7233.02

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12																								0
11	31.6	31.29	31.29	31.29	31.29	31.29	31.29	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.29	31.29	31.29	31.29	31.29	31.29	31.6	31.65	22
10	29.01	28.7	28.7	28.7	28.7	28.7	28.7	29.31	29.31	29.31	29.31	29.31	29.31	29.31	29.31	28.7	28.7	28.7	28.7	28.7	28.7	29.01	28.76	22
9	26.42	26.11	26.11	26.11	26.11	26.11	26.11	26.72	26.72	26.72	26.72	26.72	26.72	26.72	26.72	26.11	26.11	26.11	26.11	26.11	26.11	26.42	25.86	22
8	23.83	23.52	23.52	23.52	23.52	23.52	23.52	24.13	24.13	24.13	24.13	24.13	24.13	24.13	24.13	23.52	23.52	23.52	23.52	23.52	23.52	23.83	22.97	22
7	21.24	20.93	20.93	20.93	20.93	20.93	20.93									20.93	20.93	20.93	20.93	20.93	20.93	21.24	20.07	14
6		18.34	18.34	18.34	18.34	18.34	18.34									18.34	18.34	18.34	18.34	18.34	18.34		17.18	12
5																							14.28	0
4																							11.39	0
3																							8.49	0
2																							5.595	0
1																							2.7	0
	5	6	6	6	6	6	6	4	4	4	4	4	4	4	4	6	6	6	6	6	6	5		
Stack Wt	90	108	108	108	108	108	108	72	72	72	72	72	72	72	72	108	108	108	108	108	108	90		
Count		114		#																				
Sum VCG		2948		m																				
Sum Mass		2052		MT																				
VCG		25.86		m-BL																				

Bay 86

Max Height33.0233.0232.7232.7232.7232.7232.7232.4232.4232.4232.4232.4232.4232.4232.7232.7232.7232.7233.0233.02

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12																								0
11	31.6	31.6	31.29	31.29	31.29	31.29	31.29	30.99	30.99	30.99	30.99	30.99	30.99	30.99	30.99	31.29	31.29	31.29	31.29	31.29	31.6	31.6	31.65	22
10	29.01	29.01	28.7	28.7	28.7	28.7	28.7	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.7	28.7	28.7	28.7	28.7	29.01	29.01	28.76	22
9	26.42	26.42	26.11	26.11	26.11	26.11	26.11	25.81	25.81	25.81	25.81	25.81	25.81	25.81	25.81	26.11	26.11	26.11	26.11	26.11	26.42	26.42	25.86	22
8	23.83	23.83	23.52	23.52	23.52	23.52	23.52	23.22	23.22	23.22	23.22	23.22	23.22	23.22	23.22	23.52	23.52	23.52	23.52	23.52	23.83	23.83	22.97	22
7	21.24	21.24	20.93	20.93	20.93	20.93	20.93	20.63	20.63	20.63	20.63	20.63	20.63	20.63	20.63	20.93	20.93	20.93	20.93	20.93	21.24	21.24	20.07	22
6			18.34	18.34	18.34	18.34	18.34	18.04	18.04	18.04	18.04	18.04	18.04	18.04	18.04	18.34	18.34	18.34	18.34	18.34			17.18	18
5								15.45	15.45	15.45	15.45	15.45	15.45	15.45	15.45								14.28	8
4																							11.39	0
3																							8.49	0
2																							5.595	0
1																							2.7	0
	5	5	6	6	6	6	6	7	7	7	7	7	7	7	7	6	6	6	6	6	5	5		
Stack Wt	90	90	108	108	108	108	108	126	126	126	126	126	126	126	126	108	108	108	108	108	90	90		
Count		136		#																				
Sum VCG		3318		m																				
Sum Mass		2448		MT																				
VCG		24.39		m-BL																				

Bay 90

Max Height33.3333.0233.0233.0233.0232.7232.7232.7232.7232.7232.7232.7232.7232.7232.7233.0233.0233.0233.0233.33

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12																								0
11	31.9	31.6	31.6	31.6	31.6	31.29	31.29	31.29	31.29	31.29	31.29	31.29	31.29	31.29	31.29	31.29	31.29	31.6	31.6	31.6	31.6	31.9	31.65	22
10	29.31	29.01	29.01	29.01	29.01	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	29.01	29.01	29.01	29.01	29.31	28.76	22
9	26.72	26.42	26.42	26.42	26.42	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.42	26.42	26.42	26.42	26.72	25.86	22
8	24.13	23.83	23.83	23.83	23.83	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.83	23.83	23.83	23.83	24.13	22.97	22
7		21.24	21.24	21.24	21.24	20.93	20.93	20.93	20.93	20.93	20.93	20.93	20.93	20.93	20.93	20.93	20.93	21.24	21.24	21.24	21.24		20.07	20
6						18.34	18.34	18.34	18.34	18.34	18.34	18.34	18.34	18.34	18.34	18.34	18.34						17.18	12
5																							14.28	0
4																							11.39	0
3																							8.49	0
2																							5.595	0
1																							2.7	0
	4	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	4		
Stack Wt	72	90	90	90	90	108	108	108	108	108	108	108	108	108	108	108	108	90	90	90	90	72		
Count	120		#																					
Sum VCG	3068		m																					
Sum Mass	2160		MT																					
VCG	25.56		m-BL																					

Typical Deck Bay

Tier/Stack	24	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	23	Count Rows	VCG Sum
13		67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86	67.86		22	1492.82	
12	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	65.26	24	1566.352	
11	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	62.67	24	1504.173	
10	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	24	1441.993	
9	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	24	1379.814	
8	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	24	1317.635	
7	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	24	1255.456	
6	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	24	1193.277	
5	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	24	1131.097	
4	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	24	1068.918	
3	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	24	1006.739	
2	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	24	944.5598	
1	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	24	882.3806	
	12	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	12	24	310	
Stack Wt	172.8	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	187.2	172.8	24	4464	
Stack Abv Weight	158.4	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	172.8	158.4			
Count	310		#																							
Sum VCG	16185.2		m																							
Sum Mass	4464		MT																							
VCG	65.263		m-BL																							

10-High Deck Bay

Typical Deck Bay - 10 High

Tier/Stack	24	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	23	Count Rows
13																									0
12																									0
11																									0
10				60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08	60.08		20
9			57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49	57.49		22
8	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	24
7	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	24
6	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	24
5	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	24
4	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	24
3	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	24
2	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	24
1	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	24
	8	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	9	8	24
Stack Wt	125.6	141.3	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	141.3	125.6	24
Count	234	#																							
Sum VCG	11266.6	m																							
Sum Mass	3673.8	MT																							
VCG	48.148	m-BL																							

14.4.2.14 MT/TEU Homogenous Scantling Departure Container Summary

	Hold Wt	LCG	VCG	TCG	Deck Wt	LCG	VCG	TCG
Bay	MT	m-AP	m-BL	m-CL	MT	m-AP	m-BL	m-CL
2	2,408	359.500	24.508	0	4,256	359.500	44.437	0
6	3,080	345.050	19.883	0	4,648	345.050	44.445	0
10	3,864	330.600	18.040	0	4,648	330.600	44.445	0
14	4,200	316.150	15.596	0	4,648	316.150	44.445	0
18	4,312	301.700	13.744	0	4,648	301.700	44.445	0
22	4,312	287.250	13.218	0	4,648	287.250	44.445	0
26	4,312	272.800	12.428	0	4,648	272.800	44.445	0
30	4,312	243.900	11.902	0	4,648	243.900	44.445	0
34	4,312	229.450	11.902	0	4,648	229.450	44.445	0
38	4,312	215.000	11.902	0	4,648	215.000	44.445	0
42	4,312	200.550	11.902	0	4,648	200.550	44.445	0
46	4,312	186.100	11.902	0	4,648	186.100	44.445	0
50	4,312	171.650	11.902	0	4,648	171.650	44.445	0
54	4,312	157.200	11.902	0	4,648	157.200	44.445	0
58	4,312	142.750	11.902	0	4,648	142.750	44.445	0
62	4,312	128.300	11.902	0	4,648	128.300	44.445	0
66	4,312	113.850	11.902	0	4,648	113.850	44.445	0
70	4,312	99.400	12.692	0	4,648	99.400	44.445	0
74	4,312	84.950	14.797	0	4,648	84.950	44.445	0
78	1,848	70.500	29.617	0	4,648	70.500	44.445	0
82	3,192	44.800	25.857	0	4,648	44.800	44.445	0
86	3,808	30.350	24.395	0	4,648	30.350	44.445	0
90	3,360	15.900	25.565	0	4,648	15.900	44.445	0
94					4,648	1.450	44.445	0
Total Hold	90,440 MT				Total Deck	111,160 MT		
Total Cargo	201,600 MT							

Tiers	40' Bay	94	90	86	82	78	74	70	66	62	58	54	50	46	42	38	34	30	26	22	18	14	10	6	2
13	0																								
12	0																								
11	0																								
10	0																								
9	0																								
8	0																								
7	526	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20
6	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
5	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
4	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
3	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
2	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
1	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
Deck Total	3970	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	152
12	88		22	22	22	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
11	128		22	22	22	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	8	12
10	142		22	22	22	22	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	6	10	12
9	134		22	22	22		8	2	0	0	0	0	0	0	0	0	0	0	0	2	4	4	8	14	12
8	162		20	22	14		12	6	2	2	2	2	2	2	2	2	2	2	2	4	6	8	12	14	12
7	436		12	18	12		22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	18	14	10
6	396			8			22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	18	12
5	382						22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	16	10
4	372						22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	18	14
3	358						18	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	16	12	8
2	338						14	20	22	22	22	22	22	22	22	22	22	22	22	22	22	20	18	14	8
1	294						10	16	20	20	20	20	20	20	20	20	20	20	20	20	18	16	14	10	6
Hold Total	3230		120	136	114	66	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	150	138	110	86
Grand Total	7200	FEU	286	302	280	232	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	316	304	276	238
	14400	TEU																							
			7200																						

Containers in Holds – 14 MT/TEU

Bay 2

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG	Count Rows
11			32.51	32.51	32.21	31.9	31.6	31.3	30.99					30.99	31.3	31.6	31.9	32.21	32.51	32.51			VCG-Bot	14
10			29.92	29.92	29.62	29.31	29.01	28.7	28.4	28.1	28.1	28.1	28.1	28.4	28.7	29.01	29.31	29.62	29.92	29.92			28.76	18
9					27.03	26.72	26.42	26.11	25.81	25.51	25.51	25.51	25.51	25.81	26.11	26.42	26.72	27.03					25.86	14
8						24.13	23.83	23.52	23.22	22.91	22.91	22.91	22.91	23.22	23.52	23.83	24.13						22.97	12
7							21.24	20.93	20.63	20.32	20.32	20.32	20.32	20.63	20.93	21.24							20.07	10
6								18.34	18.04	17.73	17.73	17.73	17.73	18.04	18.34								17.18	8
5									15.45	15.14	15.14	15.14	15.14	15.45									14.28	6
4										12.55	12.55	12.55	12.55										11.39	4
	0	0	2	2	3	4	5	6	7	7	7	7	7	6	5	4	3	2	2	0	0			86
Stack Wt	0	0	56	56	84	112	140	168	196	196	196	196	196	168	140	112	84	56	56	0	0			2408
Stack Above Wt	-28	-28	28	28	56	84	112	140	168	168	168	168	168	140	112	84	56	28	28	-28	-28			
Count			86																					
Sum VCG			2107.7																					
Sum Mass			2408																					
VCG			24.508																					

Bay 6

Max Height 1.727 34.24 33.94 33.63 33.33 33.02 32.72 26.93 24.03 21.14 21.14 21.14 21.14 24.03 26.93 32.72 33.02 33.33 33.63 33.94 34.24 1.727

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12																								0
11		32.51	32.21	31.9	31.6	31.3	30.99									30.99	31.3	31.6	31.9	32.21	32.51		31.65	12
10		29.92	29.62	29.31	29.01	28.7	28.4									28.4	28.7	29.01	29.31	29.62	29.92		28.76	12
9			27.03	26.72	26.42	26.11	25.81	25.2								25.2	25.81	26.11	26.42	26.72	27.03		25.86	12
8				24.13	23.83	23.52	23.22	22.61	22.31						22.31	22.61	23.22	23.52	23.83	24.13			22.97	12
7					21.24	20.93	20.63	20.02	19.72	19.41	19.41	19.41	19.41	19.72	20.02	20.63	20.93	21.24					20.07	14
6						18.34	18.04	17.43	17.12	16.82	16.82	16.82	16.82	17.12	17.43	18.04	18.34						17.18	12
5							15.45	14.84	14.53	14.23	14.23	14.23	14.23	14.53	14.84	15.45							14.28	10
4								12.25	11.94	11.64	11.64	11.64	11.64	11.94	12.25								11.39	8
3								9.656	9.352	9.048	9.048	9.048	9.048	9.352	9.656								8.49	8
2									6.761	6.457	6.457	6.457	6.457	6.761									5.595	6
1										3.866	3.866	3.866	3.866										2.7	4
	0	2	3	4	5	6	7	7	7	7	7	7	7	7	7	7	6	5	4	3	2	0		
Stack Wt	0	56	84	112	140	168	196	196	196	196	196	196	196	196	196	196	168	140	112	84	56	0		
Count	110		#																					
Sum VCG	2187		m																					
Sum Mass	3080		MT																					
VCG	19.883		m-BL																					

Bay 10

Max Height 33.94 33.63 33.02 32.72 29.82 26.93 26.93 24.03 21.14 21.14 21.14 21.14 21.14 24.03 26.93 26.93 29.82 32.72 33.02 33.63 33.94

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows	
12																								0	
11	32.21	31.9	31.3	30.99															30.99	31.3	31.9	32.21	31.65	8	
10	29.62	29.31	28.7	28.4	28.1													28.1	28.4	28.7	29.31	29.62	28.76	10	
9	27.03	26.72	26.11	25.81	25.51	25.2	25.2									25.2	25.2	25.51	25.81	26.11	26.72	27.03	25.86	14	
8		24.13	23.52	23.22	22.91	22.61	22.61	22.31								22.31	22.61	22.61	22.91	23.22	23.52	24.13		22.97	14
7			20.93	20.63	20.32	20.02	20.02	19.72	19.41	19.41	19.41	19.41	19.41	19.41	19.72	20.02	20.02	20.32	20.63	20.93			20.07	18	
6			18.34	18.04	17.73	17.43	17.43	17.12	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.43	17.43	17.73	18.04	18.34			17.18	18	
5				15.45	15.14	14.84	14.84	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.84	14.84	15.14	15.45				14.28	16	
4					12.55	12.25	12.25	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.94	12.25	12.25	12.55					11.39	14	
3						9.656	9.656	9.352	9.048	9.048	9.048	9.048	9.048	9.048	9.352	9.656	9.656						8.49	12	
2								6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.761								5.595	8	
1									3.866	3.866	3.866	3.866	3.866	3.866									2.7	6	
	3	4	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	4	3			
Stack Wt	84	112	168	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	168	112	84			
Count	138			#																					
Sum VCG	2490			m																					
Sum Mass	3864			MT																					
VCG	18.040			m-BL																					

Bay 14

Max Height33.3332.7229.8226.9324.0324.0321.1421.1421.1421.1421.1421.1421.1421.1424.0324.0326.9329.8232.7233.33

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows	
12																								0	
11	31.6	30.99																			30.99	31.6	31.65	4	
10	29.01	28.4	28.1																		28.1	28.4	29.01	28.76	6
9	26.42	25.81	25.51	25.2																25.2	25.51	25.81	26.42	25.86	8
8	23.83	23.22	22.91	22.61	22.31	22.31												22.31	22.31	22.61	22.91	23.22	23.83	22.97	12
7	21.24	20.63	20.32	20.02	19.72	19.72	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.72	19.72	20.02	20.32	20.63	21.24	20.07	22	
6		18.04	17.73	17.43	17.12	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.12	17.43	17.73	18.04		17.18	20	
5		15.45	15.14	14.84	14.53	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.53	14.84	15.14	15.45		14.28	20	
4			12.55	12.25	11.94	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	11.94	12.25	12.55			11.39	18	
3				9.656	9.352	9.352	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.352	9.352	9.656				8.49	16	
2					6.761	6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761	6.761					5.595	14	
1							3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866							2.7	10	
	5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5			
Stack Wt	140	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	140			
Count	150		#																						
Sum VCG	2339		m																						
Sum Mass	4200		MT																						
VCG	15.60		m-BL																						

Bay 18

Max Height32.7226.9324.0324.0321.1421.1421.1421.1421.1421.1421.1421.1421.1421.1424.0324.0326.9332.72

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12																								0
11	30.99																					30.99	31.65	2
10	28.4																					28.4	28.76	2
9	25.81	25.2																			25.2	25.81	25.86	4
8	23.22	22.61	22.31	22.31															22.31	22.31	22.61	23.22	22.97	8
7	20.63	20.02	19.72	19.72	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.72	19.72	20.02	20.63	20.07	22	
6	18.04	17.43	17.12	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.12	17.43	18.04	17.18	22	
5	15.45	14.84	14.53	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.53	14.84	15.45	14.28	22	
4		12.25	11.94	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	11.94	12.25		11.39	20	
3		9.656	9.352	9.352	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.352	9.352	9.656	8.49		20		
2			6.761	6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761	6.761			5.595	18	
1				3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866		2.7			14		
	7	7		7	7	7	7	7	7	7	7	7	7	7	7	7	7		7	7	7	7		
Stack Wt	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196		
Count	154		#																					
Sum VCG	2117		m																					
Sum Mass	4312		MT																					
VCG	13.74		m-BL																					

Bay 22

Max Height 29.82 26.93 24.03 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 24.03 26.93 29.82

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12																								0
11																							31.65	0
10	28.1																					28.1	28.76	2
9	25.51	25.2																			25.2	25.51	25.86	4
8	22.91	22.61	22.31																	22.31	22.61	22.91	22.97	6
7	20.32	20.02	19.72	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.72	20.02	20.32	20.07	22
6	17.73	17.43	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.43	17.73	17.18	22
5	15.14	14.84	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.84	15.14	14.28	22
4	12.55	12.25	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	12.25	12.55	11.39	22
3		9.656	9.352	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.352	9.656		8.49	20
2			6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761			5.595	18
1				3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866				2.7	16
	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		
Stack Wt	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196		
Count	154		#																					
Sum VCG	2036		m																					
Sum Mass	4312		MT																					
VCG	13.22		m-BL																					

Bay 26

Max Height 26.93 24.03 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 24.03 26.93

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12																								0
11																							31.65	0
10																							28.76	0
9	25.2																					25.2	25.86	2
8	22.61	22.31																			22.31	22.61	22.97	4
7	20.02	19.72	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.72	20.02	20.07	22
6	17.43	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.43	17.18	22
5	14.84	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.84	14.28	22
4	12.25	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	12.25	11.39	22
3	9.656	9.352	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.352	9.656	8.49	22
2		6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761		5.595	20
1			3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866			2.7	18
	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		
Stack Wt	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196		
Count	154		#																					
Sum VCG	1914		m																					
Sum Mass	4312		MT																					
VCG	12.43		m-BL																					

Bay 30-66

Max Height 24.03 21.14 24.03

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12																								0
11																							31.65	0
10																							28.76	0
9																							25.86	0
8	22.31																					22.31	22.97	2
7	19.72	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.72	20.07	22
6	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.18	22
5	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.28	22
4	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	11.39	22
3	9.352	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.352	8.49	22
2	6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761	5.595	22
1		3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866		2.7	20
	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		
Stack Wt	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196		
Count	154		#																					
Sum VCG	1833		m																					
Sum Mass	4312		MT																					
VCG	11.90		m-BL																					

Bay 70

Max Height 26.93 24.03 24.03 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 24.03 24.03 26.93

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12																								0
11																							31.65	0
10																							28.76	0
9	25.2																					25.2	25.86	2
8	22.61	22.31	22.31																	22.31	22.31	22.61	22.97	6
7	20.02	19.72	19.72	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.72	19.72	20.02	20.07	22
6	17.43	17.12	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.12	17.43	17.18	22
5	14.84	14.53	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.53	14.84	14.28	22
4	12.25	11.94	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	11.94	12.25	11.39	22
3	9.656	9.352	9.352	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.352	9.352	9.656	8.49	22
2		6.761	6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761	6.761		5.595	20
1				3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866				2.7	16
	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		
Stack Wt	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196		
Count	154			#																				
Sum VCG	1955			m																				
Sum Mass	4312			MT																				
VCG	12.69			m-BL																				

Bay 74

Max Height 29.82 29.82 26.93 26.93 24.03 24.03 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 21.14 24.03 24.03 26.93 26.93 29.82 29.82

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows	
12																								0	
11																							31.65	0	
10	28.1	28.1																			28.1	28.1	28.76	4	
9	25.51	25.51	25.2	25.2															25.2	25.2	25.51	25.51	25.86	8	
8	22.91	22.91	22.61	22.61	22.31	22.31												22.31	22.31	22.61	22.61	22.91	22.91	22.97	12
7	20.32	20.32	20.02	20.02	19.72	19.72	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.72	19.72	20.02	20.02	20.32	20.32	20.07	22	
6	17.73	17.73	17.43	17.43	17.12	17.12	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	17.12	17.12	17.43	17.43	17.73	17.73	17.18	22	
5	15.14	15.14	14.84	14.84	14.53	14.53	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.53	14.53	14.84	14.84	15.14	15.14	14.28	22	
4	12.55	12.55	12.25	12.25	11.94	11.94	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.94	11.94	12.25	12.25	12.55	12.55	11.39	22	
3			9.656	9.656	9.352	9.352	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.048	9.352	9.352	9.656	9.656			8.49	18	
2					6.761	6.761	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.457	6.761	6.761					5.595	14	
1							3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866	3.866							2.7	10	
	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7			
Stack Wt	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196			
Count	154		#																						
Sum VCG	2279		m																						
Sum Mass	4312		MT																						
VCG	14.80		m-BL																						

Bay 78

Max Height 33.94

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21	32.21		22
11	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	29.62	28.76	22
10	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	27.03	25.86	22
	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
Stack Wt	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84		
Count	66		#																					
Sum VCG	1955		m																					
Sum Mass	1848		MT																					
VCG	29.62		m-BL																					

Bay 82																									
Max Height	33.33	33.02	33.02	33.02	33.02	33.02	33.02	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.63	33.02	33.02	33.02	33.02	33.02	33.02	33.33			
Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows	
12																							0		
11	31.6	31.3	31.3	31.3	31.3	31.3	31.3	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.3	31.3	31.3	31.3	31.3	31.3	31.6	31.65	22	
10	29.01	28.7	28.7	28.7	28.7	28.7	28.7	29.31	29.31	29.31	29.31	29.31	29.31	29.31	29.31	28.7	28.7	28.7	28.7	28.7	28.7	29.01	28.76	22	
9	26.42	26.11	26.11	26.11	26.11	26.11	26.11	26.72	26.72	26.72	26.72	26.72	26.72	26.72	26.72	26.11	26.11	26.11	26.11	26.11	26.11	26.42	25.86	22	
8	23.83	23.52	23.52	23.52	23.52	23.52	23.52	24.13	24.13	24.13	24.13	24.13	24.13	24.13	24.13	23.52	23.52	23.52	23.52	23.52	23.52	23.83	22.97	22	
7	21.24	20.93	20.93	20.93	20.93	20.93	20.93									20.93	20.93	20.93	20.93	20.93	20.93	21.24	20.07	14	
6		18.34	18.34	18.34	18.34	18.34	18.34										18.34	18.34	18.34	18.34	18.34	18.34		17.18	12
5																						14.28	0		
4																						11.39	0		
3																						8.49	0		
2																						5.595	0		
1																						2.7	0		
	5	6	6	6	6	6	6	4	4	4	4	4	4	4	4	6	6	6	6	6	6	5			
Stack Wt	140	168	168	168	168	168	168	112	112	112	112	112	112	112	112	168	168	168	168	168	168	140			
Count	114		#																						
Sum VCG	2948		m																						
Sum Mass	3192		MT																						
VCG	25.86		m-BL																						

Bay 86																										
Max Height	33.33	33.33	33.02	33.02	33.02	33.02	33.02	32.72	32.72	32.72	32.72	32.72	32.72	32.72	32.72	33.02	33.02	33.02	33.02	33.02	33.33	33.33				
Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows		
12																							0			
11	31.6	31.6	31.3	31.3	31.3	31.3	31.3	30.99	30.99	30.99	30.99	30.99	30.99	30.99	30.99	31.3	31.3	31.3	31.3	31.3	31.6	31.6	31.65	22		
10	29.01	29.01	28.7	28.7	28.7	28.7	28.7	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.7	28.7	28.7	28.7	28.7	29.01	29.01	28.76	22		
9	26.42	26.42	26.11	26.11	26.11	26.11	26.11	25.81	25.81	25.81	25.81	25.81	25.81	25.81	25.81	26.11	26.11	26.11	26.11	26.11	26.42	26.42	25.86	22		
8	23.83	23.83	23.52	23.52	23.52	23.52	23.52	23.22	23.22	23.22	23.22	23.22	23.22	23.22	23.22	23.52	23.52	23.52	23.52	23.52	23.83	23.83	22.97	22		
7	21.24	21.24	20.93	20.93	20.93	20.93	20.93	20.63	20.63	20.63	20.63	20.63	20.63	20.63	20.63	20.93	20.93	20.93	20.93	20.93	21.24	21.24	20.07	22		
6			18.34	18.34	18.34	18.34	18.34	18.04	18.04	18.04	18.04	18.04	18.04	18.04	18.04	18.34	18.34	18.34	18.34	18.34			17.18	18		
5								15.45	15.45	15.45	15.45	15.45	15.45	15.45											14.28	8
4																						11.39	0			
3																						8.49	0			
2																						5.595	0			
1																						2.7	0			
	5	5	6	6	6	6	6	7	7	7	7	7	7	7	7	6	6	6	6	6	5	5				
Stack Wt	140	140	168	168	168	168	168	196	196	196	196	196	196	196	196	168	168	168	168	168	140	140				
Count	136		#																							
Sum VCG	3318		m																							
Sum Mass	3808		MT																							
VCG	24.40		m-BL																							

Bay 90

Max Height33.6333.3333.3333.3333.0233.0233.0233.0233.0233.0233.0233.0233.0233.0233.3333.3333.333333.63

Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12																								0
11	31.9	31.6	31.6	31.6	31.6	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.6	31.6	31.6	31.6	31.9	31.65	22
10	29.31	29.01	29.01	29.01	29.01	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	29.01	29.01	29.01	29.01	29.31	28.76	22
9	26.72	26.42	26.42	26.42	26.42	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.42	26.42	26.42	26.42	26.72	25.86	22
8	24.13	23.83	23.83	23.83	23.83	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.52	23.83	23.83	23.83	23.83	24.13	22.97	22
7		21.24	21.24	21.24	21.24	20.93	20.93	20.93	20.93	20.93	20.93	20.93	20.93	20.93	20.93	20.93	20.93	21.24	21.24	21.24	21.24		20.07	20
6						18.34	18.34	18.34	18.34	18.34	18.34	18.34	18.34	18.34	18.34	18.34	18.34						17.18	12
5																							14.28	0
4																							11.39	0
3																							8.49	0
2																							5.595	0
1																							2.7	0
	4	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	4		
Stack Wt	112	140	140	140	140	168	168	168	168	168	168	168	168	168	168	168	168	140	140	140	140	112		
Count	120		#																					
Sum VCG	3068		m																					
Sum Mass	3360		MT																					
VCG	25.56		m-BL																					

Typical 14 MT/TEU Deck Bay

Typical Deck Bay

Tier/Stack	24	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	23	Count Rows
13																								0	
12																								0	
11																								0	
10																								0	
9																								0	
8																								0	
7		52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31	52.31		22
6	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	24
5	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	47.13	24
4	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	44.54	24
3	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	41.95	24
2	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	39.36	24
1	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	36.77	24
	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	24
Stack Wt	168	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	168	24
Bottom Tier Weight	140	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	140	
Count	166		#																						
Sum VCG	7377.9		m																						
Sum Mass	4648		MT																						
VCG	44.445		m-BL																						

15. Appendix B – Case Study Alternatively Fuelled Ship Design Data

15.1. Operating Profiles for Tank Sizing

Operating Profile Key:

2A – Max Power (90% MCR), 100% Reefer Load, 1 Bunker per Round Trip, Travel Around Cape of Africa

2B – Max Power (90% MCR), 100% Reefer Load, 1 Bunker per Round Trip, Travel Through Suez Canal

2C – Slow Steaming (57% MCR), 50% Reefer Load, 1 Bunker per Round Trip, Travel Around Cape of Africa

2D – Slow Steaming (57% MCR), 50% Reefer Load, 1 Bunker per Round Trip, Travel Through Suez Canal

1A – Max Power (90% MCR), 100% Reefer Load, 2 Bunkers per Round Trip, Travel Around Cape of Africa

1B – Max Power (90% MCR), 100% Reefer Load, 2 Bunkers per Round Trip, Travel Through Suez Canal

1C – Slow Steaming (57% MCR), 50% Reefer Load, 2 Bunkers per Round Trip, Travel Around Cape of Africa

1D – Slow Steaming (57% MCR), 50% Reefer Load, 2 Bunkers per Round Trip, Travel Through Suez Canal

Condition 2A: Max Power (90% MCR), 100% Reefer Load, 1 Bunker per Round Trip, Travel Around Cape of Africa

Condition - Fastest Time, Approx 90% MCR for Propulsion, 100% Reefers, 1 Bunker per Round Trip, Design Draft, No Suez

Time Between Fuelling/Schedule Time	77 days	Assume 15 days for 11 ports
Time between fuelling	1843 hours	
Sailing Speed	21.9 knots	
Sailing Distance (Route distance + 10% Margin)	32500 Nmi	
Sail Time Req'd	1484 hours	61.8 days sailing
Non-Sail Time	359 hours	15.0 days non-sailing
Propulsion Power Req'd at Design Draft	54,339 kW at design draft and speed with 15% SM + 7% Hull Fouling	
Propulsion Energy Req'd	80,639,437 kW-Hrs	
	2.90E+08 MJ	
ME Installed Power	65,500 kW with 4,500 kW deduction for Shaft Generator	
Shaft Generator	4,500 kW	
ME Power Demand	58,839 kW	
% MCR	90% MCR for propulsion and SG	

Main Engine Consumptions at 90% MCR							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC - w/5% Margin	g/kW-hr	164.6	3.1	10.5	10.5	10.5	
SGC -w/5% Margin	g/kW-hr		136.7	331.4	356.0		55.1
Cylinder Oil	g/kW-hr	0.6	0.6	0.6	0.6		0.6
Lube Oil	g/kW-hr	0.1	0.1	0.1	0.1		0.1
Urea	L/hr	1110	1250		1250		
NaOH	L/hr			12.4			
Sludge	L/hr			13.3			
Methane Slip	g/kW-hr		0.21				
HFO/MDO Req'd	MT	13,276	253	847	847	847	
Gas Req'd	MT	0	11,024	26,722	28,704		4,445
Methane Slip	kg		16,934				
Density	kg/m ³	980	462.5	784	758	42	71
HFO/MDO Volume req'd	m ³	13,547	294	985	985	985	
Gas Volume Req'd	m ³	0	23,836	34,088	37,864	106,686	62,756
Urea Consumed	m ³	1647	1855	0	1855	0	0
NaOH Consumed	m ³	0	0	18	0	0	0
Sludge Generated	m ³	0	0	20	0	0	0

Aux. Engine Consumption		
Baseline Sea Aux Power	2,300 kW	From 4th IMO GHG Study
Baseline Anchored/At Berth Power	1,675 kW	Average from 4th IMO GHG Study
Reefer Slots	2,200 FEU	
Reefers Carried	100%	
Reefer Power Requirements	11,000 kW	6kW for 1/3 in Hold, 4.5kW for 2/3 on Deck, MMM
Total at Sea Power	13,300 kW	Ammonia Paper Assumption
Total Anchor/At Berth Power	12,675 kW	
At Sea Power for DG's	8,800 kW	
Total Round Trip Time	1843 hours	
Total Sail Hours	1484 hours	
Total Non-Sail Hours	359 hours	
Sail Hour DG kW-hr Req'd	19,737,443 kW-Hrs	
Anchor/At Berth Power kW-hr Req'd	4,552,628 kW-Hrs	
Total Aux Power kW-Hr	24,290,071 kW-Hrs	
	8.74E+07 MJ	

Aux DG Consumptions at 85% Service Load							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC @ 85% output	g/kW-hr	198.0	3.3	62.9	62.9	62.9	
SGC @ 85% output	g/kW-hr		166.8	274.2	293.4		45.5
Lube Oil w/ 20% Margin	g/kW-hr	0.672					
Urea	g/kW-hr	13					
HFO/MDO Req'd	MT	4,809	80	1,528	1,528	1,528	
Gas Req'd	MT	0	4,052	6,660	7,127	1,105	
Density	kg/m ³	980	463	784	758	42	71
HFO/MDO Volume req'd	m ³	4,908	93	1,777	1,777	1,777	
Gas Volume Req'd	m ³	0	8,760	8,496	9,401	26,525	15,603

Other Aux DG Consumables

LO Req'd	MT	16
LO Density	kg/m ³	900
LO Volume Req'd	m³	18.1
Urea Req'd	MT	316
Urea Density	kg/m ³	1110
Urea Volume Req'd	m³	284.5

Boiler Consumption

Aux Boiler Power Output, At-Berth/Anchoring/Manuevering
Anchor/At Berth Power Req'd

700 kW
251427 kW-hrs
9.05E+05 MJ

IMO 4th GHG Study, 20,000 TEU containerships

HFO SFOC

340 g/kW-hr

IMO 4th GHG Study, Table 19

HFO LCV

40.2 MJ/kg

Boiler Heat Rate

13668 kJ/kW-hr

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
LCV	MJ/kg	40.2	48	19.9	18.6	120	
SFOC/SPOC	g/kW-hr	340	285	687	735	113.9	
Fuel Req'd	MT	85	72	173	185	29	
Density	kg/m ³	980	463	784	758	42	71
Volume Req'd	m ³	87	155	220	244	687	404

Total Base Req'd Capacities

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
HFO/Pilot MDO Volume Req'd	m ³	18,542	388	2,761	2,761	2,761	
Alternative Fuel Volume Req'd	m ³	0	32,788	42,805	47,509	133,898	78,764
HFO/Pilot MDO Mass Req'd	MT	18,171	333	2,375	2,375	2,375	
Alternative Fuel Mass Req'd	MT	0	15164	33555	36015	5579	
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
HFO/Pilot MDO Tank Volume Req'd	m ³	18921	395	2817	2817	2817	
Alternative Fuel Tank Volume Req'd	m ³	0	40604	45057	58835	157527	97540

Nominal Range

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
Design Service Speed	Knots	22.4					
Primary Fuel Tank Capacity	m ³	18,921	40,604	45,057	58,835	157,527	97,540
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
Usable Volume	m ³	18542	32788	42805	47509	133898	78764
Primary Fuel Density	MT/m ³	0.98	0.46	0.78	0.76	0.04	0.07
Primary Fuel Consumption	MT/day	232	193	468	503	78	78
Cruising Range	NMI	42018	42229	38550	38520	38530	38530

Condition 2B: Max Power (90% MCR), 100% Reefer Load, 1 Bunker per Round Trip, Travel Through Suez Canal

Condition - Fastest Time, Approx 90% MCR for Propulsion, 100% Reefers, 1 Bunker per Round Trip, Design Draft, Through Suez

Time Between Fuelling/Schedule Time	63 days	Assume 15 days for 11 ports
Time between fuelling	1502 hours	
Sailing Speed	21.9 knots	
Sailing Distance (Route distance + 10% Margin)	25000 Nmi	
Sail Time Req'd	1142 hours	47.6 days sailing
Non-Sail Time	361 hours	15.0 days non-sailing
Propulsion Power Req'd at Design Draft	54,339 kW at design draft and speed with 15% SM + 7% Hull Fouling	
Propulsion Energy Req'd	62,030,336 kW-Hrs 2.23E+08 MJ	
ME Installed Power	65,500 kW with 4,500 kW deduction for Shaft Generator	
Shaft Generator	4,500 kW	
ME Power Demand	58,839 kW	
% MCR	90% % MCR for propulsion and SG	

Main Engine Consumptions at 90% MCR							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC - w/5% Margin	g/kW-hr	164.6	3.1	10.5	10.5		10.5
SGC -w/5% Margin	g/kW-hr		136.7	331.4	356.0		55.1
Cylinder Oil	g/kW-hr	0.6	0.6	0.6	0.6		0.6
Lube Oil	g/kW-hr	0.1	0.1	0.1	0.1		0.1
Urea	L/hr	1110	1250		1250		
NaOH	L/hr			12.4			
Sludge	L/hr			13.3			
Methane Slip	g/kW-hr		0.21				
HFO/MDO Req'd	MT	10,213	195	651	651		651
Gas Req'd	MT	0	8,480	20,556	22,080		3,419
Methane Slip	kg		13,026				
Density	kg/m ³	980	462.5	784	758	42	71
HFO/MDO Volume req'd	m ³	10,421	226	757	757		757
Gas Volume Req'd	m ³	0	18,335	26,222	29,126	82,066	48,274
Urea Consumed	m ³	1267	1427	0	1427	0	0
NaOH Consumed	m ³	0	0	14	0	0	0
Sludge Generated	m ³	0	0	15	0	0	0

Aux. Engine Consumption		
Baseline Sea Aux Power	2,300 kW	From 4th IMO GHG Study
Baseline Anchored/At Berth Power	1,675 kW	Average from 4th IMO GHG Study
Reefer Slots	2,200 FEU	
Reefers Carried	100%	
Reefer Power Requirements	11,000 kW	6kW for 1/3 in Hold, 4.5kW for 2/3 on Deck, MMM
Total at Sea Power	13,300 kW	Ammonia Paper Assumption
Total Anchor/At Berth Power	12,675 kW	
At Sea Power for DG's	8,800 kW	
Total Round Trip Time	1502 hours	
Total Sail Hours	1142 hours	
Total Non-Sail Hours	361 hours	
Sail Hour DG kW-hr Req'd	15,182,648 kW-Hrs	
Anchor/At Berth Power kW-hr Req'd	4,573,742 kW-Hrs	
Total Aux Power kW-Hr	19,756,390 kW-Hrs	
	7.11E+07 MJ	

Aux DG Consumptions at 85% Service Load							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC @ 85% output	g/kW-hr	198.0	3.3	62.9	62.9		62.9
SGC @ 85% output	g/kW-hr		166.8	274.2	293.4		45.5
Lube Oil w/ 20% Margin	g/kW-hr	0.672					
Urea	g/kW-hr	13					
HFO/MDO Req'd	MT	3,912	65	1,243	1,243		1,243
Gas Req'd	MT	0	3,295	5,417	5,797		899
Density	kg/m ³	980	463	784	758	42	71
HFO/MDO Volume req'd	m ³	3,992	76	1,445	1,445		1,445
Gas Volume Req'd	m ³	0	7,125	6,910	7,646	21,574	12,691

Other Aux DG Consumables

LO Req'd	MT	13
LO Density	kg/m ³	900
LO Volume Req'd	m³	14.8
Urea Req'd	MT	257
Urea Density	kg/m ³	1110
Urea Volume Req'd	m³	231.4

Boiler Consumption

Aux Boiler Power Output, At-Berth/Anchoring/Manuevering
Anchor/At Berth Power Req'd

700 kW
252593 kW-hrs
9.09E+05 MJ

IMO 4th GHG Study, 20,000 TEU containerships

HFO SFOC

340 g/kW-hr

IMO 4th GHG Study, Table 19

HFO LCV

40.2 MJ/kg

Boiler Heat Rate

13668 kJ/kW-hr

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
LCV	MJ/kg	40.2	48	19.9	18.6	120	
SFOC/SPOC	g/kW-hr	340	285	687	735	113.9	
Fuel Req'd	MT	86	72	173	186	29	
Density	kg/m ³	980	463	784	758	42	71
Volume Req'd	m ³	88	156	221	245	690	406

Total Base Req'd Capacities

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
HFO/Pilot MDO Volume Req'd	m ³	14,500	302	2,202	2,202	2,202	
Alternative Fuel Volume Req'd	m ³	0	25,644	33,353	37,018	104,331	61,371
HFO/Pilot MDO Mass Req'd	MT	14,210	260	1,894	1,894	1,894	
Alternative Fuel Mass Req'd	MT	0	11860	26146	28062	4347	
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
HFO/Pilot MDO Tank Volume Req'd	m ³	14796	308	2247	2247	2247	
Alternative Fuel Tank Volume Req'd	m ³	0	31758	35109	45842	122742	76001

Nominal Range

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
Design Service Speed	Knots	22.4					
Primary Fuel Tank Capacity	m ³	14,796	31,758	35,109	45,842	122,742	76,001
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
Usable Volume	m ³	14500	25644	33353	37018	104331	61371
Primary Fuel Density	MT/m ³	0.98	0.46	0.78	0.76	0.04	0.07
Primary Fuel Consumption	MT/day	232	193	468	503	78	78
Cruising Range	NMi	32859	33028	30038	30013	30022	30022

Condition 2C: Slow Steaming (57% MCR), 50% Reefer Load, 1 Bunker per Round Trip, Travel Around Cape of Africa

Condition - Scheduled Route, Approx 50% MCR for Propulsion, 50% Reefers, 1 Bunker per Round Trip, Design Draft, No Suez

Time Between Fuelling/Schedule Time	98 days	As per schedule
Time between fuelling	2352 hours	
Sailing Speed	18 knots	
Sailing Distance (Route distance + 10% Margin)	32500 Nmi	
Sail Time Req'd	1806 hours	75.2 days sailing
Non-Sail Time	546 hours	22.8 days non-sailing
Propulsion Power Req'd at Design Draft	32,728 kW at design draft and speed with 15% SM + 7% Hull Fouling	
Propulsion Energy Req'd	59,091,611 kW-Hrs	
	2.13E+08 MJ	
ME Installed Power	65,500 kW with 4,500 kW deduction for Shaft Generator	
Shaft Generator	4,500 kW	
ME Power Demand	37,228 kW	
% MCR	57% MCR for propulsion and SG	

Main Engine Consumptions at 60% MCR							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC - w/5% Margin	g/kW-hr	160.0	4.1	13.8	13.8		13.8
SGC -w/5% Margin	g/kW-hr		132.0	318.6	342.6		53.4
Cylinder Oil	g/kW-hr	0.6	0.6	0.6	0.6		0.6
Lube Oil	g/kW-hr	0.1	0.1	0.1	0.1		0.1
Urea	L/hr	1110	1250		1250		
NaOH	L/hr			12.4			
Sludge	L/hr			13.3			
Methane Slip	g/kW-hr		0.21				
HFO/MDO Req'd	MT	9,456	243	813	813		813
Gas Req'd	MT	0	7,799	18,825	20,246		3,158
Methane Slip	kg		12,409				
Density	kg/m ³	980	462.5	784	758	42	71
HFO/MDO Volume req'd	m ³	9,649	283	945	945		945
Gas Volume Req'd	m ³	0	16,863	24,014	26,707	75,796	44,586
Urea Consumed	m ³	2004	2257	0	2257	0	0
NaOH Consumed	m ³	0	0	22	0	0	0
Sludge Generated	m ³	0	0	24	0	0	0

Aux. Engine Consumption		
Baseline Sea Aux Power	2,300 kW	From 4th IMO GHG Study
Baseline Anchored/At Berth Power	1,675 kW	Average from 4th IMO GHG Study
Reefer Slots	2,200 FEU	
Reefers Carried	50%	
Reefer Power Requirements	5,500 kW	6kW for 1/3 in Hold, 4.5kW for 2/3 on Deck, MMM
Total at Sea Power	7,800 kW	Ammonia Paper Assumption
Total Anchor/At Berth Power	7,175 kW	
At Sea Power for DG's	3,300 kW	
Total Round Trip Time	2352 hours	
Total Sail Hours	1806 hours	
Total Non-Sail Hours	546 hours	
Sail Hour DG kW-hr Req'd	14,083,333 kW-Hrs	
Anchor/At Berth Power kW-hr Req'd	3,920,739 kW-Hrs	
Total Aux Power kW-Hr	18,004,072 kW-Hrs	
	6.48E+07 MJ	

Aux DG Consumptions at 85% Service Load							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC @ 85% output	g/kW-hr	198	3.3	62.9	62.9		62.9
SGC @ 85% output	g/kW-hr	0	166.8	274.2	293.4		45.5
Lube Oil w/ 20% Margin	g/kW-hr	0.672					
Urea	g/kW-hr	13					
HFO/MDO Req'd	MT	3,565	59	1,132	1,132		1,132
Gas Req'd	MT	0	3,003	4,937	5,282		819
Density	kg/m ³	980	463	784	758	42	71
HFO/MDO Volume req'd	m ³	3,638	69	1,317	1,317		1,317
Gas Volume Req'd	m ³	0	6,493	6,297	6,968	19,660	11,565

Other Aux DG Consumables

LO Req'd	MT	12
LO Density	kg/m ³	900
LO Volume Req'd	m³	13.4
Urea Req'd	MT	234
Urea Density	kg/m ³	1110
Urea Volume Req'd	m³	210.9

Boiler Consumption

Aux Boiler Power Output, At-Berth/Anchoring/Manuevering
Anchor/At Berth Power Req'd

700 kW
382511 kW-hrs
1.38E+06 MJ

IMO 4th GHG Study, 20,000 TEU containerships

HFO SFOC

340 g/kW-hr

IMO 4th GHG Study, Table 19

HFO LCV

40.2 MJ/kg

Boiler Heat Rate

13668 kJ/kW-hr

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
LCV	MJ/kg	40.2	48	19.9	18.6	120	
SFOC/SPOC	g/kW-hr	340	285	687	735	113.9	
Fuel Req'd	MT	130	109	263	281	44	
Density	kg/m ³	980	463	784	758	42	71
Volume Req'd	m ³	133	236	335	371	1046	615

Total Base Req'd Capacities

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
HFO/Pilot MDO Volume Req'd	m ³	13,419	352	2,262	2,262	2,262	
Alternative Fuel Volume Req'd	m ³	0	23,619	30,646	34,046	96,502	56,766
HFO/Pilot MDO Mass Req'd	MT	13,151	303	1,945	1,945	1,945	
Alternative Fuel Mass Req'd	MT	0	10924	24024	25809	4021	
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
HFO/Pilot MDO Tank Volume Req'd	m ³	13693	359	2308	2308	2308	
Alternative Fuel Tank Volume Req'd	m ³	0	29249	32259	42162	113531	70298

Nominal Range

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
Design Service Speed	Knots	22.4					
Primary Fuel Tank Capacity	m ³	13,693	29,249	32,259	42,162	113,531	70,298
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
Usable Volume	m ³	13419	23619	30646	34046	96502	56766
Primary Fuel Density	MT/m ³	0.98	0.46	0.78	0.76	0.04	0.07
Primary Fuel Consumption	MT/day	143	118	285	306	48	48
Cruising Range	NMI	49449	49799	45376	45326	45269	45269

Condition 2D: Slow Steaming (57% MCR), 50% Reefer Load, 1 Bunker per Round Trip, Travel Through Suez Canal

Condition - Scheduled Route, Approx 50% MCR for Propulsion, 50% Reefers, 1 Bunker per Round Trip, Design Draft, Through Suez

Time Between Fuelling/Schedule Time	98 days	As per schedule
Time between fuelling	2352 hours	
Sailing Speed	18 knots	
Sailing Distance (Route distance + 10% Margin)	25000 Nmi	
Sail Time Req'd	1389 hours	57.9 days sailing
Non-Sail Time	963 hours	40.1 days non-sailing
Propulsion Power Req'd at Design Draft	32,728 kW at design draft and speed with 15% SM + 7% Hull Fouling	
Propulsion Energy Req'd	45,455,085 kW-Hrs	
	1.64E+08 MJ	
ME Installed Power	65,500 kW with 4,500 kW deduction for Shaft Generator	
Shaft Generator	4,500 kW	
ME Power Demand	37,228 kW	
% MCR	57% % MCR for propulsion and SG	

Main Engine Consumptions at 60% MCR							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC - w/5% Margin	g/kW-hr	160.0	4.1	13.8	13.8	13.8	
SGC -w/5% Margin	g/kW-hr		132.0	318.6	342.6	53.4	
Cylinder Oil	g/kW-hr	0.6	0.6	0.6	0.6	0.6	
Lube Oil	g/kW-hr	0.1	0.1	0.1	0.1	0.1	
Urea	L/hr	1110	1250		1250		
NaOH	L/hr			12.4			
Sludge	L/hr			13.3			
Methane Slip	g/kW-hr		0.21				
HFO/MDO Req'd	MT	7,274	187	625	625	625	
Gas Req'd	MT	0	5,999	14,481	15,574	2,429	
Methane Slip	kg		9,546				
Density	kg/m ³	980	462.5	784	758	42	71
HFO/MDO Volume req'd	m ³	7,422	218	727	727	727	
Gas Volume Req'd	m ³	0	12,972	18,472	20,544	58,304	34,297
Urea Consumed	m ³	1542	1736	0	1736	0	0
NaOH Consumed	m ³	0	0	17	0	0	0
Sludge Generated	m ³	0	0	18	0	0	0

Aux. Engine Consumption		
Baseline Sea Aux Power	2,300 kW	From 4th IMO GHG Study
Baseline Anchored/At Berth Power	1,675 kW	Average from 4th IMO GHG Study
Reefer Slots	2,200 FEU	
Reefers Carried	50%	
Reefer Power Requirements	5,500 kW	6kW for 1/3 in Hold, 4.5kW for 2/3 on Deck, MMM
Total at Sea Power	7,800 kW	Ammonia Paper Assumption
Total Anchor/At Berth Power	7,175 kW	
At Sea Power for DG's	3,300 kW	
Total Round Trip Time	2352 hours	
Total Sail Hours	1389 hours	
Total Non-Sail Hours	963 hours	
Sail Hour DG kW-hr Req'd	10,833,333 kW-Hrs	
Anchor/At Berth Power kW-hr Req'd	6,910,322 kW-Hrs	
Total Aux Power kW-Hr	17,743,656 kW-Hrs	
	6.39E+07 MJ	

Aux DG Consumptions at 85% Service Load							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC @ 85% output	g/kW-hr	198	3.3	62.9	62.9	62.9	
SGC @ 85% output	g/kW-hr	0	166.8	274.2	293.4	45.5	
Lube Oil w/ 20% Margin	g/kW-hr	0.672					
Urea	g/kW-hr	13					
HFO/MDO Req'd	MT	3,513	59	1,116	1,116	1,116	
Gas Req'd	MT	0	2,960	4,865	5,206	807	
Density	kg/m ³	980	463	784	758	42	71
HFO/MDO Volume req'd	m ³	3,585	68	1,298	1,298	1,298	
Gas Volume Req'd	m ³	0	6,399	6,206	6,867	19,376	11,398

Other Aux DG Consumables

LO Req'd	MT	12
LO Density	kg/m ³	900
LO Volume Req'd	m³	13.2
Urea Req'd	MT	231
Urea Density	kg/m ³	1110
Urea Volume Req'd	m³	207.8

Boiler Consumption

Aux Boiler Power Output, At-Berth/Anchoring/Manuevering
Anchor/At Berth Power Req'd

700 kW
674178 kW-hrs
2.43E+06 MJ

IMO 4th GHG Study, 20,000 TEU containerships

HFO SFOC

340 g/kW-hr

IMO 4th GHG Study, Table 19

HFO LCV

40.2 MJ/kg

Boiler Heat Rate

13668 kJ/kW-hr

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
LCV	MJ/kg	40.2	48	19.9	18.6	120	
SFOC/SPOC	g/kW-hr	340	285	687	735	113.9	
Fuel Req'd	MT	229	192	463	495	77	
Density	kg/m ³	980	463	784	758	42	71
Volume Req'd	m ³	234	415	591	654	1843	1084

Total Base Req'd Capacities

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
HFO/Pilot MDO Volume Req'd	m ³	11,241	286	2,025	2,025	2,025	
Alternative Fuel Volume Req'd	m ³	0	19,807	25,269	28,065	79,523	46,778
HFO/Pilot MDO Mass Req'd	MT	11,016	246	1,741	1,741	1,741	
Alternative Fuel Mass Req'd	MT	0	9161	19809	21275	3313	
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
HFO/Pilot MDO Tank Volume Req'd	m ³	11470	291	2066	2066	2066	
Alternative Fuel Tank Volume Req'd	m ³	0	24528	26599	34755	93557	57930

Nominal Range

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
Design Service Speed	Knots	22.4					
Primary Fuel Tank Capacity	m ³	11,470	24,528	26,599	34,755	93,557	57,930
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
Usable Volume	m ³	11241	19807	25269	28065	79523	46778
Primary Fuel Density	MT/m ³	0.98	0.46	0.78	0.76	0.04	0.07
Primary Fuel Consumption	MT/day	143	118	285	306	48	48
Cruising Range	NMI	41423	41762	37414	37363	37304	37304

Condition 1A: Max Power (90% MCR), 100% Reefer Load, 2 Bunkers per Round Trip, Travel Around Cape of Africa

Condition - Fastest Time, Approx 90% MCR for Propulsion, 100% Reefers, 2 Bunker per Round Trip, Design Draft, No Suez

Time Between Fuelling/Schedule Time	39 days	Assume 8 days for 6 ports
Time between fuelling	946 hours	
Sailing Speed	21.9 knots	
Sailing Distance (Route distance + 10% Margin)	16500 Nmi	
Sail Time Req'd	753 hours	31.4 days sailing
Non-Sail Time	192 hours	8.0 days non-sailing
Propulsion Power Req'd at Design Draft	54,339 kW at design draft and speed with 15% SM + 7% Hull Fouling	
Propulsion Energy Req'd	40,940,022 kW-Hrs	
	1.47E+08 MJ	
ME Installed Power	65,500 kW with 4,500 kW deduction for Shaft Generator	
Shaft Generator	4,500 kW	
ME Power Demand	58,839 kW	
% MCR	90% % MCR for propulsion and SG	

Main Engine Consumptions at 90% MCR							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC - w/5% Margin	g/kW-hr	164.6	3.1	10.5	10.5	10.5	
SGC - w/5% Margin	g/kW-hr		136.7	331.4	356.0	55.1	
Cylinder Oil	g/kW-hr	0.6	0.6	0.6	0.6	0.6	
Lube Oil	g/kW-hr	0.1	0.1	0.1	0.1	0.1	
Urea	L/hr	1110	1250		1250		
NaOH	L/hr			12.4			
Sludge	L/hr			13.3			
Methane Slip	g/kW-hr		0.21				
HFO/MDO Req'd	MT	6,740	129	430	430	430	
Gas Req'd	MT	0	5,597	13,567	14,573	2,257	
Methane Slip	kg		8,597				
Density	kg/m ³	980	462.5	784	758	42	71
HFO/MDO Volume req'd	m ³	6,878	149	500	500	500	
Gas Volume Req'd	m ³	0	12,101	17,306	19,223	54,164	31,861
Urea Consumed	m ³	836	942	0	942	0	0
NaOH Consumed	m ³	0	0	9	0	0	0
Sludge Generated	m ³	0	0	10	0	0	0

Aux. Engine Consumption		
Baseline Sea Aux Power	2,300 kW	From 4th IMO GHG Study
Baseline Anchored/At Berth Power	1,675 kW	Average from 4th IMO GHG Study
Reefer Slots	2,200 FEU	
Reefers Carried	100%	
Reefer Power Requirements	11,000 kW	6kW for 1/3 in Hold, 4.5kW for 2/3 on Deck, MMM
Total at Sea Power	13,300 kW	Ammonia Paper Assumption
Total Anchor/At Berth Power	12,675 kW	
At Sea Power for DG's	8,800 kW	
Total Round Trip Time	946 hours	
Total Sail Hours	753 hours	
Total Non-Sail Hours	192 hours	
Sail Hour DG kW-hr Req'd	10,020,548 kW-Hrs	
Anchor/At Berth Power kW-hr Req'd	2,435,822 kW-Hrs	
Total Aux Power kW-Hr	12,456,370 kW-Hrs	
	4.48E+07 MJ	

Aux DG Consumptions at 85% Service Load							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC @ 85% output	g/kW-hr	198.0	3.3	62.9	62.9	62.9	
SGC @ 85% output	g/kW-hr		166.8	274.2	293.4	45.5	
Lube Oil w/ 20% Margin	g/kW-hr	0.672					
Urea	g/kW-hr	13					
HFO/MDO Req'd	MT	2,466	41	784	784	784	
Gas Req'd	MT	0	2,078	3,416	3,655	567	
Density	kg/m ³	980	463	784	758	42	71
HFO/MDO Volume req'd	m ³	2,517	48	911	911	911	
Gas Volume Req'd	m ³	0	4,492	4,357	4,821	13,602	8,001

.

Other Aux DG Consumables

LO Req'd	MT	8
LO Density	kg/m ³	900
LO Volume Req'd	m³	9.3
Urea Req'd	MT	162
Urea Density	kg/m ³	1110
Urea Volume Req'd	m³	145.9

Boiler Consumption

Aux Boiler Power Output, At-Berth/Anchoring/Manuevering
Anchor/At Berth Power Req'd

700 kW
134523 kW-hrs
4.84E+05 MJ

IMO 4th GHG Study, 20,000 TEU containerships

HFO SFOC

340 g/kW-hr

IMO 4th GHG Study, Table 19

HFO LCV

40.2 MJ/kg

Boiler Heat Rate

13668 kJ/kW-hr

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
LCV	MJ/kg	40.2	48	19.9	18.6	120	
SFOC/SPOC	g/kW-hr	340	285	687	735	113.9	
Fuel Req'd	MT	46	38	92	99	15	
Density	kg/m ³	980	463	784	758	42	71
Volume Req'd	m ³	47	83	118	130	368	216

Total Base Req'd Capacities							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
HFO/Pilot MDO Volume Req'd	m ³	9,441	197	1,411	1,411	1,411	
Alternative Fuel Volume Req'd	m ³	0	16,695	21,781	24,175	68,134	40,079
HFO/Pilot MDO Mass Req'd	MT	9,252	170	1,213	1,213	1,213	
Alternative Fuel Mass Req'd	MT	0	7722	17075	18326	2839	
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
HFO/Pilot MDO Tank Volume Req'd	m ³	9634	201	1440	1440	1440	
Alternative Fuel Tank Volume Req'd	m ³	0	20675	22927	29938	80157	49633

Nominal Range							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
Design Service Speed	Knots	22.4					
Primary Fuel Tank Capacity	m ³	9,634	20,675	22,927	29,938	80,157	49,633
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
Usable Volume	m ³	9441	16695	21781	24175	68134	40079
Primary Fuel Density	MT/m ³	0.98	0.46	0.78	0.76	0.04	0.07
Primary Fuel Consumption	MT/day	232	193	468	503	78	78
Cruising Range	NMi	21395	21503	19616	19601	19606	19606

Condition 1B: Max Power (90% MCR), 100% Reefer Load, 2 Bunkers per Round Trip, Travel Through Suez Canal

Condition - Fastest Time, Approx 90% MCR for Propulsion, 100% Reefers, 2 Bunker per Round Trip, Design Draft, Through Suez

Time Between Fuelling/Schedule Time	32 days	Assume 8 days for 6 ports
Time between fuelling	763 hours	
Sailing Speed	21.9 knots	
Sailing Distance (Route distance + 10% Margin)	12500 Nmi	
Sail Time Req'd	571 hours	23.8 days sailing
Non-Sail Time	192 hours	8.0 days non-sailing
Propulsion Power Req'd at Design Draft	54,339 kW at design draft and speed with 15% SM + 7% Hull Fouling	
Propulsion Energy Req'd	31,015,168 kW-Hrs 1.12E+08 MJ	
ME Installed Power	65,500 kW with 4,500 kW deduction for Shaft Generator	
Shaft Generator	4,500 kW	
ME Power Demand	58,839 kW	
% MCR	90% % MCR for propulsion and SG	

Main Engine Consumptions at 90% MCR							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC - w/5% Margin	g/kW-hr	164.6	3.1	10.5	10.5	10.5	
SGC - w/5% Margin	g/kW-hr		136.7	331.4	356.0	55.1	
Cylinder Oil	g/kW-hr	0.6	0.6	0.6	0.6	0.6	
Lube Oil	g/kW-hr	0.1	0.1	0.1	0.1	0.1	
Urea	L/hr	1110	1250		1250		
NaOH	L/hr			12.4			
Sludge	L/hr			13.3			
Methane Slip	g/kW-hr		0.21				
HFO/MDO Req'd	MT	5,106	97	326	326	326	
Gas Req'd	MT	0	4,240	10,278	11,040	1,710	
Methane Slip	kg		6,513				
Density	kg/m ³	980	462.5	784	758	42	71
HFO/MDO Volume req'd	m ³	5,211	113	379	379	379	
Gas Volume Req'd	m ³	0	9,168	13,111	14,563	41,033	24,137
Urea Consumed	m ³	634	713	0	713	0	0
NaOH Consumed	m ³	0	0	7	0	0	0
Sludge Generated	m ³	0	0	8	0	0	0

Aux. Engine Consumption		
Baseline Sea Aux Power	2,300 kW	From 4th IMO GHG Study
Baseline Anchored/At Berth Power	1,675 kW	Average from 4th IMO GHG Study
Reefer Slots	2,200 FEU	
Reefers Carried	100%	
Reefer Power Requirements	11,000 kW	6kW for 1/3 in Hold, 4.5kW for 2/3 on Deck, MMM
Total at Sea Power	13,300 kW	Ammonia Paper Assumption
Total Anchor/At Berth Power	12,675 kW	
At Sea Power for DG's	8,800 kW	
Total Round Trip Time	763 hours	
Total Sail Hours	571 hours	
Total Non-Sail Hours	192 hours	
Sail Hour DG kW-hr Req'd	7,591,324 kW-Hrs	
Anchor/At Berth Power kW-hr Req'd	2,438,971 kW-Hrs	
Total Aux Power kW-Hr	10,030,295 kW-Hrs	
	3.61E+07 MJ	

Aux DG Consumptions at 85% Service Load							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC @ 85% output	g/kW-hr	198.0	3.3	62.9	62.9	62.9	
SGC @ 85% output	g/kW-hr		166.8	274.2	293.4	45.5	
Lube Oil w/ 20% Margin	g/kW-hr	0.672					
Urea	g/kW-hr	13					
HFO/MDO Req'd	MT	1,986	33	631	631	631	
Gas Req'd	MT	0	1,673	2,750	2,943	456	
Density	kg/m ³	980	463	784	758	42	71
HFO/MDO Volume req'd	m ³	2,027	38	734	734	734	
Gas Volume Req'd	m ³	0	3,617	3,508	3,882	10,953	6,443

Other Aux DG Consumables

LO Req'd	MT	7
LO Density	kg/m ³	900
LO Volume Req'd	m³	7.5
Urea Req'd	MT	130
Urea Density	kg/m ³	1110
Urea Volume Req'd	m³	117.5

Boiler Consumption

Aux Boiler Power Output, At-Berth/Anchoring/Manuevering
Anchor/At Berth Power Req'd

700 kW
134697 kW-hrs
4.85E+05 MJ
340 g/kW-hr
40.2 MJ/kg
13668 kJ/kW-hr

IMO 4th GHG Study, 20,000 TEU containerships

HFO SFOC

HFO LCV

Boiler Heat Rate

IMO 4th GHG Study, Table 19

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
LCV	MJ/kg	40.2	48	19.9	18.6	120	
SFOC/SPOC	g/kW-hr	340	285	687	735	113.9	
Fuel Req'd	MT	46	38	93	99	15	
Density	kg/m ³	980	463	784	758	42	71
Volume Req'd	m ³	47	83	118	131	368	217

Total Base Req'd Capacities

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
HFO/Pilot MDO Volume Req'd	m ³	7,284	152	1,112	1,112	1,112	
Alternative Fuel Volume Req'd	m ³	0	12,882	16,737	18,576	52,354	30,797
HFO/Pilot MDO Mass Req'd	MT	7,138	130	957	957	957	
Alternative Fuel Mass Req'd	MT	0	5958	13121	14082	2181	
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
HFO/Pilot MDO Tank Volume Req'd	m ³	7432	155	1135	1135	1135	
Alternative Fuel Tank Volume Req'd	m ³	0	15953	17618	23004	61593	38138

Nominal Range

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
Design Service Speed	Knots	22.4					
Primary Fuel Tank Capacity	m ³	7,432	15,953	17,618	23,004	61,593	38,138
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
Usable Volume	m ³	7284	12882	16737	18576	52354	30797
Primary Fuel Density	MT/m ³	0.98	0.46	0.78	0.76	0.04	0.07
Primary Fuel Consumption	MT/day	232	193	468	503	78	78
Cruising Range	NMI	16506	16592	15074	15061	15065	15065

Condition 1C: Slow Steaming (57% MCR), 50% Reefer Load, 2 Bunkers per Round Trip, Travel Around Cape of Africa

Condition - Scheduled Route, Approx 50% MCR for Propulsion, 50% Reefers, 2 Bunker per Round Trip, Design Draft, No Suez

Time Between Fuelling/Schedule Time	49 days	As per schedule
Time between fuelling	1176 hours	
Sailing Speed	18 knots	
Sailing Distance (Route distance + 10% Margin)	16500 Nmi	
Sail Time Req'd	917 hours	38.2 days sailing
Non-Sail Time	259 hours	10.8 days non-sailing
Propulsion Power Req'd at Design Draft	32,728 kW at design draft and speed with 15% SM + 7% Hull Fouling	
Propulsion Energy Req'd	30,000,356 kW-Hrs	
	1.08E+08 MJ	
ME Installed Power	65,500 kW with 4,500 kW deduction for Shaft Generator	
Shaft Generator	4,500 kW	
ME Power Demand	37,228 kW	
% MCR	57% MCR for propulsion and SG	

Main Engine Consumptions at 60% MCR							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC - w/5% Margin	g/kW-hr	160.0	4.1	13.8	13.8		13.8
SGC -w/5% Margin	g/kW-hr		132.0	318.6	342.6		53.4
Cylinder Oil	g/kW-hr	0.6	0.6	0.6	0.6		0.6
Lube Oil	g/kW-hr	0.1	0.1	0.1	0.1		0.1
Urea	L/hr	1110	1250		1250		
NaOH	L/hr			12.4			
Sludge	L/hr			13.3			
Methane Slip	g/kW-hr		0.21				
HFO/MDO Req'd	MT	4,801	123	413	413		413
Gas Req'd	MT	0	3,960	9,557	10,279		1,603
Methane Slip	kg		6,300				
Density	kg/m ³	980	462.5	784	758	42	71
HFO/MDO Volume req'd	m ³	4,899	144	480	480		480
Gas Volume Req'd	m ³	0	8,561	12,192	13,559	38,481	22,636
Urea Consumed	m ³	1018	1146	0	1146	0	0
NaOH Consumed	m ³	0	0	11	0	0	0
Sludge Generated	m ³	0	0	12	0	0	0

Aux. Engine Consumption		
Baseline Sea Aux Power	2,300 kW	From 4th IMO GHG Study
Baseline Anchored/At Berth Power	1,675 kW	Average from 4th IMO GHG Study
Reefer Slots	2,200 FEU	
Reefers Carried	50%	
Reefer Power Requirements	5,500 kW	6kW for 1/3 in Hold, 4.5kW for 2/3 on Deck, MMM
Total at Sea Power	7,800 kW	Ammonia Paper Assumption
Total Anchor/At Berth Power	7,175 kW	
At Sea Power for DG's	3,300 kW	
Total Round Trip Time	1176 hours	
Total Sail Hours	917 hours	
Total Non-Sail Hours	259 hours	
Sail Hour DG kW-hr Req'd	7,150,000 kW-Hrs	
Anchor/At Berth Power kW-hr Req'd	1,860,717 kW-Hrs	
Total Aux Power kW-Hr	9,010,717 kW-Hrs	
	3.24E+07 MJ	

Aux DG Consumptions at 85% Service Load							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC @ 85% output	g/kW-hr	198	3.3	62.9	62.9		62.9
SGC @ 85% output	g/kW-hr	0	166.8	274.2	293.4		45.5
Lube Oil w/ 20% Margin	g/kW-hr	0.672					
Urea	g/kW-hr	13					
HFO/MDO Req'd	MT	1,784	30	567	567		567
Gas Req'd	MT	0	1,503	2,471	2,644		410
Density	kg/m ³	980	463	784	758	42	71
HFO/MDO Volume req'd	m ³	1,821	35	659	659		659
Gas Volume Req'd	m ³	0	3,250	3,152	3,487	9,840	5,788

Other Aux DG Consumables

LO Req'd	MT	6
LO Density	kg/m ³	900
LO Volume Req'd	m³	6.7
Urea Req'd	MT	117
Urea Density	kg/m ³	1110
Urea Volume Req'd	m³	105.5

Boiler Consumption

Aux Boiler Power Output, At-Berth/Anchoring/Manuevering
Anchor/At Berth Power Req'd

700 kW
181533 kW-hrs
6.54E+05 MJ

IMO 4th GHG Study, 20,000 TEU containerships

HFO SFOC

340 g/kW-hr

IMO 4th GHG Study, Table 19

HFO LCV

40.2 MJ/kg

Boiler Heat Rate

13668 kJ/kW-hr

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
LCV	MJ/kg	40.2	48	19.9	18.6	120	
SFOC/SPOC	g/kW-hr	340	285	687	735	113.9	
Fuel Req'd	MT	62	52	125	133	21	
Density	kg/m ³	980	463	784	758	42	71
Volume Req'd	m ³	63	112	159	176	496	292

Total Base Req'd Capacities

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
HFO/Pilot MDO Volume Req'd	m ³	6,782	178	1,139	1,139	1,139	
Alternative Fuel Volume Req'd	m ³	0	11,936	15,502	17,222	48,817	28,716
HFO/Pilot MDO Mass Req'd	MT	6,647	153	979	979	979	
Alternative Fuel Mass Req'd	MT	0	5521	12153	13056	2034	
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
HFO/Pilot MDO Tank Volume Req'd	m ³	6921	182	1162	1162	1162	
Alternative Fuel Tank Volume Req'd	m ³	0	14782	16318	21328	57432	35561

Nominal Range

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
Design Service Speed	Knots	22.4					
Primary Fuel Tank Capacity	m ³	6,921	14,782	16,318	21,328	57,432	35,561
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
Usable Volume	m ³	6782	11936	15502	17222	48817	28716
Primary Fuel Density	MT/m ³	0.98	0.46	0.78	0.76	0.04	0.07
Primary Fuel Consumption	MT/day	143	118	285	306	48	48
Cruising Range	NMi	24992	25168	22953	22929	22900	22900

Condition 1D: Slow Steaming (57% MCR), 50% Reefer Load, 2 Bunkers per Round Trip, Travel Through Suez Canal

Condition - Scheduled Route, Approx 50% MCR for Propulsion, 50% Reefers, 2 Bunker per Round Trip, Design Draft, Suez

Time Between Fuelling/Schedule Time	49 days	As per schedule
Time between fuelling	1176 hours	
Sailing Speed	18 knots	
Sailing Distance (Route distance + 10% Margin)	12500 Nmi	
Sail Time Req'd	694 hours	28.9 days sailing
Non-Sail Time	482 hours	20.1 days non-sailing
Propulsion Power Req'd at Design Draft	32,728 kW	at design draft and speed with 15% SM + 7% Hull Fouling
Propulsion Energy Req'd	22,727,543 kW-Hrs	
	8.18E+07 MJ	
ME Installed Power	65,500 kW	with 4,500 kW deduction for Shaft Generator
Shaft Generator	4,500 kW	
ME Power Demand	37,228 kW	
% MCR	57% MCR	for propulsion and SG

Main Engine Consumptions at 60% MCR							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC - w/5% Margin	g/kW-hr	160.0	4.1	13.8	13.8		13.8
SGC -w/5% Margin	g/kW-hr		132.0	318.6	342.6		53.4
Cylinder Oil	g/kW-hr	0.6	0.6	0.6	0.6		0.6
Lube Oil	g/kW-hr	0.1	0.1	0.1	0.1		0.1
Urea	L/hr	1110	1250		1250		
NaOH	L/hr			12.4			
Sludge	L/hr			13.3			
Methane Slip	g/kW-hr		0.21				
HFO/MDO Req'd	MT	3,637	94	313	313		313
Gas Req'd	MT	0	3,000	7,240	7,787		1,215
Methane Slip	kg		4,773				
Density	kg/m ³	980	462.5	784	758	42	71
HFO/MDO Volume req'd	m ³	3,711	109	364	364		364
Gas Volume Req'd	m ³	0	6,486	9,236	10,272	29,152	17,148
Urea Consumed	m ³	771	868	0	868	0	0
NaOH Consumed	m ³	0	0	9	0	0	0
Sludge Generated	m ³	0	0	9	0	0	0

Aux. Engine Consumption		
Baseline Sea Aux Power	2,300 kW	From 4th IMO GHG Study
Baseline Anchored/At Berth Power	1,675 kW	Average from 4th IMO GHG Study
Reefer Slots	2,200 FEU	
Reefers Carried	50%	
Reefer Power Requirements	5,500 kW	6kW for 1/3 in Hold, 4.5kW for 2/3 on Deck, MMM
Total at Sea Power	7,800 kW	Ammonia Paper Assumption
Total Anchor/At Berth Power	7,175 kW	
At Sea Power for DG's	3,300 kW	
Total Round Trip Time	1176 hours	
Total Sail Hours	694 hours	
Total Non-Sail Hours	482 hours	
Sail Hour DG kW-hr Req'd	5,416,667 kW-Hrs	
Anchor/At Berth Power kW-hr Req'd	3,455,161 kW-Hrs	
Total Aux Power kW-Hr	8,871,828 kW-Hrs	
	3.19E+07 MJ	

Aux DG Consumptions at 85% Service Load							
Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
SFOC/SPOC @ 85% output	g/kW-hr	198	3.3	62.9	62.9		62.9
SGC @ 85% output	g/kW-hr	0	166.8	274.2	293.4		45.5
Lube Oil w/ 20% Margin	g/kW-hr	0.672					
Urea	g/kW-hr	13					
HFO/MDO Req'd	MT	1,757	29	558	558		558
Gas Req'd	MT	0	1,480	2,433	2,603		404
Density	kg/m ³	980	463	784	758	42	71
HFO/MDO Volume req'd	m ³	1,792	34	649	649		649
Gas Volume Req'd	m ³	0	3,200	3,103	3,434	9,688	5,699

Other Aux DG Consumables

LO Req'd	MT	6
LO Density	kg/m ³	900
LO Volume Req'd	m³	6.6
Urea Req'd	MT	115
Urea Density	kg/m ³	1110
Urea Volume Req'd	m³	103.9

Boiler Consumption

Aux Boiler Power Output, At-Berth/Anchoring/Manuevering
Anchor/At Berth Power Req'd

700 kW
337089 kW-hrs
1.21E+06 MJ

IMO 4th GHG Study, 20,000 TEU containerships

HFO SFOC

340 g/kW-hr

IMO 4th GHG Study, Table 19

HFO LCV

40.2 MJ/kg

Boiler Heat Rate

13668 kJ/kW-hr

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
LCV	MJ/kg	40.2	48	19.9	18.6	120	
SFOC/SPOC	g/kW-hr	340	285	687	735	113.9	
Fuel Req'd	MT	115	96	232	248	38	
Density	kg/m ³	980	463	784	758	42	71
Volume Req'd	m ³	117	208	295	327	921	542

Total Base Req'd Capacities

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
HFO/Pilot MDO Volume Req'd	m ³	5,621	143	1,012	1,012	1,012	
Alternative Fuel Volume Req'd	m ³	0	9,903	12,635	14,032	39,762	23,389
HFO/Pilot MDO Mass Req'd	MT	5,508	123	871	871	871	
Alternative Fuel Mass Req'd	MT	0	4580	9904	10637	1657	
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
HFO/Pilot MDO Tank Volume Req'd	m ³	5735	146	1033	1033	1033	
Alternative Fuel Tank Volume Req'd	m ³	0	12264	13300	17378	46778	28965

Nominal Range

Fuel Type		HFO	LNG	Methanol	Ammonia	Hydrogen	LH ₂
Design Service Speed	Knots	22.4					
Primary Fuel Tank Capacity	m ³	5,735	12,264	13,300	17,378	46,778	28,965
Max Filling Ratio	%	98%	85%	95%	85%	85%	85%
Reserved Volume	%	0%	5%	0%	5%	0%	5%
Usable Volume	m ³	5621	9903	12635	14032	39762	23389
Primary Fuel Density	MT/m ³	0.98	0.46	0.78	0.76	0.04	0.07
Primary Fuel Consumption	MT/day	143	118	285	306	48	48
Cruising Range	NMi	20711	20881	18707	18682	18652	18652

Tank Sizing – Required Tank Size Summary

	Condition		Max Power Full Reefers Cape	Max Power Full Reefers w/ Suez	Slow Steaming 50% Reefers Cape	Slow Steaming 50% Reefers w/ Suez	Max Power Full Reefers Cape 1- Way	Max Power Full Reefers w/ Suez 1-Way	Slow Steaming 50% Reefers Cape 1-Way	Slow Steaming 50% Reefers w/ Suez 1-Way
Route and Operation	Sail Range	NMi	32500	25000	32500	25000	16500	12500	16500	12500
	Vessel Speed	knots	21.9	21.9	18	18	21.9	21.9	18	18
	Engine Power	% MCR	90%	90%	57%	57%	90%	90%	57%	57%
	Time Between Bunkering	days	77	63	98	98	39	32	49	49
	Bunkering Frequency	-	1 per RT	1 per RT	1 per RT	1 per RT	Each end	Each end	Each end	Each end
	Reefer % Utilized	%	100%	100%	50%	50%	100%	100%	50%	50%
Required Volume	HFO	m ³	18,542	14,500	13,419	11,241	9,441	7,284	6,782	5,621
	LNG	m ³	32,788	25,644	23,619	19,807	16,695	12,882	11,936	9,903
	Methanol	m ³	42,805	33,353	30,646	25,269	21,781	16,737	15,502	12,635
	Ammonia	m ³	47,509	37,018	34,046	28,065	24,175	18,576	17,222	14,032
	Compressed Hydrogen	m ³	133,898	104,331	96,502	79,523	68,134	52,354	48,817	39,762
	Liquid Hydrogen	m ³	78,764	61,371	56,766	46,778	40,079	30,797	28,716	23,389
Tank Volume	HFO Tank Size (98% Full)	m ³	18,920	14,796	13,693	11,470	9,634	7,433	6,920	5,736
	LNG Tank Size (85% Full)*	m ³	40,604	31,757	29,250	24,529	20,675	15,953	14,781	12,264
	Methanol Tank Size (95% Full)	m ³	45,058	35,108	32,259	26,599	22,927	17,618	16,318	13,300
	Ammonia Tank Size (85% Full)*	m ³	58,835	45,843	42,162	34,755	29,938	23,004	21,328	17,377
	Compressed Hydrogen Tank Size	m ³	157,527	122,742	113,532	93,556	80,158	61,593	57,432	46,779
	Liquid Hydrogen Tank Size (85% Full)	m ³	97,541	76,001	70,298	57,929	49,633	38,139	35,562	28,965

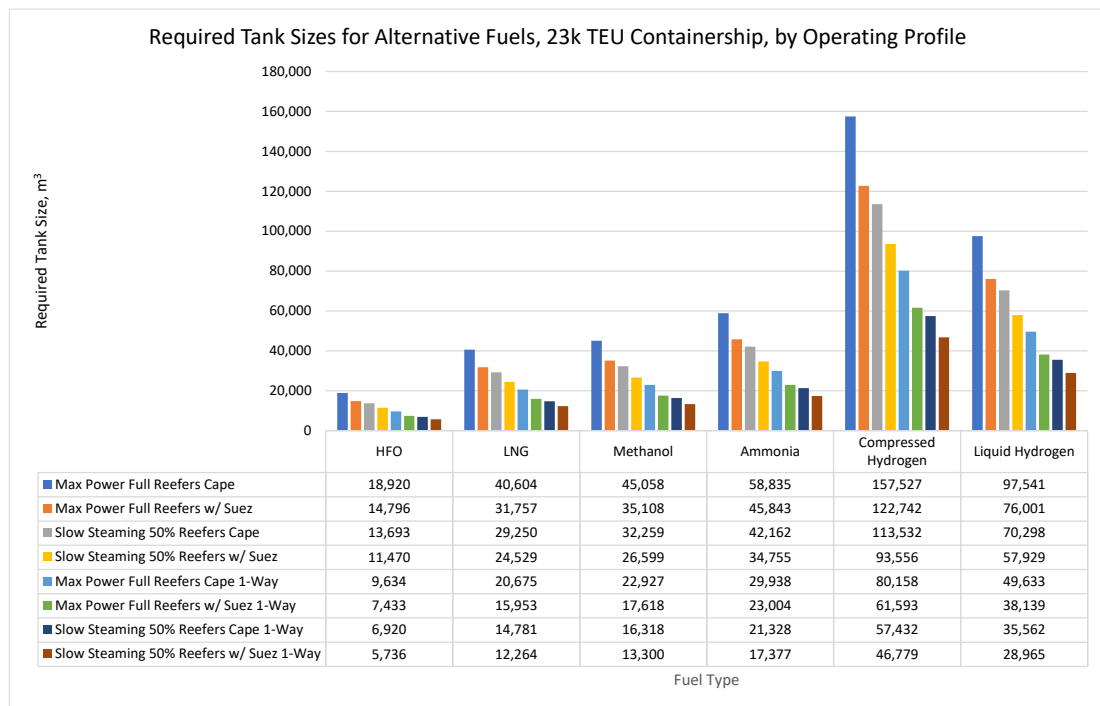
*For LNG, Ammonia, and Liquid Hydrogen, max fill level of 85% with a 5% cooling reserve assumed

**For Compressed Hydrogen, max fill level of 85% assumed

For reference, total MDO+HFO on current vessel is

11754 m³

PER SS - 12000m³ HFO + 1100 DO



Selection of Suitable Alternative Fuel Tank Sizes

Condition		Round Trip Endurance				1-Way Endurance			
		2A	2B	2C	2D	1A	1B	1C*	1D*
		Max Power Full Reefers Cape	Max Power Full Reefers w/ Suez	Slow Steaming 50% Reefers Cape	Slow Steaming 50% Reefers w/ Suez	Max Power Full Reefers Cape 1-Way	Max Power Full Reefers w/ Suez 1-Way	Slow Steaming 50% Reefers Cape 1-Way	Slow Steaming 50% Reefers w/ Suez 1-Way
HFO Tank Size	m ³	18,920	14,796	13,693	11,470	9,634	7,433	6,920	5,736
MDO Pilot Oil - LNG	m ³	388	302	352	286	197	152	178	143
MDO Pilot Oil - Methanol/Ammonia	m ³	2,761	2,202	2,262	2,025	1,411	1,112	1,139	1,012
LNG Tank Size	m ³	40,604	31,757	29,250	24,529	20,675	15,953	14,781	12,264
Ammonia Tank Size	m ³	58,835	45,843	42,162	34,755	29,938	23,004	21,328	17,377
Methanol Tank Size	m ³	45,058	35,108	32,259	26,599	22,927	17,618	16,318	13,300
Compressed Hydrogen Tank Size	m ³	157,527	122,742	113,532	93,556	80,158	61,593	57,432	46,779
Liquid Hydrogen Tank Size	m ³	97,541	76,001	70,298	57,929	49,633	38,139	35,562	28,965
LNG Tank Size Ratio to HFO		2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Methanol Tank Size Ratio to HFO		2.4	2.4	2.4	2.3	2.4	2.4	2.4	2.3
Ammonia Tank Size Ratio to HFO		3.1	3.1	3.1	3.0	3.1	3.1	3.1	3.0
Compressed Hydrogen Tank Size Ratio to HFO		8.3	8.3	8.3	8.2	8.3	8.3	8.3	8.2
Liquid Hydrogen Tank Size Ratio to HFO		5.2	5.1	5.1	5.1	5.2	5.1	5.1	5.0
Condition Energy Saving		1.00	0.78	0.72	0.61	1.00	0.77	0.72	0.60

*1C and 1D are not considered viable loadcases because the vessel would be forced to slow-steam

Tank Type	Size	Base Volume m ³	Perm. -	Tank 100% Volume m ³	HFO	LNG	Ammonia	Methanol	Comp. H ₂	LH ₂	Slots Lost FEU
HFO/Standard		12,025	0.98	11,784	2D	N/A	N/A	N/A	N/A	N/A	0
B-Type - No Top Hopper	Accommodation Only	10,209	0.98	10,005	N/A	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	30
	Accommodation + 1 Hold	24,560	0.98	24,068	N/A	2D	1B	1A	N/A	N/A	222
	Accommodation + 2 Hold	38,910	0.98	38,132	N/A	2B	2D	2B	N/A	N/A	414
	Accommodation + 2 Hold Prismatic Reduced Height	28,926	0.98	28,347	N/A	2C	1A	2D	N/A	N/A	318
C-Type Trilobe	Accommodation + 1 Hold	13,690	1	13,690	N/A	1D	1D	1D	Not Viable	Not Viable	222
	2 Hold	14,122	1	14,122	N/A	1C	1C	1D	Not Viable	Not Viable	414
	Accommodation + 2 Hold	24,068	1	24,068	N/A	2D	1B	1A	Not Viable	Not Viable	414
	3 Hold	24,499	1	24,499	N/A	2D	1B	1A	Not Viable	Not Viable	606
	Accommodation + 2 + 1x3	48,567	1	48,567	N/A	2A	2B	2A	1D	1A	990
	Accommodation + 1 + 2x3	62,688	1	62,688	N/A	2A	2A	2A	1B	2D	1374
	Accommodation + 2 + 2x3	73,067	1	73,067	N/A	2A	2A	2A	1B	2C	1566
	Accommodation + 2 + 3x3	97,566	1	97,566	N/A	2A	2A	2A	2D	2A	2142
C-Type Elongated (Longitudinal)	Accommodation + 1 Hold	18,654	1	18,654	N/A	1B	1D	1B	Not Viable	Not Viable	222
	Accommodation + 2 Hold	31,214	1	31,214	N/A	2B	1A	2C	Not Viable	1D	414
	Accommodation + 2 Hold Reduced Height	22,652	1	22,652	N/A	1A	1C	1A	Not Viable	Not Viable	318
	2 Hold	19,175	1	19,175	N/A	1A	1D	1B	Not Viable	Not Viable	414
	Accommodation + 2 + 1x2 Hold	50,389	1	50,389	N/A	2A	2B	2A	1D	1A	798
	Accommodation + 2 + 2x2 Hold	69,565	1	69,565	N/A	2A	2A	2A	1B	2D	1182
C-Type Elongated (Transverse)	Accommodation	8,694	1	8,694	N/A	Not Viable	Not Viable	Not Viable	Not Viable	Not Viable	30
	Accommodation + 1 Hold	17,840	1	17,840	N/A	1B	1D	1B	Not Viable	Not Viable	222
	Accommodation + 2 Hold	26,987	1	26,987	N/A	2D	1B	2D	Not Viable	Not Viable	414
	Accommodation + 3 Hold	36,133	1	36,133	N/A	2B	2D	2B	Not Viable	1C	606
	Accommodation + 4 Hold	45,280	1	45,280	N/A	2A	2B	2A	Not Viable	1B	798
	Accommodation + 6 Hold	63,573	1	63,573	N/A	2A	2A	2A	1B	2D	1182

Tank Type	Size	Base Volume m ³	Perm. -	Tank 100% Volume m ³	HFO	LNG	Ammonia	Methanol	Comp. H ₂	LH ₂	Slots Lost FEU
Hull Conforming	Accommodation Only	18,607	0.98	18,235	N/A	N/A	N/A	1B	N/A	N/A	0
	Accommodation + 1 Hold	44,514	0.98	43,623	N/A	N/A	N/A	2A	N/A	N/A	262
	Accommodation + 1 Hold no DB	40,580	0.98	39,768	N/A	N/A	N/A	2B	N/A	N/A	262
	Accommodation + 1 hold Reduced Height	30,586	0.98	29,975	N/A	N/A	N/A	2D	N/A	N/A	174
	Accommodation + 1 hold Reduced Height no DB	26,652	0.98	26,119	N/A	N/A	N/A	2D	N/A	N/A	174

Cells Highlighted in green represent the selected tank for a given fuel. Yellow cells are potential options that were ultimately not used.

Bay 34				B/5 Reduced Hold + Interference from Bunkering Stations Above																				
Max Height	1.425	33.79	33.79	1.425	1.425	1.425	1.425	1.425	1.425	1.425	1.425	1.425	1.425	1.425	1.425	1.425	1.425	1.425	1.425	33.79	33.79	1.425		
Tier/Stack	22	20	18	16	14	12	10	8	6	4	2	1	3	5	7	9	11	13	15	17	19	21	VCG-Bot	Count Rows
12		32.36	32.36																	32.36	32.36			4
11		29.77	29.77																	29.77	29.77		31.65	4
10		27.18	27.18																	27.18	27.18		28.76	4
9		24.59	24.59																	24.59	24.59		25.86	4
8		22	22																	22	22		22.97	4
7		19.41	19.41																	19.41	19.41		20.07	4
6		16.82	16.82																	16.82	16.82		17.18	4
5		14.23	14.23																	14.23	14.23		14.28	4
4		11.64	11.64																	11.64	11.64		11.39	4
3		9.047	9.047																	9.047	9.047		8.49	4
2		6.457	6.457																	6.457	6.457		5.595	4
1		3.866	3.866																	3.866	3.866		2.7	4
	0	12	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	12	0		
Stack Wt	0	216	216	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	216	216	0		
Count		48		#																				
Sum VCG		870		m																				
Sum Mass		864		MT																				
VCG		18.115		m-BL																				

Table 142: LNG and Ammonia Container Capacity Table (reduced container quantities highlighted in green)

Tiers	40' Bay	94	90	86	82	78	74	70	66	62	58	54	50	46	42	38	34	30	26	22	18	14	10	6	2
13	374	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	0	0	0	0	0	0	0
12	452	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0	0	0	0
11	500	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0	0
10	548	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0
9	572	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20
8	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
7	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
6	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
5	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
4	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
3	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
2	570	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20	24	24	24	24	24	24	24	22
1	570	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20	24	24	24	24	24	24	24	22
Deck Total	7030	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310	302	310	286	286	262	262	238	238	196
12	428	22	22	22	22	22	18	22	22	22	22	22	22	22	22	22	20	6	22	20	16	12	8		
11	482	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	6	22	22	22	22	22	20	18
10	482	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	20	6	22	22	22	22	22	22	18
9	454	22	22	22			22	22	22	22	22	22	22	22	22	22	20	6	22	22	22	22	22	22	14
8	438	20	22	14			22	22	22	22	22	22	22	22	22	22	20	6	22	22	22	22	22	20	16
7	418		12	18	12		22	22	22	22	22	22	22	22	22	22	20	6	22	22	22	22	18	14	10
6	378				8		22	22	22	22	22	22	22	22	22	22	20	6	22	22	22	20	18	12	8
5	364						22	22	22	22	22	22	22	22	22	22	20	6	22	22	22	20	16	10	6
4	354						22	22	22	22	22	22	22	22	22	22	20	6	22	22	20	18	14	8	4
3	340						18	22	22	22	22	22	22	22	22	22	20	6	22	20	20	16	12	8	
2	320						14	20	22	22	22	22	22	22	22	22	20	6	20	18	18	14	8	6	
1	278							10	16	20	20	20	20	20	20	20	20	4	18	16	14	10	6	4	
Hold Total	4736			120	136	114	66	236	256	262	262	262	262	262	262	262	240	70	258	250	246	224	190	144	90
Grand Total	11766	FEU	430	446	424	376	546	566	572	572	572	572	572	572	572	572	542	380	544	536	508	486	428	382	286
	23532	TEU	11766																						

Table 143: Liquid Hydrogen Container Capacity Table (reduced container quantities highlighted in green)

Tiers	40' Bay	94	90	86	82	78	74	70	66	62	58	54	50	46	42	38	34	30	26	22	18	14	10	6	2
13	374	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	0	0	0	0	0	0	0
12	452	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0	0	0	0
11	500	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0	0
10	548	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0
9	572	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20
8	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
7	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
6	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
5	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
4	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
3	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
2	570	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20	24	24	24	24	24	24	24	22
1	570	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20	24	24	24	24	24	24	24	22
Deck Total	7030	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310	302	310	286	286	262	262	238	238	196
12	314	0	0	0	0	22	18	22	22	22	22	22	22	22	6	6	4	6	22	20	20	16	12	8	
11	434		22	22	22	22	22	22	22	22	22	22	22	22	6	6	4	6	22	22	22	22	22	20	18
10	434		22	22	22	22	22	22	22	22	22	22	22	22	6	6	4	6	22	22	22	22	22	20	18
9	406		22	22	22		22	22	22	22	22	22	22	22	6	6	4	6	22	22	22	22	22	18	14
8	400		22	22	22		22	22	22	22	22	22	22	22	6	6	4	6	22	22	22	22	20	16	12
7	384		20	22	14		22	22	22	22	22	22	22	22	6	6	4	6	22	22	22	22	18	14	10
6	364		12	18	12		22	22	22	22	22	22	22	22	6	6	4	6	22	22	22	20	18	12	8
5	324			8			22	22	22	22	22	22	22	22	6	6	4	6	22	22	22	20	16	10	6
4	306						22	22	22	22	22	22	22	22	6	6	4	6	22	22	20	18	14	8	4
3	292						18	22	22	22	22	22	22	22	6	6	4	6	22	20	20	16	12	8	
2	272						14	20	22	22	22	22	22	22	6	6	4	6	20	18	18	14	8	6	
1	230						10	16	20	20	20	20	20	20	4	4	4	18	16	14	10	6	4		
Hold Total	4160		120	136	114	66	236	256	262	262	262	262	262	262	70	70	48	70	258	250	246	224	190	144	90
Grand Total	11190	FEU	430	446	424	376	546	566	572	572	572	572	572	572	380	380	350	380	544	536	508	486	428	382	286
	22380	TEU																							
			11190																						

Table 144: Compressed Hydrogen Container Capacity Table (reduced container quantities highlighted in green)

Tiers	40' Bay	94	90	86	82	78	74	70	66	62	58	54	50	46	42	38	34	30	26	22	18	14	10	6	2
13	374	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	0	0	0	0	0	0	0
12	452	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0	0	0	0
11	500	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0	0
10	548	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22	22	0	0
9	572	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20
8	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
7	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
6	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
5	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
4	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
3	574	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	22
2	570	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20	24	24	24	24	24	24	24	22
1	570	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	20	24	24	24	24	24	24	24	22
Deck Total	7030	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310	302	310	286	286	262	262	238	238	196
12	282		0	0	0	22	18	22	22	22	22	22	22	6	6	6	4	6	22	20	20	16	12	8	
11	402		22	22	22	22	22	22	22	22	22	22	22	6	6	6	4	6	22	22	22	22	22	20	18
10	402		22	22	22	22	22	22	22	22	22	22	22	6	6	6	4	6	22	22	22	22	22	20	18
9	374		22	22	22		22	22	22	22	22	22	22	6	6	6	4	6	22	22	22	22	22	18	14
8	368		22	22	22		22	22	22	22	22	22	22	6	6	6	4	6	22	22	22	22	20	16	12
7	352		20	22	14		22	22	22	22	22	22	22	6	6	6	4	6	22	22	22	22	18	14	10
6	332		12	18	12		22	22	22	22	22	22	22	6	6	6	4	6	22	22	22	20	18	12	8
5	292			8			22	22	22	22	22	22	22	6	6	6	4	6	22	22	22	20	16	10	6
4	274						22	22	22	22	22	22	22	6	6	6	4	6	22	22	20	18	14	8	4
3	260						18	22	22	22	22	22	22	6	6	6	4	6	22	20	20	16	12	8	
2	240						14	20	22	22	22	22	22	6	6	6	4	6	20	18	18	14	8	6	
1	198						10	16	20	20	20	20	20	4	4	4	4	18	16	14	10	6	4		
Hold Total	3776		120	136	114	66	236	256	262	262	262	262	70	70	70	70	48	70	258	250	246	224	190	144	90
Grand Total	10806	FEU	430	446	424	376	546	566	572	572	572	572	380	380	380	380	350	380	544	536	508	486	428	382	286
	21612	TEU																							
			10806																						

Table 145: Container Capacities and Total Loadable Weight, by Alternative Fuel Type

		Fuel	HFO	LNG	Ammonia	Methanol	LH ₂	Comp H ₂
Max Containers, Scantling Draft	Deck Weight/TEU	MT	7.20	7.24	7.00	7.00	7.39	7.48
	Deck FEU	# FEU	7,038	7,030	7,030	7,038	7,030	7,030
	Deck TEU	# TEU	14,076	14,060	14,060	14,076	14,060	14,060
	Hold Weight/TEU	MT	9.00	9.00	9.00	9.00	9.00	9.00
	Hold FEU	# FEU	4,950	4,736	4,736	4,950	4,160	3,776
	Hold TEU	# TEU	9,900	9,472	9,472	9,900	8,320	7,552
	Total Cargo Weight	MT	190,447	187,042	183,668	187,632	178,783	173,137
	Total TEU	# TEU	23,976	23,532	23,532	23,976	22,380	21,612
	Cargo Weight Delta	MT	0	-3,405	-6,779	-2,815	-11,664	-17,310
	TEU Delta		0	-444	-444	0	-1,596	-2,364
Max Containers, Design Draft	Deck Weight/TEU	MT	5.75	5.74	5.63	5.63	6.00	6.10
	Deck FEU	# FEU	7,038	7,030	7,030	7,038	7,030	7,030
	Deck TEU	# TEU	14,076	14,060	14,060	14,076	14,060	14,060
	Hold Weight/TEU	MT	9.00	9.00	9.00	9.00	9.00	9.00
	Hold FEU	# FEU	4,950	4,736	4,736	4,950	4,160	3,776
	Hold TEU	# TEU	9,900	9,472	9,472	9,900	8,320	7,552
	Total Cargo Weight	MT	170,037	165,952	164,406	168,348	159,240	153,734
	Total TEU	# TEU	23,976	23,532	23,532	23,976	22,380	21,612
	Cargo Weight Delta	MT	0	-4,085	-5,631	-1,689	-10,797	-16,303
	TEU Delta		0	-444	-444	0	-1,596	-2,364
10-Tier Deck Containers, Scantling Draft	Deck Weight/TEU	MT	9.60	9.60	9.40	9.51	9.60	9.60
	Deck FEU	# FEU	5,574	5,566	5,566	5,574	5,566	5,566
	Deck TEU	# TEU	11,148	11,132	11,132	11,148	11,132	11,132
	Hold Weight/TEU	MT	9.00	9.00	9.00	9.00	9.00	9.00
	Hold FEU	# FEU	4,950	4,736	4,736	4,950	4,160	3,776
	Hold TEU	# TEU	9,900	9,472	9,472	9,900	8,320	7,552
	Total Cargo Weight	MT	196,121	192,115	189,889	195,117	181,747	174,835
	Total TEU	# TEU	21,048	20,604	20,604	21,048	19,452	18,684
	Cargo Weight Delta	MT	0	-4,006	-6,232	-1,003	-14,374	-21,286
	TEU Delta		0	-444	-444	0	-1,596	-2,364
10-Tier Deck Containers, Design Draft	Deck Weight/TEU	MT	7.85	7.75	7.40	7.50	8.15	8.24
	Deck FEU	# FEU	5,574	5,566	5,566	5,574	5,566	5,566
	Deck TEU	# TEU	11,148	11,132	11,132	11,148	11,132	11,132
	Hold Weight/TEU	MT	9.00	9.00	9.00	9.00	9.00	9.00
	Hold FEU	# FEU	4,950	4,736	4,736	4,950	4,160	3,776
	Hold TEU	# TEU	9,900	9,472	9,472	9,900	8,320	7,552
	Total Cargo Weight	MT	176,612	171,521	167,625	172,710	165,606	159,696
	Total TEU	# TEU	21,048	20,604	20,604	21,048	19,452	18,684
	Cargo Weight Delta	MT	0	-5,091	-8,987	-3,902	-11,006	-16,916
	TEU Delta		0	-444	-444	0	-1,596	-2,364
14 MT/TEU Homogenous Scantling Draft	Deck Weight/TEU	MT	14.00	14.00	14.00	14.00	14.00	14.00
	Deck FEU	# FEU	3,970	3,964	3,964	3,970	3,962	4,002
	Deck TEU	# TEU	7,940	7,928	7,928	7,940	7,924	8,004
	Hold Weight/TEU	MT	14.00	14.00	14.00	14.00	14.00	14.00
	Hold FEU	# FEU	3,230	3,104	3,104	3,230	2,770	2,544
	Hold TEU	# TEU	6,460	6,208	6,208	6,460	5,540	5,088
	Total Cargo Weight	MT	201,600	197,904	197,904	201,600	188,496	183,288
	Total TEU	# TEU	14,400	14,136	14,136	14,400	13,464	13,092
	Cargo Weight Delta	MT	0	-3,696	-3,696	0	-13,104	-18,312
	TEU Delta		0	-264	-264	0	-936	-1,308
Backhaul to Asia	Deck Weight/TEU	MT	3.00	3.00	3.00	3.00	3.00	3.00
	Deck FEU	# FEU	7,038	7,030	7,030	7,038	7,030	7,030
	Deck TEU	# TEU	14,076	14,060	14,060	14,076	14,060	14,060
	Hold Weight/TEU	MT	3.50	3.50	3.50	3.50	3.50	3.50
	Hold FEU	# FEU	4,950	4,736	4,736	4,950	4,160	3,776
	Hold TEU	# TEU	9,900	9,472	9,472	9,900	8,320	7,552
	Total Cargo Weight	MT	76,878	75,332	75,332	76,878	71,300	68,612
	Total TEU	# TEU	23,976	23,532	23,532	23,976	22,380	21,612
	Cargo Weight Delta	MT	0	-1,546	-1,546	0	-5,578	-8,266
	TEU Delta		0	-444	-444	0	-1,596	-2,364

15.3. Lightship Weight Changes

Summary of Lightweight for Alternatively Fuelled and Baseline Case Study ULCC

Lightship Weight Summary			
	Weight	LCG	VCG
	MT	m-AP	m-BL
HFO	67,000	181.713	22.826
LNG	67,407	181.878	22.830
Ammonia	67,485	181.958	22.824
Methanol	67,270	181.915	22.810
LH ₂	71,247	184.232	22.571
Comp. H ₂	76,653	185.679	22.241

Lightweight Change Summary for Each Design

Table 146: Lightweight Change Summary, LNG, Ammonia, and Methanol

TypeB Tank - For LNG (Single Tank)

Item	Weight	LCG	VCG
-	MT	m-AP	m-BL
Forward Machinery Deck	-61.7	258.050	22.965
HFO Tank Structure	-213.6	258.050	11.38
Watertight Hold Bulkhead Fr 147	-253.0	251.125	17.85
Membrane Tank	553.5	250.830	18.085
Bunkering Stations	22.0	229.450	38.61
Fuel Gas Supply System	77.8	56.725	29.43
MGO Pilot Oil Tanks	93.6	258.050	12.865
New B/5 Bulkheads	188.1	250.825	18.8
Total	406.7	209.125	23.422

Type B Tank - For Ammonia (Split Tank)

Item	Weight	LCG	VCG
-	MT	m-AP	m-BL
Forward Machinery Deck	-61.7	258.050	22.965
HFO Tank Structure	-213.6	258.050	11.38
Watertight Hold Bulkhead Fr 147	-253.0	251.125	17.85
Membrane Tank	631.9	250.830	18.085
Bunkering Stations	22.0	229.450	38.61
Fuel Gas Supply System	77.8	56.725	29.43
MGO Pilot Oil Tanks	93.6	258.050	12.865
New B/5 Bulkheads	188.1	250.825	18.8
Total	485.1	215.863	22.560

*FS Moment of Ammonia due to high density found to be too high, tank needed to be subdivided

Methanol Tank

Item	Weight	LCG	VCG
-	MT	m-AP	m-BL
Fwd Machy Deck	-61.7	258.050	22.965
HFO Tank Structure	-213.6	258.050	11.380
Methanol Tank	499.0	258.048	16.242
MGO Pilot Oil Tanks	46.0	106.625	17.500
Total	269.7119	232.214	18.770

Table 147: Lightweight Change Summary, Hydrogen Designs

LH₂ Design

Item	Weight	LCG	VCG
-	MT	m-AP	m-BL
Fwd Machy Deck	-61.7	258.050	22.965
HFO Tank Structure	-213.6	258.050	11.380
Watertight Hold Bulkhead Fr 147	-253	251.125	17.850
Nontight Hold Bulkhead Fr 141	-154.6	236.675	17.850
Nontight Hold Bulkhead Fr 131	-154.6	207.775	17.850
LH2 Tanks - Fr 162-137	2622	243.600	17.850
LH2 Tanks - Frs 127-136	1773	207.775	17.850
Bunkering Stations	22	229.450	38.610
Fuel Gas Supply System	77.8	56.725	29.430
MGO Pilot Oil Tanks	93.6	258.825	18.800
New B/5 Bulkheads	496.2	229.150	18.802
Total	4247.1	223.966	18.553

Compressed Hydrogen Design

Item	Weight	LCG	VCG
-	MT	m-AP	m-BL
Fwd Machy Deck	-61.7	258.050	22.965
HFO Tank Structure	-213.6	258.050	11.380
Watertight Hold Bulkhead Fr 147	-253	251.125	17.850
Nontight Hold Bulkhead Fr 141	-154.6	236.675	17.850
Nontight Hold Bulkhead Fr 131	-154.6	207.775	17.850
Nontight Hold Bulkhead Fr 121	-154.6	178.875	17.850
Comp H ₂ Tanks - Fr 162-137	4170.0	243.600	17.850
Comp H ₂ Tanks - Frs 136-127	2790.0	207.775	17.850
Comp H ₂ Tanks - Frs 126-117	2790.0	178.875	17.850
Bunkering Stations	22.0	229.450	38.610
Compression System	77.8	56.725	29.430
MGO Pilot Oil Tanks	93.6	258.825	18.800
New B/5 Bulkheads	701.6	229.150	18.802
Total	9652.9	213.209	18.180

Detailed Weight Estimate for Lightweight Change Items

Table 148: Steel Removals for Alternate Fuel Designs

Alternative Fuel Weight Modifications

Density of steel

8000 kg/m³

7850 + Margin

Removals

Item	Area/Factor	Plate Thickness	Number	Volume	Weight
-	m ²	mm	#	m ³	MT
HFO/MGO Tanks				Total	213.6
Tank Top	670	10	1	6.70	53.6
Tank Top Stiffening	15%				8.0
Longitudinal Bulkhead	208	12	6	2.50	120.1
Bulkhead Stiffening	15%				18.0
Middle Tank Deck Subdivision	126	12	1	1.51	12.1
Tank Deck Stiffening	15%				1.8
Other				Total	61.7
Forward Machinery Deck	670	10	1	6.70	53.6
Forward Machinery Deck Stiffening	15%				8.0
Non-Tight Midcell Bulkheads				Total	154.6
Stringers	70	10	9	0.70	50.6
Stringer Stiffening	5%				2.5
Vertical Girder	56	10	8	0.56	35.9
Vertical Girder Stiffening	5%				1.8
Non-Tight Midcell BHD	332	12	2	3.99	63.8
Watertight Hold Bulkheads				Total	253.0
Stringers	70	10	9	0.70	50.6
Stringer Stiffening	5%				2.5
Vertical Girder	56	10	8	0.56	35.9
Vertical Girder Stiffening	5%				1.8
Non-Tight Midcell BHD	332	12	1	3.99	31.9
Watertight Bulkhead	1234	12	1	14.81	118.5
Watertight Bulkhead Stiffening	10%				11.8

Table 149: Steel Additions and Tank Weights for Alternate Fuel Designs – LNG and Ammonia

Additions

Item	Area/Factor	Plate Thickness	Number	Volume	Weight
-	m ²	mm	#	m ³	MT
Pilot MGO Tank				Total	93.6
Tank Top	91	10	2	0.91	14.5
Tank Top Stiffeners	15%				2.2
Longitudinal Bulkhead	208	12	2	2.50	40.0
Longitudinal Bulkhead Stiffeners	15%				6.0
Tank Aft Bulkhead	140	12	2	1.68	26.9
Tank Aft Bulkhead Stiffeners	15%				4.0
Longitudinal Bulkhead				Total	188.1
B/5 Bulkhead - Accom + 1 Hold	852	12	2	10.22	163.5
Bulkhead Stiffeners	15%				24.5
Additional Each Long. Bulkhead				Total	102.7
Additional Hold Bulkhead	465.29	12	2	5.58	89.3
Additional Hold Bulkhead Stiffeners	15%				13.4
LNG Tank				Total	553.5
LNG Tank (regression)	24560	m3			359.0
LNG Tank Insulation (polyurethane)	4988	300		1496.45	194.5
Ammonia Tank				Total	631.9
Type-B Tank (regression)	24560	m3			359.0
Tank Insulation (polyurethane)	498817%	300		1496.45	194.5
Centerline Bulkhead	710	12	1	8.52	68.1
CL Bulkhead Stiffening	15%				10.2

LNG Tank Insulation assumes 300mm thick polyurethane with a density of 130 kg/m³.

Table 150: Steel Additions and Tank Weights for Alternatively Fuelled Designs – Methanol and Hydrogen

Item	Area/Factor	Plate Thickness	Number	Volume	Weight
-	m ²	mm	#	m ³	MT
Methanol Tanks				Total	545.0
Fwd/Aft Bhd	1633	12	2	19.60	313.5
Bulkhead Stiffeners	15%				47.0
Tank Division Longitudinal Bulkheads	307	12	3	3.68	88.4
Longitudinal Bulkhead Stiffeners	15%				13.3
Double Bottom Fwd/Aft Bhd	77	13	4	1.00	32.0
Double Bottom Stiffeners	15%				4.8
Pilot Oil MGO Tank Bhd	456.47	12	1	5.48	43.8
Pilot Oil MGO Tank Bhd Stiffeners	5%				2.2
LH₂ Tanks - Accommodation + 2 Hold Lengths				Total	2621.6
Inner Shell	2930	6.5	3	19.04	457.0
Outer Shell	3276	8	3	26.21	629.1
Insulation	2481	125	3	310.17	930.5
Margin/Misc./Supports	30%				605.0
LH₂ Tanks - 2 Hold Lengths				Total	1774.4
Inner Shell	1961	6.5	3	12.74	305.9
Outer Shell	2238	8	3	17.90	429.7
Insulation	1678	125	3	209.80	629.4
Margin/Misc./Supports	30%				409.5
Compressed Hydrogen Tanks - Fwd	1390	MT Each	3		4170
Compressed Hydrogen Tanks - Aft	930	MT Each	3		2790

Insulation for LH₂ tank is taken to be glass bubble with a density of 125 kg/m³. Listed value for Area is volume of insulation, and listed value in plate thickness is density of insulation.

Table 151: Weight Estimation for Compressed Hydrogen Tanks

		Area	Thickness	Volume	Density	Weight
		m ²	mm	m ³	kg/m ³	MT
Accom. + 2 Hold Tanks	Carbon Fiber	2930	75	219.7	2200	483
	Shell	2930	25	73.2	8000	586
	Total					1069
	With 30% Margin					1390
2 Hold Tanks	Carbon Fiber	1961	75	147.1	2200	324
	Inner Shell	1961	25	49.0	8000	392
	Total					716
	With 30% Margin					930

15.4. Calculation of Boil-Off Gas Rates and Reliquification Energy

Calculation of Boil of Gas Rate

Ambient Temp

25 C
298.15 K

Fuel. Temp

LNG	Ammonia	Hydrogen	
-163	-33	-253	C
110.15	240.15	20.15	K

Calculation of Radiation Heating

 σ , Stefan-Boltzmann constant5.67E-08 J/sec*m²*K⁴

Reflectance

80% White-Painted Steel Plate

Emissivity

20%

Emissivity. An ideal jet-black (or black body)

Exposure Time (daylight)

8.5 hours

radiator has e = 1, whereas a perfect reflector

Exposure Time (daylight)

30600 sec

has e = 0

	LNG	Ammonia	Hydrogen	
Maximum Exposed Tank Surface Area	884.7	884.7	1647.1	m ²
Outer Temp.	298.15	K		
Inner Temp.	110.15	240.15	20.15	K
Energy Ingress	2428304	1432896	4606646	kJ/Day (sunlight)
Heat Ingress	28.11	16.58	53.32	kW/Day

Calculation of Convective Heating

	LNG	Ammonia	Hydrogen	
Insulation Thickness	300	300	800	mm
Tank surface area	4988	4988	14671	m ²
Thermal Conductivity K	0.03	0.025	0.000035	W/m-K
Conduction Heat Transfer	93.8	24.1	0.2	kW
Total Heat Ingress	121.9	40.7	53.5	kW
Energy Ingress	1.05E+07	3.52E+06	4.62E+06	kJ
Fuel Volume (85% Full)	20457.8	20457.8	42830.65	m ³
Fuel Density	463	784	71.11	kg/m ³
Enthalpy of Vaporization	0.509	1.371	0.446	kJ/g
Boil off Rate	20677	2564	10361	kg/day
	44.7	3.3	145.7	m ³
	0.2%	0.02%	0.7%	% Total Vol.

	Enthalpy of vaporization	Molar mass	Enthalpy of vaporization	Liquid density	Liquid temp.
	kJ/mol	g/mol	kJ/g	kg/m ³	C
H ₂	0.899	2.016	0.446	71.11	-253
CH ₄ /LNG	8.170	16.042	0.509	463	-163
NH ₃ /Ammonia	23.350	17.030	1.371	784	-33

Boil off reliquification energy and scaling (Romero Gómez *et al.*, 2015).

	LNG	Ammonia	Hydrogen	
Boil off Rate	20677	2564	10361	kg/day
	0.239	0.030	0.120	kg/sec
Unit Power Required	2719	1010	3104	kW/kg _{BO} /sec
	0.75	0.28	0.86	kW-hr/kg _{BO} /sec
Power Required	651	30	372	kW
	0.179	0.008	0.103	kW-hr

15.5. Calculation of Attained vs. Required EEDI

Calculation of EEDI

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Basic Input Info

LBP	394 m
Beam	61 m
SLL Draft	16.5 m
SLL Displacement Vol.	292418 m ³
SLL Displacement	299728.45 MT

LS Weight	MT
Deadweight (DWT)	MT
70% Deadweight	MT
Displacement at 70% DWT	MT
Draft at 70% DWT	

Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
232,728	232,322	232,243	232,459	228,481	223,076
162,910	162,625	162,570	162,721	159,937	156,153
229,910	230,032	230,055	229,991	231,184	232,806

Draft	Displacement
m-Keel	MT
13	225220
13.5	235457
13.23	229910

Linear Interpolation

Calculation of Required EEDI

Reference Line Value

$$RLV = a \cdot b^c$$

$$a =$$

$$b =$$

$$c =$$

$$RLV =$$

$$\text{Phase Reduction Factor} =$$

$$\text{Required EEDI} =$$

Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
174.22					
232728	232322	232243	232459	228481	223076
0.201					
14.53	14.54	14.54	14.54	14.59	14.66
30					
10.17	10.18	10.18	10.18	10.21	10.26

Calculation of Attained EEDI

MCR Installed:

65,500 kW

P Shaft Generator =

4500 kW

MCR Propulsion Limited:

61,000 kW

$$P_{AE} = 0.025 \cdot \text{MCR} + 250$$

$$P_{AE} =$$

1887.5 kW

75% MCR for V_{Ref} Calc:

45750 kW

Calculation of V_{ref}

75% MCR =

49125 kW

Speed-Power Curve

Speed	Trial Power
Knots	kW
18	25537.88927
19	29017.7179
20	32976.46763
21	37507.00696
22	42716.18546
23	48725.2297
24	55669.91774
25	63700.49787
22.5	45750

EEDI Speed =

Factors

$f_i =$	1
$f_w =$	1
$f_i =$	1
$f_i =$	1
$f_m =$	1

	HFO	MDO	LNG	Ammonia	Methanol	Hydrogen
CF Values	3.114	3.206	2.75	0	1.375	0

Attained EEDI

		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
ME	SPOC	0.0	3.4	11.3	11.3	11.3	11.3
ME	SFC	156.0	129.3	330.5	307.5	51.2	51.2
Aux	SPOC	0.0	3.3	62.9	62.9	62.9	62.9
Aux	SFC	197.7	166.8	293.4	274.2	45.5	45.5
ME	Pilot Fuel Contribution	0	495760	1650088	1650088	1650088	1650088
	Main Fuel Contribution	22224618	16267556	0	19343672	0	0
AE	Pilot Fuel Contribution	0	19667	380870	380870	380870	380870
	Main Fuel Contribution	1162016	865641	0	711628	0	0
Attained EEDI		6.37	4.82	0.55	6.03	0.56	0.58
Required EEDI		10.17	10.18	10.18	10.18	10.21	10.26

16. Appendix C – Case Study Lifecycle Inventory Data

16.1. Shipbuilding Inventory

16.1.1. Calculation of Emissions from Shipbuilding Lifecycle Phase

			Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Steel Production and Transport	Lightship Weight	MT	67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
	Structural Lightweight Change	MT	0.0	112.4	190.7	269.7	-247.7	-196.9
	Production Steel Factor	%	10%	10%	10%	10%	10%	10%
	Raw Steel Weight	MT	73,700.0	74,147.4	74,233.6	73,996.7	78,371.8	84,318.2
	Raw Steel Extraction/Transport/Production	MT-CO _{2eq} /MT-steel	1.3	1.3	1.3	1.3	1.3	1.3
	Power Demand	kW-Hr/kg-Steel	4.61	4.61	4.61	4.61	4.61	4.61
	Power CO ₂ Emissions	g-CO ₂ /kW-Hr	490	490	490	490	490	490
	Steel Production Power Required	kW-Hr	3.40E+08	3.42E+08	3.42E+08	3.41E+08	3.61E+08	3.89E+08
	Raw Steel Transport Rate	g-CO ₂ /MT-km	11.9	11.9	11.9	11.9	11.9	11.9
	Raw Steel Transport Distance	km	822	822	822	822	822	822
Shipyard - Cutting	Steel Production CO ₂	MT-CO _{2eq}	95,810.0	96,391.6	96,503.7	96,195.7	101,883.4	109,613.6
	Steel Production Power CO ₂	MT-CO _{2eq}	166,521.0	167,531.9	167,726.7	167,191.4	177,076.7	190,512.2
	Steel Transport to Yard CO ₂	MT-CO _{2eq}	720.9	725.3	726.1	723.8	766.6	824.8
	Total Steel Prod.and Transport CO ₂	MT-CO _{2eq}	263,051.9	264,648.8	264,956.5	264,110.9	279,726.7	300,950.7
	Total Surface Area	m ²	834230	834230	834230	834230	834230	834230
Shipyard - Welding	10% Increased Surface Area	m ²	917653	917653	917653	917653	917653	917653
	Cutting Surface Area	m ²	83423	83423	83423	83423	83423	83423
	Energy/Cutting Area	kW-Hr/m ²	2.4	2.4	2.4	2.4	2.4	2.4
	Energy for Cutting	kW-Hr	1.97E+05	1.97E+05	1.97E+05	1.97E+05	1.97E+05	1.97E+05
	CO ₂ from Cutting Work	MT-CO _{2eq}	96.5	96.5	96.5	96.5	96.5	96.5
Shipyard - Welding	Welding Weight	MT	1,148.0	1,150.8	1,152.8	1,154.7	1,141.8	1,143.1
	CO ₂ Emission Factor from GMAW Welding	MT-CO ₂ /MT-Weld	1.25	1.25	1.25	1.25	1.25	1.25
	Avg Weld Area	m ²	2.50E-05	2.50E-05	2.50E-05	2.50E-05	2.50E-05	2.50E-05
	Weld Volume	m ³	146.2	146.6	146.8	147.1	145.5	145.6
	Weld Length	m	5.85E+06	5.86E+06	5.87E+06	5.88E+06	5.82E+06	5.82E+06
	Welding Energy Factor	kW-Hr/m	4.2	4.2	4.2	4.2	4.2	4.2
	Welding Required Energy	kW-Hr	2.45E+07	2.46E+07	2.46E+07	2.47E+07	2.44E+07	2.44E+07
	Chromium III EF	g/kg weld	0.01	0.01	0.01	0.01	0.01	0.01
	Cobalt EF	g/kg weld	0.001	0.00	0.00	0.00	0.00	0.00
	Manganese EF	g/kg weld	3.18	3.18	3.18	3.18	3.18	3.18
	Nickel EF	g/kg weld	0.01	0.01	0.01	0.01	0.01	0.01
	PM ₁₀ EF	g/kg weld	5.20	5.20	5.20	5.20	5.20	5.20
	CO ₂ gas from welding	MT-CO _{2eq}	1,435.0	1,438.5	1,441.0	1,443.4	1,427.3	1,428.8
	CO ₂ from Welding Energy	MT-CO _{2eq}	12,022.7	12,052.1	12,072.6	12,093.3	11,957.9	11,971.2
	Total CO ₂ from Welding	MT-CO _{2eq}	13,457.7	13,490.6	13,513.6	13,536.7	13,385.1	13,400.0
	Chromium III Emissions	kg	11	12	12	12	11	11
	Cobalt Emissions	kg	1	1	1	1	1	1
Manganese Emissions	kg	3,651	3,660	3,666	3,672	3,631	3,635	
Nickel Emissions	kg	11	12	12	12	11	11	
PM ₁₀ Emissions	kg	5,970	5,984	5,994	6,005	5,937	5,944	

			Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Shipyard - Blasting	Lightship Weight	MT	67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
	Structural Lightweight Change	MT	0.0	112.4	190.7	269.7	-247.7	-196.9
	Production Steel Factor	%	10%	10%	10%	10%	10%	10%
	Raw Steel Weight	MT	73,700.0	74,147.4	74,233.6	73,996.7	78,371.8	84,318.2
	Grit Volume	kg-Grit/m ²	10.0	10.0	10.0	10.0	10.0	10.0
	Total Grit Required	MT-grit	8,342.3	8,342.3	8,342.3	8,342.3	8,342.3	8,342.3
	Diesel Consumption	kg-Diesel/m ²	0.023	0.023	0.023	0.023	0.023	0.023
	Total Diesel Required	MT-Diesel	19.2	19.2	19.2	19.2	19.2	19.2
	Diesel EF	kg-CO ₂ /kg-Diesel	2.15	2.15	2.15	2.15	2.15	2.15
	PM ₁₀ Factor	kg-PM ₁₀ /MT-Grit	13.0	13.0	13.0	13.0	13.0	13.0
Shipyard - Painting	PM _{2.5} Factor	kg-PM _{2.5} /MT-Grit	1.3	1.3	1.3	1.3	1.3	1.3
	CO ₂ from Diesel	MT-CO _{2eq}	41.3	41.3	41.3	41.3	41.3	41.3
	PM ₁₀ from Blasting	MT-PM ₁₀	108.4	108.4	108.4	108.4	108.4	108.4
	PM _{2.5} from Blasting	MT-PM _{2.5}	10.8	10.8	10.8	10.8	10.8	10.8
	Trimethylbenzene EF	kg/m ²	0.000	0.000	0.000	0.000	0.000	0.000
	Xylene EF	kg/m ²	0.250	0.250	0.250	0.250	0.250	0.250
	4-methyl 2-pentanone EF	kg/m ²	0.020	0.020	0.020	0.020	0.020	0.020
	5-methyl 2-hexane EF	kg/m ²	0.060	0.060	0.060	0.060	0.060	0.060
	Methyl isobutylene EF	kg/m ²	0.006	0.006	0.006	0.006	0.006	0.006
	TBT (tributyltin) to Water EF	kg/m ²	0.022	0.022	0.022	0.022	0.022	0.022
Other Electricity	Tar vinyl to Water EF	kg/m ²	0.003	0.003	0.003	0.003	0.003	0.003
	Copper oxide to Water EF	kg/m ²	0.022	0.022	0.022	0.022	0.022	0.022
	White spirit to Waste EF	kg/m ²	0.010	0.010	0.010	0.010	0.010	0.010
	Xylene to Waste EF	kg/m ²	0.010	0.010	0.010	0.010	0.010	0.010
	VOC	kg/m ²	0.240	0.240	0.240	0.240	0.240	0.240
	Coating	kW-Hr/MT-Ship	1.53	1.53	1.53	1.53	1.53	1.53
	Energy Required for Coating	kW-Hr	1.03E+05	1.03E+05	1.03E+05	1.03E+05	1.09E+05	1.17E+05
	CO ₂ from Coating	MT-CO _{2eq}	50.2	50.5	50.6	50.4	53.4	57.5
	Trimethylbenzene	kg	250	250	250	250	250	250
	Xylene	kg	208,558	208,558	208,558	208,558	208,558	208,558
	4-methyl 2-pentanone	kg	16,685	16,685	16,685	16,685	16,685	16,685
	5-methyl 2-hexane	kg	50,054	50,054	50,054	50,054	50,054	50,054
	Methyl isobutylene	kg	5,005	5,005	5,005	5,005	5,005	5,005
	TBT (tributyltin)	kg	18,353	18,353	18,353	18,353	18,353	18,353
	Tar vinyl	kg	2,503	2,503	2,503	2,503	2,503	2,503
	Copper oxide	kg	18,353	18,353	18,353	18,353	18,353	18,353
	White spirit	kg	8,342	8,342	8,342	8,342	8,342	8,342
	Xylene	kg	8,342	8,342	8,342	8,342	8,342	8,342
	VOC	kg	200,215	200,215	200,215	200,215	200,215	200,215
	Other Electricity	Production*	kW-Hr/MT Ship	0.00	0.00	0.00	0.00	0.00
Outfitting		kW-Hr/MT Ship	0.04	0.04	0.04	0.04	0.04	0.04
Assembly*		kW-Hr/MT Ship	0.00	0.00	0.00	0.00	0.00	0.00
Production Support		kW-Hr/MT Ship	0.96	0.96	0.96	0.96	0.96	0.96
Logistics		kW-Hr/MT Ship	17.46	17.46	17.46	17.46	17.46	17.46
Total Shipyard Electricity		kW-Hr/MT Ship	18.46	18.46	18.46	18.46	18.46	18.46
*Production and Assembly are Assumed covered in above								
Other Shipyard Electricity Power	kW-Hr	1.24E+06	1.24E+06	1.25E+06	1.24E+06	1.32E+06	1.42E+06	
CO ₂ Emissions from Other Shipyard Activity	MT-CO _{2eq}	606.0	609.7	610.4	608.5	644.5	693.4	

			Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
	Lightship Weight	MT	67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
	Structural Lightweight Change	MT	0.0	112.4	190.7	269.7	-247.7	-196.9
	Production Steel Factor	%	10%	10%	10%	10%	10%	10%
	Raw Steel Weight	MT	73,700.0	74,147.4	74,233.6	73,996.7	78,371.8	84,318.2
Sea Trials	CO ₂ Emissions	MT	583.2	429.8	581.4	607.6	541.4	541.4
	SO _x Emissions	MT	3.3	0.0	0.0	0.1	0.3	0.3
	NO _x Emissions	MT	3.2	3.1	3.4	3.4	3.3	3.3
	PM ₁₀ Emissions	MT	23.6	0.0	0.0	0.0	0.0	0.0
	PM _{2.5} Emissions	MT	21.7	0.0	0.0	0.0	0.0	0.0
	CH ₄ Emissions	MT	0.5	0.4	0.1	0.1	1.0	1.0
	CO Emissions	MT	0.6	1.0	0.0	0.1	0.1	0.1
	N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0
	NMVOC Emissions	MT	0.6	0.4	0.1	0.1	0.1	0.1
	BC Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0
	CO _{2Eq} Sea Trial Emissions	MT-CO _{2eq}	604.6	449.7	586.1	612.9	570.8	570.8
	Shipbuilding Total Emissions	CO ₂ Emissions	MT	277,886.9	279,367.2	279,850.2	279,051.9	294,488.8
SO _x Emissions		MT	3.3	0.0	0.0	0.1	0.3	0.3
NO _x Emissions		MT	3.2	3.1	3.4	3.4	3.3	3.3
PM ₁₀ Emissions		MT	138.0	114.4	114.5	114.5	114.4	114.4
PM _{2.5} Emissions		MT	32.5	10.9	10.9	10.9	10.9	10.9
CH ₄ Emissions		MT	0.5	0.4	0.1	0.1	1.0	1.0
CO Emissions		MT	0.6	1.0	0.0	0.1	0.1	0.1
N ₂ O Emissions		MT	0.0	0.0	0.0	0.0	0.0	0.0
NMVOC Emissions		MT	200.8	200.6	200.3	200.3	200.3	200.3
BC Emissions		MT	0.0	0.0	0.0	0.0	0.0	0.0
Chromium III Emissions		kg	11	12	12	12	11	11
Cobalt Emissions		kg	1	1	1	1	1	1
Manganese Emissions		kg	3,651	3,660	3,666	3,672	3,631	3,635
Nickel Emissions		kg	11	12	12	12	11	11
Trimethylbenzene		kg	250	250	250	250	250	250
Xylene		kg	208,558	208,558	208,558	208,558	208,558	208,558
4-methyl 2-pentanone		kg	16,685	16,685	16,685	16,685	16,685	16,685
5-methyl 2-hexane		kg	50,054	50,054	50,054	50,054	50,054	50,054
Methyl isobutylene		kg	5,005	5,005	5,005	5,005	5,005	5,005
TBT (tributyltin)		kg	18,353	18,353	18,353	18,353	18,353	18,353
Tar vinyl		kg	2,503	2,503	2,503	2,503	2,503	2,503
Copper oxide		kg	18,353	18,353	18,353	18,353	18,353	18,353
White spirit		kg	8,342	8,342	8,342	8,342	8,342	8,342
CO _{2Eq} Shipbuilding Emissions	MT-CO _{2eq}	277,908.3	279,387.1	279,854.9	279,057.2	294,518.3	315,810.1	
CO _{2Eq} Shipbuilding Emissions	kg-CO _{2eq}	2.78E+08	2.79E+08	2.80E+08	2.79E+08	2.95E+08	3.16E+08	

CO_{2Eq} Shipbuilding Emissions	MT-CO_{2Eq}	277,908	279,387	279,855	279,057	294,518	315,810
CO_{2Eq} Shipbuilding Emissions	kg-CO_{2Eq}	2.78E+08	2.79E+08	2.80E+08	2.79E+08	2.95E+08	3.16E+08
PM10	kg	1.38E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05
PM2.5	kg	3.25E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04
VOC	kg	200791	200585	200274	200274	200274	200274

Breakdown by Phase

		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Steel Production and Transport	kg-CO _{2eq}	2.63E+08	2.65E+08	2.65E+08	2.64E+08	2.80E+08	3.01E+08
Cutting	kg-CO _{2eq}	9.65E+04	9.65E+04	9.65E+04	9.65E+04	9.65E+04	9.65E+04
Welding	kg-CO _{2eq}	1.35E+07	1.35E+07	1.35E+07	1.35E+07	1.34E+07	1.34E+07
Blasting	kg-CO _{2eq}	4.13E+04	4.13E+04	4.13E+04	4.13E+04	4.13E+04	4.13E+04
Painting	kg-CO _{2eq}	5.02E+04	5.05E+04	5.06E+04	5.04E+04	5.34E+04	5.75E+04
Other Shipyard Activity	kg-CO _{2eq}	6.06E+05	6.10E+05	6.10E+05	6.08E+05	6.44E+05	6.93E+05
Sea Trials	kg-CO _{2eq}	6.05E+05	4.50E+05	5.86E+05	6.13E+05	5.71E+05	5.71E+05
Total	kg-CO _{2eq}	2.78E+08	2.79E+08	2.80E+08	2.79E+08	2.95E+08	3.16E+08
Steel Production and Transport	%	94.65%	94.72%	94.68%	94.64%	94.98%	95.29%
Cutting	%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%
Welding	%	4.84%	4.83%	4.83%	4.85%	4.54%	4.24%
Blasting	%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Painting	%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
Other Shipyard Activity	%	0.22%	0.22%	0.22%	0.22%	0.22%	0.22%
Sea Trials	%	0.22%	0.16%	0.21%	0.22%	0.19%	0.18%

Details of Sea Trials – Energy Requirements

Sea trial Timeline

Operational Days days 3

Operational Time and Energy Breakdown

Suez

Round Trip Scheduled Time days 1

Days Spent Sailing per Trip Days 0.9

Calculation of Sailing Time and Energy Requirements

Main Engine

		Sea Trial Speed Trial	Motoring
Route Sail Distance	Nmi	250	250
w/ 10% Margin	Nmi	250	250
		Sea Trial Speed Trial	Motoring
Speed-Power			
Speed at Design Draft	knots	26.2	19.5
Required Trial Power	kW	65056	19537
Sea Margin		1	1
Fouling Factor		1	1
Total Required Propulsive Power	kW	65056	19537
Shaft Generator	kW	0	0
Total ME Power Req'd while Sailing	kW	65056	19537
ME Installed MCR	kW	65500	65500
% MCR		99%	30%
% of Propulsive MCR		99%	30%
Route Sailing Time	Hours	9.5	12.8
	Days	0.4	0.5

Route Main Engine Power Demand kW-Hrs 6.21E+05 2.50E+05
 MJ 2.23E+06 9.02E+05

Auxiliary Engines

Baseline Aux Sea Power kW 2300 2300
 Reefer Slots FEU 2200 2200
 Power per Reefer kW/Reefer FEU 5 5 (Assume 6kW/hold Reefer, 4.5 kW/Deck Reefer, 1/3 in Hold, 2/3 on Deck)

		Sea Trial Speed Trial	Motoring
Assumed Loaded Reefer Capacity		0%	0%
Required Reefer Power	kW	0	0
Total Req'd Aux Power	kW	2300	2300
Shaft Generator	kW	0	0
Total Req'd Aux DG Power	kW	2300	2300
Route Aux DG Power Demand	kW-Hrs	2.19E+04	2.95E+04
	MJ	7.90E+04	1.06E+05

Calculation of Aux Boiler Energy Requirements

Boiler Required Power	kW	700	
		Sea Trial	Motoring
Boiler Operation days	days	0.00	0.53
	hours	0	13
			Assumed testing during maneuvering
Boiler Power per Trip	kW-Hrs	0.00E+00	8.97E+03
	MJ	0.00E+00	3.23E+04

Details of Sea Trials – Tank-to-Wake Emissions

		HFO		LNG		Ammonia		Methanol		Hydrogen	
		Sea Trial		Sea Trial		Sea Trial		Sea Trial		Sea Trial	
Main Engine Consumption Rates		Trial	Motoring	Trial	Motoring	Trial	Motoring	Trial	Motoring	Trial	Motoring
Main Engine % MCR		99%	30%	99%	30%	99%	30%	99%	30%	99%	30%
Main Engine Power	kW	65056	19537	65056	19537	65056	19537	65056	19537	65056	19537
Main Engine SPOC	g/kW-Hr	0.0	0.0	2.9	6.6	9.8	21.9	9.8	21.9	9.8	21.9
Main Engine SFC	g/kW-Hr	166.6	167.5	138.5	136.4	364.8	337.9	339.7	313.0	56.5	52.4
Urea Consumption	l/hr	1092.7	657.2	1092.7	657.2	1092.7	657.2	0.0	0.0	1092.7	657.2
NaOH Consumption	l/hr	0.0	0.0	0.0	0.0	0.0	0.0	12.8	5.7	0.0	0.0
Cylinder Oil Consumption	g/kW-Hr	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Lube Oil Consumption	g/kW-Hr	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methane Slip	g/kW-Hr	0.00	0.00	0.20	0.27	0.00	0.00	0.00	0.00	0.00	0.00
Main Engine Power Demand											
Hours Op.	hrs	10	13	10	13	10	13	10	13	10	13
Main Engine Demand	kW-Hr	6.21E+05	2.50E+05	6.21E+05	2.50E+05	6.21E+05	2.50E+05	6.21E+05	2.50E+05	6.21E+05	2.50E+05
Main Engine Consumption											
Pilot Fuel Used	MT	0.0	0.0	1.8	1.6	6.1	5.5	6.1	5.5	6.1	5.5
Fuel Used	MT	103.4	42.0	86.0	34.2	226.4	84.6	210.9	78.4	35.1	13.1
Urea Used	MT	11.6	9.4	11.6	9.4	11.6	9.4	0.0	0.0	11.6	9.4
NaOH Used	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0
Cylinder Oil Used	MT	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2
Lube Oil Used	MT	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Methane Slip	MT	0.00	0.00	0.12	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Pilot Fuel Energy	MJ	0E+00	0E+00	8E+04	7E+04	3E+05	2E+05	3E+05	2E+05	3E+05	2E+05
Main Fuel Energy	MJ	4E+06	2E+06	4E+06	2E+06	4E+06	2E+06	4E+06	2E+06	4E+06	2E+06
Pilot/Main Energy Fraction	%	0%	0%	2%	4%	6%	15%	6%	15%	6%	15%
Pilot Fuel Portion of kW-hr	kW-hr	0.00E+00	0.00E+00	1.17E+04	1.07E+04	3.83E+04	3.72E+04	3.84E+04	3.76E+04	3.83E+04	3.72E+04
Auxiliary Engine Consumption Rates											
Aux Engine Power, Seagoing	kW	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300
Aux Engine Power, Port/Idle	kW	0	0	0	0	0	0	0	0	0	0
Aux Engine Assumed % MCR	%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
Aux Engine SPOC	g/kW-Hr	0.0	0.0	3.3	3.3	62.9	62.9	62.9	62.9	62.9	62.9
Aux Engine SFC	g/kW-Hr	197.7	197.7	166.8	166.8	293.4	293.4	274.2	274.2	45.5	45.5
Lube Oil SFC	g/kW-Hr	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Urea Consumption	g/kW-Hr	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Methane Slip	g/kW-Hr	0.0	0.0	5.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Auxiliary Engine Power Demand											
Aux Engine, Seagoing	kW-Hr	2.19E+04	2.95E+04	2.19E+04	2.95E+04	2.19E+04	2.95E+04	2.19E+04	2.95E+04	2.19E+04	2.95E+04
Aux Engine, Idle	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Aux Engine, Port	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Aux Engine, Total	kW-Hr	2.19E+04	2.95E+04	2.19E+04	2.95E+04	2.19E+04	2.95E+04	2.19E+04	2.95E+04	2.19E+04	2.95E+04
Auxiliary Engine Consumption											
Pilot Fuel Used	MT	0.0	0.0	0.1	0.1	1.4	1.9	1.4	1.9	1.4	1.9
Fuel Used	MT	4.3	5.8	3.7	4.9	6.4	8.7	6.0	8.1	1.0	1.3
Urea Used	MT	0.3	0.4	0.3	0.4	0.3	0.4	0.3	0.4	0.3	0.4
Lube Oil Used	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Methane Slip	MT	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Pilot Fuel Energy	MJ	0E+00	0E+00	3E+03	4E+03	6E+04	8E+04	6E+04	8E+04	6E+04	8E+04
Main Fuel Energy	MJ	2E+05	2E+05	2E+05	2E+05	1E+05	2E+05	1E+05	2E+05	1E+05	2E+05
Pilot/Main Energy Fraction	%	0%	0%	2%	2%	49%	49%	49%	49%	49%	49%
Pilot Fuel Portion of kW-hr	kW-hr	0.00E+00	0.00E+00	3.81E+02	5.12E+02	1.08E+04	1.45E+04	1.08E+04	1.45E+04	1.08E+04	1.45E+04

		HFO		LNG		Ammonia		Methanol		Hydrogen	
		Sea Trial		Sea Trial		Sea Trial		Sea Trial		Sea Trial	
Boiler Demand and Consumption Rates											
Boiler Power, Port/Idle	kW	700	700	700	700	700	700	700	700	700	700
Boiler SFC	g/kW-Hr	340.0	340.0	285.0	285.0	735.0	735.0	687.0	687.0	113.9	113.9
Boiler Demand	kW-Hr	0.00E+00	8.97E+03	0.00E+00	8.97E+03	0.00E+00	8.97E+03	0.00E+00	8.97E+03	0.00E+00	8.97E+03
Boiler Fuel Burnt	MT	0.0	3.1	0.0	2.6	0.0	6.6	0.0	6.2	0.0	1.0
Shore-Power Requirements											
Aux Power Energy Demand	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reliquification Energy	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Shore Power Req'd Energy	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO ₂ General Emission Factors											
Pilot Fuel CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	0.000	0.000	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206
Fuel CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	3.114	3.114	2.750	2.750	0.000	0.000	1.375	1.375	0.000	0.000
Lube Oil CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206
Main Engine Emission Factors											
SO _x Emission Factor - Pilot Fuel	MT-SO _x /MT-Fuel	0.000	0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
SO _x Emission Factor	MT-SO _x /MT-Fuel	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NO _x Emission Factor	g/kW-hr	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400
PM ₁₀ Emissions Factor - Pilot	g-PM ₁₀ /kW-hr	0.000	0.000	0.266	0.310	0.350	0.497	0.350	0.497	0.350	0.497
PM ₁₀ Emissions Factor - Fuel	g-PM ₁₀ /kW-hr	26.907	27.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CH ₄ /Methane Slip - Fuel	g/kW-hr	0.010	0.010	0.201	0.274	0.010	0.010	0.010	0.010	0.010	0.010
CO	g/kW-hr	0.540	0.540	1.040	1.040	0.044	0.044	0.044	0.044	0.044	0.044
N ₂ O	g/kW-hr	0.031	0.031	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
NMVOG	g/kW-hr	0.632	0.632	0.400	0.400	0.632	0.632	0.632	0.632	0.632	0.632
Black Carbon	MT-BC/MT-Fuel*	1.51E-04	2.73E-04	2.00E-03	2.00E-03	3.00E-05	5.02E-05	3.00E-05	5.02E-05	3.00E-05	5.02E-05
	*g/kw-Hr for LNG										
Aux DG Emission Factors											
Aux SO _x Emission Factor - PO	MT-SO _x /MT-Fuel	0	0	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Aux SO _x Emission Factor - Fuel	MT-SO _x /MT-Fuel	0.020	0.020	3.17E-05	3.17E-05	0.000	0.000	0.003	0.003	0.000	0.000
Aux NO _x Emission Factor	g/kW-hr	2.414	2.414	1.300	1.300	2.414	2.414	2.414	2.414	2.414	2.414
Aux PM ₁₀ Emission Factor	g/kW-hr	1.390	1.390	0.020	0.020	0.180	0.180	0.140	0.140	0.180	0.180
Aux CH ₄ Emission Factor	g/kW-hr	0.010	0.010	0.200	0.200	0.010	0.010	0.010	0.010	0.010	0.010
Aux CO Emission Factor	g/kW-hr	0.540	0.540	1.300	1.300	0.540	0.540	0.540	0.540	0.540	0.540
Aux N ₂ O Emission Factor	g/kW-hr	0.040	0.040	0.030	0.030	0.036	0.036	0.036	0.036	0.036	0.036
Aux NMVOG Emission Factor	g/kW-hr	0.421	0.421	0.400	0.400	0.421	0.421	0.421	0.421	0.421	0.421
Aux Black Carbon Factor*	MT-BC/MT-Fuel*	1.60E-04	1.60E-04	2.00E-03	2.00E-03	1.45E-04	1.45E-04	1.45E-04	1.45E-04	1.45E-04	1.45E-04
	*g/kw-Hr for LNG										
Boiler Emission Factors											
Boiler NO _x Emission Factor	g/kW-hr	2.100	2.100	1.300	1.300	0.000	0.000	0.000	0.000	0.000	0.000
Boiler PM ₁₀ Emission Factor	g/kW-hr	1.420	1.420	0.030	0.030	0.000	0.000	0.000	0.000	0.000	0.000
Boiler CH ₄ Emission Factor	g/kW-hr	0.002	0.002	0.040	0.040	0.000	0.000	0.000	0.000	0.000	0.000
Boiler CO Emission Factor	g/kW-hr	0.200	0.200	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000
Boiler N ₂ O Emission Factor	g/kW-hr	0.040	0.040	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000
Boiler NMVOG Emission Factor	g/kW-hr	0.421	0.421	0.105	0.105	0.000	0.000	0.000	0.000	0.000	0.000
Boiler Black Carbon Factor	g/kW-hr	8.00E-02	8.00E-02	3.00E-03	3.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO ₂											
ME Pilot Fuel CO ₂ Emissions	MT	0	0	6	5	20	18	20	18	20	18
ME Main Fuel CO ₂ Emissions	MT	322	131	236	94	0	0	290	108	0	0
ME LO CO ₂ Emissions	MT	1.4	0.6	1.4	0.6	1.4	0.6	1.4	0.6	1.4	0.6
Aux Pilot Fuel CO ₂ Emissions	MT	0	0	0	0	4	6	4	6	4	6
Aux Main Fuel CO ₂ Emissions	MT	14	18	10	14	0	0	8	11	0	0
Boiler CO ₂ Emissions	MT	0	10	0	7	0	0	0	8	0	0
Total CO ₂ Emissions	MT	337	159	254	121	25	24	324	151	25	24
% CO ₂ Emissions Reduction	%			25%	24%	92%	85%	4%	5%	92%	85%
SO _x											
ME Pilot Fuel SO _x Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel SO _x Emissions	MT	2.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel SO _x Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel SO _x Emissions	MT	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total SO _x Emissions	MT	2.1	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%SO _x Emissions Reduction	%			100%	100%	99%	99%	99%	96%	99%	99%

		HFO		LNG		Ammonia		Methanol		Hydrogen	
		Sea Trial		Sea Trial		Sea Trial		Sea Trial		Sea Trial	
NO_x											
ME NO _x Emissions	MT	2.1	0.9	2.1	0.9	2.1	0.9	2.1	0.9	2.1	0.9
Aux NO _x Emissions	MT	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Boiler NO _x Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total NO _x Emissions	MT	2.2	0.9	2.1	0.9	2.2	0.9	2.2	0.9	2.2	0.9
%NO _x Emissions Reduction	%			1%	4%	0%	2%	0%	2%	0%	2%
Particulate Matter											
ME Pilot Fuel PM ₁₀ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel PM ₁₀ Emissions	MT	16.7	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel PM ₁₀ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel PM ₁₀ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler PM ₁₀ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total PM ₁₀ Emissions	MT	16.7	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%PM ₁₀ Emissions Reduction	%			100%	100%	100%	100%	100%	100%	100%	100%
Methane											
ME Pilot Fuel CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel CH ₄ Emissions	MT	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CH ₄ Emissions	MT	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
%CH ₄ Emissions Reduction	%			-1908%	-2560%	92%	82%	92%	82%	92%	82%
Carbon Monoxide											
ME Pilot Fuel CO Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel CO Emissions	MT	0.3	0.1	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel CO Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel CO Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler CO Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CO Emissions	MT	0.3	0.2	0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0
%CO Emissions Reduction	%			-94%	-97%	98%	94%	98%	94%	98%	94%
N₂O											
ME Pilot Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%N ₂ O Emissions Reduction	%			4%	8%	92%	82%	92%	82%	92%	82%
Volatile Organic Compounds											
ME Pilot Fuel NMVOC Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel NMVOC Emissions	MT	0.4	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel NMVOC Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel NMVOC Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler NMVOC Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total NMVOC Emissions	MT	0.4	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
%NMVOC Emissions Reduction	%			36%	35%	93%	83%	93%	83%	93%	83%
Black Carbon											
ME Pilot Fuel BC Emissions	MT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ME Main Fuel BC Emissions	MT	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aux Pilot Fuel BC Emissions	MT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aux Main Fuel BC Emissions	MT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Boiler BC Emissions	MT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total BC Emissions	MT	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%BC Emissions Reduction	%			92%	96%	98%	96%	98%	96%	98%	96%

		HFO		LNG		Ammonia		Methanol		Hydrogen	
		Sea Trial		Sea Trial		Sea Trial		Sea Trial		Sea Trial	
System Input Summary											
Pilot Oil (MDO)	MT	0.0	0.0	1.9	1.7	7.5	7.3	7.5	7.3	7.5	7.3
Fuel (Varies)	MT	107.7	50.8	89.6	41.6	232.9	99.9	216.9	92.6	36.1	15.5
Urea	MT	11.9	9.7	11.9	9.7	11.9	9.7	0.3	0.4	11.9	9.7
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0
Cylinder Oil	MT	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Lube Oil	MT	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.1
External Energy	kW-Hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
System Output Summary											
CO ₂ Emissions	MT	336.9	158.9	253.9	120.7	25.3	24.1	323.5	151.5	25.3	24.1
SO _x Emissions	MT	2.1	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO _x Emissions	MT	2.2	0.9	2.1	0.9	2.2	0.9	2.2	0.9	2.2	0.9
PM ₁₀ Emissions	MT	16.7	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PM _{2.5} Emissions	MT	15.4	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH ₄ Emissions	MT	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
CO Emissions	MT	0.3	0.2	0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0
N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NM VOC Emissions	MT	0.4	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
BC Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Global Warming Potential											
Eq. GWP 20yr	kg-CO _{2e}	342775	161588	269836	129222	25773	24553	323983	151950	25773	24553
Eq. GWP 100yr	kg-CO _{2e}	343138	161763	264039	125767	25800	24583	324011	151980	25800	24583
Eq. GWP MEPC (100yr)	kg-CO _{2e}	343138	161763	264039	125767	25800	24583	324011	151980	25800	24583

Details of Sea Trials – Well-to-Tank Emissions

		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio-Ammonia	Bio-Ammonia w/ Bio Diesel	Methanol	Bio-Methanol	Bio-Methanol w/ Bio Diesel	Hydrogen	E-Hydrogen	E-Hydrogen w/ Bio Diesel
Required Consumables		Sea Trial	Sea Trial	Sea Trial	Sea Trial	Sea Trial	Sea Trial	Sea Trial	Sea Trial	Sea Trial	Sea Trial	Sea Trial	Sea Trial	Sea Trial
Pilot Oil	MT	0.0	3.6	3.6	3.6	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
Fuel	MT	158.6	131.3	131.3	131.3	332.8	332.8	332.8	309.5	309.5	309.5	51.6	51.6	51.6
Urea	MT	21.6	21.6	21.6	21.6	21.6	21.6	21.6	0.7	0.7	0.7	21.6	21.6	21.6
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.0	0.0	0.0
Cylinder Oil	MT	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Lube Oil	MT	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
External Energy	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Well-to-Tank Emissions														
CO ₂ Emissions	MT	87.4	55.2	173.1	173.4	532.0	193.7	194.7	132.6	114.1	115.1	492.0	58.3	59.3
SO _x Emissions	MT	0.2	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.3	0.3	0.2	0.3	0.3
NO _x Emissions	MT	0.1	0.1	0.3	0.4	0.3	0.3	0.4	0.3	0.3	0.4	0.2	0.2	0.3
CH ₄ Emissions	MT	0.5	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.3	0.3	1.0	0.1	0.0
CO Emissions	MT	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.0
N ₂ O Emissions	MT	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
Tank-to-Wake Emissions														
CO ₂ Emissions	MT	495.8	374.6	374.6	374.6	49.4	49.4	49.4	475.0	475.0	475.0	49.4	49.4	49.4
CO ₂ Emissions Offset	MT	0.0	0.0	-361.0	-371.2	0.0	0.0	-41.9	0.0	-427.2	-469.0	0.0	0.0	-41.9
SO _x Emissions	MT	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0
NO _x Emissions	MT	3.1	3.0	3.0	3.0	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
PM ₁₀ Emissions	MT	23.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PM _{2.5} Emissions	MT	21.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH ₄ Emissions	MT	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO Emissions	MT	0.5	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N ₂ O Emissions	MT	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
NM VOC Emissions	MT	0.6	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BC Emissions	MT	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
Total Operational Emissions														
CO ₂ Emissions	MT	583.2	429.8	186.7	176.7	581.4	243.1	202.3	607.6	161.9	121.1	541.4	107.7	66.9
SO _x Emissions	MT	3.3	0.0	0.5	0.5	0.0	0.0	0.0	0.1	0.4	0.4	0.3	0.3	0.4
NO _x Emissions	MT	3.2	3.1	3.4	3.4	3.4	3.4	3.5	3.4	3.4	3.5	3.3	3.3	3.4
PM ₁₀ Emissions	MT	23.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PM _{2.5} Emissions	MT	21.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH ₄ Emissions	MT	0.5	0.4	0.3	0.3	0.1	0.1	0.0	0.1	0.3	0.3	1.0	0.1	0.0
CO Emissions	MT	0.6	1.0	1.0	1.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.1	0.1
N ₂ O Emissions	MT	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
NM VOC Emissions	MT	0.6	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BC Emissions	MT	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

		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ Bio Diesel	Methanol	Bio- Methanol	Bio- Methanol w/ Bio Diesel	Hydrogen	E-Hydrogen	E-Hydrogen w/ Bio Diesel
Global Warming WIT														
Eq.GWP 20yr	kg-CO _{2e}	1.3E+05	7.5E+04	1.9E+05	1.8E+05	5.4E+05	2.0E+05	2.0E+05	1.5E+05	1.4E+05	1.4E+05	5.8E+05	6.7E+04	6.3E+04
Eq.GWP 100yr	kg-CO _{2e}	1.0E+05	6.3E+04	1.8E+05	1.8E+05	5.4E+05	2.0E+05	2.0E+05	1.4E+05	1.3E+05	1.3E+05	5.3E+05	6.2E+04	6.1E+04
Eq. GWP MEPC (100yr)	kg-CO _{2e}	1.0E+05	6.2E+04	1.8E+05	1.8E+05	5.4E+05	2.0E+05	2.0E+05	1.4E+05	1.2E+05	1.2E+05	5.2E+05	6.2E+04	6.1E+04
Reduction	%		-88%	-65%	-65%	6%	-61%	-61%	-73%	-75%	-76%	3%	-88%	-88%
Global Warming TTW														
Eq.GWP 20yr	kg-CO _{2e}	5.0E+05	4.0E+05	4.0E+05	4.0E+05	5.0E+04	5.0E+04	5.0E+04	4.8E+05	4.8E+05	4.8E+05	5.0E+04	5.0E+04	5.0E+04
Eq.GWP 100yr	kg-CO _{2e}	5.0E+05	3.9E+05	3.9E+05	3.9E+05	5.0E+04	5.0E+04	5.0E+04	4.8E+05	4.8E+05	4.8E+05	5.0E+04	5.0E+04	5.0E+04
Eq. GWP MEPC (100yr)	kg-CO _{2e}	5.0E+05	3.9E+05	3.9E+05	3.9E+05	5.0E+04	5.0E+04	5.0E+04	4.8E+05	4.8E+05	4.8E+05	5.0E+04	5.0E+04	5.0E+04
Reduction	%		-23%	-23%	-23%	-90%	-90%	-90%	-6%	-6%	-6%	-90%	-90%	-90%
Global Warming Potential														
Eq.GWP 20yr	kg-CO _{2e}	6.3E+05	4.7E+05	2.2E+05	2.1E+05	5.9E+05	2.5E+05	2.1E+05	6.2E+05	1.9E+05	1.5E+05	6.3E+05	1.2E+05	7.1E+04
Eq.GWP 100yr	kg-CO _{2e}	6.1E+05	4.5E+05	2.1E+05	2.0E+05	5.9E+05	2.5E+05	2.0E+05	6.1E+05	1.7E+05	1.3E+05	5.8E+05	1.1E+05	7.0E+04
Eq. GWP MEPC (100yr)	kg-CO _{2e}	6.0E+05	4.5E+05	2.0E+05	1.9E+05	5.9E+05	2.5E+05	2.0E+05	6.1E+05	1.7E+05	1.3E+05	5.7E+05	1.1E+05	6.9E+04
Reduction	%		-26%	-66%	-68%	-3%	-59%	-66%	1%	-71%	-78%	-6%	-82%	-89%

16.2. Maintenance Inventory

16.2.1. Calculation of Emissions from Maintenance

		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂	
Lightship Weight		MT	67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
Number of Yard Periods		#	4	4	4	4	4	4
Shipyard Weight Replacement Weight		MT/day	7.0	7.0	7.0	7.0	7.0	7.0
Time in Shipyard		days	45	45	45	45	45	45
Each Maintenance Replacement		MT	315.0	315.0	315.0	315.0	315.0	315.0
Steel Production and Transport	Raw Steel Production	MT-CO _{2eq} /MT-steel	1.3	1.3	1.3	1.3	1.3	1.3
	Power Demand	kW-Hr/kg-Steel	4.61	4.61	4.61	4.61	4.61	4.61
	Power CO ₂ Emissions	g-CO ₂ /kW-Hr	490	490	490	490	490	490
	Steel Production Power Required	kW-Hr	1.45E+06	1.45E+06	1.45E+06	1.45E+06	1.45E+06	1.45E+06
	Raw Steel Transport Rate	g-CO ₂ /MT-km	11.9	11.9	11.9	11.9	11.9	11.9
	Raw Steel Transport Distance	km	822	822	822	822	822	822
	Steel Production CO ₂	MT-CO _{2eq}	409.5	409.5	409.5	409.5	409.5	409.5
	Steel Production Power CO ₂	MT-CO _{2eq}	711.7	711.7	711.7	711.7	711.7	711.7
	Steel Transport to Yard CO ₂	MT-CO _{2eq}	3.1	3.1	3.1	3.1	3.1	3.1
Total Steel Prod.and Transport CO ₂		MT-CO _{2eq}	1,124.3	1,124.3	1,124.3	1,124.3	1,124.3	1,124.3
Shipyard - Cutting	Removed Steel Weight	MT	315	315	315	315	315	315
	Propane Per MT Cut Steel	MT-Propane/MT Steel	0.06	0.06	0.06	0.06	0.06	0.06
	Total Propane Use	MT	19	19	19	19	19	19
	Propane CO ₂ EF	MT-CO ₂ /MT-Propane	3.0	3.0	3.0	3.0	3.0	3.0
	CO ₂ from Cutting Work	MT-CO _{2eq}	56.7	56.7	56.7	56.7	56.7	56.7

		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂	
	Lightship Weight	MT	67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
	Number of Yard Periods	#	4	4	4	4	4	4
	Shipyard Weight Replacement Weight	MT/day	7.0	7.0	7.0	7.0	7.0	7.0
	Time in Shipyard	days	45	45	45	45	45	45
Each Maintenance Replacement		MT	315.0	315.0	315.0	315.0	315.0	315.0
Shipyard - Welding	Welding Weight	MT	7.9	7.9	7.9	7.9	7.9	7.9
	CO ₂ Emission Factor from GMAW Welding	MT-CO ₂ /MT-Weld	1.25	1.25	1.25	1.25	1.25	1.25
	Avg Weld Area	m ²	2.50E-05	2.50E-05	2.50E-05	2.50E-05	2.50E-05	2.50E-05
	Weld Volume	m ³	1.0	1.0	1.0	1.0	1.0	1.0
	Weld Length	m	4.01E+04	4.01E+04	4.01E+04	4.01E+04	4.01E+04	4.01E+04
	Welding Energy Factor	kW-Hr/m	4.2	4.2	4.2	4.2	4.2	4.2
	Welding Required Energy	kW-Hr	1.68E+05	1.68E+05	1.68E+05	1.68E+05	1.68E+05	1.68E+05
	Chromium III EF	g/kg weld	0.01	0.01	0.01	0.01	0.01	0.01
	Cobalt EF	g/kg weld	0.00	0.00	0.00	0.00	0.00	0.00
	Manganese EF	g/kg weld	3.18	3.18	3.18	3.18	3.18	3.18
	Nickel EF	g/kg weld	0.01	0.01	0.01	0.01	0.01	0.01
	PM ₁₀ EF	g/kg weld	5.20	5.20	5.20	5.20	5.20	5.20
	CO ₂ gas from welding	MT-CO _{2eq}	9.8	9.8	9.8	9.8	9.8	9.8
	CO ₂ from Welding Energy	MT-CO _{2eq}	82.5	82.5	82.5	82.5	82.5	82.5
	Total CO ₂ from Welding	MT-CO _{2eq}	92.3	92.3	92.3	92.3	92.3	92.3
	Chromium III Emissions	kg	0	0	0	0	0	0
	Cobalt Emissions	kg	0	0	0	0	0	0
	Manganese Emissions	kg	25	25	25	25	25	25
	Nickel Emissions	kg	0	0	0	0	0	0
	PM ₁₀ Emissions	kg	40.95	40.95	40.95	40.95	40.95	40.95
Shipyard - Blasting	Total Surface Area	m ²	92,325	92,325	92,325	92,325	92,325	92,325
	Grit Volume	kg-Grit/m ²	10	10	10	10	10	10
	Total Grit Required	MT-grit	923.3	923.3	923.3	923.3	923.3	923.3
	Diesel Consumption	kg-Diesel/m ²	0.023	0.023	0.023	0.023	0.023	0.023
	Total Diesel Required	MT-Diesel	2.1	2.1	2.1	2.1	2.1	2.1
	Diesel EF	kg-CO ₂ /kg-Diesel	2.15	2.15	2.15	2.15	2.15	2.15
	PM ₁₀ Factor	kg-PM ₁₀ /MT-Grit	13.0	13.0	13.0	13.0	13.0	13.0
	PM _{2.5} Factor	kg-PM _{2.5} /MT-Grit	1.3	1.3	1.3	1.3	1.3	1.3
	CO ₂ from Diesel	MT-CO _{2eq}	4.6	4.6	4.6	4.6	4.6	4.6
	PM ₁₀ from Blasting	MT-PM ₁₀	12.0	12.0	12.0	12.0	12.0	12.0
PM _{2.5} from Blasting		MT-PM _{2.5}	1.2	1.2	1.2	1.2	1.2	
Shipyard - Painting	Trimethylbenzene EF	kg/m ²	0.000	0.000	0.000	0.000	0.000	0.000
	Xylene EF	kg/m ²	0.250	0.250	0.250	0.250	0.250	0.250
	4-methyl 2-pentanone EF	kg/m ²	0.020	0.020	0.020	0.020	0.020	0.020
	5-methyl 2-hexane EF	kg/m ²	0.060	0.060	0.060	0.060	0.060	0.060
	Methyl isobutylene EF	kg/m ²	0.006	0.006	0.006	0.006	0.006	0.006
	TBT (tributyltin) to Water EF	kg/m ²	0.022	0.022	0.022	0.022	0.022	0.022
	Tar vinyl to Water EF	kg/m ²	0.003	0.003	0.003	0.003	0.003	0.003
	Copper oxide to Water EF	kg/m ²	0.022	0.022	0.022	0.022	0.022	0.022
	White spirit to Waste EF	kg/m ²	0.010	0.010	0.010	0.010	0.010	0.010
	Xylene to Waste EF	kg/m ²	0.010	0.010	0.010	0.010	0.010	0.010
	VOC	kg/m ²	0.240	0.240	0.240	0.240	0.240	0.240
	Coating	kW-Hr/MT-Ship	1.53	1.53	1.53	1.53	1.53	1.53
	Energy Required for Coating	kW-Hr	1.03E+05	1.03E+05	1.03E+05	1.03E+05	1.09E+05	1.17E+05
	CO ₂ from Coating	MT-CO _{2eq}	50.2	50.5	50.6	50.4	53.4	57.5
	Trimethylbenzene	kg	28	28	28	28	28	28
	Xylene	kg	23,081	23,081	23,081	23,081	23,081	23,081
	4-methyl 2-pentanone	kg	1,847	1,847	1,847	1,847	1,847	1,847
	5-methyl 2-hexane	kg	5,540	5,540	5,540	5,540	5,540	5,540
	Methyl isobutylene	kg	554	554	554	554	554	554
	TBT (tributyltin)	kg	2,031	2,031	2,031	2,031	2,031	2,031
	Tar vinyl	kg	277	277	277	277	277	277
	Copper oxide	kg	2,031	2,031	2,031	2,031	2,031	2,031
	White spirit	kg	923	923	923	923	923	923
	Xylene	kg	923	923	923	923	923	923
	VOC	kg	22,158	22,158	22,158	22,158	22,158	22,158

		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Lightship Weight	MT	67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
Number of Yard Periods	#	4	4	4	4	4	4
Shipyard Weight Replacement Weight	MT/day	7.0	7.0	7.0	7.0	7.0	7.0
Time in Shipyard	days	45	45	45	45	45	45
Each Maintenance Replacement	MT	315.0	315.0	315.0	315.0	315.0	315.0
Other Electricity	Production*	kW-Hr/MT Ship	0.00	0.00	0.00	0.00	0.00
	Outfitting	kW-Hr/MT Ship	0.04	0.04	0.04	0.04	0.04
	Assembly*	kW-Hr/MT Ship	0.00	0.00	0.00	0.00	0.00
	Production Support	kW-Hr/MT Ship	0.96	0.96	0.96	0.96	0.96
	Logistics	kW-Hr/MT Ship	17.46	17.46	17.46	17.46	17.46
	Total Shipyard Electricity	kW-Hr/MT Ship	18.46	18.46	18.46	18.46	18.46
	*Production and Assembly are Assumed covered in above						
	Other Shipyard Electricity Power	kW-Hr	5.81E+03	5.81E+03	5.81E+03	5.81E+03	5.81E+03
CO ₂ Emissions from Other Shipyd. Act.		MT-CO _{2eq}	2.8	2.8	2.8	2.8	2.8
Maintenance Total Emissions - 1 Yard Period	CO ₂ Emissions	MT	1,331.0	1,331.3	1,331.3	1,331.2	1,334.2
	PM ₁₀ Emissions	MT	12.0	12.0	12.0	12.0	12.0
	PM _{2.5} Emissions	MT	1.2	1.2	1.2	1.2	1.2
	NM VOC Emissions	MT	22.2	22.2	22.2	22.2	22.2
	Chromium III Emissions	kg	0	0	0	0	0
	Cobalt Emissions	kg	0	0	0	0	0
	Manganese Emissions	kg	25	25	25	25	25
	Nickel Emissions	kg	0	0	0	0	0
	Trimethylbenzene	kg	28	28	28	28	28
	Xylene	kg	23,081	23,081	23,081	23,081	23,081
	4-methyl 2-pentanone	kg	1,847	1,847	1,847	1,847	1,847
	5-methyl 2-hexane	kg	5,540	5,540	5,540	5,540	5,540
	Methyl isobutylene	kg	554	554	554	554	554
	TBT (tributyltin)	kg	2,031	2,031	2,031	2,031	2,031
	Tar vinyl	kg	277	277	277	277	277
	Copper oxide	kg	2,031	2,031	2,031	2,031	2,031
	White spirit	kg	923	923	923	923	923
	CO _{2eq} Repair Emissions		MT-CO _{2eq}	1,331.0	1,331.3	1,331.3	1,331.2
	CO _{2eq} Repair Emissions		kg-CO _{2eq}	1.33E+06	1.33E+06	1.33E+06	1.33E+06
	Maintenance Total Emissions - Lifetime	CO ₂ Emissions	MT	5,323.9	5,325.1	5,325.3	5,324.7
PM ₁₀ Emissions		MT	48.2	48.2	48.2	48.2	48.2
PM _{2.5} Emissions		MT	4.8	4.8	4.8	4.8	4.8
NM VOC Emissions		MT	88.6	88.6	88.6	88.6	88.6
Chromium III Emissions		kg	0	0	0	0	0
Cobalt Emissions		kg	0	0	0	0	0
Manganese Emissions		kg	100	100	100	100	100
Nickel Emissions		kg	0	0	0	0	0
Trimethylbenzene		kg	111	111	111	111	111
Xylene		kg	92,325	92,325	92,325	92,325	92,325
4-methyl 2-pentanone		kg	7,386	7,386	7,386	7,386	7,386
5-methyl 2-hexane		kg	22,158	22,158	22,158	22,158	22,158
Methyl isobutylene		kg	2,216	2,216	2,216	2,216	2,216
TBT (tributyltin)		kg	8,125	8,125	8,125	8,125	8,125
Tar vinyl		kg	1,108	1,108	1,108	1,108	1,108
Copper oxide		kg	8,125	8,125	8,125	8,125	8,125
White spirit		kg	3,693	3,693	3,693	3,693	3,693
CO _{2eq} Repair Emissions		MT-CO _{2eq}	5,323.9	5,325.1	5,325.3	5,324.7	
CO _{2eq} Repair Emissions		kg-CO _{2eq}	5.32E+06	5.33E+06	5.33E+06	5.32E+06	
PM10		kg	4.82E+04	4.82E+04	4.82E+04	4.82E+04	
PM2.5		kg	4.80E+03	4.80E+03	4.80E+03	4.80E+03	
VOC		kg	88632	88632	88632	88632	

16.3. Ship Breaking Inventory

16.3.1. Steel Production from Scrap (Chatzinikolaou and Ventikos, 2015)

		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Compressed H ₂
Lightship Weight	MT	67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
Breaking CO ₂ EF	MT-CO ₂ /MT-Steel	1.762	1.762	1.762	1.762	1.762	1.762
Breaking CH ₄ EF	MT-CH ₄ /MT-Steel	0.196	0.196	0.196	0.196	0.196	0.196
Breaking N ₂ O EF	MT-N ₂ O/MT-Steel	0.018	0.018	0.018	0.018	0.018	0.018
Breaking CFC EF	MT-CFC/MT-Steel	0.07	0.07	0.07	0.07	0.07	0.07
Breaking CO ₂ Emission	MT-CO ₂	118,054	118,771	118,909	118,529	125,537	135,062
Breaking CH ₄ Emission	MT-CH ₄	13,132.0	13,211.7	13,227.1	13,184.9	13,964.4	15,024.0
Breaking N ₂ O Emission	MT-N ₂ O	1,206.0	1,213.3	1,214.7	1,210.9	1,282.4	1,379.8
Breaking CFC Emission	MT-CFC	4,690.0	4,718.5	4,724.0	4,708.9	4,987.3	5,365.7
CO₂eq Breaking Emissions	MT-CO₂eq	805,340.0	810,228.7	811,170.8	808,581.9	856,390.1	921,367.9
CO₂eq Breaking Emissions	kg-CO₂eq	8.05E+08	8.10E+08	8.11E+08	8.09E+08	8.56E+08	9.21E+08

CO ₂ eq Contribution							
CO ₂		118,054	118,771	118,909	118,529	125,537	135,062
CH ₄		367,696	369,928	370,358	369,176	391,004	420,671
N ₂ O		319,590	321,530	321,904	320,877	339,849	365,634

Note that this is for the full production of steel from scrapped material, not just the emissions to bring it to a steel recycling plant. This methodology yielded substantially more CO₂eq emissions, primarily driven by high CH₄ and N₂O emissions, and as such represented a much larger CO₂eq than the shipbuilding phase, which was not supported by other literature. As a result, this method was not used, and a different method was selected to represent the ship scrapping phase. However, if the CH₄ and N₂O emissions from manufacturing steel from reclaimed scrap are this high, the global warming impact of recycling ships is substantially understated by existing estimates.

16.3.2. Ship Breaking Based on Propane Use (Quang, Dong and Hai, 2021; Gratsos, Psaraftis and Zachariadis, 2010)

		Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Lightship Weight	MT	67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
Propane Per MT Cut Steel	MT-Propane/MT-Steel	0.06	1.06	2.06	3.06	4.06	5.06
Total Propane Use	MT	4020	71451	139019	205845	289263	387864
Propane CO ₂ EF	MT-CO ₂ /MT-Propane	3	3	3	3	3	3
CO₂ from Cutting Work	MT-CO₂eq	1.21E+04	2.14E+05	4.17E+05	6.18E+05	8.68E+05	1.16E+06

This method was based on propane cutting factors, but was too simplistic to be considered a realistic.

16.3.3. Ship Breaking Based on Rahman (2016)

This was the methodology adopted as representative of the ship breaking emissions as described in the methodology and used in the case study.

			Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Ship Breaking Transit	Transport to Breaking Facility	NMI	3710	3710	3710	3710	3710	3710
	CO ₂ Emissions	MT	2,377.0	1,807.7	379.4	2,275.5	379.4	379.4
	SO _x Emissions	MT	14.9	0.1	0.2	0.5	0.2	0.2
	NO _x Emissions	MT	14.7	14.2	14.7	14.7	14.7	14.7
	PM ₁₀ Emissions	MT	108.7	0.1	0.3	0.4	0.3	0.3
	PM _{2.5} Emissions	MT	100.0	0.1	0.3	0.3	0.3	0.3
	CH ₄ Emissions	MT	0.0	1.2	0.0	0.0	0.0	0.0
	CO Emissions	MT	2.4	4.8	0.1	0.1	0.1	0.1
	N ₂ O Emissions	MT	0.1	0.1	0.0	0.0	0.0	0.0
	NM VOC Emissions	MT	2.7	1.8	0.5	0.5	0.5	0.5
	BC Emissions	MT	0.2	0.0	0.0	0.0	0.0	0.0
	CO_{2eq} Transit to Ship Breaking Yard	MT-CO_{2eq}	2416	1876	387	2283	387	387
Beach Cutting	Lightship Weight	MT	67,000.0	67,406.7	67,485.1	67,269.7	71,247.1	76,652.9
	Wastage Percent	%	10%	10%	10%	10%	10%	10%
	Weight to be Scrapped	MT	60,300.0	60,666.0	60,736.6	60,542.7	64,122.4	68,987.6
	Propane UF for Cutting Beached Ship	MT-LPG/MT-Scrap	5.60E-04	5.60E-04	5.60E-04	5.60E-04	5.60E-04	5.60E-04
	Oxygen UF for Cutting Beached Ship	MT-O ₂ /MT-Scrap	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.73E-03
	Propane CO ₂ EF	MT-CO ₂ /MT-Propane	3.0	3.0	3.0	3.0	3.0	3.0
	Beach Cutting LPG	MT	33.8	34.0	34.0	33.9	35.9	38.6
	Beach Cutting O ₂	MT	345.5	347.6	348.0	346.9	367.4	395.3
	Beach Cutting CO₂	MT	101.3	101.9	102.0	101.7	107.7	115.9
Winch Dragging	Winch Dragging UF	MT-Diesel/MT-Scrap	1.54E-03	1.54E-03	1.54E-03	1.54E-03	1.54E-03	1.54E-03
	Diesel Required for Dragging	MT-Diesel	92.9	93.4	93.5	93.2	98.7	106.2
	Diesel EF	kg-CO ₂ /kg-Diesel	2.15	2.15	2.15	2.15	2.15	2.15
	CO₂ from Winch Dragging	MT-CO₂	199.7	200.9	201.1	200.5	212.3	228.4
Small Steel Cutting	Small Steel Cutting Propane UF	MT-LPG/MT-Scrap	2.81E-03	2.81E-03	2.81E-03	2.81E-03	2.81E-03	2.81E-03
	Small Steel Cutting Oxygen UF	MT-O ₂ /MT-Scrap	2.87E-02	2.87E-02	2.87E-02	2.87E-02	2.87E-02	2.87E-02
	Beach Cutting Propane	MT	169.4	170.5	170.7	170.1	180.2	193.9
	Beach Cutting O ₂	MT	1,728.8	1,739.3	1,741.3	1,735.8	1,838.4	1,977.9
	Small Steel Cutting CO₂	MT	508.3	511.4	512.0	510.4	540.6	581.6

			Baseline / HFO	LNG	Ammonia	Methanol	LH ₂	Comp. H ₂
Grab Cranes	Grab Crane Diesel Consumption Rate	MT-Diesel/MT Scrap	3.40E-03	3.40E-03	3.40E-03	3.40E-03	3.40E-03	3.40E-03
	Diesel for Grab Cranes	MT-Diesel	205.0	206.3	206.5	205.8	218.0	234.6
	CO₂ from Grab Crane Operation	MT-CO₂	440.8	443.5	444.0	442.6	468.7	504.3
Transport to Recycling Facilities	% Re-Rolled	%	70%	70%	70%	70%	70%	70%
	% Directly Recycled	%	30%	30%	30%	30%	30%	30%
	Re-rolled scrap	MT	42,210.0	42,466.2	42,515.6	42,379.9	44,885.7	48,291.3
	Re-Used Scrap	MT	18,090.0	18,199.8	18,221.0	18,162.8	19,236.7	20,696.3
	Re-rolled Diesel Use Factor	MT-Diesel/MT Scrap	3.33E-03	3.33E-03	3.33E-03	3.33E-03	3.33E-03	3.33E-03
	Scrap Use Diesel Use Factor	MT-Diesel/MT Scrap	4.99E-03	4.99E-03	4.99E-03	4.99E-03	4.99E-03	4.99E-03
	Diesel for Transport to Re-roll Mill	MT-Diesel	140.6	141.4	141.6	141.1	149.5	160.8
	Diesel for Transport to Light Production	MT-Diesel	90.3	90.8	90.9	90.6	96.0	103.3
	CO₂ from Transport to Recycling	MT-CO₂	496.3	499.3	499.9	498.3	527.7	567.8
	Total CO₂	MT-CO₂	4,162.3	3,633.3	2,145.5	4,036.0	2,243.6	2,384.5
		kg-CO₂eq	4.16E+06	3.63E+06	2.15E+06	4.04E+06	2.24E+06	2.38E+06

The resultant CO₂ emissions from this method lay exactly two orders of magnitude between that from the steel fabrication from scrap estimates and the cutting gas estimates. This method was detailed in its development, but did involve estimated quantities of consumables from interviewing breaking yard workers. Unfortunately, it primarily reports CO₂ and thus does not quite capture the local pollutant effects from shipbreaking (Ko and Gantner, 2016).

Details of Ship Breaking Transit – Energy Requirements

Sail To Breakers Timeline			
Operational Days	days	9	
Operational Time and Energy Breakdown			
		Breaking	
Round Trip Scheduled Time	days	9	
Days Spent Sailing per Trip	Days	8.4	
Calculation of Sailing Time and Energy Requirements			
<i>Main Engine</i>			
To Breakers			
		Sailing	Final Beaching
Route Sail Distance	Nmi	3710	10
Sea Trial			
		Speed Trial	Motoring
<i>Speed-Power</i>			
Speed at Design Draft	knots	18.5	12
Required Trial Power	kW	16181	4429
Sea Margin		1.15	1
Fouling Factor		1.07	1
Total Required Propulsive Power	kW	19911	4429
Shaft Generator	kW	0	0
Total ME Power Req'd while Sailing	kW	19911	4429
ME Installed MCR	kW	65500	65500
% MCR		30%	7%
% of Propulsive MCR		30%	7%
Route Sailing Time	Hours	200.5	0.8
	Days	8.4	0.0
Route Main Engine Power Demand	kW-Hrs	3.99E+06	3.69E+03
	MJ	1.44E+07	1.33E+04
<i>Auxiliary Engines</i>			
<i>Baseline Aux Sea Power</i>	kW	2300	2300
Reefer Slots	FEU	2200	2200
Power per Reefer	kW/Reefer FEU	5	5
(Assume 6kW/hold Reefer, 4.5 kW/Deck Reefer, 1/3 in Hold, 2/3 on Deck)			
Sea Trial			
		Speed Trial	Motoring
Assumed Loaded Reefer Capacity		0%	0%
Required Reefer Power	kW	0	0
Total Req'd Aux Power	kW	2300	2300
Shaft Generator	kW	0	0
Total Req'd Aux DG Power	kW	2300	2300
Route Aux DG Power Demand	kW-Hrs	4.61E+05	1.92E+03
	MJ	1.66E+06	6.90E+03
Calculation of Aux Boiler Energy Requirements			
Boiler Required Power	kW	700	
Sea Trial			
		Sea Trial	Motoring
Boiler Operation days	days	0.00	0.00
	hours	0	0
Boiler Power per Trip	kW-Hrs	0.00E+00	0.00E+00
	MJ	0.00E+00	0.00E+00

Details of Ship Breaking Transit – Tank-to-Wake Emissions

		HFO		LNG		Ammonia		Methanol		Hydrogen	
		Ship Breaking		Ship Breaking		Ship Breaking		Ship Breaking		Ship Breaking	
Main Engine Consumption Rates		Sailing	Beaching	Sailing	Beaching	Sailing	Beaching	Sailing	Beaching	Sailing	Beaching
Main Engine % MCR		30%	7%	30%	7%	30%	7%	30%	7%	30%	7%
Main Engine Power	kW	19911	4429	19911	4429	19911	4429	19911	4429	19911	4429
Main Engine SPOC	g/kW-Hr	0.0	0.0	6.5	10.4	21.6	34.8	21.6	34.8	21.6	34.8
Main Engine SFC	g/kW-Hr	167.3	175.8	136.3	139.8	338.1	323.8	313.3	298.5	52.4	50.2
Urea Consumption	l/hr	666.4	288.2	666.4	288.2	666.4	288.2	0.0	0.0	666.4	288.2
NaOH Consumption	l/hr	0.0	0.0	0.0	0.0	0.0	0.0	5.8	2.4	0.0	0.0
Cylinder Oil Consumption	g/kW-Hr	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Lube Oil Consumption	g/kW-Hr	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methane Slip	g/kW-Hr	0.00	0.00	0.27	0.30	0.00	0.00	0.00	0.00	0.00	0.00
Main Engine Power Demand											
Hours Op.	hrs	201	1	201	1	201	1	201	1	201	1
Main Engine Demand	kW-Hr	3.99E+06	3.69E+03	3.99E+06	3.69E+03	3.99E+06	3.69E+03	3.99E+06	3.69E+03	3.99E+06	3.69E+03
Main Engine Consumption											
Pilot Fuel Used	MT	0.0	0.0	25.9	0.0	86.3	0.1	86.3	0.1	86.3	0.1
Fuel Used	MT	668.2	0.6	544.3	0.5	1350.1	1.2	1250.9	1.1	209.3	0.2
Urea Used	MT	148.3	0.3	148.3	0.3	148.3	0.3	0.0	0.0	148.3	0.3
NaOH Used	MT	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0
Cylinder Oil Used	MT	2.4	0.0	2.4	0.0	2.4	0.0	2.4	0.0	2.4	0.0
Lube Oil Used	MT	0.4	0.0	0.4	0.0	0.4	0.0	0.4	0.0	0.4	0.0
Methane Slip	MT	0.00	0.00	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pilot Fuel Energy	MJ	0E+00	0E+00	1E+06	2E+03	4E+06	5E+03	4E+06	5E+03	4E+06	5E+03
Main Fuel Energy	MJ	3E+07	3E+04	3E+07	2E+04	3E+07	2E+04	2E+07	2E+04	3E+07	2E+04
Pilot/Main Energy Fraction	%	0%	0%	4%	7%	15%	25%	15%	25%	15%	25%
Pilot Fuel Portion of kW-hr	kW-hr	0.00E+00	0.00E+00	1.69E+05	2.45E+02	5.86E+05	9.09E+02	5.91E+05	9.22E+02	5.86E+05	9.09E+02
Auxiliary Engine Consumption Rates											
Aux Engine Power,	kW	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300
Aux Engine Power, Port/Idle	kW	0	0	0	0	0	0	0	0	0	0
Aux Engine Assumed % MCR	%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
Aux Engine SPOC	g/kW-Hr	0.0	0.0	3.3	3.3	62.9	62.9	62.9	62.9	62.9	62.9
Aux Engine SFC	g/kW-Hr	197.7	197.7	166.8	166.8	293.4	293.4	274.2	274.2	45.5	45.5
Lube Oil SFC	g/kW-Hr	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Urea Consumption	g/kW-Hr	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Methane Slip	g/kW-Hr	0.0	0.0	5.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Auxiliary Engine Power Demand											
Aux Engine, Seagoing	kW-Hr	4.61E+05	1.92E+03	4.61E+05	1.92E+03	4.61E+05	1.92E+03	4.61E+05	1.92E+03	4.61E+05	1.92E+03
Aux Engine, Idle	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Aux Engine, Port	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Aux Engine, Total	kW-Hr	4.61E+05	1.92E+03	4.61E+05	1.92E+03	4.61E+05	1.92E+03	4.61E+05	1.92E+03	4.61E+05	1.92E+03
Auxiliary Engine Consumption											
Pilot Fuel Used	MT	0.0	0.0	1.5	0.0	29.0	0.1	29.0	0.1	29.0	0.1
Fuel Used	MT	91.2	0.4	76.9	0.3	135.3	0.6	126.5	0.5	21.0	0.1
Urea Used	MT	6.0	0.0	6.0	0.0	6.0	0.0	6.0	0.0	6.0	0.0
Lube Oil Used	MT	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0
Methane Slip	MT	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pilot Fuel Energy	MJ	0E+00	0E+00	6E+04	3E+02	1E+06	5E+03	1E+06	5E+03	1E+06	5E+03
Main Fuel Energy	MJ	4E+06	2E+04	4E+06	2E+04	3E+06	1E+04	3E+06	1E+04	3E+06	1E+04
Pilot/Main Energy Fraction	%	0%	0%	2%	2%	49%	49%	49%	49%	49%	49%
Pilot Fuel Portion of kW-hr	kW-hr	0.00E+00	0.00E+00	8.01E+03	3.33E+01	2.27E+05	9.44E+02	2.27E+05	9.44E+02	2.27E+05	9.44E+02
Boiler Demand and Consumption											
Boiler Power, Port/Idle	kW	700	700	700	700	700	700	700	700	700	700
Boiler SFC	g/kW-Hr	340.0	340.0	285.0	285.0	735.0	735.0	687.0	687.0	113.9	113.9
Boiler Demand	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Boiler Fuel Burnt	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shore-Power Requirements											
Aux Power Energy Demand	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reliquification Energy	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Shore Power Req'd Energy	kW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

		HFO		LNG		Ammonia		Methanol		Hydrogen	
		Ship Breaking		Ship Breaking		Ship Breaking		Ship Breaking		Ship Breaking	
CO₂ General Emission Factors											
Pilot Fuel CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	0.000	0.000	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206
Fuel CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	3.114	3.114	2.750	2.750	0.000	0.000	1.375	1.375	0.000	0.000
Lube Oil CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206
Main Engine Emission Factors											
SO _x Emission Factor - Pilot Fuel	MT-SO _x /MT Fuel	0.000	0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
SO _x Emission Factor	MT-SO _x /MT Fuel	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NO _x Emission Factor	g/kW-hr	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400
PM ₁₀ Emissions Factor - Pilot	g-PM ₁₀ /kW-hr	0.000	0.000	0.309	0.357	0.494	0.654	0.494	0.654	0.494	0.654
PM ₁₀ Emissions Factor - Fuel	g-PM ₁₀ /kW-hr	27.025	28.317	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CH ₄ /Methane Slip - Fuel	g/kW-hr	0.010	0.010	0.274	0.302	0.010	0.010	0.010	0.010	0.010	0.010
CO	g/kW-hr	0.540	0.540	1.040	1.040	0.044	0.044	0.044	0.044	0.044	0.044
N ₂ O	g/kW-hr	0.031	0.031	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
NM VOC	g/kW-hr	0.632	0.632	0.400	0.400	0.632	0.632	0.632	0.632	0.632	0.632
Black Carbon	MT-BC/MT-Fuel*	2.29E-04	4.05E-04	2.00E-03	2.00E-03	4.96E-05	9.30E-05	4.96E-05	9.30E-05	4.96E-05	9.30E-05
	*g/kw-Hr for LNG										
Aux DG Emission Factors											
Aux SO _x Emission Factor - PO	MT-SO _x /MT-Fuel	0	0	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Aux SO _x Emission Factor - Fuel	MT-SO _x /MT-Fuel	0.020	0.020	3.17E-05	3.17E-05	0.000	0.000	0.003	0.003	0.000	0.000
Aux NO _x Emission Factor	g/kW-hr	2.414	2.414	1.300	1.300	2.414	2.414	2.414	2.414	2.414	2.414
Aux PM ₁₀ Emission Factor	g/kW-hr	1.390	1.390	0.020	0.020	0.180	0.180	0.140	0.140	0.180	0.180
Aux CH ₄ Emission Factor	g/kW-hr	0.010	0.010	0.200	0.200	0.010	0.010	0.010	0.010	0.010	0.010
Aux CO Emission Factor	g/kW-hr	0.540	0.540	1.300	1.300	0.540	0.540	0.540	0.540	0.540	0.540
Aux N ₂ O Emission Factor	g/kW-hr	0.040	0.040	0.030	0.030	0.036	0.036	0.036	0.036	0.036	0.036
Aux NM VOC Emission Factor	g/kW-hr	0.421	0.421	0.400	0.400	0.421	0.421	0.421	0.421	0.421	0.421
Aux Black Carbon Factor*	MT-BC/MT-Fuel*	1.60E-04	1.60E-04	2.00E-03	2.00E-03	1.45E-04	1.45E-04	1.45E-04	1.45E-04	1.45E-04	1.45E-04
	*g/kw-Hr for LNG										
Boiler Emission Factors											
Boiler NO _x Emission Factor	g/kW-hr	2.100	2.100	1.300	1.300	0.000	0.000	0.000	0.000	0.000	0.000
Boiler PM ₁₀ Emission Factor	g/kW-hr	1.420	1.420	0.030	0.030	0.000	0.000	0.000	0.000	0.000	0.000
Boiler CH ₄ Emission Factor	g/kW-hr	0.002	0.002	0.040	0.040	0.000	0.000	0.000	0.000	0.000	0.000
Boiler CO Emission Factor	g/kW-hr	0.200	0.200	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000
Boiler N ₂ O Emission Factor	g/kW-hr	0.040	0.040	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000
Boiler NM VOC Emission Factor	g/kW-hr	0.421	0.421	0.105	0.105	0.000	0.000	0.000	0.000	0.000	0.000
Boiler Black Carbon Factor	g/kW-hr	8.00E-02	8.00E-02	3.00E-03	3.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

		HFO		LNG		Ammonia		Methanol		Hydrogen	
		Ship Breaking		Ship Breaking		Ship Breaking		Ship Breaking		Ship Breaking	
CO₂											
ME Pilot Fuel CO ₂ Emissions	MT	0	0	83	0	277	0	277	0	277	0
ME Main Fuel CO ₂ Emissions	MT	2081	2	1497	1	0	0	1720	2	0	0
ME LO CO ₂ Emissions	MT	9.0	0.0	9.0	0.0	9.0	0.0	9.0	0.0	9.0	0.0
Aux Pilot Fuel CO ₂ Emissions	MT	0	0	5	0	93	0	93	0	93	0
Aux Main Fuel CO ₂ Emissions	MT	284	1	212	1	0	0	174	1	0	0
Boiler CO ₂ Emissions	MT	0	0	0	0	0	0	0	0	0	0
Total CO ₂ Emissions	MT	2374	3	1805	2	379	1	2272	3	379	1
% CO ₂ Emissions Reduction	%			24%	24%	84%	75%	4%	5%	84%	75%
SO_x											
ME Pilot Fuel SO _x Emissions	MT	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0
ME Main Fuel SO _x Emissions	MT	13.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel SO _x Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel SO _x Emissions	MT	1.8	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Total SO _x Emissions	MT	14.8	0.0	0.1	0.0	0.2	0.0	0.5	0.0	0.2	0.0
%SO _x Emissions Reduction	%			100%	100%	99%	98%	97%	91%	99%	98%
NO_x											
ME NO _x Emissions	MT	13.6	0.0	13.6	0.0	13.6	0.0	13.6	0.0	13.6	0.0
Aux NO _x Emissions	MT	1.1	0.0	0.6	0.0	1.1	0.0	1.1	0.0	1.1	0.0
Boiler NO _x Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total NO _x Emissions	MT	14.7	0.0	14.2	0.0	14.7	0.0	14.7	0.0	14.7	0.0
%NO _x Emissions Reduction	%			3%	12%	0%	0%	0%	0%	0%	0%
Particulate Matter											
ME Pilot Fuel PM ₁₀ Emissions	MT	0.0	0.0	0.1	0.0	0.3	0.0	0.3	0.0	0.3	0.0
ME Main Fuel PM ₁₀ Emissions	MT	107.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel PM ₁₀ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel PM ₁₀ Emissions	MT	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler PM ₁₀ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total PM ₁₀ Emissions	MT	108.5	0.1	0.1	0.0	0.3	0.0	0.4	0.0	0.3	0.0
%PM ₁₀ Emissions Reduction	%			100%	100%	100%	99%	100%	99%	100%	99%
Methane											
ME Pilot Fuel CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel CH ₄ Emissions	MT	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel CH ₄ Emissions	MT	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CH ₄ Emissions	MT	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%CH ₄ Emissions Reduction	%			-2559%	-2571%	82%	67%	82%	67%	82%	67%
Carbon Monoxide											
ME Pilot Fuel CO Emissions	MT	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel CO Emissions	MT	2.2	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel CO Emissions	MT	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Aux Main Fuel CO Emissions	MT	0.2	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler CO Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CO Emissions	MT	2.4	0.0	4.8	0.0	0.1	0.0	0.1	0.0	0.1	0.0
%CO Emissions Reduction	%			-98%	-109%	94%	82%	94%	82%	94%	82%

		HFO		LNG		Ammonia		Methanol		Hydrogen	
		Ship Breaking		Ship Breaking		Ship Breaking		Ship Breaking		Ship Breaking	
N ₂ O											
ME Pilot Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel N ₂ O Emissions	MT	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total N ₂ O Emissions	MT	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%N ₂ O Emissions Reduction	%			6%	12%	82%	68%	82%	68%	82%	68%
Volatile Organic Compounds											
ME Pilot Fuel NMVOC Emissions	MT	0.0	0.0	0.1	0.0	0.4	0.0	0.4	0.0	0.4	0.0
ME Main Fuel NMVOC Emissions	MT	2.5	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel NMVOC Emissions	MT	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Aux Main Fuel NMVOC Emissions	MT	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler NMVOC Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total NMVOC Emissions	MT	2.7	0.0	1.8	0.0	0.5	0.0	0.5	0.0	0.5	0.0
%NMVOC Emissions Reduction	%			34%	29%	83%	69%	83%	69%	83%	69%
Black Carbon											
ME Pilot Fuel BC Emissions	MT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ME Main Fuel BC Emissions	MT	0.15	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aux Pilot Fuel BC Emissions	MT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aux Main Fuel BC Emissions	MT	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Boiler BC Emissions	MT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total BC Emissions	MT	0.17	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
%BC Emissions Reduction	%			95%	97%	95%	91%	95%	91%	95%	91%
System Input Summary											
Pilot Oil (MDO)	MT	0.0	0.0	27.4	0.0	115.3	0.2	115.3	0.2	115.3	0.2
Fuel (Varies)	MT	759.4	1.0	621.3	0.8	1,485.5	1.8	1,377.4	1.6	230.2	0.3
Urea	MT	154.3	0.3	154.3	0.3	154.3	0.3	6.0	0.0	154.3	0.3
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0
Cylinder Oil	MT	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Lube Oil	MT	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1
External Energy	kW-Hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
System Output Summary											
CO ₂ Emissions	MT	2,373.8	3.2	1,805.2	2.4	378.6	0.8	2,272.5	3.0	378.6	0.8
SO _x Emissions	MT	14.8	0.0	0.1	0.0	0.2	0.0	0.5	0.0	0.2	0.0
NO _x Emissions	MT	14.7	0.0	14.2	0.0	14.7	0.0	14.7	0.0	14.7	0.0
PM ₁₀ Emissions	MT	108.5	0.1	0.1	0.0	0.3	0.0	0.4	0.0	0.3	0.0
PM _{2.5} Emissions	MT	99.9	0.1	0.1	0.0	0.3	0.0	0.3	0.0	0.3	0.0
CH ₄ Emissions	MT	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO Emissions	MT	2.4	0.0	4.8	0.0	0.1	0.0	0.1	0.0	0.1	0.0
N ₂ O Emissions	MT	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NMVOC Emissions	MT	2.7	0.0	1.8	0.0	0.5	0.0	0.5	0.0	0.5	0.0
BC Emissions	MT	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Global Warming Potential											
Eq. GWP 20yr	kg-CO _{2e}	2415042	3264	1939971	2620	386115	824	2280017	3062	386115	824
Eq. GWP 100yr	kg-CO _{2e}	2417651	3268	1885294	2551	386584	825	2280489	3063	386584	825
Eq. GWP MEPC (100yr)	kg-CO _{2e}	2417651	3268	1885294	2551	386584	825	2280489	3063	386584	825

Details of Ship Breaking Transit – Well-to-Tank Emissions

		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ Bio Diesel	Methanol	Bio- Methanol	Bio- Methanol w/ Bio Diesel	Hydrogen	E-Hydrogen	E-Hydrogen w/ Bio Diesel
Required Consumables		To Breakers	To Breakers	To Breakers	To Breakers	To Breakers	To Breakers	To Breakers	To Breakers	To Breakers	To Breakers	To Breakers	To Breakers	To Breakers
Pilot Oil	MT	0.0	27.4	27.4	27.4	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6
Fuel	MT	760.4	622.1	622.1	622.1	1,487.2	1,487.2	1,487.2	1,379.0	1,379.0	1,379.0	230.5	230.5	230.5
Urea	MT	154.6	154.6	154.6	154.6	154.6	154.6	154.6	6.0	6.0	6.0	154.6	154.6	154.6
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.8	1.8	0.0	0.0	0.0
Cylinder Oil	MT	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Lube Oil	MT	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
External Energy	KW-Hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Well-to-Tank Emissions														
CO ₂ Emissions	MT	416.0	264.6	823.0	825.0	2,403.3	891.3	898.9	616.3	534.0	541.7	2,224.6	286.0	293.7
SO _x Emissions	MT	1.2	0.0	2.2	2.2	0.0	0.0	0.2	0.1	1.3	1.5	1.1	1.4	1.6
NO _x Emissions	MT	0.6	0.3	1.6	1.8	1.2	1.2	2.0	1.3	1.5	2.3	0.9	0.8	1.6
CH ₄ Emissions	MT	2.2	1.1	0.7	0.6	0.7	0.5	0.1	0.8	1.7	1.3	4.7	0.6	0.2
CO Emissions	MT	0.3	0.1	0.3	0.3	0.1	0.0	0.0	0.2	0.7	0.7	0.3	0.2	0.2
N ₂ O Emissions	MT	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
Tank-to-Wake Emissions														
CO ₂ Emissions	MT	2,377.0	1,807.7	1,807.7	1,807.7	379.4	379.4	379.4	2,275.5	2,275.5	2,275.5	379.4	379.4	379.4
CO ₂ Emissions Offset	MT	0.0	0.0	-1,710.8	-1,788.4	0.0	0.0	-326.9	0.0	-1,903.0	-2,229.9	0.0	0.0	-326.9
SO _x Emissions	MT	14.9	0.1	0.1	0.1	0.2	0.2	0.2	0.5	0.5	0.5	0.2	0.2	0.2
NO _x Emissions	MT	14.7	14.2	14.2	14.2	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
PM ₁₀ Emissions	MT	108.7	0.1	0.1	0.1	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3
PM _{2.5} Emissions	MT	100.0	0.1	0.1	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
CH ₄ Emissions	MT	0.0	1.2	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO Emissions	MT	2.4	4.8	4.8	4.8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N ₂ O Emissions	MT	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NM VOC Emissions	MT	2.7	1.8	1.8	1.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
BC Emissions	MT	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Operational Emissions														
CO ₂ Emissions	MT	2,793.0	2,072.3	919.9	844.3	2,782.7	1,270.7	951.4	2,891.8	906.5	587.3	2,604.0	665.4	346.2
SO _x Emissions	MT	16.1	0.1	2.2	2.3	0.2	0.2	0.3	0.6	1.8	2.0	1.2	1.6	1.7
NO _x Emissions	MT	15.3	14.5	15.8	16.0	15.9	15.9	16.7	16.0	16.2	17.0	15.6	15.5	16.3
PM ₁₀ Emissions	MT	108.7	0.1	0.1	0.1	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3
PM _{2.5} Emissions	MT	100.0	0.1	0.1	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
CH ₄ Emissions	MT	2.3	2.3	1.9	1.7	0.7	0.5	0.1	0.8	1.7	1.3	4.7	0.6	0.2
CO Emissions	MT	2.7	4.8	5.0	5.0	0.3	0.1	0.1	0.3	0.8	0.8	0.4	0.4	0.4
N ₂ O Emissions	MT	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NM VOC Emissions	MT	2.7	1.8	1.8	1.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
BC Emissions	MT	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Global Warming WTT														
Eq.GWP 20yr	kg-CO _{2e}	6.0E+05	3.6E+05	8.8E+05	8.8E+05	2.5E+06	9.4E+05	9.1E+05	6.9E+05	6.8E+05	6.5E+05	2.6E+06	3.4E+05	3.1E+05
Eq.GWP 100yr	kg-CO _{2e}	4.9E+05	3.0E+05	8.5E+05	8.5E+05	2.4E+06	9.1E+05	9.1E+05	6.5E+05	5.9E+05	5.9E+05	2.4E+06	3.1E+05	3.0E+05
Eq. GWP MEPC (100yr)	kg-CO _{2e}	4.8E+05	3.0E+05	8.4E+05	8.4E+05	2.4E+06	9.1E+05	9.1E+05	6.4E+05	5.8E+05	5.8E+05	2.4E+06	3.1E+05	3.0E+05
Reduction	%		-88%	-65%	-65%	0%	-62%	-62%	-73%	-76%	-76%	-2%	-87%	-87%
Global Warming TTW														
Eq.GWP 20yr	kg-CO _{2e}	2.4E+06	1.9E+06	1.9E+06	1.9E+06	3.9E+05	3.9E+05	3.9E+05	2.3E+06	2.3E+06	2.3E+06	3.9E+05	3.9E+05	3.9E+05
Eq.GWP 100yr	kg-CO _{2e}	2.4E+06	1.9E+06	1.9E+06	1.9E+06	3.9E+05	3.9E+05	3.9E+05	2.3E+06	2.3E+06	2.3E+06	3.9E+05	3.9E+05	3.9E+05
Eq. GWP MEPC (100yr)	kg-CO _{2e}	2.4E+06	1.9E+06	1.9E+06	1.9E+06	3.9E+05	3.9E+05	3.9E+05	2.3E+06	2.3E+06	2.3E+06	3.9E+05	3.9E+05	3.9E+05
Reduction	%		-22%	-22%	-22%	-84%	-84%	-84%	-6%	-6%	-6%	-84%	-84%	-84%
Global Warming Potential														
Eq.GWP 20yr	kg-CO _{2e}	3.0E+06	2.3E+06	1.1E+06	1.0E+06	2.9E+06	1.3E+06	9.7E+05	3.0E+06	1.1E+06	7.0E+05	3.0E+06	7.3E+05	3.7E+05
Eq.GWP 100yr	kg-CO _{2e}	2.9E+06	2.2E+06	1.0E+06	9.5E+05	2.8E+06	1.3E+06	9.7E+05	2.9E+06	9.7E+05	6.4E+05	2.8E+06	7.0E+05	3.6E+05
Eq. GWP MEPC (100yr)	kg-CO _{2e}	2.9E+06	2.2E+06	1.0E+06	9.3E+05	2.8E+06	1.3E+06	9.7E+05	2.9E+06	9.6E+05	6.3E+05	2.7E+06	6.9E+05	3.6E+05
Reduction	%		-25%	-65%	-68%	-3%	-55%	-67%	1%	-67%	-78%	-5%	-76%	-87%

16.4. Ship Operations Inventory

Details of Operational Route – Energy Requirements

Total Operational Lifetime						
Operating Lifetime	Years	25				
	days	9131				
Shipyard Interval	years	5				
Average Time in Shipyard	days	45				
Non-Operational Days	days	225				
Operational Days	days	8906				
Operational Time and Energy Breakdown						
Round Trip Scheduled Time	days	Suez 98	Cape 98	(Asia->Europe->Asia)		
Days Spent Sailing per Trip	Days	66.3	73.5			
Days Spent in Port per Trip	Days	16.5	16.5			
Idle/Waiting Days Per Trip	Days	15.2	8.0			
Potential Round Trips in Lifetime	Round Trips	91	91			
Calculation of Sailing Time and Energy Requirements						
Main Engine						
		Suez		Cape		
		Design Draft	Light Draft	Design Draft	Light Draft	
Route Sail Distance	Nmi	11016	11596	14404	15011	Note: Design Draft is Asia->Europe, Light draft is backhaul Europe->Asia
w/ 10% Margin	Nmi	12118	12756	15844	16512	
Total Sail Distance at Each Draft	NMi	1102702	1160760	1441840	1502601	
Total Sail Distances	NMi	2263461		2944442		
		Suez		Cape		
Speed-Power		Design Draft	Light Draft	Design Draft	Light Draft	
Speed at Design Draft	knots	15.25	16.0	18.0	18.7	
Required Trial Power	kW	18566	18237	26597	25994	
Sea Margin		1.15	1.15	1.15	1.15	
Fouling Factor		1.07	1.07	1.07	1.07	
Total Required Propulsive Power	kW	22845	22441	32728	31986	
Shaft Generator	kW	4500	1750	4500	1750	
Total ME Power Req'd while Sailing	kW	27345	24191	37228	33736	
ME Installed MCR	kW	65500	65500	65500	65500	
% MCR		42%	37%	57%	52%	
% of Propulsive MCR		35%	34%	50%	49%	
Route Sailing Time	Hours	795	797	880	883	
	Days	33	33	37	37	
Combined Route Sail Time	Days	66		73		
Life Time Sailing Time	Hours	72308	72547	80102	80353	
	Days	3013	3023	3338	3348	
Combined Lifetime Sail Time	Days	6036		6686		
Route Main Engine Power Demand	kW-Hrs	2.17E+07	1.93E+07	3.28E+07	2.98E+07	
	MJ	7.82E+07	6.94E+07	1.18E+08	1.07E+08	
Lifetime Main Engine Power Demand	kW-Hrs	1.98E+09	1.75E+09	2.98E+09	2.71E+09	
	MJ	7.12E+09	6.32E+09	1.07E+10	9.76E+09	
Total Main Engine Power Demand	kW-Hrs	1.34E+10		2.05E+10		
	MJ	4.84E+10		7.38E+10		
Auxiliary Engines						
Baseline Aux Sea Power	kW	2300				
Reefer Slots	FEU	2200				
Power per Reefer	kW/Reefer FEU	5	(Assume 6kW/hold Reefer, 4.5 kW/Deck Reefer, 1/3 in Hold, 2/3 on Deck)			

		Suez		Cape	
		To/In EU	To/In Asia	To/In EU	To/In Asia
Assumed Loaded Reefer Capacity		50%	25%	50%	25%
Required Reefer Power	kW	5500	2750	5500	2750
Total Req'd Aux Power	kW	7800	5050	7800	5050
Shaft Generator	kW	4500	1750	4500	1750
Total Req'd Aux DG Power	kW	3300	3300	3300	3300
Route Aux DG Power Demand	kW-Hrs	2.62E+06	2.63E+06	2.90E+06	2.91E+06
	MJ	9.44E+06	9.47E+06	1.05E+07	1.05E+07
Lifetime Aux DG Power Demand	kW-Hrs	2.39E+08	2.39E+08	2.64E+08	2.65E+08
	MJ	8.59E+08	8.62E+08	9.52E+08	9.55E+08
Total Aux DG Power Demand	kW-Hrs	1.72E+09		1.91E+09	
	MJ	6.20E+09		6.86E+09	

Calculation of Port Time and Energy Requirements

Total Number of Ports	Ports	11
Average Days per Port	days/Port	1.5

Baseline Power at Port	kW	1675

		Suez		Cape	
		To/In EU	To/In Asia	To/In EU	To/In Asia
Number of Ports Visited		5	6	5	6
Days Spent in Port	days	7.5	9	7.5	9
	hours	180	216	180	216
Days Spent in Port over Lifetime	days	682.5	819	682.5	819
	hours	16380	19656	16380	19656
Required Reefer Power	kW	5500	2750	5500	2750
Total In-Port Power	kW	7175	4425	7175	4425
Route In-Port Power	kW-Hrs	1.29E+06	9.56E+05	1.29E+06	9.56E+05
	MJ	4.65E+06	3.44E+06	4.65E+06	3.44E+06
Total In-Port Lifetime Power	kW-Hrs	1.18E+08	8.70E+07	1.18E+08	8.70E+07
	MJ	4.23E+08	3.13E+08	4.23E+08	3.13E+08
Total In-Port Power Demand Full Route	kW-Hrs	7.36E+08		7.36E+08	
	MJ	2.65E+09		2.65E+09	

Calculation of Idle/Anchor Time and Energy Requirements

		Suez		Cape		
		To/In EU	To/In Asia	To/In EU	To/In Asia	
Idle/Waiting Days Per Trip	Days	15.2		8.0		
% Idle Time at Locations		40%	60%	40%	60%	Assuming more waiting time in Asia due to Singapore
Idle/Waiting Days per Trip	Days	6.07	9.10	3.21	4.82	
	Hours	146	219	77	116	
Idle/Waiting Days In Lifetime	Days	595	892	292	439	
	Hours	14276	21414	7016	10524	
Idle Power	kW	7175	4425	7175	4425	Same as In-Port Power
Idle Power per Trip	kW-Hrs	1.05E+06	9.67E+05	5.53E+05	5.12E+05	
	MJ	3.76E+06	3.48E+06	1.99E+06	1.84E+06	
Total Idle Lifetime Power	kW-Hrs	9.51E+07	8.80E+07	5.03E+07	4.66E+07	
	MJ	3.42E+08	3.17E+08	1.81E+08	1.68E+08	
Total Aux Power Demand	kW-Hrs	1.83E+08		9.69E+07		
	MJ	6.59E+08		3.49E+08		

Calculation of Aux Boiler Energy Requirements

Boiler Required Power	kW	700			
		Suez		Cape	
		To/In EU	To/In Asia	To/In EU	To/In Asia
Boiler Operation days	days	13.57	18.10	10.71	13.82
	hours	326	435	257	332
Boiler Operation in lifetime	days	1235	1648	975	1258
	hours	29636	39540	23396	30180
Boiler Power per Trip	kW-Hrs	2.28E+05	3.04E+05	1.80E+05	2.32E+05
	MJ	8.21E+05	1.09E+06	6.48E+05	8.36E+05
Boiler Lifetime Power	kW-Hrs	2.07E+07	2.77E+07	1.64E+07	2.11E+07
	MJ	7.47E+07	9.96E+07	5.90E+07	7.61E+07
Total Boiler Power Demand	kW-Hrs	4.84E+07		3.75E+07	
	MJ	1.74E+08		1.35E+08	

Assumed operational during port/idle days only

Calculation of Re-Liquifaction Energy

Reliquifaction Power Required	kW/kg ₆₀ /sec	2719	1010	3104	From Gomez 2015
		LNG	Ammonia	Hydrogen	
Boil-Off Rates	kg/day	20677	2564	10361	Assuming average ambient temperature of 25C for Europe
	kg/sec	0.239	0.030	0.120	
Power Consumption per Fuel	kW	651	30	372	
		Suez		Cape	
		To/In EU	To/In Asia	To/In EU	To/In Asia
Reliquifaction Time		13.57	0.00	10.71	0.00
		326	0	257	0
Reliquifaction in Lifetime	days	1235	0	975	0
	hours	29636	0	23396	0
Reliquifaction Power Req'd per Trip	kW-Hrs	2.12E+05		1.67E+05	LNG
	MJ	7.63E+05		6.02E+05	
	kW-Hrs	9.76E+03		7.71E+03	Ammonia
	MJ	3.51E+04		2.77E+04	
	kW-Hrs	1.21E+05		9.57E+04	Hydrogen
	MJ	4.36E+05		3.45E+05	
Reliquifaction Power Req'd in Lifetime	kW-Hrs	1.93E+07		1.52E+07	LNG
	MJ	6.94E+07		5.48E+07	
	kW-Hrs	8.88E+05		7.01E+05	Ammonia
	MJ	3.20E+06		2.52E+06	
	kW-Hrs	1.10E+07		8.71E+06	Hydrogen
	MJ	3.97E+07		3.14E+07	

Details of Operational Inventory – Tank-to-Wake Inventory – Suez Canal Route

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Suez		Suez		Suez		Suez		Suez	
Main Engine Consumption Rates		To EU	To Asia	To EU	To Asia	To EU	To Asia	To EU	To Asia	To EU	To Asia
Main Engine % MCR		42%	37%	42%	37%	42%	37%	42%	37%	42%	37%
Main Engine Power	kW	27,345	24,191	27,345	24,191	27,345	24,191	27,345	24,191	27,345	24,191
Main Engine SPOC	g/kW-Hr	0.0	0.0	5.2	5.7	17.5	19.0	17.5	19.0	17.5	19.0
Main Engine SFC	g/kW-Hr	164.0	165.3	134.4	135.2	341.3	340.3	316.8	315.7	52.9	52.7
Urea Consumption	l/hr	827.5	767.1	827.5	767.1	827.5	767.1	0.0	0.0	827.5	767.1
NaOH Consumption	l/hr	0.0	0.0	0.0	0.0	0.0	0.0	6.6	6.5	0.0	0.0
Cylinder Oil Consumption	g/kW-Hr	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Lube Oil Consumption	g/kW-Hr	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methane Slip	g/kW-Hr	0.00	0.00	0.26	0.27	0.00	0.00	0.00	0.00	0.00	0.00
Main Engine Power Demand											
Hours Op.	hrs	795	797	795	797	795	797	795	797	795	797
Main Engine Demand	KW-Hr	2.17E+07	1.93E+07	2.17E+07	1.93E+07	2.17E+07	1.93E+07	2.17E+07	1.93E+07	2.17E+07	1.93E+07
Main Engine Consumption											
Pilot Fuel Used	MT	0.0	0.0	113.9	109.8	379.8	366.3	379.8	366.3	379.8	366.3
Fuel Used	MT	3,562.4	3,188.5	2,920.7	2,608.0	7,414.9	6,562.5	6,882.7	6,088.3	1,149.3	1,017.2
Urea Used	MT	729.8	678.8	729.8	678.8	729.8	678.8	0.0	0.0	729.8	678.8
NaOH Used	MT	0.0	0.0	0.0	0.0	0.0	0.0	8.0	7.8	0.0	0.0
Cylinder Oil Used	MT	13.0	11.6	13.0	11.6	13.0	11.6	13.0	11.6	13.0	11.6
Lube Oil Used	MT	2.2	1.9	2.2	1.9	2.2	1.9	2.2	1.9	2.2	1.9
Methane Slip	MT	0.00	0.00	5.65	5.12	0.00	0.00	0.00	0.00	0.00	0.00
Pilot Fuel Energy	MJ	0E+00	0E+00	5E+06	5E+06	2E+07	2E+07	2E+07	2E+07	2E+07	2E+07
Main Fuel Energy	MJ	1E+08	1E+08	1E+08	1E+08	1E+08	1E+08	1E+08	1E+08	1E+08	1E+08
Pilot/Main Energy Fraction	%	0%	0%	3%	4%	12%	13%	12%	13%	12%	13%
Pilot Fuel Portion of kW-hr	kW-hr	0.00E+00	0.00E+00	7.54E+05	7.23E+05	2.56E+06	2.47E+06	2.57E+06	2.49E+06	2.56E+06	2.47E+06
Aux. Engine Cons. Rates											
Aux Engine Power,	kW	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
Aux Engine Power, Port/Idle	kW	7175	4425	7175	4425	7175	4425	7175	4425	7175	4425
Aux Engine Assumed % MCR	%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
Aux Engine SPOC	g/kW-Hr	0.0	0.0	3.3	3.3	62.9	62.9	62.9	62.9	62.9	62.9
Aux Engine SFC	g/kW-Hr	197.7	197.7	166.8	166.8	293.4	293.4	274.2	274.2	45.5	45.5
Lube Oil SFC	g/kW-Hr	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Urea Consumption	g/kW-Hr	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Methane Slip	g/kW-Hr	0.0	0.0	5.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Aux. Engine Power Demand											
Aux Engine, Seagoing	KW-Hr	2.62E+06	2.63E+06	2.62E+06	2.63E+06	2.62E+06	2.63E+06	2.62E+06	2.63E+06	2.62E+06	2.63E+06
Aux Engine, Idle	KW-Hr	1.05E+06	9.67E+05	1.05E+06	9.67E+05	1.05E+06	9.67E+05	1.05E+06	9.67E+05	1.05E+06	9.67E+05
Aux Engine, Port	KW-Hr	0.00E+00	9.56E+05	0.00E+00	9.56E+05	0.00E+00	9.56E+05	0.00E+00	9.56E+05	0.00E+00	9.56E+05
Aux Engine, Total	KW-Hr	3.67E+06	4.55E+06	3.67E+06	4.55E+06	3.67E+06	4.55E+06	3.67E+06	4.55E+06	3.67E+06	4.55E+06
Auxiliary Engine Consumption											
Pilot Fuel Used	MT	0.0	0.0	11.9	14.8	230.8	286.6	230.8	286.6	230.8	286.6
Fuel Used	MT	725.1	900.3	611.6	759.4	1075.9	1335.8	1005.6	1248.6	166.8	207.1
Urea Used	MT	47.7	59.2	47.7	59.2	47.7	59.2	47.7	59.2	47.7	59.2
Lube Oil Used	MT	2.5	3.1	2.5	3.1	2.5	3.1	2.5	3.1	2.5	3.1
Methane Slip	MT	0.0	0.0	20.2	25.0	0.0	0.0	0.0	0.0	0.0	0.0
Pilot Fuel Energy	MJ	0E+00	0E+00	5E+05	6E+05	1E+07	1E+07	1E+07	1E+07	1E+07	1E+07
Main Fuel Energy	MJ	3E+07	4E+07	3E+07	4E+07	2E+07	2E+07	2E+07	2E+07	2E+07	2E+07
Pilot/Main Energy Fraction	%	0%	0%	2%	2%	49%	49%	49%	49%	49%	49%
Pilot Fuel Portion of kW-hr	kW-hr	0.00E+00	0.00E+00	6.37E+04	7.90E+04	1.81E+06	2.24E+06	1.81E+06	2.24E+06	1.81E+06	2.24E+06

		HFO Fueled Ship	LNG Fueled Ship	Ammonia Fueled Ship	Methanol Fueled Ship	Hydrogen Fueled Ship					
		Suez	Suez	Suez	Suez	Suez					
Boiler Consumption Rates											
Boiler Power, Port/Idle	kW	700	700	700	700	700	700	700	700	700	700
Boiler SFC	g/kW-Hr	340.0	340.0	285.0	285.0	735.0	735.0	687.0	687.0	113.9	113.9
Boiler Demand	kW-Hr	2.28E+05	3.04E+05	2.28E+05	3.04E+05	2.28E+05	3.04E+05	2.28E+05	3.04E+05	2.28E+05	3.04E+05
Boiler Fuel Burnt	MT	77.5	103.4	65.0	86.7	167.6	223.6	156.6	209.0	26.0	34.6
Shore-Power Requirements											
Aux Power Energy Demand	kW-Hr	1.29E+06	0.00E+00	1.29E+06	0.00E+00	1.29E+06	0.00E+00	1.29E+06	0.00E+00	1.29E+06	0.00E+00
Reliquification Energy	kW-Hr	0.00E+00	0.00E+00	2.12E+05	0.00E+00	9.76E+03	0.00E+00	0.00E+00	0.00E+00	1.21E+05	0.00E+00
Shore Power Req'd Energy	kW-Hr	1.29E+06	0.00E+00	1.50E+06	0.00E+00	1.30E+06	0.00E+00	1.29E+06	0.00E+00	1.41E+06	0.00E+00
CO ₂ General Emission Factors											
Pilot Fuel CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	0.000	0.000	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206
Fuel CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	3.114	3.114	2.750	2.750	0.000	0.000	1.375	1.375	0.000	0.000
Lube Oil CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206
Main Engine Emission Factors											
SO _x Emission Factor - Pilot Fuel	MT-SO _x /MT Fuel	0.000	0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
SO _x Emission Factor	MT-SO _x /MT Fuel	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NO _x Emission Factor	g/kW-hr	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400
PM ₁₀ Emissions Factor Pilot	g-PM ₁₀ /kW-hr	0.000	0.000	0.294	0.300	0.443	0.462	0.443	0.462	0.443	0.462
PM ₁₀ Emissions Factor Fuel	g-PM ₁₀ /kW-hr	26.504	26.715	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CH ₄ /Methane Slip - Fuel	g/kW-hr	0.010	0.010	0.260	0.266	0.010	0.010	0.010	0.010	0.010	0.010
CO	g/kW-hr	0.540	0.540	1.040	1.040	0.044	0.044	0.044	0.044	0.044	0.044
N ₂ O	g/kW-hr	0.031	0.031	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
NM VOC	g/kW-hr	0.632	0.632	0.400	0.400	0.632	0.632	0.632	0.632	0.632	0.632
Black Carbon	MT-BC/MT-Fuel*	2.07E-04	2.16E-04	2.00E-03	2.00E-03	4.00E-05	4.31E-05	4.00E-05	4.31E-05	4.00E-05	4.31E-05
	*g/kw-Hr for LNG										
Aux DG Emission Factors											
Aux SO _x Emission Factor - PO	MT-SO _x /MT Fuel	0	0	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Aux SO _x Emission Factor - Fuel	MT-SO _x /MT Fuel	0.020	0.020	3.17E-05	3.17E-05	0.000	0.000	0.003	0.003	0.000	0.000
Aux NO _x Emission Factor	g/kW-hr	2.414	2.414	1.300	1.300	2.414	2.414	2.414	2.414	2.414	2.414
Aux PM ₁₀ Emission Factor	g/kW-hr	1.390	1.390	0.020	0.020	0.180	0.180	0.140	0.140	0.180	0.180
Aux CH ₄ Emission Factor	g/kW-hr	0.010	0.010	0.200	0.200	0.010	0.010	0.010	0.010	0.010	0.010
Aux CO Emission Factor	g/kW-hr	0.540	0.540	1.300	1.300	0.540	0.540	0.540	0.540	0.540	0.540
Aux N ₂ O Emission Factor	g/kW-hr	0.040	0.040	0.030	0.030	0.036	0.036	0.036	0.036	0.036	0.036
Aux NMVOC Emission Factor	g/kW-hr	0.421	0.421	0.400	0.400	0.421	0.421	0.421	0.421	0.421	0.421
Aux Black Carbon Factor*	MT-BC/MT-Fuel*	1.60E-04	1.60E-04	2.00E-03	2.00E-03	1.45E-04	1.45E-04	1.45E-04	1.45E-04	1.45E-04	1.45E-04
	*g/kw-Hr for LNG										

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Suez		Suez		Suez		Suez		Suez	
Boiler Emission Factors											
Boiler SO _x Emission Factor	MT-SO _x /MT-Fuel	0.020	0.020	3.17E-05	3.17E-05	0.000	0.000	2.64E-03	2.64E-03	0.000	0.000
Boiler NO _x Emission Factor	g/kW-hr	2.100	2.100	1.300	1.300	0.000	0.000	0.000	0.000	0.000	0.000
Boiler PM ₁₀ Emission Factor	g/kW-hr	1.420	1.420	0.030	0.030	0.000	0.000	0.000	0.000	0.000	0.000
Boiler CH ₄ Emission Factor	g/kW-hr	0.002	0.002	0.040	0.040	0.000	0.000	0.000	0.000	0.000	0.000
Boiler CO Emission Factor	g/kW-hr	0.200	0.200	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000
Boiler N ₂ O Emission Factor	g/kW-hr	0.040	0.040	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000
Boiler NMVOC Emission Factor	g/kW-hr	0.421	0.421	0.105	0.105	0.000	0.000	0.000	0.000	0.000	0.000
Boiler Black Carbon Factor	g/kW-hr	8.00E-02	8.00E-02	3.00E-03	3.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO ₂											
ME Pilot Fuel CO ₂ Emissions	MT	0	0	365	352	1218	1174	1218	1174	1218	1174
ME Main Fuel CO ₂ Emissions	MT	11093	9929	8032	7172	0	0	9464	8371	0	0
ME LO CO ₂ Emissions	MT	48.8	43.3	48.8	43.3	48.8	43.3	48.8	43.3	48.8	43.3
Aux Pilot Fuel CO ₂ Emissions	MT	0	0	38	48	740	919	740	919	740	919
Aux Main Fuel CO ₂ Emissions	MT	2258	2804	1682	2088	0	0	1383	1717	0	0
Boiler CO ₂ Emissions	MT	241	322	179	238	0	0	215	287	0	0
Total CO ₂ Emissions	MT	13642	13098	10345	9942	2007	2136	13068	12512	2007	2136
% CO ₂ Emissions Reduction	%			24%	24%	85%	84%	4%	4%	85%	84%
SO _x											
ME Pilot Fuel SO _x Emissions	MT	0.0	0.0	0.2	0.2	0.6	0.6	0.6	0.6	0.6	0.6
ME Main Fuel SO _x Emissions	MT	69.6	62.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel SO _x Emissions	MT	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.4	0.4	0.4
Aux Main Fuel SO _x Emissions	MT	14.2	17.6	0.0	0.0	0.0	0.0	2.7	3.3	0.0	0.0
Boiler SO _x Emissions	MT	1.5	2.0	0.0	0.0	0.0	0.0	0.4	0.6	0.0	0.0
Total SO _x Emissions	MT	85.3	82.0	0.3	0.3	1.0	1.0	4.0	4.9	1.0	1.0
%SO _x Emissions Reduction	%			100%	100%	99%	99%	95%	94%	99%	99%
NO _x											
ME NO _x Emissions	MT	73.9	65.6	73.9	65.6	73.9	65.6	73.9	65.6	73.9	65.6
Aux NO _x Emissions	MT	8.9	11.0	4.8	5.9	8.9	11.0	8.9	11.0	8.9	11.0
Boiler NO _x Emissions	MT	0.5	0.6	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Total NO _x Emissions	MT	83.2	77.2	78.9	71.9	82.7	76.6	82.7	76.6	82.7	76.6
%NO _x Emissions Reduction	%			5%	7%	1%	1%	1%	1%	1%	1%
Particulate Matter											
ME Pilot Fuel PM ₁₀ Emissions	MT	0.0	0.0	0.2	0.2	1.1	1.1	1.1	1.1	1.1	1.1
ME Main Fuel PM ₁₀ Emissions	MT	575.9	515.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel PM ₁₀ Emissions	MT	0.0	0.0	0.0	0.0	0.3	0.4	0.3	0.3	0.3	0.4
Aux Main Fuel PM ₁₀ Emissions	MT	5.1	6.3	0.1	0.1	0.0	0.0	0.3	0.3	0.0	0.0
Boiler PM ₁₀ Emissions	MT	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total PM ₁₀ Emissions	MT	581.3	522.0	0.3	0.3	1.5	1.5	1.7	1.8	1.5	1.5
%PM ₁₀ Emissions Reduction	%			100%	100%	100%	100%	100%	100%	100%	100%

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Suez		Suez		Suez		Suez		Suez	
Methane											
ME Pilot Fuel CH ₄ Emissions	MT	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel CH ₄ Emissions	MT	0.2	0.2	5.5	4.9	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel CH ₄ Emissions	MT	0.0	0.0	0.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Boiler CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CH ₄ Emissions	MT	0.3	0.2	6.4	6.0	0.0	0.0	0.0	0.0	0.0	0.0
%CH ₄ Emissions Reduction	%			-2412%	-2430%	83%	80%	83%	80%	83%	80%
Carbon Monoxide											
ME Pilot Fuel CO Emissions	MT	0.0	0.0	0.8	0.8	0.1	0.1	0.1	0.1	0.1	0.1
ME Main Fuel CO Emissions	MT	11.7	10.4	21.8	19.3	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel CO Emissions	MT	0.0	0.0	0.1	0.1	1.0	1.2	1.0	1.2	1.0	1.2
Aux Main Fuel CO Emissions	MT	2.0	2.5	4.7	5.8	0.0	0.0	0.0	0.0	0.0	0.0
Boiler CO Emissions	MT	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total CO Emissions	MT	13.8	12.9	27.4	26.0	1.1	1.3	1.1	1.3	1.1	1.3
%CO Emissions Reduction	%			-99%	-101%	92%	90%	92%	90%	92%	90%
N₂O											
ME Pilot Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
ME Main Fuel N ₂ O Emissions	MT	0.7	0.6	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Aux Main Fuel N ₂ O Emissions	MT	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Boiler N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total N ₂ O Emissions	MT	0.8	0.8	0.8	0.7	0.1	0.2	0.1	0.2	0.1	0.2
%N ₂ O Emissions Reduction	%			8%	9%	83%	80%	83%	80%	83%	80%
Volatile Organic Compounds											
ME Pilot Fuel NMVOC Emissions	MT	0.0	0.0	0.3	0.3	1.6	1.6	1.6	1.6	1.6	1.6
ME Main Fuel NMVOC Emissions	MT	13.7	12.2	8.4	7.4	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel NMVOC Emissions	MT	0.0	0.0	0.0	0.0	0.8	0.9	0.8	0.9	0.8	0.9
Aux Main Fuel NMVOC Emissions	MT	1.5	1.9	1.4	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Boiler NMVOC Emissions	MT	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total NMVOC Emissions	MT	15.4	14.2	10.2	9.6	2.4	2.5	2.4	2.5	2.4	2.5
%NMVOC Emissions Reduction	%			34%	33%	85%	82%	84%	82%	85%	82%

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Suez		Suez		Suez		Suez		Suez	
System Input Summary											
Pilot Oil (MDO)	MT	0.0	0.0	125.9	124.7	610.7	652.9	610.7	652.9	610.7	652.9
Fuel (Varies)	MT	4,365.0	4,192.2	3,597.3	3,454.1	8,658.3	8,121.8	8,044.9	7,545.8	1,342.0	1,258.9
Urea	MT	777.5	738.0	777.5	738.0	777.5	738.0	47.7	59.2	777.5	738.0
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	8.0	7.8	0.0	0.0
Cylinder Oil	MT	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Lube Oil	MT	2.3	2.0	2.3	2.0	2.3	2.0	2.3	2.0	2.3	2.0
External Energy	kW-Hr	1.29E+06	0.00E+00	1.50E+06	0.00E+00	1.30E+06	0.00E+00	1.29E+06	0.00E+00	1.41E+06	0.00E+00
System Output Summary											
CO ₂ Emissions	MT	13,641.5	13,097.9	10,345.0	9,941.6	2,006.6	2,136.4	13,068.3	12,511.9	2,006.6	2,136.4
SO _x Emissions	MT	85.3	82.0	0.3	0.3	1.0	1.0	4.0	4.9	1.0	1.0
NO _x Emissions	MT	83.2	77.2	78.9	71.9	82.7	76.6	82.7	76.6	82.7	76.6
PM ₁₀ Emissions	MT	581.3	522.0	0.3	0.3	1.5	1.5	1.7	1.8	1.5	1.5
PM _{2.5} Emissions	MT	534.8	480.2	0.3	0.3	1.3	1.4	1.5	1.6	1.3	1.4
CH ₄ Emissions	MT	0.3	0.2	6.4	6.0	0.0	0.0	0.0	0.0	0.0	0.0
CO Emissions	MT	13.8	12.9	27.4	26.0	1.1	1.3	1.1	1.3	1.1	1.3
N ₂ O Emissions	MT	0.8	0.8	0.8	0.7	0.1	0.2	0.1	0.2	0.1	0.2
NM VOC Emissions	MT	15.4	14.2	10.2	9.6	2.4	2.5	2.4	2.5	2.4	2.5
BC Emissions	MT	0.9	0.9	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.1

Details of Operational Inventory – Tank-to-Wake Inventory – Cape of Africa Route

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Cape		Cape		Cape		Cape		Cape	
Main Engine Consumption Rates		To EU	To Asia	To EU	To Asia	To EU	To Asia	To EU	To Asia	To EU	To Asia
Main Engine % MCR		57%	52%	57%	52%	57%	52%	57%	52%	57%	52%
Main Engine Power	kW	37,228	33,736	37,228	33,736	37,228	33,736	37,228	33,736	37,228	33,736
Main Engine SPOC	g/kW-Hr	0.0	0.0	4.3	4.6	14.2	15.2	14.2	15.2	14.2	15.2
Main Engine SFC	g/kW-Hr	160.6	161.5	132.3	133.0	342.5	342.3	318.4	318.0	53.1	53.1
Urea Consumption	l/hr	978.4	925.0	978.4	925.0	978.4	925.0	0.0	0.0	978.4	925.0
NaOH Consumption	l/hr	0.0	0.0	0.0	0.0	0.0	0.0	8.6	7.8	0.0	0.0
Cylinder Oil Consumption	g/kW-Hr	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Lube Oil Consumption	g/kW-Hr	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methane Slip	g/kW-Hr	0.00	0.00	0.24	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Main Engine Power Demand											
Hours Op.	hrs	880	883	880	883	880	883	880	883	880	883
Main Engine Demand	kW-Hr	3.28E+07	2.98E+07	3.28E+07	2.98E+07	3.28E+07	2.98E+07	3.28E+07	2.98E+07	3.28E+07	2.98E+07
Main Engine Consumption											
Pilot Fuel Used	MT	0.0	0.0	139.9	135.7	466.1	452.5	466.1	452.5	466.1	452.5
Fuel Used	MT	5,261.2	4,811.5	4,336.0	3,960.4	11,223.5	10,197.7	10,432.8	9,473.8	1,739.6	1,580.6
Urea Used	MT	955.9	906.7	955.9	906.7	955.9	906.7	0.0	0.0	955.9	906.7
NaOH Used	MT	0.0	0.0	0.0	0.0	0.0	0.0	11.5	10.5	0.0	0.0
Cylinder Oil Used	MT	19.7	17.9	19.7	17.9	19.7	17.9	19.7	17.9	19.7	17.9
Lube Oil Used	MT	3.3	3.0	3.3	3.0	3.3	3.0	3.3	3.0	3.3	3.0
Methane Slip	MT	0.00	0.00	8.01	7.41	0.00	0.00	0.00	0.00	0.00	0.00
Pilot Fuel Energy	MJ	0E+00	0E+00	6E+06	6E+06	2E+07	2E+07	2E+07	2E+07	2E+07	2E+07
Main Fuel Energy	MJ	2E+08	2E+08	2E+08	2E+08	2E+08	2E+08	2E+08	2E+08	2E+08	2E+08
Pilot/Main Energy Fraction	%	0%	0%	3%	3%	10%	10%	10%	10%	10%	10%
Pilot Fuel Portion of kW-hr	kW-hr	0.00E+00	0.00E+00	9.40E+05	9.08E+05	3.12E+06	3.03E+06	3.14E+06	3.05E+06	3.12E+06	3.03E+06
Aux. Engine Cons. Rates											
Aux Engine Power,	kW	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
Aux Engine Power, Port/Idle	kW	7175	4425	7175	4425	7175	4425	7175	4425	7175	4425
Aux Engine Assumed % MCR	%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
Aux Engine SPOC	g/kW-Hr	0.0	0.0	3.3	3.3	62.9	62.9	62.9	62.9	62.9	62.9
Aux Engine SFC	g/kW-Hr	197.7	197.7	166.8	166.8	293.4	293.4	274.2	274.2	45.5	45.5
Lube Oil SFC	g/kW-Hr	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Urea Consumption	g/kW-Hr	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Methane Slip	g/kW-Hr	0.0	0.0	5.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Cape		Cape		Cape		Cape		Cape	
Aux. Engine Power Demand											
Aux Engine, Seagoing	kW-Hr	2.90E+06	2.91E+06	2.90E+06	2.91E+06	2.90E+06	2.91E+06	2.90E+06	2.91E+06	2.90E+06	2.91E+06
Aux Engine, Idle	kW-Hr	5.53E+05	5.12E+05	5.53E+05	5.12E+05	5.53E+05	5.12E+05	5.53E+05	5.12E+05	5.53E+05	5.12E+05
Aux Engine, Port	kW-Hr	0.00E+00	9.56E+05	0.00E+00	9.56E+05	0.00E+00	9.56E+05	0.00E+00	9.56E+05	0.00E+00	9.56E+05
Aux Engine, Total	kW-Hr	3.46E+06	4.38E+06	3.46E+06	4.38E+06	3.46E+06	4.38E+06	3.46E+06	4.38E+06	3.46E+06	4.38E+06
Auxiliary Engine Consumption											
Pilot Fuel Used	MT	0.0	0.0	11.3	14.3	217.6	275.8	217.6	275.8	217.6	275.8
Fuel Used	MT	683.7	866.3	576.7	730.7	1014.4	1285.4	948.2	1201.4	157.2	199.2
Urea Used	MT	45.0	57.0	45.0	57.0	45.0	57.0	45.0	57.0	45.0	57.0
Lube Oil Used	MT	2.3	3.0	2.3	3.0	2.3	3.0	2.3	3.0	2.3	3.0
Methane Slip	MT	0.0	0.0	19.0	24.1	0.0	0.0	0.0	0.0	0.0	0.0
Pilot Fuel Energy	MJ	0E+00	0E+00	5E+05	6E+05	9E+06	1E+07	9E+06	1E+07	9E+06	1E+07
Main Fuel Energy	MJ	3E+07	3E+07	3E+07	4E+07	2E+07	2E+07	2E+07	2E+07	2E+07	2E+07
Pilot/Main Energy Fraction	%	0%	0%	2%	2%	49%	49%	49%	49%	49%	49%
Pilot Fuel Portion of kW-hr	kW-hr	0.00E+00	0.00E+00	6.00E+04	7.60E+04	1.70E+06	2.16E+06	1.70E+06	2.16E+06	1.70E+06	2.16E+06
Boiler Consumption Rates											
Boiler Power, Port/Idle	kW	700	700	700	700	700	700	700	700	700	700
Boiler SFC	g/kW-Hr	340.0	340.0	285.0	285.0	735.0	735.0	687.0	687.0	113.9	113.9
Boiler Demand	kW-Hr	1.80E+05	2.32E+05	1.80E+05	2.32E+05	1.80E+05	2.32E+05	1.80E+05	2.32E+05	1.80E+05	2.32E+05
Boiler Fuel Burnt	MT	61.2	78.9	51.3	66.2	132.3	170.6	123.6	159.5	20.5	26.4
Shore-Power Requirements											
Aux Power Energy Demand	kW-Hr	1.29E+06	0.00E+00	1.29E+06	0.00E+00	1.29E+06	0.00E+00	1.29E+06	0.00E+00	1.29E+06	0.00E+00
Reliquification Energy	kW-Hr	0.00E+00	0.00E+00	1.67E+05	0.00E+00	7.71E+03	0.00E+00	0.00E+00	0.00E+00	9.57E+04	0.00E+00
Shore Power Req'd Energy	kW-Hr	1.29E+06	0.00E+00	1.46E+06	0.00E+00	1.30E+06	0.00E+00	1.29E+06	0.00E+00	1.39E+06	0.00E+00
CO₂ General Emission Factors											
Pilot Fuel CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	0.000	0.000	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206
Fuel CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	3.114	3.114	2.750	2.750	0.000	0.000	1.375	1.375	0.000	0.000
Lube Oil CO ₂ Emission Factor	MT-CO ₂ /MT Fuel	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206	3.206
Main Engine Emission Factors											
SO _x Emission Factor - Pilot Fuel	MT-SO _x /MT Fuel	0.000	0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
SO _x Emission Factor	MT-SO _x /MT Fuel	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NO _x Emission Factor	g/kW-hr	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400	3.400
PM ₁₀ Emissions Factor - Pilot	g-PM ₁₀ /kW-hr	0.000	0.000	0.282	0.286	0.404	0.415	0.404	0.415	0.404	0.415
PM ₁₀ Emissions Factor - Fuel	g-PM ₁₀ /kW-hr	25.982	26.131	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CH ₄ /Methane Slip - Fuel	g/kW-hr	0.010	0.010	0.245	0.249	0.010	0.010	0.010	0.010	0.010	0.010
CO	g/kW-hr	0.540	0.540	1.040	1.040	0.044	0.044	0.044	0.044	0.044	0.044
N ₂ O	g/kW-hr	0.031	0.031	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
NM VOC	g/kW-hr	0.632	0.632	0.400	0.400	0.632	0.632	0.632	0.632	0.632	0.632
Black Carbon	MT-BC/MT-Fuel*	1.83E-04	1.88E-04	2.00E-03	2.00E-03	4.00E-05	4.00E-05	4.00E-05	4.00E-05	4.00E-05	4.00E-05
	*g/kw-Hr for LNG										

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Cape		Cape		Cape		Cape		Cape	
Aux DG Emission Factors											
Aux SO _x Emission Factor - PO	MT-SO _x /MT-Fuel	0	0	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Aux SO _x Emission Factor - Fuel	MT-SO _x /MT-Fuel	0.020	0.020	3.17E-05	3.17E-05	0.000	0.000	0.003	0.003	0.000	0.000
Aux NO _x Emission Factor	g/kW-hr	2.414	2.414	1.300	1.300	2.414	2.414	2.414	2.414	2.414	2.414
Aux PM ₁₀ Emission Factor	g/kW-hr	1.390	1.390	0.020	0.020	0.180	0.180	0.140	0.140	0.180	0.180
Aux CH ₄ Emission Factor	g/kW-hr	0.010	0.010	0.200	0.200	0.010	0.010	0.010	0.010	0.010	0.010
Aux CO Emission Factor	g/kW-hr	0.540	0.540	1.300	1.300	0.540	0.540	0.540	0.540	0.540	0.540
Aux N ₂ O Emission Factor	g/kW-hr	0.040	0.040	0.030	0.030	0.036	0.036	0.036	0.036	0.036	0.036
Aux NMVOC Emission Factor	g/kW-hr	0.421	0.421	0.400	0.400	0.421	0.421	0.421	0.421	0.421	0.421
Aux Black Carbon Factor*	MT-BC/MT-Fuel*	1.60E-04	1.60E-04	2.00E-03	2.00E-03	1.45E-04	1.45E-04	1.45E-04	1.45E-04	1.45E-04	1.45E-04
	*g/kw-Hr for LNG										
Boiler Emission Factors											
Boiler SO _x Emission Factor	MT-SO _x /MT-Fuel	0.020	0.020	3.17E-05	3.17E-05	0.000	0.000	2.64E-03	2.64E-03	0.000	0.000
Boiler NO _x Emission Factor	g/kW-hr	2.100	2.100	1.300	1.300	0.000	0.000	0.000	0.000	0.000	0.000
Boiler PM ₁₀ Emission Factor	g/kW-hr	1.420	1.420	0.030	0.030	0.000	0.000	0.000	0.000	0.000	0.000
Boiler CH ₄ Emission Factor	g/kW-hr	0.002	0.002	0.040	0.040	0.000	0.000	0.000	0.000	0.000	0.000
Boiler CO Emission Factor	g/kW-hr	0.200	0.200	0.200	0.200	0.000	0.000	0.000	0.000	0.000	0.000
Boiler N ₂ O Emission Factor	g/kW-hr	0.040	0.040	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000
Boiler NMVOC Emission Factor	g/kW-hr	0.421	0.421	0.105	0.105	0.000	0.000	0.000	0.000	0.000	0.000
Boiler Black Carbon Factor	g/kW-hr	8.00E-02	8.00E-02	3.00E-03	3.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO₂											
ME Pilot Fuel CO ₂ Emissions	MT	0	0	448	435	1494	1451	1494	1451	1494	1451
ME Main Fuel CO ₂ Emissions	MT	16383	14983	11924	10891	0	0	14345	13027	0	0
ME LO CO ₂ Emissions	MT	73.5	66.9	73.5	66.9	73.5	66.9	73.5	66.9	73.5	66.9
Aux Pilot Fuel CO ₂ Emissions	MT	0	0	36	46	698	884	698	884	698	884
Aux Main Fuel CO ₂ Emissions	MT	2129	2698	1586	2009	0	0	1304	1652	0	0
Boiler CO ₂ Emissions	MT	191	246	141	182	0	0	170	219	0	0
Total CO ₂ Emissions	MT	18777	17993	14209	13630	2266	2402	18085	17299	2266	2402
% CO ₂ Emissions Reduction	%			24%	24%	88%	87%	4%	4%	88%	87%
SO_x											
ME Pilot Fuel SO _x Emissions	MT	0.0	0.0	0.2	0.2	0.7	0.7	0.7	0.7	0.7	0.7
ME Main Fuel SO _x Emissions	MT	102.9	94.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel SO _x Emissions	MT	0.0	0.0	0.0	0.0	0.3	0.4	0.3	0.4	0.3	0.4
Aux Main Fuel SO _x Emissions	MT	13.4	16.9	0.0	0.0	0.0	0.0	2.5	3.2	0.0	0.0
Boiler SO _x Emissions	MT	1.2	1.5	0.0	0.0	0.0	0.0	0.3	0.4	0.0	0.0
Total SO _x Emissions	MT	117.4	112.5	0.4	0.4	1.1	1.1	3.9	4.7	1.1	1.1
%SO _x Emissions Reduction	%			100%	100%	99%	99%	97%	96%	99%	99%

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Cape		Cape		Cape		Cape		Cape	
NO_x											
ME NO _x Emissions	MT	111.4	101.3	111.4	101.3	111.4	101.3	111.4	101.3	111.4	101.3
Aux NO _x Emissions	MT	8.3	10.6	4.5	5.7	8.3	10.6	8.3	10.6	8.3	10.6
Boiler NO _x Emissions	MT	0.4	0.5	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Total NO _x Emissions	MT	120.1	112.3	116.1	107.3	119.8	111.9	119.8	111.9	119.8	111.9
%NO _x Emissions Reduction	%			3%	5%	0%	0%	0%	0%	0%	0%
Particulate Matter											
ME Pilot Fuel PM ₁₀ Emissions	MT	0.0	0.0	0.3	0.3	1.3	1.3	1.3	1.3	1.3	1.3
ME Main Fuel PM ₁₀ Emissions	MT	851.4	778.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel PM ₁₀ Emissions	MT	0.0	0.0	0.0	0.0	0.3	0.4	0.2	0.3	0.3	0.4
Aux Main Fuel PM ₁₀ Emissions	MT	4.8	6.1	0.1	0.1	0.0	0.0	0.2	0.3	0.0	0.0
Boiler PM ₁₀ Emissions	MT	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total PM ₁₀ Emissions	MT	856.5	784.8	0.3	0.4	1.6	1.6	1.8	1.9	1.6	1.6
%PM ₁₀ Emissions Reduction	%			100%	100%	100%	100%	100%	100%	100%	100%
Methane											
ME Pilot Fuel CH ₄ Emissions	MT	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
ME Main Fuel CH ₄ Emissions	MT	0.3	0.3	7.8	7.2	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Main Fuel CH ₄ Emissions	MT	0.0	0.0	0.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Boiler CH ₄ Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CH ₄ Emissions	MT	0.4	0.3	8.7	8.3	0.0	0.1	0.0	0.1	0.0	0.1
%CH ₄ Emissions Reduction	%			-2302%	-2325%	87%	85%	87%	85%	87%	85%
Carbon Monoxide											
ME Pilot Fuel CO Emissions	MT	0.0	0.0	1.0	0.9	0.1	0.1	0.1	0.1	0.1	0.1
ME Main Fuel CO Emissions	MT	17.7	16.1	33.1	30.0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel CO Emissions	MT	0.0	0.0	0.1	0.1	0.9	1.2	0.9	1.2	0.9	1.2
Aux Main Fuel CO Emissions	MT	1.9	2.4	4.4	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Boiler CO Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CO Emissions	MT	19.6	18.5	38.6	36.7	1.1	1.3	1.1	1.3	1.1	1.3
%CO Emissions Reduction	%			-97%	-99%	95%	93%	95%	93%	95%	93%
N₂O											
ME Pilot Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
ME Main Fuel N ₂ O Emissions	MT	1.0	0.9	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Aux Main Fuel N ₂ O Emissions	MT	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Boiler N ₂ O Emissions	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total N ₂ O Emissions	MT	1.2	1.1	1.1	1.0	0.2	0.2	0.2	0.2	0.2	0.2
%N ₂ O Emissions Reduction	%			6%	7%	87%	85%	87%	85%	87%	85%

		HFO Fueled Ship		LNG Fueled Ship		Ammonia Fueled Ship		Methanol Fueled Ship		Hydrogen Fueled Ship	
		Cape		Cape		Cape		Cape		Cape	
Volatile Organic Compounds											
ME Pilot Fuel NMVOC Emissions	MT	0.0	0.0	0.4	0.4	2.0	1.9	2.0	1.9	2.0	1.9
ME Main Fuel NMVOC Emissions	MT	20.7	18.8	12.7	11.6	0.0	0.0	0.0	0.0	0.0	0.0
Aux Pilot Fuel NMVOC Emissions	MT	0.0	0.0	0.0	0.0	0.7	0.9	0.7	0.9	0.7	0.9
Aux Main Fuel NMVOC Emissions	MT	1.5	1.8	1.4	1.7	0.0	0.0	0.0	0.0	0.0	0.0
Boiler NMVOC Emissions	MT	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total NMVOC Emissions	MT	22.2	20.8	14.5	13.7	2.7	2.8	2.7	2.8	2.7	2.8
%NMVOC Emissions Reduction	%			35%	34%	88%	86%	88%	86%	88%	86%
Black Carbon											
ME Pilot Fuel BC Emissions	MT	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02
ME Main Fuel BC Emissions	MT	0.96	0.91	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Aux Pilot Fuel BC Emissions	MT	0.00	0.00	0.00	0.00	0.03	0.04	0.03	0.04	0.03	0.04
Aux Main Fuel BC Emissions	MT	0.11	0.14	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Boiler BC Emissions	MT	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total BC Emissions	MT	1.09	1.06	0.07	0.07	0.05	0.06	0.05	0.06	0.05	0.06
%BC Emissions Reduction	%			93%	94%	95%	95%	95%	95%	95%	95%
System Input Summary											
Pilot Oil (MDO)	MT	0.0	0.0	151.1	150.0	683.8	728.2	683.8	728.2	683.8	728.2
Fuel (Varies)	MT	6,006.1	5,756.7	4,964.0	4,757.3	12,370.2	11,653.7	11,504.6	10,834.7	1,917.4	1,806.3
Urea	MT	1,000.9	963.6	1,000.9	963.6	1,000.9	963.6	45.0	57.0	1,000.9	963.6
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	11.5	10.5	0.0	0.0
Cylinder Oil	MT	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Lube Oil	MT	3.4	3.1	3.4	3.1	3.4	3.1	3.4	3.1	3.4	3.1
External Energy	kW-Hr	1.29E+06	0.00E+00	1.46E+06	0.00E+00	1.30E+06	0.00E+00	1.29E+06	0.00E+00	1.39E+06	0.0
System Output Summary											
CO ₂ Emissions	MT	18,776.6	17,993.3	14,209.0	13,630.2	2,265.7	2,401.6	18,084.6	17,299.3	2,265.7	2,401.6
SO _x Emissions	MT	117.4	112.5	0.4	0.4	1.1	1.1	3.9	4.7	1.1	1.1
NO _x Emissions	MT	120.1	112.3	116.1	107.3	119.8	111.9	119.8	111.9	119.8	111.9
PM ₁₀ Emissions	MT	856.5	784.8	0.3	0.4	1.6	1.6	1.8	1.9	1.6	1.6
PM _{2.5} Emissions	MT	788.0	722.0	0.3	0.3	1.4	1.5	1.6	1.7	1.4	1.5
CH ₄ Emissions	MT	0.4	0.3	8.7	8.3	0.0	0.1	0.0	0.1	0.0	0.1
CO Emissions	MT	19.6	18.5	38.6	36.7	1.1	1.3	1.1	1.3	1.1	1.3
N ₂ O Emissions	MT	1.2	1.1	1.1	1.0	0.2	0.2	0.2	0.2	0.2	0.2
NMVOC Emissions	MT	22.2	20.8	14.5	13.7	2.7	2.8	2.7	2.8	2.7	2.8
BC Emissions	MT	1.1	1.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Details of Operational Inventory – Well-to-Tank and Total Operational Emissions – Suez Route

		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ BD	Methanol	Bio- Methanol	Bio- Methanol w/ BD	Hydrogen	E- Hydrogen	E- Hydrogen w/ BD
Required Consumables		Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez	Suez
Pilot Oil	MT	0.0	250.5	250.5	250.5	1,263.5	1,263.5	1,263.5	1,263.5	1,263.5	1,263.5	1,263.5	1,263.5	1,263.5
Fuel	MT	8,557.3	7,051.4	7,051.4	7,051.4	16,780.1	16,780.1	16,780.1	15,590.8	15,590.8	15,590.8	2,600.9	2,600.9	2,600.9
Urea	MT	1,515.5	1,515.5	1,515.5	1,515.5	1,515.5	1,515.5	1,515.5	106.9	106.9	106.9	1,515.5	1,515.5	1,515.5
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.8	15.8	15.8	0.0	0.0	0.0
Cylinder Oil	MT	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Lube Oil	MT	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
External Energy	kW-Hr	1.29E+06	1.50E+06	1.50E+06	1.50E+06	1.30E+06	1.30E+06	1.30E+06	1.29E+06	1.29E+06	1.29E+06	1.41E+06	1.41E+06	1.41E+06
Well-to-Tank Emissions														
CO ₂ Emissions	MT	5,104.2	3,458.6	9,788.0	9,804.4	27,519.0	10,459.0	10,541.7	7,366.2	6,435.4	6,518.2	25,539.8	3,667.2	3,750.0
SO _x Emissions	MT	0.0	0.3	24.7	25.0	0.1	0.0	1.6	0.7	14.9	16.5	11.9	15.9	17.5
NO _x Emissions	MT	0.0	3.2	17.9	19.5	13.7	13.7	21.8	14.3	17.4	25.5	10.6	9.4	17.5
CH ₄ Emissions	MT	38.4	12.3	7.3	6.3	7.5	5.8	1.1	9.3	18.9	14.1	52.7	6.6	1.9
CO Emissions	MT	0.0	0.9	3.2	3.2	1.2	0.0	0.0	2.0	7.8	7.8	3.1	2.3	2.3
N ₂ O Emissions	MT	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2
Tank-to-Wake Emissions														
CO ₂ Emissions	MT	26,739.4	20,286.5	20,286.5	20,286.5	4,142.9	4,142.9	4,142.9	25,580.3	25,580.3	25,580.3	4,142.9	4,142.9	4,142.9
CO ₂ Emissions Offset	MT	0.0	0.0	-19,391.3	-20,100.1	0.0	0.0	-3,574.9	0.0	-21,515.3	-25,090.2	0.0	0.0	-3,574.9
SO _x Emissions	MT	167.3	0.6	0.6	0.6	2.0	2.0	2.0	8.9	8.9	8.9	2.0	2.0	2.0
NO _x Emissions	MT	160.4	150.8	150.8	150.8	159.3	159.3	159.3	159.3	159.3	159.3	159.3	159.3	159.3
PM ₁₀ Emissions	MT	1,103.3	0.6	0.6	0.6	3.0	3.0	3.0	3.4	3.4	3.4	3.0	3.0	3.0
PM _{2.5} Emissions	MT	1,015.0	0.6	0.6	0.6	2.8	2.8	2.8	3.2	3.2	3.2	2.8	2.8	2.8
CH ₄ Emissions	MT	0.5	12.4	12.4	12.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CO Emissions	MT	26.7	53.4	53.4	53.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
N ₂ O Emissions	MT	1.6	1.5	1.5	1.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
NMVOE Emissions	MT	29.6	19.7	19.7	19.7	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
BC Emissions	MT	1.7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Operational Emissions														
CO ₂ Emissions	MT	31,843.7	23,745.2	10,683.2	9,990.8	31,661.9	14,601.9	11,109.8	32,946.4	10,500.4	7,008.3	29,682.8	7,810.2	4,318.0
SO _x Emissions	MT	167.3	0.9	25.3	25.6	2.1	2.0	3.6	9.5	23.8	25.4	13.8	17.9	19.5
NO _x Emissions	MT	160.4	154.0	168.8	170.4	173.0	173.0	181.1	173.6	176.7	184.8	169.9	168.7	176.7
PM ₁₀ Emissions	MT	1,103.3	0.6	0.6	0.6	3.0	3.0	3.0	3.4	3.4	3.4	3.0	3.0	3.0
PM _{2.5} Emissions	MT	1,015.0	0.6	0.6	0.6	2.8	2.8	2.8	3.2	3.2	3.2	2.8	2.8	2.8
CH ₄ Emissions	MT	38.9	24.8	19.7	18.8	7.6	5.9	1.2	9.3	19.0	14.2	52.7	6.7	2.0
CO Emissions	MT	26.7	54.4	56.7	56.7	3.6	2.4	2.4	4.4	10.2	10.2	5.5	4.7	4.7
N ₂ O Emissions	MT	1.7	1.5	1.6	1.6	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.5
NMVOE Emissions	MT	29.6	19.7	19.7	19.7	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
BC Emissions	MT	1.7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Global Warming WtT														
Eq. GWP MEPC (100yr)	kg-CO _{2e}	6.2E+06	3.8E+06	1.0E+07	1.0E+07	2.8E+07	1.1E+07	1.1E+07	7.7E+06	7.0E+06	6.9E+06	2.7E+07	3.9E+06	3.9E+06
Reduction	%		-38%	62%	61%	348%	72%	71%	23%	13%	12%	336%	-37%	-38%
Global Warming TtW														
Eq. GWP MEPC (100yr)	kg-CO _{2e}	2.7E+07	2.1E+07	2.1E+07	2.1E+07	4.2E+06	4.2E+06	4.2E+06	2.6E+07	2.6E+07	2.6E+07	4.2E+06	4.2E+06	4.2E+06
CO ₂ Emissions Offset	kg-CO _{2e}	0.0E+00	0.0E+00	-1.9E+07	-2.0E+07	0.0E+00	0.0E+00	-3.6E+06	0.0E+00	-2.2E+07	-2.5E+07	0.0E+00	0.0E+00	-3.6E+06
Total TtW GWP	kg-CO _{2e}	2.7E+07	2.1E+07	1.6E+06	9.3E+05	4.2E+06	4.2E+06	6.5E+05	2.6E+07	4.1E+06	5.7E+05	4.2E+06	4.2E+06	6.5E+05
Reduction	%		-23%	-94%	-97%	-84%	-84%	-98%	-6%	-85%	-98%	-84%	-84%	-98%
Total Global Warming Potential														
Eq. GWP MEPC (100yr)	kg-CO _{2e}	3.34E+07	2.48E+07	1.17E+07	1.09E+07	3.20E+07	1.49E+07	1.13E+07	3.33E+07	1.11E+07	7.52E+06	3.13E+07	8.11E+06	4.50E+06
Reduction	%		-26%	-65%	-67%	-4%	-55%	-66%	0%	-67%	-77%	-6%	-76%	-87%
Transport Efficiencies - WtW														
Travel Distance	NMI	24,873	24,873	24,873	24,873	24,873	24,873	24,873	24,873	24,873	24,873	24,873	24,873	24,873
	km	46,065	46,065	46,065	46,065	46,065	46,065	46,065	46,065	46,065	46,065	46,065	46,065	46,065
	TEU	45,024	44,136	44,136	44,136	44,136	44,136	44,136	45,024	45,024	45,024	41,832	41,832	41,832
	MT-Loaded	253,490	246,853	246,853	246,853	242,957	242,957	242,957	249,588	249,588	249,588	236,906	236,906	236,906
CO _{2eq} Wrk-Trans. Eff. (TEU)	kg-CO _{2e} /TEU km	1.61E-02	1.20E-02	5.62E-03	5.28E-03	1.54E-02	7.18E-03	5.44E-03	1.61E-02	5.37E-03	3.62E-03	1.51E-02	3.91E-03	2.17E-03
CO _{2eq} Wrk-Trans. Eff. (MT)	kg-CO _{2e} /MT- km	2.86E-03	2.13E-03	9.98E-04	9.37E-04	2.74E-03	1.27E-03	9.65E-04	2.85E-03	9.53E-04	6.44E-04	2.68E-03	6.95E-04	3.85E-04

Details of Operational Inventory – Well-to-Tank and Total Operational Emissions – Cape Route

		HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ BD	Methanol	Bio- Methanol	Bio- Methanol w/ BD	Hydrogen	E- Hydrogen	E- Hydrogen w/ BD
Required Consumables		Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape	Cape
Pilot Oil	MT	0.0	301.1	301.1	301.1	1,412.0	1,412.0	1,412.0	1,412.0	1,412.0	1,412.0	1,412.0	1,412.0	1,412.0
Fuel	MT	11,762.8	9,721.2	9,721.2	9,721.2	24,023.9	24,023.9	24,023.9	22,339.4	22,339.4	22,339.4	3,723.7	3,723.7	3,723.7
Urea	MT	1,964.5	1,964.5	1,964.5	1,964.5	1,964.5	1,964.5	1,964.5	101.9	101.9	101.9	1,964.5	1,964.5	1,964.5
NaOH	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.0	22.0	22.0	0.0	0.0	0.0
Cylinder Oil	MT	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Lube Oil	MT	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
External Energy	kW-Hr	1.29E+06	1.46E+06	1.46E+06	1.46E+06	1.30E+06	1.30E+06	1.30E+06	1.29E+06	1.29E+06	1.29E+06	1.39E+06	1.39E+06	1.39E+06
Well-to-Tank Emissions														
CO ₂ Emissions	MT	6,854.7	4,537.7	13,263.5	13,283.2	38,981.8	14,557.3	14,649.8	10,138.7	8,805.1	8,897.6	36,124.5	4,809.7	4,902.2
SO _x Emissions	MT	0.0	0.4	34.1	34.4	0.2	0.0	1.8	0.9	21.3	23.1	17.0	22.8	24.6
NO _x Emissions	MT	0.0	4.4	24.7	26.7	19.7	19.7	28.7	20.4	24.9	33.9	15.2	13.4	22.4
CH ₄ Emissions	MT	52.7	16.8	9.8	8.7	8.9	6.5	1.2	11.4	25.2	19.9	73.6	7.6	2.4
CO Emissions	MT	0.0	1.3	4.5	4.5	1.7	0.0	0.0	2.8	11.1	11.1	4.5	3.4	3.4
N ₂ O Emissions	MT	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.1	0.1	0.2	0.1	0.2	0.2
Tank-to-Wake Emissions														
CO ₂ Emissions	MT	36,769.9	27,839.2	27,839.2	27,839.2	4,667.3	4,667.3	4,667.3	35,384.0	35,384.0	35,384.0	4,667.3	4,667.3	4,667.3
CO ₂ Emissions Offset	MT	0.0	0.0	-26,733.4	-27,585.3	0.0	0.0	-3,995.0	0.0	-30,828.3	-34,823.3	0.0	0.0	-3,995.0
SO _x Emissions	MT	230.0	0.8	0.8	0.8	2.2	2.2	2.2	8.6	8.6	8.6	2.2	2.2	2.2
NO _x Emissions	MT	232.5	223.4	223.4	223.4	231.6	231.6	231.6	231.6	231.6	231.6	231.6	231.6	231.6
PM ₁₀ Emissions	MT	1,641.3	0.7	0.7	0.7	3.2	3.2	3.2	3.6	3.6	3.6	3.2	3.2	3.2
PM _{2.5} Emissions	MT	1,510.0	0.6	0.6	0.6	3.0	3.0	3.0	3.3	3.3	3.3	3.0	3.0	3.0
CH ₄ Emissions	MT	0.7	17.0	17.0	17.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CO Emissions	MT	38.1	75.3	75.3	75.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
N ₂ O Emissions	MT	2.3	2.1	2.1	2.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
NMVOE Emissions	MT	43.0	28.2	28.2	28.2	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
BC Emissions	MT	2.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Operational Emissions														
CO ₂ Emissions	MT	43,624.6	32,376.9	14,369.2	13,537.1	43,649.2	19,224.6	15,322.1	45,522.7	13,360.7	9,458.2	40,791.8	9,477.0	5,574.5
SO _x Emissions	MT	230.0	1.2	34.8	35.2	2.4	2.2	4.0	9.6	30.0	31.8	19.2	25.0	26.8
NO _x Emissions	MT	232.5	227.9	248.2	250.1	251.3	251.3	260.3	252.1	256.5	265.6	246.8	245.0	254.1
PM ₁₀ Emissions	MT	1,641.3	0.7	0.7	0.7	3.2	3.2	3.2	3.6	3.6	3.6	3.2	3.2	3.2
PM _{2.5} Emissions	MT	1,510.0	0.6	0.6	0.6	3.0	3.0	3.0	3.3	3.3	3.3	3.0	3.0	3.0
CH ₄ Emissions	MT	53.4	33.8	26.8	25.7	9.0	6.6	1.3	11.5	25.3	20.0	73.7	7.7	2.5
CO Emissions	MT	38.1	76.6	79.8	79.8	4.0	2.4	2.4	5.2	13.5	13.5	6.8	5.7	5.7
N ₂ O Emissions	MT	2.4	2.2	2.3	2.3	0.5	0.5	0.6	0.5	0.4	0.5	0.4	0.5	0.6
NMVOE Emissions	MT	43.0	28.2	28.2	28.2	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
BC Emissions	MT	2.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Global Warming WtT														
Eq. GWP MEPC (100yr)	kg-CO _{2e}	8.4E+06	5.0E+06	1.4E+07	1.4E+07	3.9E+07	1.5E+07	1.5E+07	1.0E+07	9.5E+06	9.5E+06	3.8E+07	5.1E+06	5.0E+06
Reduction	%		-40%	62%	62%	370%	77%	76%	69%	54%	53%	516%	-18%	-19%
Global Warming TtW														
Eq. GWP MEPC (100yr)	kg-CO _{2e}	3.7E+07	2.9E+07	2.9E+07	2.9E+07	4.8E+06	4.8E+06	4.8E+06	3.5E+07	3.5E+07	3.5E+07	4.8E+06	4.8E+06	4.8E+06
CO ₂ Emissions Offset	kg-CO _{2e}	0.0E+00	0.0E+00	-2.7E+07	-2.8E+07	0.0E+00	0.0E+00	-4.0E+06	0.0E+00	-3.1E+07	-3.5E+07	0.0E+00	0.0E+00	-4.0E+06
Total TtW GWP	kg-CO _{2e}	3.7E+07	2.9E+07	2.1E+06	1.3E+06	4.8E+06	4.8E+06	7.6E+05	3.5E+07	4.6E+06	6.5E+05	4.8E+06	4.8E+06	7.6E+05
Reduction	%		-23%	-94%	-97%	-87%	-87%	-98%	-5%	-88%	-98%	-87%	-87%	-98%
Total Global Warming Potential														
Eq. GWP MEPC (100yr)	kg-CO _{2e}	4.58E+07	3.39E+07	1.57E+07	1.49E+07	4.40E+07	1.96E+07	1.55E+07	4.60E+07	1.42E+07	1.01E+07	4.30E+07	9.83E+06	5.79E+06
Reduction	%		-26%	-66%	-68%	-4%	-57%	-66%	0%	-69%	-78%	-6%	-79%	-87%
Transport Efficiencies - WtW														
Travel Distance	NMI	32,357	32,357	32,357	32,357	32,357	32,357	32,357	32,357	32,357	32,357	32,357	32,357	32,357
	km	59,924	59,924	59,924	59,924	59,924	59,924	59,924	59,924	59,924	59,924	59,924	59,924	59,924
TEU	TEU	45,024	44,136	44,136	44,136	44,136	44,136	44,136	45,024	45,024	45,024	41,832	41,832	41,832
	MT-Loaded	253,490	246,853	246,853	246,853	242,957	242,957	242,957	249,588	249,588	249,588	236,906	236,906	236,906
CO _{2eq} Wrk-Trans. Eff. (TEU)	kg-CO _{2e} /TEU km	2.21E-02	1.63E-02	7.58E-03	7.17E-03	2.12E-02	9.43E-03	7.48E-03	2.22E-02	6.84E-03	4.89E-03	2.07E-02	4.74E-03	2.79E-03
CO _{2eq} Wrk-Trans. Eff. (MT)	kg-CO _{2e} /MT- km	3.92E-03	2.90E-03	1.35E-03	1.27E-03	3.77E-03	1.67E-03	1.33E-03	3.94E-03	1.21E-03	8.69E-04	3.68E-03	8.42E-04	4.96E-04

16.5. Lifecycle Inventory/Analysis of CO₂Eq Emissions and Work-Transport

16.5.1. Total Lifecycle Emissions Inventory

			Suez Canal Route															
			HFO / Baseline Ship	LNG Ship			Ammonia Ship			Methanol Ship			LH ₂ Ship			Compressed Hydrogen Ship		
			HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ Bio Diesel	Methanol	Bio- Methanol	Bio- Methanol w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel
Total Shipbuilding Emissions	CO ₂ Emissions	MT	277,887	279,367	279,367	279,367	279,850	279,850	279,850	279,052	279,052	279,052	294,489	294,489	294,489	315,781	315,781	315,781
	SO _x Emissions	MT	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.3	0.3	0.3	0.3	0.3
	NO _x Emissions	MT	3.2	3.1	3.1	3.1	3.4	3.4	3.4	3.4	3.4	3.4	3.3	3.3	3.3	3.3	3.3	3.3
	PM ₁₀ Emissions	MT	138.0	114.4	114.4	114.4	114.5	114.5	114.5	114.5	114.5	114.5	114.4	114.4	114.4	114.4	114.4	114.4
	PM _{2.5} Emissions	MT	32.5	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9
	CH ₄ Emissions	MT	0.5	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	1.0	1.0	1.0	1.0	1.0	1.0
	CO Emissions	MT	0.6	1.0	1.0	1.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	N ₂ O Emissions	MT	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
	NM VOC Emissions	MT	200.8	200.6	200.6	200.6	200.3	200.3	200.3	200.3	200.3	200.3	200.3	200.3	200.3	200.3	200.3	200.3
	BC Emissions	MT	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
	Chromium III Emissions	kg	11	12	12	12	12	12	12	12	12	12	11	11	11	11	11	11
	Cobalt Emissions	kg	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Manganese Emissions	kg	3,651	3,660	3,660	3,660	3,666	3,666	3,666	3,672	3,672	3,672	3,631	3,631	3,631	3,635	3,635	3,635
	Nickel Emissions	kg	11	12	12	12	12	12	12	12	12	12	11	11	11	11	11	11
	Trimethylbenzene	kg	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
	Xylene	kg	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558
	4-methyl 2-pentanone	kg	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685
	5-methyl 2-hexane	kg	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054
	Methyl isobutylene	kg	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005
	TBT (tributyltin)	kg	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353
	Tar vinyl	kg	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503
	Copper oxide	kg	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353
	White spirit	kg	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342
Total Maintenance Emissions (4 Cycles)	CO ₂ Emissions	MT	5,324	5,325	5,325	5,325	5,325	5,325	5,325	5,325	5,325	5,325	5,337	5,337	5,337	5,353	5,353	5,353
	PM ₁₀ Emissions	MT	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2
	PM _{2.5} Emissions	MT	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
	N ₂ O Emissions	MT	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6
	Chromium III Emissions	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cobalt Emissions	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Manganese Emissions	kg	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	Nickel Emissions	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Trimethylbenzene	kg	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
	Xylene	kg	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325
	4-methyl 2-pentanone	kg	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386
	5-methyl 2-hexane	kg	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158
	Methyl isobutylene	kg	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216
	TBT (tributyltin)	kg	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125
	Tar vinyl	kg	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108
	Copper oxide	kg	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125
	White spirit	kg	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693

			Suez Canal Route															
			HFO / Baseline Ship	LNG Ship			Ammonia Ship			Methanol Ship			LH ₂ Ship			Compressed Hydrogen Ship		
			HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ Bio Diesel	Methanol	Bio- Methanol	Bio- Methanol w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel
Total Operational Emissions (g1 T)	CO ₂ Emissions	MT	2.90E+06	2.16E+06	9.72E+05	9.09E+05	2.88E+06	1.33E+06	1.01E+06	3.00E+06	9.56E+05	6.38E+05	2.70E+06	7.11E+05	3.93E+05	3.71E+06	8.62E+05	5.07E+05
	SO _x Emissions	MT	15,223.8	81.5	2,304.3	2,333.5	191.9	179.4	326.7	868.0	2,163.9	2,311.2	1,258.6	1,627.9	1,775.2	1,745.6	2,274.3	2,438.9
	NO _x Emissions	MT	14,597.4	14,017.7	15,357.5	15,503.5	15,745.4	15,745.4	16,481.8	15,794.4	16,076.8	16,813.2	15,461.4	15,347.8	16,084.2	22,460.3	22,297.6	23,120.6
	PM ₁₀ Emissions	MT	100,398	56	56	56	273	273	273	313	313	313	273	273	273	293	293	293
	PM _{2.5} Emissions	MT	92,366	52	52	52	251	251	251	288	288	288	251	251	251	269	269	269
	CH ₄ Emissions	MT	3,535.8	2,255.3	1,793.3	1,707.9	690.0	539.5	108.8	850.1	1,725.3	1,294.6	4,799.8	610.5	179.8	6,702.8	705.1	223.7
	CO Emissions	MT	2,429.1	4,946.9	5,159.4	5,159.4	324.2	219.1	219.1	397.1	925.1	925.1	503.1	432.1	432.1	621.0	519.4	519.4
	N ₂ O Emissions	MT	155.4	140.5	145.8	146.5	40.9	40.9	44.7	36.4	34.5	38.2	35.2	39.8	43.5	40.9	47.4	51.6
	NM VOC Emissions	MT	2,694.1	1,797.2	1,797.2	1,797.2	444.2	444.2	444.2	446.3	446.3	446.3	444.2	444.2	444.2	502.1	502.1	502.1
	BC Emissions	MT	157.2	9.1	9.1	9.1	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.9	9.9	9.9
Total Ship Breaking Emissions	CO ₂ Emissions	MT	4,539	3,829	3,829	3,829	4,542	4,542	4,542	4,645	4,645	4,645	4,461	4,461	4,461	4,602	4,602	4,602
	SO _x Emissions	MT	16.1	0.1	0.1	0.1	0.2	0.2	0.2	0.6	0.6	0.6	1.2	1.2	1.2	1.2	1.2	1.2
	NO _x Emissions	MT	15.3	14.5	14.5	14.5	15.9	15.9	15.9	16.0	16.0	16.0	15.6	15.6	15.6	15.6	15.6	15.6
	PM ₁₀ Emissions	MT	108.7	0.1	0.1	0.1	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
	PM _{2.5} Emissions	MT	100.0	0.1	0.1	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	CH ₄ Emissions	MT	2.3	2.3	2.3	2.3	0.7	0.7	0.7	0.8	0.8	0.8	4.7	4.7	4.7	4.7	4.7	4.7
	CO Emissions	MT	2.7	4.8	4.8	4.8	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
	N ₂ O Emissions	MT	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NM VOC Emissions	MT	2.7	1.8	1.8	1.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	BC Emissions	MT	0.2	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
Total Emissions	CO ₂ Emissions	MT	3.19E+06	2.45E+06	1.26E+06	1.20E+06	3.17E+06	1.62E+06	1.30E+06	3.29E+06	1.24E+06	9.27E+05	3.01E+06	1.02E+06	6.97E+05	4.04E+06	1.19E+06	8.33E+05
	SO _x Emissions	MT	15,243.2	81.6	2,304.4	2,333.6	192.1	179.6	326.9	868.7	2,164.6	2,311.9	1,260.1	1,629.4	1,776.7	1,747.1	2,275.7	2,440.3
	NO _x Emissions	MT	14,616.0	14,035.3	15,375.1	15,521.1	15,764.7	15,764.7	16,501.1	15,813.8	16,096.1	16,832.6	15,480.3	15,366.7	16,103.2	22,479.2	22,316.6	23,139.6
	PM ₁₀ Emissions	MT	100,693	219	219	219	436	436	436	476	476	476	436	436	436	456	456	456
	PM _{2.5} Emissions	MT	92,504	67	67	67	267	267	267	304	304	304	267	267	267	285	285	285
	CH ₄ Emissions	MT	3,538.6	2,258.0	1,796.0	1,710.6	690.8	540.3	109.6	851.1	1,726.3	1,295.6	4,805.5	616.2	185.5	6,708.5	710.8	229.4
	CO Emissions	MT	2,432.3	4,952.7	5,165.3	5,165.3	324.5	219.4	219.4	397.5	925.5	925.5	503.6	432.6	432.6	621.5	519.9	519.9
	N ₂ O Emissions	MT	244.2	229.3	234.6	235.3	129.6	129.6	133.4	125.1	123.1	126.9	123.9	128.5	132.2	129.6	136.1	140.3
	NM VOC Emissions	MT	2,897.6	1,999.6	1,999.6	1,999.6	644.9	644.9	644.9	647.0	647.0	647.0	644.9	644.9	644.9	702.9	702.9	702.9
	BC Emissions	MT	157.4	9.1	9.1	9.1	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.9	9.9	9.9
	Chromium III Emissions	kg	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Cobalt Emissions	kg	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Manganese Emissions	kg	3,751	3,760	3,760	3,760	3,766	3,766	3,766	3,772	3,772	3,772	3,731	3,731	3,731	3,735	3,735	3,735
	Nickel Emissions	kg	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Trimethylbenzene	kg	361	361	361	361	361	361	361	361	361	361	361	361	361	361	361	361
	Xylene	kg	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883
	4-methyl 2-pentanone	kg	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071
	5-methyl 2-hexane	kg	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212
	Methyl isobutylene	kg	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221
	TBT (tributyltin)	kg	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478
	Tar vinyl	kg	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611
	Copper oxide	kg	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478
	White spirit	kg	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035

			Cape of Africa Route															
			HFO / Baseline Ship	LNG Ship			Ammonia Ship			Methanol Ship			LH ₂ Ship			Compressed Hydrogen Ship		
			HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ Bio Diesel	Methanol	Bio- Methanol	Bio- Methanol w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel
Total Shipbuilding Emissions	CO ₂ Emissions	MT	277,887	279,367	279,367	279,367	279,850	279,850	279,850	279,052	279,052	279,052	294,489	294,489	294,489	315,781	315,781	315,781
	SO _x Emissions	MT	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.3	0.3	0.3	0.3	0.3
	NO _x Emissions	MT	3.2	3.1	3.1	3.1	3.4	3.4	3.4	3.4	3.4	3.4	3.3	3.3	3.3	3.3	3.3	3.3
	PM ₁₀ Emissions	MT	138.0	114.4	114.4	114.4	114.5	114.5	114.5	114.5	114.5	114.5	114.4	114.4	114.4	114.4	114.4	114.4
	PM _{2.5} Emissions	MT	32.5	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9
	CH ₄ Emissions	MT	0.5	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	1.0	1.0	1.0	1.0	1.0	1.0
	CO Emissions	MT	0.6	1.0	1.0	1.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	N ₂ O Emissions	MT	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
	NM VOC Emissions	MT	200.8	200.6	200.6	200.6	200.3	200.3	200.3	200.3	200.3	200.3	200.3	200.3	200.3	200.3	200.3	200.3
	BC Emissions	MT	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
	Chromium III Emissions	kg	11	12	12	12	12	12	12	12	12	12	11	11	11	11	11	11
	Cobalt Emissions	kg	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Manganese Emissions	kg	3,651	3,660	3,660	3,660	3,666	3,666	3,666	3,672	3,672	3,672	3,631	3,631	3,631	3,635	3,635	3,635
	Nickel Emissions	kg	11	12	12	12	12	12	12	12	12	12	11	11	11	11	11	11
	Trimethylbenzene	kg	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
	Xylene	kg	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558	208,558
	4-methyl 2-pentanone	kg	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685	16,685
	5-methyl 2-hexane	kg	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054	50,054
	Methyl isobutylene	kg	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005
	TBT (tributyltin)	kg	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353
	Tar vinyl	kg	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503	2,503
	Copper oxide	kg	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353	18,353
	White spirit	kg	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342	8,342
Total Maintenance Emissions (4 Cycles)	CO ₂ Emissions	MT	5,324	5,325	5,325	5,325	5,325	5,325	5,325	5,325	5,325	5,325	5,337	5,337	5,337	5,353	5,353	5,353
	SO _x Emissions	MT																
	NO _x Emissions	MT																
	PM ₁₀ Emissions	MT	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2
	PM _{2.5} Emissions	MT	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
	CH ₄ Emissions	MT																
	CO Emissions	MT																
	N ₂ O Emissions	MT	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6
	NM VOC Emissions	MT																
	BC Emissions	MT																
	Chromium III Emissions	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cobalt Emissions	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Manganese Emissions	kg	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	Nickel Emissions	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Trimethylbenzene	kg	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
	Xylene	kg	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325	92,325
	4-methyl 2-pentanone	kg	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386	7,386
	5-methyl 2-hexane	kg	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158	22,158
	Methyl isobutylene	kg	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216
	TBT (tributyltin)	kg	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125
	Tar vinyl	kg	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108
	Copper oxide	kg	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125	8,125
	White spirit	kg	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693	3,693

			Cape of Africa Route															
			HFO / Baseline Ship	LNG Ship			Ammonia Ship			Methanol Ship			LH ₂ Ship			Compressed Hydrogen Ship		
			HFO / VLSFO	LNG - Fossil	Bio LNG	Bio LNG - w/ Bio Diesel	Ammonia	Bio- Ammonia	Bio- Ammonia w/ Bio Diesel	Methanol	Bio- Methanol	Bio- Methanol w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel	Hydrogen	E- Hydrogen	E- Hydrogen w/ Bio Diesel
Total Operational Emissions (g1 T)	CO ₂ Emissions	MT	3.97E+06	2.95E+06	1.31E+06	1.23E+06	3.97E+06	1.75E+06	1.39E+06	4.14E+06	1.22E+06	8.61E+05	3.71E+06	8.62E+05	5.07E+05	7.11E+05	3.93E+05	3.71E+06
	SO _x Emissions	MT	20,926.7	106.0	3,170.5	3,205.6	218.3	200.5	365.1	869.8	2,726.7	2,891.3	1,745.6	2,274.3	2,438.9	1,627.9	1,775.2	1,745.6
	NO _x Emissions	MT	21,156.5	20,735.0	22,582.1	22,757.6	22,866.9	22,866.9	23,689.9	22,938.7	23,343.2	24,166.2	22,460.3	22,297.6	23,120.6	15,347.8	16,084.2	22,460.3
	PM ₁₀ Emissions	MT	149,357	63	63	63	293	293	293	331	331	331	293	293	293	273	273	293
	PM _{2.5} Emissions	MT	137,409	58	58	58	269	269	269	304	304	304	269	269	269	251	251	269
	CH ₄ Emissions	MT	4,862.8	3,078.3	2,441.4	2,338.7	818.9	603.4	122.1	1,048.4	2,302.5	1,821.2	6,702.8	705.1	223.7	610.5	179.8	6,702.8
	CO Emissions	MT	3,466.8	6,970.1	7,263.0	7,263.0	364.9	214.4	214.4	469.4	1,225.9	1,225.9	621.0	519.4	519.4	432.1	432.1	621.0
	N ₂ O Emissions	MT	217.2	200.0	207.2	208.1	49.1	49.1	53.3	42.6	39.8	44.0	40.9	47.4	51.6	39.8	43.5	40.9
	NM VOC Emissions	MT	3,914.0	2,566.4	2,566.4	2,566.4	502.1	502.1	502.1	504.2	504.2	504.2	502.1	502.1	502.1	444.2	444.2	502.1
	BC Emissions	MT	195.8	12.9	12.9	12.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.6	9.6	9.9
Total Ship Breaking Emissions	CO ₂ Emissions	MT	4,539	3,829	3,829	3,829	4,542	4,542	4,542	4,645	4,645	4,645	4,461	4,461	4,461	4,602	4,602	4,602
	SO _x Emissions	MT	16.1	0.1	0.1	0.1	0.2	0.2	0.2	0.6	0.6	0.6	1.2	1.2	1.2	1.2	1.2	1.2
	NO _x Emissions	MT	15.3	14.5	14.5	14.5	15.9	15.9	15.9	16.0	16.0	16.0	15.6	15.6	15.6	15.6	15.6	15.6
	PM ₁₀ Emissions	MT	108.7	0.1	0.1	0.1	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
	PM _{2.5} Emissions	MT	100.0	0.1	0.1	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	CH ₄ Emissions	MT	2.3	2.3	2.3	2.3	0.7	0.7	0.7	0.8	0.8	0.8	4.7	4.7	4.7	4.7	4.7	4.7
	CO Emissions	MT	2.7	4.8	4.8	4.8	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
	N ₂ O Emissions	MT	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NM VOC Emissions	MT	2.7	1.8	1.8	1.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	BC Emissions	MT	0.2	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
Total Emissions	CO ₂ Emissions	MT	4.26E+06	3.23E+06	1.60E+06	1.52E+06	4.26E+06	2.04E+06	1.68E+06	4.43E+06	1.50E+06	1.15E+06	4.02E+06	1.17E+06	8.12E+05	1.04E+06	7.19E+05	4.04E+06
	SO _x Emissions	MT	20,946.0	106.1	3,170.6	3,205.7	218.6	200.7	365.3	870.5	2,727.3	2,891.9	1,747.1	2,275.7	2,440.3	1,629.4	1,776.7	1,747.1
	NO _x Emissions	MT	21,175.1	20,752.6	22,599.7	22,775.2	22,886.2	22,886.2	23,709.2	22,958.0	23,362.5	24,185.5	22,479.2	22,316.6	23,139.6	15,366.7	16,103.2	22,479.2
	PM ₁₀ Emissions	MT	149,652	226	226	226	456	456	456	494	494	494	456	456	456	436	436	456
	PM _{2.5} Emissions	MT	137,546	74	74	74	285	285	285	320	320	320	285	285	285	267	267	285
	CH ₄ Emissions	MT	4,865.5	3,081.1	2,444.1	2,341.5	819.7	604.2	122.9	1,049.4	2,303.5	1,822.2	6,708.5	710.8	229.4	616.2	185.5	6,708.5
	CO Emissions	MT	3,470.1	6,975.9	7,268.9	7,268.9	365.1	214.7	214.7	469.8	1,226.3	1,226.3	621.5	519.9	519.9	432.6	432.6	621.5
	N ₂ O Emissions	MT	306.0	288.8	296.0	296.9	137.7	137.7	141.9	131.3	128.4	132.6	129.6	136.1	140.3	128.5	132.2	129.6
	NM VOC Emissions	MT	4,117.5	2,768.8	2,768.8	2,768.8	702.9	702.9	702.9	704.9	704.9	704.9	702.9	702.9	702.9	644.9	644.9	702.9
	BC Emissions	MT	196.0	12.9	12.9	12.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.7	9.7	9.9
	Chromium III Emissions	kg	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Cobalt Emissions	kg	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Manganese Emissions	kg	3,751	3,760	3,760	3,760	3,766	3,766	3,766	3,772	3,772	3,772	3,731	3,731	3,731	3,735	3,735	3,735
	Nickel Emissions	kg	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Trimethylbenzene	kg	361	361	361	361	361	361	361	361	361	361	361	361	361	361	361	361
	Xylene	kg	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883	300,883
	4-methyl 2-pentanone	kg	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071	24,071
	5-methyl 2-hexane	kg	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212	72,212
	Methyl isobutylene	kg	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221	7,221
	TBT (tributyltin)	kg	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478
	Tar vinyl	kg	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611	3,611
	Copper oxide	kg	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478	26,478
	White spirit	kg	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035	12,035

16.5.2. CO_{2eq} Emissions Inventory and Work-Transport Factors

		HFO/Baseline Ship		LNG Ship					
		HFO/VLSFO		LNG - Fossil		Bio LNG		Bio LNG - w/ Bio	
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape
Operational Emissions 1-RT	kg-CO _{2eq}	3.34E+07	4.58E+07	2.48E+07	3.39E+07	1.17E+07	1.57E+07	1.09E+07	1.49E+07
Travel Distance	km	4.61E+04	5.99E+04	4.61E+04	5.99E+04	4.61E+04	5.99E+04	4.61E+04	5.99E+04
TEU Delivered	TEU	4.50E+04	4.50E+04	4.41E+04	4.41E+04	4.41E+04	4.41E+04	4.41E+04	4.41E+04
Metric Tons Cargo Delivered	MT	2.53E+05	2.53E+05	2.47E+05	2.47E+05	2.47E+05	2.47E+05	2.47E+05	2.47E+05
Number of Round Trips	#	91	91	91	91	91	91	91	91
Shipbuilding Emissions	kg-CO _{2eq}	2.78E+08	2.78E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08
Operational Emissions Lifetime	kg-CO _{2eq}	3.04E+09	4.16E+09	2.26E+09	3.09E+09	1.06E+09	1.43E+09	9.96E+08	1.35E+09
Maintenance Emissions	kg-CO _{2eq}	5.32E+06	5.32E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06
Ship Breaking Emissions	kg-CO _{2eq}	4.64E+06	4.64E+06	3.93E+06	3.93E+06	3.93E+06	3.93E+06	3.93E+06	3.93E+06
Total Emissions	kg-CO_{2eq}	3.33E+09	4.45E+09	2.55E+09	3.37E+09	1.35E+09	1.72E+09	1.28E+09	1.64E+09
CO_{2eq} Baseline Comparison	%			-23.33%	-24.20%	-59.42%	-61.37%	-61.38%	-63.13%
Shipbuilding Emiss. %	%	8.4%	6.2%	11.0%	8.3%	20.7%	16.2%	21.8%	17.0%
Operational Emiss. %	%	91.3%	93.5%	88.7%	91.4%	78.6%	83.2%	77.5%	82.4%
Maintenance Emiss. %	%	0.2%	0.1%	0.2%	0.2%	0.4%	0.3%	0.4%	0.3%
Breaking Emiss. %	%	0.1%	0.1%	0.2%	0.1%	0.3%	0.2%	0.3%	0.2%
Shipbuilding Emissions	kg-PM ₁₀	1.38E+05	1.38E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05
Operational Emissions Lifetime	kg-PM ₁₀	1.00E+08	1.49E+08	5.63E+04	6.31E+04	5.63E+04	6.31E+04	5.63E+04	6.31E+04
Maintenance Emissions	kg-PM ₁₀	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04
Shhip Breaking Emissions	kg-PM ₁₀	1.09E+05	1.09E+05	6.15E+01	6.15E+01	6.15E+01	6.15E+01	6.15E+01	6.15E+01
Total PM₁₀	kg-PM₁₀	1.01E+08	1.50E+08	2.19E+05	2.26E+05	2.19E+05	2.26E+05	2.19E+05	2.26E+05
Shipbuilding Emiss. %	%	0.1%	0.1%	52.3%	50.7%	52.3%	50.7%	52.3%	50.7%
Operational Emiss. %	%	99.7%	99.8%	25.7%	28.0%	25.7%	28.0%	25.7%	28.0%
Maintenance Emiss. %	%	0.0%	0.0%	22.0%	21.3%	22.0%	21.3%	22.0%	21.3%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Shipbuilding Emissions	kg-PM _{2.5}	3.25E+04	3.25E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04
Operational Emissions Lifetime	kg-PM _{2.5}	9.24E+07	1.37E+08	5.18E+04	5.81E+04	5.18E+04	5.81E+04	5.18E+04	5.81E+04
Maintenance Emissions	kg-PM _{2.5}	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03
Shhip Breaking Emissions	kg-PM _{2.5}	1.00E+05	1.00E+05	5.66E+01	5.66E+01	5.66E+01	5.66E+01	5.66E+01	5.66E+01
Total PM_{2.5}	kg-PM_{2.5}	9.25E+07	1.38E+08	6.75E+04	7.38E+04	6.75E+04	7.38E+04	6.75E+04	7.38E+04
Shipbuilding Emiss. %	%	0.0%	0.0%	16.1%	14.7%	16.1%	14.7%	16.1%	14.7%
Operational Emiss. %	%	99.9%	99.9%	76.7%	78.7%	76.7%	78.7%	76.7%	78.7%
Maintenance Emiss. %	%	0.0%	0.0%	7.1%	6.5%	7.1%	6.5%	7.1%	6.5%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Shipbuilding Emissions	kg-VOC	2.01E+05	2.01E+05	2.01E+05	2.01E+05	2.01E+05	2.01E+05	2.01E+05	2.01E+05
Operational Emissions Lifetime	kg-VOC	2.69E+06	3.91E+06	1.80E+06	2.57E+06	1.80E+06	2.57E+06	1.80E+06	2.57E+06
Maintenance Emissions	kg-VOC	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04
Shhip Breaking Emissions	kg-VOC	2.72E+03	2.72E+03	1.78E+03	1.78E+03	1.78E+03	1.78E+03	1.78E+03	1.78E+03
Total VOC	kg-VOC	2.99E+06	4.21E+06	2.09E+06	2.86E+06	2.09E+06	2.86E+06	2.09E+06	2.86E+06
Shipbuilding Emiss. %	%	6.7%	4.8%	9.6%	7.0%	9.6%	7.0%	9.6%	7.0%
Operational Emiss. %	%	90.2%	93.1%	86.1%	89.8%	86.1%	89.8%	86.1%	89.8%
Maintenance Emiss. %	%	3.0%	2.1%	4.2%	3.1%	4.2%	3.1%	4.2%	3.1%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
CO_{2eq} Wrk-Trans. Eff. (TEU)	kg-CO_{2eq}/TEU-km	1.76E-02	1.81E-02	1.38E-02	1.40E-02	7.29E-03	7.14E-03	6.94E-03	6.82E-03
CO_{2eq} Wrk-Trans. Eff. (MT)	kg-CO_{2eq}/MT-km	3.13E-03	3.22E-03	2.46E-03	2.51E-03	1.30E-03	1.28E-03	1.24E-03	1.22E-03
Comparison CO_{2eq} Wrk-Trans. Eff. (TEU)	%	0%	0%	-22%	-23%	-59%	-61%	-61%	-62%
CO_{2eq} Wrk-Trans. Eff. (MT)	%	0%	0%	-21%	-22%	-58%	-60%	-60%	-62%
Additional Ships Factor	TEU Basis	1.00	1.00	1.02	1.02	1.02	1.02	1.02	1.02
	MT Basis	1.00	1.00	1.03	1.03	1.03	1.03	1.03	1.03
Equivalent CO_{2eq} Wrk-Trans. Eff. (TEU)	kg-CO_{2eq}/TEU-km	1.76E-02	1.81E-02	1.41E-02	1.43E-02	7.44E-03	7.29E-03	7.08E-03	6.96E-03
Equivalent CO_{2eq} Wrk-Trans. Eff. (MT)	kg-CO_{2eq}/MT-km	3.13E-03	3.22E-03	2.53E-03	2.57E-03	1.34E-03	1.31E-03	1.27E-03	1.25E-03
Comparison CO_{2eq} Wrk-Trans. Eff. (TEU)	%	0%	0%	-20%	-21%	-58%	-60%	-60%	-62%
CO_{2eq} Wrk-Trans. Eff. (MT)	%	0%	0%	-19%	-20%	-57%	-59%	-59%	-61%

		HFO/Baseline Ship		Ammonia Ship					
		HFO/VLSFO		Ammonia		Bio-Ammonia		Bio-Ammonia w/ Bio	
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape
Operational Emissions 1-RT	kg-CO _{2Eq}	3.34E+07	4.58E+07	3.20E+07	4.40E+07	1.49E+07	1.96E+07	1.13E+07	1.55E+07
Travel Distance	km	4.61E+04	5.99E+04	4.61E+04	5.99E+04	4.61E+04	5.99E+04	4.61E+04	5.99E+04
TEU Delivered	TEU	4.50E+04	4.50E+04	4.41E+04	4.41E+04	4.41E+04	4.41E+04	4.41E+04	4.41E+04
Metric Tons Cargo Delivered	MT	2.53E+05	2.53E+05	2.43E+05	2.43E+05	2.43E+05	2.43E+05	2.43E+05	2.43E+05
Number of Round Trips	#	91	91	91	91	91	91	91	91
Shipbuilding Emissions	kg-CO _{2Eq}	2.78E+08	2.78E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Operational Emissions Lifetime	kg-CO _{2Eq}	3.04E+09	4.16E+09	2.91E+09	4.01E+09	1.35E+09	1.78E+09	1.03E+09	1.41E+09
Maintenance Emissions	kg-CO _{2Eq}	5.32E+06	5.32E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06	5.33E+06
Ship Breaking Emissions	kg-CO _{2Eq}	4.64E+06	4.64E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06	4.57E+06
Total Emissions	kg-CO_{2Eq}	3.33E+09	4.45E+09	3.20E+09	4.30E+09	1.64E+09	2.07E+09	1.32E+09	1.70E+09
CO_{2Eq} Baseline Comparison	%			-3.75%	-3.45%	-50.55%	-53.52%	-60.44%	-61.77%
Shipbuilding Emiss. %	%	8.4%	6.2%	8.7%	6.5%	17.0%	13.5%	21.3%	16.4%
Operational Emiss. %	%	91.3%	93.5%	90.9%	93.3%	82.4%	86.0%	78.0%	83.0%
Maintenance Emiss. %	%	0.2%	0.1%	0.2%	0.1%	0.3%	0.3%	0.4%	0.3%
Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.3%	0.2%	0.3%	0.3%
Shipbuilding Emissions	kg-PM ₁₀	1.38E+05	1.38E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05
Operational Emissions Lifetime	kg-PM ₁₀	1.00E+08	1.49E+08	2.73E+05	2.93E+05	2.73E+05	2.93E+05	2.73E+05	2.93E+05
Maintenance Emissions	kg-PM ₁₀	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04
Shhip Breaking Emissions	kg-PM ₁₀	1.09E+05	1.09E+05	3.31E+02	3.31E+02	3.31E+02	3.31E+02	3.31E+02	3.31E+02
Total PM₁₀	kg-PM₁₀	1.01E+08	1.50E+08	4.36E+05	4.56E+05	4.36E+05	4.56E+05	4.36E+05	4.56E+05
Shipbuilding Emiss. %	%	0.1%	0.1%	26.2%	25.1%	26.2%	25.1%	26.2%	25.1%
Operational Emiss. %	%	99.7%	99.8%	62.6%	64.2%	62.6%	64.2%	62.6%	64.2%
Maintenance Emiss. %	%	0.0%	0.0%	11.0%	10.6%	11.0%	10.6%	11.0%	10.6%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Shipbuilding Emissions	kg-PM _{2.5}	3.25E+04	3.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Operational Emissions Lifetime	kg-PM _{2.5}	9.24E+07	1.37E+08	2.51E+05	2.69E+05	2.51E+05	2.69E+05	2.51E+05	2.69E+05
Maintenance Emissions	kg-PM _{2.5}	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03
Shhip Breaking Emissions	kg-PM _{2.5}	1.00E+05	1.00E+05	3.04E+02	3.04E+02	3.04E+02	3.04E+02	3.04E+02	3.04E+02
Total PM_{2.5}	kg-PM_{2.5}	9.25E+07	1.38E+08	2.57E+05	2.74E+05	2.57E+05	2.74E+05	2.57E+05	2.74E+05
Shipbuilding Emiss. %	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Operational Emiss. %	%	99.9%	99.9%	98.0%	98.1%	98.0%	98.1%	98.0%	98.1%
Maintenance Emiss. %	%	0.0%	0.0%	1.9%	1.7%	1.9%	1.7%	1.9%	1.7%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Shipbuilding Emissions	kg-VOC	2.01E+05	2.01E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05
Operational Emissions Lifetime	kg-VOC	2.69E+06	3.91E+06	4.44E+05	5.02E+05	4.44E+05	5.02E+05	4.44E+05	5.02E+05
Maintenance Emissions	kg-VOC	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04
Shhip Breaking Emissions	kg-VOC	2.72E+03	2.72E+03	4.67E+02	4.67E+02	4.67E+02	4.67E+02	4.67E+02	4.67E+02
Total VOC	kg-VOC	2.99E+06	4.21E+06	7.34E+05	7.91E+05	7.34E+05	7.91E+05	7.34E+05	7.91E+05
Shipbuilding Emiss. %	%	6.7%	4.8%	27.3%	25.3%	27.3%	25.3%	27.3%	25.3%
Operational Emiss. %	%	90.2%	93.1%	60.6%	63.4%	60.6%	63.4%	60.6%	63.4%
Maintenance Emiss. %	%	3.0%	2.1%	12.1%	11.2%	12.1%	11.2%	12.1%	11.2%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
CO_{2eq} Wrk-Trans. Eff. (TEU)	kg-CO_{2eq}/TEU-km	1.76E-02	1.81E-02	1.73E-02	1.79E-02	8.89E-03	8.60E-03	7.11E-03	7.07E-03
CO_{2eq} Wrk-Trans. Eff. (MT)	kg-CO_{2eq}/MT-km	3.13E-03	3.22E-03	3.14E-03	3.24E-03	1.61E-03	1.56E-03	1.29E-03	1.28E-03
Comparison CO_{2eq} Wrk-Trans. Eff. (TEU)	%	0%	0%	-2%	-2%	-50%	-53%	-60%	-61%
CO_{2eq} Wrk-Trans. Eff. (MT)	%	0%	0%	0%	1%	-48%	-52%	-59%	-60%
Additional Ships Factor	TEU Basis	1.00	1.00	1.02	1.02	1.02	1.02	1.02	1.02
	MT Basis	1.00	1.00	1.04	1.04	1.04	1.04	1.04	1.04
Equivalent CO_{2eq} Wrk-Trans. Eff. (TEU)	kg-CO_{2eq}/TEU-km	1.76E-02	1.81E-02	1.77E-02	1.82E-02	9.07E-03	8.77E-03	7.25E-03	7.21E-03
Equivalent CO_{2eq} Wrk-Trans. Eff. (MT)	kg-CO_{2eq}/MT-km	3.13E-03	3.22E-03	3.28E-03	3.38E-03	1.68E-03	1.63E-03	1.35E-03	1.34E-03
Comparison CO_{2eq} Wrk-Trans. Eff. (TEU)	%	0%	0%	0%	0%	-49%	-52%	-59%	-60%
CO_{2eq} Wrk-Trans. Eff. (MT)	%	0%	0%	5%	5%	-46%	-49%	-57%	-58%

		HFO/Baseline Ship		Methanol Ship					
		HFO/VLSFO		Methanol		Bio-Methanol		Bio-Methanol w/ Bio	
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape
Operational Emissions 1-RT	kg-CO _{2Eq}	3.34E+07	4.58E+07	3.33E+07	4.60E+07	1.11E+07	1.42E+07	7.52E+06	1.01E+07
Travel Distance	km	4.61E+04	5.99E+04	4.61E+04	5.99E+04	4.61E+04	5.99E+04	4.61E+04	5.99E+04
TEU Delivered	TEU	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04
Metric Tons Cargo Delivered	MT	2.53E+05	2.53E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05
Number of Round Trips	#	91	91	91	91	91	91	91	91
Shipbuilding Emissions	kg-CO _{2Eq}	2.78E+08	2.78E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08	2.79E+08
Operational Emissions Lifetime	kg-CO _{2Eq}	3.04E+09	4.16E+09	3.03E+09	4.18E+09	1.01E+09	1.29E+09	6.84E+08	9.23E+08
Maintenance Emissions	kg-CO _{2Eq}	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06	5.32E+06
Ship Breaking Emissions	kg-CO _{2Eq}	4.64E+06	4.64E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06
Total Emissions	kg-CO_{2Eq}	3.33E+09	4.45E+09	3.32E+09	4.47E+09	1.30E+09	1.58E+09	9.73E+08	1.21E+09
CO_{2Eq} Baseline Comparison	%			-0.16%	0.47%	-60.85%	-64.51%	-70.74%	-72.76%
Shipbuilding Emiss. %	%	8.4%	6.2%	8.4%	6.2%	21.4%	17.7%	28.7%	23.0%
Operational Emiss. %	%	91.3%	93.5%	91.3%	93.5%	77.8%	81.7%	70.3%	76.2%
Maintenance Emiss. %	%	0.2%	0.1%	0.2%	0.1%	0.4%	0.3%	0.5%	0.4%
Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.4%	0.3%	0.5%	0.4%
Shipbuilding Emissions	kg-PM ₁₀	1.38E+05	1.38E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05
Operational Emissions Lifetime	kg-PM ₁₀	1.00E+08	1.49E+08	3.13E+05	3.31E+05	3.13E+05	3.31E+05	3.13E+05	3.31E+05
Maintenance Emissions	kg-PM ₁₀	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04
Shhip Breaking Emissions	kg-PM ₁₀	1.09E+05	1.09E+05	3.57E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02	3.57E+02
Total PM₁₀	kg-PM₁₀	1.01E+08	1.50E+08	4.76E+05	4.94E+05	4.76E+05	4.94E+05	4.76E+05	4.94E+05
Shipbuilding Emiss. %	%	0.1%	0.1%	24.0%	23.2%	24.0%	23.2%	24.0%	23.2%
Operational Emiss. %	%	99.7%	99.8%	65.8%	67.0%	65.8%	67.0%	65.8%	67.0%
Maintenance Emiss. %	%	0.0%	0.0%	10.1%	9.8%	10.1%	9.8%	10.1%	9.8%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Shipbuilding Emissions	kg-PM _{2.5}	3.25E+04	3.25E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04
Operational Emissions Lifetime	kg-PM _{2.5}	9.24E+07	1.37E+08	2.88E+05	3.04E+05	2.88E+05	3.04E+05	2.88E+05	3.04E+05
Maintenance Emissions	kg-PM _{2.5}	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03
Shhip Breaking Emissions	kg-PM _{2.5}	1.00E+05	1.00E+05	3.29E+02	3.29E+02	3.29E+02	3.29E+02	3.29E+02	3.29E+02
Total PM_{2.5}	kg-PM_{2.5}	9.25E+07	1.38E+08	3.04E+05	3.20E+05	3.04E+05	3.20E+05	3.04E+05	3.20E+05
Shipbuilding Emiss. %	%	0.0%	0.0%	3.6%	3.4%	3.6%	3.4%	3.6%	3.4%
Operational Emiss. %	%	99.9%	99.9%	94.7%	95.0%	94.7%	95.0%	94.7%	95.0%
Maintenance Emiss. %	%	0.0%	0.0%	1.6%	1.5%	1.6%	1.5%	1.6%	1.5%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Shipbuilding Emissions	kg-VOC	2.01E+05	2.01E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05
Operational Emissions Lifetime	kg-VOC	2.69E+06	3.91E+06	4.46E+05	5.04E+05	4.46E+05	5.04E+05	4.46E+05	5.04E+05
Maintenance Emissions	kg-VOC	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04
Shhip Breaking Emissions	kg-VOC	2.72E+03	2.72E+03	4.70E+02	4.70E+02	4.70E+02	4.70E+02	4.70E+02	4.70E+02
Total VOC	kg-VOC	2.99E+06	4.21E+06	7.36E+05	7.94E+05	7.36E+05	7.94E+05	7.36E+05	7.94E+05
Shipbuilding Emiss. %	%	6.7%	4.8%	27.2%	25.2%	27.2%	25.2%	27.2%	25.2%
Operational Emiss. %	%	90.2%	93.1%	60.7%	63.5%	60.7%	63.5%	60.7%	63.5%
Maintenance Emiss. %	%	3.0%	2.1%	12.0%	11.2%	12.0%	11.2%	12.0%	11.2%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
CO_{2eq} Wrk-Trans. Eff. (TEU)	kg-CO_{2eq}/TEU-km	1.76E-02	1.81E-02	1.76E-02	1.82E-02	6.90E-03	6.43E-03	5.16E-03	4.94E-03
CO_{2eq} Wrk-Trans. Eff. (MT)	kg-CO_{2eq}/MT-km	3.13E-03	3.22E-03	3.17E-03	3.29E-03	1.24E-03	1.16E-03	9.30E-04	8.91E-04
Comparison CO_{2eq} Wrk-Trans. Eff. (TEU)	%	0%	0%	0%	0%	-61%	-65%	-71%	-73%
CO_{2eq} Wrk-Trans. Eff. (MT)	%	0%	0%	1%	2%	-60%	-64%	-70%	-72%
Additional Ships Factor	TEU Basis	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MT Basis	1.00	1.00	1.02	1.02	1.02	1.02	1.02	1.02
Equivalent CO_{2eq} Wrk-Trans. Eff. (TEU)	kg-CO_{2eq}/TEU-km	1.76E-02	1.81E-02	1.76E-02	1.82E-02	6.90E-03	6.43E-03	5.16E-03	4.94E-03
Equivalent CO_{2eq} Wrk-Trans. Eff. (MT)	kg-CO_{2eq}/MT-km	3.13E-03	3.22E-03	3.22E-03	3.34E-03	1.26E-03	1.18E-03	9.45E-04	9.05E-04
Comparison CO_{2eq} Wrk-Trans. Eff. (TEU)	%	0%	0%	0%	0%	-61%	-65%	-71%	-73%
CO_{2eq} Wrk-Trans. Eff. (MT)	%	0%	0%	3%	4%	-60%	-63%	-70%	-72%

		HFO/Baseline Ship		LH ₂ Ship					
		HFO/VLSFO		Hydrogen		E-Hydrogen		E-Hydrogen w/ Bio	
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape
Operational Emissions 1-RT	kg-CO _{2Eq}	3.34E+07	4.58E+07	3.13E+07	4.30E+07	8.11E+06	9.83E+06	4.50E+06	5.79E+06
Travel Distance	km	4.61E+04	5.99E+04	4.61E+04	5.99E+04	4.61E+04	5.99E+04	4.61E+04	5.99E+04
TEU Delivered	TEU	4.50E+04	4.50E+04	4.18E+04	4.18E+04	4.18E+04	4.18E+04	4.18E+04	4.18E+04
Metric Tons Cargo Delivered	MT	2.53E+05	2.53E+05	2.37E+05	2.37E+05	2.37E+05	2.37E+05	2.37E+05	2.37E+05
Number of Round Trips	#	91	91	91	91	91	91	91	91
Shipbuilding Emissions	kg-CO _{2Eq}	2.78E+08	2.78E+08	2.95E+08	2.95E+08	2.95E+08	2.95E+08	2.95E+08	2.95E+08
Operational Emissions Lifetime	kg-CO _{2Eq}	3.04E+09	4.16E+09	2.84E+09	3.91E+09	7.38E+08	8.95E+08	4.10E+08	5.27E+08
Maintenance Emissions	kg-CO _{2Eq}	5.32E+06	5.32E+06	5.34E+06	5.34E+06	5.34E+06	5.34E+06	5.34E+06	5.34E+06
Ship Breaking Emissions	kg-CO _{2Eq}	4.64E+06	4.64E+06	4.60E+06	4.60E+06	4.60E+06	4.60E+06	4.60E+06	4.60E+06
Total Emissions	kg-CO_{2Eq}	3.33E+09	4.45E+09	3.15E+09	4.22E+09	1.04E+09	1.20E+09	7.14E+08	8.32E+08
CO_{2Eq} Baseline Comparison	%			-5.31%	-5.31%	-68.64%	-73.06%	-78.53%	-81.32%
Shipbuilding Emiss. %	%	8.4%	6.2%	9.4%	7.0%	28.2%	24.6%	41.3%	35.4%
Operational Emiss. %	%	91.3%	93.5%	90.3%	92.8%	70.8%	74.6%	57.4%	63.4%
Maintenance Emiss. %	%	0.2%	0.1%	0.2%	0.1%	0.5%	0.4%	0.7%	0.6%
Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.4%	0.4%	0.6%	0.6%
Shipbuilding Emissions	kg-PM ₁₀	1.38E+05	1.38E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05
Operational Emissions Lifetime	kg-PM ₁₀	1.00E+08	1.49E+08	2.73E+05	2.93E+05	2.73E+05	2.93E+05	2.73E+05	2.93E+05
Maintenance Emissions	kg-PM ₁₀	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04
Shhip Breaking Emissions	kg-PM ₁₀	1.09E+05	1.09E+05	3.31E+02	3.31E+02	3.31E+02	3.31E+02	3.31E+02	3.31E+02
Total PM₁₀	kg-PM₁₀	1.01E+08	1.50E+08	4.36E+05	4.56E+05	4.36E+05	4.56E+05	4.36E+05	4.56E+05
Shipbuilding Emiss. %	%	0.1%	0.1%	26.2%	25.1%	26.2%	25.1%	26.2%	25.1%
Operational Emiss. %	%	99.7%	99.8%	62.6%	64.2%	62.6%	64.2%	62.6%	64.2%
Maintenance Emiss. %	%	0.0%	0.0%	11.0%	10.6%	11.0%	10.6%	11.0%	10.6%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Shipbuilding Emissions	kg-PM _{2.5}	3.25E+04	3.25E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04
Operational Emissions Lifetime	kg-PM _{2.5}	9.24E+07	1.37E+08	2.51E+05	2.69E+05	2.51E+05	2.69E+05	2.51E+05	2.69E+05
Maintenance Emissions	kg-PM _{2.5}	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03
Shhip Breaking Emissions	kg-PM _{2.5}	1.00E+05	1.00E+05	3.04E+02	3.04E+02	3.04E+02	3.04E+02	3.04E+02	3.04E+02
Total PM_{2.5}	kg-PM_{2.5}	9.25E+07	1.38E+08	2.67E+05	2.85E+05	2.67E+05	2.85E+05	2.67E+05	2.85E+05
Shipbuilding Emiss. %	%	0.0%	0.0%	4.1%	3.8%	4.1%	3.8%	4.1%	3.8%
Operational Emiss. %	%	99.9%	99.9%	94.0%	94.4%	94.0%	94.4%	94.0%	94.4%
Maintenance Emiss. %	%	0.0%	0.0%	1.8%	1.7%	1.8%	1.7%	1.8%	1.7%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Shipbuilding Emissions	kg-VOC	2.01E+05	2.01E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05
Operational Emissions Lifetime	kg-VOC	2.69E+06	3.91E+06	4.44E+05	5.02E+05	4.44E+05	5.02E+05	4.44E+05	5.02E+05
Maintenance Emissions	kg-VOC	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04
Shhip Breaking Emissions	kg-VOC	2.72E+03	2.72E+03	4.67E+02	4.67E+02	4.67E+02	4.67E+02	4.67E+02	4.67E+02
Total VOC	kg-VOC	2.99E+06	4.21E+06	7.34E+05	7.91E+05	7.34E+05	7.91E+05	7.34E+05	7.91E+05
Shipbuilding Emiss. %	%	6.7%	4.8%	27.3%	25.3%	27.3%	25.3%	27.3%	25.3%
Operational Emiss. %	%	90.2%	93.1%	60.6%	63.4%	60.6%	63.4%	60.6%	63.4%
Maintenance Emiss. %	%	3.0%	2.1%	12.1%	11.2%	12.1%	11.2%	12.1%	11.2%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
CO_{2eq} Wrk-Trans. Eff. (TEU)	kg-CO_{2eq}/TEU-km	1.76E-02	1.81E-02	1.80E-02	1.85E-02	5.95E-03	5.26E-03	4.07E-03	3.65E-03
CO_{2eq} Wrk-Trans. Eff. (MT)	kg-CO_{2eq}/MT-km	3.13E-03	3.22E-03	3.17E-03	3.26E-03	1.05E-03	9.28E-04	7.19E-04	6.44E-04
Comparison CO_{2eq} Wrk-Trans. Eff. (TEU)	%	0%	0%	2%	2%	-66%	-71%	-77%	-80%
CO_{2eq} Wrk-Trans. Eff. (MT)	%	0%	0%	1%	1%	-66%	-71%	-77%	-80%
Additional Ships Factor	TEU Basis	1.00	1.00	1.08	1.08	1.08	1.08	1.08	1.08
	MT Basis	1.00	1.00	1.07	1.07	1.07	1.07	1.07	1.07
Equivalent CO_{2eq} Wrk-Trans. Eff. (TEU)	kg-CO_{2eq}/TEU-km	1.76E-02	1.81E-02	1.93E-02	1.99E-02	6.40E-03	5.66E-03	4.38E-03	3.92E-03
Equivalent CO_{2eq} Wrk-Trans. Eff. (MT)	kg-CO_{2eq}/MT-km	3.13E-03	3.22E-03	3.39E-03	3.49E-03	1.12E-03	9.93E-04	7.69E-04	6.89E-04
Comparison CO_{2eq} Wrk-Trans. Eff. (TEU)	%	0%	0%	10%	10%	-64%	-69%	-75%	-78%
CO_{2eq} Wrk-Trans. Eff. (MT)	%	0%	0%	8%	8%	-64%	-69%	-75%	-79%

		HFO/Baseline Ship		Compressed Hydrogen Ship					
		HFO/VLSFO		Hydrogen		E-Hydrogen		E-Hydrogen w/ Bio	
		Suez	Cape	Suez	Cape	Suez	Cape	Suez	Cape
Operational Emissions 1-RT	kg-CO _{2Eq}	3.34E+07	4.58E+07	3.13E+07	4.30E+07	8.11E+06	9.83E+06	4.50E+06	5.79E+06
Travel Distance	km	4.61E+04	5.99E+04	4.61E+04	5.99E+04	4.61E+04	5.99E+04	4.61E+04	5.99E+04
TEU Delivered	TEU	4.50E+04	4.50E+04	4.03E+04	4.03E+04	4.03E+04	4.03E+04	4.03E+04	4.03E+04
Metric Tons Cargo Delivered	MT	2.53E+05	2.53E+05	2.28E+05	2.28E+05	2.28E+05	2.28E+05	2.28E+05	2.28E+05
Number of Round Trips	#	91	91	91	91	91	91	91	91
Shipbuilding Emissions	kg-CO _{2Eq}	2.78E+08	2.78E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08	3.16E+08
Operational Emissions Lifetime	kg-CO _{2Eq}	3.04E+09	4.16E+09	2.84E+09	3.91E+09	7.38E+08	8.95E+08	4.10E+08	5.27E+08
Maintenance Emissions	kg-CO _{2Eq}	5.32E+06	5.32E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06	5.35E+06
Ship Breaking Emissions	kg-CO _{2Eq}	4.64E+06	4.64E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06	4.74E+06
Total Emissions	kg-CO_{2Eq}	3.33E+09	4.45E+09	3.17E+09	4.24E+09	1.06E+09	1.22E+09	7.35E+08	8.53E+08
CO_{2Eq} Baseline Comparison	%			-4.66%	-4.83%	-68.00%	-72.58%	-77.89%	-80.83%
Shipbuilding Emiss. %	%	8.4%	6.2%	10.0%	7.5%	29.7%	25.9%	42.9%	37.0%
Operational Emiss. %	%	91.3%	93.5%	89.7%	92.3%	69.4%	73.3%	55.7%	61.8%
Maintenance Emiss. %	%	0.2%	0.1%	0.2%	0.1%	0.5%	0.4%	0.7%	0.6%
Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.4%	0.4%	0.6%	0.6%
Shipbuilding Emissions	kg-PM ₁₀	1.38E+05	1.38E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05	1.14E+05
Operational Emissions Lifetime	kg-PM ₁₀	1.00E+08	1.49E+08	2.73E+05	2.93E+05	2.73E+05	2.93E+05	2.73E+05	2.93E+05
Maintenance Emissions	kg-PM ₁₀	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04	4.82E+04
Shhip Breaking Emissions	kg-PM ₁₀	1.09E+05	1.09E+05	3.31E+02	3.31E+02	3.31E+02	3.31E+02	3.31E+02	3.31E+02
Total PM₁₀	kg-PM₁₀	1.01E+08	1.50E+08	4.36E+05	4.56E+05	4.36E+05	4.56E+05	4.36E+05	4.56E+05
Shipbuilding Emiss. %	%	0.1%	0.1%	26.2%	25.1%	26.2%	25.1%	26.2%	25.1%
Operational Emiss. %	%	99.7%	99.8%	62.6%	64.2%	62.6%	64.2%	62.6%	64.2%
Maintenance Emiss. %	%	0.0%	0.0%	11.0%	10.6%	11.0%	10.6%	11.0%	10.6%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Shipbuilding Emissions	kg-PM _{2.5}	3.25E+04	3.25E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04	1.09E+04
Operational Emissions Lifetime	kg-PM _{2.5}	9.24E+07	1.37E+08	2.51E+05	2.69E+05	2.51E+05	2.69E+05	2.51E+05	2.69E+05
Maintenance Emissions	kg-PM _{2.5}	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03
Shhip Breaking Emissions	kg-PM _{2.5}	1.00E+05	1.00E+05	3.04E+02	3.04E+02	3.04E+02	3.04E+02	3.04E+02	3.04E+02
Total PM_{2.5}	kg-PM_{2.5}	9.25E+07	1.38E+08	2.67E+05	2.85E+05	2.67E+05	2.85E+05	2.67E+05	2.85E+05
Shipbuilding Emiss. %	%	0.0%	0.0%	4.1%	3.8%	4.1%	3.8%	4.1%	3.8%
Operational Emiss. %	%	99.9%	99.9%	94.0%	94.4%	94.0%	94.4%	94.0%	94.4%
Maintenance Emiss. %	%	0.0%	0.0%	1.8%	1.7%	1.8%	1.7%	1.8%	1.7%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Shipbuilding Emissions	kg-VOC	2.01E+05	2.01E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05
Operational Emissions Lifetime	kg-VOC	2.69E+06	3.91E+06	4.44E+05	5.02E+05	4.44E+05	5.02E+05	4.44E+05	5.02E+05
Maintenance Emissions	kg-VOC	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04	8.86E+04
Shhip Breaking Emissions	kg-VOC	2.72E+03	2.72E+03	4.67E+02	4.67E+02	4.67E+02	4.67E+02	4.67E+02	4.67E+02
Total VOC	kg-VOC	2.99E+06	4.21E+06	7.34E+05	7.91E+05	7.34E+05	7.91E+05	7.34E+05	7.91E+05
Shipbuilding Emiss. %	%	6.7%	4.8%	27.3%	25.3%	27.3%	25.3%	27.3%	25.3%
Operational Emiss. %	%	90.2%	93.1%	60.6%	63.4%	60.6%	63.4%	60.6%	63.4%
Maintenance Emiss. %	%	3.0%	2.1%	12.1%	11.2%	12.1%	11.2%	12.1%	11.2%
Ship Breaking Emiss. %	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
CO_{2eq} Wrk-Trans. Eff. (TEU)	kg-CO_{2eq}/TEU-km	1.76E-02	1.81E-02	1.88E-02	1.93E-02	6.30E-03	5.55E-03	4.35E-03	3.88E-03
CO_{2eq} Wrk-Trans. Eff. (MT)	kg-CO_{2eq}/MT-km	3.13E-03	3.22E-03	3.31E-03	3.40E-03	1.11E-03	9.80E-04	7.68E-04	6.85E-04
Comparison CO_{2eq} Wrk-Trans. Eff. (TEU)	%	0%	0%	7%	6%	-64%	-69%	-75%	-79%
CO_{2eq} Wrk-Trans. Eff. (MT)	%	0%	0%	6%	6%	-64%	-70%	-75%	-79%
Additional Ships Factor	TEU Basis	1.00	1.00	1.12	1.12	1.12	1.12	1.12	1.12
	MT Basis	1.00	1.00	1.11	1.11	1.11	1.11	1.11	1.11
Equivalent CO_{2eq} Wrk-Trans. Eff. (TEU)	kg-CO_{2eq}/TEU-km	1.76E-02	1.81E-02	2.10E-02	2.15E-02	7.04E-03	6.21E-03	4.86E-03	4.34E-03
Equivalent CO_{2eq} Wrk-Trans. Eff. (MT)	kg-CO_{2eq}/MT-km	3.13E-03	3.22E-03	3.68E-03	3.78E-03	1.23E-03	1.09E-03	8.53E-04	7.61E-04
Comparison CO_{2eq} Wrk-Trans. Eff. (TEU)	%	0%	0%	19%	19%	-60%	-66%	-72%	-76%
CO_{2eq} Wrk-Trans. Eff. (MT)	%	0%	0%	18%	17%	-61%	-66%	-73%	-76%

17. Appendix D – Loading Condition Printouts

17.1. Loading Condition Summaries

Fuel	-	HFO							LNG				
Hold Load	MT/Teu	9	9	9	9	14	3.5	0	9	9	9	9	14
Deck Load	MT/TEU	7.2	5.75	9.6	7.85	14	3	0	7.24	5.74	9.6	7.75	14
Draft Condition	-	Scantling	Design	Scantling	Design	Scantling	Backhaul	Ballast	Scantling	Design	Scantling	Design	Scantling
Consumable Condition	-	Dept.	Dept.	Dept.	Dept.	Dept.	Dept.	Arrival	Dept.	Dept.	Dept.	Dept.	Dept.
Description		Max TEU	Max TEU	10-Tier	10-Tier	Homog.	Backhaul	Ballast	Max TEU	Max TEU	10-Tier	10-Tier	Homog.
Net Displacement	MT	302,601	259,373	300,980	259,553	300,572	183,528	154,113	303,756	259,314	301,536	259,293	300,539
Intact VCG	m-BL	28.843	29.322	28.805	29.402	27.107	25.709	14.899	28.785	29.363	28.655	29.284	27.310
Draft at AP	m	17.680	16.179	16.812	16.285	16.647	11.223	11.038	18.241	16.133	17.125	16.133	16.561
Draft at MS	m	16.534	14.534	16.535	14.533	16.529	10.899	9.351	16.534	14.535	16.534	14.534	16.534
Draft at FP	m	15.388	12.889	16.258	12.781	16.411	10.574	7.663	14.827	12.936	15.943	12.935	16.508
Heel0	deg	0.000	0.000	0.000	0.000	0.000	0.000	-0.023	0.000	0.000	0.000	0.000	0.000
Trim at Perps	m	2.292	3.290	0.554	3.504	0.237	0.649	3.375	3.413	3.197	1.182	3.198	0.054
GMO Trans	m	1.130	1.929	0.997	1.778	2.617	9.189	23.604	1.149	1.719	1.081	1.787	2.297
KMO Trans	m	30.069	31.366	29.896	31.402	29.863	35.039	38.675	30.163	31.350	29.963	31.351	29.840
FSc Trans	m	0.021	0.108	0.020	0.151	0.067	0.034	0.041	0.156	0.184	0.155	0.213	0.250
Containers In Hold Weight	MT	89,100	89,100	89,100	89,100	90,440	34,650	0	85,176	85,176	85,176	85,176	86,912
Containers On Deck Weight	MT	101,347	80,937	107,021	87,512	111,160	42,228	0	101,795	80,705	106,867	86,273	110,992
SEAWATER BALLAST Weight	MT	33,546	10,728	26,251	4,333	20,364	28,042	84,204	34,945	11,593	27,653	6,004	20,795
DIESEL OIL Weight	MT	4,223	4,223	4,223	4,223	4,223	4,223	660	3,014	3,014	3,014	3,014	3,014
Primary Fuel	MT	5,422	5,422	5,422	5,422	5,422	5,422	988	9,462	9,462	9,462	9,462	9,462
Propeller Immersion	%	165.4	150.8	157.4	151.7	155.8	103.6	101.3	170.6	150.3	160.3	150.3	155.1

Fuel	-	Ammonia						Methanol				
Hold Load	MT/Teu	9	9	9	9	14		9	9	9	9	14
Deck Load	MT/TEU	7	5.63	9.4	7.4	14		7	5.63	9.51	7.5	14
Draft Condition	-	Scantling	Design	Scantling	Design	Scantling		Scantling	Design	Scantling	Design	Scantling
Consumable Condition	-	Dept.	Dept.	Dept.	Dept.	Dept.		Dept.	Dept.	Dept.	Dept.	Dept.
Description		Max TEU	Max TEU	10-Tier	10-Tier	Homog.		Max TEU	Max TEU	10-Tier	10-Tier	Homog.
Net Displacement	MT	302,417	259,212	300,784	258,768	299,264		302,682	259,605	301,241	259,606	301,673
Intact VCG	m-BL	28.643	29.409	28.668	28.975	27.498		28.696	29.456	28.867	29.179	27.192
Draft at AP	m	17.621	16.142	16.749	16.038	16.933		17.769	16.293	17.013	16.296	17.204
Draft at MS	m	16.531	14.529	16.531	14.516	16.440		16.529	14.535	16.530	14.535	16.534
Draft at FP	m	15.440	12.917	16.313	12.994	15.948		15.289	12.777	16.046	12.773	15.864
Heel0	deg	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Trim at Perps	m	2.181	3.225	0.436	3.044	0.984		2.480	3.515	0.967	3.523	1.340
GMO Trans	m	1.269	1.784	1.073	2.158	2.299		1.278	1.800	0.952	1.859	2.672
KMO Trans	m	30.061	31.359	29.885	31.337	29.985		30.089	31.402	29.942	31.404	29.979
FSc Trans	m	0.075	0.082	0.071	0.130	0.126		0.038	0.058	0.048	0.273	0.039
Containers In Hold Weight	MT	85,176	85,176	85,176	85,176	86,912		89,100	89,100	89,100	89,100	90,440
Containers On Deck Weight	MT	98,420	79,158	104,641	82,377	110,992		98,532	79,248	106,018	83,610	111,160
SEAWATER BALLAST Weight	MT	30,857	6,915	23,004	3,251	13,397		30,382	6,589	21,455	2,228	15,405
DIESEL OIL Weight	MT	3,014	3,014	3,014	3,014	3,014		1,861	1,861	1,861	1,861	1,861
Primary Fuel	MT	15,507	15,507	15,507	15,507	15,507		13,580	13,580	13,580	13,580	13,580
Propeller Immersion	%	164.8	150.4	156.8	149.5	158.4		166.2	151.8	159.2	151.8	161.0

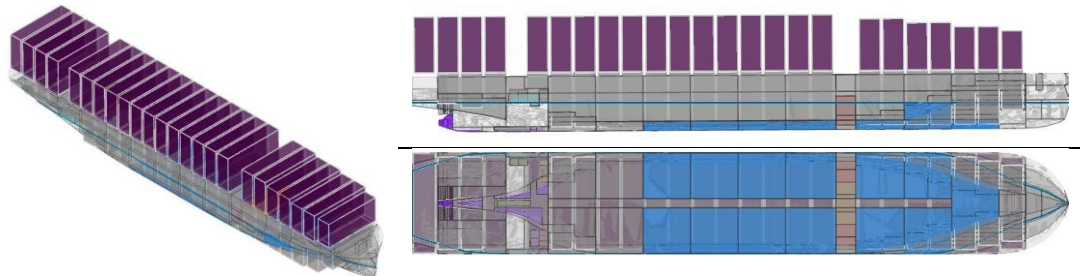
Fuel	-	Liquid Hydrogen					Compressed Hydrogen				
Hold Load	MT/Teu	9	9	9	9	14	9	9	9	9	14
Deck Load	MT/TEU	7.39	6	9.6	8.15	14	7.48	6.1	9.6	8.24	14
Draft Condition	-	Scantling	Design	Scantling	Design	Scantling	Scantling	Design	Scantling	Design	Scantling
Consumable Condition	-	Dept.	Dept.	Dept.	Dept.	Dept.	Dept.	Dept.	Dept.	Dept.	Dept.
Description		Max TEU	Max TEU	10-Tier	10-Tier	Homog.	Max TEU	Max TEU	10-Tier	10-Tier	Homog.
Net Displacement	MT	302,975	259,647	297,494	297,494	297,004	303,858	259,560	295,165	259,022	296,436
Intact VCG	m-BL	28.913	29.273	28.705	28.705	27.272	28.859	29.428	28.786	29.403	27.518
Draft at AP	m	18.000	16.413	16.443	16.443	16.410	18.323	16.278	16.303	15.988	16.365
Draft at MS	m	16.520	14.526	16.396	16.396	16.375	16.531	14.534	16.294	14.533	16.351
Draft at FP	m	15.040	12.639	16.349	16.349	16.339	14.738	12.790	16.285	13.078	16.336
Heel0	deg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Trim at Perps	m	2.960	3.774	0.094	0.094	0.072	3.586	3.487	0.018	2.910	0.029
GMO Trans	m	1.134	2.073	1.055	1.055	2.508	1.198	1.853	1.006	1.444	2.257
KMO Trans	m	30.134	31.450	29.902	29.902	29.908	30.178	31.398	29.936	31.303	29.913
FSc Trans	m	0.012	0.019	0.079	0.079	0.059	0.049	0.034	0.086	0.350	0.068
Containers In Hold Weight	MT	74,808	74,880	74,880	74,880	77,560	67,968	67,968	67,968	67,968	71,232
Containers On Deck Weight	MT	103,907	84,360	106,871	106,871	110,936	105,176	85,765	106,871	91,720	112,056
SEAWATER BALLAST Weight	MT	45,007	21,155	36,491	36,491	29,256	46,631	21,744	36,243	15,251	29,065
DIESEL OIL Weight	MT	3,014	3,014	3,014	3,014	3,014	3,014	3,014	3,014	3,014	3,014
Primary Fuel	MT	3,034	3,034	3,034	3,034	3,034	2,459	2,459	2,459	2,459	2,459
Propeller Immersion	%	168.3	152.9	153.9	153.9	153.6	171.3	151.7	152.6	149.0	153.2

17.2. Loading Condition Detailed Printouts

HFO Condition Printouts

HFO 9 MT Hold 7.2 MT Deck Max Scantling Departure

Trim and Stability Summary



Loading					
Intact Displacement	302,601	MT	Sea Density	1.0250	MT/m ³
Deadweight	235,601	MT			
Available Deadweight	23	MT			
Stability			Trim		
KM0 Trans	30.069	m	Draft at LCF	16.636	m
VCG Upright	28.847	m-BL	LCF	179.473F	m-AP
GM0 Solid Trans	1.226	m	LCB	190.393F	m-AP
GM0 Trans	1.130	m	LCG	190.511F	m-AP
GMt Required	0.895	m	TPM	223.20	MT/cm
GMt Margin	0.234	m	MTM	6,037	m-MT/cm
GM at Equilibrium	0.956	m	Trim at Perps	2A	m
			Heel0	0.00	deg
			Propeller Immersion	165.38	%
Drafts - Perps			Drafts - Marks		
AP	17.680	m	Fwd	15.448	m
MS	16.534	m	Mid	16.550	m
FP	15.388	m	Aft	17.572	m
Strength					
Shear Min	-7,694	MT			
Shear Max	15,929	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,133,944H	m-MT			
Moment Max Sag	1,347S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	363.469	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
 Hull from Geometry
 GMt from GZ Curve Slope
 FSt Adjustment = SolidGMt-GMt
 47 Tanks from Geometry
 0 Tanks from Tables
 62 Empty Tanks
 GZ Curve from Geometry
 Downflood Angles from 3D Data

Alarm Summary

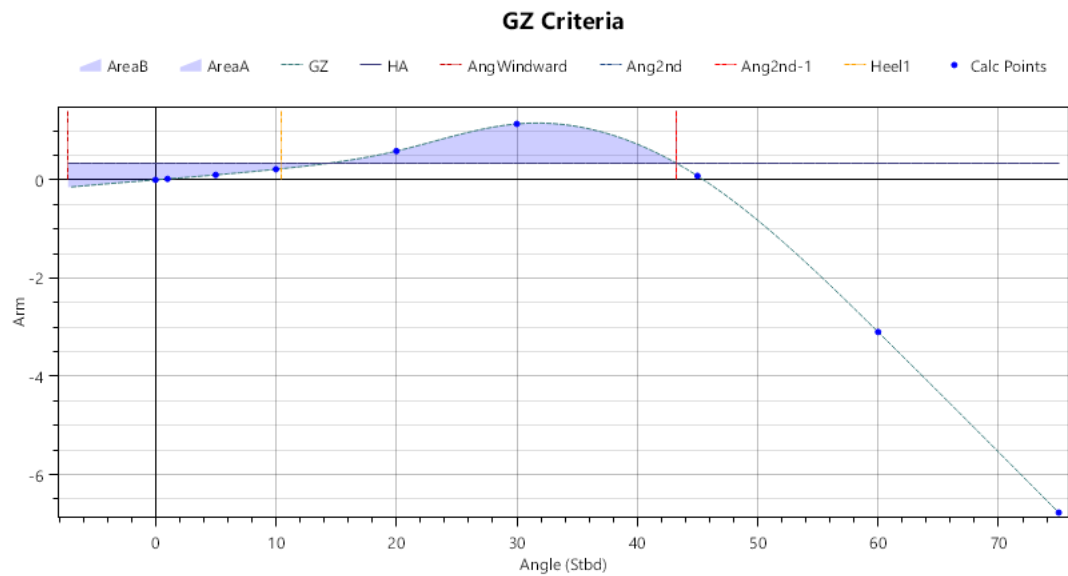
Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	235,601 MT		235,624 MT
Pass	Propeller Immersion	165.38 %	100.00 %	
Pass	Visibility	363.469 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.130 m	0.895 m	

2008 IS Code 2.2 General Criteria



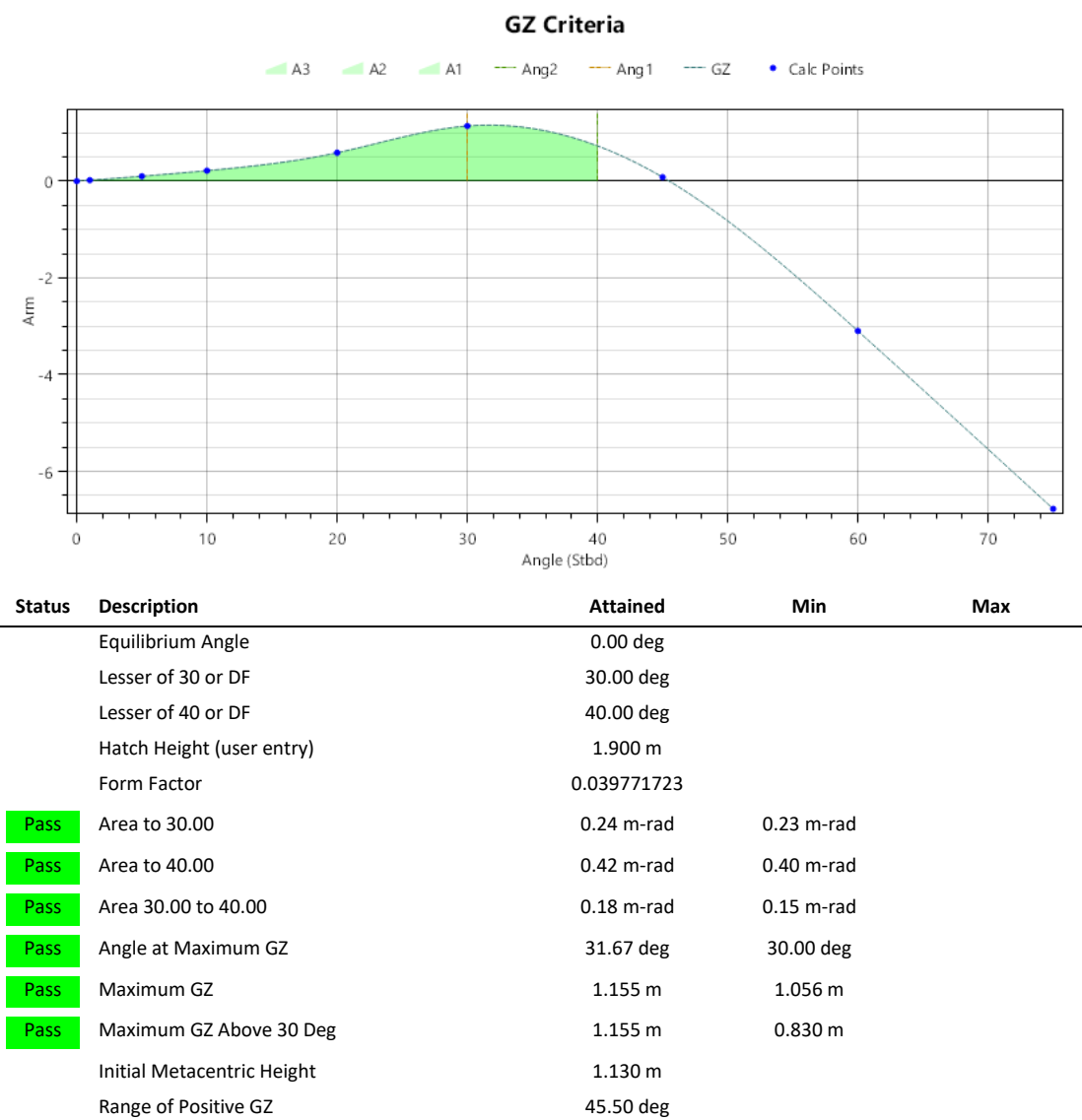
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.24 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.42 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.18 m-rad	0.03 m-rad	
	Angle to Downflooding	64.23 deg		
Pass	Angle at Maximum GZ	31.67 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.155 m	0.200 m	
Pass	Initial Metacentric Height	1.130 m	0.150 m	
	Range of Positive GZ	45.50 deg		

2008 IS Code 2.3 Weather Criteria

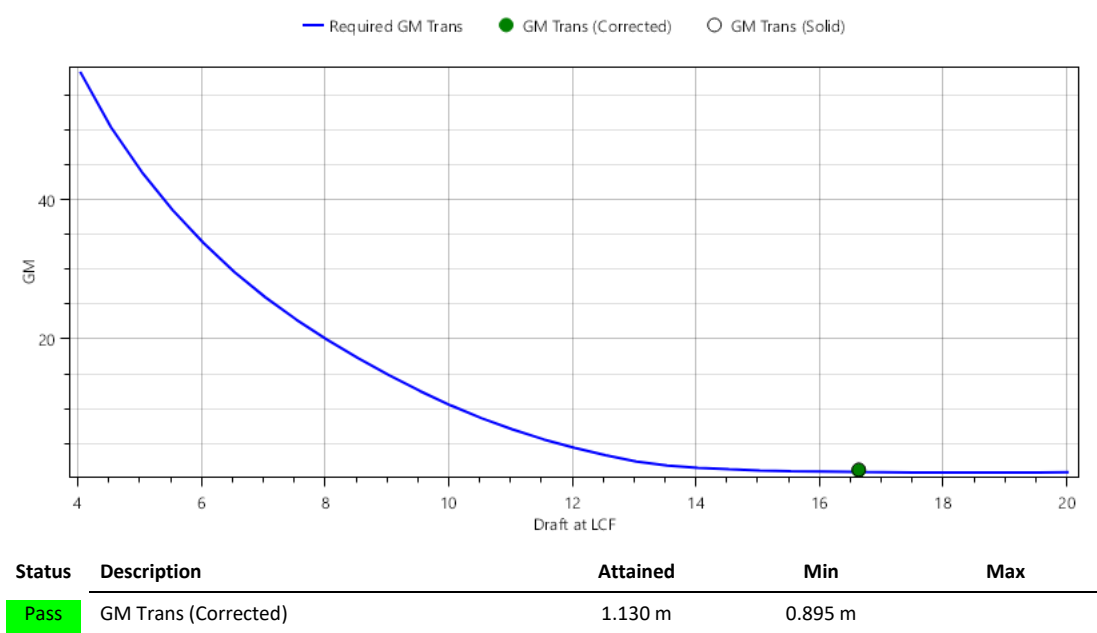


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2239667778		
	Steady Wind Heeling Lever LW1	0.224 m		
	80% Deck Edge Immersion Angle	13.01 deg		
Pass	Heeling Angle at LW1	10.45 deg		13.01 deg
	Gusty Wind Heeling Lever LW2	0.336 m		
	Heeling Angle at LW2	14.38 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.72 deg		
	Angle Windward	-7.28 deg		
	Second Intersect	43.26 deg		
	Limiting Angle	43.26 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.24 m-rad		
Pass	Area Ratio B/A	2.4503407329	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,000	181.713F	22.826	0.000	0
	SEAWATER BALLAST	33,546	241.206F	2.839	0.001P	383
	HEAVY FUEL OIL	5,422	248.720F	12.213	0.990P	2,722
	DIESEL OIL	4,223	247.542F	10.944	1.115S	1,766
	LUBE OIL	578	58.686F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	363	43.995F	3.060	2.528P	1,427
	Containers In Hold	89,100	194.349F	19.458	0.000	0
	Containers On Deck	101,347	172.707F	51.505	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		302,601	190.511F	28.843	0.001S	6,476

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,000	181.713F	22.826	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
7DBWBT S	2,277	100.00	2,277	1.0250	2,334	0
7DBWBT P	2,277	100.00	2,277	1.0250	2,334	0
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	71.00	1,543	1.0250	1,582	191
2WWBT P	2,173	71.00	1,543	1.0250	1,582	191
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0

HEAVY FUEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
HFO OVERFLOW TANK	357	10.00	36	0.9800	35	989

ULHFO 2S	1,544	95.00	1,467	0.9800	1,438	417
ULHFO 2P	1,544	95.00	1,467	0.9800	1,438	417
ULHFO 1 S	1,201	95.00	1,141	0.9800	1,118	417
ULHFO 1 P	1,201	95.00	1,141	0.9800	1,118	417
NO 1 HFO SETT TK	140	50.00	70	0.9800	69	16
NO 2 HFO SETT TK	140	50.00	70	0.9800	69	16
NO 2 HFO SERV TK	140	50.00	70	0.9800	69	16
NO 1 HFO SERV TK	140	50.00	70	0.9800	69	16

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
MGO 3P	1,544	95.00	1,467	0.8600	1,262	366
MGO 3S	1,544	95.00	1,467	0.8600	1,262	366
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
MGO 4C	1,786	95.00	1,696	0.8600	1,459	977
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SETT TK	74	50.00	37	0.9000	33	13

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,121
WASTE OIL TANK	138	10.00	14	1.0000	14	104
HFO SLUDGE TANK	51	10.00	5	1.0000	5	56
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	4,716	200.550F	0.000	18.250	0	0	262	0	262	194.250F	206.850F
Bay 38	4,716	215.000F	0.000	18.250	0	0	262	0	262	208.700F	221.300F
Bay 34	4,716	229.450F	0.000	18.250	0	0	262	0	262	223.150F	235.750F
Bay 30	4,716	243.900F	0.000	18.250	0	0	262	0	262	237.600F	250.200F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F

Containers On Deck

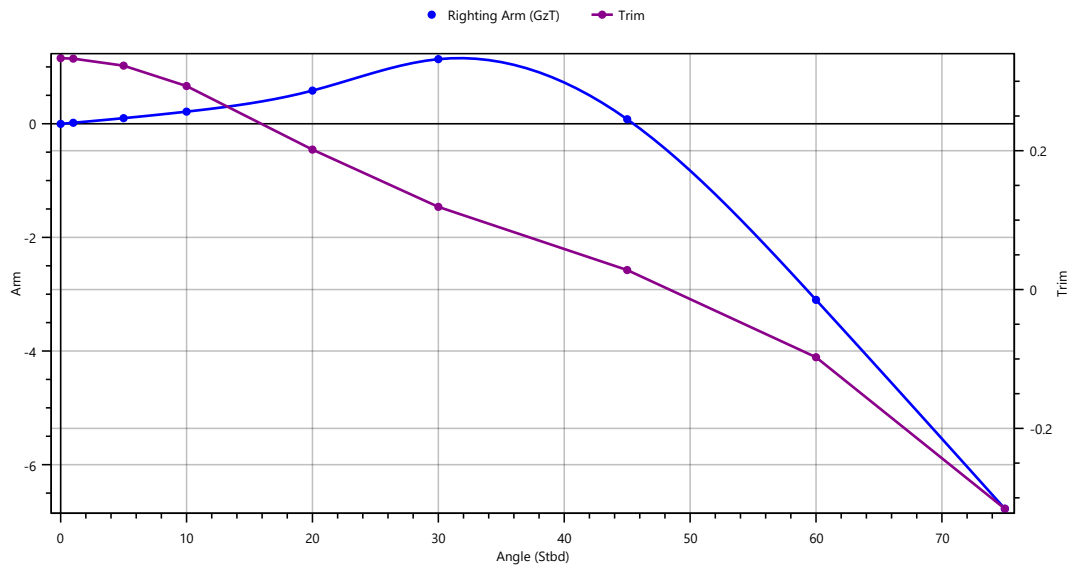
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 10	3,427	330.600F	0.000	48.326	0	0	238	0	238	324.300F	336.900F
Stack 6	3,427	345.050F	0.000	48.326	0	0	238	0	238	338.750F	351.350F
Stack 2	2,822	359.500F	0.000	47.023	0	0	196	0	196	353.200F	365.800F
Stack 14	3,773	316.150F	0.000	49.621	0	0	262	0	262	309.850F	322.450F
Stack 18	3,773	301.700F	0.000	49.621	0	0	262	0	262	295.400F	308.000F
Stack 58	4,464	142.750F	0.000	52.210	0	0	310	0	310	136.450F	149.050F
Stack 26	4,118	272.800F	0.000	50.916	0	0	286	0	286	266.500F	279.100F
Stack 94	4,464	1.450F	0.000	52.210	0	0	310	0	310	4.646A	7.546F
Stack 90	4,464	15.900F	0.000	52.210	0	0	310	0	310	9.600F	22.200F
Stack 86	4,464	30.350F	0.000	52.210	0	0	310	0	310	24.050F	36.650F
Stack 82	4,464	44.800F	0.000	52.210	0	0	310	0	310	38.500F	51.100F
Stack 78	4,464	70.500F	0.000	52.210	0	0	310	0	310	64.200F	76.800F
Stack 74	4,464	84.950F	0.000	52.210	0	0	310	0	310	78.650F	91.250F
Stack 70	4,464	99.400F	0.000	52.210	0	0	310	0	310	93.100F	105.700F
Stack 66	4,464	113.850F	0.000	52.210	0	0	310	0	310	107.550F	120.150F
Stack 62	4,464	128.300F	0.000	52.210	0	0	310	0	310	122.000F	134.600F
Stack 54	4,464	157.200F	0.000	52.210	0	0	310	0	310	150.900F	163.500F
Stack 50	4,464	171.650F	0.000	52.210	0	0	310	0	310	165.350F	177.950F
Stack 46	4,464	186.100F	0.000	52.210	0	0	310	0	310	179.800F	192.400F
Stack 42	4,464	200.550F	0.000	52.210	0	0	310	0	310	194.250F	206.850F
Stack 38	4,464	215.000F	0.000	52.210	0	0	310	0	310	208.700F	221.300F
Stack 34	4,464	229.450F	0.000	52.210	0	0	310	0	310	223.150F	235.750F
Stack 30	4,464	243.900F	0.000	52.210	0	0	310	0	310	237.600F	250.200F

Stack 4,118 287.250F 0.000 50.916 0 0 286 0 286 280.950F 293.550F
22

CONSTANT

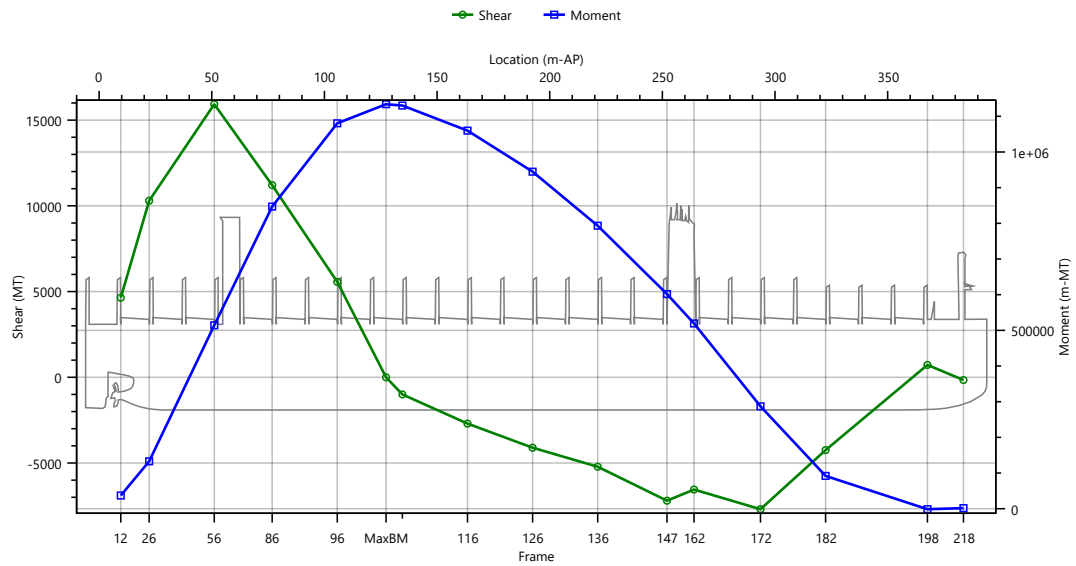
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
Water in Piping	50	160.000F	1.350	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.33	-0.003	-0.002	0.00	0.33A	17.645	15.353	5
0.00	1.00	0.33	0.017	0.001	1.00S	0.33A	17.642	15.354	2
0.00	5.00	0.32	0.098	-0.001	5.00S	0.32A	17.586	15.368	3
0.00	10.00	0.29	0.213	-0.001	10.00S	0.29A	17.418	15.402	3
0.00	20.00	0.20	0.583	-0.003	20.00S	0.20A	16.819	15.432	3
0.00	30.00	0.12	1.137	0.002	30.00S	0.12A	15.883	15.064	3
0.00	45.00	0.03	0.079	-0.003	45.00S	0.03A	13.674	13.481	4
0.00	60.00	-0.10	-3.100	0.001	60.00S	0.10F	10.082	10.753	8
0.00	75.00	-0.32	-6.776	0.000	75.00S	0.32F	1.188	3.360	9

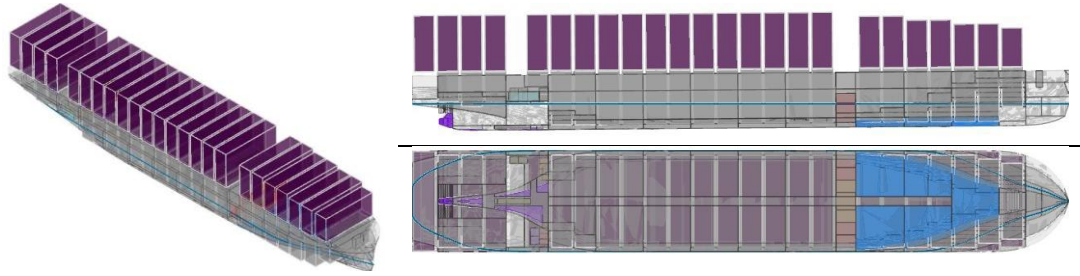
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	1,650	6,293	4,643	12,454S	49,416S	36,963H
22.200F	4,207	14,505	10,297	47,433S	180,248S	132,815H
51.100F	17,112	33,040	15,929	331,627S	845,825S	514,198H
76.800F	36,787	47,994	11,207	1,009,661S	1,856,593S	846,931H
105.700F	65,088	70,653	5,565	2,471,989S	3,552,410S	1,080,421H
127.356F	87,559	87,557	-2	4,124,746S	5,258,689S	1,133,944H
134.600F	95,072	94,073	-999	4,786,210S	5,916,386S	1,130,175H
163.500F	124,890	122,189	-2,701	7,965,343S	9,025,288S	1,059,945H
192.400F	154,413	150,305	-4,108	12,001,983S	12,946,775S	944,792H
221.300F	183,637	178,419	-5,218	16,887,520S	17,680,800S	793,281H
252.050F	214,367	207,169	-7,198	23,007,974S	23,609,711S	601,737H
264.050F	226,205	219,656	-6,549	25,651,523S	26,170,817S	519,294H
293.550F	254,514	246,820	-7,694	32,745,967S	33,033,090S	287,123H
322.450F	278,910	274,662	-4,247	40,468,145S	40,560,110S	91,964H
367.650F	299,557	300,277	720	53,628,546S	53,627,199S	1,347S
383.650F	302,171	302,010	-160	58,445,386S	58,447,003S	1,617H

HFO 9 MT Hold 5.75 MT Deck Max Design Departure

Trim and Stability Summary

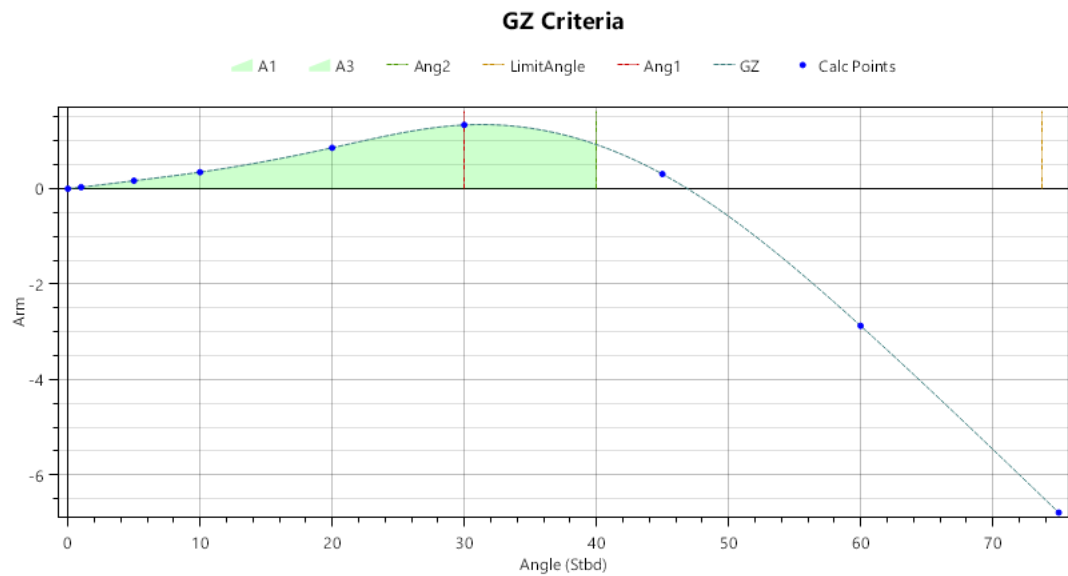


Loading					
Intact Displacement	259,373	MT	Sea Density	1.0250	MT/m ³
Deadweight	192,373	MT			
Available Deadweight	27	MT			
Stability			Trim		
KM0 Trans	31.366	m	Draft at LCF	14.671	m
VCG Upright	29.326	m-BL	LCF	180.545F	m-AP
GM0 Solid Trans	2.044	m	LCB	189.849F	m-AP
GM0 Trans	1.929	m	LCG	190.029F	m-AP
GMt Required	1.231	m	TPM	216.90	MT/cm
GMt Margin	0.698	m	MTM	5,589	m-MT/cm
GM at Equilibrium	1.715	m	Trim at Perps	3A	m
			Heel0	0.00	deg
			Propeller Immersion	150.76	%
Drafts - Perps			Drafts - Marks		
AP	16.179	m	Fwd	12.975	m
MS	14.534	m	Mid	14.557	m
FP	12.889	m	Aft	16.024	m
Bridge Visibility					
Visibility Distance	394.818	m	Visibility Distance Required	500.000	m
Calculation Notes					
Drafts from Keel					
Hull from Geometry					
GMt from GZ Curve Slope					
FSt Adjustment = SolidGMt-GMt					
37 Tanks from Geometry					
0 Tanks from Tables					
72 Empty Tanks					
GZ Curve from Geometry					
Downflood Angles from 3D Data					

Alarm Summary

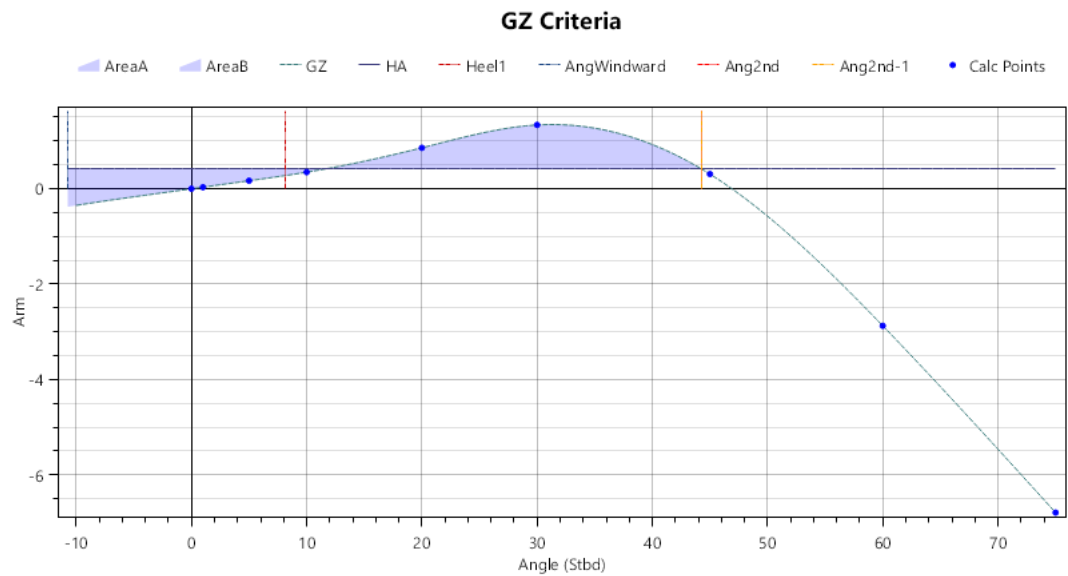
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	192,373 MT		236,644 MT
Pass	Propeller Immersion	150.76 %	100.00 %	
Pass	Visibility	394.818 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.929 m	1.231 m	
Pass	Design Deadweight	192,373 MT		192,400 MT

2008 IS Code 2.2 General Criteria



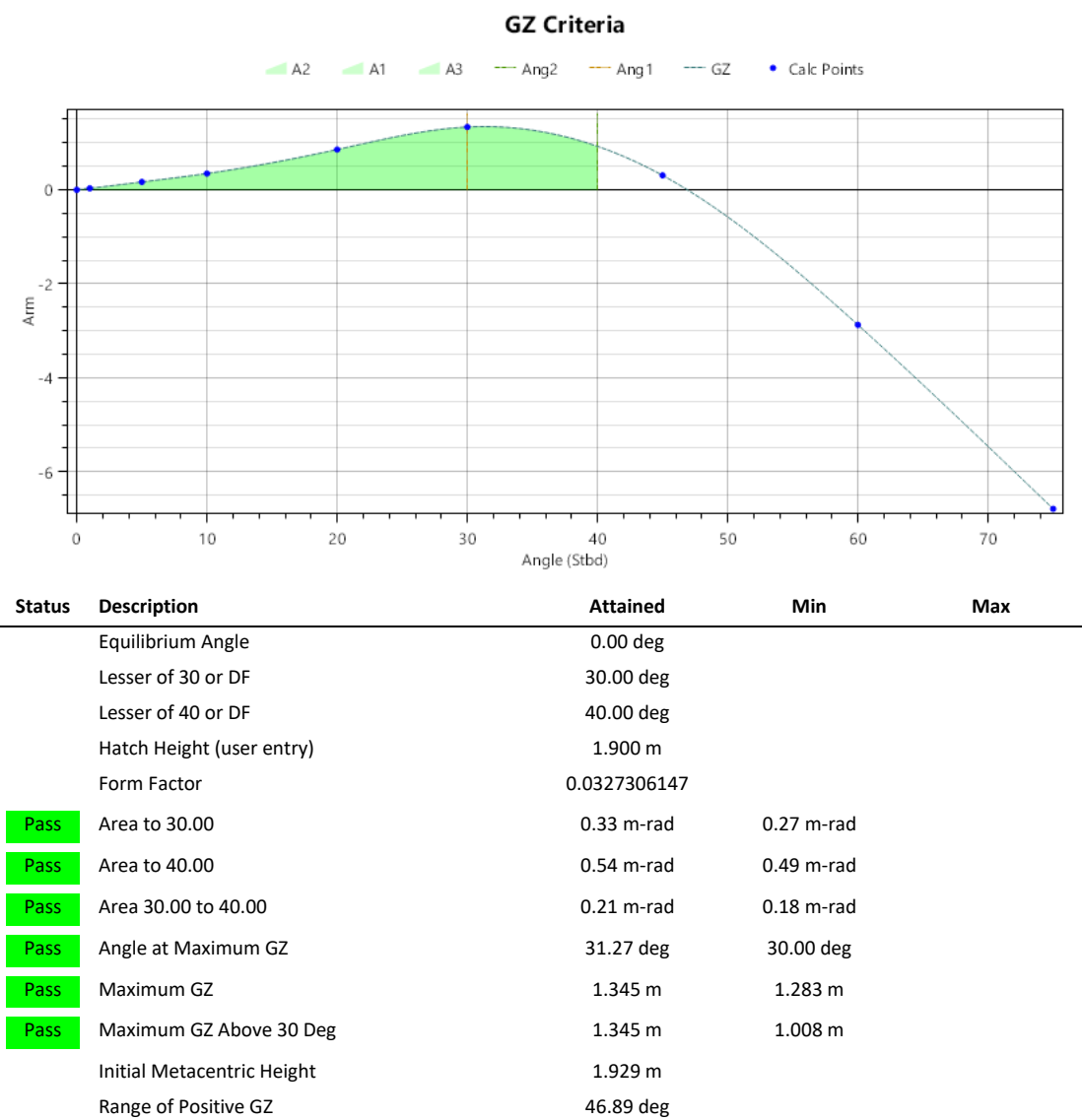
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.33 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.54 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.21 m-rad	0.03 m-rad	
	Angle to Downflooding	73.74 deg		
Pass	Angle at Maximum GZ	31.27 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.345 m	0.200 m	
Pass	Initial Metacentric Height	1.929 m	0.150 m	
	Range of Positive GZ	46.89 deg		

2008 IS Code 2.3 Weather Criteria

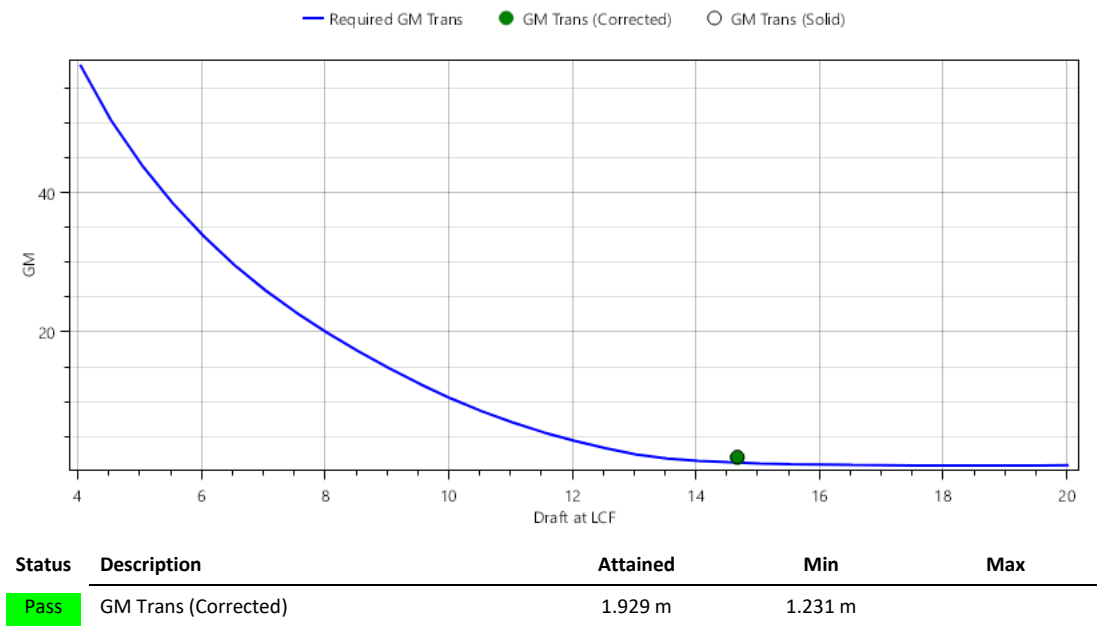


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2761584806		
	Steady Wind Heeling Lever LW1	0.276 m		
	80% Deck Edge Immersion Angle	15.78 deg		
Pass	Heeling Angle at LW1	8.20 deg		15.78 deg
	Gusty Wind Heeling Lever LW2	0.414 m		
	Heeling Angle at LW2	11.64 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	18.92 deg		
	Angle Windward	-10.72 deg		
	Second Intersect	44.26 deg		
	Limiting Angle	44.26 deg		
	Capsizing Area A	-0.16 m-rad		
	Righting Area B	0.32 m-rad		
Pass	Area Ratio B/A	2.0274338013	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,000	181.713F	22.826	0.000	0
	SEAWATER BALLAST	10,728	303.493F	2.215	0.002P	21,806
	HEAVY FUEL OIL	5,422	248.718F	12.213	0.990P	2,720
	DIESEL OIL	4,223	247.540F	10.944	1.115S	1,766
	LUBE OIL	578	58.674F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	363	43.925F	3.061	2.519P	1,441
	Containers In Hold	89,100	194.349F	19.458	0.000	0
	Containers On Deck	80,937	172.707F	51.505	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		259,373	190.029F	29.322	0.001S	27,911

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,000	181.713F	22.826	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
3DBWBT S	2,316	85.00	1,969	1.0250	2,018	10,903
3DBWBT P	2,316	85.00	1,969	1.0250	2,018	10,903
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0

HEAVY FUEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
NO 2 HFO SERV TK	140	50.00	70	0.9800	69	16
NO 1 HFO SERV TK	140	50.00	70	0.9800	69	16
NO 2 HFO SETT TK	140	50.00	70	0.9800	69	16
NO 1 HFO SETT TK	140	50.00	70	0.9800	69	16
HFO OVERFLOW TANK	357	10.00	36	0.9800	35	988
ULHFO 2S	1,544	95.00	1,467	0.9800	1,438	417
ULHFO 1 P	1,201	95.00	1,141	0.9800	1,118	417
ULHFO 1 S	1,201	95.00	1,141	0.9800	1,118	417
ULHFO 2P	1,544	95.00	1,467	0.9800	1,438	417

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
MGO 4C	1,786	95.00	1,696	0.8600	1,459	977
MGO 3S	1,544	95.00	1,467	0.8600	1,262	366
MGO 3P	1,544	95.00	1,467	0.8600	1,262	366
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO SUMP	117	50.00	58	0.9000	52	62
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,133
WASTE OIL TANK	138	10.00	14	1.0000	14	105
HFO SLUDGE TANK	51	10.00	5	1.0000	5	56
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F

Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 38	4,716	215.000F	0.000	18.250	0	0	262	0	262	208.700F	221.300F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	4,716	200.550F	0.000	18.250	0	0	262	0	262	194.250F	206.850F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 34	4,716	229.450F	0.000	18.250	0	0	262	0	262	223.150F	235.750F
Bay 30	4,716	243.900F	0.000	18.250	0	0	262	0	262	237.600F	250.200F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 22	3,289	287.250F	0.000	50.916	0	0	286	0	286	280.950F	293.550F
Stack 18	3,013	301.700F	0.000	49.621	0	0	262	0	262	295.400F	308.000F
Stack 14	3,013	316.150F	0.000	49.621	0	0	262	0	262	309.850F	322.450F

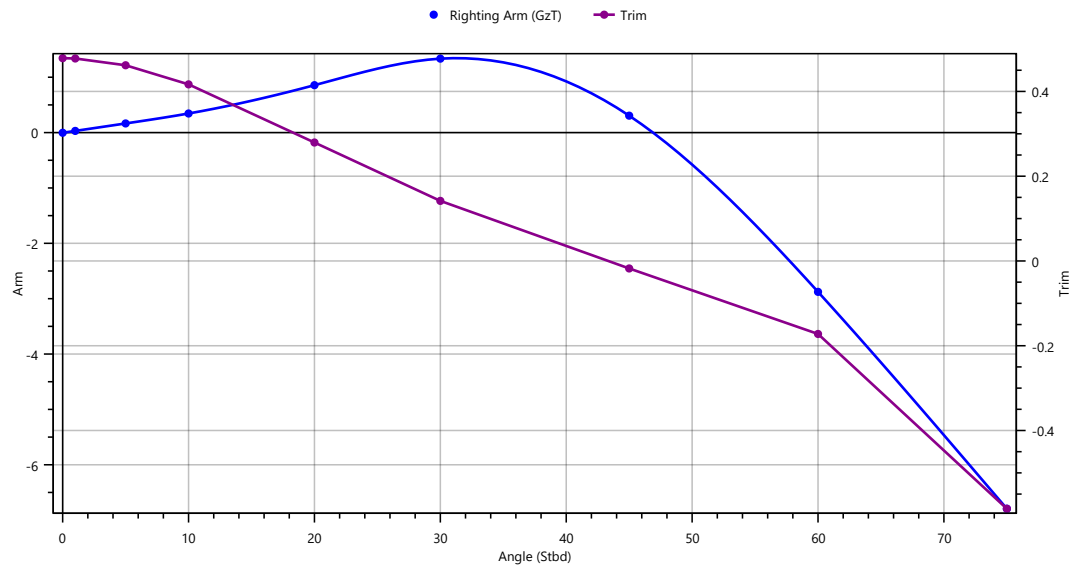
Stack 10	2,737	330.600F	0.000	48.326	0	0	238	0	238	324.300F	336.900F
Stack 6	2,737	345.050F	0.000	48.326	0	0	238	0	238	338.750F	351.350F
Stack 2	2,254	359.500F	0.000	47.023	0	0	196	0	196	353.200F	365.800F
Stack 26	3,289	272.800F	0.000	50.916	0	0	286	0	286	266.500F	279.100F
Stack 30	3,565	243.900F	0.000	52.210	0	0	310	0	310	237.600F	250.200F
Stack 70	3,565	99.400F	0.000	52.210	0	0	310	0	310	93.100F	105.700F
Stack 38	3,565	215.000F	0.000	52.210	0	0	310	0	310	208.700F	221.300F
Stack 94	3,565	1.450F	0.000	52.210	0	0	310	0	310	4.646A	7.546F
Stack 90	3,565	15.900F	0.000	52.210	0	0	310	0	310	9.600F	22.200F
Stack 86	3,565	30.350F	0.000	52.210	0	0	310	0	310	24.050F	36.650F
Stack 34	3,565	229.450F	0.000	52.210	0	0	310	0	310	223.150F	235.750F
Stack 82	3,565	44.800F	0.000	52.210	0	0	310	0	310	38.500F	51.100F
Stack 74	3,565	84.950F	0.000	52.210	0	0	310	0	310	78.650F	91.250F
Stack 66	3,565	113.850F	0.000	52.210	0	0	310	0	310	107.550F	120.150F
Stack 62	3,565	128.300F	0.000	52.210	0	0	310	0	310	122.000F	134.600F
Stack 58	3,565	142.750F	0.000	52.210	0	0	310	0	310	136.450F	149.050F
Stack 54	3,565	157.200F	0.000	52.210	0	0	310	0	310	150.900F	163.500F
Stack 50	3,565	171.650F	0.000	52.210	0	0	310	0	310	165.350F	177.950F
Stack 46	3,565	186.100F	0.000	52.210	0	0	310	0	310	179.800F	192.400F
Stack 42	3,565	200.550F	0.000	52.210	0	0	310	0	310	194.250F	206.850F
Stack 78	3,565	70.500F	0.000	52.210	0	0	310	0	310	64.200F	76.800F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000

Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
Stores Distributed	120	160.000F	27.200	0.000

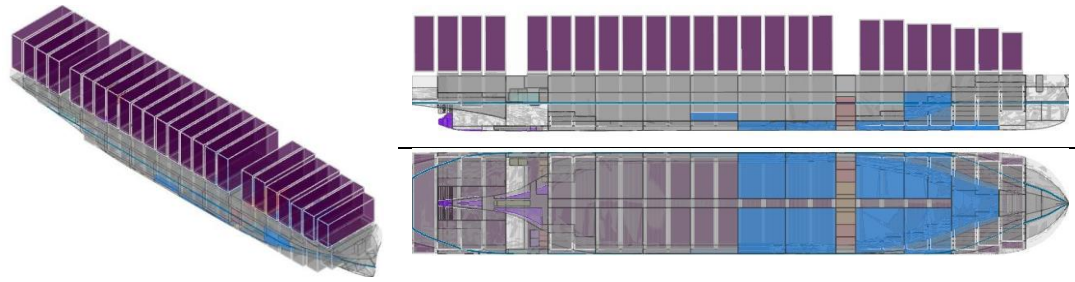
Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.48	-0.003	0.000	0.00	0.48A	16.144	12.854	5
0.00	1.00	0.48	0.030	0.001	1.00S	0.48A	16.140	12.855	2
0.00	5.00	0.46	0.165	-0.001	5.00S	0.46A	16.059	12.883	3
0.00	10.00	0.42	0.345	-0.002	10.00S	0.42A	15.823	12.957	3
0.00	20.00	0.28	0.856	-0.005	20.00S	0.28A	15.007	13.085	3
0.00	30.00	0.14	1.336	0.003	30.00S	0.14A	13.707	12.732	3
0.00	45.00	-0.02	0.306	-0.001	45.00S	0.02F	10.139	10.260	5
0.00	60.00	-0.17	-2.877	0.001	60.00S	0.17F	4.197	5.382	8
0.00	75.00	-0.58	-6.794	0.000	75.00S	0.58F	-11.917	-7.897	9

HFO 10 Tier Deck Scantling Departure 9.6 MT Deck 9 MT Hold

Trim and Stability Summary



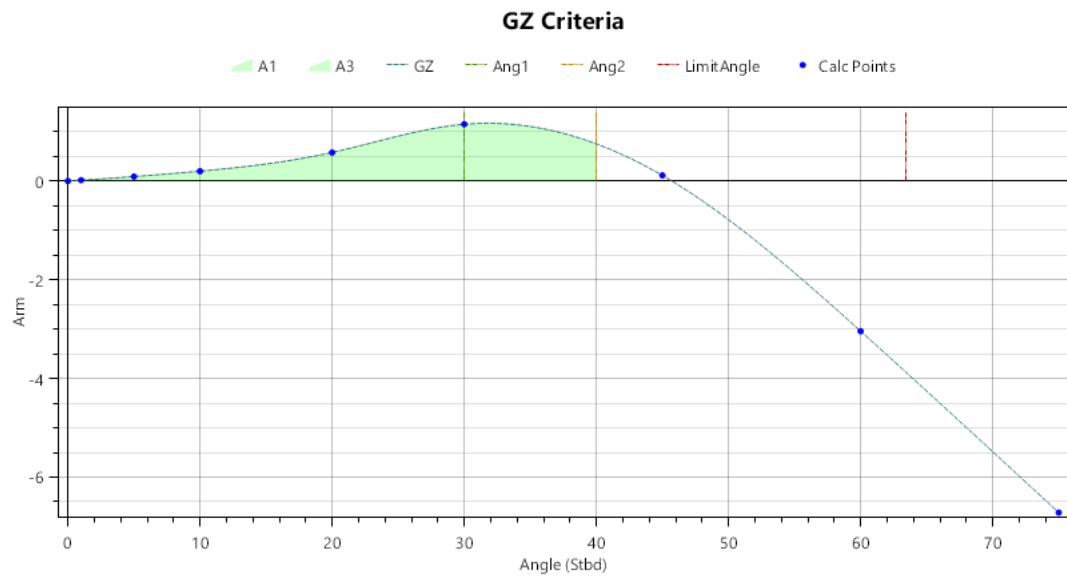
Loading					
Intact Displacement	300,980	MT	Sea Density	1.0250	MT/m ³
Deadweight	233,980	MT			
Available Deadweight	6	MT			
Stability			Trim		
KM0 Trans	29.896	m	Draft at LCF	16.557	m
VCG Upright	28.809	m-BL	LCF	181.356F	m-AP
GM0 Solid Trans	1.091	m	LCB	194.013F	m-AP
GM0 Trans	0.997	m	LCG	194.040F	m-AP
GMt Required	0.901	m	TPM	222.19	MT/cm
GMt Margin	0.096	m	MTM	5,965	m-MT/cm
GM at Equilibrium	0.823	m	Trim at Perps	1A	m
			Heel0	0.00	deg
			Propeller Immersion	157.36	%
Drafts - Perps			Drafts - Marks		
AP	16.812	m	Fwd	16.272	m
MS	16.535	m	Mid	16.539	m
FP	16.258	m	Aft	16.786	m
Strength					
Shear Min	-11,132	MT			
Shear Max	18,340	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,542,533H	m-MT			
Moment Max Sag	3,437S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	342.161	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
45 Tanks from Geometry
0 Tanks from Tables
64 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

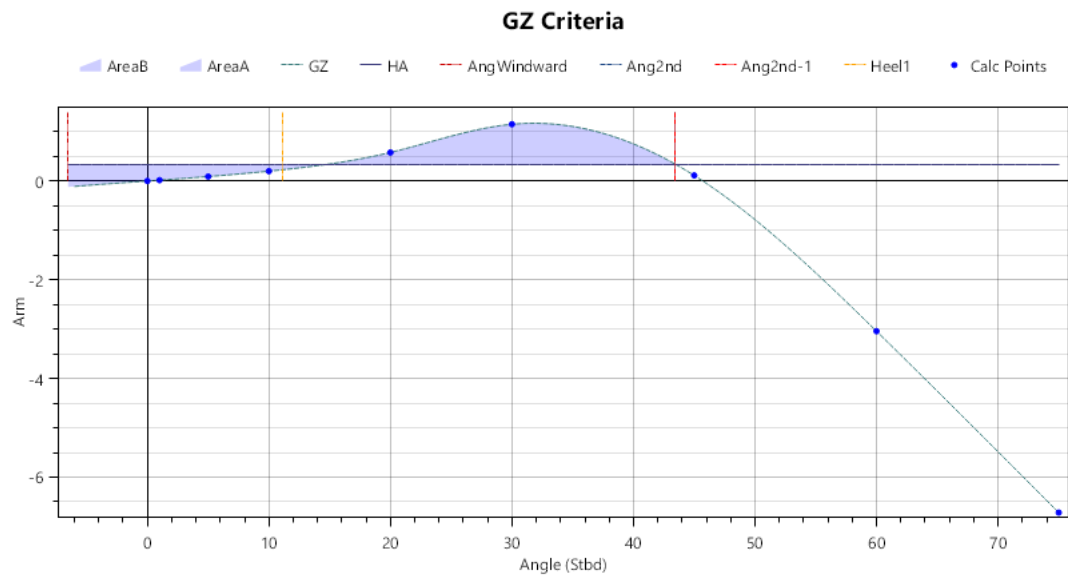
Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	233,980 MT		233,986 MT
Pass	Propeller Immersion	157.36 %	100.00 %	
Pass	Visibility	342.161 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	0.997 m	0.901 m	

2008 IS Code 2.2 General Criteria



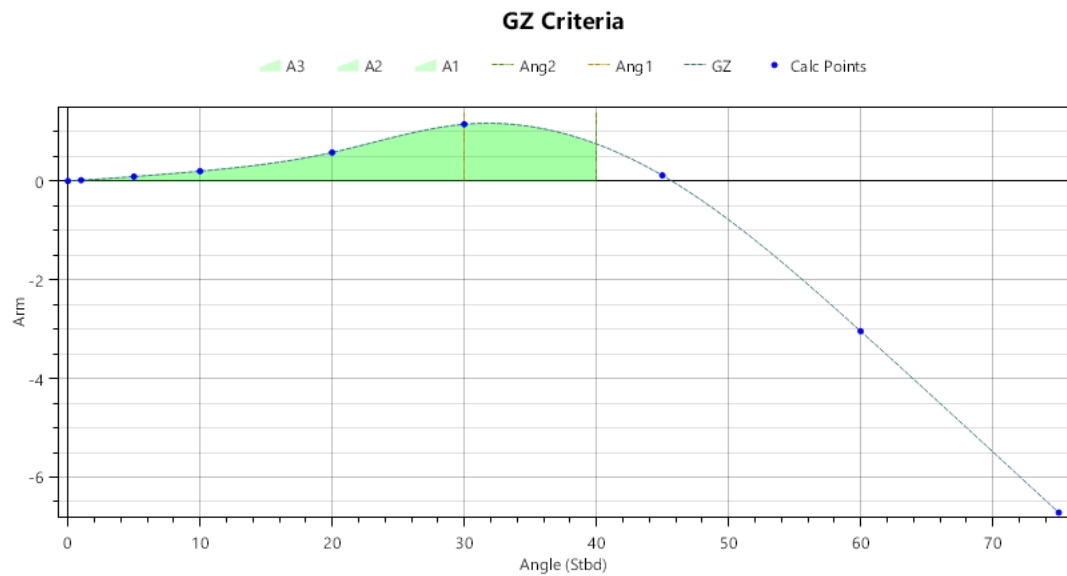
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.23 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.42 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.18 m-rad	0.03 m-rad	
	Angle to Downflooding	63.40 deg		
Pass	Angle at Maximum GZ	31.79 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.167 m	0.200 m	
Pass	Initial Metacentric Height	0.997 m	0.150 m	
	Range of Positive GZ	45.69 deg		

2008 IS Code 2.3 Weather Criteria



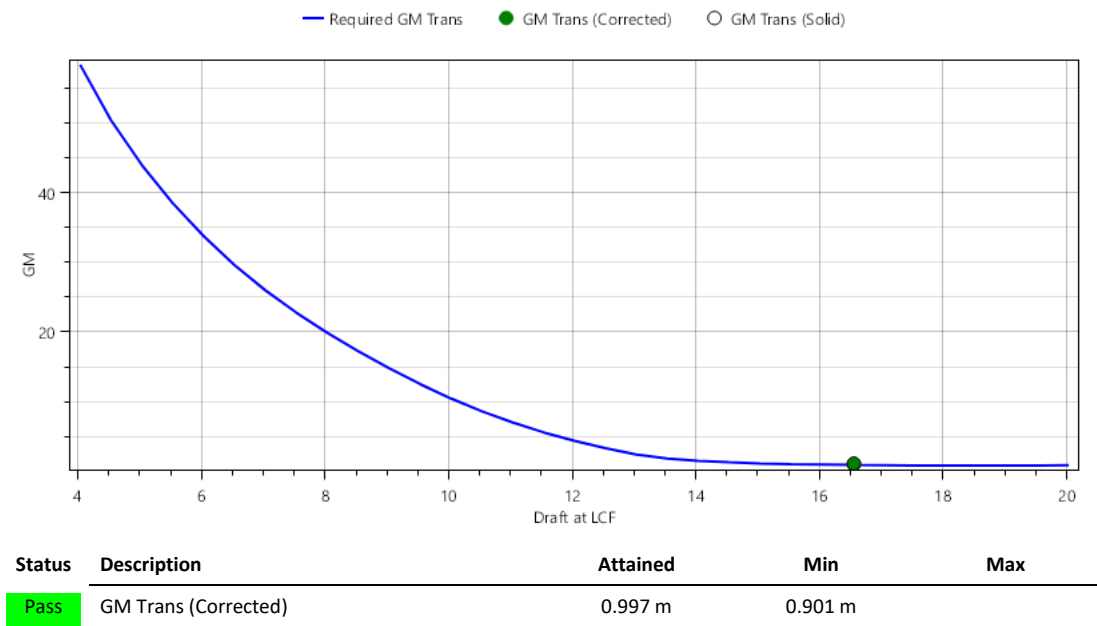
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2258213436		
	Steady Wind Heeling Lever LW1	0.226 m		
	80% Deck Edge Immersion Angle	14.55 deg		
Pass	Heeling Angle at LW1	11.17 deg		14.55 deg
	Gusty Wind Heeling Lever LW2	0.339 m		
	Heeling Angle at LW2	14.91 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.71 deg		
	Angle Windward	-6.54 deg		
	Second Intersect	43.44 deg		
	Limiting Angle	43.44 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.24 m-rad		
Pass	Area Ratio B/A	2.5475282142	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0397276018		
Pass	Area to 30.00	0.23 m-rad	0.23 m-rad	
Pass	Area to 40.00	0.42 m-rad	0.40 m-rad	
Pass	Area 30.00 to 40.00	0.18 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	31.79 deg	30.00 deg	
Pass	Maximum GZ	1.167 m	1.057 m	
Pass	Maximum GZ Above 30 Deg	1.167 m	0.831 m	
	Initial Metacentric Height	0.997 m		
	Range of Positive GZ	45.69 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,000	181.713F	22.826	0.000	0
	SEAWATER BALLAST	26,251	270.391F	4.149	0.001P	83
	HEAVY FUEL OIL	5,422	248.725F	12.213	0.990P	2,723
	DIESEL OIL	4,223	247.546F	10.944	1.115S	1,765
	LUBE OIL	578	58.707F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	363	44.117F	3.060	2.544P	1,403
	Containers In Hold	89,100	194.349F	19.458	0.000	0
	Containers On Deck	107,021	179.871F	48.102	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		300,980	194.040F	28.805	0.001S	6,152

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,000	181.713F	22.826	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
6WWBT HEEL S	1,265	29.00	367	1.0250	376	41
6WWBT HEEL P	1,265	29.00	367	1.0250	376	41
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	100.00	2,173	1.0250	2,227	0
2WWBT P	2,173	100.00	2,173	1.0250	2,227	0
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0

HEAVY FUEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
NO 2 HFO SETT TK	140	50.00	70	0.9800	69	16
NO 1 HFO SETT TK	140	50.00	70	0.9800	69	16
HFO OVERFLOW TANK	357	10.00	36	0.9800	35	991

ULHFO 2S	1,544	95.00	1,467	0.9800	1,438	417
ULHFO 2P	1,544	95.00	1,467	0.9800	1,438	417
ULHFO 1 S	1,201	95.00	1,141	0.9800	1,118	417
ULHFO 1 P	1,201	95.00	1,141	0.9800	1,118	417
NO 1 HFO SERV TK	140	50.00	70	0.9800	69	16
NO 2 HFO SERV TK	140	50.00	70	0.9800	69	16

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
MGO 3S	1,544	95.00	1,467	0.8600	1,262	366
MGO 3P	1,544	95.00	1,467	0.8600	1,262	366
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
MGO 4C	1,786	95.00	1,696	0.8600	1,459	977

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	29
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,098
WASTE OIL TANK	138	10.00	14	1.0000	14	103
HFO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0
LO SLUDGE TANK	51	10.00	5	1.0000	5	56

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	4,716	200.550F	0.000	18.250	0	0	262	0	262	194.250F	206.850F
Bay 38	4,716	215.000F	0.000	18.250	0	0	262	0	262	208.700F	221.300F
Bay 34	4,716	229.450F	0.000	18.250	0	0	262	0	262	223.150F	235.750F
Bay 30	4,716	243.900F	0.000	18.250	0	0	262	0	262	237.600F	250.200F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

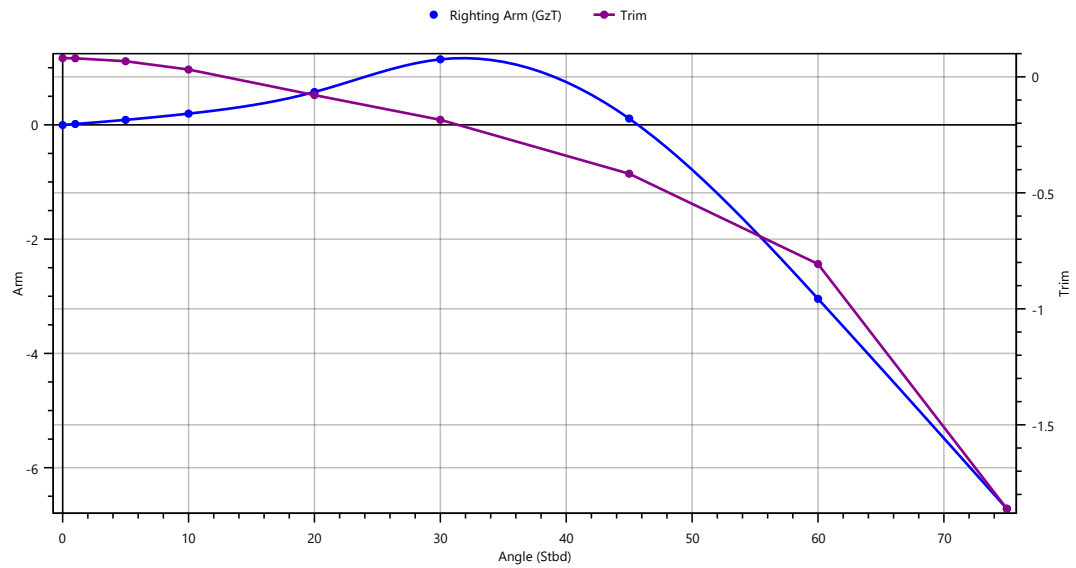
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 14	4,493	316.150F	0.000	48.148	0	0	262	0	262	309.850F	322.450F
Stack 10	4,493	330.600F	0.000	48.148	0	0	238	0	238	324.300F	336.900F
Stack 6	4,493	345.050F	0.000	48.148	0	0	238	0	238	338.750F	351.350F
Stack 2	3,686	359.500F	0.000	46.832	0	0	196	0	196	353.200F	365.800F
Stack 18	4,493	301.700F	0.000	48.148	0	0	262	0	262	295.400F	308.000F
Stack 22	4,493	287.250F	0.000	48.148	0	0	286	0	286	280.950F	293.550F
Stack 62	4,493	128.300F	0.000	48.148	0	0	310	0	310	122.000F	134.600F
Stack 30	4,493	243.900F	0.000	48.148	0	0	310	0	310	237.600F	250.200F
Stack 94	4,493	1.450F	0.000	48.150	0	0	310	0	310	4.646A	7.546F
Stack 90	4,493	15.900F	0.000	48.148	0	0	310	0	310	9.600F	22.200F
Stack 86	4,493	30.350F	0.000	48.148	0	0	310	0	310	24.050F	36.650F
Stack 82	4,493	44.800F	0.000	48.148	0	0	310	0	310	38.500F	51.100F
Stack 26	4,493	272.800F	0.000	48.148	0	0	286	0	286	266.500F	279.100F
Stack 78	4,493	70.500F	0.000	48.148	0	0	310	0	310	64.200F	76.800F
Stack 70	4,493	99.400F	0.000	48.148	0	0	310	0	310	93.100F	105.700F
Stack 66	4,493	113.850F	0.000	48.148	0	0	310	0	310	107.550F	120.150F
Stack 58	4,493	142.750F	0.000	48.148	0	0	310	0	310	136.450F	149.050F
Stack 54	4,493	157.200F	0.000	48.148	0	0	310	0	310	150.900F	163.500F
Stack 50	4,493	171.650F	0.000	48.148	0	0	310	0	310	165.350F	177.950F
Stack 46	4,493	186.100F	0.000	48.148	0	0	310	0	310	179.800F	192.400F
Stack 42	4,493	200.550F	0.000	48.148	0	0	310	0	310	194.250F	206.850F
Stack 38	4,493	215.000F	0.000	48.148	0	0	310	0	310	208.700F	221.300F
Stack 34	4,493	229.450F	0.000	48.148	0	0	310	0	310	223.150F	235.750F

Stack 4,493 84.950F 0.000 48.148 0 0 310 0 310 78.650F 91.250F
74

CONSTANT

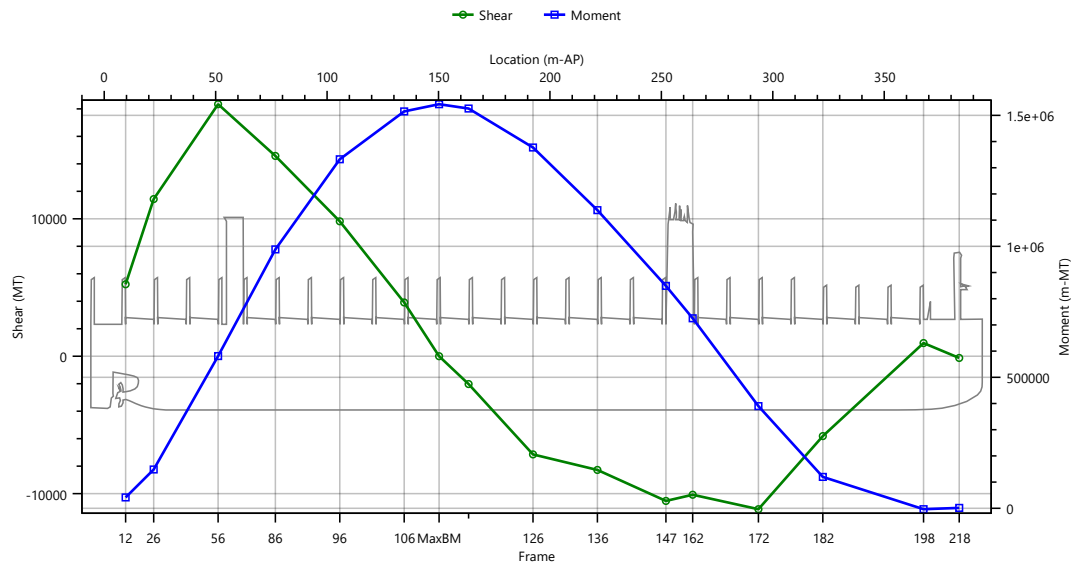
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
Bosun Stores	40	385.000F	28.755	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.08	-0.003	0.000	0.00	0.08A	16.777	16.223	5
0.00	1.00	0.08	0.015	0.001	1.00S	0.08A	16.774	16.224	2
0.00	5.00	0.07	0.087	-0.001	5.00S	0.07A	16.706	16.243	3
0.00	10.00	0.03	0.196	-0.001	10.00S	0.03A	16.509	16.292	3
0.00	20.00	-0.08	0.575	-0.002	20.00S	0.08F	15.824	16.365	3
0.00	30.00	-0.19	1.147	0.000	30.00S	0.19F	14.778	16.051	3
0.00	45.00	-0.42	0.110	-0.001	45.00S	0.42F	12.021	14.892	5
0.00	60.00	-0.81	-3.044	0.003	60.00S	0.81F	7.440	12.988	8
0.00	75.00	-1.86	-6.718	0.000	75.01S	1.86F	-4.614	8.192	9

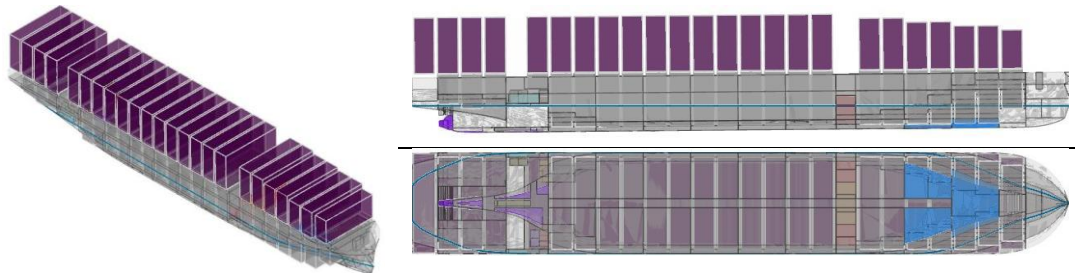
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	1,087	6,322	5,236	8,186S	49,651S	41,465H
22.200F	3,126	14,562	11,436	32,856S	181,027S	148,171H
51.100F	14,814	33,153	18,340	267,934S	849,038S	581,104H
76.800F	33,564	48,138	14,575	874,632S	1,862,899S	988,268H
105.700F	61,038	70,855	9,817	2,231,298S	3,563,657S	1,332,360H
134.600F	90,420	94,332	3,912	4,419,223S	5,934,238S	1,515,016H
150.261F	106,383	106,383	0	5,960,297S	7,502,829S	1,542,533H
163.500F	119,864	117,838	-2,026	7,457,967S	8,983,997S	1,526,030H
192.400F	149,238	142,093	-7,146	11,346,666S	12,723,906S	1,377,240H
221.300F	178,541	170,265	-8,276	16,083,253S	17,221,372S	1,138,118H
252.050F	209,603	199,072	-10,531	22,051,451S	22,900,408S	848,956H
264.050F	221,640	211,559	-10,081	24,638,985S	25,364,309S	725,324H
293.550F	250,604	239,471	-11,132	31,607,839S	31,997,841S	390,002H
322.450F	275,859	270,046	-5,814	39,229,004S	39,348,824S	119,820H
367.650F	297,698	298,656	958	52,281,291S	52,277,853S	3,437S
383.650F	300,516	300,389	-126	57,070,196S	57,071,718S	1,522H

HFO 10 Tier Deck Design Departure 7.85 MT Deck 9 MT Hold

Trim and Stability Summary



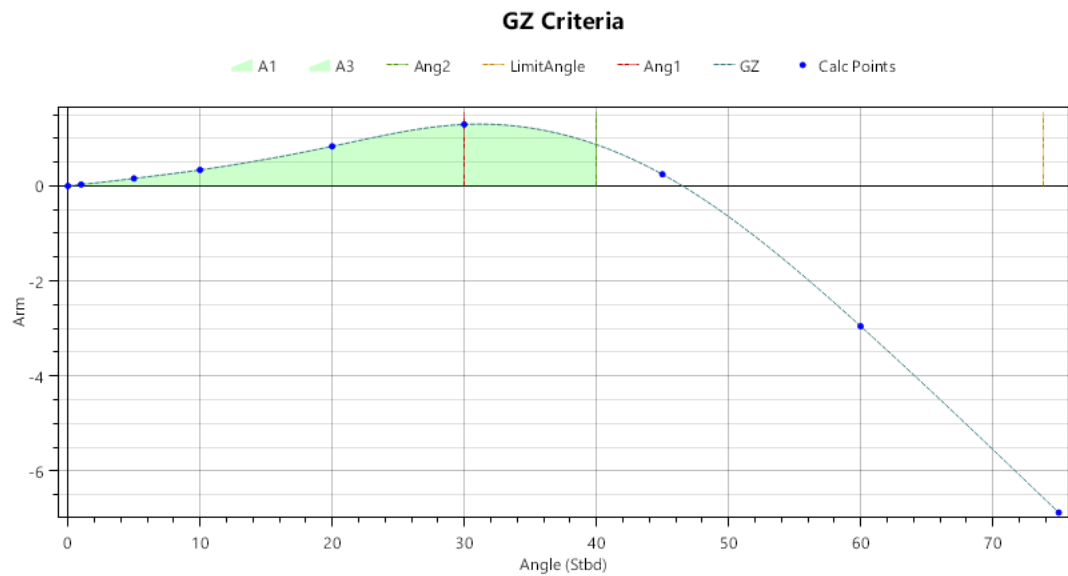
Loading					
Intact Displacement	259,553	MT	Sea Density	1.0250	MT/m ³
Deadweight	192,553	MT			
Available Deadweight	43	MT			
Stability			Trim		
KM0 Trans	31.402	m	Draft at LCF	14.683	m
VCG Upright	29.407	m-BL	LCF	180.196F	m-AP
GM0 Solid Trans	1.999	m	LCB	189.370F	m-AP
GM0 Trans	1.778	m	LCG	189.561F	m-AP
GMt Required	1.227	m	TPM	217.18	MT/cm
GMt Margin	0.551	m	MTM	5,610	m-MT/cm
GM at Equilibrium	1.562	m	Trim at Perps	4A	m
			Heel0	0.00	deg
			Propeller Immersion	151.74	%
Drafts - Perps			Drafts - Marks		
AP	16.285	m	Fwd	12.873	m
MS	14.533	m	Mid	14.558	m
FP	12.781	m	Aft	16.119	m
Strength					
Shear Min	-11,958	MT			
Shear Max	17,244	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,553,454H	m-MT			
Moment Max Sag	--	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	397.774	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
35 Tanks from Geometry
0 Tanks from Tables
74 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

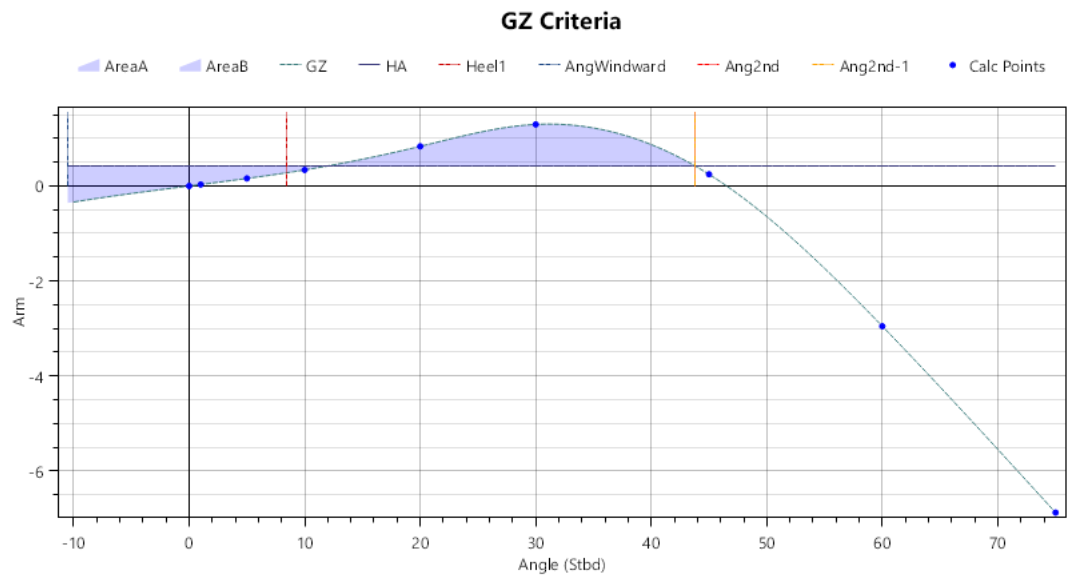
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	192,553 MT		236,869 MT
Pass	Propeller Immersion	151.74 %	100.00 %	
Pass	Visibility	397.774 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.778 m	1.227 m	
Pass	Design Deadweight	192,553 MT		192,596 MT

2008 IS Code 2.2 General Criteria



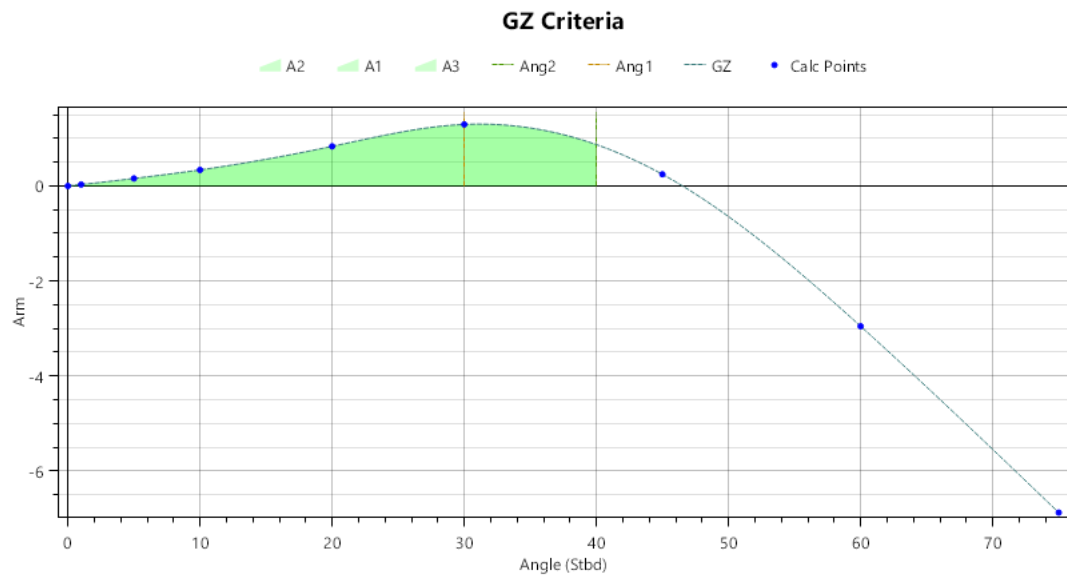
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.32 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.52 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.03 m-rad	
	Angle to Downflooding	73.86 deg		
Pass	Angle at Maximum GZ	31.14 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.300 m	0.200 m	
Pass	Initial Metacentric Height	1.778 m	0.150 m	
	Range of Positive GZ	46.51 deg		

2008 IS Code 2.3 Weather Criteria



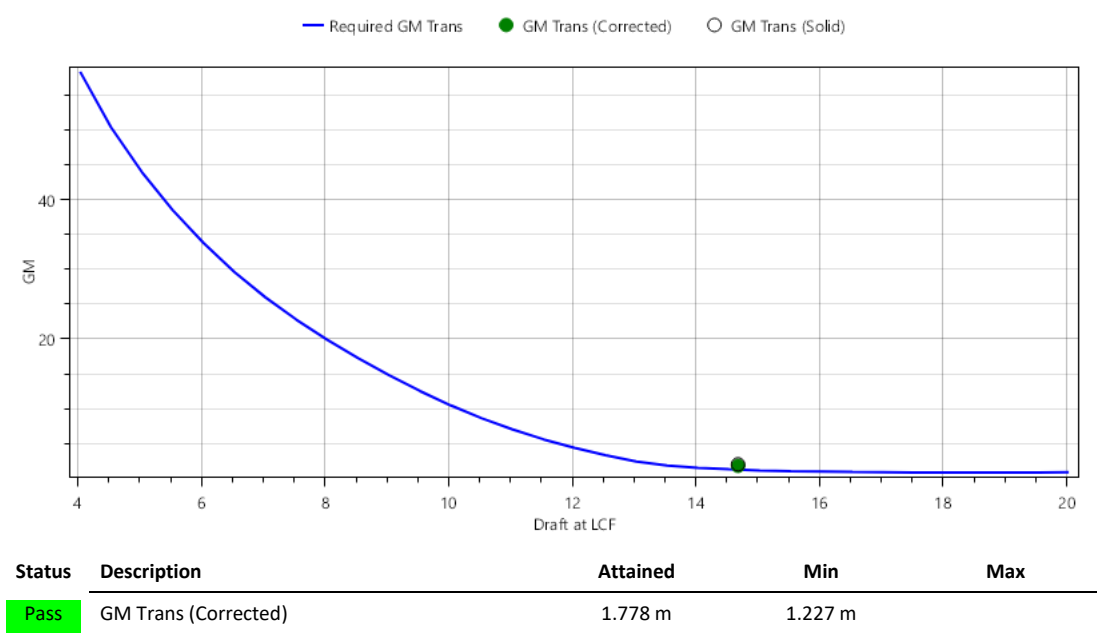
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2759071822		
	Steady Wind Heeling Lever LW1	0.276 m		
	80% Deck Edge Immersion Angle	15.58 deg		
Pass	Heeling Angle at LW1	8.48 deg		15.58 deg
	Gusty Wind Heeling Lever LW2	0.414 m		
	Heeling Angle at LW2	11.90 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	18.98 deg		
	Angle Windward	-10.50 deg		
	Second Intersect	43.83 deg		
	Limiting Angle	43.83 deg		
	Capsizing Area A	-0.15 m-rad		
	Righting Area B	0.30 m-rad		
Pass	Area Ratio B/A	1.928310763	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0326477099		
Pass	Area to 30.00	0.32 m-rad	0.28 m-rad	
Pass	Area to 40.00	0.52 m-rad	0.49 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.18 m-rad	
Pass	Angle at Maximum GZ	31.14 deg	30.00 deg	
Pass	Maximum GZ	1.300 m	1.286 m	
Pass	Maximum GZ Above 30 Deg	1.300 m	1.011 m	
	Initial Metacentric Height	1.778 m		
	Range of Positive GZ	46.51 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,000	181.713F	22.826	0.000	0
	SEAWATER BALLAST	4,333	324.544F	2.088	0.005P	33,003
	HEAVY FUEL OIL	5,422	248.717F	12.213	0.990P	2,720
	DIESEL OIL	4,223	247.540F	10.944	1.115S	1,766
	LUBE OIL	578	58.671F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	363	43.910F	3.061	2.518P	1,443
	Containers In Hold	89,100	194.349F	19.458	0.000	0
	Containers On Deck	87,512	179.872F	48.102	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		259,553	189.561F	29.402	0.001S	39,110

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,000	181.713F	22.826	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
2DBWBTS	1,918	40.00	767	1.0250	786	16,501
2DBWBT P	1,918	40.00	767	1.0250	786	16,501
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0

HEAVY FUEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
NO 2 HFO SERV TK	140	50.00	70	0.9800	69	16
NO 1 HFO SERV TK	140	50.00	70	0.9800	69	16
NO 2 HFO SETT TK	140	50.00	70	0.9800	69	16
NO 1 HFO SETT TK	140	50.00	70	0.9800	69	16
ULHFO 2P	1,544	95.00	1,467	0.9800	1,438	417
ULHFO 1 S	1,201	95.00	1,141	0.9800	1,118	417
ULHFO 1 P	1,201	95.00	1,141	0.9800	1,118	417
ULHFO 2S	1,544	95.00	1,467	0.9800	1,438	417
HFO OVERFLOW TANK	357	10.00	36	0.9800	35	988

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT

NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
MGO 4C	1,786	95.00	1,696	0.8600	1,459	977
MGO 3S	1,544	95.00	1,467	0.8600	1,262	366
MGO 3P	1,544	95.00	1,467	0.8600	1,262	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13

FRESH WATER

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,136
WASTE OIL TANK	138	10.00	14	1.0000	14	105
HFO SLUDGE TANK	51	10.00	5	1.0000	5	56
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F

Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	4,716	200.550F	0.000	18.250	0	0	262	0	262	194.250F	206.850F
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 38	4,716	215.000F	0.000	18.250	0	0	262	0	262	208.700F	221.300F
Bay 34	4,716	229.450F	0.000	18.250	0	0	262	0	262	223.150F	235.750F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 30	4,716	243.900F	0.000	18.250	0	0	262	0	262	237.600F	250.200F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 26	3,674	272.800F	0.000	48.148	0	0	286	0	286	266.500F	279.100F
Stack 22	3,674	287.250F	0.000	48.148	0	0	286	0	286	280.950F	293.550F
Stack 18	3,674	301.700F	0.000	48.148	0	0	262	0	262	295.400F	308.000F
Stack 14	3,674	316.150F	0.000	48.148	0	0	262	0	262	309.850F	322.450F

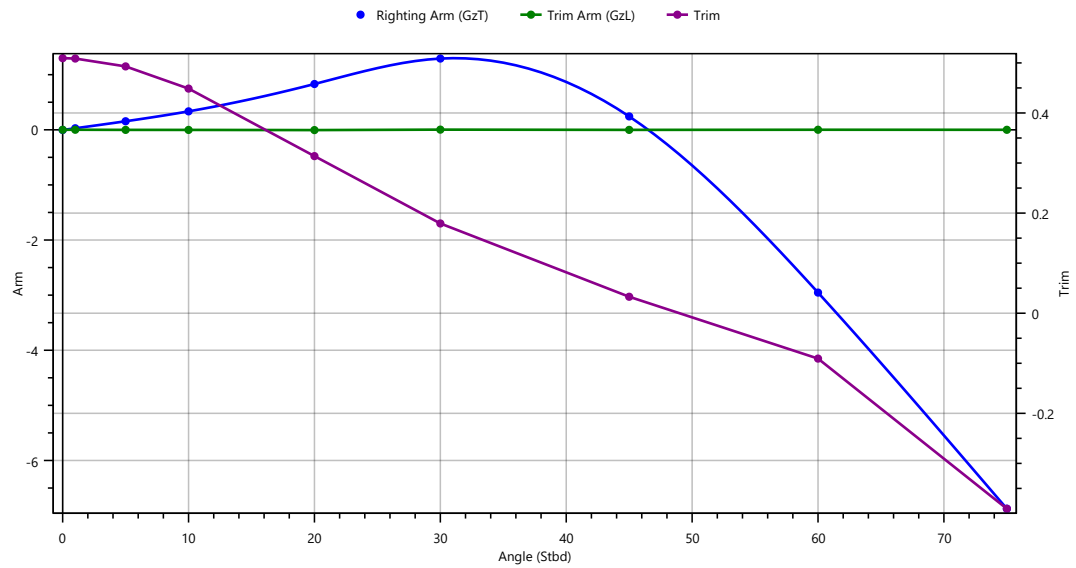
Stack 6	3,674	345.050F	0.000	48.148	0	0	238	0	238	338.750F	351.350F
Stack 2	3,014	359.500F	0.000	46.832	0	0	196	0	196	353.200F	365.800F
Stack 30	3,674	243.900F	0.000	48.148	0	0	310	0	310	237.600F	250.200F
Stack 34	3,674	229.450F	0.000	48.148	0	0	310	0	310	223.150F	235.750F
Stack 78	3,674	70.500F	0.000	48.148	0	0	310	0	310	64.200F	76.800F
Stack 42	3,674	200.550F	0.000	48.148	0	0	310	0	310	194.250F	206.850F
Stack 94	3,674	1.450F	0.000	48.150	0	0	310	0	310	4.646A	7.546F
Stack 90	3,674	15.900F	0.000	48.148	0	0	310	0	310	9.600F	22.200F
Stack 38	3,674	215.000F	0.000	48.148	0	0	310	0	310	208.700F	221.300F
Stack 86	3,674	30.350F	0.000	48.148	0	0	310	0	310	24.050F	36.650F
Stack 74	3,674	84.950F	0.000	48.148	0	0	310	0	310	78.650F	91.250F
Stack 70	3,674	99.400F	0.000	48.148	0	0	310	0	310	93.100F	105.700F
Stack 66	3,674	113.850F	0.000	48.148	0	0	310	0	310	107.550F	120.150F
Stack 62	3,674	128.300F	0.000	48.148	0	0	310	0	310	122.000F	134.600F
Stack 58	3,674	142.750F	0.000	48.148	0	0	310	0	310	136.450F	149.050F
Stack 54	3,674	157.200F	0.000	48.148	0	0	310	0	310	150.900F	163.500F
Stack 50	3,674	171.650F	0.000	48.148	0	0	310	0	310	165.350F	177.950F
Stack 46	3,674	186.100F	0.000	48.148	0	0	310	0	310	179.800F	192.400F
Stack 82	3,674	44.800F	0.000	48.148	0	0	310	0	310	38.500F	51.100F
Stack 10	3,674	330.600F	0.000	48.148	0	0	238	0	238	324.300F	336.900F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000

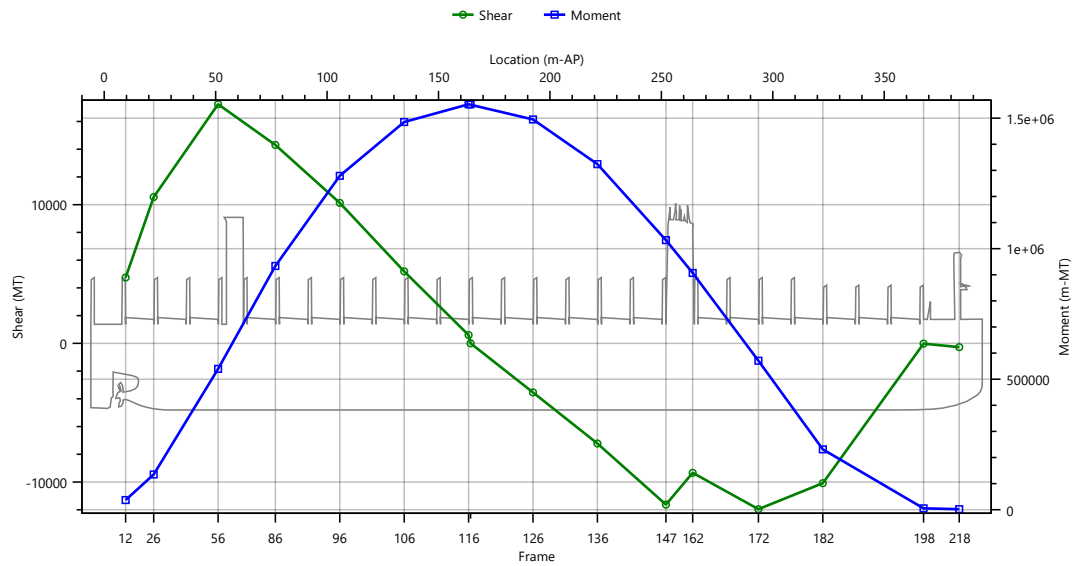
Provisions	7	258.450F	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.51	-0.003	0.000	0.00	0.51A	16.250	12.746	5
0.00	1.00	0.51	0.028	0.001	1.00S	0.51A	16.246	12.748	2
0.00	5.00	0.49	0.155	-0.001	5.00S	0.49A	16.166	12.775	3
0.00	10.00	0.45	0.335	-0.002	10.00S	0.45A	15.933	12.847	3
0.00	20.00	0.31	0.831	-0.005	20.00S	0.31A	15.128	12.970	3
0.00	30.00	0.18	1.293	0.003	30.00S	0.18A	13.842	12.609	3
0.00	45.00	0.03	0.243	-0.002	45.00S	0.03A	10.325	10.099	5
0.00	60.00	-0.09	-2.954	0.001	60.00S	0.09F	4.499	5.122	8
0.00	75.00	-0.39	-6.876	0.000	75.00S	0.39F	-11.195	-8.509	9

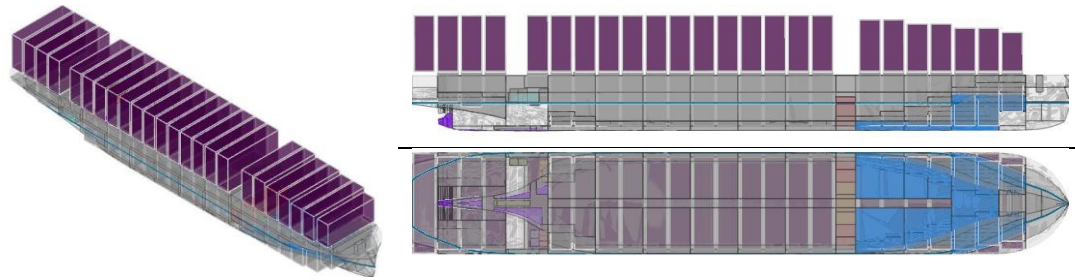
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	756	5,503	4,747	5,923S	42,976S	37,053H
22.200F	2,374	12,924	10,550	23,916S	158,874S	134,958H
51.100F	12,637	29,881	17,244	217,961S	757,409S	539,448H
76.800F	29,738	44,043	14,305	748,196S	1,681,999S	933,803H
105.700F	54,994	65,122	10,128	1,963,185S	3,242,257S	1,279,072H
134.600F	81,774	86,961	5,187	3,939,768S	5,425,000S	1,485,232H
163.500F	108,230	108,829	599	6,686,387S	8,239,583S	1,553,195H
164.388F	109,035	109,039	3	6,782,846S	8,336,299S	1,553,454H
192.400F	134,232	130,694	-3,538	10,191,063S	11,686,099S	1,495,036H
221.300F	159,778	152,557	-7,221	14,440,610S	15,764,488S	1,323,877H
252.050F	186,420	174,793	-11,626	19,765,003S	20,797,709S	1,032,706H
264.050F	196,614	187,281	-9,333	22,063,348S	22,970,333S	906,985H
293.550F	220,765	208,807	-11,958	28,223,936S	28,794,615S	570,679H
322.450F	241,010	230,929	-10,081	34,910,432S	35,141,671S	231,238H
367.650F	257,250	257,229	-21	46,243,027S	46,248,293S	5,267H
383.650F	259,236	258,962	-274	50,377,339S	50,379,330S	1,990H

HFO 14 MT TEU HOMO 14400 TEU

Trim and Stability Summary



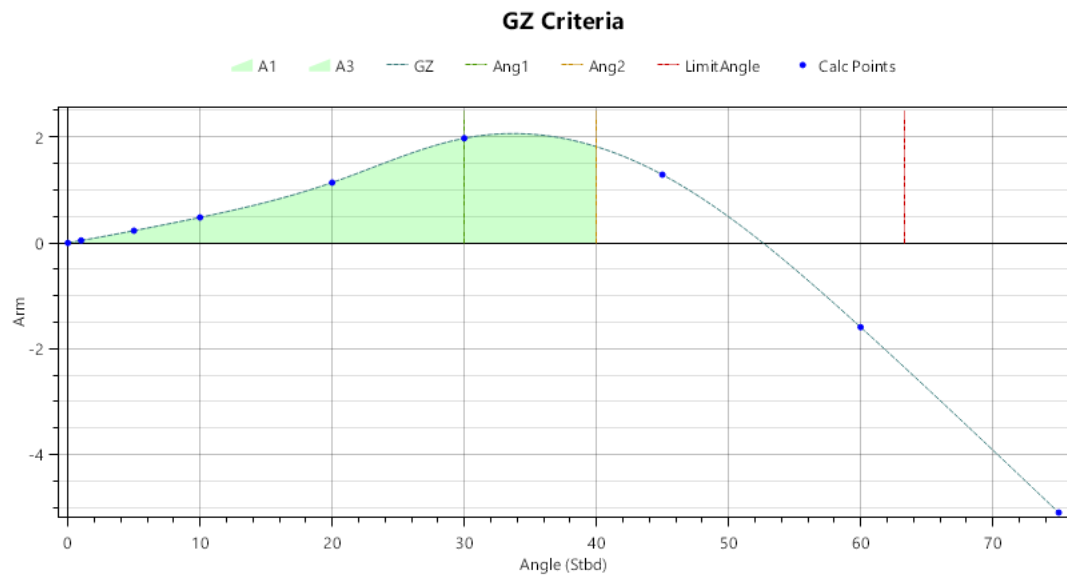
Loading					
Intact Displacement	300,572	MT	Sea Density	1.0250	MT/m ³
Deadweight	233,572	MT			
Available Deadweight	136	MT			
Stability			Trim		
KM0 Trans	29.863	m	Draft at LCF	16.538	m
VCG Upright	27.111	m-BL	LCF	181.766F	m-AP
GM0 Solid Trans	2.756	m	LCB	194.677F	m-AP
GM0 Trans	2.617	m	LCG	194.688F	m-AP
GMt Required	0.903	m	TPM	221.92	MT/cm
GMt Margin	1.714	m	MTM	5,958	m-MT/cm
GM at Equilibrium	2.442	m	Trim at Perps	0A	m
			Heel0	0.00	deg
			Propeller Immersion	155.84	%
Drafts - Perps			Drafts - Marks		
AP	16.647	m	Fwd	16.417	m
MS	16.529	m	Mid	16.531	m
FP	16.411	m	Aft	16.636	m
Strength					
Shear Min	-18,164	MT			
Shear Max	23,081	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	2,272,675H	m-MT			
Moment Max Sag	3,818S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	338.492	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
39 Tanks from Geometry
0 Tanks from Tables
70 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

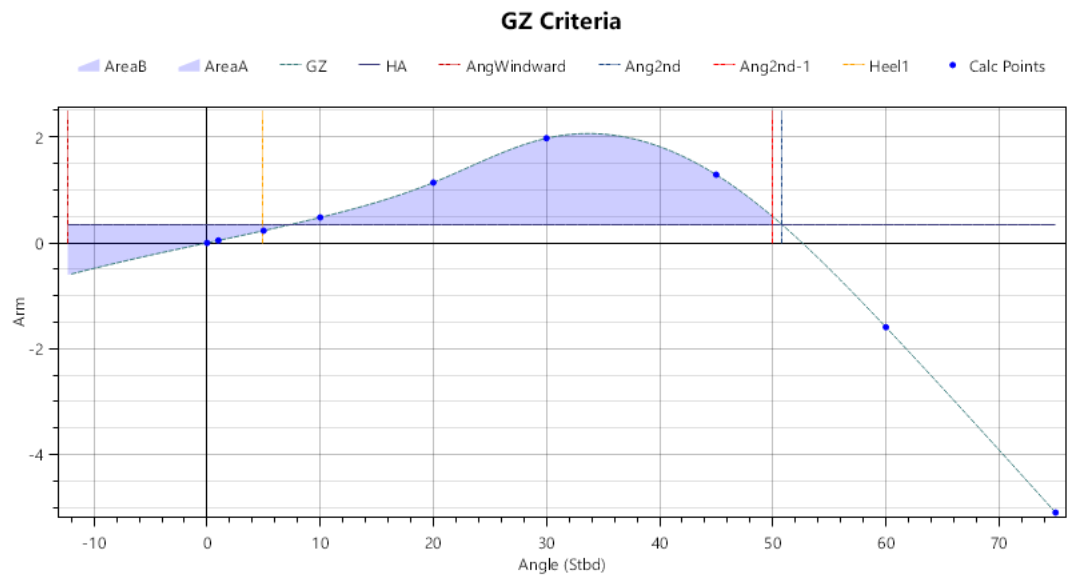
Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	233,572 MT		233,708 MT
Pass	Propeller Immersion	155.84 %	100.00 %	
Pass	Visibility	338.492 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	2.617 m	0.903 m	

2008 IS Code 2.2 General Criteria



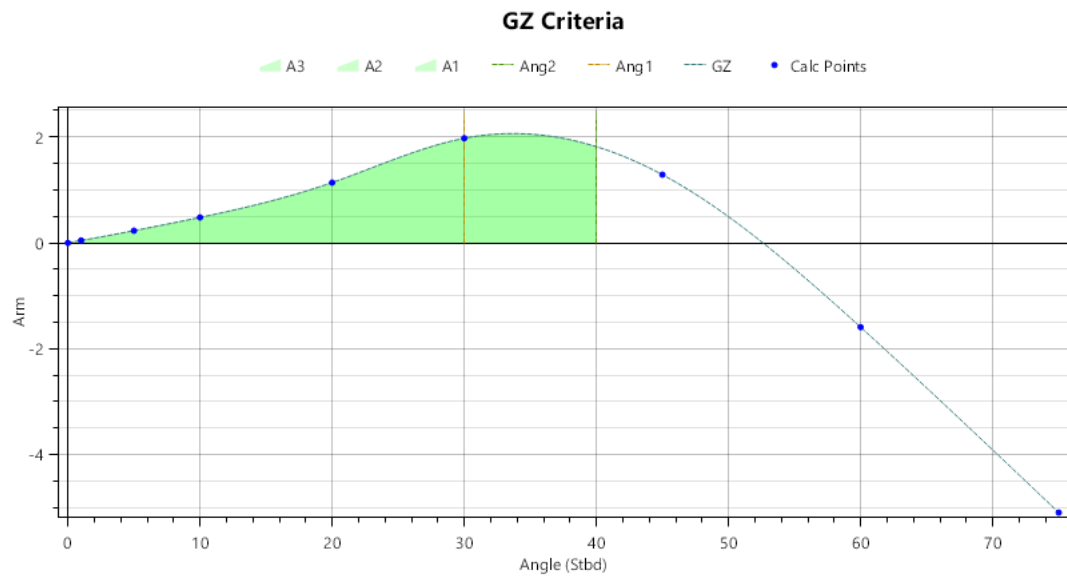
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.45 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.80 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.35 m-rad	0.03 m-rad	
	Angle to Downflooding	63.28 deg		
Pass	Angle at Maximum GZ	33.70 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	2.065 m	0.200 m	
Pass	Initial Metacentric Height	2.617 m	0.150 m	
	Range of Positive GZ	52.60 deg		

2008 IS Code 2.3 Weather Criteria



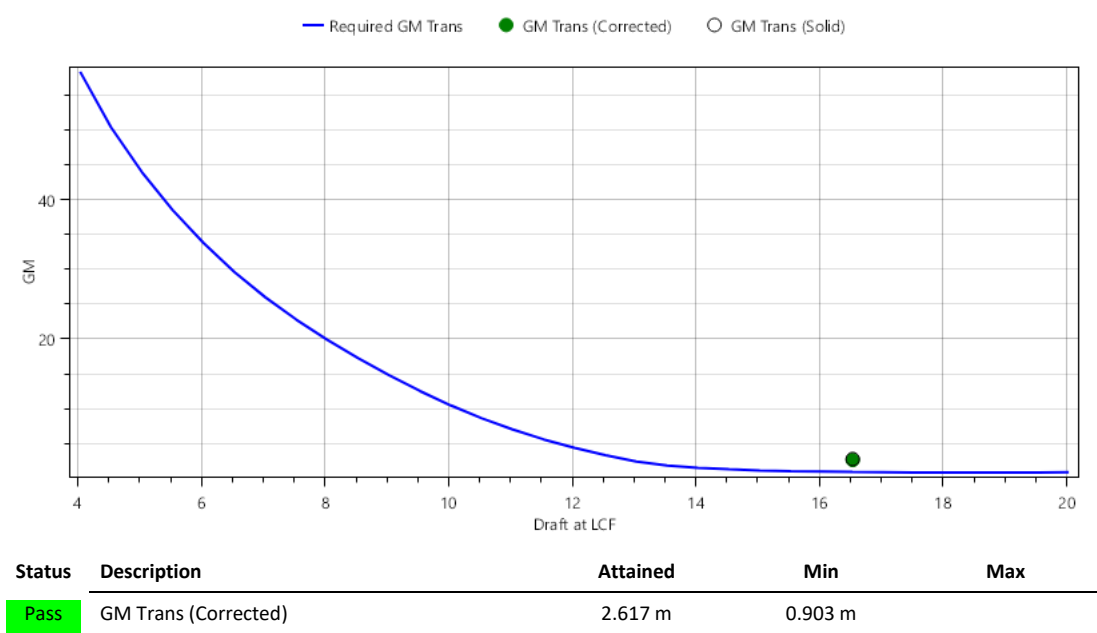
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2263016749		
	Steady Wind Heeling Lever LW1	0.226 m		
	80% Deck Edge Immersion Angle	14.82 deg		
Pass	Heeling Angle at LW1	4.95 deg		14.82 deg
	Gusty Wind Heeling Lever LW2	0.339 m		
	Heeling Angle at LW2	7.28 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.26 deg		
	Angle Windward	-12.30 deg		
	Second Intersect	50.84 deg		
	Limiting Angle	50.00 deg		
	Capsizing Area A	-0.16 m-rad		
	Righting Area B	0.75 m-rad		
Pass	Area Ratio B/A	4.7114715218	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0409492811		
Pass	Area to 30.00	0.45 m-rad	0.22 m-rad	
Pass	Area to 40.00	0.80 m-rad	0.39 m-rad	
Pass	Area 30.00 to 40.00	0.35 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	33.70 deg	30.00 deg	
Pass	Maximum GZ	2.065 m	1.026 m	
Pass	Maximum GZ Above 30 Deg	2.065 m	0.806 m	
	Initial Metacentric Height	2.617 m		
	Range of Positive GZ	52.60 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,000	181.713F	22.826	0.000	0
	SEAWATER BALLAST	20,364	319.493F	7.615	0.001P	14,184
	HEAVY FUEL OIL	5,422	248.726F	12.213	0.990P	2,723
	DIESEL OIL	4,223	247.546F	10.944	1.115S	1,765
	LUBE OIL	578	58.710F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	363	44.140F	3.060	2.546P	1,398
	Containers In Hold	90,440	190.180F	15.182	0.000	0
	Containers On Deck	111,160	180.586F	44.444	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		300,572	194.688F	27.107	0.001S	20,249

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,000	181.713F	22.826	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1 WWBT S	4,837	90.00	4,353	1.0250	4,462	7,092
1 WWBT P	4,837	90.00	4,353	1.0250	4,462	7,092
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0

HEAVY FUEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
NO 2 HFO SERV TK	140	50.00	70	0.9800	69	16
NO 1 HFO SERV TK	140	50.00	70	0.9800	69	16
NO 2 HFO SETT TK	140	50.00	70	0.9800	69	16
NO 1 HFO SETT TK	140	50.00	70	0.9800	69	16
HFO OVERFLOW TANK	357	10.00	36	0.9800	35	991
ULHFO 2S	1,544	95.00	1,467	0.9800	1,438	417
ULHFO 2P	1,544	95.00	1,467	0.9800	1,438	417
ULHFO 1 S	1,201	95.00	1,141	0.9800	1,118	417
ULHFO 1 P	1,201	95.00	1,141	0.9800	1,118	417

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMOM Trans m-MT
MGO 3S	1,544	95.00	1,467	0.8600	1,262	366
MGO 3P	1,544	95.00	1,467	0.8600	1,262	366
MGO 4C	1,786	95.00	1,696	0.8600	1,459	977
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMOM Trans m-MT
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMOM Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMOM Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	29
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
WASTE OIL TANK	138	10.00	14	1.0000	14	103
HFO SLUDGE TANK	51	10.00	5	1.0000	5	56
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,094
ST CWT	140	100.00	140	1.0000	140	0

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 78	1,848	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 90	3,360	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	3,808	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F

Bay 82	3,192	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 74	4,312	84.950F	0.000	14.796	0	0	236	0	236	78.650F	91.250F
Bay 34	4,312	229.450F	0.000	11.901	0	0	262	0	262	223.150F	235.750F
Bay 66	4,312	113.850F	0.000	11.901	0	0	262	0	262	107.550F	120.150F
Bay 62	4,312	128.300F	0.000	11.901	0	0	262	0	262	122.000F	134.600F
Bay 58	4,312	142.750F	0.000	11.901	0	0	262	0	262	136.450F	149.050F
Bay 54	4,312	157.200F	0.000	11.901	0	0	262	0	262	150.900F	163.500F
Bay 50	4,312	171.650F	0.000	11.901	0	0	262	0	262	165.350F	177.950F
Bay 46	4,312	186.100F	0.000	11.901	0	0	262	0	262	179.800F	192.400F
Bay 42	4,312	200.550F	0.000	11.901	0	0	262	0	262	194.250F	206.850F
Bay 38	4,312	215.000F	0.000	11.901	0	0	262	0	262	208.700F	221.300F
Bay 70	4,312	99.400F	0.000	12.691	0	0	256	0	256	93.100F	105.700F
Bay 30	4,312	243.900F	0.000	11.901	0	0	262	0	262	237.600F	250.200F
Bay 26	4,312	272.800F	0.000	12.428	0	0	258	0	258	266.500F	279.100F
Bay 18	4,312	301.700F	0.000	13.744	0	0	246	0	246	295.400F	308.000F
Bay 22	4,312	287.250F	0.000	13.217	0	0	250	0	250	280.950F	293.550F
Bay 14	4,200	316.150F	0.000	15.596	0	0	224	0	224	309.850F	322.450F
Bay 10	3,864	330.600F	0.000	18.040	0	0	190	0	190	324.300F	336.900F
Bay 6	3,080	345.050F	0.000	19.883	0	0	144	0	144	338.750F	351.350F
Bay 2	2,408	359.500F	0.000	24.508	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 18	4,648	301.700F	0.000	44.445	0	0	262	0	262	295.400F	308.000F
Stack 14	4,648	316.150F	0.000	44.445	0	0	262	0	262	309.850F	322.450F
Stack 10	4,648	330.600F	0.000	44.445	0	0	238	0	238	324.300F	336.900F

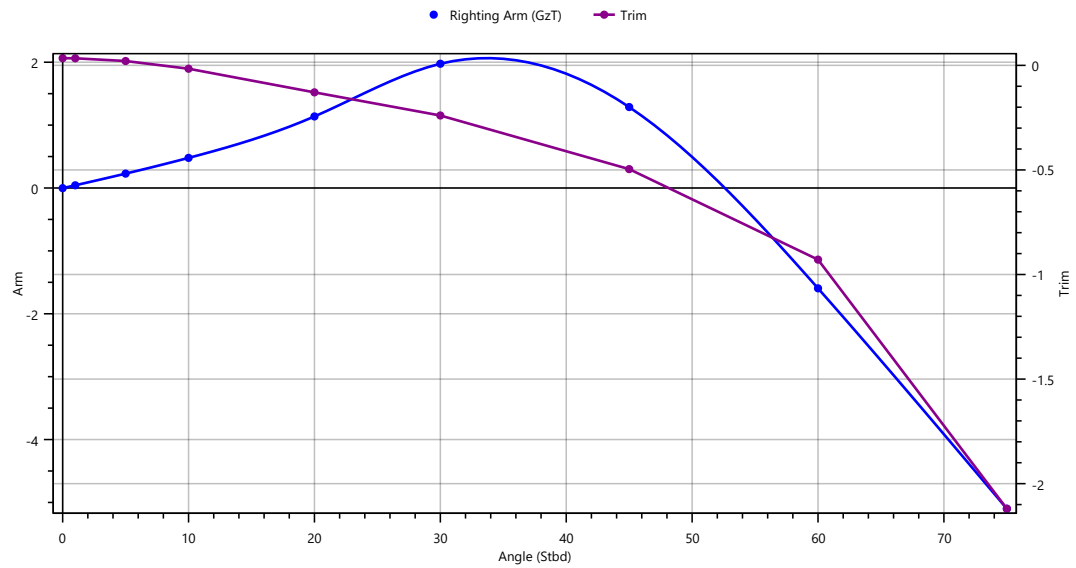
Stack 6	4,648	345.050F	0.000	44.445	0	0	238	0	238	338.750F	351.350F
Stack 2	4,256	359.500F	0.000	44.436	0	0	196	0	196	353.200F	365.800F
Stack 22	4,648	287.250F	0.000	44.445	0	0	286	0	286	280.950F	293.550F
Stack 26	4,648	272.800F	0.000	44.445	0	0	286	0	286	266.500F	279.100F
Stack 66	4,648	113.850F	0.000	44.445	0	0	310	0	310	107.550F	120.150F
Stack 34	4,648	229.450F	0.000	44.445	0	0	310	0	310	223.150F	235.750F
Stack 94	4,648	1.450F	0.000	44.440	0	0	310	0	310	4.646A	7.546F
Stack 90	4,648	15.900F	0.000	44.445	0	0	310	0	310	9.600F	22.200F
Stack 86	4,648	30.350F	0.000	44.445	0	0	310	0	310	24.050F	36.650F
Stack 82	4,648	44.800F	0.000	44.445	0	0	310	0	310	38.500F	51.100F
Stack 78	4,648	70.500F	0.000	44.445	0	0	310	0	310	64.200F	76.800F
Stack 74	4,648	84.950F	0.000	44.445	0	0	310	0	310	78.650F	91.250F
Stack 70	4,648	99.400F	0.000	44.445	0	0	310	0	310	93.100F	105.700F
Stack 62	4,648	128.300F	0.000	44.445	0	0	310	0	310	122.000F	134.600F
Stack 58	4,648	142.750F	0.000	44.445	0	0	310	0	310	136.450F	149.050F
Stack 54	4,648	157.200F	0.000	44.445	0	0	310	0	310	150.900F	163.500F
Stack 50	4,648	171.650F	0.000	44.445	0	0	310	0	310	165.350F	177.950F
Stack 46	4,648	186.100F	0.000	44.445	0	0	310	0	310	179.800F	192.400F
Stack 42	4,648	200.550F	0.000	44.445	0	0	310	0	310	194.250F	206.850F
Stack 38	4,648	215.000F	0.000	44.445	0	0	310	0	310	208.700F	221.300F
Stack 30	4,648	243.900F	0.000	44.445	0	0	310	0	310	237.600F	250.200F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000

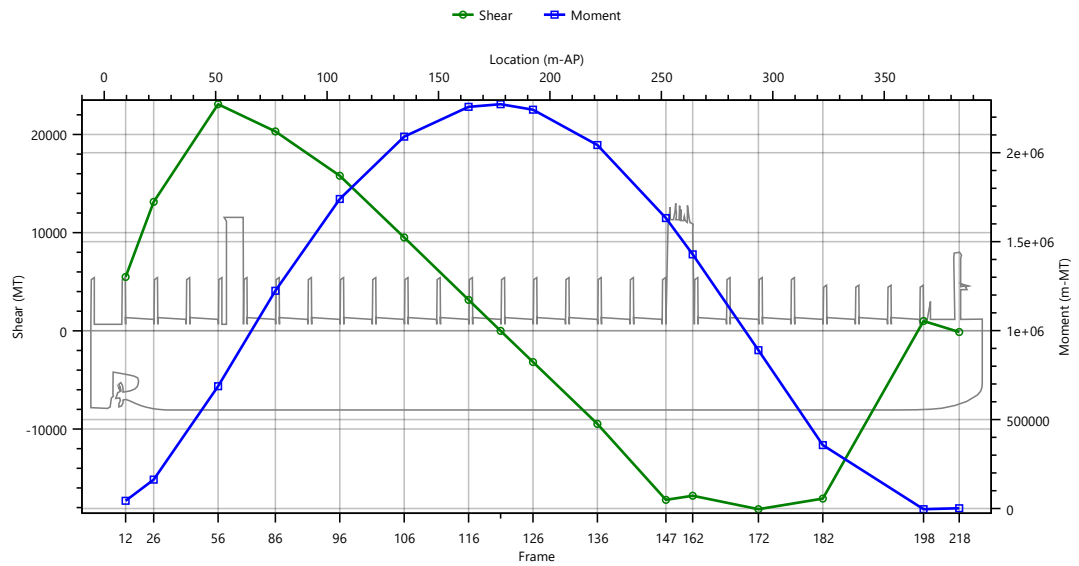
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
Stores Distributed	120	160.000F	27.200	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.03	-0.003	0.000	0.00	0.03A	16.612	16.376	5
0.00	1.00	0.03	0.043	0.001	1.00S	0.03A	16.609	16.377	2
0.00	5.00	0.02	0.229	0.000	5.00S	0.02A	16.540	16.397	3
0.00	10.00	-0.02	0.479	-0.001	10.00S	0.02F	16.338	16.448	3
0.00	20.00	-0.13	1.138	-0.002	20.00S	0.13F	15.639	16.526	3
0.00	30.00	-0.24	1.976	0.000	30.00S	0.24F	14.573	16.222	3
0.00	45.00	-0.50	1.287	-0.001	45.00S	0.50F	11.720	15.132	5
0.00	60.00	-0.93	-1.595	0.003	60.00S	0.93F	6.968	13.356	8
0.00	75.00	-2.12	-5.100	0.000	75.01S	2.12F	-5.630	8.954	9

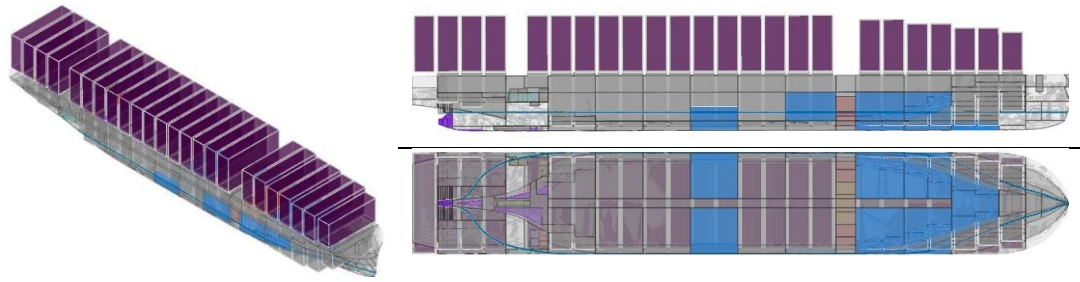
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	990	6,477	5,487	7,470S	50,916S	43,446H
22.200F	2,935	16,072	13,137	30,341S	192,785S	162,445H
51.100F	14,393	37,474	23,081	256,541S	944,045S	687,504H
76.800F	32,964	53,274	20,310	850,051S	2,074,078S	1,224,027H
105.700F	60,276	76,069	15,793	2,186,942S	3,926,928S	1,739,986H
134.600F	89,538	99,049	9,511	4,351,008S	6,441,475S	2,090,467H
163.500F	118,902	122,057	3,155	7,363,005S	9,620,819S	2,257,814H
177.867F	133,490	133,488	-3	9,176,102S	11,448,777S	2,272,675H
192.400F	148,239	145,062	-3,176	11,223,262S	13,465,054S	2,241,791H
221.300F	177,545	168,066	-9,479	15,930,910S	17,974,119S	2,043,209H
252.050F	208,655	191,443	-17,213	21,869,108S	23,501,776S	1,632,668H
264.050F	220,725	203,930	-16,795	24,445,459S	25,874,120S	1,428,661H
293.550F	249,797	231,633	-18,164	31,388,806S	32,278,716S	889,910H
322.450F	275,199	258,114	-17,085	38,988,690S	39,345,206S	356,516H
367.650F	297,247	298,248	1,001	52,016,333S	52,012,515S	3,818S
383.650F	300,102	299,981	-120	56,798,349S	56,799,853S	1,504H

HFO Backhaul 3.5 MT Hold 3 MT Deck

Trim and Stability Summary



Loading					
Intact Displacement	183,528	MT	Sea Density	1.0250	MT/m ³
Deadweight	116,528	MT			
Available Deadweight	73,889	MT			
Stability			Trim		
KM0 Trans	35.039	m	Draft at LCF	10.902	m
VCG Upright	25.714	m-BL	LCF	194.801F	m-AP
GM0 Solid Trans	9.331	m	LCB	197.578F	m-AP
GM0 Trans	9.189	m	LCG	197.609F	m-AP
GMt Required	7.429	m	TPM	193.87	MT/cm
GMt Margin	1.761	m	MTM	4,053	m-MT/cm
GM at Equilibrium	8.859	m	Trim at Perps	1A	m
			Heel0	0.00	deg
			Propeller Immersion	103.61	%
Drafts - Perps			Drafts - Marks		
AP	11.223	m	Fwd	10.591	m
MS	10.899	m	Mid	10.903	m
FP	10.574	m	Aft	11.192	m
Strength					
Shear Min	-14,669	MT			
Shear Max	16,069	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,437,451H	m-MT			
Moment Max Sag	--	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	391.950	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
47 Tanks from Geometry
0 Tanks from Tables
62 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

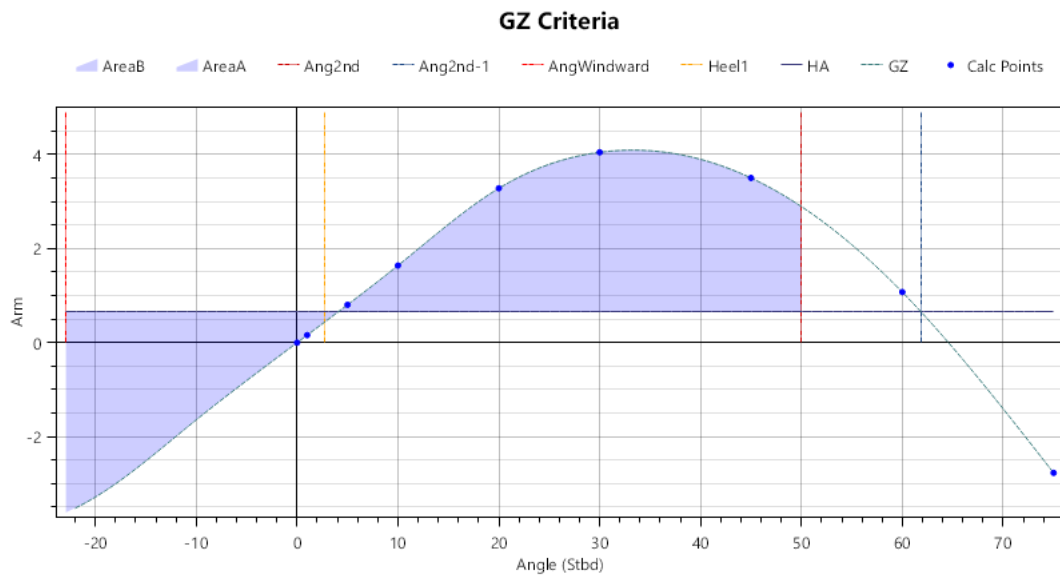
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	116,528 MT		234,070 MT
Pass	Propeller Immersion	103.61 %	100.00 %	
Pass	Visibility	391.950 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	9.189 m	7.429 m	
Pass	Design Deadweight	116,528 MT		190,417 MT

2008 IS Code 2.2 General Criteria



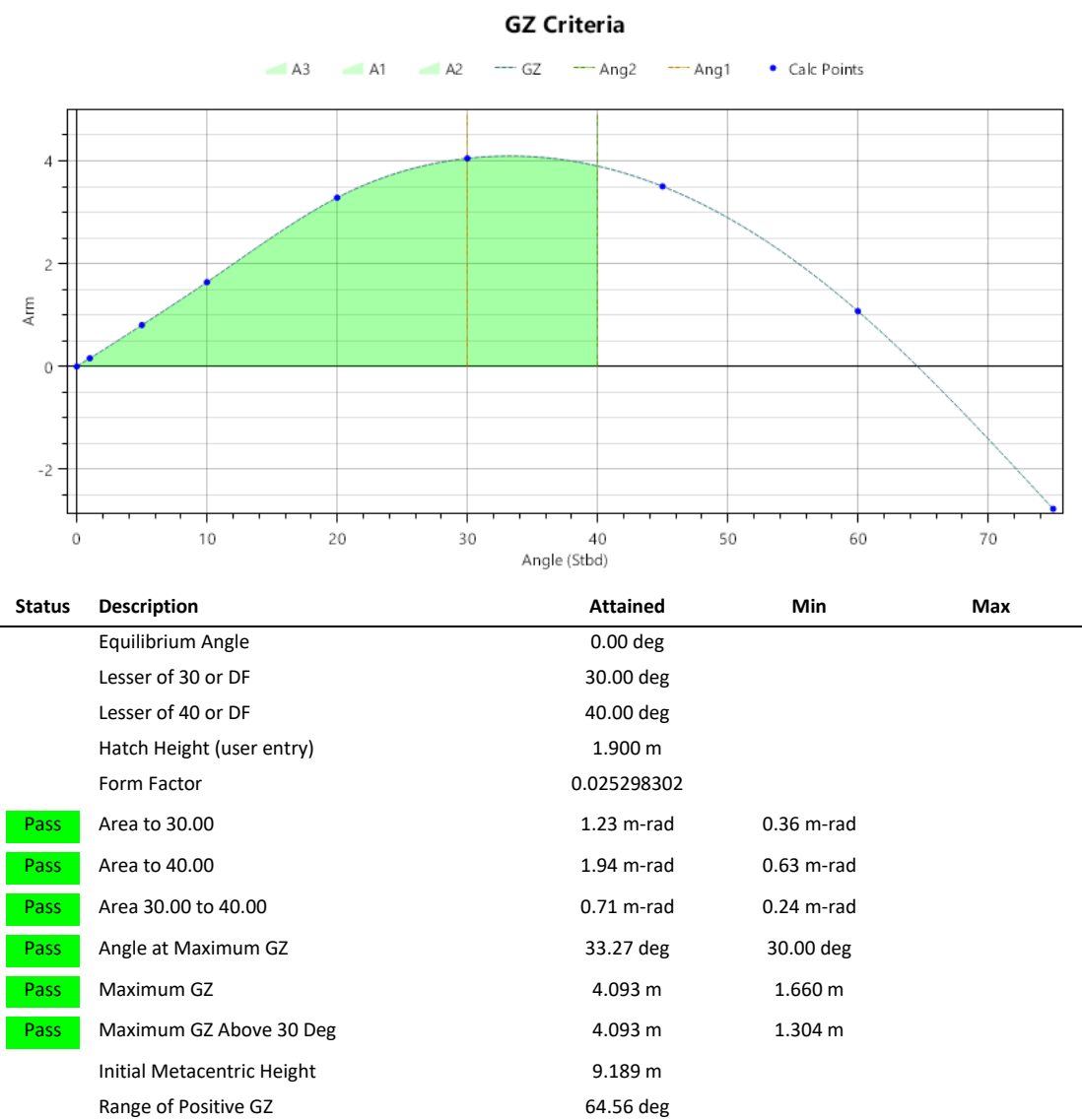
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	1.23 m-rad	0.06 m-rad	
Pass	Area to 40.00	1.94 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.71 m-rad	0.03 m-rad	
	Angle to Downflooding	75.00 deg		
Pass	Angle at Maximum GZ	33.27 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	4.093 m	0.200 m	
Pass	Initial Metacentric Height	9.189 m	0.150 m	
	Range of Positive GZ	64.56 deg		

2008 IS Code 2.3 Weather Criteria

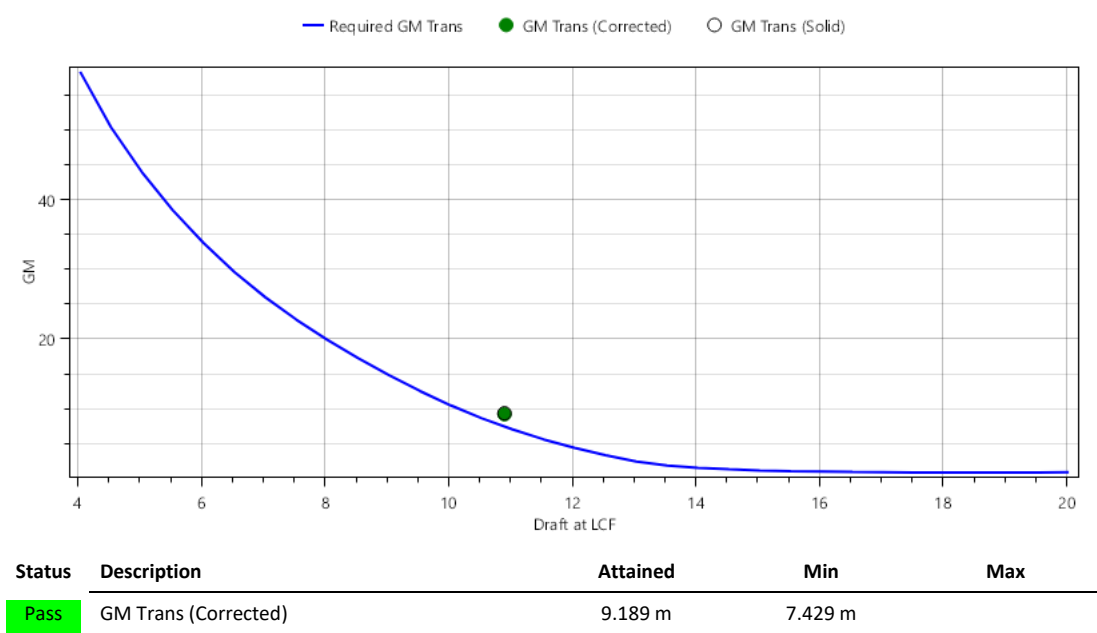


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.4308176459		
	Steady Wind Heeling Lever LW1	0.431 m		
	80% Deck Edge Immersion Angle	25.10 deg		
Pass	Heeling Angle at LW1	2.71 deg		16.00 deg
	Gusty Wind Heeling Lever LW2	0.646 m		
	Heeling Angle at LW2	4.04 deg		
	Bilge Area	0.00 m²		
	Roll Angle	25.63 deg		
	Angle Windward	-22.92 deg		
	Second Intersect	61.88 deg		
	Limiting Angle	50.00 deg		
	Capsizing Area A	-1.04 m-rad		
	Righting Area B	2.00 m-rad		
Pass	Area Ratio B/A	1.9272641437	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,000	181.713F	22.826	0.000	0
	SEAWATER BALLAST	28,042	267.523F	6.771	0.001P	83
	HEAVY FUEL OIL	5,422	248.725F	12.213	0.990P	2,723
	DIESEL OIL	4,223	247.545F	10.944	1.115S	1,765
	LUBE OIL	578	58.705F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	363	44.111F	3.060	2.543P	1,404
	Containers In Hold	34,650	194.349F	19.458	0.000	0
	Containers On Deck	42,228	172.707F	51.505	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		183,528	197.609F	25.709	0.002S	6,154

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,000	181.713F	22.826	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
6WWBT HEEL S	1,265	50.00	632	1.0250	648	41
6WWBT HEEL P	1,265	50.00	632	1.0250	648	41
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
4WWBT S	1,346	100.00	1,346	1.0250	1,380	0
3WWBT S	1,668	100.00	1,668	1.0250	1,710	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	100.00	2,173	1.0250	2,227	0
2WWBT P	2,173	100.00	2,173	1.0250	2,227	0
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3WWBT P	1,668	100.00	1,668	1.0250	1,710	0
4WWBT P	1,346	100.00	1,346	1.0250	1,380	0

HEAVY FUEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
HFO OVERFLOW TANK	357	10.00	36	0.9800	35	990

ULHFO 2S	1,544	95.00	1,467	0.9800	1,438	417
ULHFO 2P	1,544	95.00	1,467	0.9800	1,438	417
ULHFO 1 S	1,201	95.00	1,141	0.9800	1,118	417
ULHFO 1 P	1,201	95.00	1,141	0.9800	1,118	417
NO 1 HFO SETT TK	140	50.00	70	0.9800	69	16
NO 2 HFO SETT TK	140	50.00	70	0.9800	69	16
NO 2 HFO SERV TK	140	50.00	70	0.9800	69	16
NO 1 HFO SERV TK	140	50.00	70	0.9800	69	16

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
MGO 3P	1,544	95.00	1,467	0.8600	1,262	366
MGO 3S	1,544	95.00	1,467	0.8600	1,262	366
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
MGO 4C	1,786	95.00	1,696	0.8600	1,459	977
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SETT TK	74	50.00	37	0.9000	33	13

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	29
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,100
WASTE OIL TANK	138	10.00	14	1.0000	14	103
HFO SLUDGE TANK	51	10.00	5	1.0000	5	56
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 66	1,834	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 90	840	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	952	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	798	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 78	462	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 74	1,652	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 70	1,792	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 62	1,834	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 22	1,750	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 54	1,834	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	1,834	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	1,834	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	1,834	200.550F	0.000	18.250	0	0	262	0	262	194.250F	206.850F
Bay 38	1,834	215.000F	0.000	18.250	0	0	262	0	262	208.700F	221.300F
Bay 34	1,834	229.450F	0.000	18.250	0	0	262	0	262	223.150F	235.750F
Bay 30	1,834	243.900F	0.000	18.250	0	0	262	0	262	237.600F	250.200F
Bay 26	1,806	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 18	1,722	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 58	1,834	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 14	1,568	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 10	1,330	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 2	630	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F
Bay 6	1,008	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F

Containers On Deck

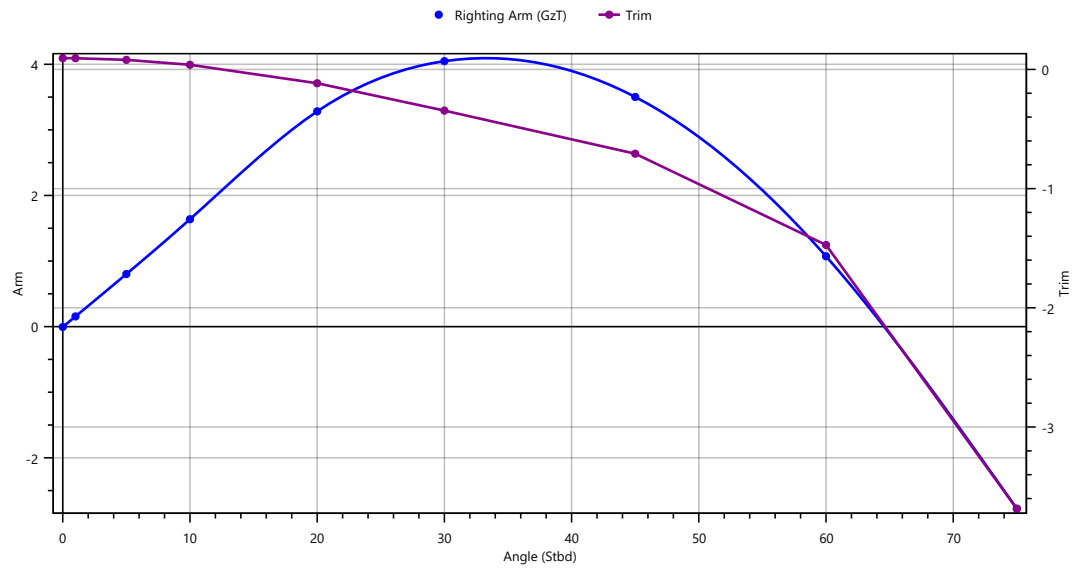
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 10	1,428	330.600F	0.000	48.326	0	0	238	0	238	324.300F	336.900F
Stack 6	1,428	345.050F	0.000	48.326	0	0	238	0	238	338.750F	351.350F
Stack 2	1,176	359.500F	0.000	47.023	0	0	196	0	196	353.200F	365.800F
Stack 14	1,572	316.150F	0.000	49.621	0	0	262	0	262	309.850F	322.450F
Stack 18	1,572	301.700F	0.000	49.621	0	0	262	0	262	295.400F	308.000F
Stack 62	1,860	128.300F	0.000	52.210	0	0	310	0	310	122.000F	134.600F
Stack 26	1,716	272.800F	0.000	50.916	0	0	286	0	286	266.500F	279.100F
Stack 94	1,860	1.450F	0.000	52.210	0	0	310	0	310	4.646A	7.546F
Stack 90	1,860	15.900F	0.000	52.210	0	0	310	0	310	9.600F	22.200F
Stack 86	1,860	30.350F	0.000	52.210	0	0	310	0	310	24.050F	36.650F
Stack 82	1,860	44.800F	0.000	52.210	0	0	310	0	310	38.500F	51.100F
Stack 78	1,860	70.500F	0.000	52.210	0	0	310	0	310	64.200F	76.800F
Stack 74	1,860	84.950F	0.000	52.210	0	0	310	0	310	78.650F	91.250F
Stack 70	1,860	99.400F	0.000	52.210	0	0	310	0	310	93.100F	105.700F
Stack 66	1,860	113.850F	0.000	52.210	0	0	310	0	310	107.550F	120.150F
Stack 58	1,860	142.750F	0.000	52.210	0	0	310	0	310	136.450F	149.050F
Stack 54	1,860	157.200F	0.000	52.210	0	0	310	0	310	150.900F	163.500F
Stack 50	1,860	171.650F	0.000	52.210	0	0	310	0	310	165.350F	177.950F
Stack 46	1,860	186.100F	0.000	52.210	0	0	310	0	310	179.800F	192.400F
Stack 42	1,860	200.550F	0.000	52.210	0	0	310	0	310	194.250F	206.850F
Stack 38	1,860	215.000F	0.000	52.210	0	0	310	0	310	208.700F	221.300F
Stack 34	1,860	229.450F	0.000	52.210	0	0	310	0	310	223.150F	235.750F
Stack 30	1,860	243.900F	0.000	52.210	0	0	310	0	310	237.600F	250.200F

Stack 1,716 287.250F 0.000 50.916 0 0 286 0 286 280.950F 293.550F
22

CONSTANT

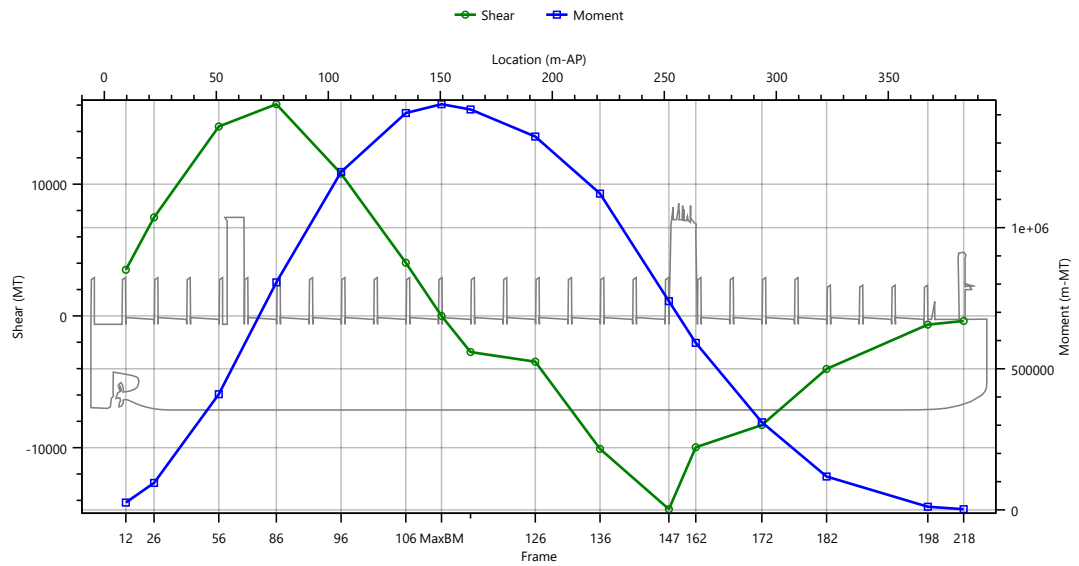
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
Water in Piping	50	160.000F	1.350	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.09	-0.005	0.001	0.00	0.09A	11.188	10.539	5
0.00	1.00	0.09	0.155	0.002	1.00S	0.09A	11.185	10.540	2
0.00	5.00	0.08	0.802	0.000	5.00S	0.08A	11.109	10.556	3
0.00	10.00	0.04	1.637	0.001	10.00S	0.04A	10.872	10.604	3
0.00	20.00	-0.12	3.282	0.004	20.00S	0.12F	9.851	10.649	3
0.00	30.00	-0.35	4.048	0.001	30.00S	0.35F	7.726	10.101	3
0.00	45.00	-0.71	3.502	-0.002	45.00S	0.71F	1.848	6.710	5
0.00	60.00	-1.47	1.073	0.000	60.01S	1.47F	-10.380	-0.249	9
0.00	75.00	-3.69	-2.777	0.000	75.03S	3.69F	-44.986	-19.605	17

Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	188	3,689	3,501	2,289S	28,194S	25,905H
22.200F	497	7,976	7,479	6,015S	101,494S	95,479H
51.100F	4,176	18,552	14,377	59,143S	469,022S	409,879H
76.800F	14,109	30,178	16,069	280,315S	1,086,475S	806,160H
105.700F	31,421	42,217	10,796	927,958S	2,125,363S	1,197,406H
134.600F	50,629	54,665	4,037	2,112,970S	3,519,143S	1,406,173H
150.540F	61,258	61,258	0	3,004,707S	4,442,159S	1,437,451H
163.500F	69,884	67,141	-2,743	3,854,545S	5,273,343S	1,418,799H
192.400F	89,058	85,582	-3,476	6,151,454S	7,474,306S	1,322,852H
221.300F	108,147	98,053	-10,093	9,001,262S	10,121,935S	1,120,673H
252.050F	128,327	113,657	-14,669	12,637,569S	13,377,200S	739,631H
264.050F	136,114	126,145	-9,969	14,224,292S	14,816,132S	591,841H
293.550F	154,620	146,335	-8,285	18,515,900S	18,826,435S	310,535H
322.450F	169,921	165,898	-4,024	23,216,927S	23,335,100S	118,173H
367.650F	181,865	181,204	-661	31,220,932S	31,232,063S	11,131H
383.650F	183,320	182,937	-383	34,144,288S	34,146,696S	2,408H

HFO Ballast Arrival

Trim and Stability Summary

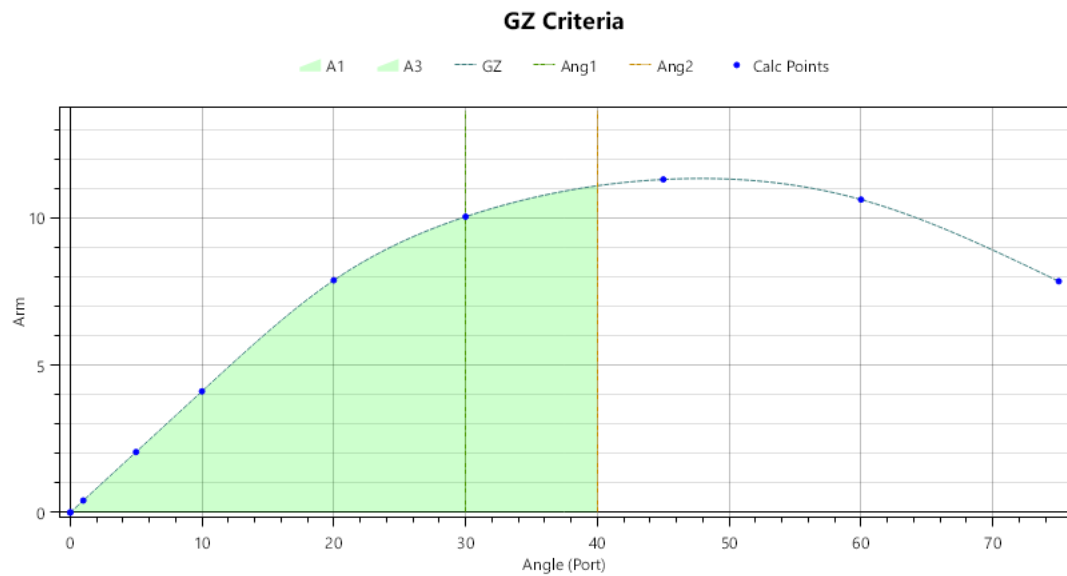


Loading					
Intact Displacement	154,113	MT	Sea Density	1.0250	MT/m ³
Deadweight	87,113	MT			
Available Deadweight	149,336	MT			
Stability			Trim		
KM0 Trans	38.675	m	Draft at LCF	9.377	m
VCG Upright	14.906	m-BL	LCF	193.922F	m-AP
GM0 Solid Trans	23.776	m	LCB	191.046F	m-AP
GM0 Trans	23.604	m	LCG	191.131F	m-AP
GMt Required	13.235	m	TPM	189.46	MT/cm
GMt Margin	10.369	m	MTM	3,869	m-MT/cm
GM at Equilibrium	23.600	m	Trim at Perps	3A	m
			Heel0	0.02P	deg
			Propeller Immersion	101.31	%
Drafts - Perps			Drafts - Marks		
AP	11.038	m	Fwd	7.752	m
MS	9.351	m	Mid	9.374	m
FP	7.663	m	Aft	10.879	m
Strength					
Shear Min	-12,938	MT			
Shear Max	14,820	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,513,689H	m-MT			
Moment Max Sag	--	m-MT			
Moment at Max %Allow	--	m-MT			
Calculation Notes					
Drafts from Keel					
Hull from Geometry					
GMt from GZ Curve Slope					
FSt Adjustment = SolidGMt-GMt					
67 Tanks from Geometry					
0 Tanks from Tables					
42 Empty Tanks					
GZ Curve from Geometry					
Downflood Angles from 3D Data					

Alarm Summary

Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	87,113 MT		236,449 MT
Pass	Propeller Immersion	101.31 %	100.00 %	
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	23.604 m	13.235 m	

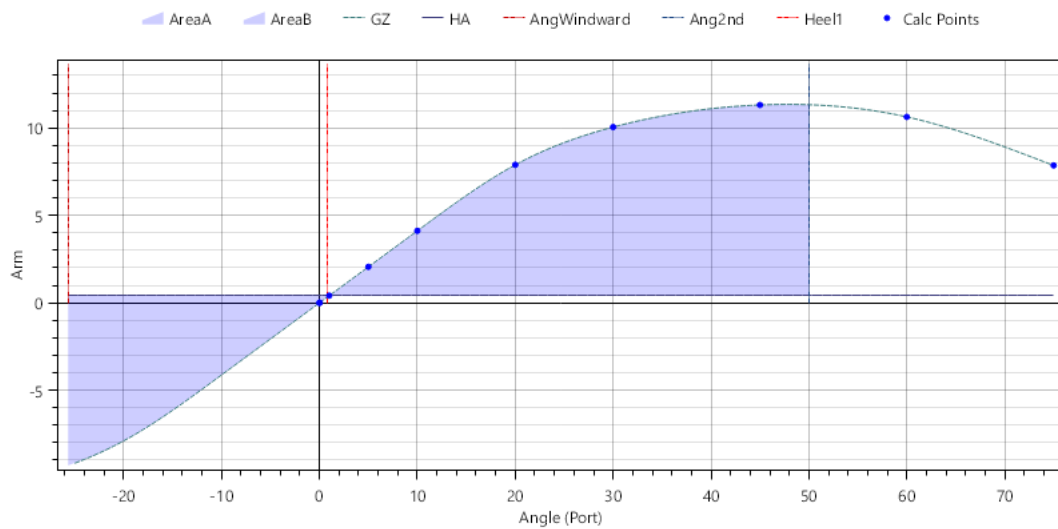
2008 IS Code 2.2 General Criteria



Status	Description	Attained	Min	Max
	Equilibrium Angle	-0.02 deg		
Pass	Area to 30.00	3.01 m-rad	0.06 m-rad	
Pass	Area to 40.00	4.87 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	1.86 m-rad	0.03 m-rad	
	Angle to Downflooding	75.00 deg		
Pass	Angle at Maximum GZ	47.84 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	11.345 m	0.200 m	
Pass	Initial Metacentric Height	23.604 m	0.150 m	
	Range of Positive GZ	74.98 deg		

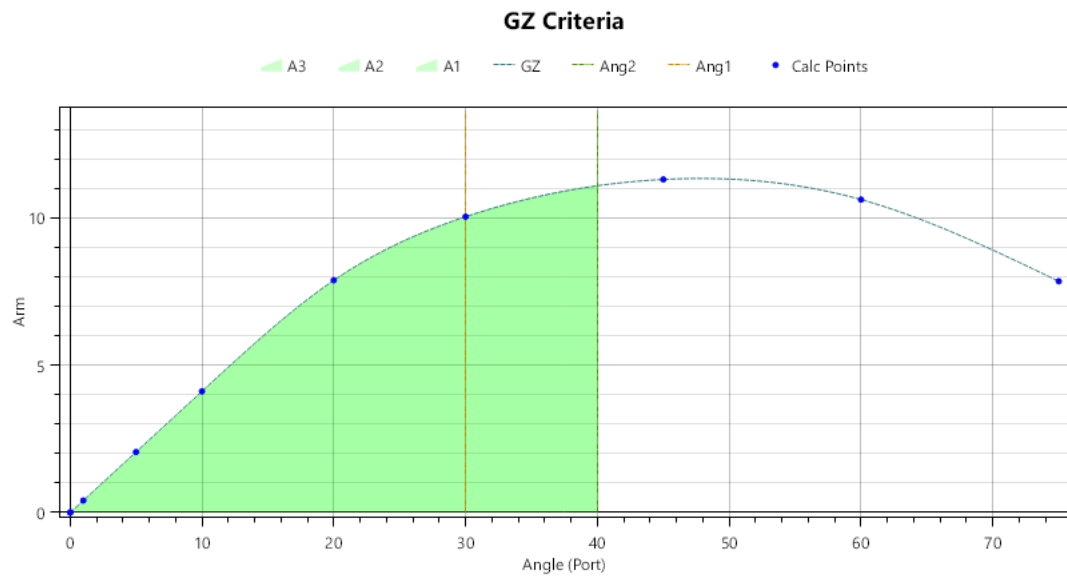
2008 IS Code 2.3 Weather Criteria

GZ Criteria



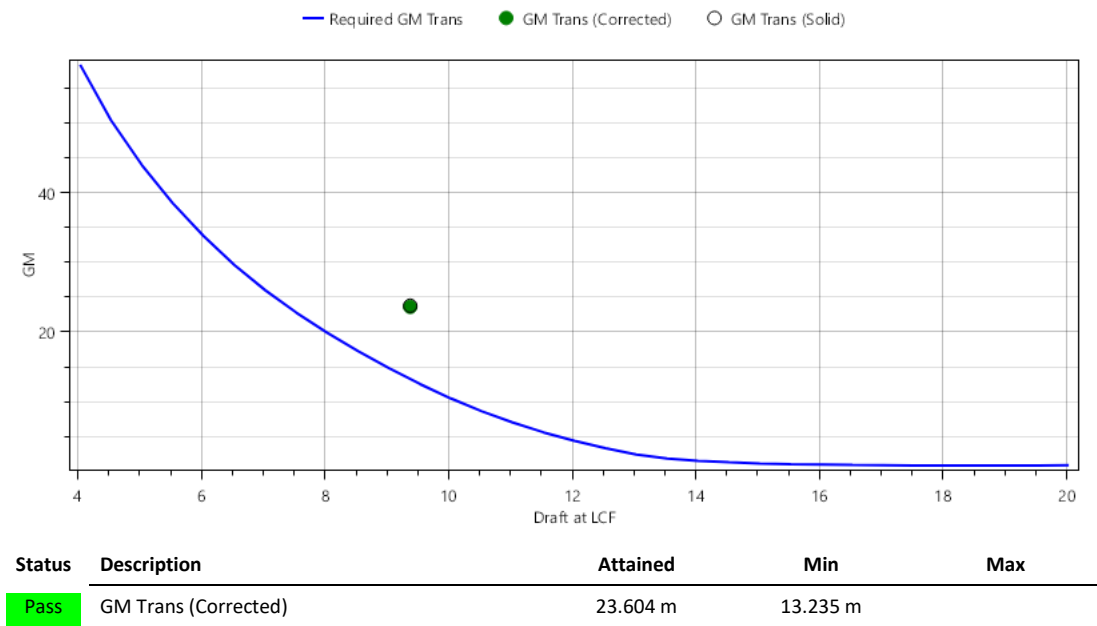
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2937141784		
	Steady Wind Heeling Lever LW1	0.294 m		
	80% Deck Edge Immersion Angle	26.08 deg		
Pass	Heeling Angle at LW1	0.74 deg		16.00 deg
	Gusty Wind Heeling Lever LW2	0.441 m		
	Heeling Angle at LW2	1.09 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	26.41 deg		
	Angle Windward	-25.68 deg		
	Second Intersect	75.00 deg		
	Limiting Angle	50.00 deg		
	Capsizing Area A	-2.49 m-rad		
	Righting Area B	6.45 m-rad		
Pass	Area Ratio B/A	2.5946108617	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.02 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0264886571		
Pass	Area to 30.00	3.01 m-rad	0.34 m-rad	
Pass	Area to 40.00	4.87 m-rad	0.60 m-rad	
Pass	Area 30.00 to 40.00	1.86 m-rad	0.23 m-rad	
Pass	Angle at Maximum GZ	47.84 deg	30.00 deg	
Pass	Maximum GZ	11.345 m	1.586 m	
Pass	Maximum GZ Above 30 Deg	11.345 m	1.246 m	
	Initial Metacentric Height	23.604 m		
	Range of Positive GZ	74.98 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,000	181.713F	22.826	0.000	0
	SEAWATER BALLAST	84,204	199.821F	8.677	0.000P	0
	HEAVY FUEL OIL	988	206.837F	11.165	5.432P	2,259
	DIESEL OIL	660	190.830F	9.224	7.129S	1,765
	LUBE OIL	168	57.489F	13.255	7.405P	150
	FRESH WATER	27	61.569F	17.466	29.211S	26
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	593	48.513F	3.350	1.641P	2,120
	Containers In Hold	0				0
	Containers On Deck	0				0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		154,113	191.131F	14.899	0.014P	6,321

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,000	181.713F	22.826	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
10DBWBT S	4,871	100.00	4,871	1.0250	4,993	0
9WWBT S	1,887	100.00	1,887	1.0250	1,935	0
4WWBT P	1,346	100.00	1,346	1.0250	1,380	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
3WWBT S	1,668	100.00	1,668	1.0250	1,710	0
3WWBT P	1,668	100.00	1,668	1.0250	1,710	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
4WWBT S	1,346	100.00	1,346	1.0250	1,380	0
2WWBT S	2,173	100.00	2,173	1.0250	2,227	0
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
1 WWBT S	4,837	100.00	4,837	1.0250	4,958	0
1 WWBT P	4,837	100.00	4,837	1.0250	4,958	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
10DBWBT P	4,871	100.00	4,871	1.0250	4,993	0
2WWBT P	2,173	100.00	2,173	1.0250	2,227	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0

5WWBT S	1,265	100.00	1,265	1.0250	1,296	0
9WWBT P	1,887	100.00	1,887	1.0250	1,935	0
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
9DBWBT S	2,199	100.00	2,199	1.0250	2,254	0
9DBWBT P	2,199	100.00	2,199	1.0250	2,254	0
8WWBT S	1,263	100.00	1,263	1.0250	1,295	0
8DBWBT S	2,216	100.00	2,216	1.0250	2,271	0
8DBWBT P	2,216	100.00	2,216	1.0250	2,271	0
7WWBT S	1,265	100.00	1,265	1.0250	1,296	0
8WWBT P	1,263	100.00	1,263	1.0250	1,295	0
7DBWBT S	2,277	100.00	2,277	1.0250	2,334	0
7DBWBT P	2,277	100.00	2,277	1.0250	2,334	0
6WWBT HEEL S	1,265	100.00	1,265	1.0250	1,296	0
6WWBT HEEL P	1,265	100.00	1,265	1.0250	1,296	0
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
7WWBT P	1,265	100.00	1,265	1.0250	1,296	0
5WWBT P	1,265	100.00	1,265	1.0250	1,296	0

HEAVY FUEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 2 HFO SETT TK	140	50.00	70	0.9800	69	16
NO 1 HFO SERV TK	140	50.00	70	0.9800	69	16
NO 1 HFO SETT TK	140	50.00	70	0.9800	69	16
HFO OVERFLOW TANK	357	50.00	179	0.9800	175	1,113
ULHFO 2S	1,544	10.00	154	0.9800	151	417
ULHFO 2P	1,544	10.00	154	0.9800	151	417
ULHFO 1 S	1,201	10.00	120	0.9800	118	123
NO 2 HFO SERV TK	140	50.00	70	0.9800	69	16
ULHFO 1 P	1,201	10.00	120	0.9800	118	123

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
MGO 4C	1,786	10.00	179	0.8600	154	977
MGO 3S	1,544	10.00	154	0.8600	133	366
MGO 3P	1,544	10.00	154	0.8600	133	366

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO STOR TK	110	10.00	11	0.9000	10	19
ME LO SETT TK	74	50.00	37	0.9000	33	13

SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	10.00	7	0.9000	7	13
NO 1 CYL OIL STOR TK	183	20.00	37	0.9000	33	31
ME LO SUMP	117	50.00	58	0.9000	52	62

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	10.00	27	1.0000	27	26

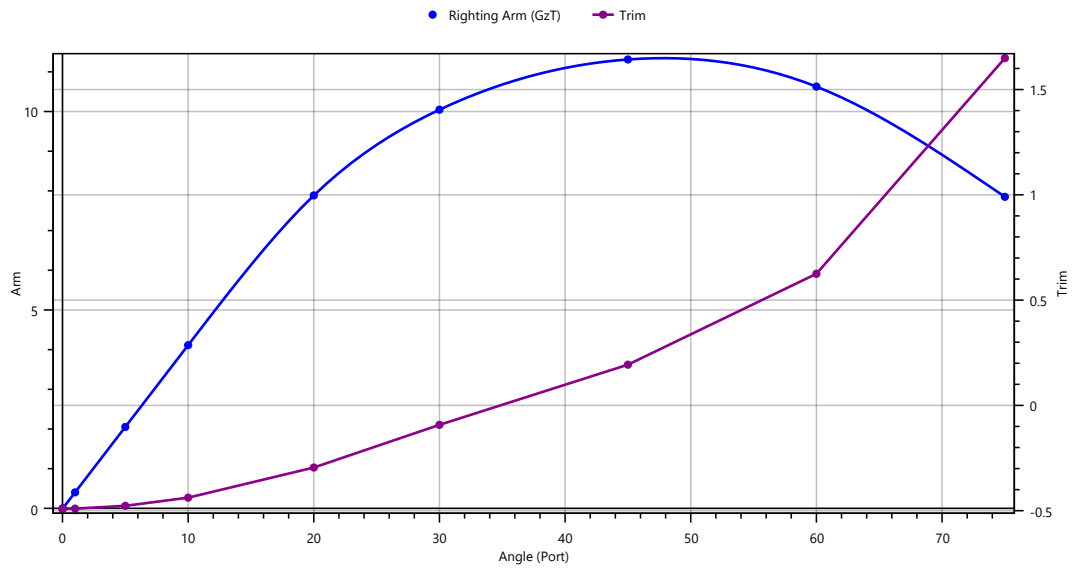
MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
GRAY WATER HOLDING TANK	177	50.00	88	1.0000	88	244
BILGE HOLDING TANK	158	50.00	79	1.0000	79	151
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,134
WASTE OIL TANK	138	50.00	69	1.0000	69	478
HFO SLUDGE TANK	51	50.00	25	1.0000	25	57
LO SLUDGE TANK	51	50.00	25	1.0000	25	57
ST CWT	140	100.00	140	1.0000	140	0

CONSTANT

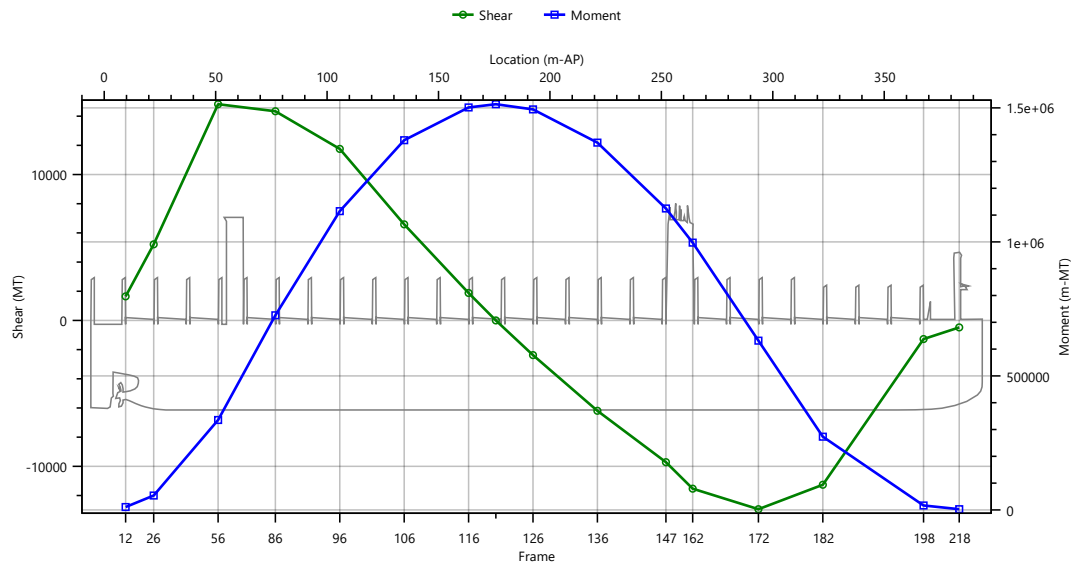
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
180.00	0.00	-0.49	-0.010	0.001	0.00	0.49A	11.003	7.628	6
180.00	0.02	-0.49	0.000	0.001	0.02P	0.49A	11.003	7.628	12
180.00	1.00	-0.49	0.402	-0.001	1.00P	0.49A	11.000	7.629	2
180.00	5.00	-0.48	2.052	0.001	5.00P	0.48A	10.922	7.642	3
180.00	10.00	-0.44	4.113	0.003	10.00P	0.44A	10.681	7.668	3
180.00	20.00	-0.30	7.886	0.004	20.00P	0.30A	9.601	7.572	3
180.00	30.00	-0.09	10.046	0.000	30.00P	0.09A	7.293	6.658	4
180.00	45.00	0.19	11.311	0.003	45.00P	0.19F	1.138	2.468	5
180.00	60.00	0.62	10.628	-0.004	60.00P	0.62F	-11.579	-7.281	8
180.00	75.00	1.65	7.851	0.000	75.01P	1.65F	-46.956	-35.613	17

Strength Summary

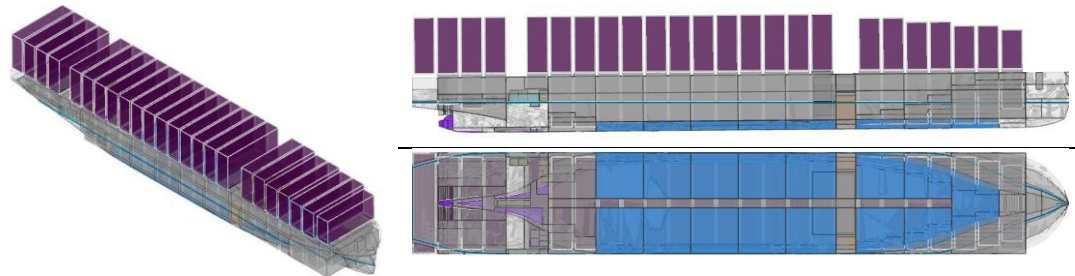


Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	181	1,829	1,648	2,230S	13,035S	10,805H
22.200F	479	5,695	5,216	5,825S	59,518S	53,693H
51.100F	3,764	18,585	14,820	54,770S	390,299S	335,530H
76.800F	12,773	27,110	14,337	254,390S	980,559S	726,169H
105.700F	28,606	40,362	11,756	842,954S	1,957,697S	1,114,742H
134.600F	45,969	52,554	6,585	1,920,812S	3,300,194S	1,379,382H
163.500F	63,019	64,902	1,882	3,496,724S	4,998,325S	1,501,601H
175.737F	70,106	70,106	0	4,311,354S	5,825,043S	1,513,689H
192.400F	79,628	77,251	-2,377	5,559,043S	7,053,364S	1,494,321H
221.300F	95,791	89,598	-6,193	8,094,917S	9,465,266S	1,370,350H
252.050F	112,462	102,747	-9,715	11,298,380S	12,423,053S	1,124,674H
264.050F	118,769	107,237	-11,532	12,685,907S	13,683,131S	997,225H
293.550F	133,378	120,440	-12,938	16,409,215S	17,040,745S	631,530H
322.450F	144,831	133,568	-11,263	20,439,672S	20,712,897S	273,224H
367.650F	153,066	151,789	-1,277	27,212,187S	27,228,799S	16,612H
383.650F	154,001	153,523	-478	29,670,075S	29,672,803S	2,727H

LNG Condition Printouts

LNG 9MT Hold 7.24 MT Deck Max Scantling Departure

Trim and Stability Summary



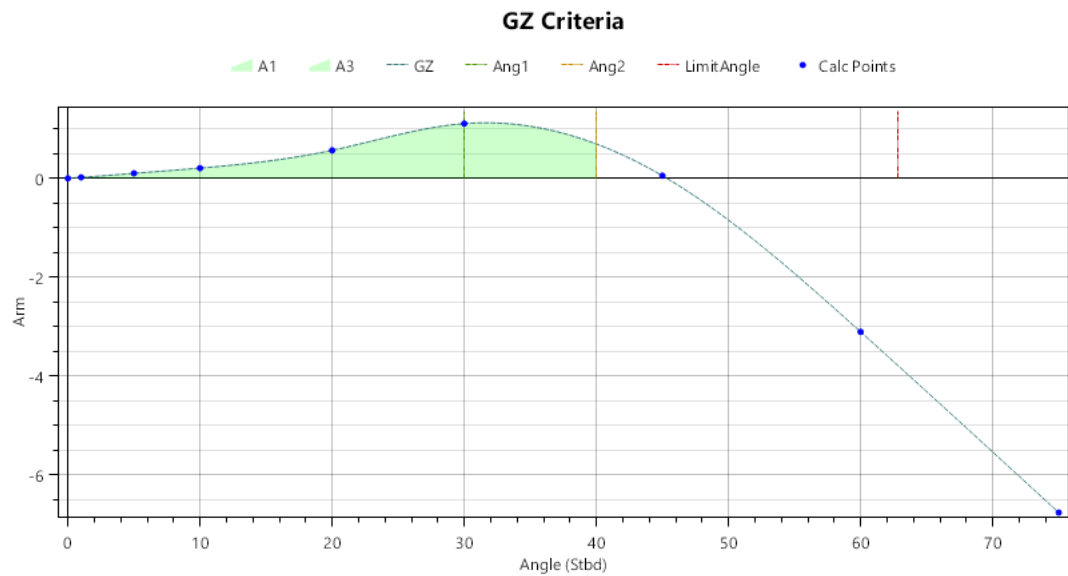
Loading					
Intact Displacement	303,756	MT	Sea Density	1.0250	MT/m ³
Deadweight	236,349	MT			
Available Deadweight	19	MT			
Stability			Trim		
KM0 Trans	30.163	m	Draft at LCF	16.695	m
VCG Upright	28.787	m-BL	LCF	178.463	m-AP
GM0 Solid Trans	1.378	m	LCB	188.053	m-AP
GM0 Trans	1.149	m	LCG	188.222	m-AP
GMt Required	0.891	m	TPM	223.61	MT/cm
GMt Margin	0.258	m	MTM	6,065	m-MT/cm
GM at Equilibrium	0.905	m	Trim at Perps	3A	m
			Heel0	0.00	deg
			Propeller Immersion	170.56	%
Drafts - Perps			Drafts - Marks		
AP	18.241	m	Fwd	14.917	m
MS	16.534	m	Mid	16.558	m
FP	14.827	m	Aft	18.080	m
Strength					
Shear Min	-6,231	MT			
Shear Max	14,474	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	950,799H	m-MT			
Moment Max Sag	67S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	378.129	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
 Hull from Geometry
 GMt from GZ Curve Slope
 FSt Adjustment = SolidGMt-GMt
 38 Tanks from Geometry
 0 Tanks from Tables
 67 Empty Tanks
 GZ Curve from Geometry
 Downflood Angles from 3D Data

Alarm Summary

Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	236,349 MT		236,368 MT
Pass	Propeller Immersion	170.56 %	100.00 %	
Pass	Visibility	378.129 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.149 m	0.891 m	

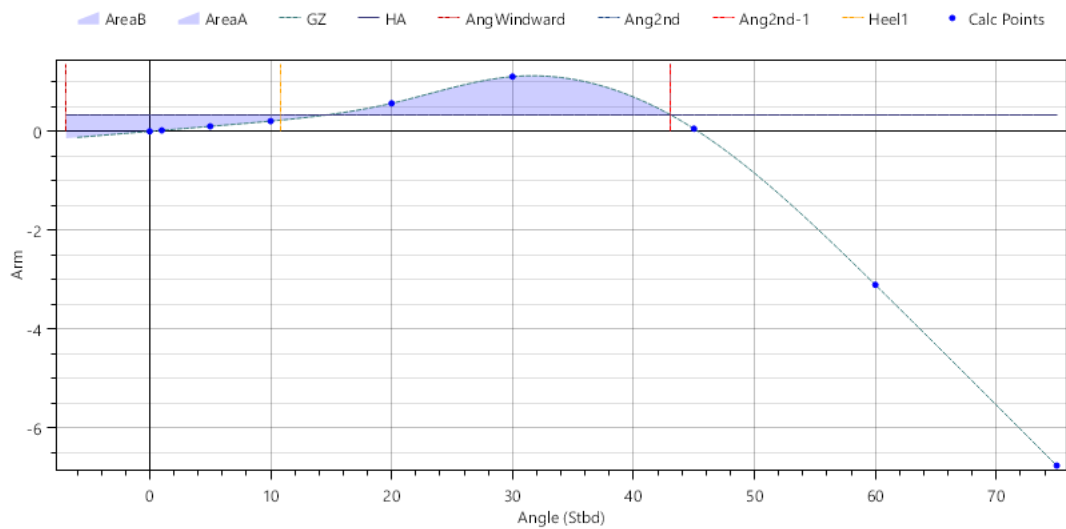
2008 IS Code 2.2 General Criteria



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.23 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.40 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.17 m-rad	0.03 m-rad	
	Angle to Downflooding	62.79 deg		
Pass	Angle at Maximum GZ	31.62 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.123 m	0.200 m	
Pass	Initial Metacentric Height	1.149 m	0.150 m	
	Range of Positive GZ	45.32 deg		

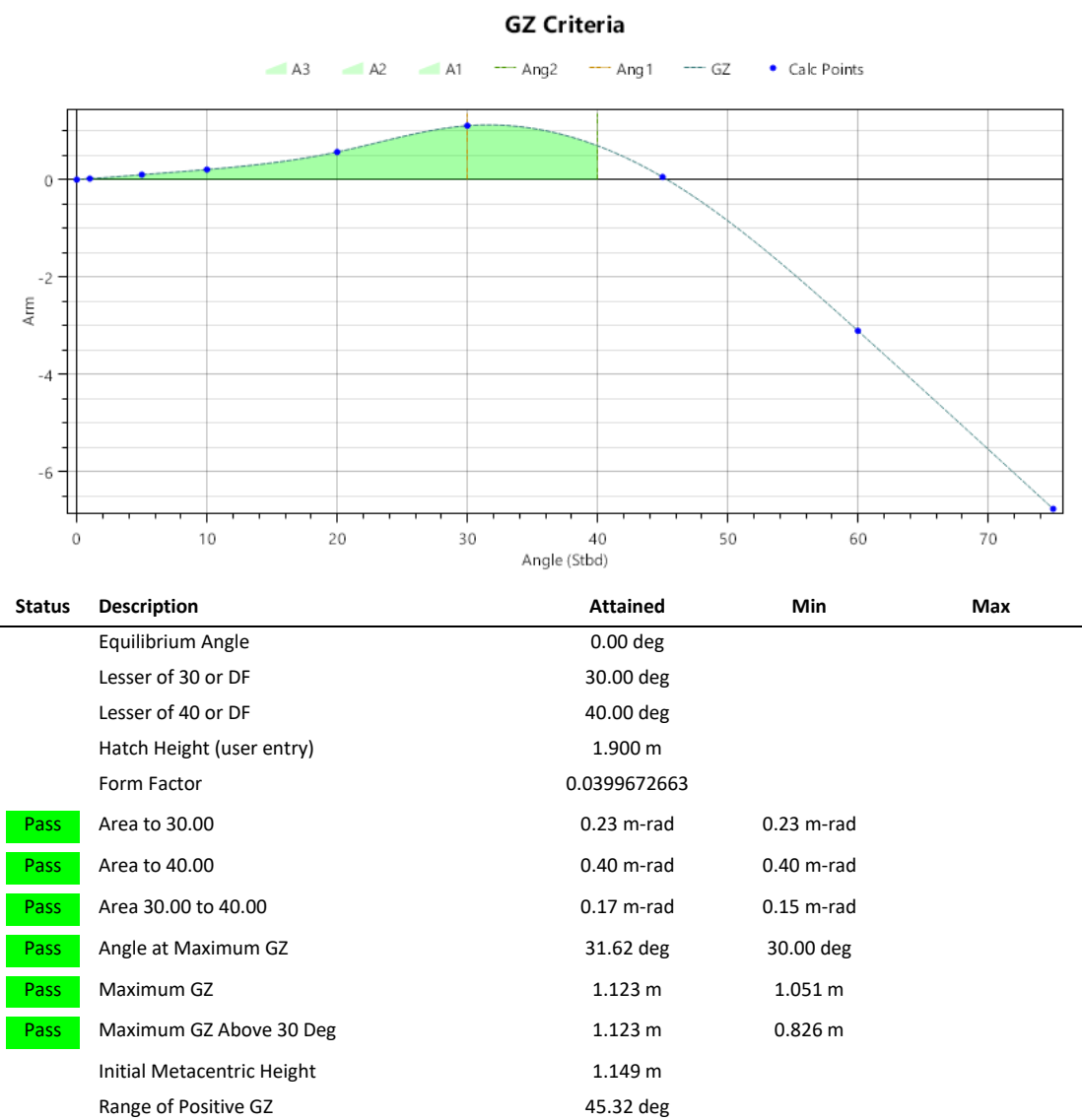
2008 IS Code 2.3 Weather Criteria

GZ Criteria

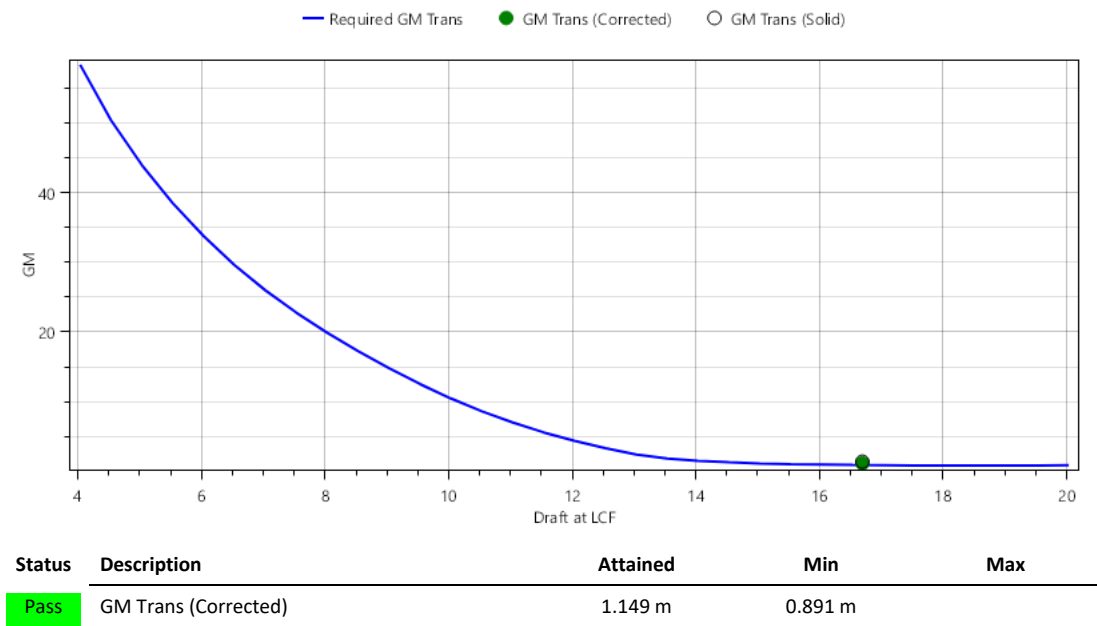


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.222773958		
	Steady Wind Heeling Lever LW1	0.223 m		
	80% Deck Edge Immersion Angle	12.01 deg		
Pass	Heeling Angle at LW1	10.81 deg		12.01 deg
	Gusty Wind Heeling Lever LW2	0.334 m		
	Heeling Angle at LW2	14.79 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.74 deg		
	Angle Windward	-6.93 deg		
	Second Intersect	43.05 deg		
	Limiting Angle	43.05 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.23 m-rad		
Pass	Area Ratio B/A	2.3717075909	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT MT	LCG m-AP	VCG m-BL	TCG m-CL	FST m-MT
	Lightship	67,407	181.878	22.830	0.000	0
	SEAWATER BALLAST	34,945	220.515	2.029	0.148P	2,350
	DIESEL OIL	3,014	243.324	13.196	1.562S	789
	LUBE OIL	578	58.672	18.954	3.418S	179
	FRESH WATER	549	62.003	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.567	2.886	2.290P	1,386
	FUEL GAS TANK	9,462	250.806	15.992	0.000	42,626
	Containers In Hold	85,176	192.061	19.500	0.000	0
	Containers On Deck	101,795	172.642	51.521	0.000	0
	CONSTANT	473	179.784	30.295	0.000	0
	Spaces	0				0
		303,756	188.222	28.785	0.002S	47,330

Lightship

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Lightship Constant	0	197.000	0.000	0.000
Lightship	67,407	181.878	22.830	0.000

SEAWATER BALLAST

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
8DBWBT S	2,216	95.54	2,117	1.0250	2,170	442
8DBWBT P	2,216	95.54	2,117	1.0250	2,170	442
7DBWBT S	2,277	100.00	2,277	1.0250	2,334	0
7DBWBT P	2,277	100.00	2,277	1.0250	2,334	0
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT P	2,173	10.00	217	1.0250	223	1,465
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0

DIESEL OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT

NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
MGO PILOT P	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT S	1,645	98.00	1,612	0.8600	1,386	366

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO SUMP	117	50.00	58	0.9000	52	62
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,134
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
ST CWT	140	100.00	140	1.0000	140	0

FUEL GAS TANK

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
TYPE-B PRISMATIC TANK	24,068	85.00	20,458	0.4625	9,462	42,626

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 82	2,052	44.800	0.000	25.856	0	0	114	0	114	38.500	51.100
Bay 90	2,160	15.900	0.000	25.564	0	0	120	0	120	9.600	22.200
Bay 86	2,448	30.350	0.000	24.394	0	0	136	0	136	24.050	36.650
Bay 78	1,188	70.500	0.000	29.617	0	0	66	0	66	64.200	76.800
Bay 38	4,716	215.000	0.000	18.250	0	0	262	0	262	208.700	221.300
Bay 70	4,608	99.400	0.000	18.640	0	0	256	0	256	93.100	105.700
Bay 66	4,716	113.850	0.000	18.250	0	0	262	0	262	107.550	120.150

Bay 62	4,716	128.300	0.000	18.250	0	0	262	0	262	122.000	134.600
Bay 58	4,716	142.750	0.000	18.250	0	0	262	0	262	136.450	149.050
Bay 54	4,716	157.200	0.000	18.250	0	0	262	0	262	150.900	163.500
Bay 50	4,716	171.650	0.000	18.250	0	0	262	0	262	165.350	177.950
Bay 46	4,716	186.100	0.000	18.250	0	0	262	0	262	179.800	192.400
Bay 42	4,716	200.550	0.000	18.250	0	0	262	0	262	194.250	206.850
Bay 74	4,248	84.950	0.000	19.431	0	0	236	0	236	78.650	91.250
Bay 34	4,320	229.450	0.000	18.115	0	0	240	0	240	223.150	235.750
Bay 30	1,260	243.900	0.000	18.618	0	0	70	0	70	237.600	250.200
Bay 22	4,500	287.250	0.000	18.736	0	0	250	0	250	280.950	293.550
Bay 26	4,644	272.800	0.000	18.500	0	0	258	0	258	266.500	279.100
Bay 18	4,428	301.700	0.000	18.952	0	0	246	0	246	295.400	308.000
Bay 14	4,032	316.150	0.000	19.655	0	0	224	0	224	309.850	322.450
Bay 10	3,348	330.600	0.000	20.588	0	0	190	0	190	324.300	336.900
Bay 6	2,592	345.050	0.000	21.828	0	0	144	0	144	338.750	351.350
Bay 2	1,620	359.500	0.000	24.782	0	0	90	0	90	353.200	365.800

Containers On Deck

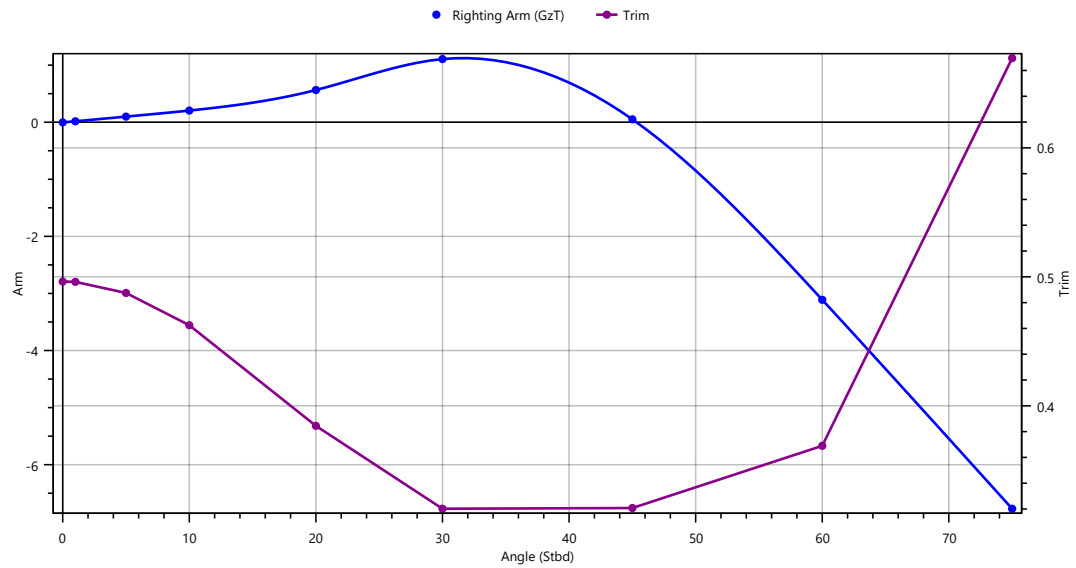
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 26	4,141	272.800	0.000	50.916	0	0	286	0	286	266.500	279.100
Stack 22	4,141	287.250	0.000	50.916	0	0	286	0	286	280.950	293.550
Stack 18	3,794	301.700	0.000	49.621	0	0	262	0	262	295.400	308.000
Stack 14	3,794	316.150	0.000	49.621	0	0	262	0	262	309.850	322.450
Stack 10	3,446	330.600	0.000	48.326	0	0	238	0	238	324.300	336.900
Stack 2	2,838	359.500	0.000	47.023	0	0	196	0	196	353.200	365.800
Stack 30	4,489	243.900	0.000	52.210	0	0	310	0	310	237.600	250.200
Stack 34	4,373	229.450	0.000	52.585	0	0	310	0	310	223.150	235.750
Stack 74	4,489	84.950	0.000	52.210	0	0	310	0	310	78.650	91.250
Stack 42	4,489	200.550	0.000	52.210	0	0	310	0	310	194.250	206.850
Stack 94	4,489	1.450	0.000	52.210	0	0	310	0	310	-4.646	7.546
Stack 90	4,489	15.900	0.000	52.210	0	0	310	0	310	9.600	22.200
Stack 38	4,489	215.000	0.000	52.210	0	0	310	0	310	208.700	221.300
Stack 86	4,489	30.350	0.000	52.210	0	0	310	0	310	24.050	36.650
Stack 78	4,489	70.500	0.000	52.210	0	0	310	0	310	64.200	76.800
Stack 70	4,489	99.400	0.000	52.210	0	0	310	0	310	93.100	105.700
Stack 66	4,489	113.850	0.000	52.210	0	0	310	0	310	107.550	120.150
Stack 62	4,489	128.300	0.000	52.210	0	0	310	0	310	122.000	134.600
Stack 58	4,489	142.750	0.000	52.210	0	0	310	0	310	136.450	149.050
Stack 54	4,489	157.200	0.000	52.210	0	0	310	0	310	150.900	163.500
Stack 50	4,489	171.650	0.000	52.210	0	0	310	0	310	165.350	177.950
Stack 46	4,489	186.100	0.000	52.210	0	0	310	0	310	179.800	192.400
Stack 82	4,489	44.800	0.000	52.210	0	0	310	0	310	38.500	51.100
Stack 6	3,446	345.050	0.000	48.326	0	0	238	0	238	338.750	351.350

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL

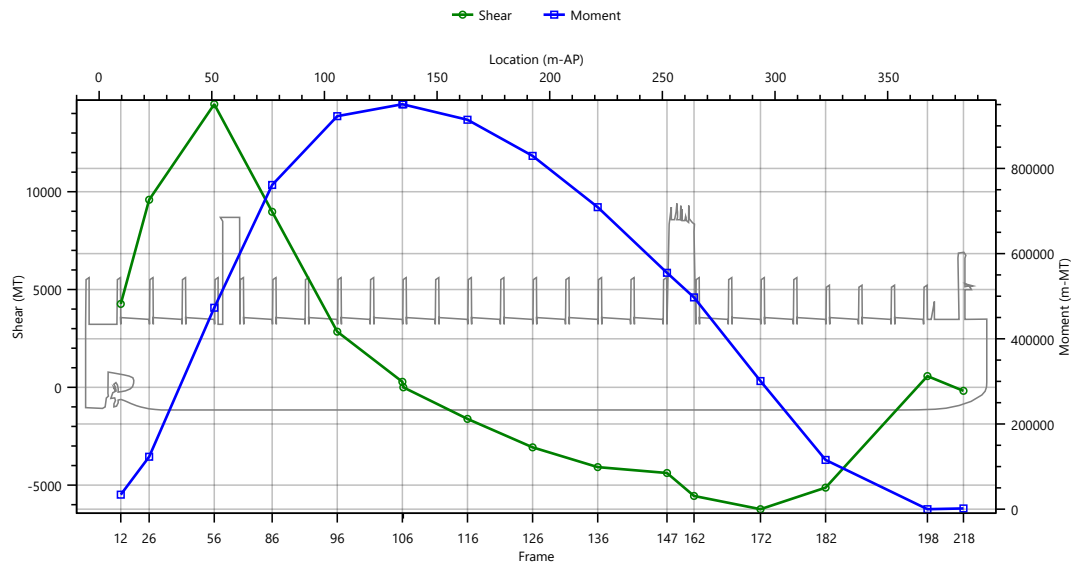
Stores Distributed	120	160.000	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000	40.000	0.000
ER Misc Tanks	50	62.350	25.000	0.000
Bosun Stores	40	385.000	28.755	0.000
Water in Piping	50	160.000	1.350	0.000
Crew & Effects	6	258.450	55.000	0.000
Provisions	7	258.450	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.50	-0.004	0.002	0.00	0.50A	18.206	14.792	6
0.00	1.00	0.50	0.016	0.000	1.00S	0.50A	18.204	14.792	2
0.00	5.00	0.49	0.098	-0.001	5.00S	0.49A	18.155	14.802	3
0.00	10.00	0.46	0.204	-0.002	10.00S	0.46A	18.006	14.826	3
0.00	20.00	0.38	0.564	-0.003	20.00S	0.38A	17.469	14.825	3
0.00	30.00	0.32	1.106	0.003	30.00S	0.32A	16.617	14.416	3
0.00	45.00	0.32	0.050	-0.005	45.00S	0.32A	14.770	12.564	4
0.00	60.00	0.37	-3.111	0.003	60.00S	0.37A	11.840	9.303	6
0.00	75.00	0.67	-6.772	0.000	75.00S	0.67A	4.876	0.271	9

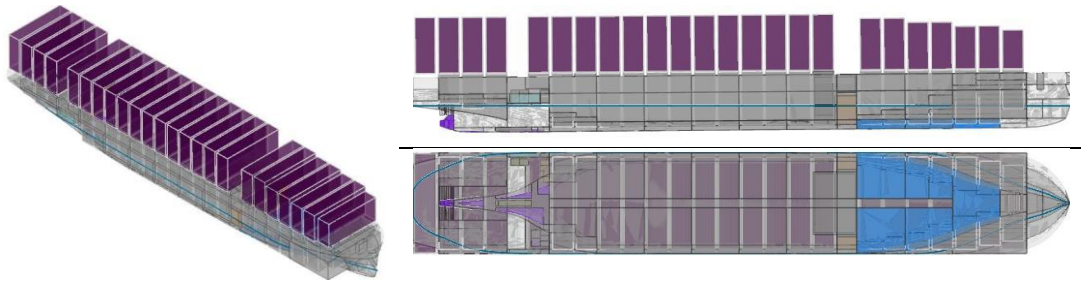
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600	2,055	6,318	4,263	15,561S	49,619S	34,057H
22.200	4,966	14,554	9,589	57,841S	180,919S	123,079H
51.100	18,667	33,141	14,474	375,704S	848,607S	472,903H
76.800	38,942	47,916	8,974	1,101,665S	1,862,887S	761,222H
105.700	67,780	70,625	2,845	2,634,373S	3,557,119S	922,746H
134.600	98,153	98,434	281	5,032,354S	5,983,096S	950,741H
135.012	98,585	98,585	0	5,072,894S	6,023,694S	950,799H
163.500	128,214	126,599	-1,615	8,304,396S	9,218,706S	914,310H
192.400	157,834	154,765	-3,069	12,438,863S	13,268,333S	829,471H
221.300	187,009	182,929	-4,080	17,422,915S	18,131,933S	709,018H
252.050	217,525	213,145	-4,381	23,644,204S	24,199,174S	554,970H
264.050	229,236	223,682	-5,554	26,324,914S	26,822,099S	497,185H
293.550	257,122	250,891	-6,231	33,502,906S	33,803,747S	300,841H
322.450	280,964	275,835	-5,129	41,292,736S	41,408,342S	115,605H
367.650	300,858	301,432	573	54,527,117S	54,527,049S	67S
383.650	303,346	303,165	-181	59,363,662S	59,365,331S	1,670H

LNG 9 MT Hold 5.74 MT Deck Max Design Departure

Trim and Stability Summary

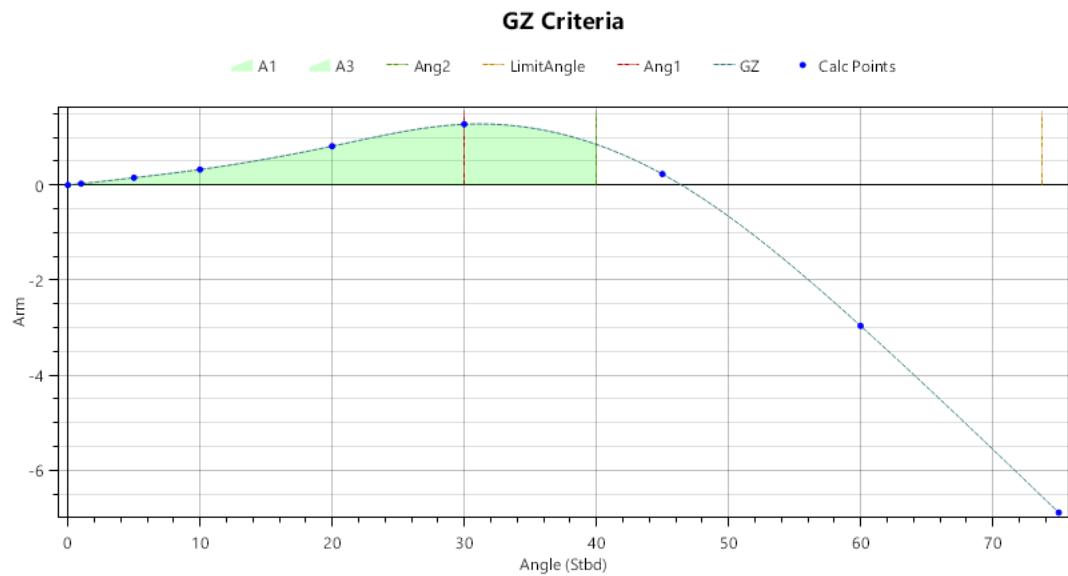


Loading					
Intact Displacement	259,314	MT	Sea Density	1.0250	MT/m ³
Deadweight	191,907	MT			
Available Deadweight	2	MT			
Stability			Trim		
KM0 Trans	31.350	m	Draft at LCF	14.667	m
VCG Upright	29.365	m-BL	LCF	180.701	m-AP
GM0 Solid Trans	1.987	m	LCB	190.058	m-AP
GM0 Trans	1.719	m	LCG	190.233	m-AP
GMt Required	1.232	m	TPM	216.78	MT/cm
GMt Margin	0.487	m	MTM	5,580	m-MT/cm
GM at Equilibrium	1.590	m	Trim at Perps	3A	m
			Heel0	0.00	deg
			Propeller Immersion	150.34	%
Drafts - Perps			Drafts - Marks		
AP	16.133	m	Fwd	13.020	m
MS	14.535	m	Mid	14.557	m
FP	12.936	m	Aft	15.983	m
Bridge Visibility					
Visibility Distance	393.524	m	Visibility Distance Required	500.000	m
Calculation Notes					
Drafts from Keel					
Hull from Geometry					
GMt from GZ Curve Slope					
FSt Adjustment = SolidGMt-GMt					
28 Tanks from Geometry					
0 Tanks from Tables					
77 Empty Tanks					
GZ Curve from Geometry					
Downflood Angles from 3D Data					

Alarm Summary

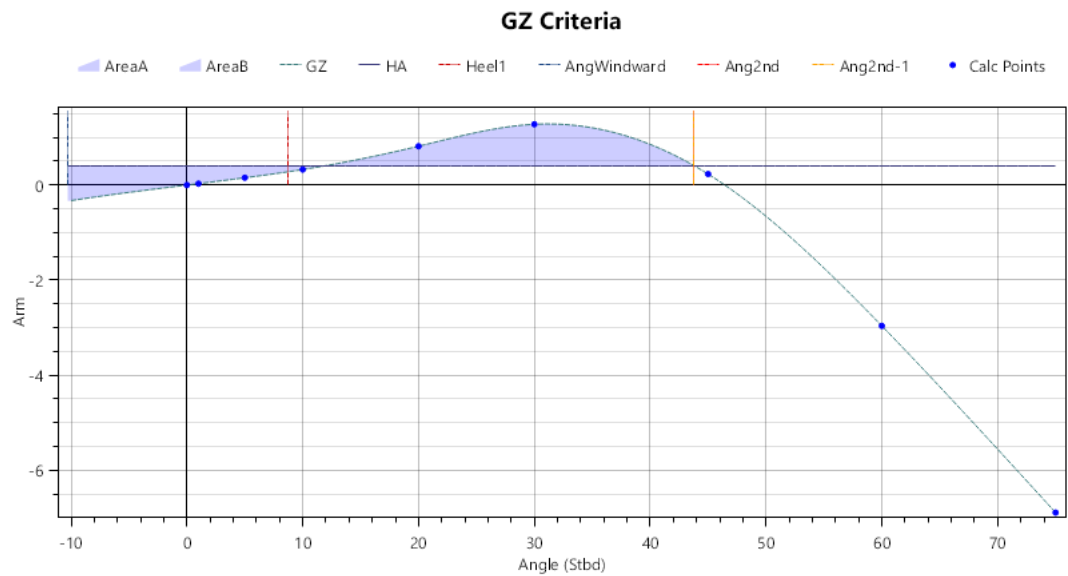
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	191,907 MT		236,140 MT
Pass	Propeller Immersion	150.34 %	100.00 %	
Pass	Visibility	393.524 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.719 m	1.232 m	
Pass	Design Deadweight	191,907 MT		191,909 MT

2008 IS Code 2.2 General Criteria



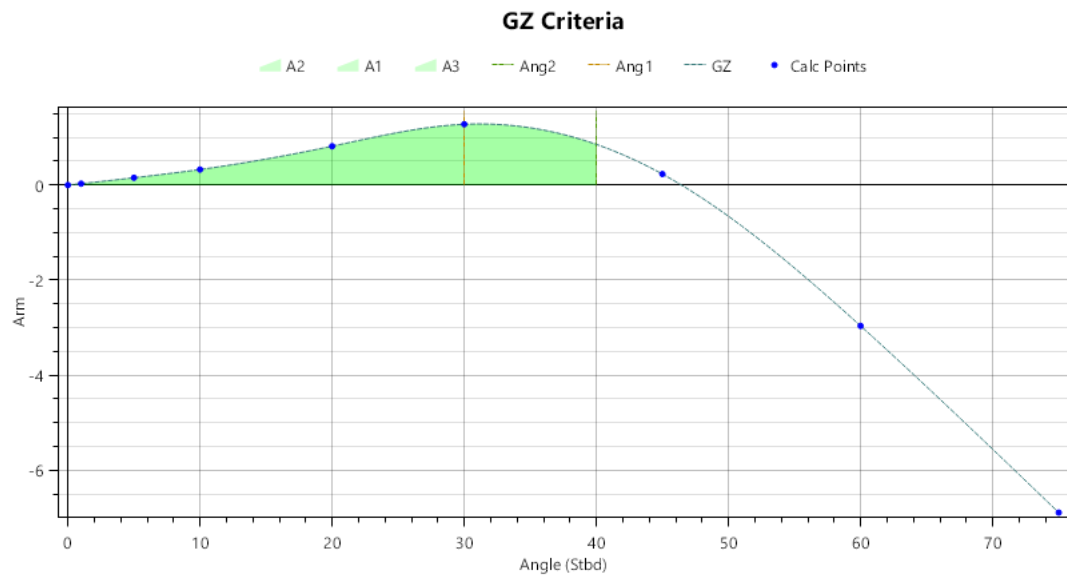
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.31 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.52 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.03 m-rad	
	Angle to Downflooding	73.68 deg		
Pass	Angle at Maximum GZ	31.15 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.285 m	0.200 m	
Pass	Initial Metacentric Height	1.719 m	0.150 m	
	Range of Positive GZ	46.44 deg		

2008 IS Code 2.3 Weather Criteria



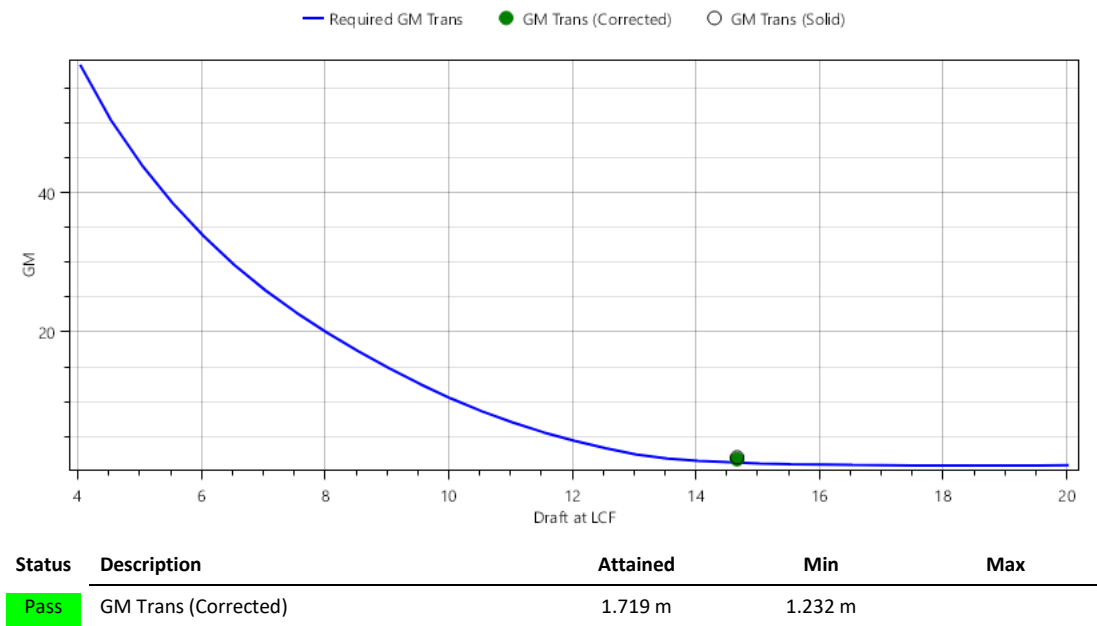
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2762422147		
	Steady Wind Heeling Lever LW1	0.276 m		
	80% Deck Edge Immersion Angle	15.86 deg		
Pass	Heeling Angle at LW1	8.70 deg		15.86 deg
	Gusty Wind Heeling Lever LW2	0.414 m		
	Heeling Angle at LW2	12.17 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	18.98 deg		
	Angle Windward	-10.28 deg		
	Second Intersect	43.73 deg		
	Limiting Angle	43.73 deg		
	Capsizing Area A	-0.15 m-rad		
	Righting Area B	0.29 m-rad		
Pass	Area Ratio B/A	1.9109144956	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0327289882		
Pass	Area to 30.00	0.31 m-rad	0.27 m-rad	
Pass	Area to 40.00	0.52 m-rad	0.49 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.18 m-rad	
Pass	Angle at Maximum GZ	31.15 deg	30.00 deg	
Pass	Maximum GZ	1.285 m	1.283 m	
Pass	Maximum GZ Above 30 Deg	1.285 m	1.008 m	
	Initial Metacentric Height	1.719 m		
	Range of Positive GZ	46.44 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT MT	LCG m-AP	VCG m-BL	TCG m-CL	FST m-MT
	Lightship	67,407	181.878	22.830	0.000	0
	SEAWATER BALLAST	11,593	302.193	2.430	0.503P	2,658
	DIESEL OIL	3,014	243.325	13.196	1.562S	789
	LUBE OIL	578	58.675	18.954	3.418S	179
	FRESH WATER	549	62.003	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.583	2.886	2.292P	1,384
	FUEL GAS TANK	9,462	250.808	15.992	0.000	42,626
	Containers In Hold	85,176	192.061	19.500	0.000	0
	Containers On Deck	80,705	172.642	51.520	0.000	0
	CONSTANT	473	179.784	30.295	0.000	0
	Spaces	0				0
		259,314	190.233	29.363	0.000S	47,636

Lightship

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Lightship Constant	0	197.000	0.000	0.000
Lightship	67,407	181.878	22.830	0.000

SEAWATER BALLAST

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT P	2,173	9.00	196	1.0250	200	1,431
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT S	2,316	98.00	2,270	1.0250	2,326	1,227

DIESEL OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
MGO PILOT S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT

SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,132
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

FUEL GAS TANK

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
TYPE-B PRISMATIC TANK	24,068	85.00	20,458	0.4625	9,462	42,626

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 86	2,448	30.350	0.000	24.394	0	0	136	0	136	24.050	36.650
Bay 82	2,052	44.800	0.000	25.856	0	0	114	0	114	38.500	51.100
Bay 78	1,188	70.500	0.000	29.617	0	0	66	0	66	64.200	76.800
Bay 74	4,248	84.950	0.000	19.431	0	0	236	0	236	78.650	91.250
Bay 70	4,608	99.400	0.000	18.640	0	0	256	0	256	93.100	105.700
Bay 66	4,716	113.850	0.000	18.250	0	0	262	0	262	107.550	120.150
Bay 62	4,716	128.300	0.000	18.250	0	0	262	0	262	122.000	134.600
Bay 58	4,716	142.750	0.000	18.250	0	0	262	0	262	136.450	149.050
Bay 90	2,160	15.900	0.000	25.564	0	0	120	0	120	9.600	22.200
Bay 54	4,716	157.200	0.000	18.250	0	0	262	0	262	150.900	163.500
Bay 50	4,716	171.650	0.000	18.250	0	0	262	0	262	165.350	177.950
Bay 42	4,716	200.550	0.000	18.250	0	0	262	0	262	194.250	206.850
Bay 46	4,716	186.100	0.000	18.250	0	0	262	0	262	179.800	192.400
Bay 38	4,716	215.000	0.000	18.250	0	0	262	0	262	208.700	221.300
Bay 34	4,320	229.450	0.000	18.115	0	0	240	0	240	223.150	235.750
Bay 30	1,260	243.900	0.000	18.618	0	0	70	0	70	237.600	250.200
Bay 26	4,644	272.800	0.000	18.500	0	0	258	0	258	266.500	279.100

Bay 22	4,500	287.250	0.000	18.736	0	0	250	0	250	280.950	293.550
Bay 14	4,032	316.150	0.000	19.655	0	0	224	0	224	309.850	322.450
Bay 10	3,348	330.600	0.000	20.588	0	0	190	0	190	324.300	336.900
Bay 6	2,592	345.050	0.000	21.828	0	0	144	0	144	338.750	351.350
Bay 18	4,428	301.700	0.000	18.952	0	0	246	0	246	295.400	308.000
Bay 2	1,620	359.500	0.000	24.782	0	0	90	0	90	353.200	365.800

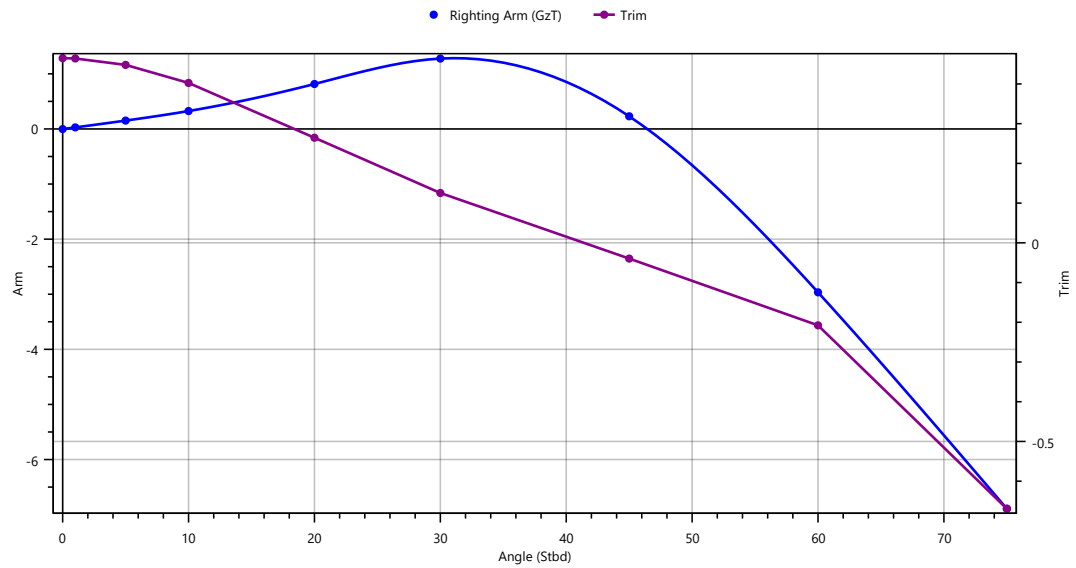
Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 34	3,467	229.450	0.000	52.585	0	0	310	0	310	223.150	235.750
Stack 30	3,559	243.900	0.000	52.210	0	0	310	0	310	237.600	250.200
Stack 22	3,283	287.250	0.000	50.916	0	0	286	0	286	280.950	293.550
Stack 18	3,008	301.700	0.000	49.621	0	0	262	0	262	295.400	308.000
Stack 14	3,008	316.150	0.000	49.621	0	0	262	0	262	309.850	322.450
Stack 10	2,732	330.600	0.000	48.326	0	0	238	0	238	324.300	336.900
Stack 6	2,732	345.050	0.000	48.326	0	0	238	0	238	338.750	351.350
Stack 2	2,250	359.500	0.000	47.023	0	0	196	0	196	353.200	365.800
Stack 38	3,559	215.000	0.000	52.210	0	0	310	0	310	208.700	221.300
Stack 42	3,559	200.550	0.000	52.210	0	0	310	0	310	194.250	206.850
Stack 86	3,559	30.350	0.000	52.210	0	0	310	0	310	24.050	36.650
Stack 50	3,559	171.650	0.000	52.210	0	0	310	0	310	165.350	177.950
Stack 94	3,559	1.450	0.000	52.210	0	0	310	0	310	-4.646	7.546
Stack 46	3,559	186.100	0.000	52.210	0	0	310	0	310	179.800	192.400
Stack 90	3,559	15.900	0.000	52.210	0	0	310	0	310	9.600	22.200
Stack 82	3,559	44.800	0.000	52.210	0	0	310	0	310	38.500	51.100
Stack 78	3,559	70.500	0.000	52.210	0	0	310	0	310	64.200	76.800
Stack 74	3,559	84.950	0.000	52.210	0	0	310	0	310	78.650	91.250
Stack 70	3,559	99.400	0.000	52.210	0	0	310	0	310	93.100	105.700
Stack 66	3,559	113.850	0.000	52.210	0	0	310	0	310	107.550	120.150
Stack 62	3,559	128.300	0.000	52.210	0	0	310	0	310	122.000	134.600
Stack 58	3,559	142.750	0.000	52.210	0	0	310	0	310	136.450	149.050
Stack 54	3,559	157.200	0.000	52.210	0	0	310	0	310	150.900	163.500
Stack 26	3,283	272.800	0.000	50.916	0	0	286	0	286	266.500	279.100

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000	40.000	0.000
ER Misc Tanks	50	62.350	25.000	0.000
Bosun Stores	40	385.000	28.755	0.000
Water in Piping	50	160.000	1.350	0.000
Crew & Effects	6	258.450	55.000	0.000
Provisions	7	258.450	40.000	0.000

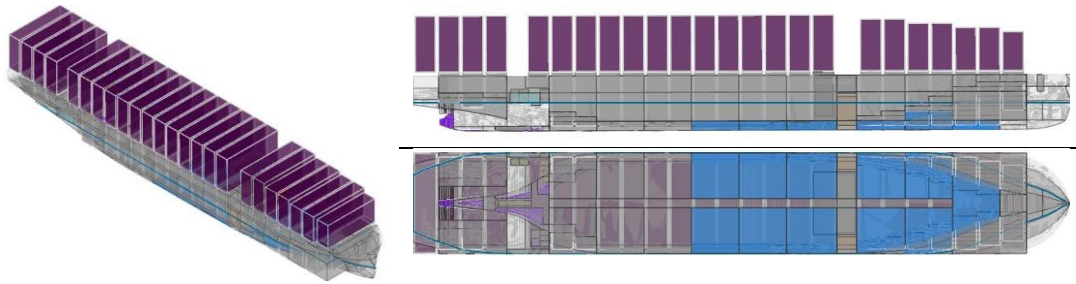
Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.46	-0.002	0.000	0.00	0.46A	16.098	12.901	5
0.00	1.00	0.46	0.028	0.001	1.00S	0.46A	16.095	12.903	2
0.00	5.00	0.45	0.152	-0.001	5.00S	0.45A	16.012	12.932	3
0.00	10.00	0.40	0.325	-0.002	10.00S	0.40A	15.775	13.007	3
0.00	20.00	0.26	0.816	-0.005	20.00S	0.26A	14.956	13.136	3
0.00	30.00	0.13	1.278	0.002	30.00S	0.13A	13.649	12.786	3
0.00	45.00	-0.04	0.230	-0.001	45.00S	0.04F	10.059	10.332	5
0.00	60.00	-0.21	-2.965	0.001	60.00S	0.21F	4.069	5.497	8
0.00	75.00	-0.67	-6.893	0.000	75.00S	0.67F	-12.227	-7.624	9

LNG 10 Tier Deck Scantling Departure 9.6 MT Deck 9 MT Hold

Trim and Stability Summary



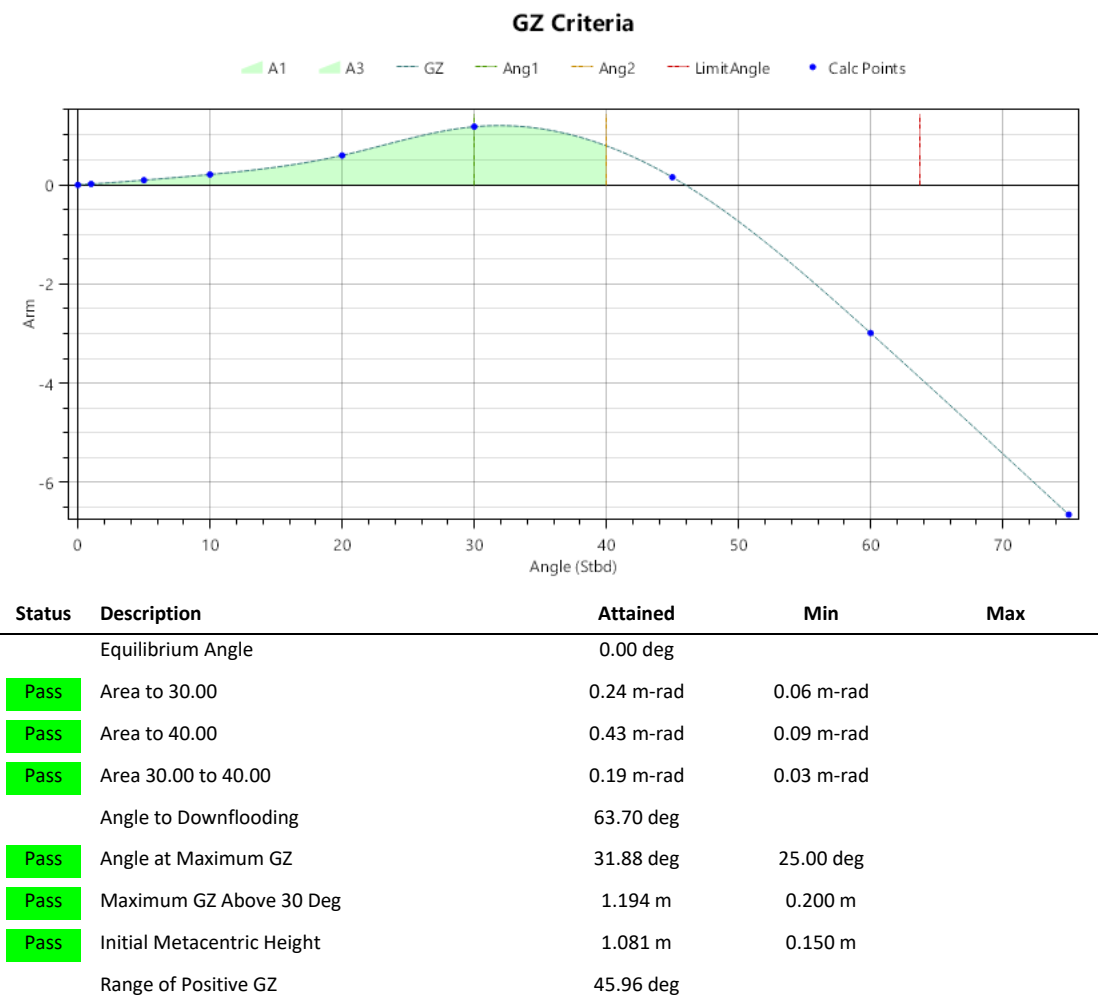
Loading					
Intact Displacement	301,536	MT	Sea Density	1.0250	MT/m ³
Deadweight	234,129	MT			
Available Deadweight	19	MT			
Stability			Trim		
KM0 Trans	29.963	m	Draft at LCF	16.583	m
VCG Upright	28.656	m-BL	LCF	180.620	m-AP
GM0 Solid Trans	1.308	m	LCB	192.708	m-AP
GM0 Trans	1.081	m	LCG	192.767	m-AP
GMt Required	0.899	m	TPM	222.62	MT/cm
GMt Margin	0.181	m	MTM	5,997	m-MT/cm
GM at Equilibrium	0.857	m	Trim at Perps	1A	m
			Heel0	0.00	deg
			Propeller Immersion	160.26	%
Drafts - Perps			Drafts - Marks		
AP	17.125	m	Fwd	15.974	m
MS	16.534	m	Mid	16.542	m
FP	15.943	m	Aft	17.069	m
Strength					
Shear Min	-9,379	MT			
Shear Max	17,527	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,377,398H	m-MT			
Moment Max Sag	2,660S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	349.673	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
35 Tanks from Geometry
0 Tanks from Tables
70 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

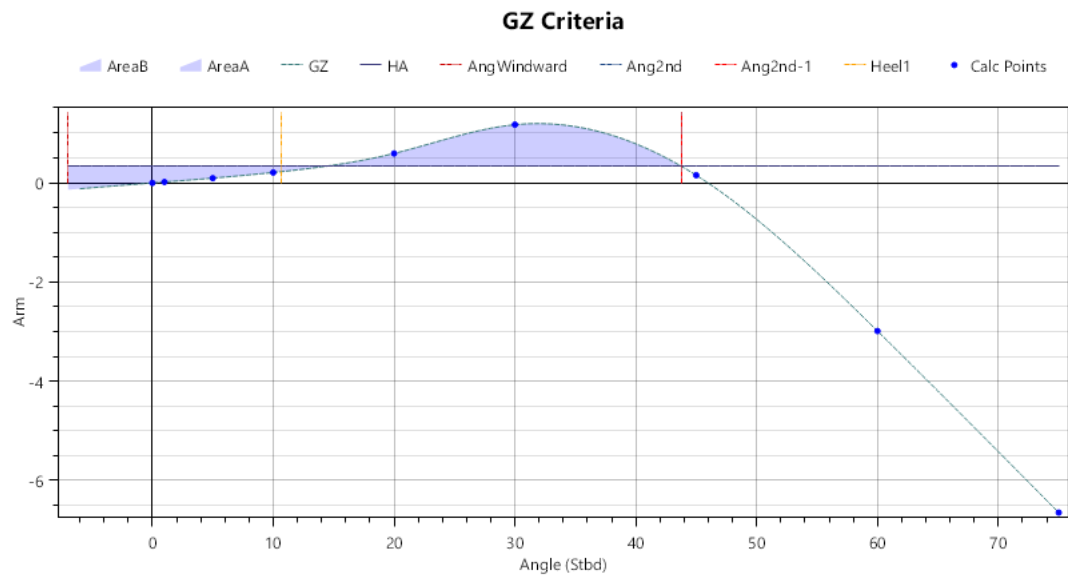
Alarm Summary

Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	234,129 MT		234,148 MT
Pass	Propeller Immersion	160.26 %	100.00 %	
Pass	Visibility	349.673 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.081 m	0.899 m	

2008 IS Code 2.2 General Criteria

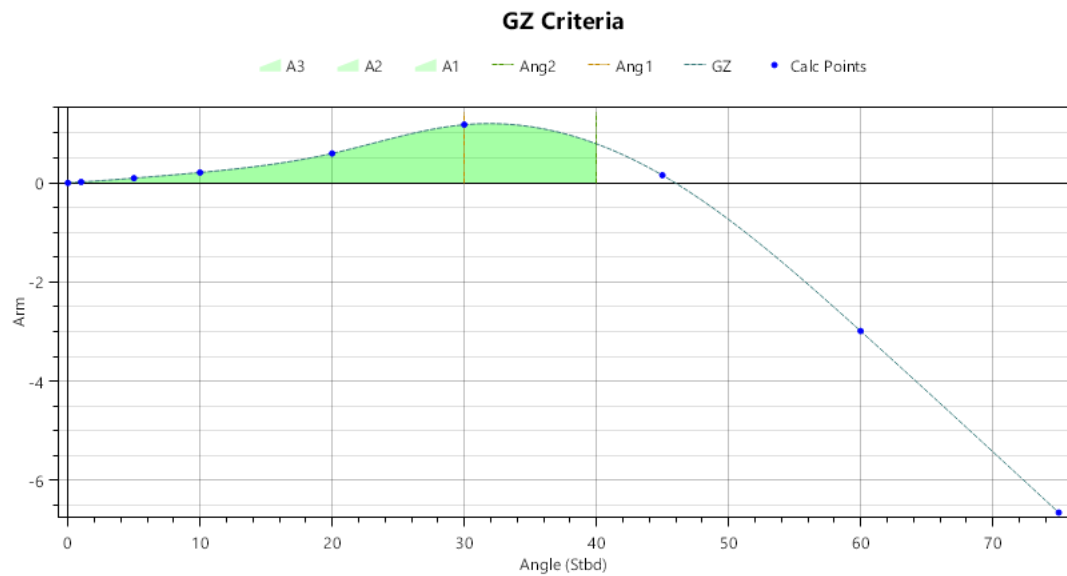


2008 IS Code 2.3 Weather Criteria



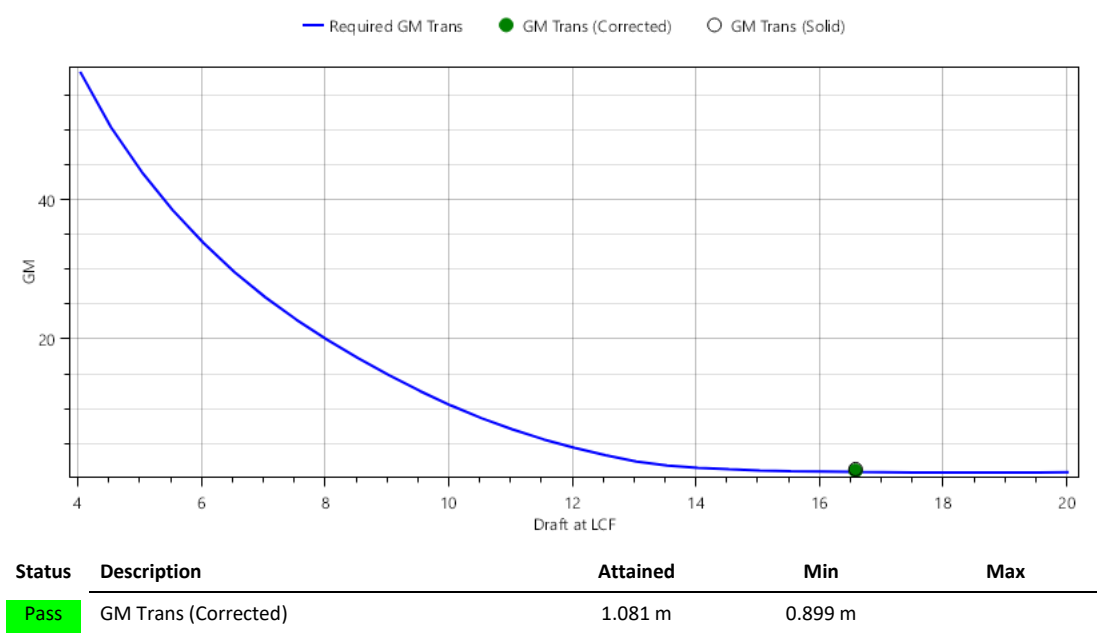
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2251559239		
	Steady Wind Heeling Lever LW1	0.225 m		
	80% Deck Edge Immersion Angle	14.00 deg		
Pass	Heeling Angle at LW1	10.72 deg		14.00 deg
	Gusty Wind Heeling Lever LW2	0.338 m		
	Heeling Angle at LW2	14.51 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.71 deg		
	Angle Windward	-6.99 deg		
	Second Intersect	43.74 deg		
	Limiting Angle	43.74 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.26 m-rad		
Pass	Area Ratio B/A	2.628664209	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0398276039		
Pass	Area to 30.00	0.24 m-rad	0.23 m-rad	
Pass	Area to 40.00	0.43 m-rad	0.40 m-rad	
Pass	Area 30.00 to 40.00	0.19 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	31.88 deg	30.00 deg	
Pass	Maximum GZ	1.194 m	1.055 m	
Pass	Maximum GZ Above 30 Deg	1.194 m	0.829 m	
	Initial Metacentric Height	1.081 m		
	Range of Positive GZ	45.96 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT MT	LCG m-AP	VCG m-BL	TCG m-CL	FST m-MT
	Lightship	67,407	181.878	22.830	0.000	0
	SEAWATER BALLAST	27,653	253.774	2.535	0.190P	1,718
	DIESEL OIL	3,014	243.328	13.196	1.562S	789
	LUBE OIL	578	58.699	18.954	3.418S	179
	FRESH WATER	549	62.003	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.726	2.885	2.310P	1,356
	FUEL GAS TANK	9,462	250.819	15.992	0.000	42,626
	Containers In Hold	85,176	192.061	19.500	0.000	0
	Containers On Deck	106,867	179.800	48.117	0.000	0
	CONSTANT	473	179.784	30.295	0.000	0
	Spaces	0				0
		301,536	192.767	28.655	0.002S	46,668

Lightship

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Lightship Constant	0	197.000	0.000	0.000
Lightship	67,407	181.878	22.830	0.000

SEAWATER BALLAST

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	39.00	848	1.0250	869	1,179
2WWBT P	2,173	48.00	1,043	1.0250	1,069	538
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0

DIESEL OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
MGO PILOT P	1,645	98.00	1,612	0.8600	1,386	365
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14

NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
MGO PILOT S	1,645	98.00	1,612	0.8600	1,386	365

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,107
WASTE OIL TANK	138	10.00	14	1.0000	14	104
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

FUEL GAS TANK

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
TYPE-B PRISMATIC TANK	24,068	85.00	20,458	0.4625	9,462	42,626

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 86	2,448	30.350	0.000	24.394	0	0	136	0	136	24.050	36.650
Bay 90	2,160	15.900	0.000	25.564	0	0	120	0	120	9.600	22.200
Bay 82	2,052	44.800	0.000	25.856	0	0	114	0	114	38.500	51.100
Bay 42	4,716	200.550	0.000	18.250	0	0	262	0	262	194.250	206.850
Bay 74	4,248	84.950	0.000	19.431	0	0	236	0	236	78.650	91.250
Bay 70	4,608	99.400	0.000	18.640	0	0	256	0	256	93.100	105.700
Bay 66	4,716	113.850	0.000	18.250	0	0	262	0	262	107.550	120.150
Bay 62	4,716	128.300	0.000	18.250	0	0	262	0	262	122.000	134.600
Bay 58	4,716	142.750	0.000	18.250	0	0	262	0	262	136.450	149.050
Bay 54	4,716	157.200	0.000	18.250	0	0	262	0	262	150.900	163.500

Bay 50	4,716	171.650	0.000	18.250	0	0	262	0	262	165.350	177.950
Bay 46	4,716	186.100	0.000	18.250	0	0	262	0	262	179.800	192.400
Bay 78	1,188	70.500	0.000	29.617	0	0	66	0	66	64.200	76.800
Bay 38	4,716	215.000	0.000	18.250	0	0	262	0	262	208.700	221.300
Bay 34	4,320	229.450	0.000	18.115	0	0	240	0	240	223.150	235.750
Bay 26	4,644	272.800	0.000	18.500	0	0	258	0	258	266.500	279.100
Bay 30	1,260	243.900	0.000	18.618	0	0	70	0	70	237.600	250.200
Bay 22	4,500	287.250	0.000	18.736	0	0	250	0	250	280.950	293.550
Bay 18	4,428	301.700	0.000	18.952	0	0	246	0	246	295.400	308.000
Bay 14	4,032	316.150	0.000	19.655	0	0	224	0	224	309.850	322.450
Bay 10	3,348	330.600	0.000	20.588	0	0	190	0	190	324.300	336.900
Bay 6	2,592	345.050	0.000	21.828	0	0	144	0	144	338.750	351.350
Bay 2	1,620	359.500	0.000	24.782	0	0	90	0	90	353.200	365.800

Containers On Deck

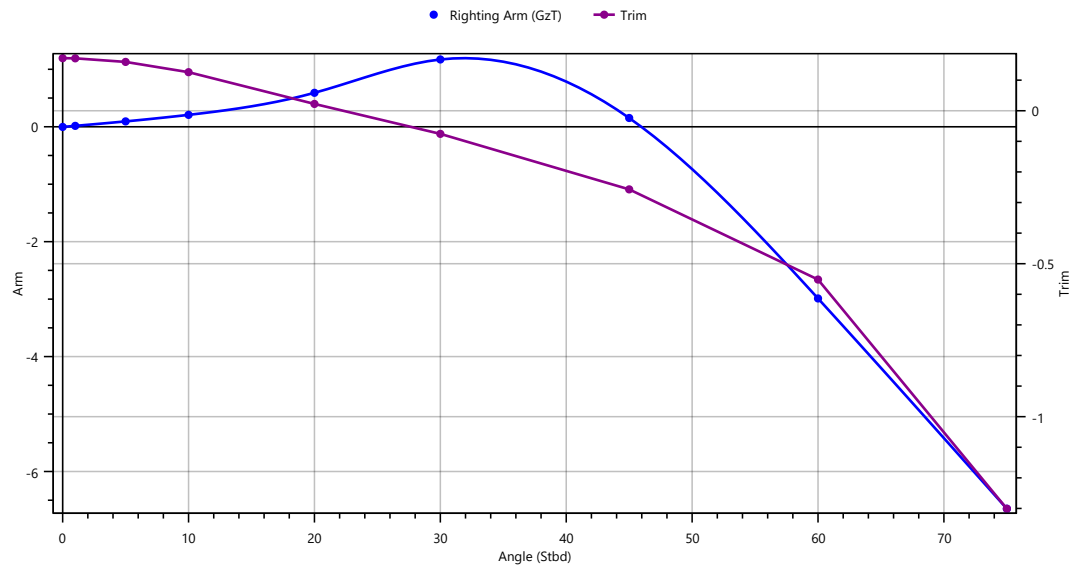
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 26	4,493	272.800	0.000	48.148	0	0	286	0	286	266.500	279.100
Stack 22	4,493	287.250	0.000	48.148	0	0	286	0	286	280.950	293.550
Stack 18	4,493	301.700	0.000	48.148	0	0	262	0	262	295.400	308.000
Stack 10	4,493	330.600	0.000	48.148	0	0	238	0	238	324.300	336.900
Stack 6	4,493	345.050	0.000	48.148	0	0	238	0	238	338.750	351.350
Stack 2	3,686	359.500	0.000	46.832	0	0	196	0	196	353.200	365.800
Stack 30	4,493	243.900	0.000	48.148	0	0	310	0	310	237.600	250.200
Stack 34	4,339	229.450	0.000	48.505	0	0	310	0	310	223.150	235.750
Stack 74	4,493	84.950	0.000	48.148	0	0	310	0	310	78.650	91.250
Stack 42	4,493	200.550	0.000	48.148	0	0	310	0	310	194.250	206.850
Stack 94	4,493	1.450	0.000	48.150	0	0	310	0	310	-4.646	7.546
Stack 90	4,493	15.900	0.000	48.148	0	0	310	0	310	9.600	22.200
Stack 38	4,493	215.000	0.000	48.148	0	0	310	0	310	208.700	221.300
Stack 86	4,493	30.350	0.000	48.148	0	0	310	0	310	24.050	36.650
Stack 78	4,493	70.500	0.000	48.148	0	0	310	0	310	64.200	76.800
Stack 70	4,493	99.400	0.000	48.148	0	0	310	0	310	93.100	105.700
Stack 66	4,493	113.850	0.000	48.148	0	0	310	0	310	107.550	120.150
Stack 62	4,493	128.300	0.000	48.148	0	0	310	0	310	122.000	134.600
Stack 58	4,493	142.750	0.000	48.148	0	0	310	0	310	136.450	149.050
Stack 54	4,493	157.200	0.000	48.148	0	0	310	0	310	150.900	163.500
Stack 50	4,493	171.650	0.000	48.148	0	0	310	0	310	165.350	177.950
Stack 46	4,493	186.100	0.000	48.148	0	0	310	0	310	179.800	192.400
Stack 82	4,493	44.800	0.000	48.148	0	0	310	0	310	38.500	51.100
Stack 14	4,493	316.150	0.000	48.148	0	0	262	0	262	309.850	322.450

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000	40.000	0.000
ER Misc Tanks	50	62.350	25.000	0.000

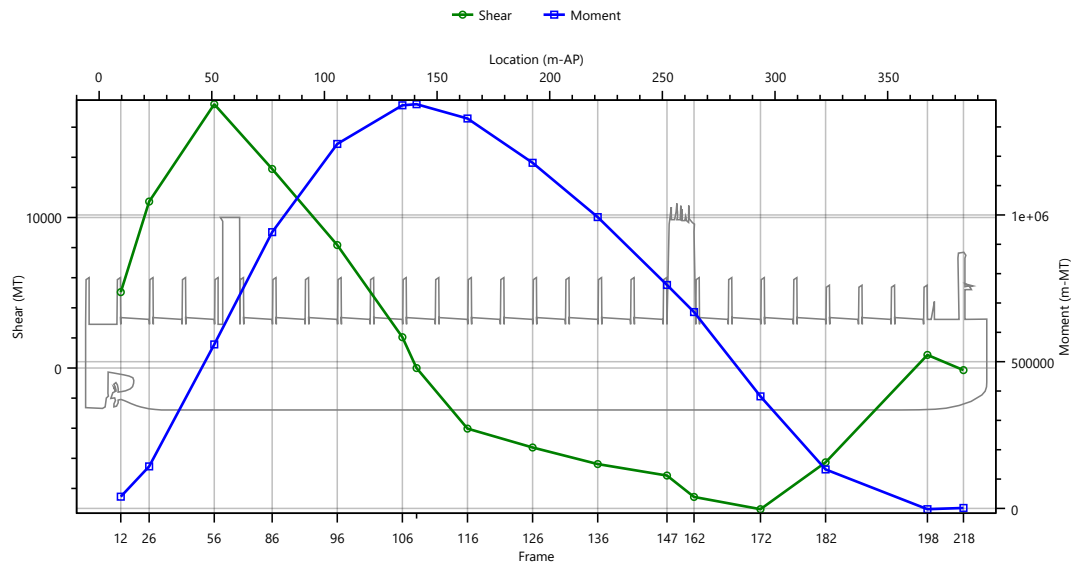
Bosun Stores	40	385.000	28.755	0.000
Water in Piping	50	160.000	1.350	0.000
Crew & Effects	6	258.450	55.000	0.000
Provisions	7	258.450	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.17	-0.004	0.000	0.00	0.17A	17.090	15.908	5
0.00	1.00	0.17	0.015	0.001	1.00S	0.17A	17.087	15.909	2
0.00	5.00	0.16	0.093	-0.001	5.00S	0.16A	17.024	15.926	3
0.00	10.00	0.13	0.207	-0.001	10.00S	0.13A	16.837	15.970	3
0.00	20.00	0.02	0.591	-0.003	20.00S	0.02A	16.182	16.028	3
0.00	30.00	-0.08	1.171	0.001	30.00S	0.08F	15.175	15.695	3
0.00	45.00	-0.26	0.153	-0.001	45.00S	0.26F	12.614	14.381	5
0.00	60.00	-0.55	-2.988	0.002	60.00S	0.55F	8.386	12.180	8
0.00	75.00	-1.30	-6.648	0.000	75.00S	1.30F	-2.509	6.438	9

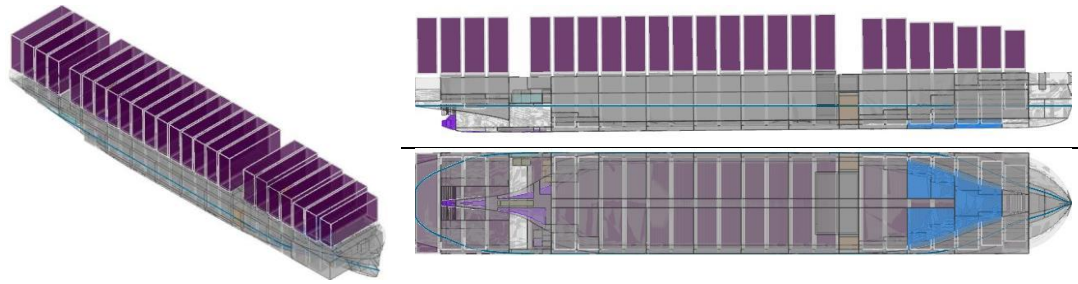
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600	1,280	6,322	5,042	9,640S	49,651S	40,011H
22.200	3,503	14,562	11,059	37,881S	181,027S	143,146H
51.100	15,627	33,154	17,527	290,242S	849,041S	558,799H
76.800	34,711	47,936	13,225	922,279S	1,863,698S	941,420H
105.700	62,484	70,653	8,169	2,316,622S	3,558,616S	1,241,994H
134.600	92,083	94,130	2,047	4,549,670S	5,923,358S	1,373,688H
140.901	98,543	98,540	-3	5,150,246S	6,527,643S	1,377,398H
163.500	121,661	117,636	-4,026	7,638,616S	8,967,276S	1,328,660H
192.400	151,089	145,810	-5,279	11,580,231S	12,757,963S	1,177,732H
221.300	180,363	173,982	-6,381	16,370,083S	17,362,852S	992,769H
252.050	211,304	204,160	-7,143	22,392,685S	23,154,156S	761,471H
264.050	223,269	214,705	-8,565	25,000,214S	25,669,292S	669,078H
293.550	251,995	242,617	-9,379	32,013,833S	32,395,615S	381,782H
322.450	276,939	270,674	-6,265	39,670,870S	39,803,693S	132,823H
367.650	298,342	299,212	870	52,761,117S	52,758,457S	2,660S
383.650	301,085	300,946	-139	57,559,669S	57,561,223S	1,554H

LNG 10 Tier Deck Design Departure 7.75 MT Deck 9 MT Hold

Trim and Stability Summary



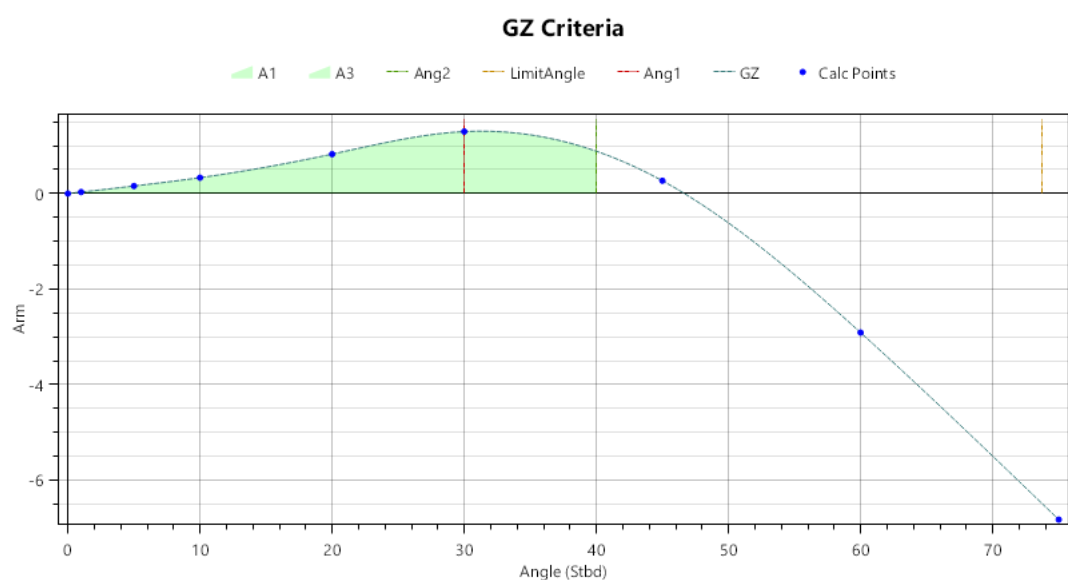
Loading					
Intact Displacement	259,293	MT	Sea Density	1.0250	MT/m ³
Deadweight	191,886	MT			
Available Deadweight	23	MT			
Stability			Trim		
KM0 Trans	31.351	m	Draft at LCF	14.666	m
VCG Upright	29.286	m-BL	LCF	180.702	m-AP
GM0 Solid Trans	2.067	m	LCB	190.057	m-AP
GM0 Trans	1.787	m	LCG	190.231	m-AP
GMt Required	1.233	m	TPM	216.77	MT/cm
GMt Margin	0.554	m	MTM	5,580	m-MT/cm
GM at Equilibrium	1.649	m	Trim at Perps	3A	m
			Heel0	0.00	deg
			Propeller Immersion	150.34	%
Drafts - Perps			Drafts - Marks		
AP	16.133	m	Fwd	13.019	m
MS	14.534	m	Mid	14.556	m
FP	12.935	m	Aft	15.982	m
Strength					
Shear Min	-12,959	MT			
Shear Max	17,417	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,576,547H	m-MT			
Moment Max Sag	--	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	393.546	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
25 Tanks from Geometry
0 Tanks from Tables
80 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

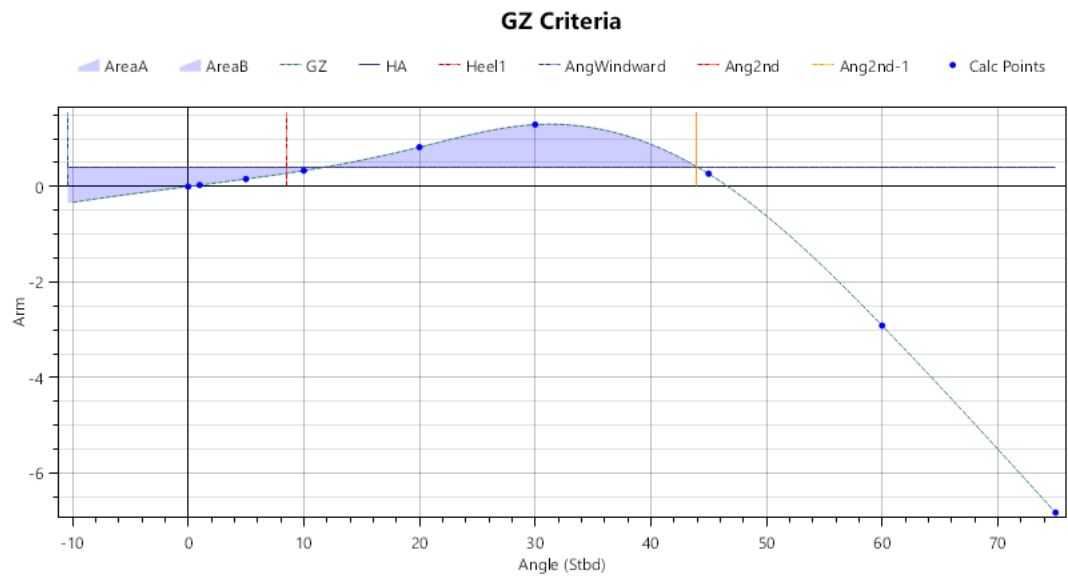
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	191,886 MT		236,141 MT
Pass	Propeller Immersion	150.34 %	100.00 %	
Pass	Visibility	393.546 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.787 m	1.233 m	
Pass	Design Deadweight	191,886 MT		191,910 MT

2008 IS Code 2.2 General Criteria



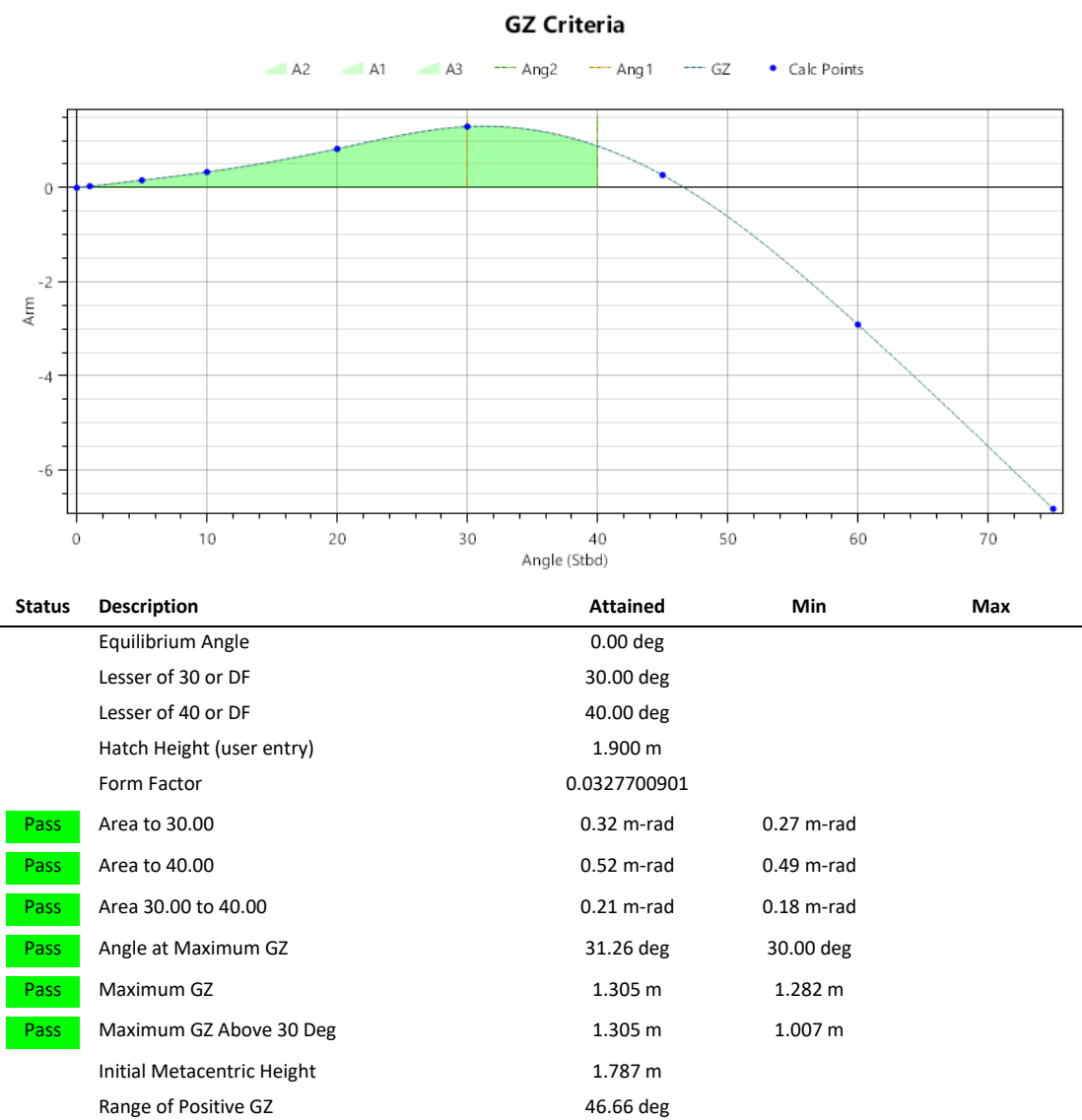
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.32 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.52 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.21 m-rad	0.03 m-rad	
	Angle to Downflooding	73.69 deg		
Pass	Angle at Maximum GZ	31.26 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.305 m	0.200 m	
Pass	Initial Metacentric Height	1.787 m	0.150 m	
	Range of Positive GZ	46.66 deg		

2008 IS Code 2.3 Weather Criteria

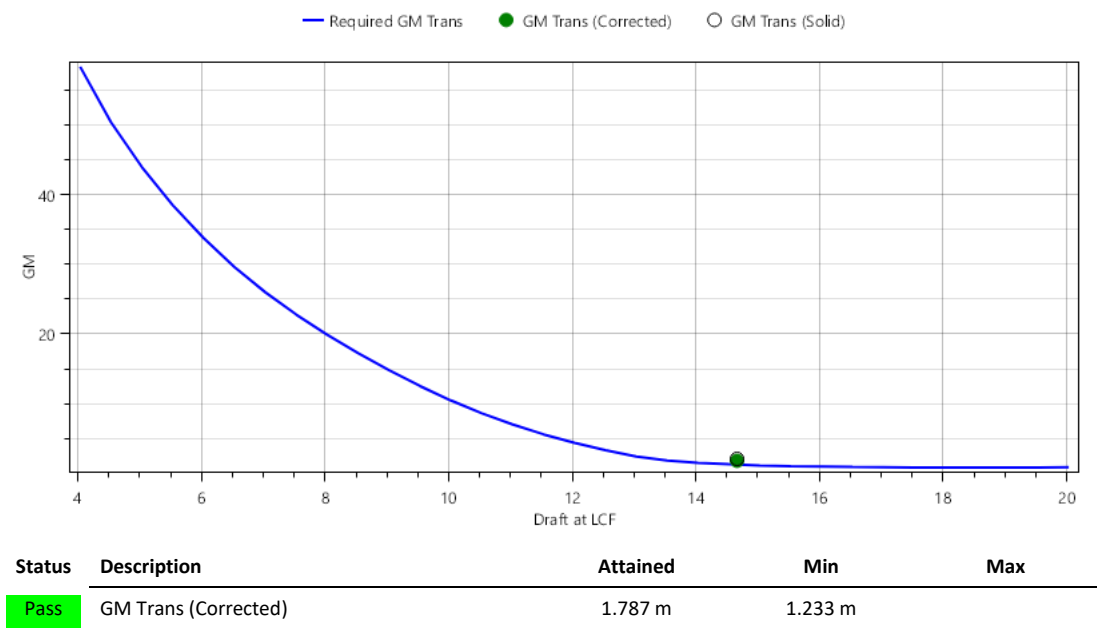


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2762712195		
	Steady Wind Heeling Lever LW1	0.276 m		
	80% Deck Edge Immersion Angle	15.86 deg		
Pass	Heeling Angle at LW1	8.56 deg		15.86 deg
	Gusty Wind Heeling Lever LW2	0.414 m		
	Heeling Angle at LW2	12.05 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	18.96 deg		
	Angle Windward	-10.40 deg		
	Second Intersect	43.98 deg		
	Limiting Angle	43.98 deg		
	Capsizing Area A	-0.15 m-rad		
	Righting Area B	0.30 m-rad		
Pass	Area Ratio B/A	1.9536267353	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT MT	LCG m-AP	VCG m-BL	TCG m-CL	FST m-MT
	Lightship	67,407	181.878	22.830	0.000	0
	SEAWATER BALLAST	6,004	319.789	2.302	0.965P	10,189
	DIESEL OIL	3,014	243.325	13.196	1.562S	789
	LUBE OIL	578	58.675	18.954	3.418S	179
	FRESH WATER	549	62.003	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.583	2.886	2.291P	1,384
	FUEL GAS TANK	9,462	250.808	15.992	0.000	42,626
	Containers In Hold	85,176	192.061	19.500	0.000	0
	Containers On Deck	86,273	179.800	48.117	0.000	0
	CONSTANT	473	179.784	30.295	0.000	0
	Spaces	0				0
		259,293	190.231	29.284	0.000S	55,167

Lightship

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Lightship Constant	0	197.000	0.000	0.000
Lightship	67,407	181.878	22.830	0.000

SEAWATER BALLAST

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
2DBWBTS	1,918	75.00	1,439	1.0250	1,475	6,607
2DBWBT P	1,918	90.00	1,726	1.0250	1,770	3,582
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0

DIESEL OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
MGO PILOT S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13

ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ST CWT	140	100.00	140	1.0000	140	0
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,132
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
WASTE OIL TANK	138	10.00	14	1.0000	14	105

FUEL GAS TANK

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
TYPE-B PRISMATIC TANK	24,068	85.00	20,458	0.4625	9,462	42,626

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900	0.000	25.564	0	0	120	0	120	9.600	22.200
Bay 86	2,448	30.350	0.000	24.394	0	0	136	0	136	24.050	36.650
Bay 82	2,052	44.800	0.000	25.856	0	0	114	0	114	38.500	51.100
Bay 78	1,188	70.500	0.000	29.617	0	0	66	0	66	64.200	76.800
Bay 74	4,248	84.950	0.000	19.431	0	0	236	0	236	78.650	91.250
Bay 70	4,608	99.400	0.000	18.640	0	0	256	0	256	93.100	105.700
Bay 66	4,716	113.850	0.000	18.250	0	0	262	0	262	107.550	120.150
Bay 62	4,716	128.300	0.000	18.250	0	0	262	0	262	122.000	134.600
Bay 58	4,716	142.750	0.000	18.250	0	0	262	0	262	136.450	149.050
Bay 54	4,716	157.200	0.000	18.250	0	0	262	0	262	150.900	163.500
Bay 46	4,716	186.100	0.000	18.250	0	0	262	0	262	179.800	192.400
Bay 50	4,716	171.650	0.000	18.250	0	0	262	0	262	165.350	177.950
Bay 42	4,716	200.550	0.000	18.250	0	0	262	0	262	194.250	206.850
Bay 38	4,716	215.000	0.000	18.250	0	0	262	0	262	208.700	221.300
Bay 34	4,320	229.450	0.000	18.115	0	0	240	0	240	223.150	235.750
Bay 30	1,260	243.900	0.000	18.618	0	0	70	0	70	237.600	250.200
Bay 22	4,500	287.250	0.000	18.736	0	0	250	0	250	280.950	293.550
Bay 18	4,428	301.700	0.000	18.952	0	0	246	0	246	295.400	308.000
Bay 14	4,032	316.150	0.000	19.655	0	0	224	0	224	309.850	322.450
Bay 10	3,348	330.600	0.000	20.588	0	0	190	0	190	324.300	336.900

Bay 26	4,644	272.800	0.000	18.500	0	0	258	0	258	266.500	279.100
Bay 2	1,620	359.500	0.000	24.782	0	0	90	0	90	353.200	365.800
Bay 6	2,592	345.050	0.000	21.828	0	0	144	0	144	338.750	351.350

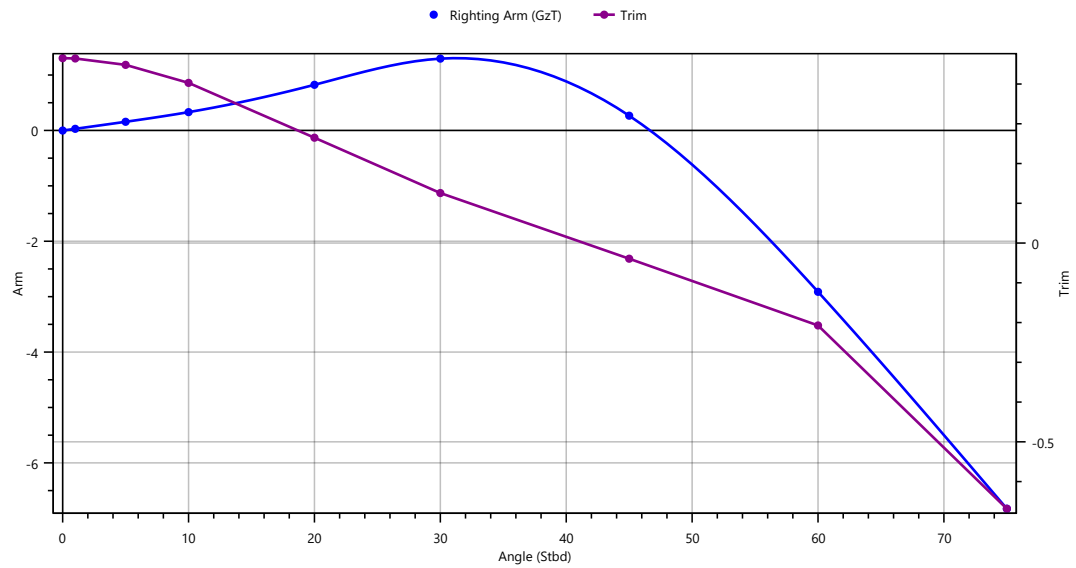
Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 38	3,627	215.000	0.000	48.148	0	0	310	0	310	208.700	221.300
Stack 34	3,503	229.450	0.000	48.505	0	0	310	0	310	223.150	235.750
Stack 26	3,627	272.800	0.000	48.148	0	0	286	0	286	266.500	279.100
Stack 22	3,627	287.250	0.000	48.148	0	0	286	0	286	280.950	293.550
Stack 18	3,627	301.700	0.000	48.148	0	0	262	0	262	295.400	308.000
Stack 14	3,627	316.150	0.000	48.148	0	0	262	0	262	309.850	322.450
Stack 10	3,627	330.600	0.000	48.148	0	0	238	0	238	324.300	336.900
Stack 6	3,627	345.050	0.000	48.148	0	0	238	0	238	338.750	351.350
Stack 42	3,627	200.550	0.000	48.148	0	0	310	0	310	194.250	206.850
Stack 2	2,976	359.500	0.000	46.832	0	0	196	0	196	353.200	365.800
Stack 46	3,627	186.100	0.000	48.148	0	0	310	0	310	179.800	192.400
Stack 86	3,627	30.350	0.000	48.148	0	0	310	0	310	24.050	36.650
Stack 54	3,627	157.200	0.000	48.148	0	0	310	0	310	150.900	163.500
Stack 94	3,627	1.450	0.000	48.150	0	0	310	0	310	-4.646	7.546
Stack 90	3,627	15.900	0.000	48.148	0	0	310	0	310	9.600	22.200
Stack 82	3,627	44.800	0.000	48.148	0	0	310	0	310	38.500	51.100
Stack 78	3,627	70.500	0.000	48.148	0	0	310	0	310	64.200	76.800
Stack 74	3,627	84.950	0.000	48.148	0	0	310	0	310	78.650	91.250
Stack 70	3,627	99.400	0.000	48.148	0	0	310	0	310	93.100	105.700
Stack 66	3,627	113.850	0.000	48.148	0	0	310	0	310	107.550	120.150
Stack 62	3,627	128.300	0.000	48.148	0	0	310	0	310	122.000	134.600
Stack 58	3,627	142.750	0.000	48.148	0	0	310	0	310	136.450	149.050
Stack 50	3,627	171.650	0.000	48.148	0	0	310	0	310	165.350	177.950
Stack 30	3,627	243.900	0.000	48.148	0	0	310	0	310	237.600	250.200

CONSTANT

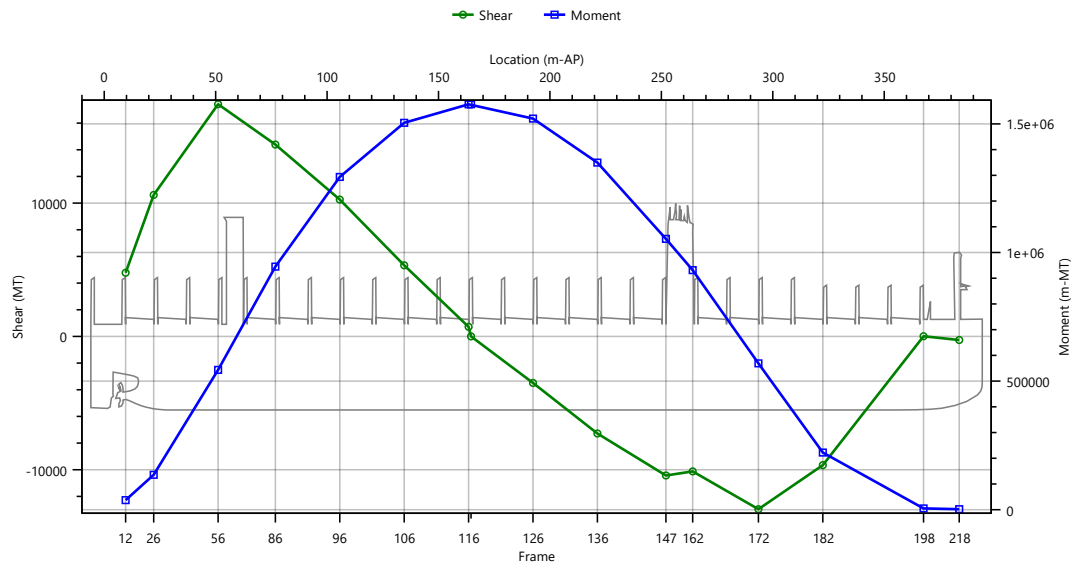
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000	40.000	0.000
ER Misc Tanks	50	62.350	25.000	0.000
Bosun Stores	40	385.000	28.755	0.000
Water in Piping	50	160.000	1.350	0.000
Crew & Effects	6	258.450	55.000	0.000
Provisions	7	258.450	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.47	-0.002	0.000	0.00	0.47A	16.098	12.900	5
0.00	1.00	0.46	0.029	0.001	1.00S	0.46A	16.094	12.902	2
0.00	5.00	0.45	0.156	-0.001	5.00S	0.45A	16.012	12.930	3
0.00	10.00	0.40	0.330	-0.002	10.00S	0.40A	15.775	13.004	3
0.00	20.00	0.26	0.823	-0.005	20.00S	0.26A	14.956	13.134	3
0.00	30.00	0.13	1.296	0.002	30.00S	0.13A	13.649	12.784	3
0.00	45.00	-0.04	0.266	-0.001	45.00S	0.04F	10.059	10.330	5
0.00	60.00	-0.21	-2.913	0.001	60.00S	0.21F	4.067	5.493	8
0.00	75.00	-0.67	-6.828	0.000	75.00S	0.67F	-12.229	-7.633	9

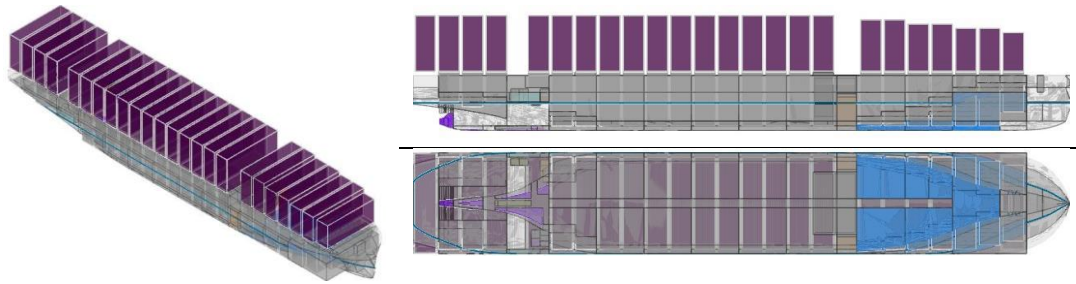
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600	680	5,456	4,776	5,386S	42,595S	37,208H
22.200	2,218	12,831	10,612	21,934S	157,608S	135,674H
51.100	12,276	29,694	17,417	208,507S	752,170S	543,663H
76.800	29,217	43,607	14,391	727,338S	1,672,422S	945,085H
105.700	54,328	64,592	10,264	1,925,064S	3,218,812S	1,293,749H
134.600	81,003	86,338	5,335	3,880,792S	5,384,983S	1,504,191H
163.500	107,395	108,112	717	6,604,116S	8,180,286S	1,576,171H
164.591	108,383	108,384	1	6,721,872S	8,298,420S	1,576,547H
192.400	133,373	129,883	-3,489	10,084,206S	11,604,819S	1,520,613H
221.300	158,933	151,653	-7,280	14,309,030S	15,658,519S	1,349,489H
252.050	185,635	175,203	-10,432	19,608,256S	20,661,199S	1,052,942H
264.050	195,865	185,741	-10,124	21,897,392S	22,828,824S	931,432H
293.550	220,133	207,174	-12,959	28,037,499S	28,606,418S	568,919H
322.450	240,528	230,873	-9,654	34,707,828S	34,930,052S	222,225H
367.650	256,956	256,969	13	46,023,412S	46,028,380S	4,968H
383.650	258,972	258,703	-269	50,153,287S	50,155,259S	1,972H

LNG 14 MT TEU HOMO 14398 TEU

Trim and Stability Summary



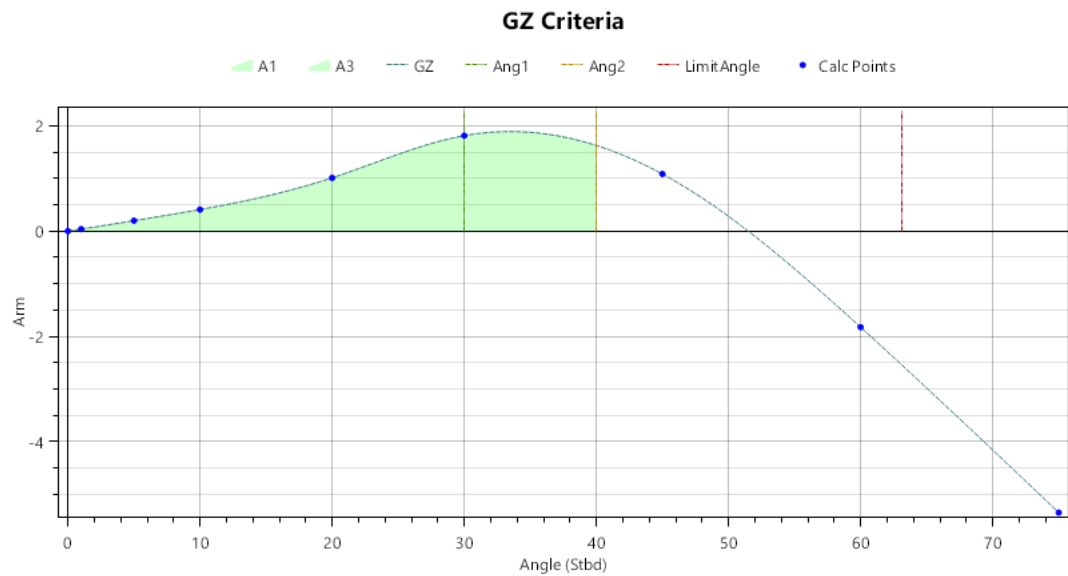
Loading					
Intact Displacement	300,539	MT	Sea Density	1.0250	MT/m ³
Deadweight	233,132	MT			
Available Deadweight	14	MT			
Stability			Trim		
KM0 Trans	29.840	m	Draft at LCF	16.536	m
VCG Upright	27.312	m-BL	LCF	182.005	m-AP
GM0 Solid Trans	2.529	m	LCB	195.050	m-AP
GM0 Trans	2.297	m	LCG	195.052	m-AP
GMt Required	0.903	m	TPM	221.78	MT/cm
GMt Margin	1.395	m	MTM	5,946	m-MT/cm
GM at Equilibrium	2.052	m	Trim at Perps	0A	m
			Heel0	0.00	deg
			Propeller Immersion	155.05	%
Drafts - Perps			Drafts - Marks		
AP	16.561	m	Fwd	16.509	m
MS	16.534	m	Mid	16.535	m
FP	16.508	m	Aft	16.559	m
Strength					
Shear Min	-19,167	MT			
Shear Max	23,295	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	2,306,987H	m-MT			
Moment Max Sag	4,078S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	336.328	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
30 Tanks from Geometry
0 Tanks from Tables
75 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

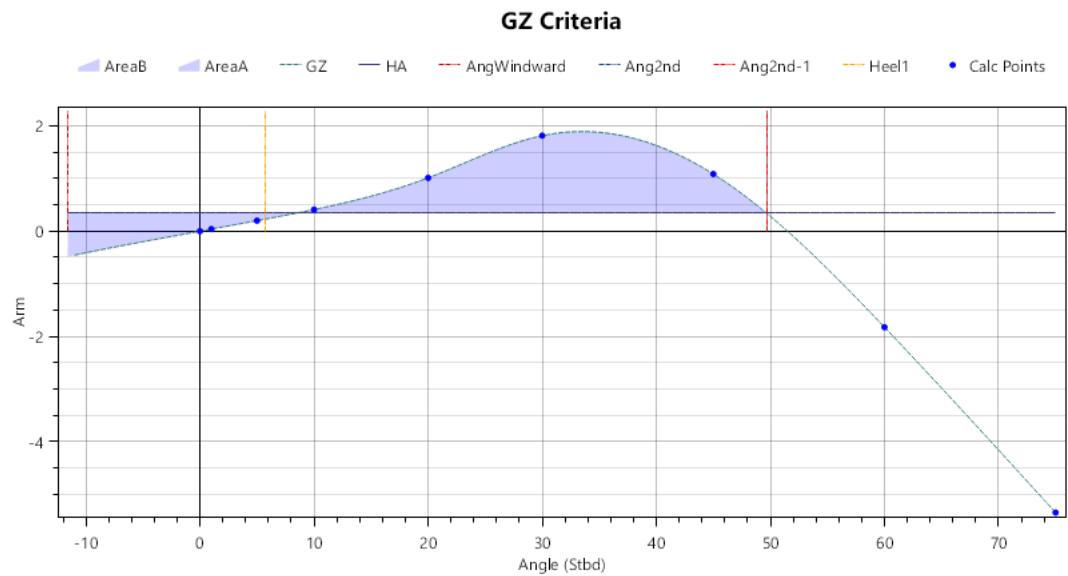
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	233,132 MT		233,146 MT
Pass	Propeller Immersion	155.05 %	100.00 %	
Pass	Visibility	336.328 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	2.297 m	0.903 m	

2008 IS Code 2.2 General Criteria



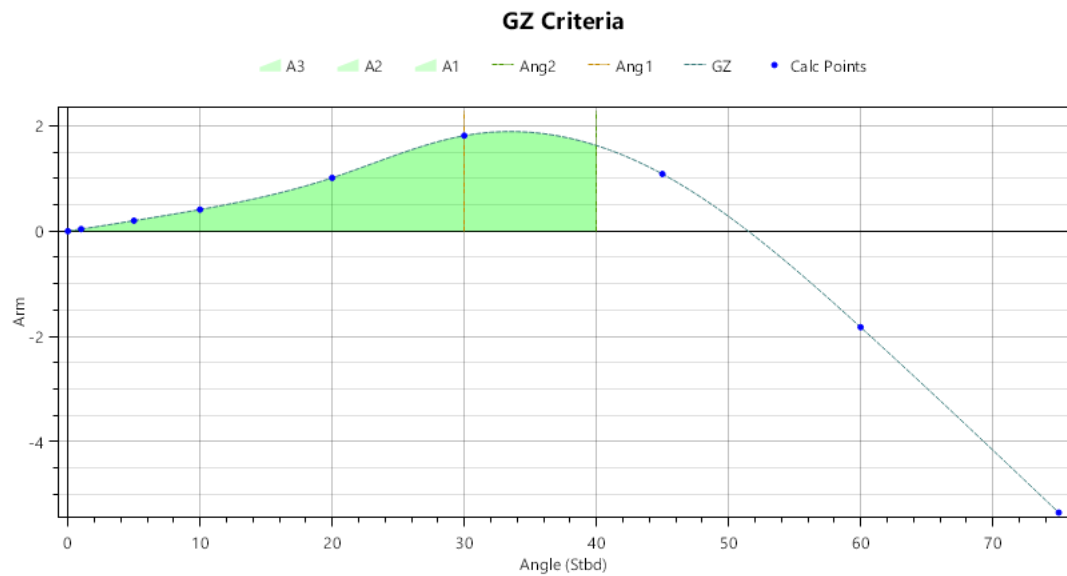
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.40 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.72 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.32 m-rad	0.03 m-rad	
	Angle to Downflooding	63.17 deg		
Pass	Angle at Maximum GZ	33.47 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.889 m	0.200 m	
Pass	Initial Metacentric Height	2.297 m	0.150 m	
	Range of Positive GZ	51.48 deg		

2008 IS Code 2.3 Weather Criteria



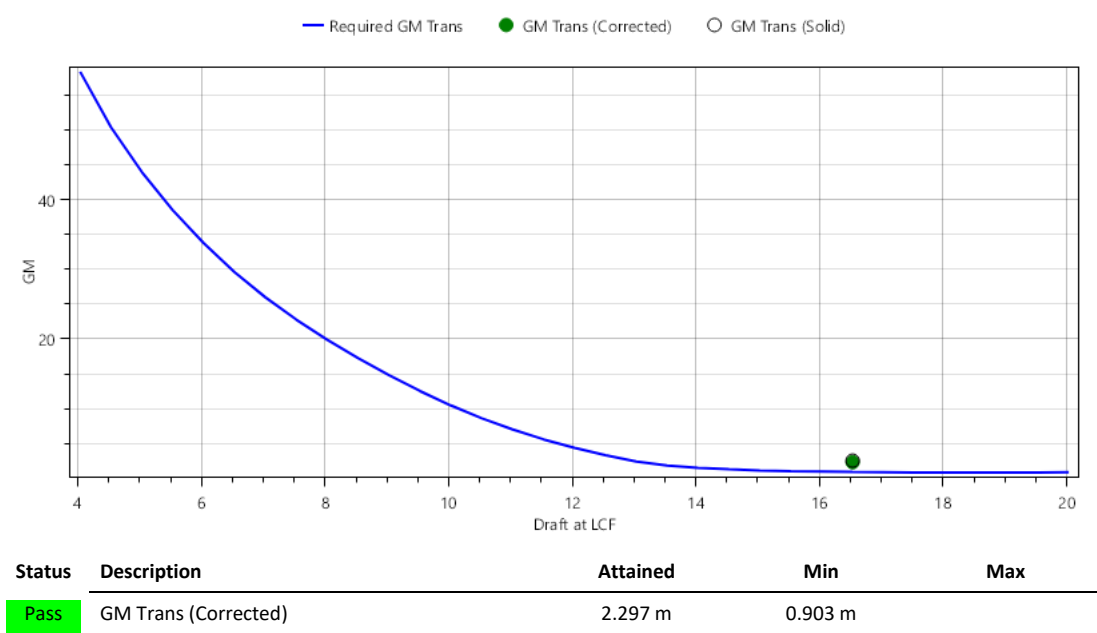
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2263707164		
	Steady Wind Heeling Lever LW1	0.226 m		
	80% Deck Edge Immersion Angle	14.96 deg		
Pass	Heeling Angle at LW1	5.76 deg		14.96 deg
	Gusty Wind Heeling Lever LW2	0.340 m		
	Heeling Angle at LW2	8.47 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.34 deg		
	Angle Windward	-11.58 deg		
	Second Intersect	49.66 deg		
	Limiting Angle	49.66 deg		
	Capsizing Area A	-0.14 m-rad		
	Righting Area B	0.63 m-rad		
Pass	Area Ratio B/A	4.4388215506	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.040832067		
Pass	Area to 30.00	0.40 m-rad	0.22 m-rad	
Pass	Area to 40.00	0.72 m-rad	0.39 m-rad	
Pass	Area 30.00 to 40.00	0.32 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	33.47 deg	30.00 deg	
Pass	Maximum GZ	1.889 m	1.029 m	
Pass	Maximum GZ Above 30 Deg	1.889 m	0.808 m	
	Initial Metacentric Height	2.297 m		
	Range of Positive GZ	51.48 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,407	181.878	22.830	0.000	0
	SEAWATER BALLAST	20,795	322.100	8.410	0.247P	30,077
	DIESEL OIL	3,014	243.330	13.196	1.562S	789
	LUBE OIL	578	58.713	18.954	3.418S	179
	FRESH WATER	549	62.003	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.805	2.885	2.320P	1,340
	FUEL GAS TANK	9,462	250.825	15.992	0.000	42,626
	Containers In Hold	86,912	188.064	15.313	0.000	0
	Containers On Deck	110,992	180.578	44.461	0.000	0
	CONSTANT	473	179.784	30.295	0.000	0
	Spaces	0				0
		300,539	195.052	27.310	0.002S	75,011

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000	0.000	0.000
Lightship	67,407	181.878	22.830	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
3DBWBT S	2,316	83.50	1,934	1.0250	1,982	14,298
2WWBT P	2,173	10.00	217	1.0250	223	1,482
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1 WWBT S	4,837	100.00	4,837	1.0250	4,958	0
1 WWBT P	4,837	100.00	4,837	1.0250	4,958	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT P	2,316	83.50	1,934	1.0250	1,982	14,298

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
MGO PILOT S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	29
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,092
WASTE OIL TANK	138	10.00	14	1.0000	14	103
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

FUEL GAS TANK

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
TYPE-B PRISMATIC TANK	24,068	85.00	20,458	0.4625	9,462	42,626

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	3,360	15.900	0.000	25.564	0	0	120	0	120	9.600	22.200
Bay 82	3,192	44.800	0.000	25.856	0	0	114	0	114	38.500	51.100
Bay 78	1,848	70.500	0.000	29.617	0	0	66	0	66	64.200	76.800
Bay 74	4,312	84.950	0.000	14.796	0	0	236	0	236	78.650	91.250
Bay 70	4,312	99.400	0.000	12.691	0	0	256	0	256	93.100	105.700
Bay 66	4,312	113.850	0.000	11.901	0	0	262	0	262	107.550	120.150
Bay 62	4,312	128.300	0.000	11.901	0	0	262	0	262	122.000	134.600
Bay 58	4,312	142.750	0.000	11.901	0	0	262	0	262	136.450	149.050
Bay 54	4,312	157.200	0.000	11.901	0	0	262	0	262	150.900	163.500
Bay 86	3,808	30.350	0.000	24.394	0	0	136	0	136	24.050	36.650
Bay 50	4,312	171.650	0.000	11.901	0	0	262	0	262	165.350	177.950
Bay 46	4,312	186.100	0.000	11.901	0	0	262	0	262	179.800	192.400
Bay 38	4,312	215.000	0.000	11.901	0	0	262	0	262	208.700	221.300
Bay 42	4,312	200.550	0.000	11.901	0	0	262	0	262	194.250	206.850

Bay 34	3,920	229.450	0.000	11.638	0	0	240	0	240	223.150	235.750
Bay 30	1,176	243.900	0.000	12.603	0	0	70	0	70	237.600	250.200
Bay 26	4,312	272.800	0.000	12.428	0	0	258	0	258	266.500	279.100
Bay 22	4,312	287.250	0.000	13.217	0	0	250	0	250	280.950	293.550
Bay 18	4,312	301.700	0.000	13.744	0	0	246	0	246	295.400	308.000
Bay 10	3,864	330.600	0.000	18.040	0	0	190	0	190	324.300	336.900
Bay 6	3,080	345.050	0.000	19.883	0	0	144	0	144	338.750	351.350
Bay 2	2,408	359.500	0.000	24.508	0	0	90	0	90	353.200	365.800
Bay 14	4,200	316.150	0.000	15.596	0	0	224	0	224	309.850	322.450

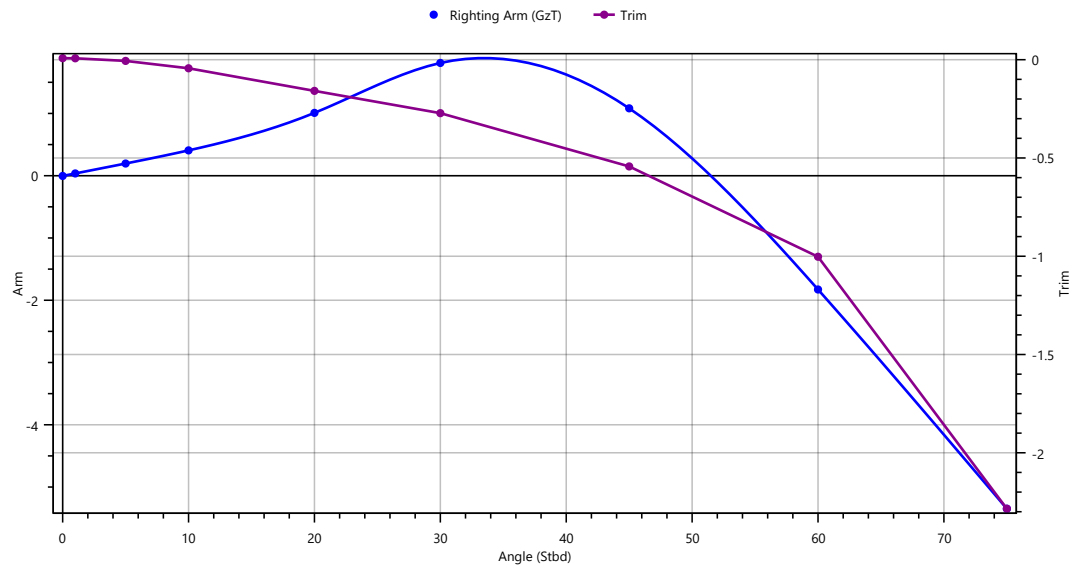
Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 34	4,424	229.450	0.000	44.768	0	0	310	0	310	223.150	235.750
Stack 30	4,648	243.900	0.000	44.445	0	0	310	0	310	237.600	250.200
Stack 26	4,648	272.800	0.000	44.445	0	0	286	0	286	266.500	279.100
Stack 18	4,648	301.700	0.000	44.445	0	0	262	0	262	295.400	308.000
Stack 14	4,648	316.150	0.000	44.445	0	0	262	0	262	309.850	322.450
Stack 10	4,648	330.600	0.000	44.445	0	0	238	0	238	324.300	336.900
Stack 6	4,648	345.050	0.000	44.445	0	0	238	0	238	338.750	351.350
Stack 2	4,312	359.500	0.000	44.538	0	0	196	0	196	353.200	365.800
Stack 38	4,648	215.000	0.000	44.445	0	0	310	0	310	208.700	221.300
Stack 42	4,648	200.550	0.000	44.445	0	0	310	0	310	194.250	206.850
Stack 82	4,648	44.800	0.000	44.445	0	0	310	0	310	38.500	51.100
Stack 50	4,648	171.650	0.000	44.445	0	0	310	0	310	165.350	177.950
Stack 94	4,648	1.450	0.000	44.440	0	0	310	0	310	-4.646	7.546
Stack 46	4,648	186.100	0.000	44.445	0	0	310	0	310	179.800	192.400
Stack 90	4,648	15.900	0.000	44.445	0	0	310	0	310	9.600	22.200
Stack 78	4,648	70.500	0.000	44.445	0	0	310	0	310	64.200	76.800
Stack 74	4,648	84.950	0.000	44.445	0	0	310	0	310	78.650	91.250
Stack 70	4,648	99.400	0.000	44.445	0	0	310	0	310	93.100	105.700
Stack 66	4,648	113.850	0.000	44.445	0	0	310	0	310	107.550	120.150
Stack 62	4,648	128.300	0.000	44.445	0	0	310	0	310	122.000	134.600
Stack 58	4,648	142.750	0.000	44.445	0	0	310	0	310	136.450	149.050
Stack 54	4,648	157.200	0.000	44.445	0	0	310	0	310	150.900	163.500
Stack 86	4,648	30.350	0.000	44.445	0	0	310	0	310	24.050	36.650
Stack 22	4,648	287.250	0.000	44.445	0	0	286	0	286	280.950	293.550

CONSTANT

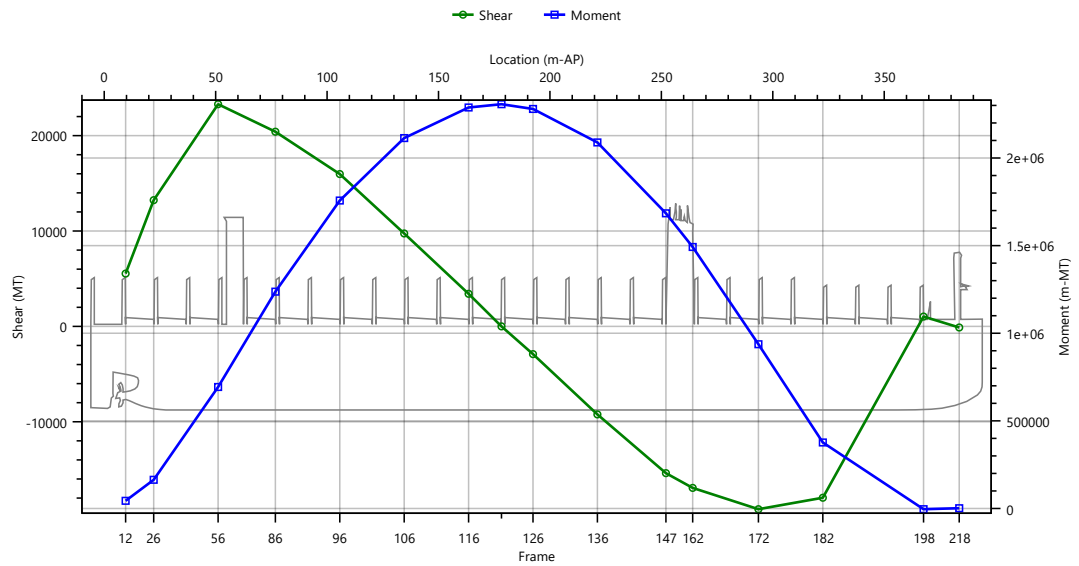
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000	40.000	0.000
ER Misc Tanks	50	62.350	25.000	0.000
Bosun Stores	40	385.000	28.755	0.000
Water in Piping	50	160.000	1.350	0.000
Crew & Effects	6	258.450	55.000	0.000
Provisions	7	258.450	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.01	-0.004	0.000	0.00	0.01A	16.526	16.473	3
0.00	1.00	0.01	0.036	0.001	1.00S	0.01A	16.523	16.474	2
0.00	5.00	-0.01	0.196	0.000	5.00S	0.01F	16.453	16.495	3
0.00	10.00	-0.04	0.407	0.000	10.00S	0.04F	16.248	16.548	3
0.00	20.00	-0.16	1.009	-0.002	20.00S	0.16F	15.540	16.631	3
0.00	30.00	-0.27	1.811	0.000	30.00S	0.27F	14.463	16.333	3
0.00	45.00	-0.54	1.082	-0.001	45.00S	0.54F	11.558	15.292	5
0.00	60.00	-1.00	-1.828	0.000	60.00S	1.00F	6.712	13.607	9
0.00	75.00	-2.28	-5.348	0.000	75.01S	2.28F	-6.216	9.504	9

Strength Summary

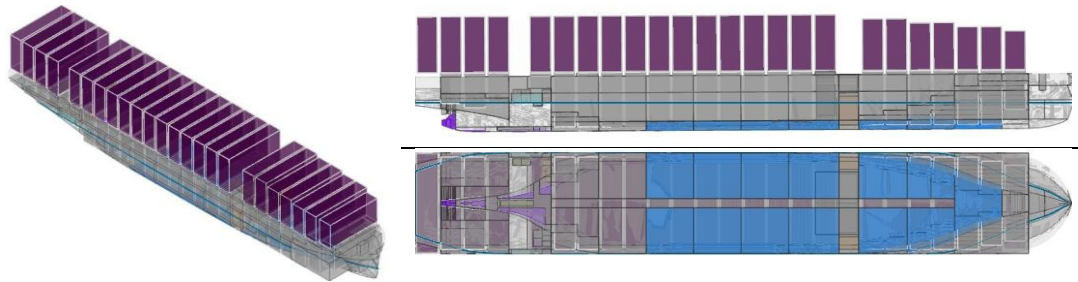


Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600	941	6,477	5,536	7,111S	50,916S	43,806H
22.200	2,838	16,072	13,234	29,070S	192,785S	163,715H
51.100	14,179	37,474	23,295	250,758S	944,044S	693,286H
76.800	32,661	53,072	20,411	837,592S	2,074,851S	1,237,259H
105.700	59,896	75,867	15,971	2,164,562S	3,921,861S	1,757,299H
134.600	89,105	98,847	9,743	4,316,818S	6,430,568S	2,113,750H
163.500	118,439	121,855	3,416	7,315,804S	9,604,072S	2,288,268H
178.261	133,421	133,421	0	9,174,662S	11,481,649S	2,306,987H
192.400	147,770	144,860	-2,910	11,162,541S	13,442,467S	2,279,927H
221.300	177,094	167,864	-9,230	15,856,845S	17,945,693S	2,088,848H
252.050	208,250	192,862	-15,388	21,781,815S	23,466,178S	1,684,363H
264.050	220,345	203,410	-16,935	24,353,450S	25,845,747S	1,492,298H
293.550	249,496	230,329	-19,167	31,286,688S	32,223,912S	937,224H
322.450	274,999	257,033	-17,965	38,879,278S	39,255,921S	376,644H
367.650	297,185	298,215	1,030	51,901,319S	51,897,241S	4,078S
383.650	300,064	299,948	-116	56,682,562S	56,684,048S	1,487H

Ammonia Condition Printouts

Ammonia 9 MT Hold 7 MT Deck Max Scantling Departure

Trim and Stability Summary



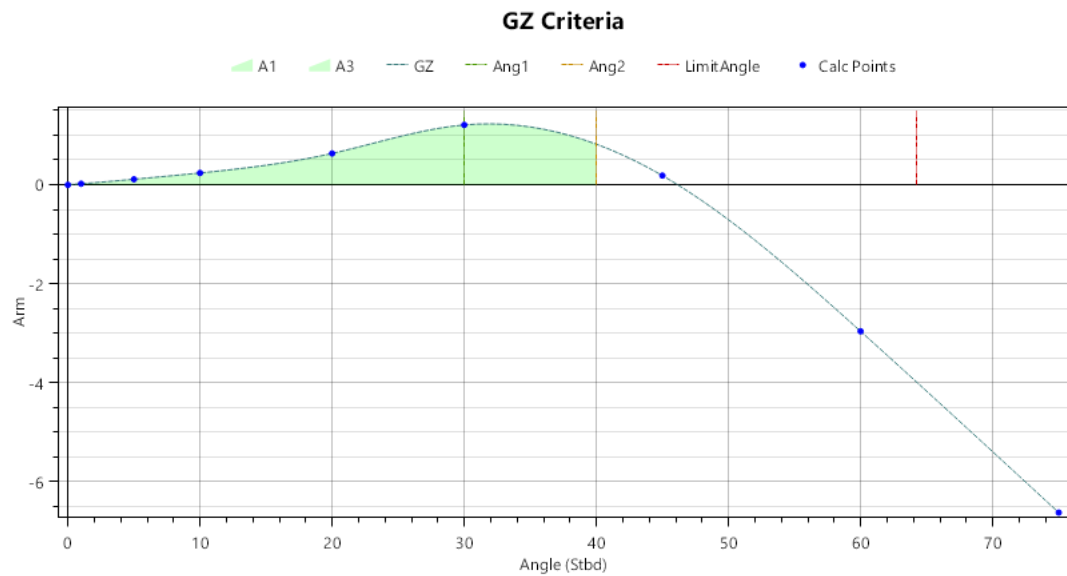
Loading					
Intact Displacement	302,417	MT	Sea Density	1.0250	MT/m ³
Deadweight	234,932	MT			
Available Deadweight	97	MT			
Stability			Trim		
KM0 Trans	30.061	m	Draft at LCF	16.627	m
VCG Upright	28.645	m-BL	LCF	179.582	m-AP
GM0 Solid Trans	1.418	m	LCB	190.628	m-AP
GM0 Trans	1.269	m	LCG	190.739	m-AP
GMt Required	0.896	m	TPM	223.14	MT/cm
GMt Margin	0.373	m	MTM	6,034	m-MT/cm
GM at Equilibrium	1.046	m	Trim at Perps	2A	m
			Heel0	0.00	deg
			Propeller Immersion	164.84	%
Drafts - Perps			Drafts - Marks		
AP	17.621	m	Fwd	15.497	m
MS	16.531	m	Mid	16.546	m
FP	15.440	m	Aft	17.518	m
Strength					
Shear Min	-6,905	MT			
Shear Max	15,593	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,081,404H	m-MT			
Moment Max Sag	1,478S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	362.087	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
 Hull from Geometry
 GMt from GZ Curve Slope
 FSt Adjustment = SolidGMt-GMt
 38 Tanks from Geometry
 0 Tanks from Tables
 68 Empty Tanks
 GZ Curve from Geometry
 Downflood Angles from 3D Data

Alarm Summary

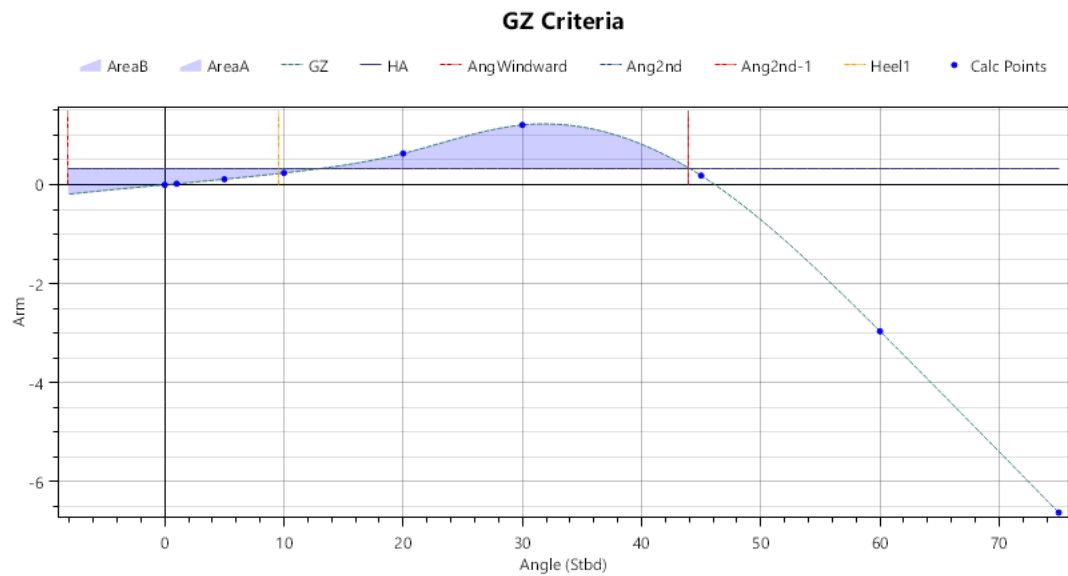
Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	234,932 MT		235,029 MT
Pass	Propeller Immersion	164.84 %	100.00 %	
Pass	Visibility	362.087 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.269 m	0.896 m	

2008 IS Code 2.2 General Criteria



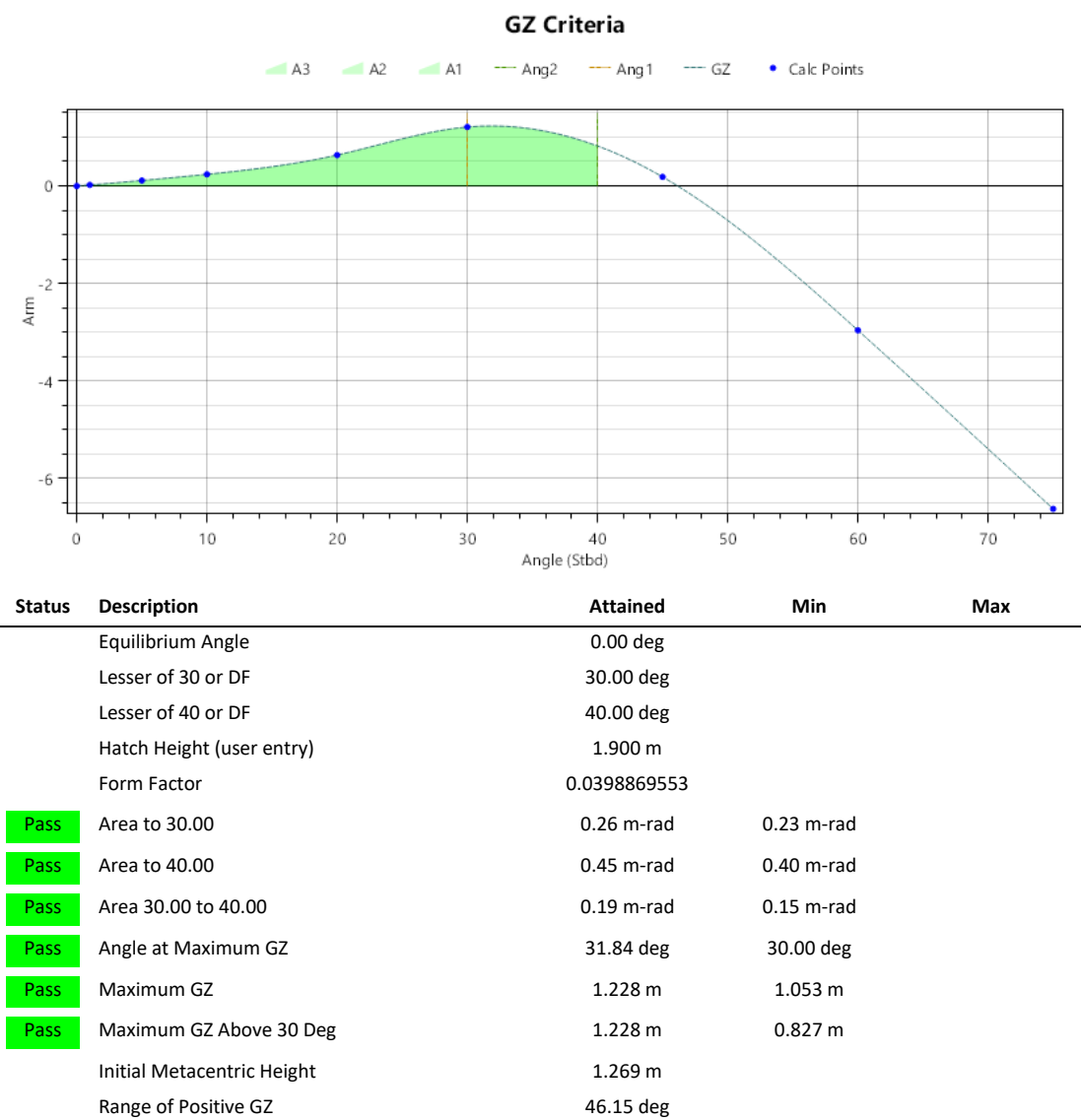
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.26 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.45 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.19 m-rad	0.03 m-rad	
	Angle to Downflooding	64.19 deg		
Pass	Angle at Maximum GZ	31.84 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.228 m	0.200 m	
Pass	Initial Metacentric Height	1.269 m	0.150 m	
	Range of Positive GZ	46.15 deg		

2008 IS Code 2.3 Weather Criteria

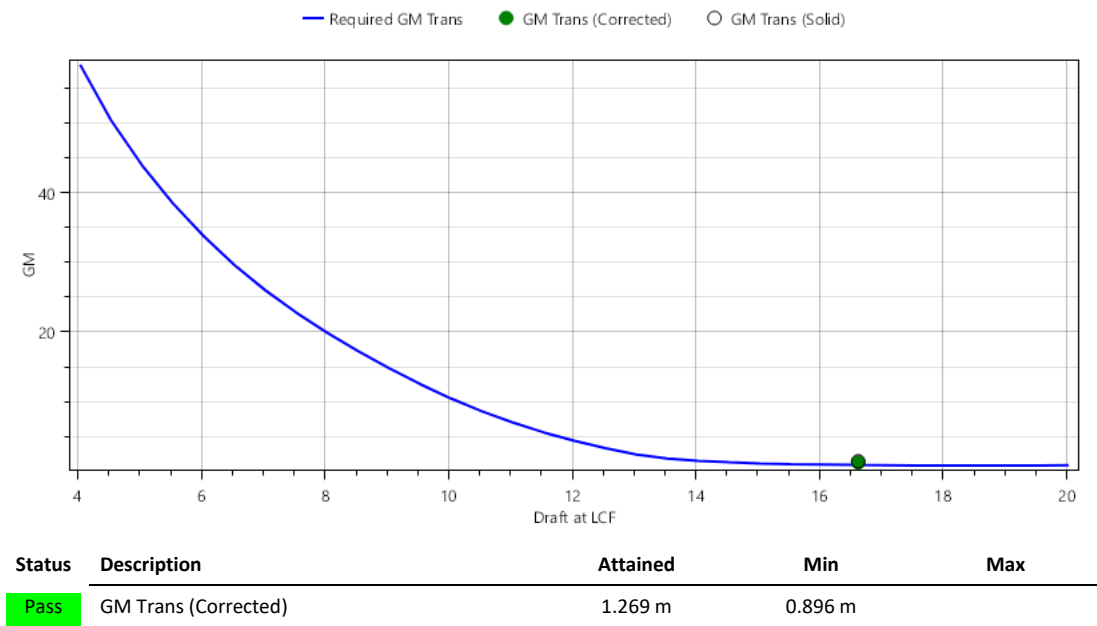


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2241615226		
	Steady Wind Heeling Lever LW1	0.224 m		
	80% Deck Edge Immersion Angle	13.11 deg		
Pass	Heeling Angle at LW1	9.56 deg		13.11 deg
	Gusty Wind Heeling Lever LW2	0.336 m		
	Heeling Angle at LW2	13.39 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.68 deg		
	Angle Windward	-8.13 deg		
	Second Intersect	43.97 deg		
	Limiting Angle	43.97 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.28 m-rad		
Pass	Area Ratio B/A	2.6626243653	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,485	181.958	22.824	0.000	0
	SEAWATER BALLAST	30,857	235.329	2.116	0.170P	2,971
	DIESEL OIL	3,014	243.326	13.196	1.562S	789
	LUBE OIL	578	58.687	18.954	3.418S	179
	FRESH WATER	549	62.003	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.655	2.886	2.301P	1,370
	FUEL GAS TANK	15,507	250.813	15.992	0.000	17,465
	Containers In Hold	85,176	192.061	19.500	0.000	0
	Containers On Deck	98,420	172.642	51.521	0.000	0
	CONSTANT	473	179.784	30.295	0.000	0
	Spaces	0				0
		302,417	190.739	28.643	0.002S	22,774

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000	0.000	0.000
Lightship	67,485	181.958	22.824	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
7DBWBT S	2,277	100.00	2,277	1.0250	2,334	0
7DBWBT P	2,277	100.00	2,277	1.0250	2,334	0
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	5.61	122	1.0250	125	1,310
2WWBT P	2,173	15.71	341	1.0250	350	1,662
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14

NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
MGO PILOT P	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT S	1,645	98.00	1,612	0.8600	1,386	366

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,119
WASTE OIL TANK	138	10.00	14	1.0000	14	104
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

FUEL GAS TANK

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
TYPE-B PRISMATIC TANK S	12,034	85.00	10,229	0.7580	7,754	8,733
TYPE-B PRISMATIC TANK P	12,034	85.00	10,229	0.7580	7,754	8,733

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 82	2,052	44.800	0.000	25.856	0	0	114	0	114	38.500	51.100
Bay 90	2,160	15.900	0.000	25.564	0	0	120	0	120	9.600	22.200
Bay 86	2,448	30.350	0.000	24.394	0	0	136	0	136	24.050	36.650
Bay 78	1,188	70.500	0.000	29.617	0	0	66	0	66	64.200	76.800
Bay 38	4,716	215.000	0.000	18.250	0	0	262	0	262	208.700	221.300
Bay 70	4,608	99.400	0.000	18.640	0	0	256	0	256	93.100	105.700
Bay 66	4,716	113.850	0.000	18.250	0	0	262	0	262	107.550	120.150

Bay 62	4,716	128.300	0.000	18.250	0	0	262	0	262	122.000	134.600
Bay 58	4,716	142.750	0.000	18.250	0	0	262	0	262	136.450	149.050
Bay 54	4,716	157.200	0.000	18.250	0	0	262	0	262	150.900	163.500
Bay 50	4,716	171.650	0.000	18.250	0	0	262	0	262	165.350	177.950
Bay 46	4,716	186.100	0.000	18.250	0	0	262	0	262	179.800	192.400
Bay 42	4,716	200.550	0.000	18.250	0	0	262	0	262	194.250	206.850
Bay 74	4,248	84.950	0.000	19.431	0	0	236	0	236	78.650	91.250
Bay 34	4,320	229.450	0.000	18.115	0	0	240	0	240	223.150	235.750
Bay 30	1,260	243.900	0.000	18.618	0	0	70	0	70	237.600	250.200
Bay 22	4,500	287.250	0.000	18.736	0	0	250	0	250	280.950	293.550
Bay 26	4,644	272.800	0.000	18.500	0	0	258	0	258	266.500	279.100
Bay 18	4,428	301.700	0.000	18.952	0	0	246	0	246	295.400	308.000
Bay 14	4,032	316.150	0.000	19.655	0	0	224	0	224	309.850	322.450
Bay 10	3,348	330.600	0.000	20.588	0	0	190	0	190	324.300	336.900
Bay 6	2,592	345.050	0.000	21.828	0	0	144	0	144	338.750	351.350
Bay 2	1,620	359.500	0.000	24.782	0	0	90	0	90	353.200	365.800

Containers On Deck

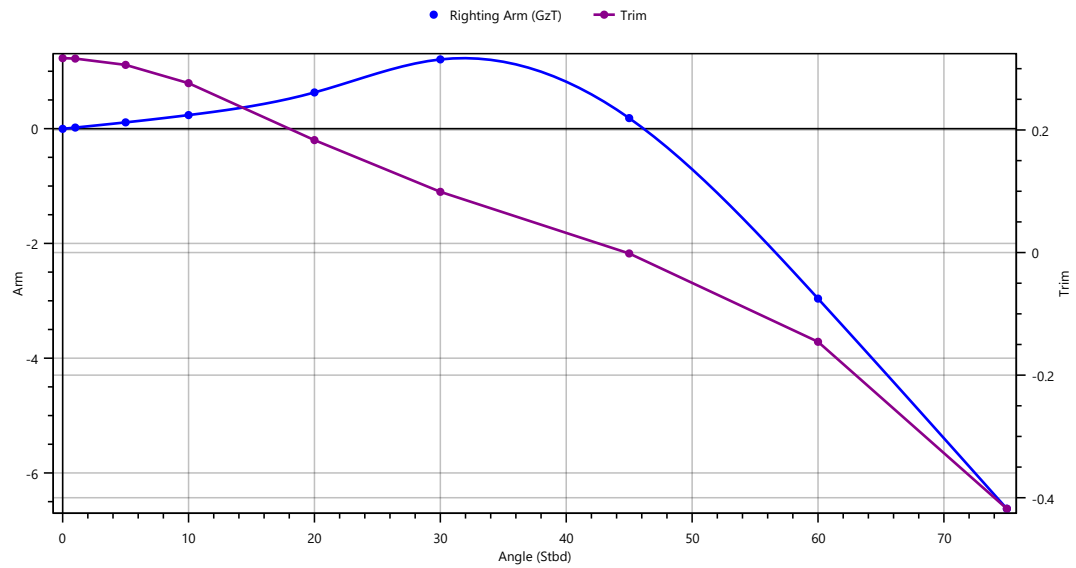
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 26	4,004	272.800	0.000	50.916	0	0	286	0	286	266.500	279.100
Stack 22	4,004	287.250	0.000	50.916	0	0	286	0	286	280.950	293.550
Stack 18	3,668	301.700	0.000	49.621	0	0	262	0	262	295.400	308.000
Stack 14	3,668	316.150	0.000	49.621	0	0	262	0	262	309.850	322.450
Stack 10	3,332	330.600	0.000	48.326	0	0	238	0	238	324.300	336.900
Stack 2	2,744	359.500	0.000	47.023	0	0	196	0	196	353.200	365.800
Stack 30	4,340	243.900	0.000	52.210	0	0	310	0	310	237.600	250.200
Stack 34	4,228	229.450	0.000	52.585	0	0	310	0	310	223.150	235.750
Stack 74	4,340	84.950	0.000	52.210	0	0	310	0	310	78.650	91.250
Stack 42	4,340	200.550	0.000	52.210	0	0	310	0	310	194.250	206.850
Stack 94	4,340	1.450	0.000	52.210	0	0	310	0	310	-4.646	7.546
Stack 90	4,340	15.900	0.000	52.210	0	0	310	0	310	9.600	22.200
Stack 38	4,340	215.000	0.000	52.210	0	0	310	0	310	208.700	221.300
Stack 86	4,340	30.350	0.000	52.210	0	0	310	0	310	24.050	36.650
Stack 78	4,340	70.500	0.000	52.210	0	0	310	0	310	64.200	76.800
Stack 70	4,340	99.400	0.000	52.210	0	0	310	0	310	93.100	105.700
Stack 66	4,340	113.850	0.000	52.210	0	0	310	0	310	107.550	120.150
Stack 62	4,340	128.300	0.000	52.210	0	0	310	0	310	122.000	134.600
Stack 58	4,340	142.750	0.000	52.210	0	0	310	0	310	136.450	149.050
Stack 54	4,340	157.200	0.000	52.210	0	0	310	0	310	150.900	163.500
Stack 50	4,340	171.650	0.000	52.210	0	0	310	0	310	165.350	177.950
Stack 46	4,340	186.100	0.000	52.210	0	0	310	0	310	179.800	192.400
Stack 82	4,340	44.800	0.000	52.210	0	0	310	0	310	38.500	51.100
Stack 6	3,332	345.050	0.000	48.326	0	0	238	0	238	338.750	351.350

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL

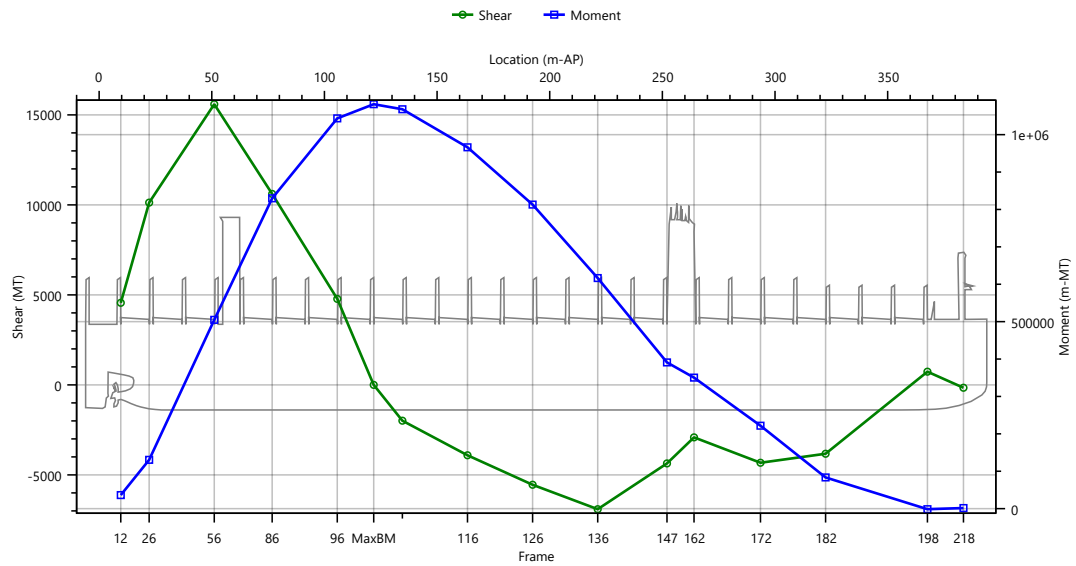
Stores Distributed	120	160.000	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000	40.000	0.000
ER Misc Tanks	50	62.350	25.000	0.000
Bosun Stores	40	385.000	28.755	0.000
Water in Piping	50	160.000	1.350	0.000
Crew & Effects	6	258.450	55.000	0.000
Provisions	7	258.450	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.32	-0.003	-0.002	0.00	0.32A	17.586	15.405	5
0.00	1.00	0.32	0.019	0.001	1.00S	0.32A	17.583	15.407	2
0.00	5.00	0.31	0.109	-0.001	5.00S	0.31A	17.526	15.420	3
0.00	10.00	0.28	0.236	-0.001	10.00S	0.28A	17.356	15.456	3
0.00	20.00	0.18	0.631	-0.003	20.00S	0.18A	16.751	15.489	3
0.00	30.00	0.10	1.206	0.002	30.00S	0.10A	15.807	15.125	3
0.00	45.00	0.00	0.184	-0.004	45.00S	0.00F	13.558	13.569	4
0.00	60.00	-0.15	-2.962	0.001	60.00S	0.15F	9.893	10.894	8
0.00	75.00	-0.42	-6.624	0.000	75.00S	0.42F	0.787	3.661	9

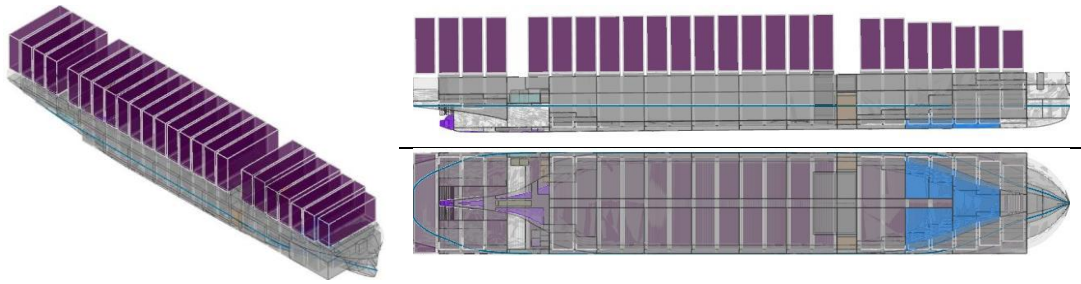
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600	1,610	6,169	4,560	12,143S	48,406S	36,263H
22.200	4,131	14,257	10,126	46,385S	176,894S	130,509H
51.100	16,951	32,544	15,593	327,124S	831,949S	504,826H
76.800	36,562	47,172	10,610	1,000,174S	1,829,962S	829,788H
105.700	64,805	69,583	4,778	2,455,114S	3,498,667S	1,043,554H
121.874	81,557	81,557	0	3,638,626S	4,720,030S	1,081,404H
134.600	94,744	92,755	-1,989	4,760,459S	5,828,364S	1,067,905H
163.500	124,532	120,622	-3,909	7,929,645S	8,895,820S	966,175H
192.400	154,039	148,491	-5,548	11,955,682S	12,768,694S	813,012H
221.300	183,262	176,357	-6,905	16,830,376S	17,446,938S	616,562H
252.050	214,007	209,644	-4,362	22,939,499S	23,330,489S	390,990H
264.050	225,856	222,940	-2,916	25,578,788S	25,929,126S	350,337H
293.550	254,200	249,875	-4,325	32,663,404S	32,885,171S	221,767H
322.450	278,644	274,819	-3,825	40,377,179S	40,460,609S	83,430H
367.650	299,360	300,093	734	53,527,286S	53,525,808S	1,478S
383.650	301,985	301,827	-159	58,341,075S	58,342,672S	1,597H

Ammonia 9 MT Hold 5.63 MT Deck Max Design Departure

Trim and Stability Summary

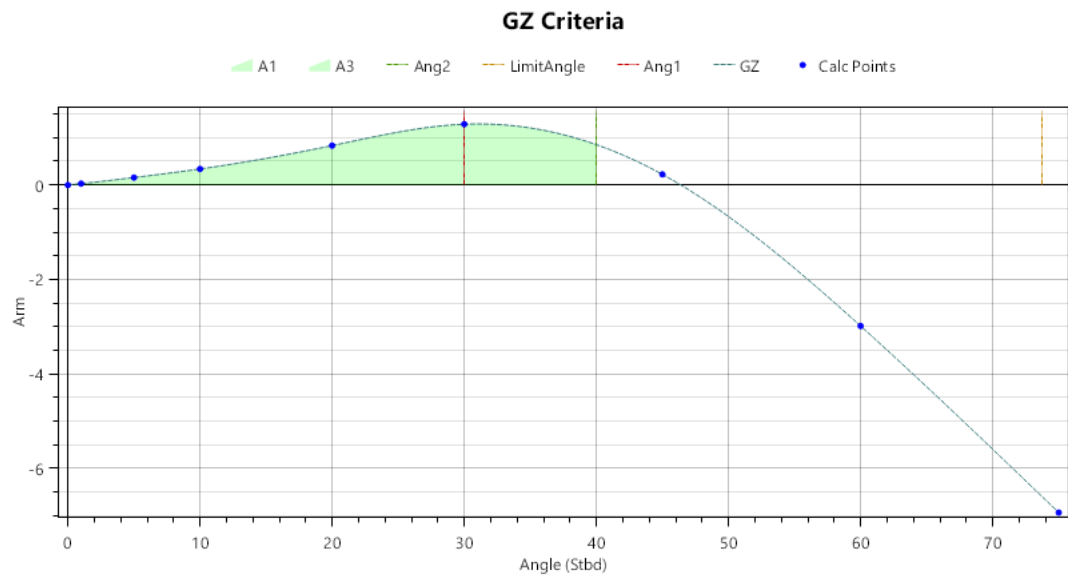


Loading					
Intact Displacement	259,212	MT	Sea Density	1.0250	MT/m ³
Deadweight	191,727	MT			
Available Deadweight	128	MT			
Stability			Trim		
KM0 Trans	31.359	m	Draft at LCF	14.663	m
VCG Upright	29.411	m-BL	LCF	180.666	m-AP
GM0 Solid Trans	1.950	m	LCB	190.000	m-AP
GM0 Trans	1.784	m	LCG	190.177	m-AP
GMt Required	1.234	m	TPM	216.79	MT/cm
GMt Margin	0.551	m	MTM	5,580	m-MT/cm
GM at Equilibrium	1.489	m	Trim at Perps	3A	m
			Heel0	0.00	deg
			Propeller Immersion	150.41	%
Drafts - Perps			Drafts - Marks		
AP	16.142	m	Fwd	13.001	m
MS	14.529	m	Mid	14.552	m
FP	12.917	m	Aft	15.989	m
Bridge Visibility					
Visibility Distance	393.959	m	Visibility Distance Required	500.000	m
Calculation Notes					
Drafts from Keel					
Hull from Geometry					
GMt from GZ Curve Slope					
FSt Adjustment = SolidGMt-GMt					
27 Tanks from Geometry					
0 Tanks from Tables					
79 Empty Tanks					
GZ Curve from Geometry					
Downflood Angles from 3D Data					

Alarm Summary

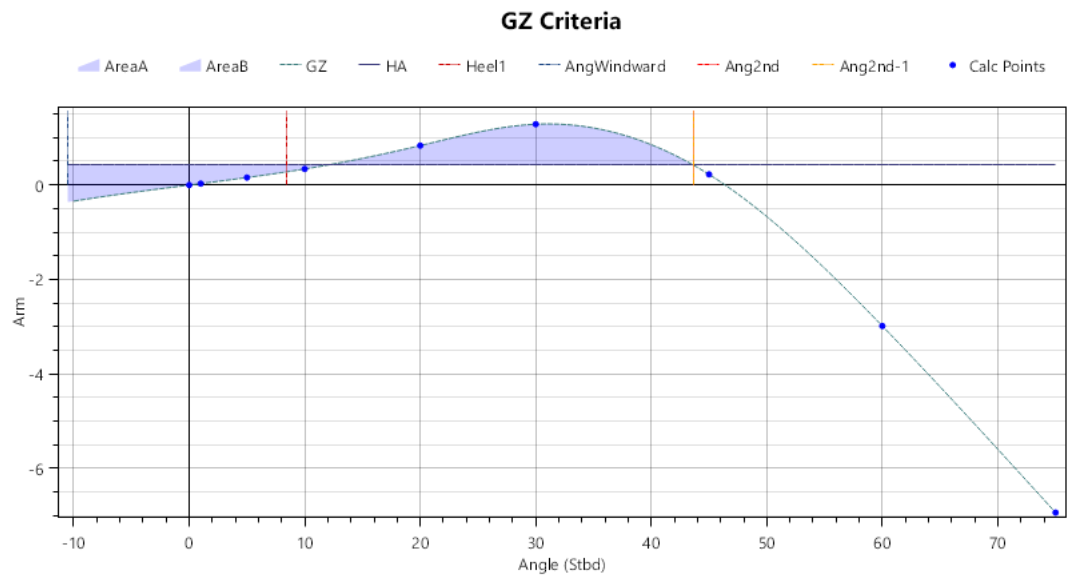
Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	191,727 MT		236,091 MT
Pass	Propeller Immersion	150.41 %	100.00 %	
Pass	Visibility	393.959 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.784 m	1.234 m	
Pass	Design Deadweight	191,727 MT		191,856 MT

2008 IS Code 2.2 General Criteria



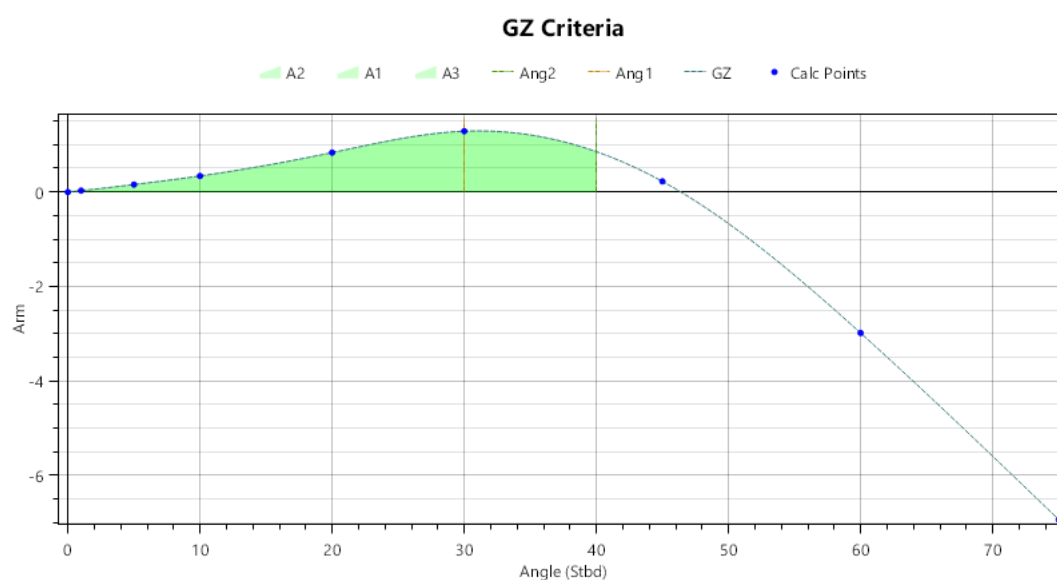
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.32 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.52 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.03 m-rad	
	Angle to Downflooding	73.73 deg		
Pass	Angle at Maximum GZ	31.05 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.290 m	0.200 m	
Pass	Initial Metacentric Height	1.784 m	0.150 m	
	Range of Positive GZ	46.38 deg		

2008 IS Code 2.3 Weather Criteria



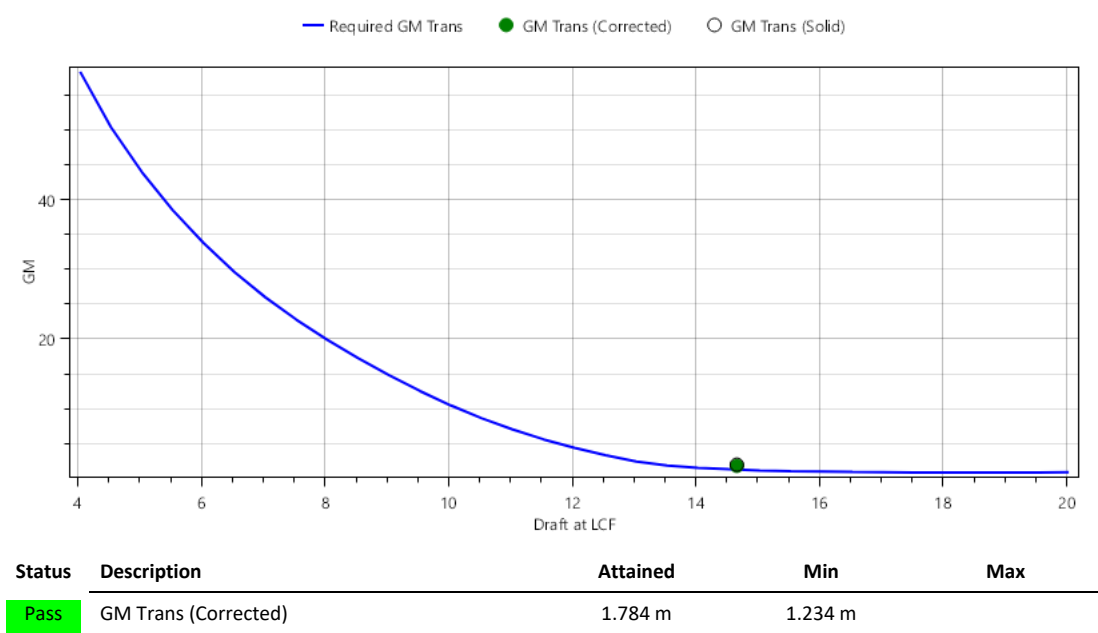
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2763858843		
	Steady Wind Heeling Lever LW1	0.276 m		
	80% Deck Edge Immersion Angle	15.85 deg		
Pass	Heeling Angle at LW1	8.46 deg		15.85 deg
	Gusty Wind Heeling Lever LW2	0.415 m		
	Heeling Angle at LW2	11.87 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	18.96 deg		
	Angle Windward	-10.50 deg		
	Second Intersect	43.68 deg		
	Limiting Angle	43.68 deg		
	Capsizing Area A	-0.15 m-rad		
	Righting Area B	0.29 m-rad		
Pass	Area Ratio B/A	1.8913905001	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.032681142		
Pass	Area to 30.00	0.32 m-rad	0.28 m-rad	
Pass	Area to 40.00	0.52 m-rad	0.49 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.18 m-rad	
Pass	Angle at Maximum GZ	31.05 deg	30.00 deg	
Pass	Maximum GZ	1.290 m	1.285 m	
Pass	Maximum GZ Above 30 Deg	1.290 m	1.010 m	
	Initial Metacentric Height	1.784 m		
	Range of Positive GZ	46.38 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT MT	LCG m-AP	VCG m-BL	TCG m-CL	FST m-MT
	Lightship	67,485	181.958	22.824	0.000	0
	SEAWATER BALLAST	6,915	318.258	2.684	0.746P	1,466
	DIESEL OIL	3,014	243.325	13.196	1.562S	789
	LUBE OIL	578	58.675	18.954	3.418S	179
	FRESH WATER	549	62.003	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.581	2.886	2.291P	1,384
	FUEL GAS TANK	15,507	250.807	15.992	0.000	17,465
	Containers In Hold	85,176	192.061	19.500	0.000	0
	Containers On Deck	79,158	172.642	51.521	0.000	0
	CONSTANT	473	179.784	30.295	0.000	0
	Spaces	0				0
		259,212	190.177	29.409	0.003S	21,283

Lightship

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Lightship Constant	0	197.000	0.000	0.000
Lightship	67,485	181.958	22.824	0.000

SEAWATER BALLAST

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
2WWBT P	2,173	10.00	217	1.0250	223	1,466
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBTP	1,918	100.00	1,918	1.0250	1,966	0
1DBWBTP	2,693	100.00	2,693	1.0250	2,760	0

DIESEL OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
MGO PILOT S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13

SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ST CWT	140	100.00	140	1.0000	140	0
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,132
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
WASTE OIL TANK	138	10.00	14	1.0000	14	105

FUEL GAS TANK

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
TYPE-B PRISMATIC TANK S	12,034	85.00	10,229	0.7580	7,754	8,733
TYPE-B PRISMATIC TANK P	12,034	85.00	10,229	0.7580	7,754	8,733

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 86	2,448	30.350	0.000	24.394	0	0	136	0	136	24.050	36.650
Bay 82	2,052	44.800	0.000	25.856	0	0	114	0	114	38.500	51.100
Bay 78	1,188	70.500	0.000	29.617	0	0	66	0	66	64.200	76.800
Bay 74	4,248	84.950	0.000	19.431	0	0	236	0	236	78.650	91.250
Bay 70	4,608	99.400	0.000	18.640	0	0	256	0	256	93.100	105.700
Bay 66	4,716	113.850	0.000	18.250	0	0	262	0	262	107.550	120.150
Bay 62	4,716	128.300	0.000	18.250	0	0	262	0	262	122.000	134.600
Bay 58	4,716	142.750	0.000	18.250	0	0	262	0	262	136.450	149.050
Bay 90	2,160	15.900	0.000	25.564	0	0	120	0	120	9.600	22.200
Bay 54	4,716	157.200	0.000	18.250	0	0	262	0	262	150.900	163.500
Bay 50	4,716	171.650	0.000	18.250	0	0	262	0	262	165.350	177.950
Bay 42	4,716	200.550	0.000	18.250	0	0	262	0	262	194.250	206.850
Bay 46	4,716	186.100	0.000	18.250	0	0	262	0	262	179.800	192.400
Bay 38	4,716	215.000	0.000	18.250	0	0	262	0	262	208.700	221.300
Bay 34	4,320	229.450	0.000	18.115	0	0	240	0	240	223.150	235.750
Bay 30	1,260	243.900	0.000	18.618	0	0	70	0	70	237.600	250.200
Bay 26	4,644	272.800	0.000	18.500	0	0	258	0	258	266.500	279.100
Bay 18	4,428	301.700	0.000	18.952	0	0	246	0	246	295.400	308.000

Bay 14	4,032	316.150	0.000	19.655	0	0	224	0	224	309.850	322.450
Bay 10	3,348	330.600	0.000	20.588	0	0	190	0	190	324.300	336.900
Bay 6	2,592	345.050	0.000	21.828	0	0	144	0	144	338.750	351.350
Bay 22	4,500	287.250	0.000	18.736	0	0	250	0	250	280.950	293.550
Bay 2	1,620	359.500	0.000	24.782	0	0	90	0	90	353.200	365.800

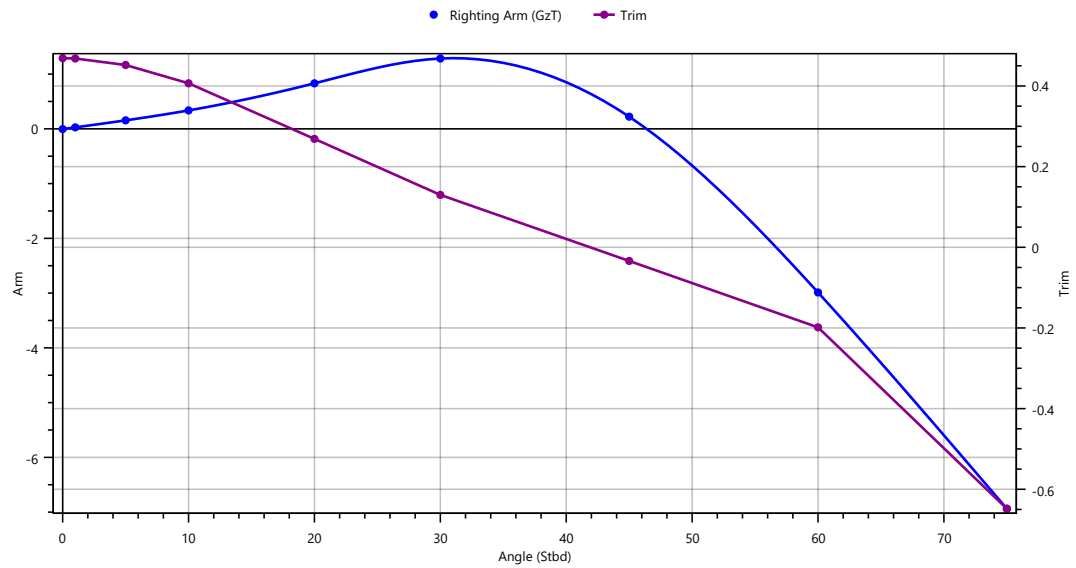
Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 34	3,401	229.450	0.000	52.585	0	0	310	0	310	223.150	235.750
Stack 30	3,491	243.900	0.000	52.210	0	0	310	0	310	237.600	250.200
Stack 22	3,220	287.250	0.000	50.916	0	0	286	0	286	280.950	293.550
Stack 18	2,950	301.700	0.000	49.621	0	0	262	0	262	295.400	308.000
Stack 14	2,950	316.150	0.000	49.621	0	0	262	0	262	309.850	322.450
Stack 10	2,680	330.600	0.000	48.326	0	0	238	0	238	324.300	336.900
Stack 6	2,680	345.050	0.000	48.326	0	0	238	0	238	338.750	351.350
Stack 2	2,207	359.500	0.000	47.023	0	0	196	0	196	353.200	365.800
Stack 38	3,491	215.000	0.000	52.210	0	0	310	0	310	208.700	221.300
Stack 42	3,491	200.550	0.000	52.210	0	0	310	0	310	194.250	206.850
Stack 86	3,491	30.350	0.000	52.210	0	0	310	0	310	24.050	36.650
Stack 50	3,491	171.650	0.000	52.210	0	0	310	0	310	165.350	177.950
Stack 94	3,491	1.450	0.000	52.210	0	0	310	0	310	-4.646	7.546
Stack 46	3,491	186.100	0.000	52.210	0	0	310	0	310	179.800	192.400
Stack 90	3,491	15.900	0.000	52.210	0	0	310	0	310	9.600	22.200
Stack 82	3,491	44.800	0.000	52.210	0	0	310	0	310	38.500	51.100
Stack 78	3,491	70.500	0.000	52.210	0	0	310	0	310	64.200	76.800
Stack 74	3,491	84.950	0.000	52.210	0	0	310	0	310	78.650	91.250
Stack 70	3,491	99.400	0.000	52.210	0	0	310	0	310	93.100	105.700
Stack 66	3,491	113.850	0.000	52.210	0	0	310	0	310	107.550	120.150
Stack 62	3,491	128.300	0.000	52.210	0	0	310	0	310	122.000	134.600
Stack 58	3,491	142.750	0.000	52.210	0	0	310	0	310	136.450	149.050
Stack 54	3,491	157.200	0.000	52.210	0	0	310	0	310	150.900	163.500
Stack 26	3,220	272.800	0.000	50.916	0	0	286	0	286	266.500	279.100

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000	40.000	0.000
ER Misc Tanks	50	62.350	25.000	0.000
Bosun Stores	40	385.000	28.755	0.000
Water in Piping	50	160.000	1.350	0.000
Crew & Effects	6	258.450	55.000	0.000
Provisions	7	258.450	40.000	0.000

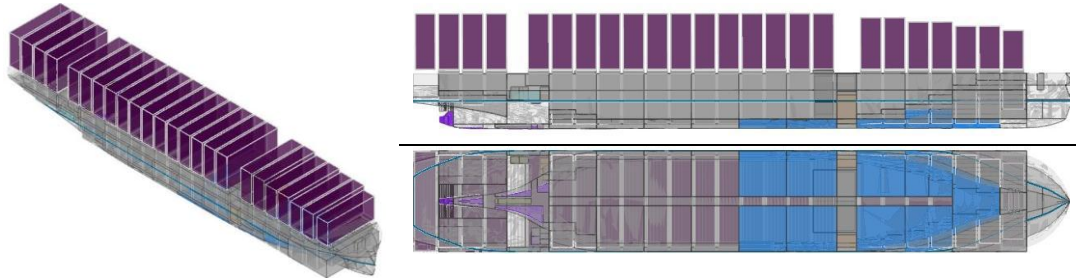
Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.47	-0.005	0.000	0.00	0.47A	16.107	12.882	5
0.00	1.00	0.47	0.027	0.001	1.00S	0.47A	16.103	12.883	2
0.00	5.00	0.45	0.155	-0.001	5.00S	0.45A	16.021	12.912	3
0.00	10.00	0.41	0.336	-0.002	10.00S	0.41A	15.783	12.987	3
0.00	20.00	0.27	0.831	-0.005	20.00S	0.27A	14.965	13.116	3
0.00	30.00	0.13	1.284	0.003	30.00S	0.13A	13.659	12.765	3
0.00	45.00	-0.03	0.222	-0.001	45.00S	0.03F	10.071	10.304	5
0.00	60.00	-0.20	-2.988	0.001	60.00S	0.20F	4.087	5.452	8
0.00	75.00	-0.65	-6.938	0.000	75.00S	0.65F	-12.183	-7.725	9

Ammonia 10 Tier Deck Scantling Departure 9.4 MT Deck 9 MT Hold

Trim and Stability Summary



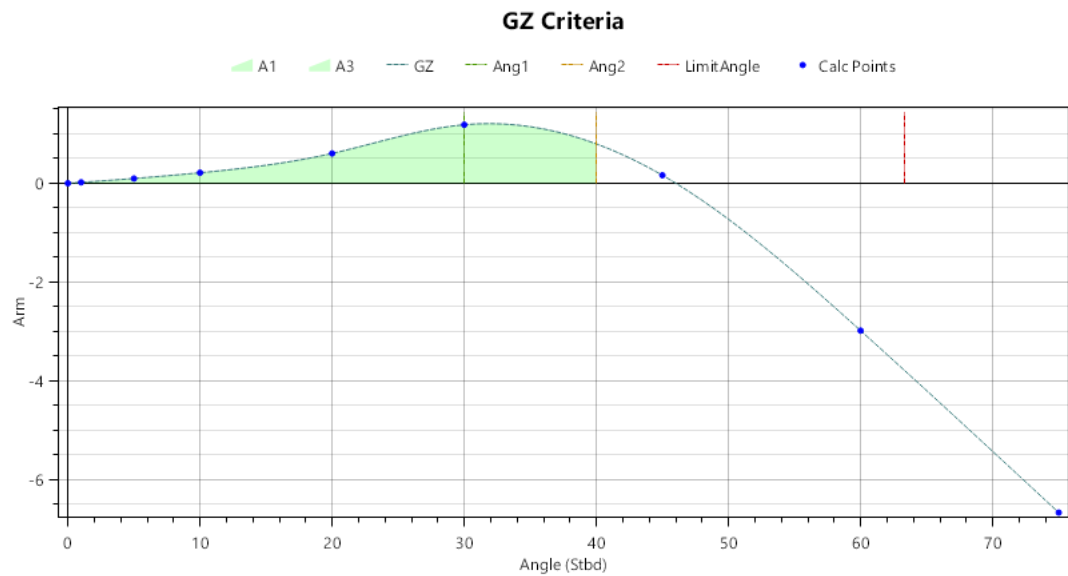
Loading					
Intact Displacement	300,784	MT	Sea Density	1.0250	MT/m ³
Deadweight	233,299	MT			
Available Deadweight	97	MT			
Stability			Trim		
KM0 Trans	29.885	m	Draft at LCF	16.548	m
VCG Upright	28.670	m-BL	LCF	181.507	m-AP
GM0 Solid Trans	1.216	m	LCB	194.262	m-AP
GM0 Trans	1.073	m	LCG	194.284	m-AP
GMt Required	0.902	m	TPM	222.09	MT/cm
GMt Margin	0.171	m	MTM	5,959	m-MT/cm
GM at Equilibrium	0.975	m	Trim at Perps	0A	m
			Heel0	0.00	deg
			Propeller Immersion	156.78	%
Drafts - Perps			Drafts - Marks		
AP	16.749	m	Fwd	16.324	m
MS	16.531	m	Mid	16.534	m
FP	16.313	m	Aft	16.728	m
Strength					
Shear Min	-10,236	MT			
Shear Max	18,128	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,488,877H	m-MT			
Moment Max Sag	3,590S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	340.806	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
34 Tanks from Geometry
0 Tanks from Tables
72 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

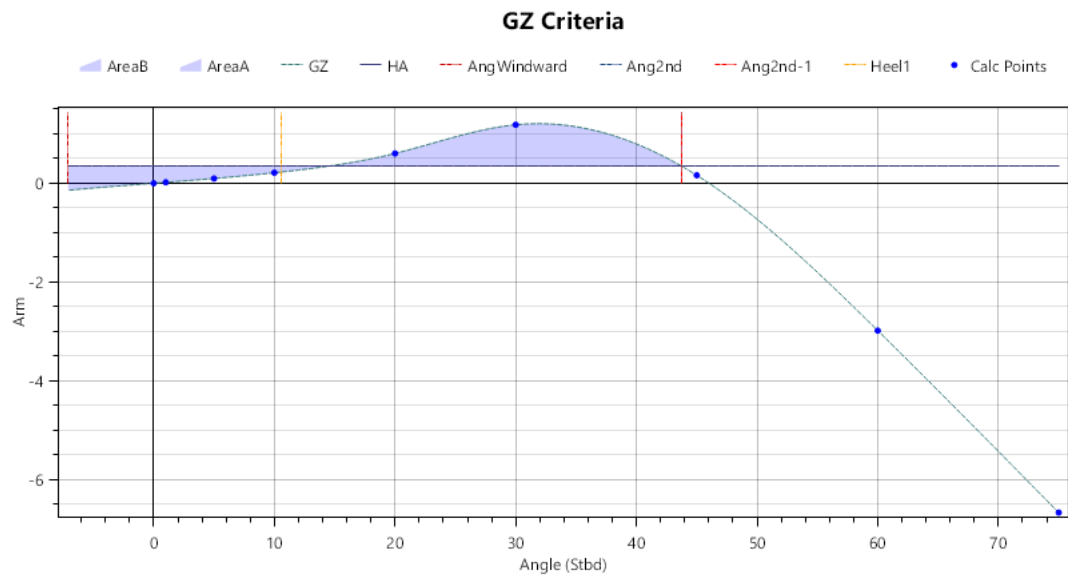
Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	233,299 MT		233,397 MT
Pass	Propeller Immersion	156.78 %	100.00 %	
Pass	Visibility	340.806 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.073 m	0.902 m	

2008 IS Code 2.2 General Criteria



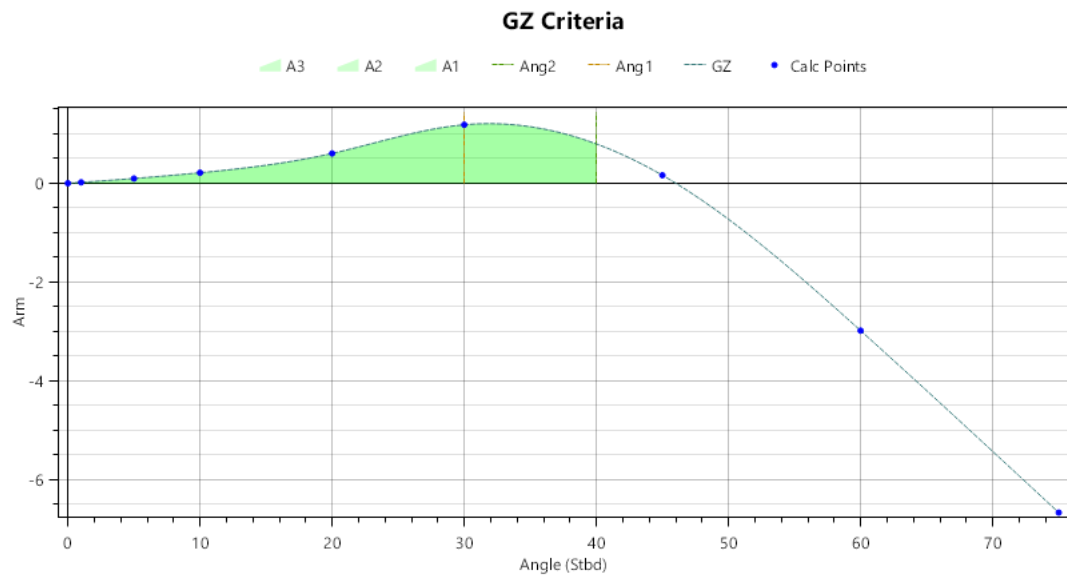
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.24 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.43 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.19 m-rad	0.03 m-rad	
	Angle to Downflooding	63.36 deg		
Pass	Angle at Maximum GZ	31.86 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.206 m	0.200 m	
Pass	Initial Metacentric Height	1.073 m	0.150 m	
	Range of Positive GZ	46.01 deg		

2008 IS Code 2.3 Weather Criteria



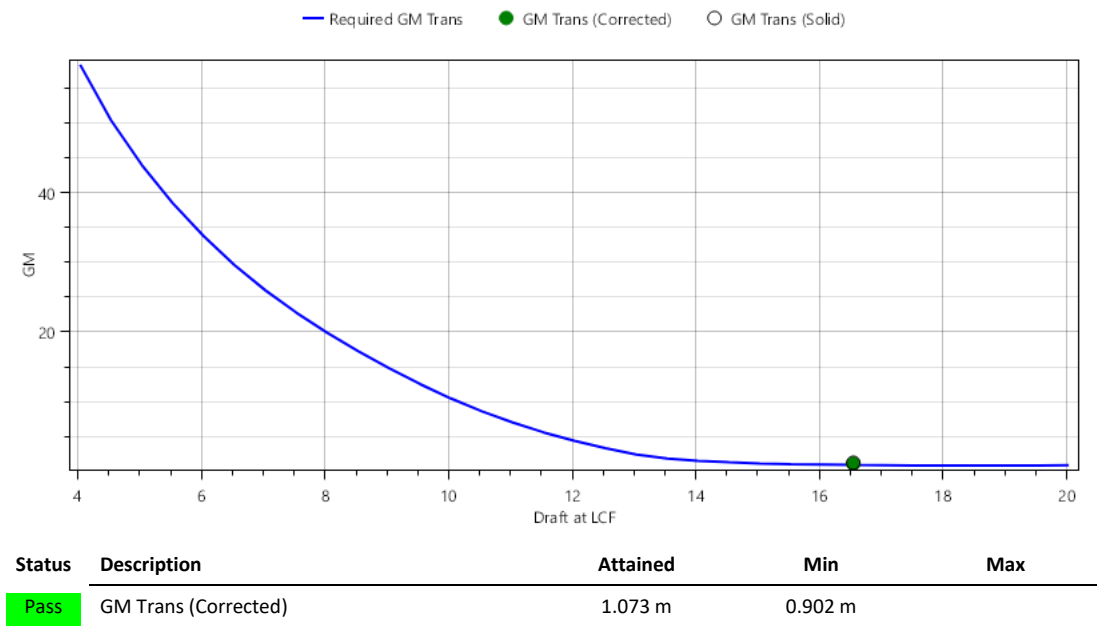
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2260447583		
	Steady Wind Heeling Lever LW1	0.226 m		
	80% Deck Edge Immersion Angle	14.65 deg		
Pass	Heeling Angle at LW1	10.58 deg		14.65 deg
	Gusty Wind Heeling Lever LW2	0.339 m		
	Heeling Angle at LW2	14.33 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.69 deg		
	Angle Windward	-7.11 deg		
	Second Intersect	43.79 deg		
	Limiting Angle	43.79 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.26 m-rad		
Pass	Area Ratio B/A	2.6677562506	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.039812848		
Pass	Area to 30.00	0.24 m-rad	0.23 m-rad	
Pass	Area to 40.00	0.43 m-rad	0.40 m-rad	
Pass	Area 30.00 to 40.00	0.19 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	31.86 deg	30.00 deg	
Pass	Maximum GZ	1.206 m	1.055 m	
Pass	Maximum GZ Above 30 Deg	1.206 m	0.829 m	
	Initial Metacentric Height	1.073 m		
	Range of Positive GZ	46.01 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT MT	LCG m-AP	VCG m-BL	TCG m-CL	FST m-MT
	Lightship	67,485	181.958	22.824	0.000	0
	SEAWATER BALLAST	23,004	269.224	2.684	0.254P	1,727
	DIESEL OIL	3,014	243.329	13.196	1.562S	789
	LUBE OIL	578	58.708	18.954	3.418S	179
	FRESH WATER	549	62.003	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.778	2.885	2.316P	1,345
	FUEL GAS TANK	15,507	250.823	15.992	0.000	17,465
	Containers In Hold	85,176	192.061	19.500	0.000	0
	Containers On Deck	104,641	179.800	48.117	0.000	0
	CONSTANT	473	179.784	30.295	0.000	0
	Spaces	0				0
		300,784	194.284	28.668	0.000S	21,505

Lightship

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Lightship Constant	0	197.000	0.000	0.000
Lightship	67,485	181.958	22.824	0.000

SEAWATER BALLAST

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	39.00	848	1.0250	869	1,181
2WWBT P	2,173	49.00	1,065	1.0250	1,091	546
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0

DIESEL OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
MGO PILOT S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14

NO 1 MGO SETT TK 140 50.00 70 0.8600 60 14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	29
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,097
WASTE OIL TANK	138	10.00	14	1.0000	14	103
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

FUEL GAS TANK

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
TYPE-B PRISMATIC TANK S	12,034	85.00	10,229	0.7580	7,754	8,733
TYPE-B PRISMATIC TANK P	12,034	85.00	10,229	0.7580	7,754	8,733

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900	0.000	25.564	0	0	120	0	120	9.600	22.200
Bay 86	2,448	30.350	0.000	24.394	0	0	136	0	136	24.050	36.650
Bay 46	4,716	186.100	0.000	18.250	0	0	262	0	262	179.800	192.400
Bay 78	1,188	70.500	0.000	29.617	0	0	66	0	66	64.200	76.800
Bay 74	4,248	84.950	0.000	19.431	0	0	236	0	236	78.650	91.250
Bay 70	4,608	99.400	0.000	18.640	0	0	256	0	256	93.100	105.700
Bay 66	4,716	113.850	0.000	18.250	0	0	262	0	262	107.550	120.150
Bay 62	4,716	128.300	0.000	18.250	0	0	262	0	262	122.000	134.600
Bay 58	4,716	142.750	0.000	18.250	0	0	262	0	262	136.450	149.050
Bay 54	4,716	157.200	0.000	18.250	0	0	262	0	262	150.900	163.500
Bay 50	4,716	171.650	0.000	18.250	0	0	262	0	262	165.350	177.950

Bay 82	2,052	44.800	0.000	25.856	0	0	114	0	114	38.500	51.100
Bay 42	4,716	200.550	0.000	18.250	0	0	262	0	262	194.250	206.850
Bay 38	4,716	215.000	0.000	18.250	0	0	262	0	262	208.700	221.300
Bay 30	1,260	243.900	0.000	18.618	0	0	70	0	70	237.600	250.200
Bay 34	4,320	229.450	0.000	18.115	0	0	240	0	240	223.150	235.750
Bay 26	4,644	272.800	0.000	18.500	0	0	258	0	258	266.500	279.100
Bay 22	4,500	287.250	0.000	18.736	0	0	250	0	250	280.950	293.550
Bay 18	4,428	301.700	0.000	18.952	0	0	246	0	246	295.400	308.000
Bay 14	4,032	316.150	0.000	19.655	0	0	224	0	224	309.850	322.450
Bay 10	3,348	330.600	0.000	20.588	0	0	190	0	190	324.300	336.900
Bay 2	1,620	359.500	0.000	24.782	0	0	90	0	90	353.200	365.800
Bay 6	2,592	345.050	0.000	21.828	0	0	144	0	144	338.750	351.350

Containers On Deck

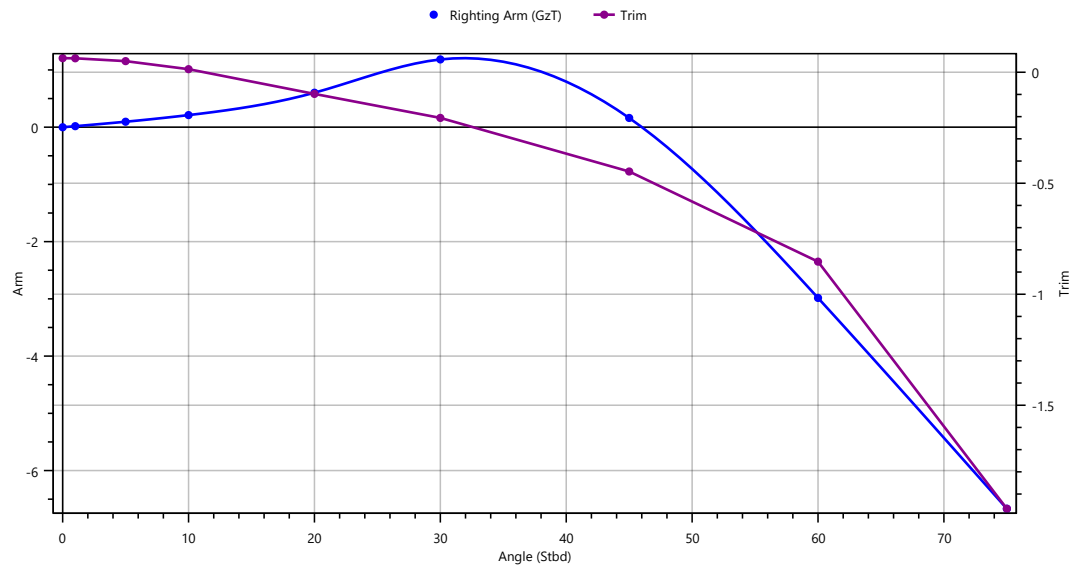
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 30	4,399	243.900	0.000	48.148	0	0	310	0	310	237.600	250.200
Stack 26	4,399	272.800	0.000	48.148	0	0	286	0	286	266.500	279.100
Stack 22	4,399	287.250	0.000	48.148	0	0	286	0	286	280.950	293.550
Stack 18	4,399	301.700	0.000	48.148	0	0	262	0	262	295.400	308.000
Stack 10	4,399	330.600	0.000	48.148	0	0	238	0	238	324.300	336.900
Stack 6	4,399	345.050	0.000	48.148	0	0	238	0	238	338.750	351.350
Stack 2	3,610	359.500	0.000	46.832	0	0	196	0	196	353.200	365.800
Stack 34	4,249	229.450	0.000	48.505	0	0	310	0	310	223.150	235.750
Stack 38	4,399	215.000	0.000	48.148	0	0	310	0	310	208.700	221.300
Stack 78	4,399	70.500	0.000	48.148	0	0	310	0	310	64.200	76.800
Stack 46	4,399	186.100	0.000	48.148	0	0	310	0	310	179.800	192.400
Stack 94	4,399	1.450	0.000	48.150	0	0	310	0	310	-4.646	7.546
Stack 90	4,399	15.900	0.000	48.148	0	0	310	0	310	9.600	22.200
Stack 86	4,399	30.350	0.000	48.148	0	0	310	0	310	24.050	36.650
Stack 82	4,399	44.800	0.000	48.148	0	0	310	0	310	38.500	51.100
Stack 74	4,399	84.950	0.000	48.148	0	0	310	0	310	78.650	91.250
Stack 70	4,399	99.400	0.000	48.148	0	0	310	0	310	93.100	105.700
Stack 66	4,399	113.850	0.000	48.148	0	0	310	0	310	107.550	120.150
Stack 62	4,399	128.300	0.000	48.148	0	0	310	0	310	122.000	134.600
Stack 58	4,399	142.750	0.000	48.148	0	0	310	0	310	136.450	149.050
Stack 54	4,399	157.200	0.000	48.148	0	0	310	0	310	150.900	163.500
Stack 50	4,399	171.650	0.000	48.148	0	0	310	0	310	165.350	177.950
Stack 42	4,399	200.550	0.000	48.148	0	0	310	0	310	194.250	206.850
Stack 14	4,399	316.150	0.000	48.148	0	0	262	0	262	309.850	322.450

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000	40.000	0.000
ER Misc Tanks	50	62.350	25.000	0.000
Bosun Stores	40	385.000	28.755	0.000

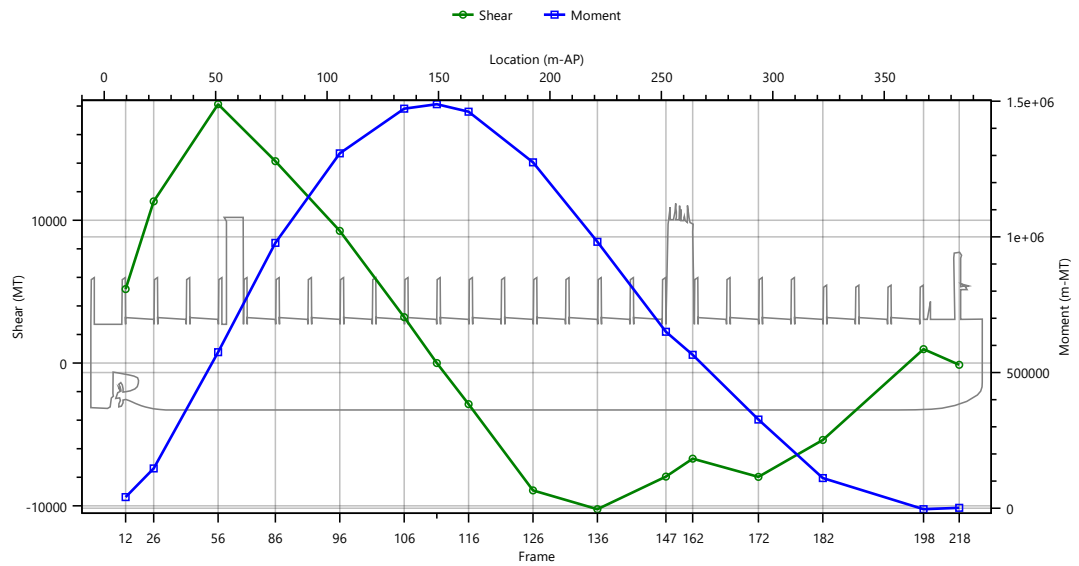
Water in Piping	50	160.000	1.350	0.000
Crew & Effects	6	258.450	55.000	0.000
Provisions	7	258.450	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.06	-0.002	0.000	0.00	0.06A	16.714	16.278	5
0.00	1.00	0.06	0.017	0.001	1.00S	0.06A	16.710	16.279	2
0.00	5.00	0.05	0.095	0.000	5.00S	0.05A	16.642	16.298	3
0.00	10.00	0.01	0.211	-0.001	10.00S	0.01A	16.443	16.348	3
0.00	20.00	-0.10	0.602	-0.002	20.00S	0.10F	15.752	16.424	3
0.00	30.00	-0.21	1.184	0.000	30.00S	0.21F	14.699	16.113	3
0.00	45.00	-0.45	0.161	-0.001	45.00S	0.45F	11.904	14.979	5
0.00	60.00	-0.85	-2.984	0.003	60.00S	0.85F	7.255	13.123	8
0.00	75.00	-1.97	-6.667	0.000	75.01S	1.97F	-5.034	8.492	9

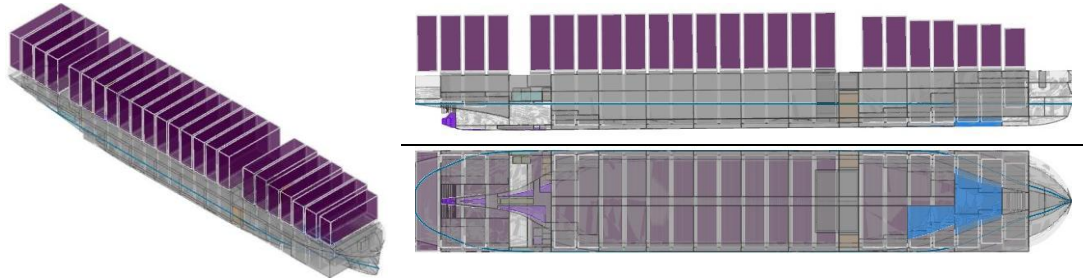
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600	1,049	6,229	5,180	7,907S	48,888S	40,981H
22.200	3,052	14,375	11,323	31,878S	178,495S	146,618H
51.100	14,650	32,779	18,128	263,511S	838,563S	575,052H
76.800	33,331	47,468	14,137	865,090S	1,842,989S	977,899H
105.700	60,741	69,997	9,257	2,214,062S	3,521,849S	1,307,788H
134.600	90,075	93,288	3,213	4,392,671S	5,865,124S	1,472,453H
149.249	104,988	104,988	-1	5,821,417S	7,310,294S	1,488,877H
163.500	119,485	116,606	-2,879	7,420,922S	8,882,165S	1,461,242H
192.400	148,843	139,922	-8,921	11,298,398S	12,573,068S	1,274,670H
221.300	178,143	167,907	-10,236	16,023,474S	17,005,267S	981,793H
252.050	209,219	201,265	-7,954	21,979,610S	22,629,828S	650,218H
264.050	221,267	214,569	-6,698	24,562,601S	25,127,945S	565,344H
293.550	250,268	242,294	-7,973	31,520,954S	31,847,745S	326,791H
322.450	275,574	270,186	-5,388	39,133,110S	39,244,253S	111,143H
367.650	297,487	298,460	974	52,174,350S	52,170,760S	3,590S
383.650	300,318	300,194	-124	56,959,997S	56,961,497S	1,500H

Ammonia 10 Tier Deck Design Departure 7.4 MT Deck 9 MT Hold

Trim and Stability Summary



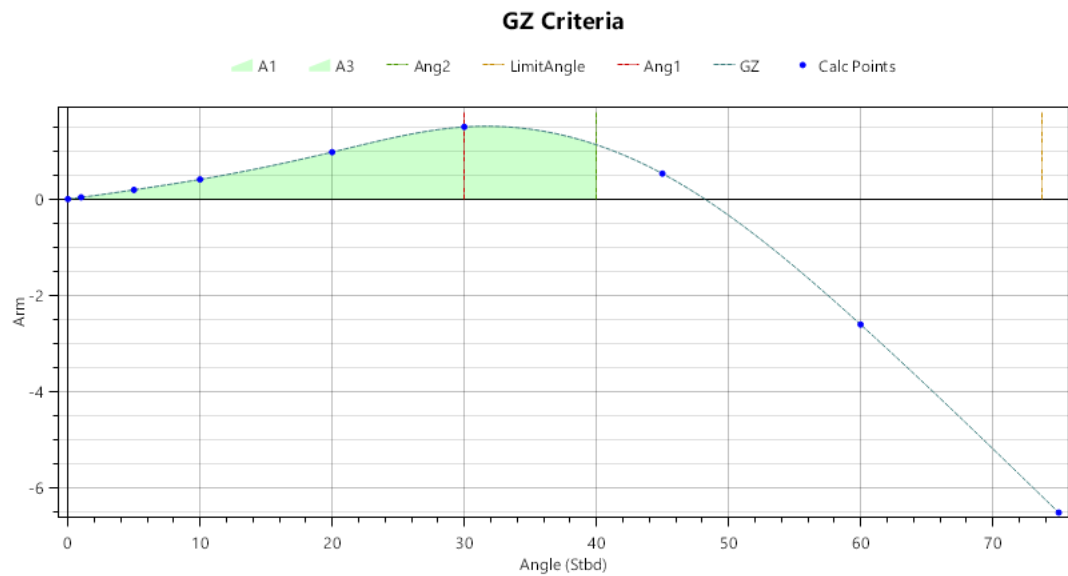
Loading					
Intact Displacement	258,768	MT	Sea Density	1.0250	MT/m ³
Deadweight	191,283	MT			
Available Deadweight	412	MT			
Stability			Trim		
KM0 Trans	31.337	m	Draft at LCF	14.640	m
VCG Upright	28.977	m-BL	LCF	181.018	m-AP
GM0 Solid Trans	2.362	m	LCB	190.416	m-AP
GM0 Trans	2.158	m	LCG	190.579	m-AP
GMt Required	1.242	m	TPM	216.46	MT/cm
GMt Margin	0.916	m	MTM	5,558	m-MT/cm
GM at Equilibrium	1.833	m	Trim at Perps	3A	m
			Heel0	0.00	deg
			Propeller Immersion	149.45	%
Drafts - Perps			Drafts - Marks		
AP	16.038	m	Fwd	13.074	m
MS	14.516	m	Mid	14.537	m
FP	12.994	m	Aft	15.894	m
Strength					
Shear Min	-9,299	MT			
Shear Max	16,990	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,483,669H	m-MT			
Moment Max Sag	--	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	391.610	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
25 Tanks from Geometry
0 Tanks from Tables
81 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	191,283 MT		235,903 MT
Pass	Propeller Immersion	149.45 %	100.00 %	
Pass	Visibility	391.610 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	2.158 m	1.242 m	
Pass	Design Deadweight	191,283 MT		191,694 MT

2008 IS Code 2.2 General Criteria



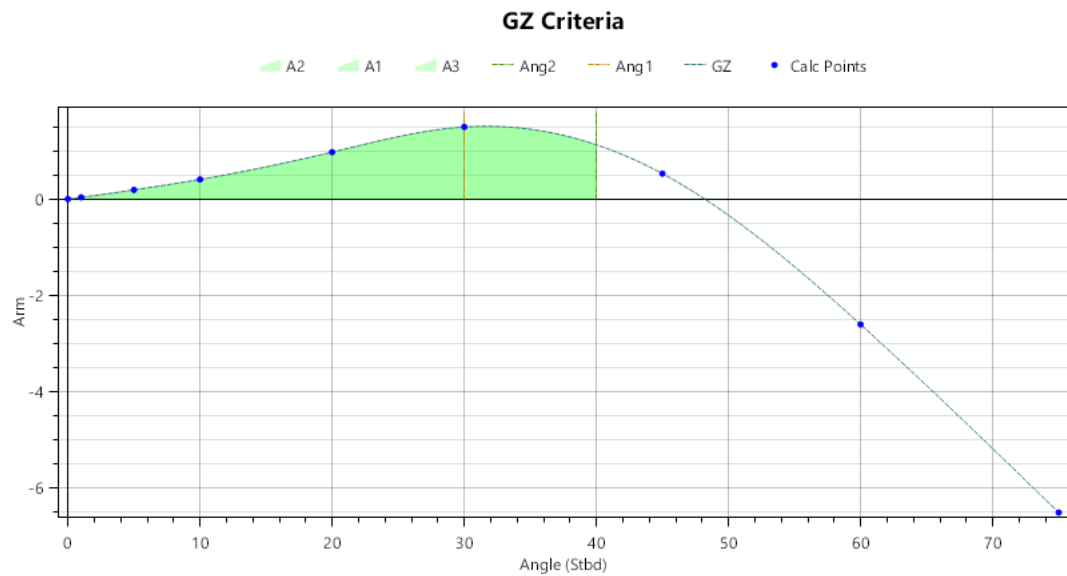
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.37 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.62 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.24 m-rad	0.03 m-rad	
	Angle to Downflooding	73.69 deg		
Pass	Angle at Maximum GZ	31.65 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.511 m	0.200 m	
Pass	Initial Metacentric Height	2.158 m	0.150 m	
	Range of Positive GZ	48.20 deg		

2008 IS Code 2.3 Weather Criteria



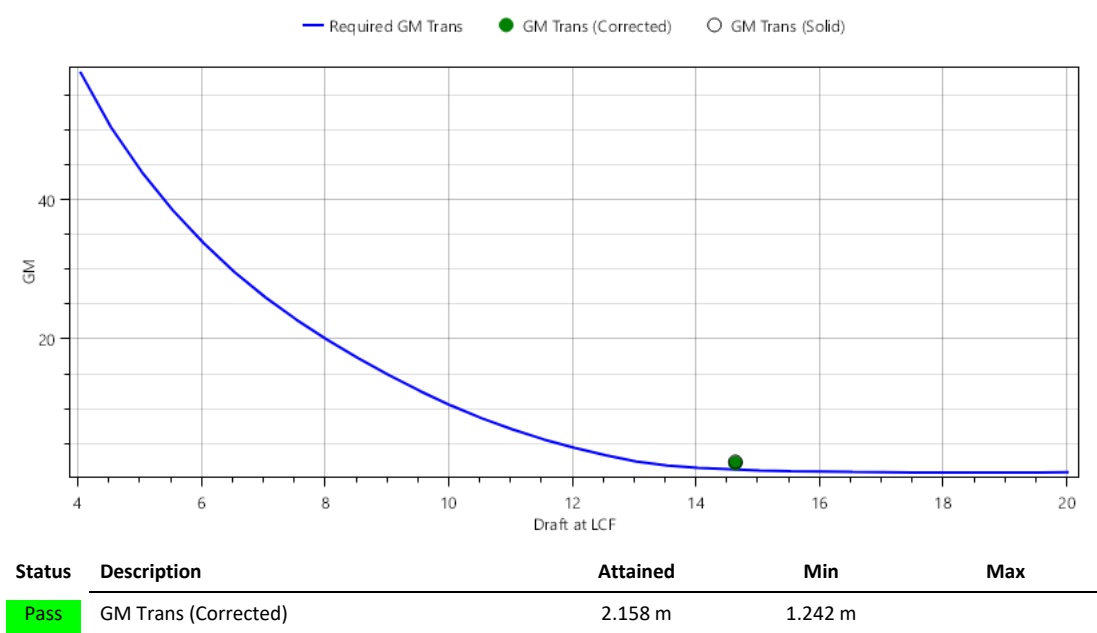
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2770194782		
	Steady Wind Heeling Lever LW1	0.277 m		
	80% Deck Edge Immersion Angle	16.04 deg		
Pass	Heeling Angle at LW1	7.17 deg		16.00 deg
	Gusty Wind Heeling Lever LW2	0.416 m		
	Heeling Angle at LW2	10.24 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	18.86 deg		
	Angle Windward	-11.69 deg		
	Second Intersect	45.73 deg		
	Limiting Angle	45.73 deg		
	Capsizing Area A	-0.17 m-rad		
	Righting Area B	0.41 m-rad		
Pass	Area Ratio B/A	2.3508184036	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0329277965		
Pass	Area to 30.00	0.37 m-rad	0.27 m-rad	
Pass	Area to 40.00	0.62 m-rad	0.49 m-rad	
Pass	Area 30.00 to 40.00	0.24 m-rad	0.18 m-rad	
Pass	Angle at Maximum GZ	31.65 deg	30.00 deg	
Pass	Maximum GZ	1.511 m	1.276 m	
Pass	Maximum GZ Above 30 Deg	1.511 m	1.002 m	
	Initial Metacentric Height	2.158 m		
	Range of Positive GZ	48.20 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT MT	LCG m-AP	VCG m-BL	TCG m-CL	FST m-MT
	Lightship	67,485	181.958	22.824	0.000	0
	SEAWATER BALLAST	3,251	330.606	2.413	1.550P	13,762
	DIESEL OIL	3,014	243.325	13.196	1.562S	789
	LUBE OIL	578	58.677	18.954	3.418S	179
	FRESH WATER	549	62.003	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.594	2.886	2.293P	1,382
	FUEL GAS TANK	15,507	250.808	15.992	0.000	17,465
	Containers In Hold	85,176	192.061	19.500	0.000	0
	Containers On Deck	82,377	179.800	48.117	0.000	0
	CONSTANT	473	179.784	30.295	0.000	0
	Spaces	0				0
		258,768	190.579	28.975	0.003S	33,577

Lightship

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Lightship Constant	0	197.000	0.000	0.000
Lightship	67,485	181.958	22.824	0.000

SEAWATER BALLAST

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
2DBWBT P	1,918	25.00	480	1.0250	492	13,762
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0

DIESEL OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
MGO PILOT S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13

ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
WASTE OIL TANK	138	10.00	14	1.0000	14	105
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,130

FUEL GAS TANK

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
TYPE-B PRISMATIC TANK S	12,034	85.00	10,229	0.7580	7,754	8,733
TYPE-B PRISMATIC TANK P	12,034	85.00	10,229	0.7580	7,754	8,733

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900	0.000	25.564	0	0	120	0	120	9.600	22.200
Bay 86	2,448	30.350	0.000	24.394	0	0	136	0	136	24.050	36.650
Bay 82	2,052	44.800	0.000	25.856	0	0	114	0	114	38.500	51.100
Bay 78	1,188	70.500	0.000	29.617	0	0	66	0	66	64.200	76.800
Bay 74	4,248	84.950	0.000	19.431	0	0	236	0	236	78.650	91.250
Bay 70	4,608	99.400	0.000	18.640	0	0	256	0	256	93.100	105.700
Bay 66	4,716	113.850	0.000	18.250	0	0	262	0	262	107.550	120.150
Bay 62	4,716	128.300	0.000	18.250	0	0	262	0	262	122.000	134.600
Bay 58	4,716	142.750	0.000	18.250	0	0	262	0	262	136.450	149.050
Bay 54	4,716	157.200	0.000	18.250	0	0	262	0	262	150.900	163.500
Bay 46	4,716	186.100	0.000	18.250	0	0	262	0	262	179.800	192.400
Bay 50	4,716	171.650	0.000	18.250	0	0	262	0	262	165.350	177.950
Bay 42	4,716	200.550	0.000	18.250	0	0	262	0	262	194.250	206.850
Bay 38	4,716	215.000	0.000	18.250	0	0	262	0	262	208.700	221.300
Bay 34	4,320	229.450	0.000	18.115	0	0	240	0	240	223.150	235.750
Bay 30	1,260	243.900	0.000	18.618	0	0	70	0	70	237.600	250.200
Bay 22	4,500	287.250	0.000	18.736	0	0	250	0	250	280.950	293.550
Bay 18	4,428	301.700	0.000	18.952	0	0	246	0	246	295.400	308.000
Bay 14	4,032	316.150	0.000	19.655	0	0	224	0	224	309.850	322.450
Bay 10	3,348	330.600	0.000	20.588	0	0	190	0	190	324.300	336.900

Bay 26	4,644	272.800	0.000	18.500	0	0	258	0	258	266.500	279.100
Bay 2	1,620	359.500	0.000	24.782	0	0	90	0	90	353.200	365.800
Bay 6	2,592	345.050	0.000	21.828	0	0	144	0	144	338.750	351.350

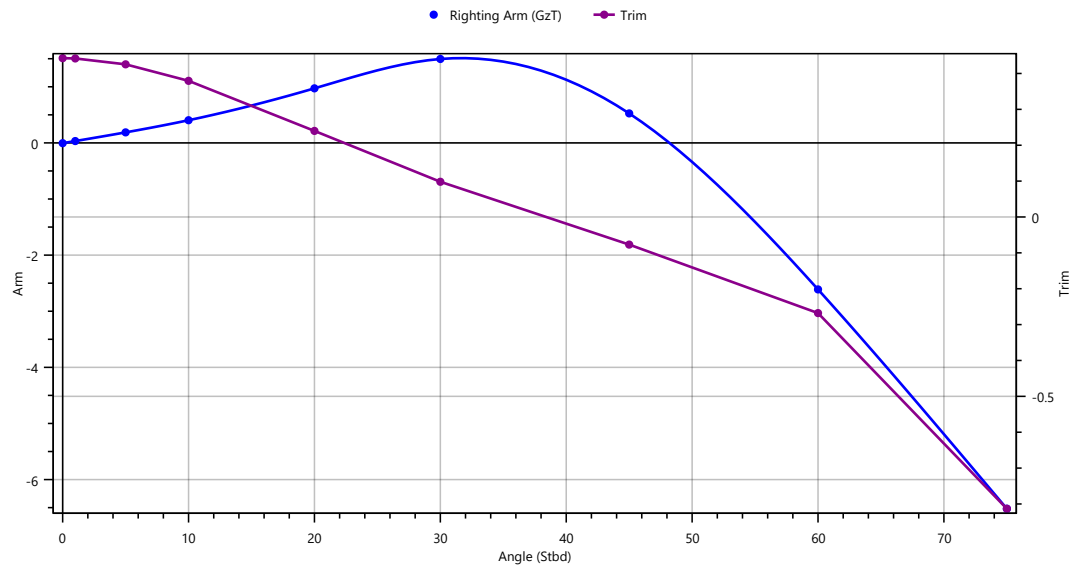
Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 38	3,463	215.000	0.000	48.148	0	0	310	0	310	208.700	221.300
Stack 34	3,345	229.450	0.000	48.505	0	0	310	0	310	223.150	235.750
Stack 26	3,463	272.800	0.000	48.148	0	0	286	0	286	266.500	279.100
Stack 22	3,463	287.250	0.000	48.148	0	0	286	0	286	280.950	293.550
Stack 18	3,463	301.700	0.000	48.148	0	0	262	0	262	295.400	308.000
Stack 14	3,463	316.150	0.000	48.148	0	0	262	0	262	309.850	322.450
Stack 10	3,463	330.600	0.000	48.148	0	0	238	0	238	324.300	336.900
Stack 6	3,463	345.050	0.000	48.148	0	0	238	0	238	338.750	351.350
Stack 42	3,463	200.550	0.000	48.148	0	0	310	0	310	194.250	206.850
Stack 2	2,842	359.500	0.000	46.832	0	0	196	0	196	353.200	365.800
Stack 46	3,463	186.100	0.000	48.148	0	0	310	0	310	179.800	192.400
Stack 86	3,463	30.350	0.000	48.148	0	0	310	0	310	24.050	36.650
Stack 54	3,463	157.200	0.000	48.148	0	0	310	0	310	150.900	163.500
Stack 94	3,463	1.450	0.000	48.150	0	0	310	0	310	-4.646	7.546
Stack 90	3,463	15.900	0.000	48.148	0	0	310	0	310	9.600	22.200
Stack 82	3,463	44.800	0.000	48.148	0	0	310	0	310	38.500	51.100
Stack 78	3,463	70.500	0.000	48.148	0	0	310	0	310	64.200	76.800
Stack 74	3,463	84.950	0.000	48.148	0	0	310	0	310	78.650	91.250
Stack 70	3,463	99.400	0.000	48.148	0	0	310	0	310	93.100	105.700
Stack 66	3,463	113.850	0.000	48.148	0	0	310	0	310	107.550	120.150
Stack 62	3,463	128.300	0.000	48.148	0	0	310	0	310	122.000	134.600
Stack 58	3,463	142.750	0.000	48.148	0	0	310	0	310	136.450	149.050
Stack 50	3,463	171.650	0.000	48.148	0	0	310	0	310	165.350	177.950
Stack 30	3,463	243.900	0.000	48.148	0	0	310	0	310	237.600	250.200

CONSTANT

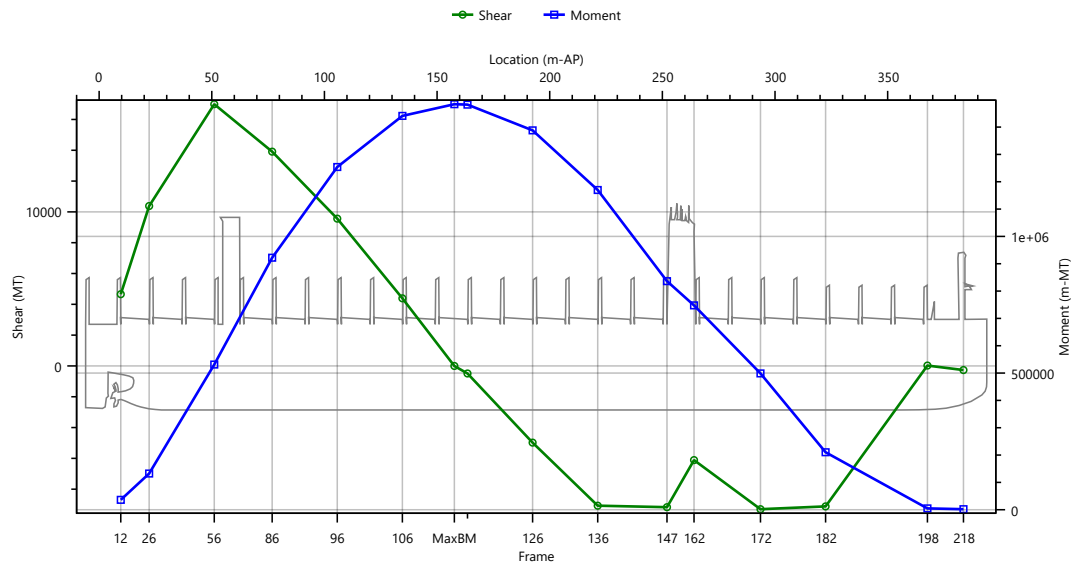
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000	40.000	0.000
ER Misc Tanks	50	62.350	25.000	0.000
Bosun Stores	40	385.000	28.755	0.000
Water in Piping	50	160.000	1.350	0.000
Crew & Effects	6	258.450	55.000	0.000
Provisions	7	258.450	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.44	-0.005	0.000	0.00	0.44A	16.003	12.959	5
0.00	1.00	0.44	0.033	0.001	1.00S	0.44A	15.999	12.961	2
0.00	5.00	0.43	0.187	-0.001	5.00S	0.43A	15.916	12.990	3
0.00	10.00	0.38	0.404	-0.002	10.00S	0.38A	15.676	13.066	3
0.00	20.00	0.24	0.972	-0.005	20.00S	0.24A	14.849	13.199	3
0.00	30.00	0.10	1.496	0.002	30.00S	0.10A	13.529	12.854	3
0.00	45.00	-0.08	0.526	-0.001	45.00S	0.08F	9.890	10.419	5
0.00	60.00	-0.27	-2.611	0.001	60.00S	0.27F	3.792	5.635	8
0.00	75.00	-0.81	-6.520	0.000	75.00S	0.81F	-12.882	-7.289	9

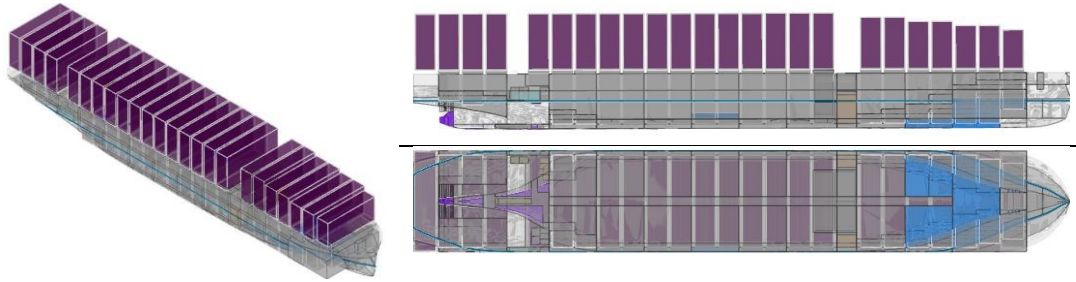
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600	636	5,293	4,657	5,077S	41,260S	36,183H
22.200	2,123	12,503	10,380	20,755S	153,177S	132,422H
51.100	12,049	29,038	16,990	202,675S	733,840S	531,165H
76.800	28,878	42,788	13,910	714,202S	1,636,218S	922,016H
105.700	53,884	63,445	9,561	1,900,585S	3,154,508S	1,253,922H
134.600	80,474	84,864	4,390	3,842,212S	5,283,110S	1,440,899H
157.671	101,521	101,519	-2	5,942,049S	7,425,718S	1,483,669H
163.500	106,800	106,310	-490	6,549,252S	8,031,379S	1,482,127H
192.400	132,732	127,754	-4,978	10,011,453S	11,399,409S	1,387,956H
221.300	158,267	149,196	-9,072	14,217,358S	15,387,139S	1,169,781H
252.050	184,964	175,794	-9,169	19,495,970S	20,332,291S	836,321H
264.050	195,198	189,086	-6,112	21,777,072S	22,524,710S	747,638H
293.550	219,490	210,191	-9,299	27,897,809S	28,396,544S	498,735H
322.450	239,928	230,810	-9,118	34,550,148S	34,760,447S	210,299H
367.650	256,419	256,444	24	45,840,185S	45,845,044S	4,858H
383.650	258,445	258,177	-268	49,961,559S	49,963,517S	1,958H

Ammonia 14 MT TEU HOMO 14398 TEU

Trim and Stability Summary



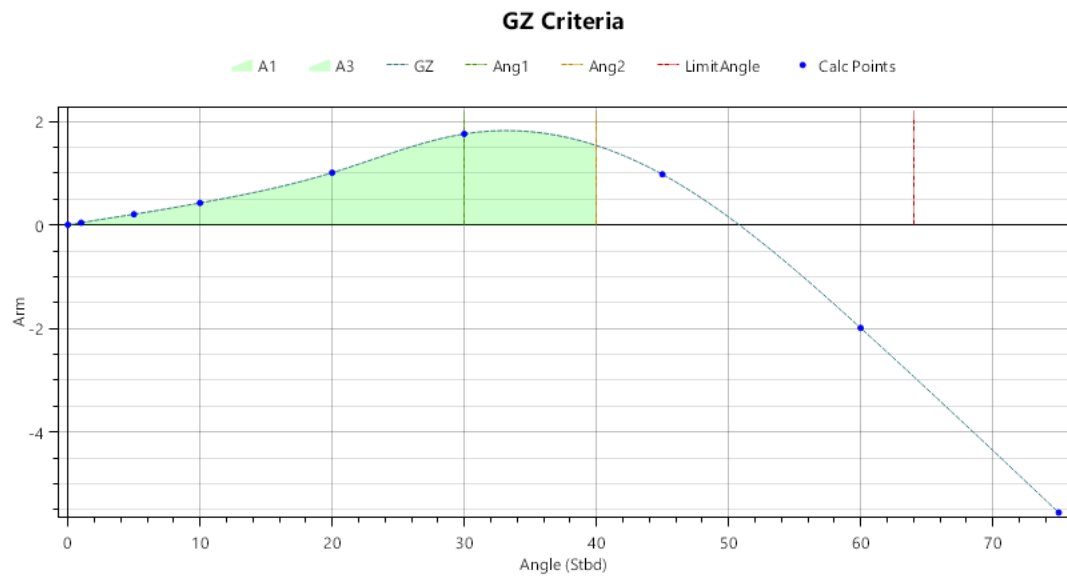
Loading					
Intact Displacement	299,264	MT	Sea Density	1.0250	MT/m ³
Deadweight	231,779	MT			
Available Deadweight	2,109	MT			
Stability			Trim		
KM0 Trans	29.985	m	Draft at LCF	16.481	m
VCG Upright	27.500	m-BL	LCF	180.933	m-AP
GM0 Solid Trans	2.486	m	LCB	193.204	m-AP
GM0 Trans	2.299	m	LCG	193.252	m-AP
GMt Required	0.909	m	TPM	222.18	MT/cm
GMt Margin	1.390	m	MTM	5,974	m-MT/cm
GM at Equilibrium	2.572	m	Trim at Perps	1A	m
			Heel0	0.00	deg
			Propeller Immersion	158.45	%
Drafts - Perps			Drafts - Marks		
AP	16.933	m	Fwd	15.974	m
MS	16.440	m	Mid	16.447	m
FP	15.948	m	Aft	16.886	m
Strength					
Shear Min	-17,096	MT			
Shear Max	22,390	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	2,101,323H	m-MT			
Moment Max Sag	2,623S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	348.104	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
29 Tanks from Geometry
0 Tanks from Tables
77 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

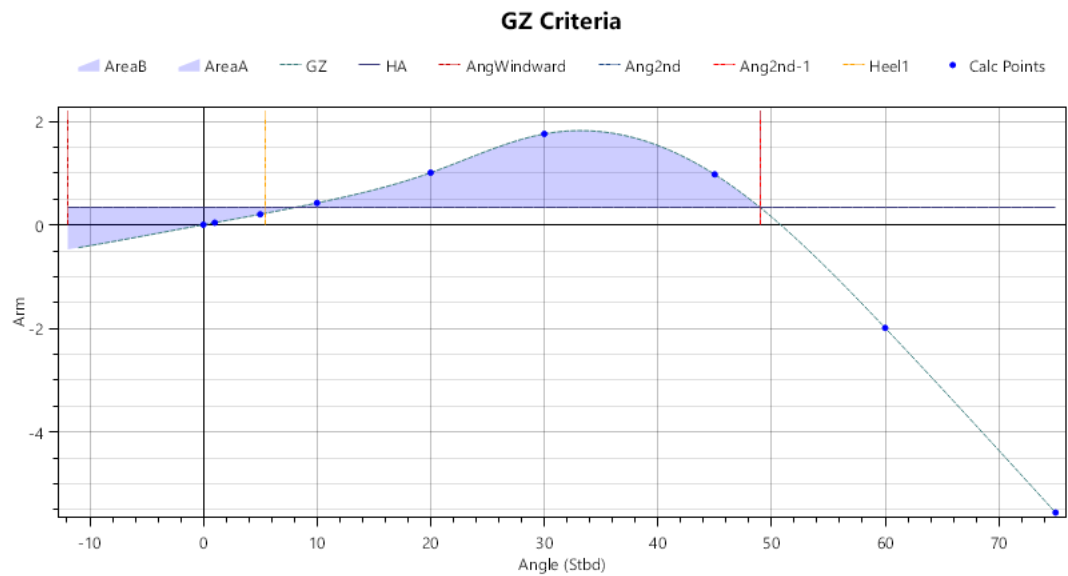
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	231,779 MT		233,888 MT
Pass	Propeller Immersion	158.45 %	100.00 %	
Pass	Visibility	348.104 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	2.299 m	0.909 m	

2008 IS Code 2.2 General Criteria



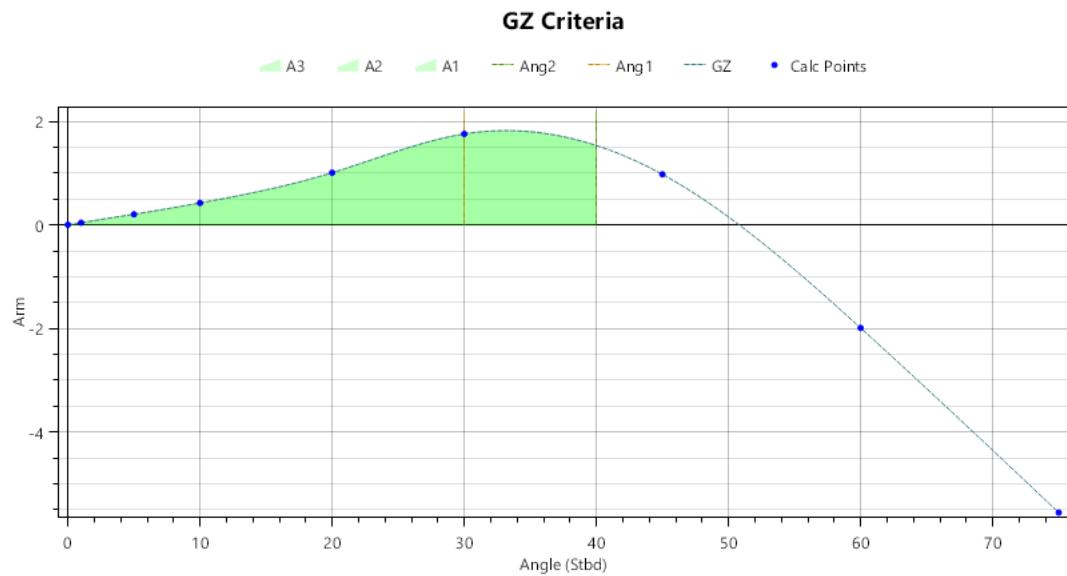
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.40 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.71 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.31 m-rad	0.03 m-rad	
	Angle to Downflooding	64.01 deg		
Pass	Angle at Maximum GZ	33.17 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.824 m	0.200 m	
Pass	Initial Metacentric Height	2.299 m	0.150 m	
	Range of Positive GZ	50.82 deg		

2008 IS Code 2.3 Weather Criteria



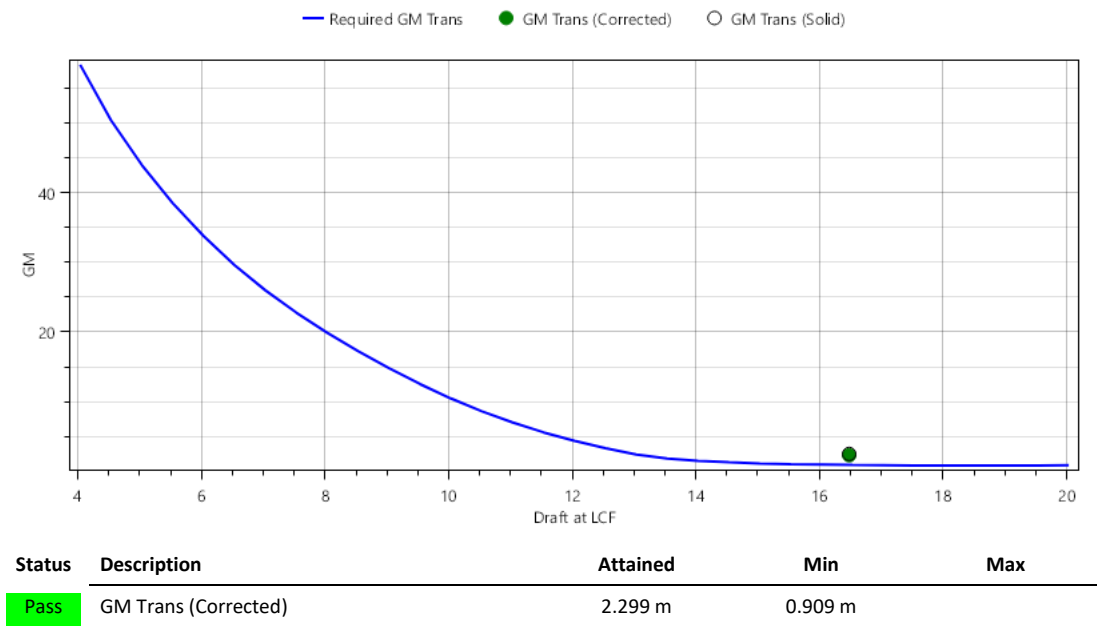
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2275576311		
	Steady Wind Heeling Lever LW1	0.228 m		
	80% Deck Edge Immersion Angle	14.35 deg		
Pass	Heeling Angle at LW1	5.49 deg		14.35 deg
	Gusty Wind Heeling Lever LW2	0.341 m		
	Heeling Angle at LW2	8.13 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.42 deg		
	Angle Windward	-11.93 deg		
	Second Intersect	48.98 deg		
	Limiting Angle	48.98 deg		
	Capsizing Area A	-0.14 m-rad		
	Righting Area B	0.60 m-rad		
Pass	Area Ratio B/A	4.1482156685	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0403193576		
Pass	Area to 30.00	0.40 m-rad	0.22 m-rad	
Pass	Area to 40.00	0.71 m-rad	0.40 m-rad	
Pass	Area 30.00 to 40.00	0.31 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	33.17 deg	30.00 deg	
Pass	Maximum GZ	1.824 m	1.042 m	
Pass	Maximum GZ Above 30 Deg	1.824 m	0.818 m	
	Initial Metacentric Height	2.299 m		
	Range of Positive GZ	50.82 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT MT	LCG m-AP	VCG m-BL	TCG m-CL	FST m-MT
	Lightship	67,485	181.958	22.824	0.000	0
	SEAWATER BALLAST	13,397	326.575	7.332	0.567P	17,872
	DIESEL OIL	3,014	243.328	13.196	1.562S	789
	LUBE OIL	578	58.701	18.954	3.418S	179
	FRESH WATER	549	62.003	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.740	2.885	2.311P	1,353
	FUEL GAS TANK	15,507	250.820	15.992	0.000	17,465
	Containers In Hold	86,912	188.064	15.313	0.000	0
	Containers On Deck	110,992	180.578	44.461	0.000	0
	CONSTANT	473	179.784	30.295	0.000	0
	Spaces	0				0
		299,264	193.252	27.498	0.006P	37,658

Lightship

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Lightship Constant	0	197.000	0.000	0.000
Lightship	67,485	181.958	22.824	0.000

SEAWATER BALLAST

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1 WWBT S	4,837	65.00	3,144	1.0250	3,222	8,915
1 WWBT P	4,837	65.00	3,144	1.0250	3,222	8,915
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
6WWBT HEEL P	1,265	20.00	253	1.0250	259	41

DIESEL OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
MGO PILOT S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT

SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,104
WASTE OIL TANK	138	10.00	14	1.0000	14	104
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

FUEL GAS TANK

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
TYPE-B PRISMATIC TANK P	12,034	85.00	10,229	0.7580	7,754	8,733
TYPE-B PRISMATIC TANK S	12,034	85.00	10,229	0.7580	7,754	8,733

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	3,360	15.900	0.000	25.564	0	0	120	0	120	9.600	22.200
Bay 82	3,192	44.800	0.000	25.856	0	0	114	0	114	38.500	51.100
Bay 78	1,848	70.500	0.000	29.617	0	0	66	0	66	64.200	76.800
Bay 74	4,312	84.950	0.000	14.796	0	0	236	0	236	78.650	91.250
Bay 70	4,312	99.400	0.000	12.691	0	0	256	0	256	93.100	105.700
Bay 66	4,312	113.850	0.000	11.901	0	0	262	0	262	107.550	120.150
Bay 62	4,312	128.300	0.000	11.901	0	0	262	0	262	122.000	134.600
Bay 58	4,312	142.750	0.000	11.901	0	0	262	0	262	136.450	149.050
Bay 54	4,312	157.200	0.000	11.901	0	0	262	0	262	150.900	163.500
Bay 86	3,808	30.350	0.000	24.394	0	0	136	0	136	24.050	36.650
Bay 50	4,312	171.650	0.000	11.901	0	0	262	0	262	165.350	177.950
Bay 46	4,312	186.100	0.000	11.901	0	0	262	0	262	179.800	192.400
Bay 38	4,312	215.000	0.000	11.901	0	0	262	0	262	208.700	221.300
Bay 42	4,312	200.550	0.000	11.901	0	0	262	0	262	194.250	206.850
Bay 34	3,920	229.450	0.000	11.638	0	0	240	0	240	223.150	235.750
Bay 30	1,176	243.900	0.000	12.603	0	0	70	0	70	237.600	250.200

Bay 26	4,312	272.800	0.000	12.428	0	0	258	0	258	266.500	279.100
Bay 22	4,312	287.250	0.000	13.217	0	0	250	0	250	280.950	293.550
Bay 18	4,312	301.700	0.000	13.744	0	0	246	0	246	295.400	308.000
Bay 10	3,864	330.600	0.000	18.040	0	0	190	0	190	324.300	336.900
Bay 6	3,080	345.050	0.000	19.883	0	0	144	0	144	338.750	351.350
Bay 2	2,408	359.500	0.000	24.508	0	0	90	0	90	353.200	365.800
Bay 14	4,200	316.150	0.000	15.596	0	0	224	0	224	309.850	322.450

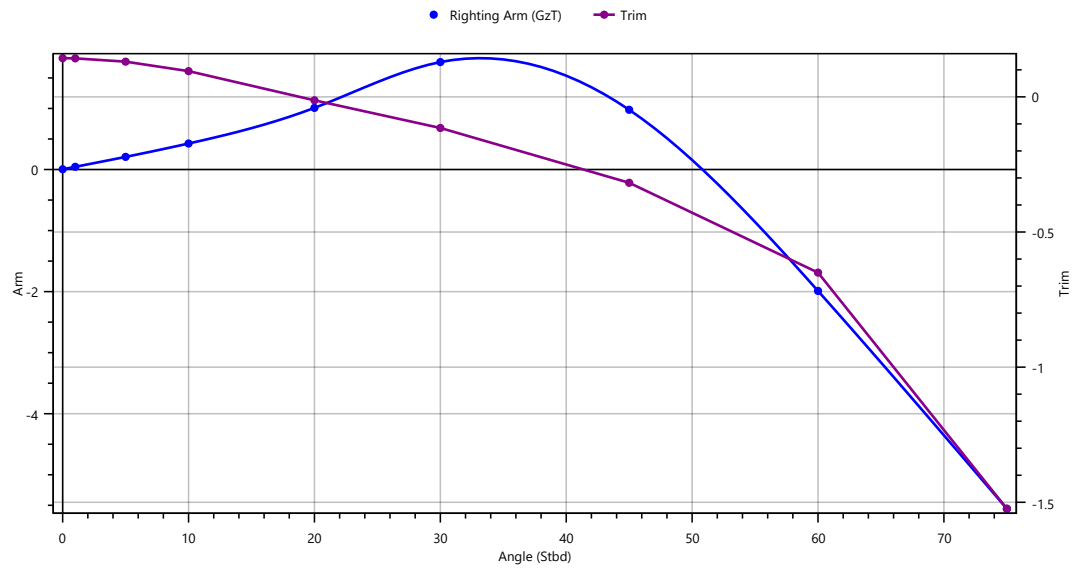
Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 34	4,424	229.450	0.000	44.768	0	0	310	0	310	223.150	235.750
Stack 30	4,648	243.900	0.000	44.445	0	0	310	0	310	237.600	250.200
Stack 22	4,648	287.250	0.000	44.445	0	0	286	0	286	280.950	293.550
Stack 18	4,648	301.700	0.000	44.445	0	0	262	0	262	295.400	308.000
Stack 14	4,648	316.150	0.000	44.445	0	0	262	0	262	309.850	322.450
Stack 10	4,648	330.600	0.000	44.445	0	0	238	0	238	324.300	336.900
Stack 6	4,648	345.050	0.000	44.445	0	0	238	0	238	338.750	351.350
Stack 2	4,312	359.500	0.000	44.538	0	0	196	0	196	353.200	365.800
Stack 38	4,648	215.000	0.000	44.445	0	0	310	0	310	208.700	221.300
Stack 42	4,648	200.550	0.000	44.445	0	0	310	0	310	194.250	206.850
Stack 82	4,648	44.800	0.000	44.445	0	0	310	0	310	38.500	51.100
Stack 50	4,648	171.650	0.000	44.445	0	0	310	0	310	165.350	177.950
Stack 94	4,648	1.450	0.000	44.440	0	0	310	0	310	-4.646	7.546
Stack 46	4,648	186.100	0.000	44.445	0	0	310	0	310	179.800	192.400
Stack 90	4,648	15.900	0.000	44.445	0	0	310	0	310	9.600	22.200
Stack 78	4,648	70.500	0.000	44.445	0	0	310	0	310	64.200	76.800
Stack 74	4,648	84.950	0.000	44.445	0	0	310	0	310	78.650	91.250
Stack 70	4,648	99.400	0.000	44.445	0	0	310	0	310	93.100	105.700
Stack 66	4,648	113.850	0.000	44.445	0	0	310	0	310	107.550	120.150
Stack 62	4,648	128.300	0.000	44.445	0	0	310	0	310	122.000	134.600
Stack 58	4,648	142.750	0.000	44.445	0	0	310	0	310	136.450	149.050
Stack 54	4,648	157.200	0.000	44.445	0	0	310	0	310	150.900	163.500
Stack 86	4,648	30.350	0.000	44.445	0	0	310	0	310	24.050	36.650
Stack 26	4,648	272.800	0.000	44.445	0	0	286	0	286	266.500	279.100

CONSTANT

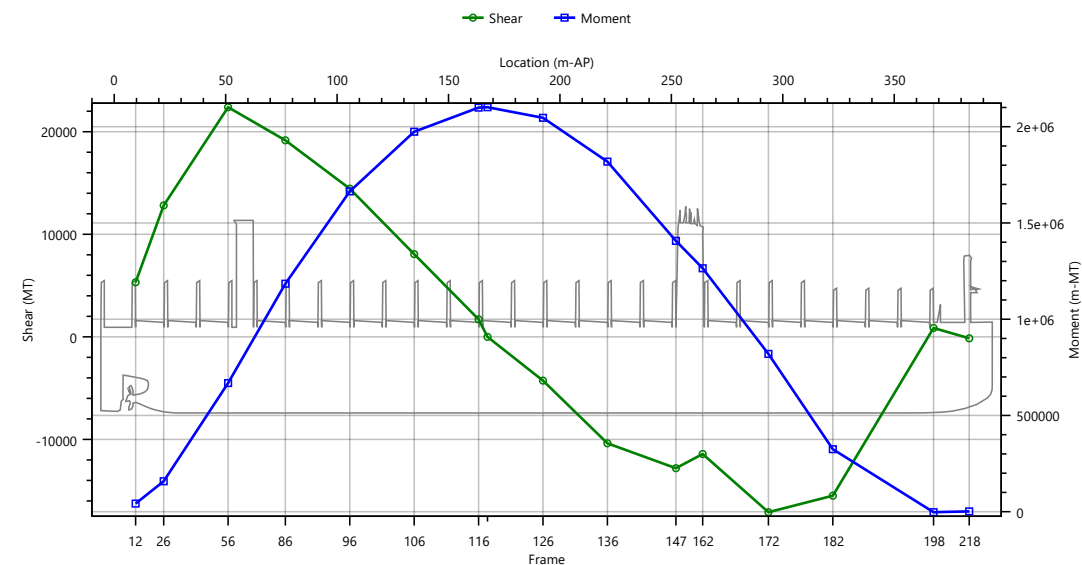
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000	40.000	0.000
ER Misc Tanks	50	62.350	25.000	0.000
Bosun Stores	40	385.000	28.755	0.000
Water in Piping	50	160.000	1.350	0.000
Crew & Effects	6	258.450	55.000	0.000
Provisions	7	258.450	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.14	0.004	-0.002	0.00	0.14A	16.898	15.913	3
0.00	1.00	0.14	0.044	0.001	1.00S	0.14A	16.894	15.915	2
0.00	5.00	0.13	0.207	-0.001	5.00S	0.13A	16.828	15.933	3
0.00	10.00	0.10	0.426	-0.001	10.00S	0.10A	16.635	15.980	3
0.00	20.00	-0.01	1.010	-0.002	20.00S	0.01F	15.960	16.047	3
0.00	30.00	-0.12	1.760	0.001	30.00S	0.12F	14.926	15.718	3
0.00	45.00	-0.32	0.978	-0.001	45.00S	0.32F	12.227	14.413	5
0.00	60.00	-0.65	-1.989	0.002	60.00S	0.65F	7.752	12.224	8
0.00	75.00	-1.52	-5.556	0.000	75.01S	1.52F	-3.916	6.565	9

Strength Summary

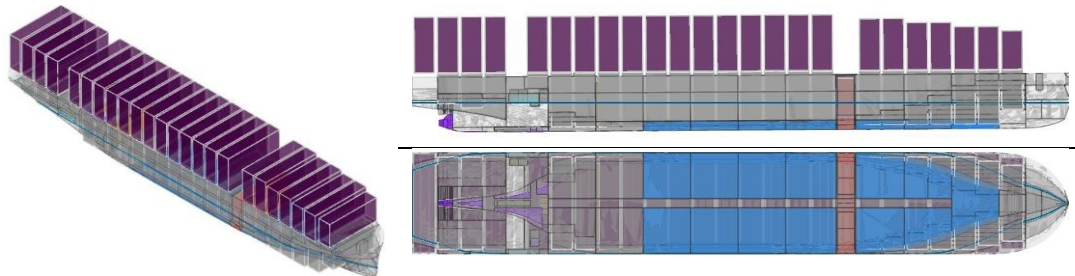


Xfr	Buoyancy	Weight	Shear	Buoy Moment	Wt Moment	Moment
m-AP	MT	MT	MT	m-MT	m-MT	m-MT
9.600	1,158	6,477	5,319	8,730S	50,916S	42,186H
22.200	3,261	16,072	12,811	34,701S	192,785S	158,084H
51.100	15,084	37,475	22,390	275,741S	944,049S	668,308H
76.800	33,912	53,072	19,160	890,490S	2,074,881S	1,184,392H
105.700	61,421	75,867	14,446	2,257,866S	3,921,891S	1,664,025H
134.600	90,782	98,847	8,065	4,456,694S	6,430,598S	1,973,904H
163.500	120,148	121,855	1,707	7,504,910S	9,604,102S	2,099,193H
167.503	124,206	124,203	-4	7,994,031S	10,095,354S	2,101,323H
192.400	149,389	145,120	-4,269	11,400,027S	13,446,257S	2,046,230H
221.300	178,501	168,123	-10,378	16,138,355S	17,956,975S	1,818,620H
252.050	209,299	196,491	-12,808	22,101,449S	23,508,362S	1,406,913H
264.050	221,217	209,793	-11,424	24,684,634S	25,949,184S	1,264,551H
293.550	249,844	232,748	-17,096	31,636,180S	32,455,858S	819,678H
322.450	274,717	259,229	-15,488	39,229,953S	39,554,577S	324,624H
367.650	296,075	296,940	865	52,218,458S	52,215,836S	2,623S
383.650	298,814	298,674	-141	56,980,702S	56,982,253S	1,550H

Methanol Condition Printouts

Methanol 9 MT Hold 7 MT Deck Max Scantling Departure

Trim and Stability Summary



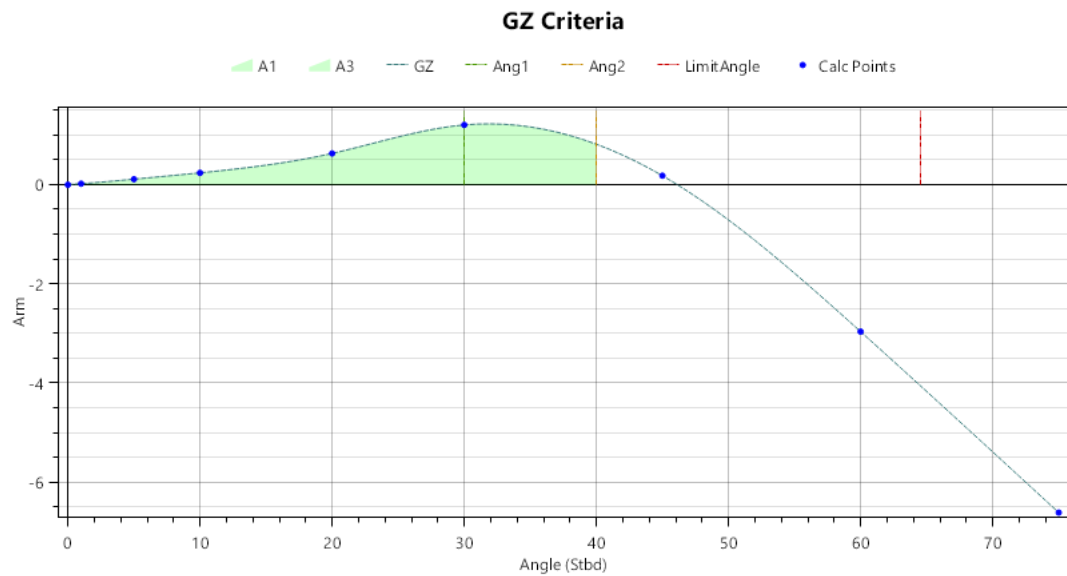
Loading					
Intact Displacement	302,682	MT	Sea Density	1.0250	MT/m ³
Deadweight	235,413	MT			
Available Deadweight	130	MT			
Stability			Trim		
KM0 Trans	30.089	m	Draft at LCF	16.641	m
VCG Upright	28.696	m-BL	LCF	179.297F	m-AP
GM0 Solid Trans	1.393	m	LCB	190.005F	m-AP
GM0 Trans	1.278	m	LCG	190.132F	m-AP
GMt Required	0.895	m	TPM	223.26	MT/cm
GMt Margin	0.382	m	MTM	6,042	m-MT/cm
GM at Equilibrium	0.945	m	Trim at Perps	2A	m
			Heel0	0.00	deg
			Propeller Immersion	166.21	%
Drafts - Perps			Drafts - Marks		
AP	17.769	m	Fwd	15.354	m
MS	16.529	m	Mid	16.547	m
FP	15.289	m	Aft	17.652	m
Strength					
Shear Min	-8,370	MT			
Shear Max	15,191	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,049,635H	m-MT			
Moment Max Sag	1,118S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	365.918	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
40 Tanks from Geometry
0 Tanks from Tables
62 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

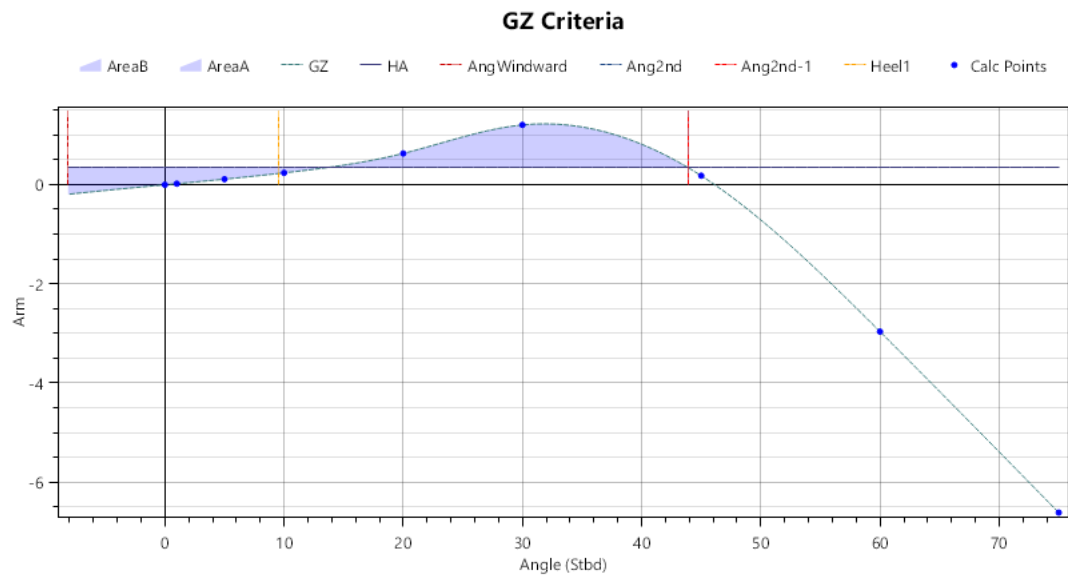
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	235,413 MT		235,543 MT
Pass	Propeller Immersion	166.21 %	100.00 %	
Pass	Visibility	365.918 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.278 m	0.895 m	

2008 IS Code 2.2 General Criteria



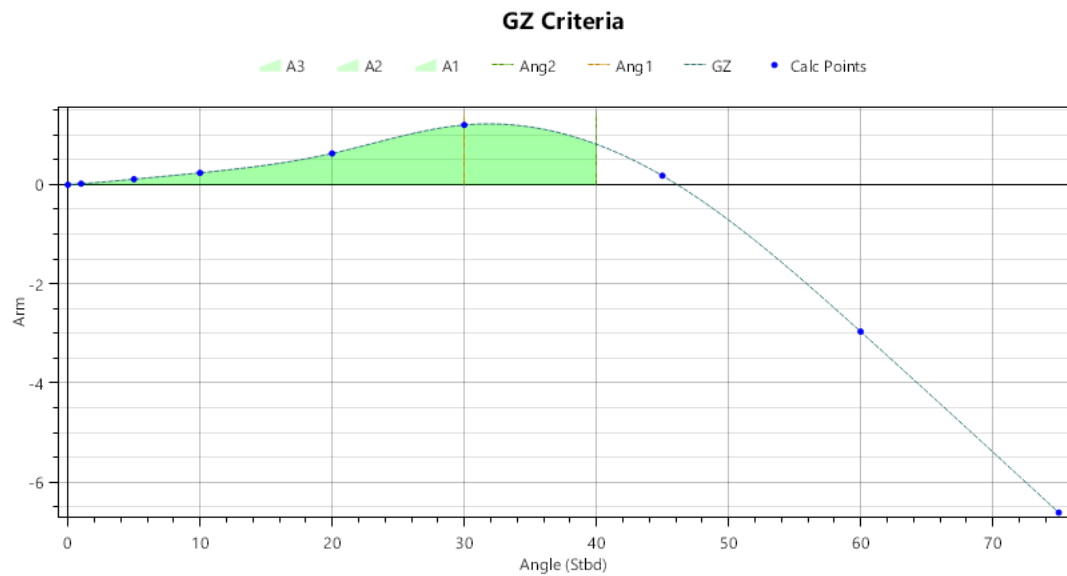
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.25 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.45 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.19 m-rad	0.03 m-rad	
	Angle to Downflooding	64.58 deg		
Pass	Angle at Maximum GZ	31.84 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.225 m	0.200 m	
Pass	Initial Metacentric Height	1.278 m	0.150 m	
	Range of Positive GZ	46.11 deg		

2008 IS Code 2.3 Weather Criteria



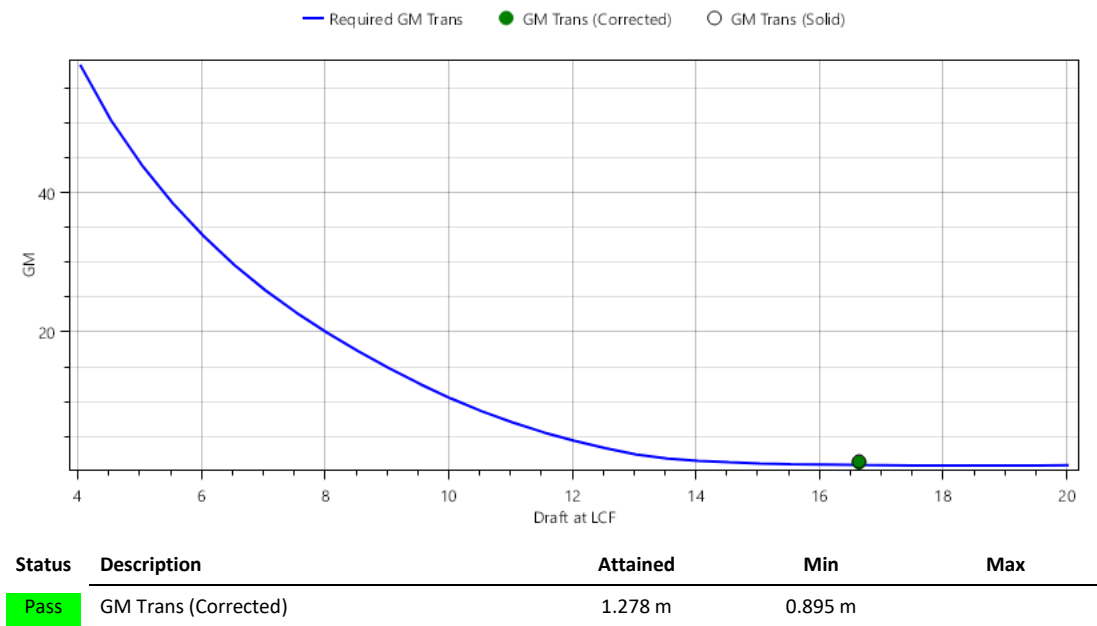
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2238757332		
	Steady Wind Heeling Lever LW1	0.224 m		
	80% Deck Edge Immersion Angle	12.85 deg		
Pass	Heeling Angle at LW1	9.55 deg		12.85 deg
	Gusty Wind Heeling Lever LW2	0.336 m		
	Heeling Angle at LW2	13.40 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.69 deg		
	Angle Windward	-8.14 deg		
	Second Intersect	43.94 deg		
	Limiting Angle	43.94 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.27 m-rad		
Pass	Area Ratio B/A	2.635318744	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0398769347		
Pass	Area to 30.00	0.25 m-rad	0.23 m-rad	
Pass	Area to 40.00	0.45 m-rad	0.40 m-rad	
Pass	Area 30.00 to 40.00	0.19 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	31.84 deg	30.00 deg	
Pass	Maximum GZ	1.225 m	1.053 m	
Pass	Maximum GZ Above 30 Deg	1.225 m	0.828 m	
	Initial Metacentric Height	1.278 m		
	Range of Positive GZ	46.11 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,270	181.916F	22.810	0.000	0
	SEAWATER BALLAST	30,382	234.194F	2.047	0.001P	0
	METHANOL	13,580	258.046F	15.552	0.000	7,509
	DIESEL OIL	1,861	102.410F	17.229	0.000	2,428
	LUBE OIL	578	58.683F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.633F	2.886	2.298P	1,374
	Containers In Hold	89,100	194.349F	19.458	0.000	0
	Containers On Deck	98,532	172.707F	51.505	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		302,682	190.132F	28.696	0.004S	11,489

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,270	181.916F	22.810	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
7DBWBT S	2,277	100.00	2,277	1.0250	2,334	0
7DBWBT P	2,277	100.00	2,277	1.0250	2,334	0
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0

METHANOL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
METHANOL S2	3,714	95.00	3,528	0.7840	2,766	1,337
METHANOL S1	4,608	95.00	4,377	0.7840	3,432	2,406
METHANOL P2	3,714	95.00	3,528	0.7840	2,766	1,337

METHANOL P1	4,608	95.00	4,377	0.7840	3,432	2,406
DB METHANOL S	795	95.00	755	0.7840	592	11
DB METHANOL P	795	95.00	755	0.7840	592	11

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
MGO PILOT OIL TK S	961	98.00	942	0.8600	810	1,185
MGO PILOT OIL TK P	961	98.00	942	0.8600	810	1,185

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,123

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F

Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 34	4,716	229.450F	0.000	18.250	0	0	262	0	262	223.150F	235.750F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	4,716	200.550F	0.000	18.250	0	0	262	0	262	194.250F	206.850F
Bay 38	4,716	215.000F	0.000	18.250	0	0	262	0	262	208.700F	221.300F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 30	4,716	243.900F	0.000	18.250	0	0	262	0	262	237.600F	250.200F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 18	3,668	301.700F	0.000	49.621	0	0	262	0	262	295.400F	308.000F
Stack 14	3,668	316.150F	0.000	49.621	0	0	262	0	262	309.850F	322.450F

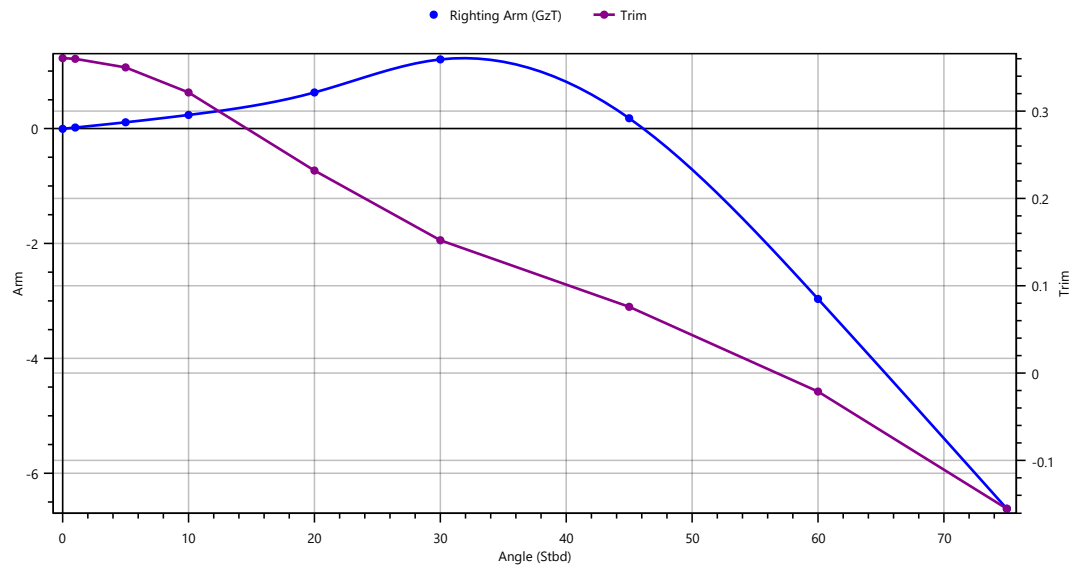
Stack 10	3,332	330.600F	0.000	48.326	0	0	238	0	238	324.300F	336.900F
Stack 6	3,332	345.050F	0.000	48.326	0	0	238	0	238	338.750F	351.350F
Stack 2	2,744	359.500F	0.000	47.023	0	0	196	0	196	353.200F	365.800F
Stack 22	4,004	287.250F	0.000	50.916	0	0	286	0	286	280.950F	293.550F
Stack 26	4,004	272.800F	0.000	50.916	0	0	286	0	286	266.500F	279.100F
Stack 66	4,340	113.850F	0.000	52.210	0	0	310	0	310	107.550F	120.150F
Stack 34	4,340	229.450F	0.000	52.210	0	0	310	0	310	223.150F	235.750F
Stack 94	4,340	1.450F	0.000	52.210	0	0	310	0	310	4.646A	7.546F
Stack 90	4,340	15.900F	0.000	52.210	0	0	310	0	310	9.600F	22.200F
Stack 86	4,340	30.350F	0.000	52.210	0	0	310	0	310	24.050F	36.650F
Stack 82	4,340	44.800F	0.000	52.210	0	0	310	0	310	38.500F	51.100F
Stack 78	4,340	70.500F	0.000	52.210	0	0	310	0	310	64.200F	76.800F
Stack 74	4,340	84.950F	0.000	52.210	0	0	310	0	310	78.650F	91.250F
Stack 70	4,340	99.400F	0.000	52.210	0	0	310	0	310	93.100F	105.700F
Stack 62	4,340	128.300F	0.000	52.210	0	0	310	0	310	122.000F	134.600F
Stack 58	4,340	142.750F	0.000	52.210	0	0	310	0	310	136.450F	149.050F
Stack 54	4,340	157.200F	0.000	52.210	0	0	310	0	310	150.900F	163.500F
Stack 50	4,340	171.650F	0.000	52.210	0	0	310	0	310	165.350F	177.950F
Stack 46	4,340	186.100F	0.000	52.210	0	0	310	0	310	179.800F	192.400F
Stack 42	4,340	200.550F	0.000	52.210	0	0	310	0	310	194.250F	206.850F
Stack 38	4,340	215.000F	0.000	52.210	0	0	310	0	310	208.700F	221.300F
Stack 30	4,340	243.900F	0.000	52.210	0	0	310	0	310	237.600F	250.200F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000

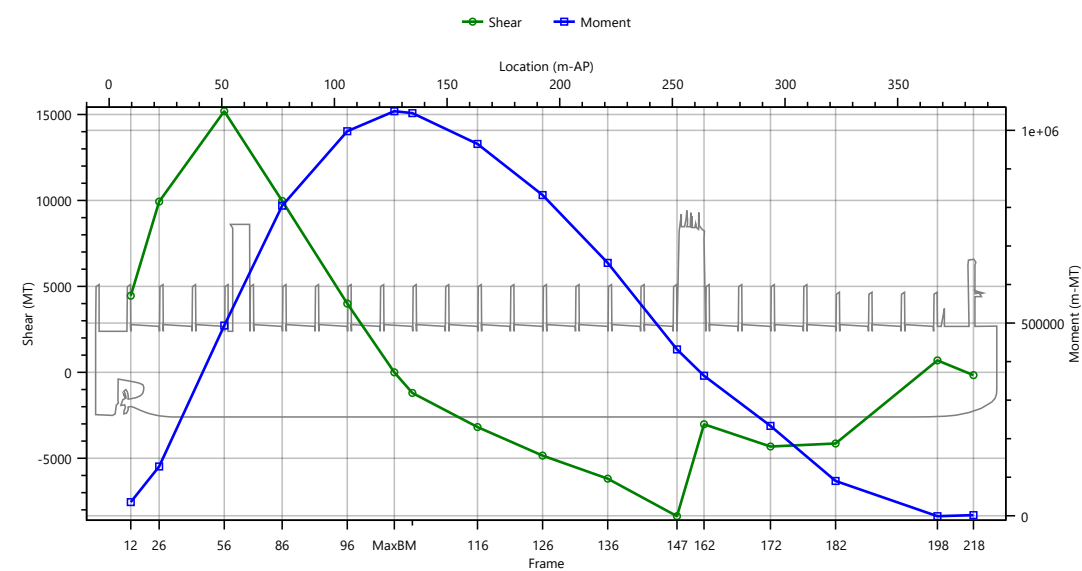
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.36	-0.005	-0.003	0.00	0.36A	17.734	15.254	5
0.00	1.00	0.36	0.017	0.001	1.00S	0.36A	17.731	15.256	2
0.00	5.00	0.35	0.108	-0.001	5.00S	0.35A	17.676	15.269	3
0.00	10.00	0.32	0.236	-0.001	10.00S	0.32A	17.511	15.301	3
0.00	20.00	0.23	0.628	-0.003	20.00S	0.23A	16.922	15.327	3
0.00	30.00	0.15	1.203	0.002	30.00S	0.15A	15.998	14.952	3
0.00	45.00	0.08	0.179	-0.003	45.00S	0.08A	13.845	13.323	4
0.00	60.00	-0.02	-2.966	-0.002	60.00S	0.02F	10.356	10.501	7
0.00	75.00	-0.16	-6.617	0.000	75.00S	0.16F	1.760	2.829	9

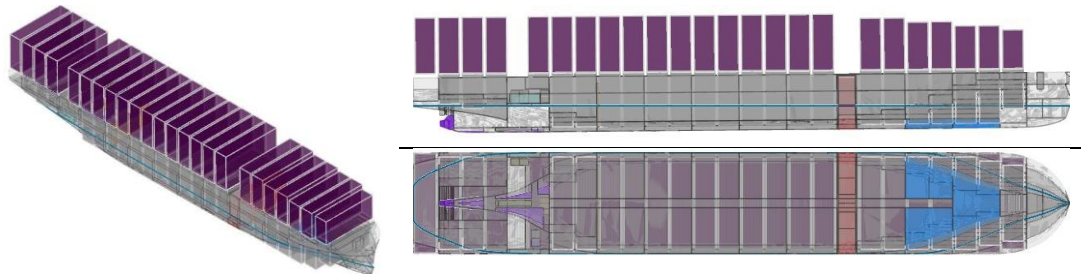
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	1,713	6,169	4,457	12,931S	48,406S	35,475H
22.200F	4,325	14,257	9,932	49,038S	176,894S	127,857H
51.100F	17,354	32,545	15,191	338,457S	831,951S	493,494H
76.800F	37,122	47,094	9,973	1,023,935S	1,828,410S	804,475H
105.700F	65,504	69,505	4,001	2,497,156S	3,494,867S	997,711H
126.591F	87,223	87,222	-1	4,092,330S	5,141,965S	1,049,635H
134.600F	95,544	94,343	-1,201	4,824,258S	5,868,914S	1,044,656H
163.500F	125,394	122,210	-3,183	8,017,551S	8,982,261S	964,710H
192.400F	154,924	150,079	-4,845	12,068,924S	12,901,026S	832,102H
221.300F	184,131	177,945	-6,186	16,969,058S	17,625,161S	656,104H
252.050F	214,816	206,447	-8,370	23,104,100S	23,535,679S	431,579H
264.050F	226,630	223,608	-3,022	25,752,899S	26,116,174S	363,275H
293.550F	254,859	250,543	-4,316	32,858,757S	33,091,933S	233,176H
322.450F	279,153	275,013	-4,141	40,589,489S	40,679,770S	90,281H
367.650F	299,665	300,358	694	53,757,492S	53,756,374S	1,118S
383.650F	302,256	302,092	-164	58,575,857S	58,577,482S	1,625H

Methanol 9 MT Hold 5.63 MT Deck Max Design Departure

Trim and Stability Summary

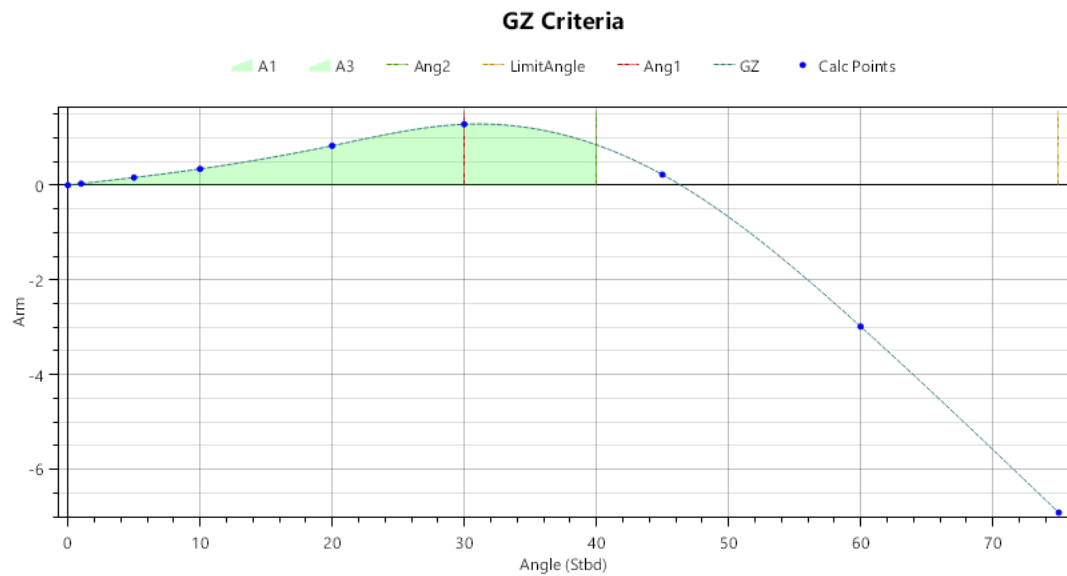


Loading					
Intact Displacement	259,605	MT	Sea Density	1.0250	MT/m ³
Deadweight	192,335	MT			
Available Deadweight	2	MT			
Stability			Trim		
KM0 Trans	31.402	m	Draft at LCF	14.685	m
VCG Upright	29.456	m-BL	LCF	180.174F	m-AP
GM0 Solid Trans	1.946	m	LCB	189.341F	m-AP
GM0 Trans	1.800	m	LCG	189.534F	m-AP
GMt Required	1.226	m	TPM	217.21	MT/cm
GMt Margin	0.574	m	MTM	5,611	m-MT/cm
GM at Equilibrium	1.898	m	Trim at Perps	4A	m
			Heel0	0.00	deg
			Propeller Immersion	151.81	%
Drafts - Perps			Drafts - Marks		
AP	16.293	m	Fwd	12.870	m
MS	14.535	m	Mid	14.559	m
FP	12.777	m	Aft	16.127	m
Bridge Visibility					
Visibility Distance	397.922	m	Visibility Distance Required	500.000	m
Calculation Notes					
Drafts from Keel					
Hull from Geometry					
GMt from GZ Curve Slope					
FSt Adjustment = SolidGMt-GMt					
30 Tanks from Geometry					
0 Tanks from Tables					
72 Empty Tanks					
GZ Curve from Geometry					
Downflood Angles from 3D Data					

Alarm Summary

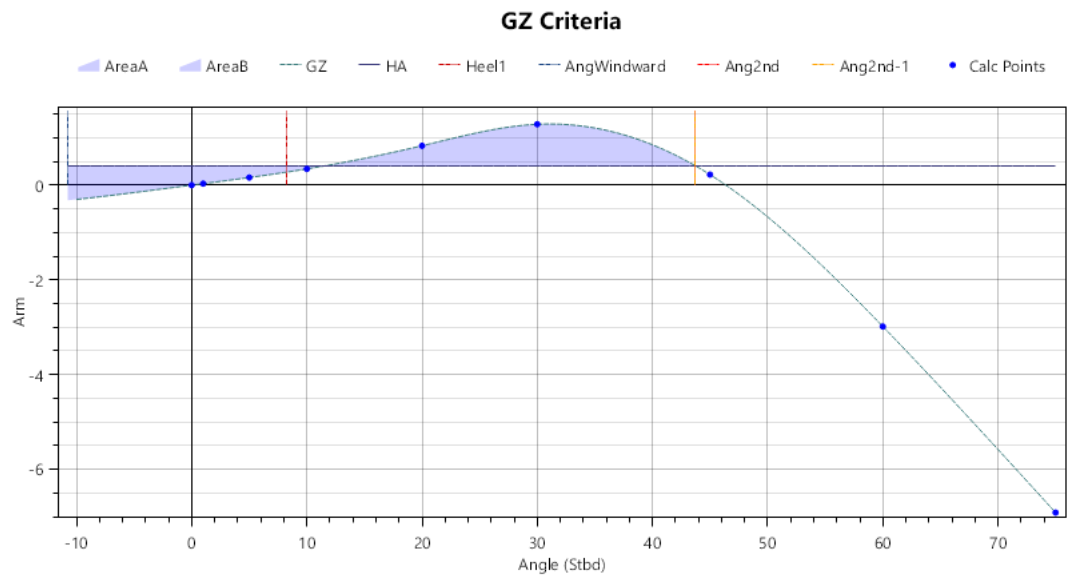
Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	192,335 MT		236,612 MT
Pass	Propeller Immersion	151.81 %	100.00 %	
Pass	Visibility	397.922 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.800 m	1.226 m	
Pass	Design Deadweight	192,335 MT		192,337 MT

2008 IS Code 2.2 General Criteria



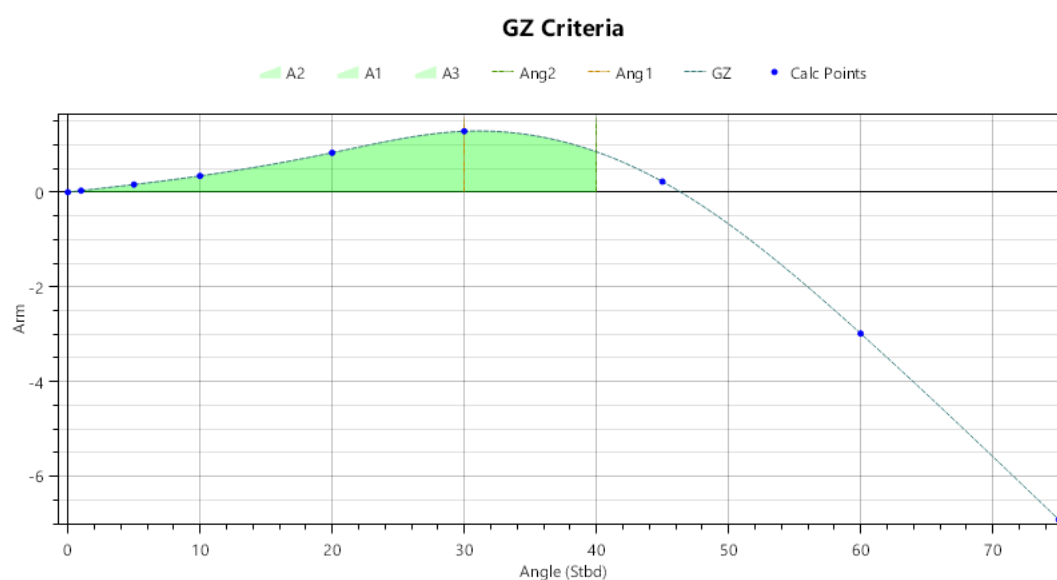
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.32 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.52 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.03 m-rad	
	Angle to Downflooding	74.98 deg		
Pass	Angle at Maximum GZ	31.07 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.295 m	0.200 m	
Pass	Initial Metacentric Height	1.800 m	0.150 m	
	Range of Positive GZ	46.39 deg		

2008 IS Code 2.3 Weather Criteria



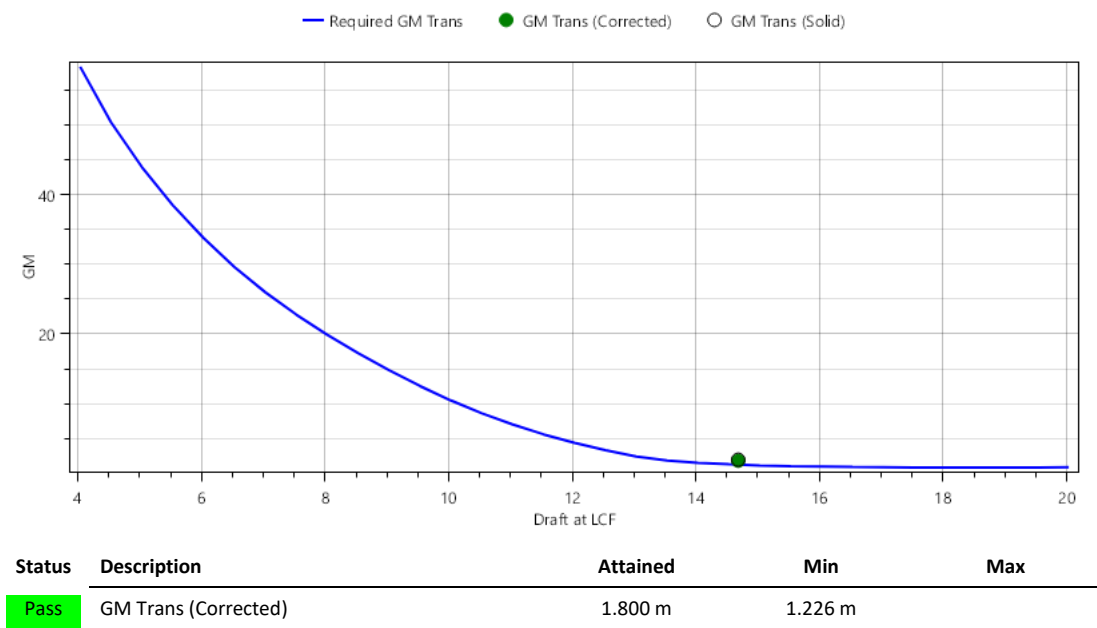
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2758339352		
	Steady Wind Heeling Lever LW1	0.276 m		
	80% Deck Edge Immersion Angle	15.57 deg		
Pass	Heeling Angle at LW1	8.22 deg		15.57 deg
	Gusty Wind Heeling Lever LW2	0.414 m		
	Heeling Angle at LW2	11.67 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	18.97 deg		
	Angle Windward	-10.75 deg		
	Second Intersect	43.71 deg		
	Limiting Angle	43.71 deg		
	Capsizing Area A	-0.15 m-rad		
	Righting Area B	0.29 m-rad		
Pass	Area Ratio B/A	1.9304553654	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0326218152		
Pass	Area to 30.00	0.32 m-rad	0.28 m-rad	
Pass	Area to 40.00	0.52 m-rad	0.49 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.18 m-rad	
Pass	Angle at Maximum GZ	31.07 deg	30.00 deg	
Pass	Maximum GZ	1.295 m	1.287 m	
Pass	Maximum GZ Above 30 Deg	1.295 m	1.012 m	
	Initial Metacentric Height	1.800 m		
	Range of Positive GZ	46.39 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,270	181.916F	22.810	0.000	0
	SEAWATER BALLAST	6,589	318.751F	2.518	0.311P	3,574
	METHANOL	13,580	258.045F	15.552	0.000	7,509
	DIESEL OIL	1,861	102.409F	17.229	0.000	2,428
	LUBE OIL	578	58.671F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.560F	2.886	2.289P	1,388
	Containers In Hold	89,100	194.349F	19.458	0.000	0
	Containers On Deck	79,248	172.706F	51.505	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		259,605	189.534F	29.456	0.003P	15,077

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,270	181.916F	22.810	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
2DBWBTS	1,918	94.75	1,818	1.0250	1,863	3,574
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0

METHANOL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
METHANOL S2	3,714	95.00	3,528	0.7840	2,766	1,337
METHANOL S1	4,608	95.00	4,377	0.7840	3,432	2,406
METHANOL P1	4,608	95.00	4,377	0.7840	3,432	2,406
DB METHANOL S	795	95.00	755	0.7840	592	12
DB METHANOL P	795	95.00	755	0.7840	592	12
METHANOL P2	3,714	95.00	3,528	0.7840	2,766	1,337

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
MGO PILOT OIL TK S	961	98.00	942	0.8600	810	1,185
MGO PILOT OIL TK P	961	98.00	942	0.8600	810	1,185
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14

NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,136
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F

Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 38	4,716	215.000F	0.000	18.250	0	0	262	0	262	208.700F	221.300F
Bay 42	4,716	200.550F	0.000	18.250	0	0	262	0	262	194.250F	206.850F
Bay 34	4,716	229.450F	0.000	18.250	0	0	262	0	262	223.150F	235.750F
Bay 30	4,716	243.900F	0.000	18.250	0	0	262	0	262	237.600F	250.200F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F

Containers On Deck

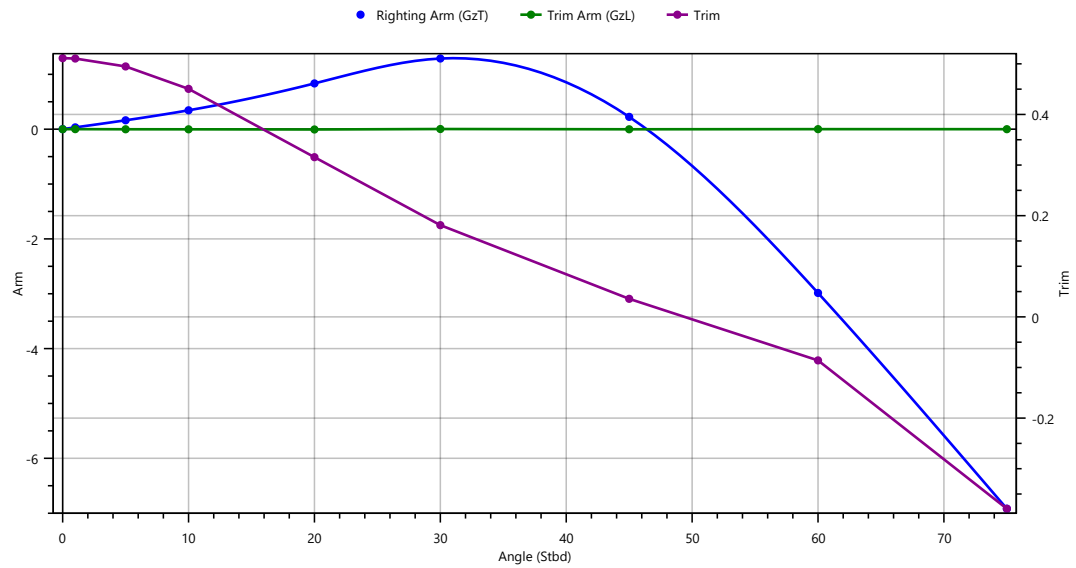
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 34	3,491	229.450F	0.000	52.210	0	0	310	0	310	223.150F	235.750F
Stack 30	3,491	243.900F	0.000	52.210	0	0	310	0	310	237.600F	250.200F
Stack 26	3,220	272.800F	0.000	50.916	0	0	286	0	286	266.500F	279.100F
Stack 22	3,220	287.250F	0.000	50.916	0	0	286	0	286	280.950F	293.550F
Stack 14	2,950	316.150F	0.000	49.621	0	0	262	0	262	309.850F	322.450F
Stack 10	2,680	330.600F	0.000	48.326	0	0	238	0	238	324.300F	336.900F
Stack 6	2,680	345.050F	0.000	48.326	0	0	238	0	238	338.750F	351.350F
Stack 2	2,207	359.500F	0.000	47.023	0	0	196	0	196	353.200F	365.800F

Stack 38	3,491	215.000F	0.000	52.210	0	0	310	0	310	208.700F	221.300F
Stack 42	3,491	200.550F	0.000	52.210	0	0	310	0	310	194.250F	206.850F
Stack 82	3,491	44.800F	0.000	52.210	0	0	310	0	310	38.500F	51.100F
Stack 50	3,491	171.650F	0.000	52.210	0	0	310	0	310	165.350F	177.950F
Stack 94	3,491	1.450F	0.000	52.210	0	0	310	0	310	4.646A	7.546F
Stack 46	3,491	186.100F	0.000	52.210	0	0	310	0	310	179.800F	192.400F
Stack 90	3,491	15.900F	0.000	52.210	0	0	310	0	310	9.600F	22.200F
Stack 78	3,491	70.500F	0.000	52.210	0	0	310	0	310	64.200F	76.800F
Stack 74	3,491	84.950F	0.000	52.210	0	0	310	0	310	78.650F	91.250F
Stack 70	3,491	99.400F	0.000	52.210	0	0	310	0	310	93.100F	105.700F
Stack 66	3,491	113.850F	0.000	52.210	0	0	310	0	310	107.550F	120.150F
Stack 62	3,491	128.300F	0.000	52.210	0	0	310	0	310	122.000F	134.600F
Stack 58	3,491	142.750F	0.000	52.210	0	0	310	0	310	136.450F	149.050F
Stack 54	3,491	157.200F	0.000	52.210	0	0	310	0	310	150.900F	163.500F
Stack 86	3,491	30.350F	0.000	52.210	0	0	310	0	310	24.050F	36.650F
Stack 18	2,950	301.700F	0.000	49.621	0	0	262	0	262	295.400F	308.000F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000

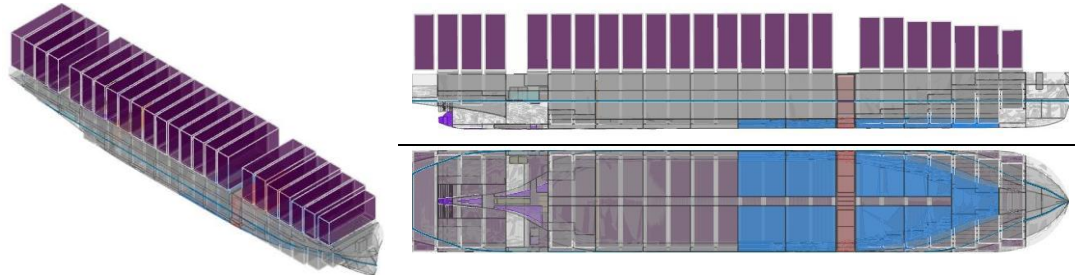
Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.51	0.002	0.000	0.00	0.51A	16.258	12.742	5
0.00	1.00	0.51	0.033	0.001	1.00S	0.51A	16.254	12.744	2
0.00	5.00	0.49	0.162	-0.001	5.00S	0.49A	16.174	12.771	3
0.00	10.00	0.45	0.345	-0.002	10.00S	0.45A	15.941	12.843	3
0.00	20.00	0.32	0.834	-0.005	20.00S	0.32A	15.136	12.966	3
0.00	30.00	0.18	1.289	0.003	30.00S	0.18A	13.851	12.605	3
0.00	45.00	0.04	0.225	-0.002	45.00S	0.04A	10.338	10.093	5
0.00	60.00	-0.09	-2.986	0.001	60.00S	0.09F	4.522	5.113	8
0.00	75.00	-0.38	-6.920	0.000	75.00S	0.38F	-11.141	-8.534	9

Methanol 10 Tier Deck Scantling Departure 9.51 MT Deck 9 MT Hold

Trim and Stability Summary



Loading					
Intact Displacement	301,241	MT	Sea Density	1.0250	MT/m ³
Deadweight	233,971	MT			
Available Deadweight	117	MT			
Stability			Trim		
KM0 Trans	29.942	m	Draft at LCF	16.569	m
VCG Upright	28.867	m-BL	LCF	180.868F	m-AP
GM0 Solid Trans	1.075	m	LCB	193.158F	m-AP
GM0 Trans	0.952	m	LCG	193.207F	m-AP
GMt Required	0.900	m	TPM	222.47	MT/cm
GMt Margin	0.052	m	MTM	5,985	m-MT/cm
GM at Equilibrium	1.162	m	Trim at Perps	1A	m
			Heel0	0.00	deg
			Propeller Immersion	159.23	%
Drafts - Perps			Drafts - Marks		
AP	17.013	m	Fwd	16.072	m
MS	16.530	m	Mid	16.537	m
FP	16.046	m	Aft	16.968	m
Strength					
Shear Min	-11,658	MT			
Shear Max	17,653	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,461,540H	m-MT			
Moment Max Sag	2,909S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	347.121	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
38 Tanks from Geometry
0 Tanks from Tables
64 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	233,971 MT		234,088 MT
Pass	Propeller Immersion	159.23 %	100.00 %	
Pass	Visibility	347.121 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	0.952 m	0.900 m	

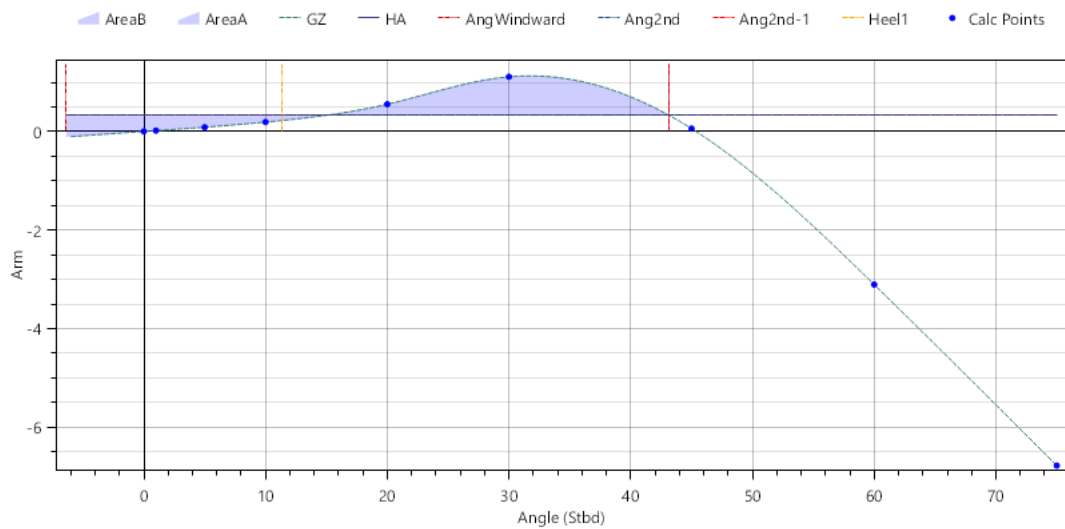
2008 IS Code 2.2 General Criteria



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.23 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.40 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.18 m-rad	0.03 m-rad	
	Angle to Downflooding	67.45 deg		
Pass	Angle at Maximum GZ	31.70 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.133 m	0.200 m	
Pass	Initial Metacentric Height	0.952 m	0.150 m	
	Range of Positive GZ	45.39 deg		

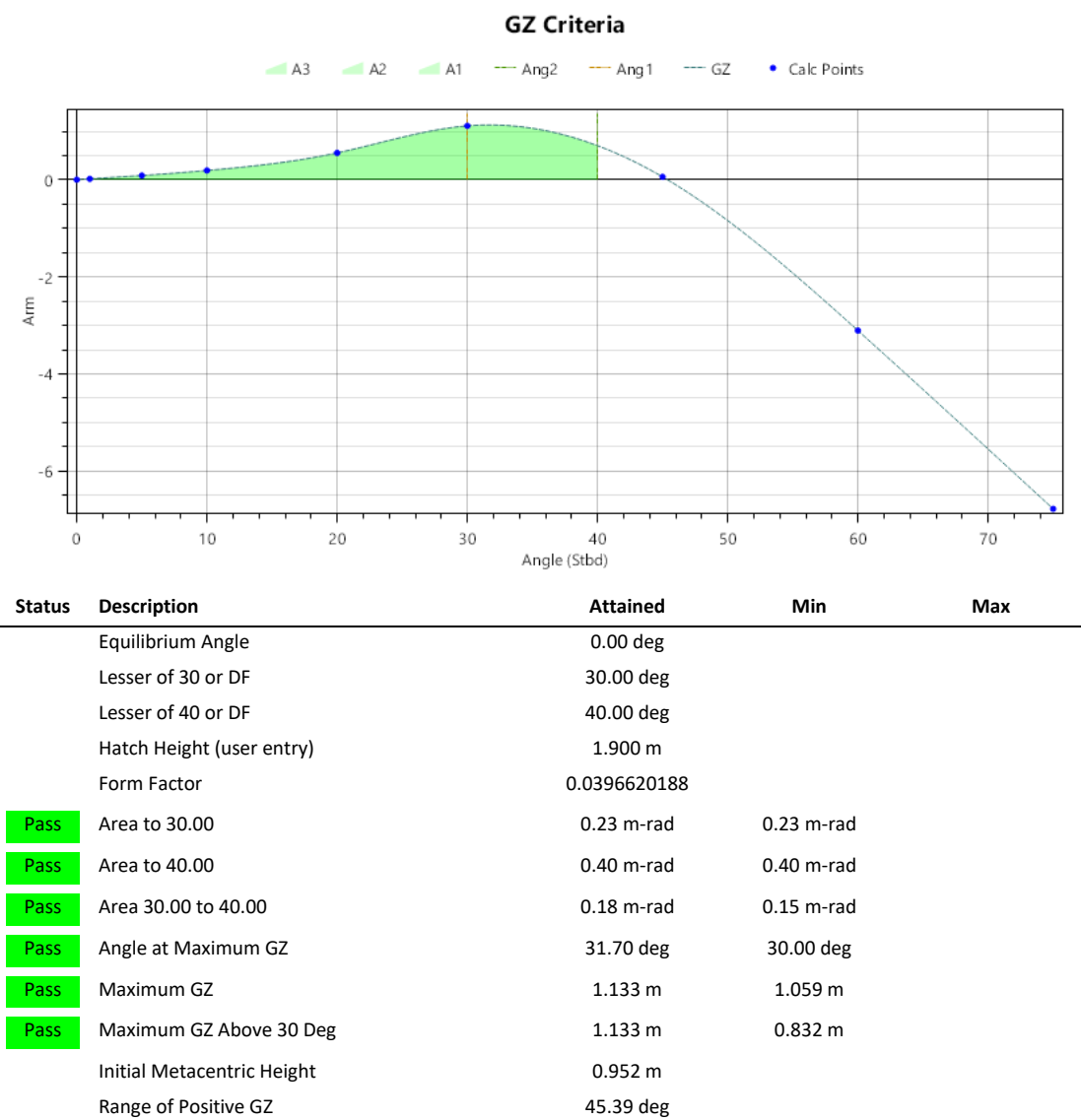
2008 IS Code 2.3 Weather Criteria

GZ Criteria

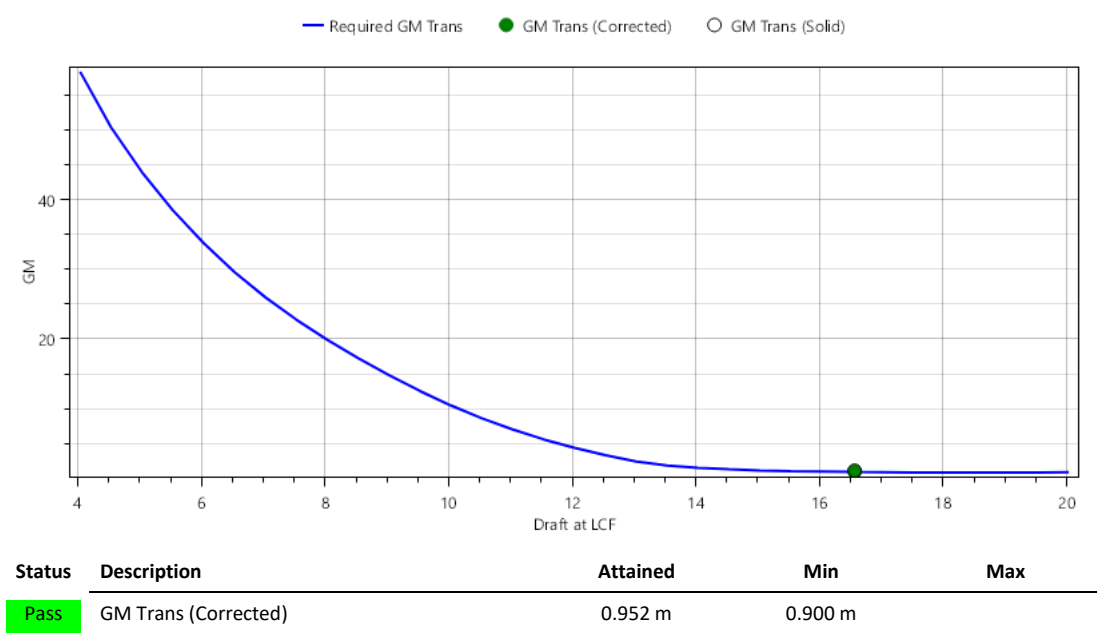


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2254895951		
	Steady Wind Heeling Lever LW1	0.225 m		
	80% Deck Edge Immersion Angle	14.21 deg		
Pass	Heeling Angle at LW1	11.34 deg		14.21 deg
	Gusty Wind Heeling Lever LW2	0.338 m		
	Heeling Angle at LW2	15.20 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.74 deg		
	Angle Windward	-6.40 deg		
	Second Intersect	43.11 deg		
	Limiting Angle	43.11 deg		
	Capsizing Area A	-0.09 m-rad		
	Righting Area B	0.23 m-rad		
Pass	Area Ratio B/A	2.4415616711	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,270	181.916F	22.810	0.000	0
	SEAWATER BALLAST	21,455	266.375F	2.215	0.121P	2,895
	METHANOL	13,580	258.047F	15.552	0.000	7,508
	DIESEL OIL	1,861	102.410F	17.229	0.000	2,428
	LUBE OIL	578	58.702F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.741F	2.885	2.311P	1,353
	Containers In Hold	89,100	194.349F	19.458	0.000	0
	Containers On Deck	106,018	179.872F	48.102	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		301,241	193.207F	28.867	0.005P	14,362

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,270	181.916F	22.810	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	6.73	146	1.0250	150	1,359
2WWBT P	2,173	11.72	255	1.0250	261	1,536
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0

METHANOL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
METHANOL S2	3,714	95.00	3,528	0.7840	2,766	1,337
METHANOL S1	4,608	95.00	4,377	0.7840	3,432	2,406
METHANOL P2	3,714	95.00	3,528	0.7840	2,766	1,337
METHANOL P1	4,608	95.00	4,377	0.7840	3,432	2,406
DB METHANOL S	795	95.00	755	0.7840	592	11

DB METHANOL P 795 95.00 755 0.7840 592 11

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
MGO PILOT OIL TK P	961	98.00	942	0.8600	810	1,185
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
MGO PILOT OIL TK S	961	98.00	942	0.8600	810	1,185

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,104
WASTE OIL TANK	138	10.00	14	1.0000	14	104
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
ST CWT	140	100.00	140	1.0000	140	0

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F

Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 38	4,716	215.000F	0.000	18.250	0	0	262	0	262	208.700F	221.300F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	4,716	200.550F	0.000	18.250	0	0	262	0	262	194.250F	206.850F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 34	4,716	229.450F	0.000	18.250	0	0	262	0	262	223.150F	235.750F
Bay 30	4,716	243.900F	0.000	18.250	0	0	262	0	262	237.600F	250.200F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 22	4,451	287.250F	0.000	48.148	0	0	286	0	286	280.950F	293.550F
Stack 18	4,451	301.700F	0.000	48.148	0	0	262	0	262	295.400F	308.000F
Stack 14	4,451	316.150F	0.000	48.148	0	0	262	0	262	309.850F	322.450F

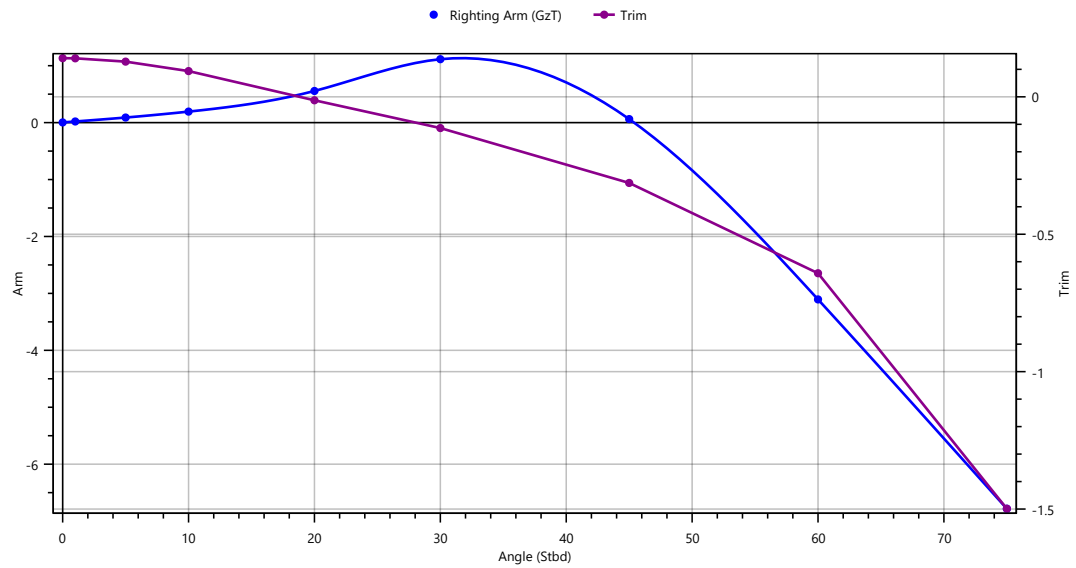
Stack 10	4,451	330.600F	0.000	48.148	0	0	238	0	238	324.300F	336.900F
Stack 6	4,451	345.050F	0.000	48.148	0	0	238	0	238	338.750F	351.350F
Stack 2	3,652	359.500F	0.000	46.832	0	0	196	0	196	353.200F	365.800F
Stack 26	4,451	272.800F	0.000	48.148	0	0	286	0	286	266.500F	279.100F
Stack 30	4,451	243.900F	0.000	48.148	0	0	310	0	310	237.600F	250.200F
Stack 70	4,451	99.400F	0.000	48.148	0	0	310	0	310	93.100F	105.700F
Stack 38	4,451	215.000F	0.000	48.148	0	0	310	0	310	208.700F	221.300F
Stack 94	4,451	1.450F	0.000	48.150	0	0	310	0	310	4.646A	7.546F
Stack 90	4,451	15.900F	0.000	48.148	0	0	310	0	310	9.600F	22.200F
Stack 86	4,451	30.350F	0.000	48.148	0	0	310	0	310	24.050F	36.650F
Stack 34	4,451	229.450F	0.000	48.148	0	0	310	0	310	223.150F	235.750F
Stack 82	4,451	44.800F	0.000	48.148	0	0	310	0	310	38.500F	51.100F
Stack 74	4,451	84.950F	0.000	48.148	0	0	310	0	310	78.650F	91.250F
Stack 66	4,451	113.850F	0.000	48.148	0	0	310	0	310	107.550F	120.150F
Stack 62	4,451	128.300F	0.000	48.148	0	0	310	0	310	122.000F	134.600F
Stack 58	4,451	142.750F	0.000	48.148	0	0	310	0	310	136.450F	149.050F
Stack 54	4,451	157.200F	0.000	48.148	0	0	310	0	310	150.900F	163.500F
Stack 50	4,451	171.650F	0.000	48.148	0	0	310	0	310	165.350F	177.950F
Stack 46	4,451	186.100F	0.000	48.148	0	0	310	0	310	179.800F	192.400F
Stack 42	4,451	200.550F	0.000	48.148	0	0	310	0	310	194.250F	206.850F
Stack 78	4,451	70.500F	0.000	48.148	0	0	310	0	310	64.200F	76.800F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000

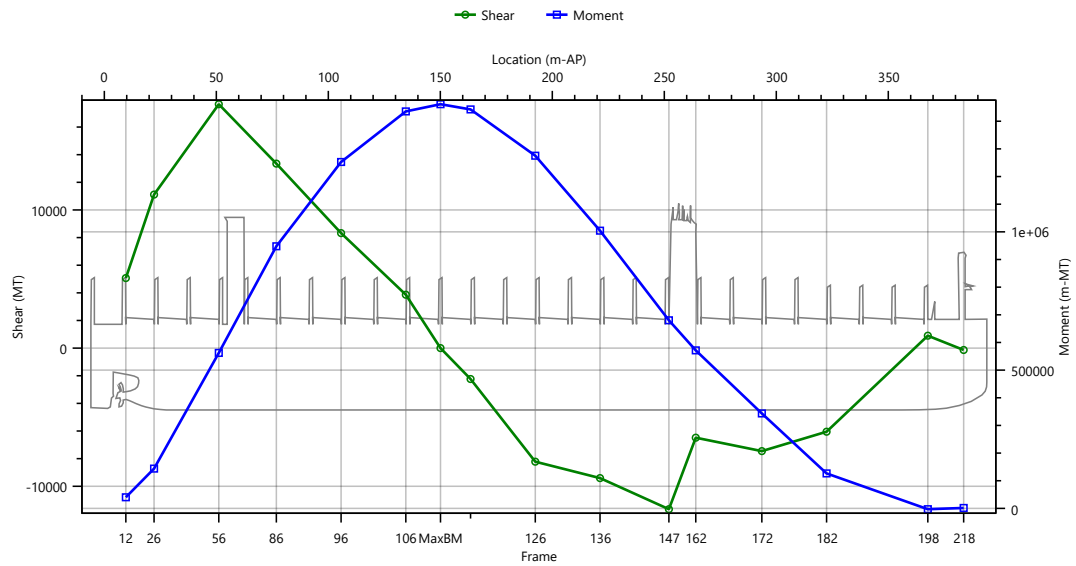
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
Stores Distributed	120	160.000F	27.200	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.14	0.003	0.000	0.00	0.14A	16.978	16.011	5
0.00	1.00	0.14	0.020	0.001	1.00S	0.14A	16.975	16.012	2
0.00	5.00	0.13	0.089	-0.001	5.00S	0.13A	16.911	16.030	3
0.00	10.00	0.09	0.193	-0.001	10.00S	0.09A	16.720	16.076	3
0.00	20.00	-0.01	0.556	-0.002	20.00S	0.01F	16.053	16.140	3
0.00	30.00	-0.11	1.114	0.001	30.00S	0.11F	15.032	15.813	3
0.00	45.00	-0.31	0.062	-0.001	45.00S	0.31F	12.398	14.553	5
0.00	60.00	-0.64	-3.106	0.002	60.00S	0.64F	8.038	12.453	8
0.00	75.00	-1.50	-6.783	0.000	75.00S	1.50F	-3.279	7.030	9

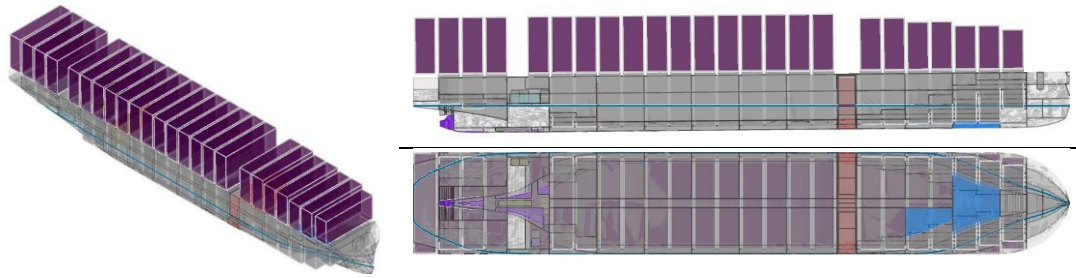
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	1,210	6,280	5,070	9,109S	49,308S	40,199H
22.200F	3,366	14,478	11,112	36,051S	179,888S	143,836H
51.100F	15,333	32,985	17,653	282,150S	844,327S	562,177H
76.800F	34,295	47,648	13,353	905,005S	1,852,821S	947,816H
105.700F	61,957	70,280	8,323	2,285,654S	3,538,265S	1,252,611H
134.600F	91,474	95,339	3,865	4,502,220S	5,937,696S	1,435,476H
150.080F	107,302	107,304	2	6,040,760S	7,502,300S	1,461,540H
163.500F	120,998	118,760	-2,238	7,572,707S	9,015,411S	1,442,704H
192.400F	150,399	142,179	-8,220	11,494,695S	12,769,963S	1,275,268H
221.300F	179,674	170,267	-9,408	16,264,560S	17,268,787S	1,004,227H
252.050F	210,648	198,990	-11,658	22,266,410S	22,946,595S	680,186H
264.050F	222,634	216,151	-6,483	24,866,189S	25,437,588S	571,399H
293.550F	251,433	243,979	-7,454	31,862,083S	32,205,445S	343,362H
322.450F	276,476	270,425	-6,050	39,504,244S	39,630,704S	126,460H
367.650F	298,018	298,917	898	52,577,010S	52,574,101S	2,909S
383.650F	300,785	300,650	-135	57,370,594S	57,372,139S	1,545H

10 Tier Deck Design Departure 7.5 MT Deck 9 MT Hold

Trim and Stability Summary



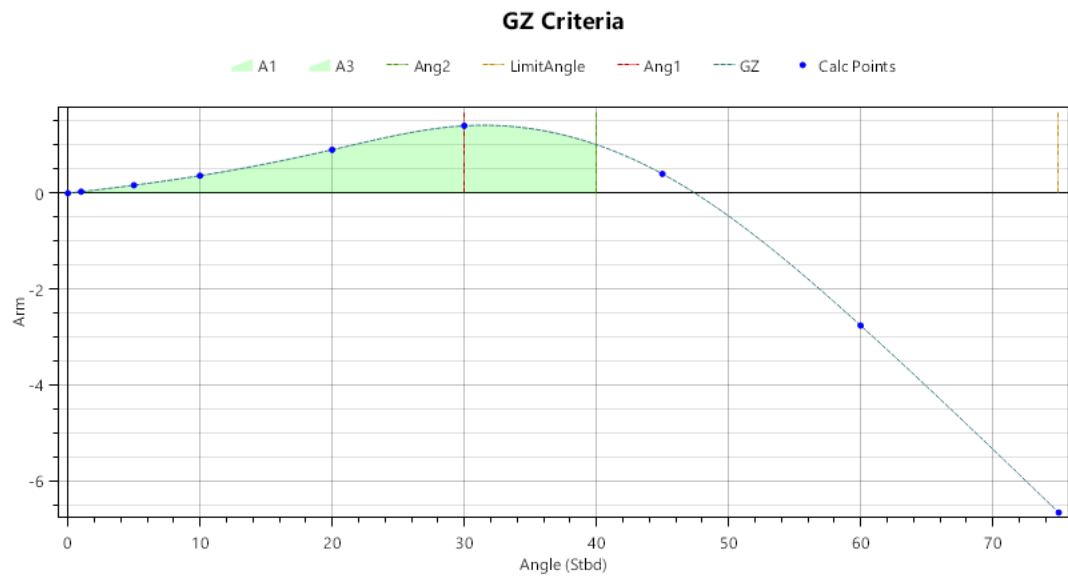
Loading					
Intact Displacement	259,606	MT	Sea Density	1.0250	MT/m ³
Deadweight	192,337	MT			
Available Deadweight	8	MT			
Stability			Trim		
KM0 Trans	31.404	m	Draft at LCF	14.685	m
VCG Upright	29.179	m-BL	LCF	180.162F	m-AP
GM0 Solid Trans	2.225	m	LCB	189.324F	m-AP
GM0 Trans	1.859	m	LCG	189.515F	m-AP
GMt Required	1.226	m	TPM	217.21	MT/cm
GMt Margin	0.633	m	MTM	5,614	m-MT/cm
GM at Equilibrium	1.687	m	Trim at Perps	4A	m
			Heel0	0.00	deg
			Propeller Immersion	151.85	%
Drafts - Perps			Drafts - Marks		
AP	16.296	m	Fwd	12.866	m
MS	14.535	m	Mid	14.559	m
FP	12.773	m	Aft	16.130	m
Strength					
Shear Min	-13,104	MT			
Shear Max	16,560	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,467,145H	m-MT			
Moment Max Sag	--	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	398.033	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
29 Tanks from Geometry
0 Tanks from Tables
73 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

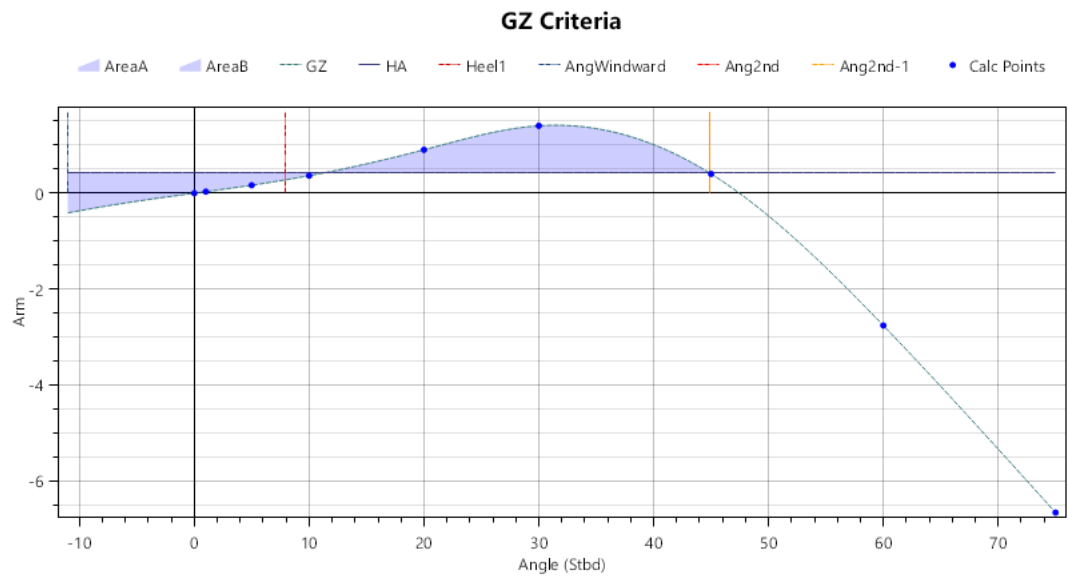
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	192,337 MT		236,620 MT
Pass	Propeller Immersion	151.85 %	100.00 %	
Pass	Visibility	398.033 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.859 m	1.226 m	
Pass	Design Deadweight	192,337 MT		192,344 MT

2008 IS Code 2.2 General Criteria



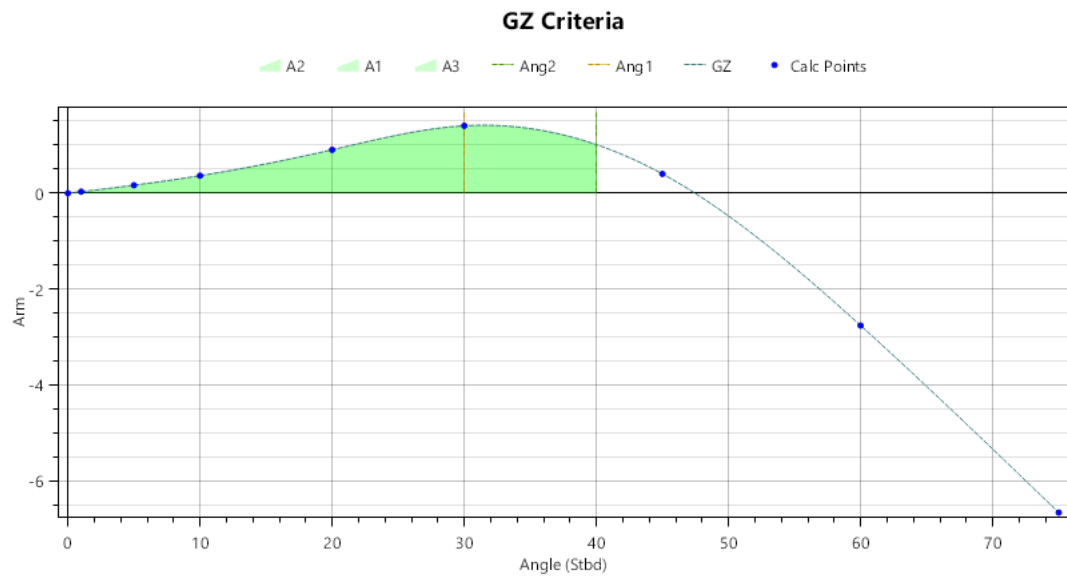
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.35 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.57 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.23 m-rad	0.03 m-rad	
	Angle to Downflooding	74.97 deg		
Pass	Angle at Maximum GZ	31.45 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.415 m	0.200 m	
Pass	Initial Metacentric Height	1.859 m	0.150 m	
	Range of Positive GZ	47.46 deg		

2008 IS Code 2.3 Weather Criteria



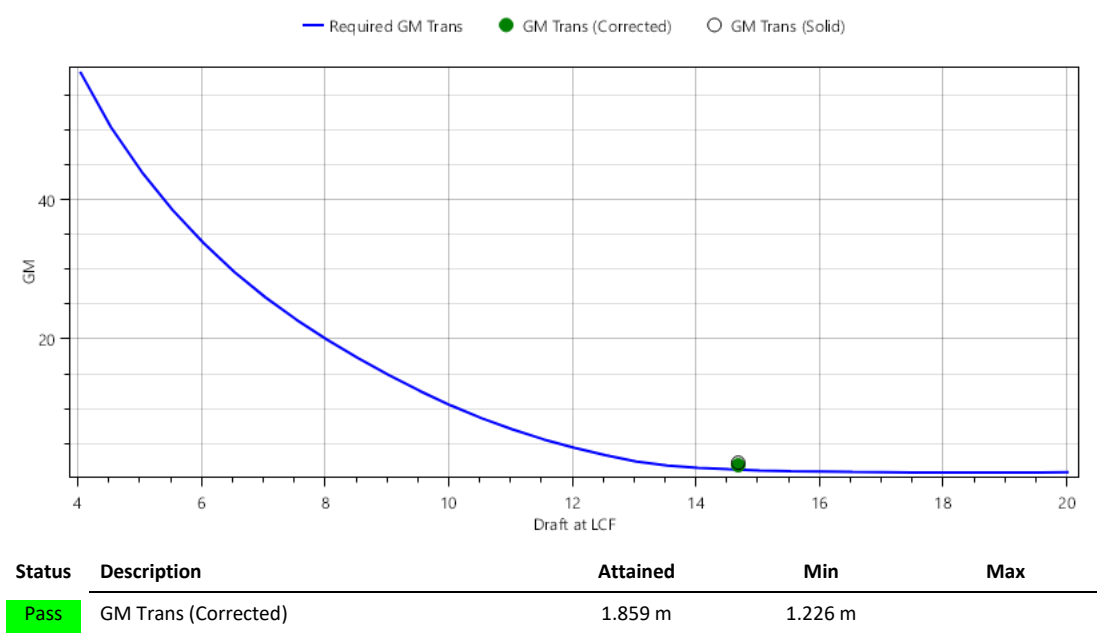
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2758323878		
	Steady Wind Heeling Lever LW1	0.276 m		
	80% Deck Edge Immersion Angle	15.56 deg		
Pass	Heeling Angle at LW1	7.94 deg		15.56 deg
	Gusty Wind Heeling Lever LW2	0.414 m		
	Heeling Angle at LW2	11.12 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	18.95 deg		
	Angle Windward	-11.01 deg		
	Second Intersect	44.91 deg		
	Limiting Angle	44.91 deg		
	Capsizing Area A	-0.16 m-rad		
	Righting Area B	0.35 m-rad		
Pass	Area Ratio B/A	2.2127104901	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.032774625		
Pass	Area to 30.00	0.35 m-rad	0.27 m-rad	
Pass	Area to 40.00	0.57 m-rad	0.49 m-rad	
Pass	Area 30.00 to 40.00	0.23 m-rad	0.18 m-rad	
Pass	Angle at Maximum GZ	31.45 deg	30.00 deg	
Pass	Maximum GZ	1.415 m	1.281 m	
Pass	Maximum GZ Above 30 Deg	1.415 m	1.007 m	
	Initial Metacentric Height	1.859 m		
	Range of Positive GZ	47.46 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,270	181.916F	22.810	0.000	0
	SEAWATER BALLAST	2,228	333.469F	1.988	0.425P	59,468
	METHANOL	13,580	258.045F	15.552	0.000	7,509
	DIESEL OIL	1,861	102.409F	17.229	0.000	2,428
	LUBE OIL	578	58.671F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.559F	2.886	2.289P	1,388
	Containers In Hold	89,100	194.349F	19.458	0.000	0
	Containers On Deck	83,610	179.871F	48.102	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		259,606	189.515F	29.179	0.001S	70,971

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,270	181.916F	22.810	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
2DBWBT P	1,918	5.00	96	1.0250	98	6,575
1DBWBT	2,693	77.18	2,078	1.0250	2,130	52,893

METHANOL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
METHANOL S2	3,714	95.00	3,528	0.7840	2,766	1,337
METHANOL P1	4,608	95.00	4,377	0.7840	3,432	2,406
DB METHANOL S	795	95.00	755	0.7840	592	12
DB METHANOL P	795	95.00	755	0.7840	592	12
METHANOL S1	4,608	95.00	4,377	0.7840	3,432	2,406
METHANOL P2	3,714	95.00	3,528	0.7840	2,766	1,337

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
MGO PILOT OIL TK S	961	98.00	942	0.8600	810	1,185
MGO PILOT OIL TK P	961	98.00	942	0.8600	810	1,185
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14

NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,136
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F

Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 38	4,716	215.000F	0.000	18.250	0	0	262	0	262	208.700F	221.300F
Bay 42	4,716	200.550F	0.000	18.250	0	0	262	0	262	194.250F	206.850F
Bay 34	4,716	229.450F	0.000	18.250	0	0	262	0	262	223.150F	235.750F
Bay 30	4,716	243.900F	0.000	18.250	0	0	262	0	262	237.600F	250.200F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F

Containers On Deck

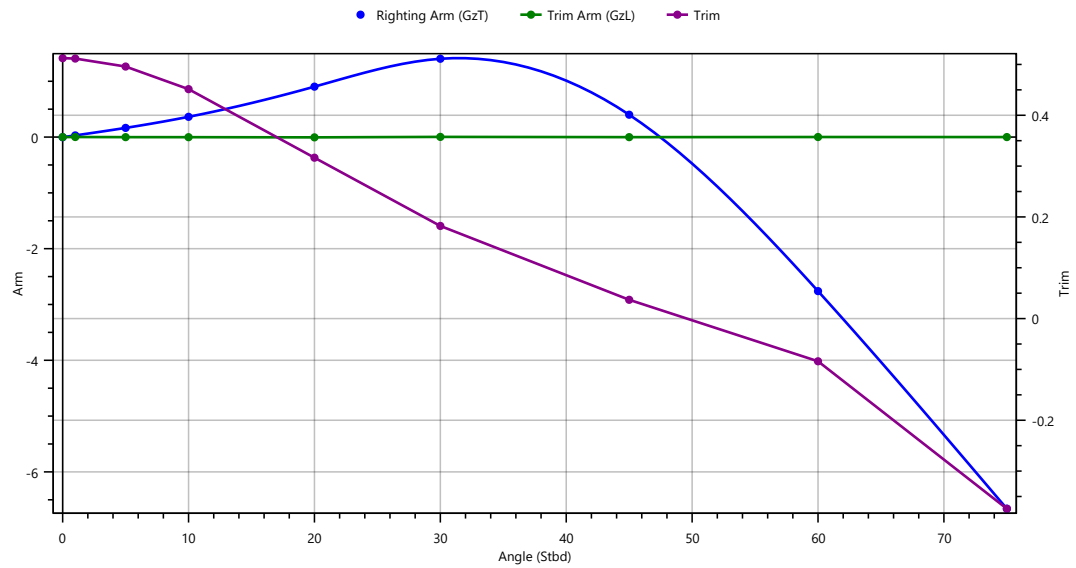
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 34	3,510	229.450F	0.000	48.148	0	0	310	0	310	223.150F	235.750F
Stack 30	3,510	243.900F	0.000	48.148	0	0	310	0	310	237.600F	250.200F
Stack 26	3,510	272.800F	0.000	48.148	0	0	286	0	286	266.500F	279.100F
Stack 18	3,510	301.700F	0.000	48.148	0	0	262	0	262	295.400F	308.000F
Stack 14	3,510	316.150F	0.000	48.148	0	0	262	0	262	309.850F	322.450F
Stack 10	3,510	330.600F	0.000	48.148	0	0	238	0	238	324.300F	336.900F
Stack 6	3,510	345.050F	0.000	48.148	0	0	238	0	238	338.750F	351.350F
Stack 2	2,880	359.500F	0.000	46.832	0	0	196	0	196	353.200F	365.800F

Stack 38	3,510	215.000F	0.000	48.148	0	0	310	0	310	208.700F	221.300F
Stack 42	3,510	200.550F	0.000	48.148	0	0	310	0	310	194.250F	206.850F
Stack 82	3,510	44.800F	0.000	48.148	0	0	310	0	310	38.500F	51.100F
Stack 50	3,510	171.650F	0.000	48.148	0	0	310	0	310	165.350F	177.950F
Stack 94	3,510	1.450F	0.000	48.150	0	0	310	0	310	4.646A	7.546F
Stack 46	3,510	186.100F	0.000	48.148	0	0	310	0	310	179.800F	192.400F
Stack 90	3,510	15.900F	0.000	48.148	0	0	310	0	310	9.600F	22.200F
Stack 78	3,510	70.500F	0.000	48.148	0	0	310	0	310	64.200F	76.800F
Stack 74	3,510	84.950F	0.000	48.148	0	0	310	0	310	78.650F	91.250F
Stack 70	3,510	99.400F	0.000	48.148	0	0	310	0	310	93.100F	105.700F
Stack 66	3,510	113.850F	0.000	48.148	0	0	310	0	310	107.550F	120.150F
Stack 62	3,510	128.300F	0.000	48.148	0	0	310	0	310	122.000F	134.600F
Stack 58	3,510	142.750F	0.000	48.148	0	0	310	0	310	136.450F	149.050F
Stack 54	3,510	157.200F	0.000	48.148	0	0	310	0	310	150.900F	163.500F
Stack 86	3,510	30.350F	0.000	48.148	0	0	310	0	310	24.050F	36.650F
Stack 22	3,510	287.250F	0.000	48.148	0	0	286	0	286	280.950F	293.550F

CONSTANT

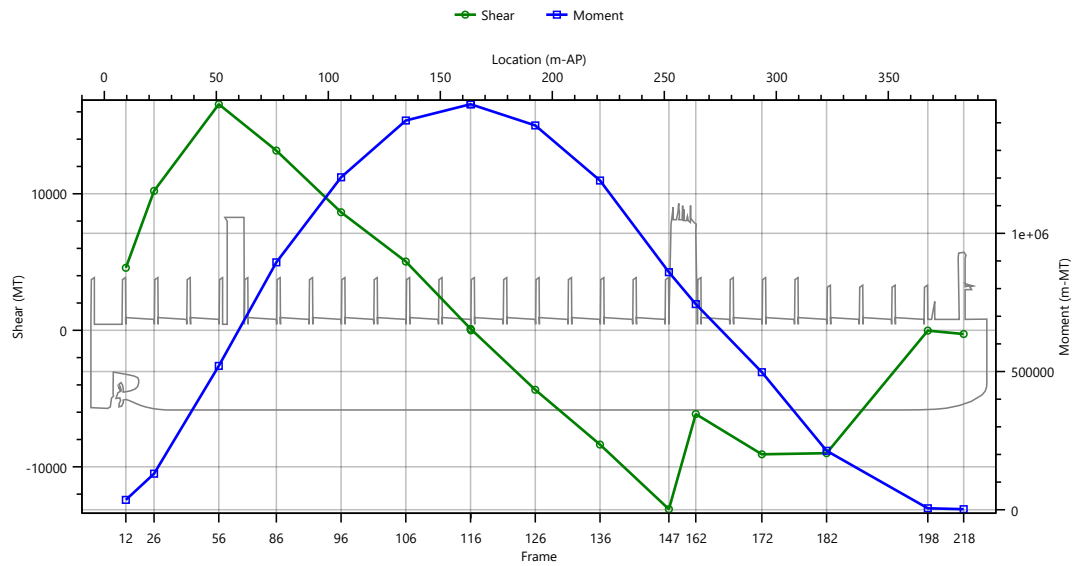
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.51	-0.003	0.000	0.00	0.51A	16.261	12.738	5
0.00	1.00	0.51	0.030	0.001	1.00S	0.51A	16.258	12.740	2
0.00	5.00	0.50	0.164	-0.001	5.00S	0.50A	16.177	12.767	3
0.00	10.00	0.45	0.363	-0.002	10.00S	0.45A	15.944	12.840	3
0.00	20.00	0.32	0.903	-0.005	20.00S	0.32A	15.139	12.962	3
0.00	30.00	0.18	1.403	0.003	30.00S	0.18A	13.855	12.601	3
0.00	45.00	0.04	0.401	-0.001	45.00S	0.04A	10.343	10.088	5
0.00	60.00	-0.08	-2.761	0.001	60.00S	0.08F	4.529	5.106	8
0.00	75.00	-0.37	-6.660	0.000	75.00S	0.37F	-11.123	-8.551	9

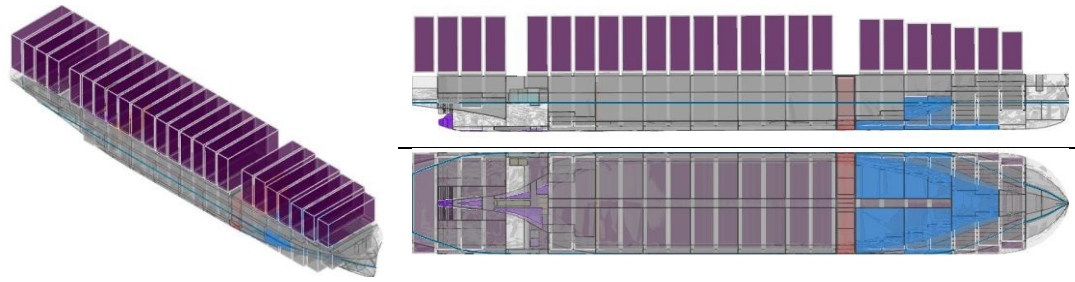
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	762	5,339	4,577	5,967S	41,641S	35,674H
22.200F	2,387	12,597	10,210	24,076S	154,443S	130,367H
51.100F	12,666	29,226	16,560	218,724S	739,080S	520,357H
76.800F	29,781	42,944	13,163	749,883S	1,645,014S	895,131H
105.700F	55,049	63,695	8,646	1,966,291S	3,169,085S	1,202,794H
134.600F	81,839	86,873	5,034	3,944,619S	5,352,771S	1,408,152H
163.500F	108,302	108,413	111	6,693,233S	8,160,370S	1,467,137H
163.661F	108,448	108,445	-3	6,710,645S	8,177,790S	1,467,145H
192.400F	134,309	129,950	-4,359	10,200,077S	11,590,434S	1,390,357H
221.300F	159,857	151,486	-8,371	14,451,888S	15,642,904S	1,191,016H
252.050F	186,498	173,394	-13,104	19,778,710S	20,638,151S	859,441H
264.050F	196,691	190,556	-6,135	22,077,990S	22,822,029S	744,039H
293.550F	220,838	211,755	-9,083	28,240,795S	28,738,502S	497,708H
322.450F	241,076	232,074	-9,001	34,929,290S	35,142,615S	213,325H
367.650F	257,306	257,282	-24	46,264,597S	46,269,884S	5,287H
383.650F	259,290	259,016	-274	50,399,783S	50,401,773S	1,990H

Methanol 14 MT TEU HOMO 14400 TEU

Trim and Stability Summary



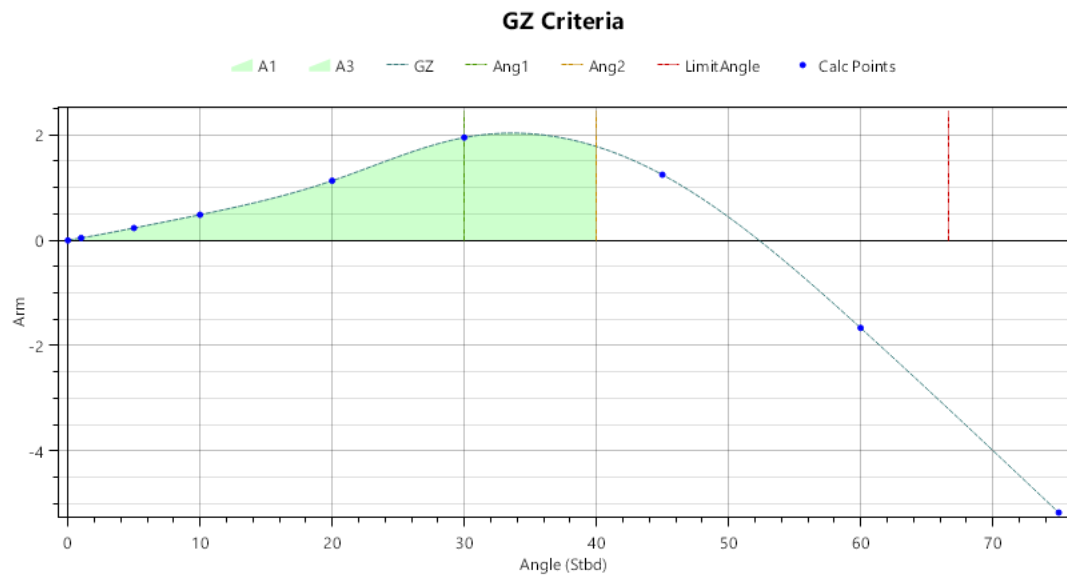
Loading					
Intact Displacement	301,673	MT	Sea Density	1.0250	MT/m ³
Deadweight	234,403	MT			
Available Deadweight	30	MT			
Stability			Trim		
KM0 Trans	29.979	m	Draft at LCF	16.590	m
VCG Upright	27.192	m-BL	LCF	180.447F	m-AP
GM0 Solid Trans	2.787	m	LCB	192.378F	m-AP
GM0 Trans	2.672	m	LCG	192.441F	m-AP
GMt Required	0.899	m	TPM	222.71	MT/cm
GMt Margin	1.773	m	MTM	6,015	m-MT/cm
GM at Equilibrium	2.339	m	Trim at Perps	1A	m
			Heel0	0.00	deg
			Propeller Immersion	160.98	%
Drafts - Perps			Drafts - Marks		
AP	17.204	m	Fwd	15.899	m
MS	16.534	m	Mid	16.543	m
FP	15.864	m	Aft	17.141	m
Strength					
Shear Min	-18,907	MT			
Shear Max	21,638	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	2,006,754H	m-MT			
Moment Max Sag	2,444S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	351.603	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
34 Tanks from Geometry
0 Tanks from Tables
68 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

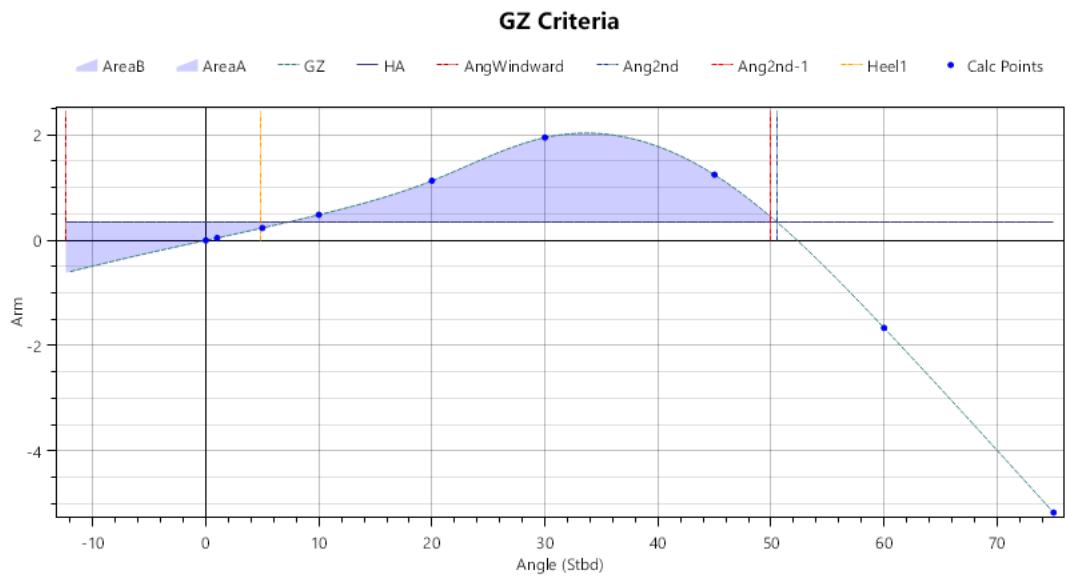
Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	234,403 MT		234,433 MT
Pass	Propeller Immersion	160.98 %	100.00 %	
Pass	Visibility	351.603 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	2.672 m	0.899 m	

2008 IS Code 2.2 General Criteria



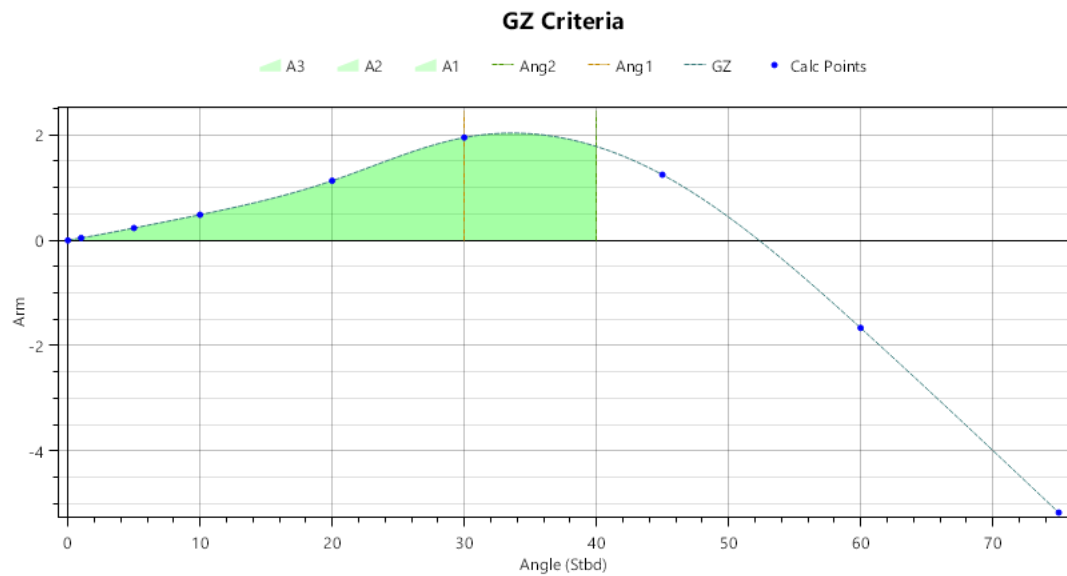
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.45 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.79 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.34 m-rad	0.03 m-rad	
	Angle to Downflooding	66.69 deg		
Pass	Angle at Maximum GZ	33.62 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	2.034 m	0.200 m	
Pass	Initial Metacentric Height	2.672 m	0.150 m	
	Range of Positive GZ	52.30 deg		

2008 IS Code 2.3 Weather Criteria



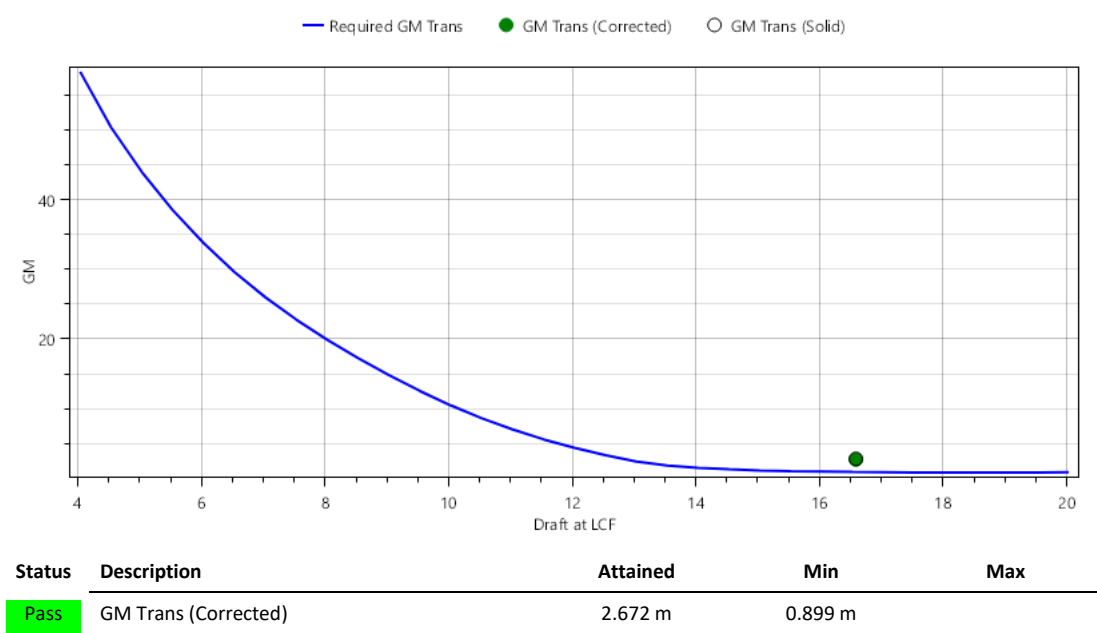
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2249961144		
	Steady Wind Heeling Lever LW1	0.225 m		
	80% Deck Edge Immersion Angle	13.86 deg		
Pass	Heeling Angle at LW1	4.89 deg		13.86 deg
	Gusty Wind Heeling Lever LW2	0.337 m		
	Heeling Angle at LW2	7.18 deg		
	Bilge Area	0.00 m²		
	Roll Angle	17.27 deg		
	Angle Windward	-12.38 deg		
	Second Intersect	50.55 deg		
	Limiting Angle	50.00 deg		
	Capsizing Area A	-0.16 m-rad		
	Righting Area B	0.73 m-rad		
Pass	Area Ratio B/A	4.5554246838	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0408885768		
Pass	Area to 30.00	0.45 m-rad	0.22 m-rad	
Pass	Area to 40.00	0.79 m-rad	0.39 m-rad	
Pass	Area 30.00 to 40.00	0.34 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	33.62 deg	30.00 deg	
Pass	Maximum GZ	2.034 m	1.027 m	
Pass	Maximum GZ Above 30 Deg	2.034 m	0.807 m	
	Initial Metacentric Height	2.672 m		
	Range of Positive GZ	52.30 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	67,270	181.916F	22.810	0.000	0
	SEAWATER BALLAST	15,405	303.777F	4.843	0.001P	430
	METHANOL	13,580	258.047F	15.552	0.000	7,508
	DIESEL OIL	1,861	102.410F	17.229	0.000	2,428
	LUBE OIL	578	58.697F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	VOIDS	0				0
	SPACES	0				0
	MISC TANKS	358	43.714F	2.885	2.308P	1,358
	Containers In Hold	90,440	190.180F	15.182	0.000	0
	Containers On Deck	111,160	180.586F	44.444	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		301,673	192.441F	27.192	0.004S	11,902

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	67,270	181.916F	22.810	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	89.00	1,934	1.0250	1,982	215
2WWBT P	2,173	89.00	1,934	1.0250	1,982	215
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0

METHANOL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
METHANOL S2	3,714	95.00	3,528	0.7840	2,766	1,337
METHANOL S1	4,608	95.00	4,377	0.7840	3,432	2,406
METHANOL P2	3,714	95.00	3,528	0.7840	2,766	1,337
METHANOL P1	4,608	95.00	4,377	0.7840	3,432	2,406
DB METHANOL S	795	95.00	755	0.7840	592	11
DB METHANOL P	795	95.00	755	0.7840	592	11

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
MGO PILOT OIL TK P	961	98.00	942	0.8600	810	1,185
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
MGO PILOT OIL TK S	961	98.00	942	0.8600	810	1,185

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,109
WASTE OIL TANK	138	10.00	14	1.0000	14	104
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	3,360	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	3,808	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 46	4,312	186.100F	0.000	11.901	0	0	262	0	262	179.800F	192.400F
Bay 78	1,848	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F

Bay 74	4,312	84.950F	0.000	14.796	0	0	236	0	236	78.650F	91.250F
Bay 70	4,312	99.400F	0.000	12.691	0	0	256	0	256	93.100F	105.700F
Bay 66	4,312	113.850F	0.000	11.901	0	0	262	0	262	107.550F	120.150F
Bay 62	4,312	128.300F	0.000	11.901	0	0	262	0	262	122.000F	134.600F
Bay 58	4,312	142.750F	0.000	11.901	0	0	262	0	262	136.450F	149.050F
Bay 54	4,312	157.200F	0.000	11.901	0	0	262	0	262	150.900F	163.500F
Bay 50	4,312	171.650F	0.000	11.901	0	0	262	0	262	165.350F	177.950F
Bay 82	3,192	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 42	4,312	200.550F	0.000	11.901	0	0	262	0	262	194.250F	206.850F
Bay 38	4,312	215.000F	0.000	11.901	0	0	262	0	262	208.700F	221.300F
Bay 30	4,312	243.900F	0.000	11.901	0	0	262	0	262	237.600F	250.200F
Bay 34	4,312	229.450F	0.000	11.901	0	0	262	0	262	223.150F	235.750F
Bay 26	4,312	272.800F	0.000	12.428	0	0	258	0	258	266.500F	279.100F
Bay 22	4,312	287.250F	0.000	13.217	0	0	250	0	250	280.950F	293.550F
Bay 18	4,312	301.700F	0.000	13.744	0	0	246	0	246	295.400F	308.000F
Bay 14	4,200	316.150F	0.000	15.596	0	0	224	0	224	309.850F	322.450F
Bay 10	3,864	330.600F	0.000	18.040	0	0	190	0	190	324.300F	336.900F
Bay 2	2,408	359.500F	0.000	24.508	0	0	90	0	90	353.200F	365.800F
Bay 6	3,080	345.050F	0.000	19.883	0	0	144	0	144	338.750F	351.350F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 30	4,648	243.900F	0.000	44.445	0	0	310	0	310	237.600F	250.200F
Stack 26	4,648	272.800F	0.000	44.445	0	0	286	0	286	266.500F	279.100F
Stack 22	4,648	287.250F	0.000	44.445	0	0	286	0	286	280.950F	293.550F
Stack 18	4,648	301.700F	0.000	44.445	0	0	262	0	262	295.400F	308.000F

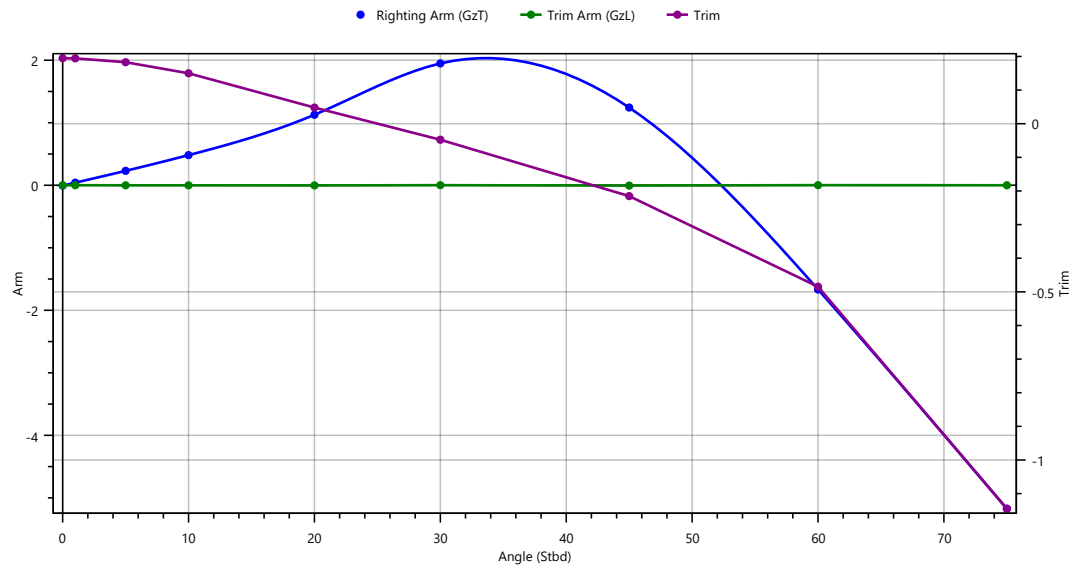
Stack 10	4,648	330.600F	0.000	44.445	0	0	238	0	238	324.300F	336.900F
Stack 6	4,648	345.050F	0.000	44.445	0	0	238	0	238	338.750F	351.350F
Stack 2	4,256	359.500F	0.000	44.436	0	0	196	0	196	353.200F	365.800F
Stack 34	4,648	229.450F	0.000	44.445	0	0	310	0	310	223.150F	235.750F
Stack 38	4,648	215.000F	0.000	44.445	0	0	310	0	310	208.700F	221.300F
Stack 78	4,648	70.500F	0.000	44.445	0	0	310	0	310	64.200F	76.800F
Stack 46	4,648	186.100F	0.000	44.445	0	0	310	0	310	179.800F	192.400F
Stack 94	4,648	1.450F	0.000	44.440	0	0	310	0	310	4.646A	7.546F
Stack 90	4,648	15.900F	0.000	44.445	0	0	310	0	310	9.600F	22.200F
Stack 86	4,648	30.350F	0.000	44.445	0	0	310	0	310	24.050F	36.650F
Stack 82	4,648	44.800F	0.000	44.445	0	0	310	0	310	38.500F	51.100F
Stack 74	4,648	84.950F	0.000	44.445	0	0	310	0	310	78.650F	91.250F
Stack 70	4,648	99.400F	0.000	44.445	0	0	310	0	310	93.100F	105.700F
Stack 66	4,648	113.850F	0.000	44.445	0	0	310	0	310	107.550F	120.150F
Stack 62	4,648	128.300F	0.000	44.445	0	0	310	0	310	122.000F	134.600F
Stack 58	4,648	142.750F	0.000	44.445	0	0	310	0	310	136.450F	149.050F
Stack 54	4,648	157.200F	0.000	44.445	0	0	310	0	310	150.900F	163.500F
Stack 50	4,648	171.650F	0.000	44.445	0	0	310	0	310	165.350F	177.950F
Stack 42	4,648	200.550F	0.000	44.445	0	0	310	0	310	194.250F	206.850F
Stack 14	4,648	316.150F	0.000	44.445	0	0	262	0	262	309.850F	322.450F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000

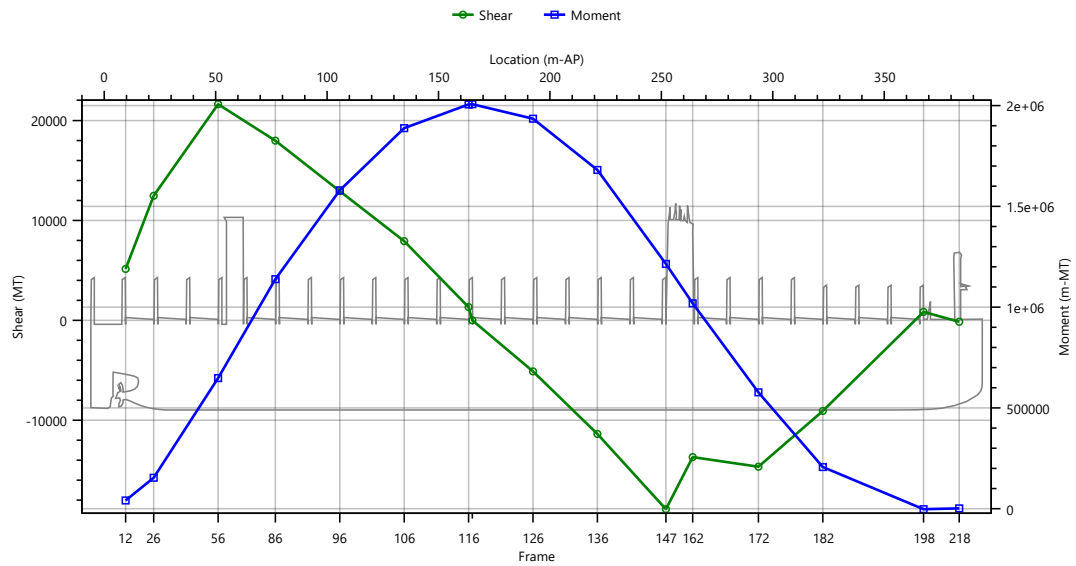
Provisions	7	258.450F	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.19	-0.005	0.000	0.00	0.19A	17.169	15.829	5
0.00	1.00	0.19	0.041	0.001	1.00S	0.19A	17.166	15.829	2
0.00	5.00	0.18	0.230	-0.001	5.00S	0.18A	17.104	15.846	3
0.00	10.00	0.15	0.482	-0.001	10.00S	0.15A	16.920	15.888	3
0.00	20.00	0.05	1.127	-0.003	20.00S	0.05A	16.273	15.942	3
0.00	30.00	-0.05	1.949	0.001	30.00S	0.05F	15.276	15.603	3
0.00	45.00	-0.22	1.243	-0.005	45.00S	0.22F	12.767	14.248	4
0.00	60.00	-0.48	-1.667	0.002	60.00S	0.48F	8.634	11.966	8
0.00	75.00	-1.14	-5.174	0.000	75.00S	1.14F	-1.930	5.945	9

Strength Summary

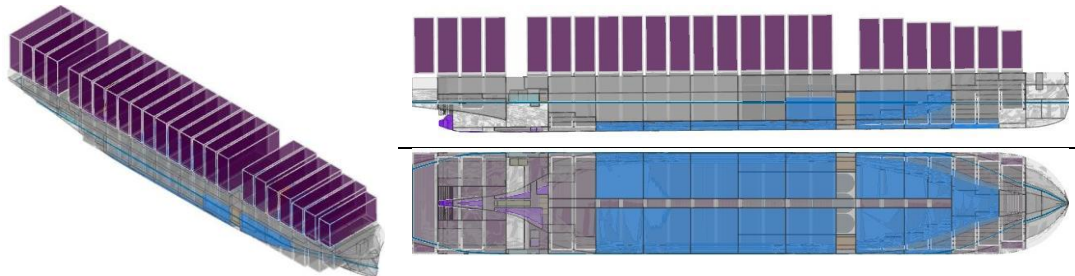


Xfr	Buoyancy	Weight	Shear	Buoy Moment	Wt Moment	Moment
m-AP	MT	MT	MT	m-MT	m-MT	m-MT
9.600F	1,331	6,477	5,146	10,024S	50,916S	40,892H
22.200F	3,601	16,072	12,472	39,201S	192,786S	153,585H
51.100F	15,837	37,475	21,638	296,037S	944,051S	648,014H
76.800F	35,006	52,994	17,989	934,585S	2,073,331S	1,138,746H
105.700F	62,854	75,789	12,936	2,338,575S	3,918,092S	1,579,517H
134.600F	92,508	100,435	7,927	4,583,150S	6,471,150S	1,888,000H
163.500F	122,120	123,443	1,323	7,684,902S	9,690,545S	2,005,643H
165.175F	123,831	123,835	4	7,890,917S	9,897,671S	2,006,754H
192.400F	151,560	146,448	-5,112	11,639,997S	13,574,831S	1,934,834H
221.300F	180,826	169,452	-11,374	16,443,400S	18,123,948S	1,680,548H
252.050F	211,736	192,828	-18,907	22,479,823S	23,694,220S	1,214,397H
264.050F	223,682	209,990	-13,692	25,092,426S	26,111,281S	1,018,855H
293.550F	252,347	237,693	-14,655	32,117,383S	32,694,645S	577,263H
322.450F	277,211	268,139	-9,072	39,783,476S	39,990,142S	206,666H
367.650F	298,503	299,349	846	52,883,234S	52,880,790S	2,444S
383.650F	301,226	301,082	-143	57,684,178S	57,685,747S	1,569H

Liquid Hydrogen Condition Printouts

LH₂ 9 MT Hold 7.39 MT Deck Max Scantling Departure

Trim and Stability Summary



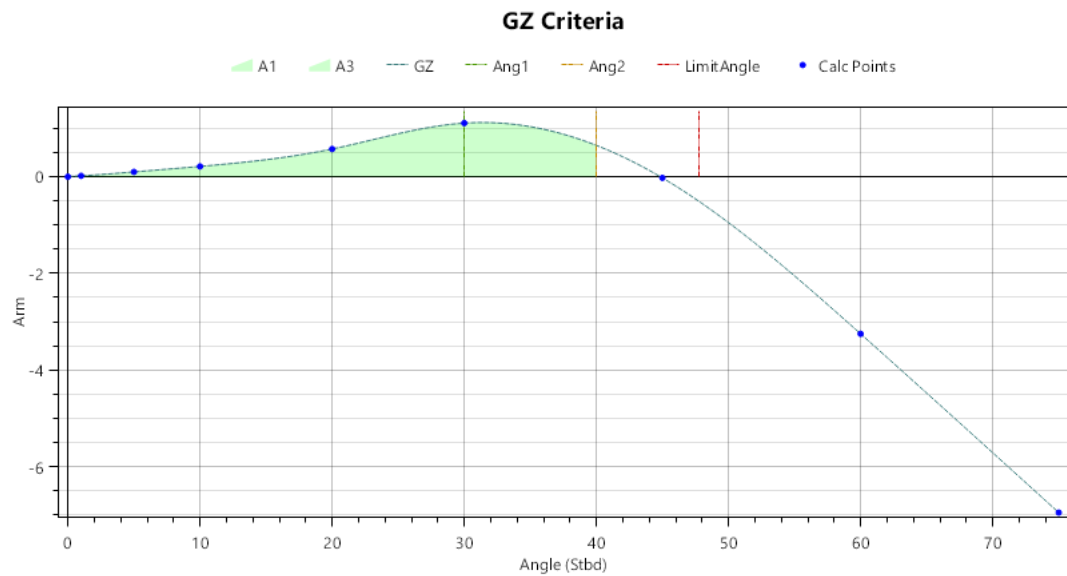
Loading					
Intact Displacement	302,975	MT	Sea Density	1.0250	MT/m ³
Deadweight	231,727	MT			
Available Deadweight	327	MT			
Stability			Trim		
KM0 Trans	30.134	m	Draft at LCF	16.657	m
VCG Upright	28.913	m-BL	LCF	178.861F	m-AP
GM0 Solid Trans	1.222	m	LCB	189.009F	m-AP
GM0 Trans	1.134	m	LCG	189.157F	m-AP
GMt Required	0.894	m	TPM	223.43	MT/cm
GMt Margin	0.241	m	MTM	6,052	m-MT/cm
GM at Equilibrium	0.802	m	Trim at Perps	3A	m
			Heel0	0.00	deg
			Propeller Immersion	168.34	%
Drafts - Perps			Drafts - Marks		
AP	18.000	m	Fwd	15.118	m
MS	16.520	m	Mid	16.541	m
FP	15.040	m	Aft	17.861	m
Strength					
Shear Min	-13,060	MT			
Shear Max	15,524	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,160,147H	m-MT			
Moment Max Sag	534S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	372.237	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
 Hull from Geometry
 GMt from GZ Curve Slope
 FSt Adjustment = SolidGMt-GMt
 48 Tanks from Geometry
 0 Tanks from Tables
 61 Empty Tanks
 GZ Curve from Geometry
 Downflood Angles from 3D Data

Alarm Summary

Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	231,727 MT		232,055 MT
Pass	Propeller Immersion	168.34 %	100.00 %	
Pass	Visibility	372.237 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.134 m	0.894 m	

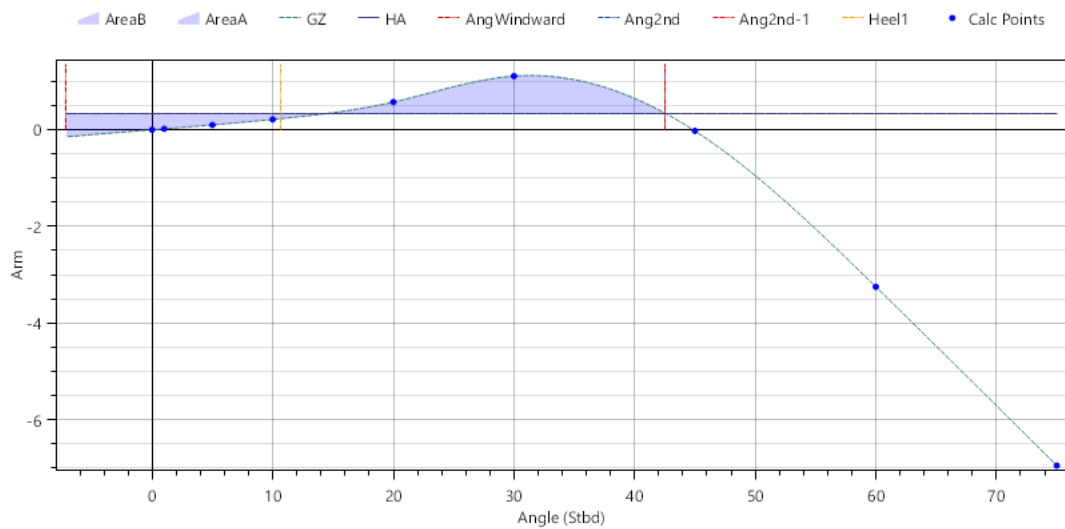
2008 IS Code 2.2 General Criteria



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.23 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.40 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.17 m-rad	0.03 m-rad	
	Angle to Downflooding	47.82 deg		
Pass	Angle at Maximum GZ	31.36 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.118 m	0.200 m	
Pass	Initial Metacentric Height	1.134 m	0.150 m	
	Range of Positive GZ	44.82 deg		

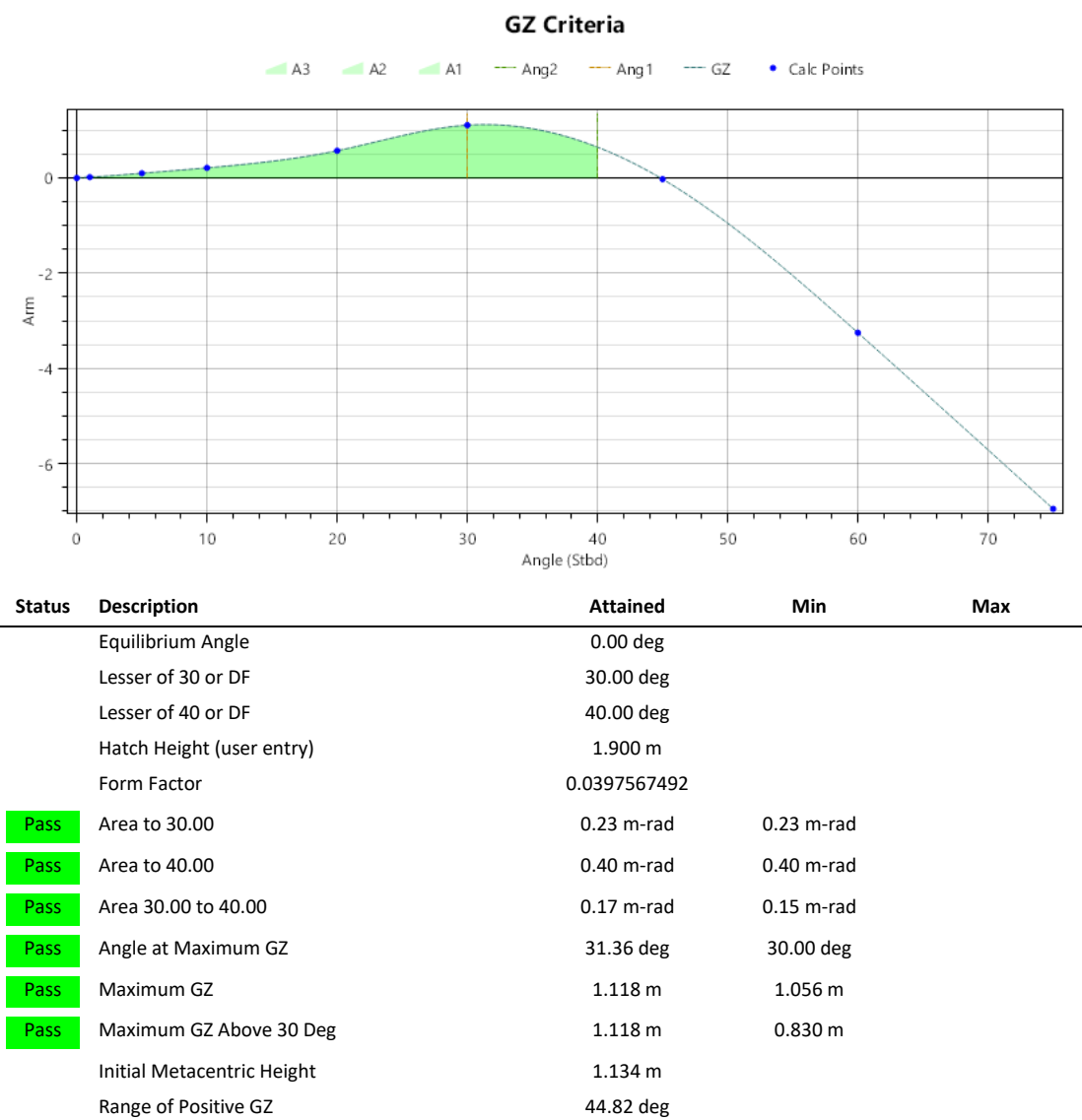
2008 IS Code 2.3 Weather Criteria

GZ Criteria

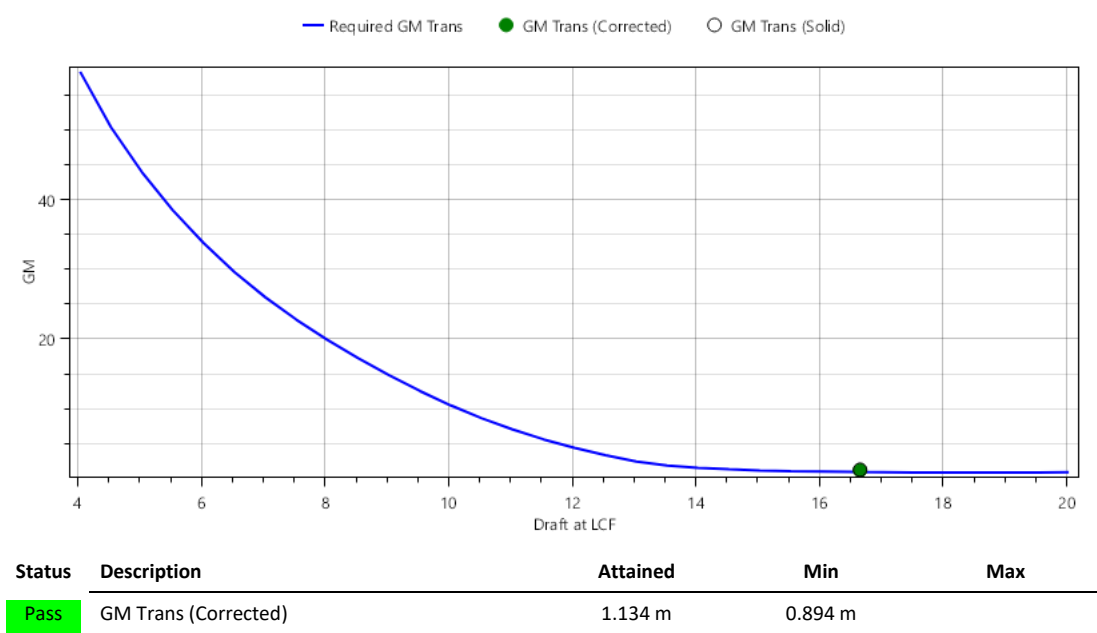


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2235681209		
	Steady Wind Heeling Lever LW1	0.224 m		
	80% Deck Edge Immersion Angle	12.43 deg		
Pass	Heeling Angle at LW1	10.60 deg		12.43 deg
	Gusty Wind Heeling Lever LW2	0.335 m		
	Heeling Angle at LW2	14.61 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.75 deg		
	Angle Windward	-7.15 deg		
	Second Intersect	42.55 deg		
	Limiting Angle	42.55 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.22 m-rad		
Pass	Area Ratio B/A	2.2683390608	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	71,247	184.232F	22.571	0.000	0
	SEAWATER BALLAST	45,007	233.652F	4.444	0.000P	88
	DIESEL OIL	3,014	243.325F	13.196	0.000	789
	LUBE OIL	578	58.678F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	MISC TANKS	358	43.600F	2.886	2.294P	1,381
	LH2	3,034	229.945F	15.868	0.000P	1,277
	Containers In Hold	74,808	188.881F	19.692	0.000	0
	Containers On Deck	103,907	172.641F	51.520	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		302,975	189.157F	28.913	0.004S	3,714

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	71,247	184.232F	22.571	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
8DBWBT S	2,216	100.00	2,216	1.0250	2,271	0
8DBWBT P	2,216	100.00	2,216	1.0250	2,271	0
7DBWBT S	2,277	100.00	2,277	1.0250	2,334	0
7DBWBT P	2,277	100.00	2,277	1.0250	2,334	0
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
4WWBT S	1,346	80.00	1,077	1.0250	1,104	44
4WWBT P	1,346	80.00	1,077	1.0250	1,104	44
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
3WWBT S	1,668	100.00	1,668	1.0250	1,710	0
3WWBT P	1,668	100.00	1,668	1.0250	1,710	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	100.00	2,173	1.0250	2,227	0
2WWBT P	2,173	100.00	2,173	1.0250	2,227	0
2DBWBT S	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
MGO PILOT OIL TK S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT OIL TK P	1,645	98.00	1,612	0.8600	1,386	366

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO SUMP	117	50.00	58	0.9000	52	62
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,129
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61

LH2

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
LH2 2 AFT S	6,373	85.00	5,417	0.0710	385	159
LH2 2 AFT C	6,373	85.00	5,417	0.0710	385	159
LH2 2 AFT P	6,373	85.00	5,417	0.0710	385	159
LH2 1FWD S	10,383	85.00	8,826	0.0710	627	267
LH2 1FWD C	10,383	85.00	8,826	0.0710	627	267
LH2 1FWD P	10,383	85.00	8,826	0.0710	627	267

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	1,260	200.550F	0.000	18.618	0	0	70	0	70	194.250F	206.850F
Bay 38	1,260	215.000F	0.000	18.618	0	0	48	0	48	208.700F	221.300F
Bay 34	864	229.450F	0.000	18.115	0	0	70	0	70	223.150F	235.750F
Bay 30	1,260	243.900F	0.000	18.618	0	0	70	0	70	237.600F	250.200F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 10	3,348	330.600F	0.000	20.588	0	0	190	0	190	324.300F	336.900F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F

Containers On Deck

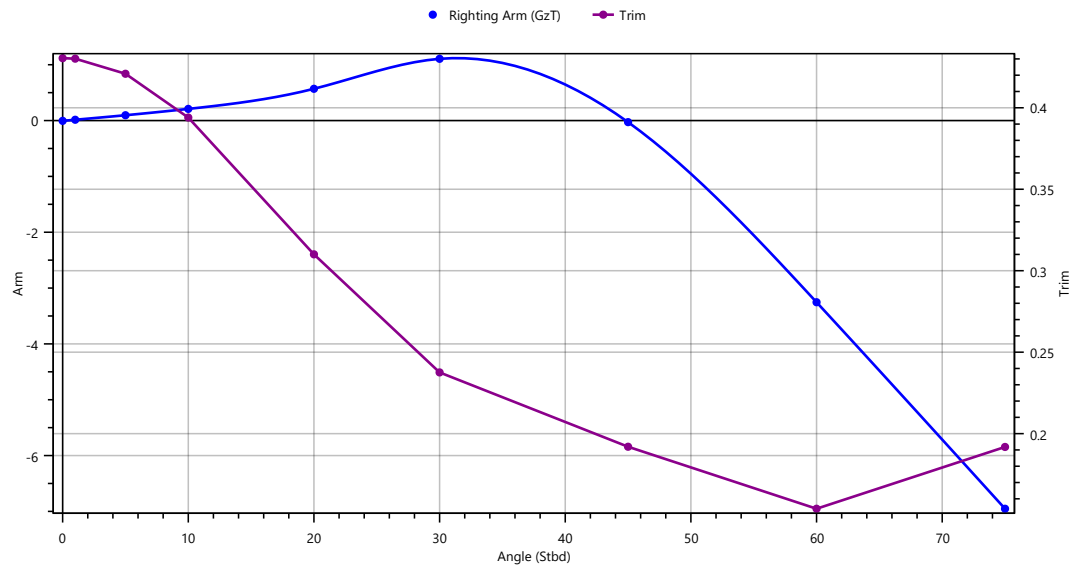
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 10	3,518	330.600F	0.000	48.326	0	0	238	0	238	324.300F	336.900F
Stack 6	3,518	345.050F	0.000	48.326	0	0	238	0	238	338.750F	351.350F
Stack 2	2,897	359.500F	0.000	47.023	0	0	196	0	196	353.200F	365.800F
Stack 14	3,872	316.150F	0.000	49.621	0	0	262	0	262	309.850F	322.450F
Stack 18	3,872	301.700F	0.000	49.621	0	0	262	0	262	295.400F	308.000F
Stack 58	4,582	142.750F	0.000	52.210	0	0	310	0	310	136.450F	149.050F
Stack 26	4,227	272.800F	0.000	50.916	0	0	286	0	286	266.500F	279.100F
Stack 94	4,582	1.450F	0.000	52.210	0	0	310	0	310	4.646A	7.546F
Stack 90	4,582	15.900F	0.000	52.210	0	0	310	0	310	9.600F	22.200F
Stack 86	4,582	30.350F	0.000	52.210	0	0	310	0	310	24.050F	36.650F
Stack 82	4,582	44.800F	0.000	52.210	0	0	310	0	310	38.500F	51.100F
Stack 78	4,582	70.500F	0.000	52.210	0	0	310	0	310	64.200F	76.800F
Stack 74	4,582	84.950F	0.000	52.210	0	0	310	0	310	78.650F	91.250F
Stack 70	4,582	99.400F	0.000	52.210	0	0	310	0	310	93.100F	105.700F
Stack 66	4,582	113.850F	0.000	52.210	0	0	310	0	310	107.550F	120.150F
Stack 62	4,582	128.300F	0.000	52.210	0	0	310	0	310	122.000F	134.600F
Stack 54	4,582	157.200F	0.000	52.210	0	0	310	0	310	150.900F	163.500F
Stack 50	4,582	171.650F	0.000	52.210	0	0	310	0	310	165.350F	177.950F
Stack 46	4,582	186.100F	0.000	52.210	0	0	310	0	310	179.800F	192.400F
Stack 42	4,582	200.550F	0.000	52.210	0	0	310	0	310	194.250F	206.850F
Stack 38	4,582	215.000F	0.000	52.210	0	0	310	0	310	208.700F	221.300F
Stack 34	4,464	229.450F	0.000	52.585	0	0	302	0	302	223.150F	235.750F
Stack 30	4,582	243.900F	0.000	52.210	0	0	310	0	310	237.600F	250.200F

Stack 4,227 287.250F 0.000 50.916 0 0 286 0 286 280.950F 293.550F
22

CONSTANT

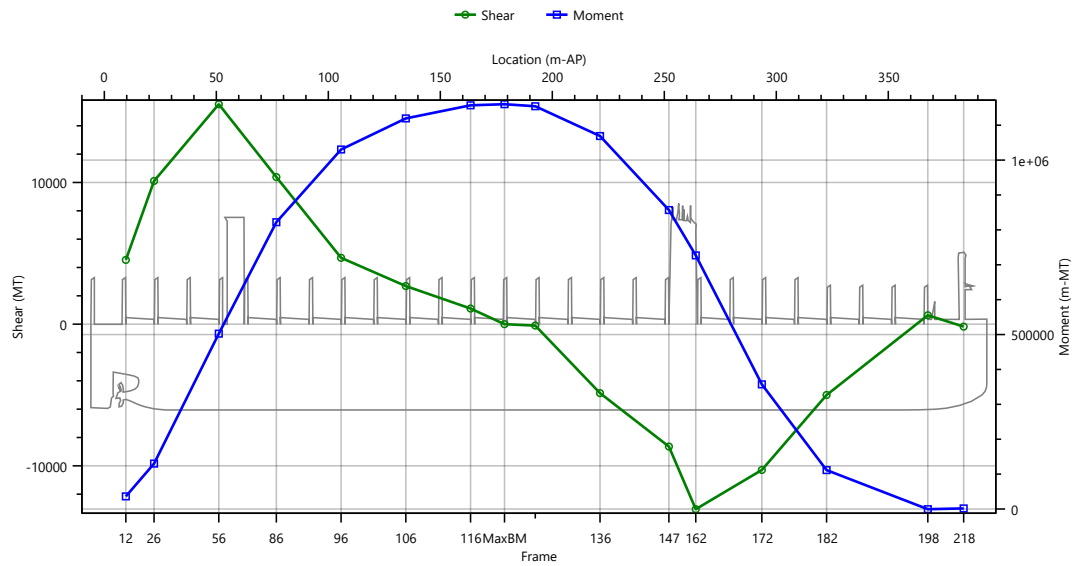
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
Water in Piping	50	160.000F	1.350	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.43	-0.005	0.001	0.00	0.43A	17.965	15.005	6
0.00	1.00	0.43	0.015	0.000	1.00S	0.43A	17.963	15.006	2
0.00	5.00	0.42	0.096	-0.001	5.00S	0.42A	17.911	15.017	3
0.00	10.00	0.39	0.209	-0.002	10.00S	0.39A	17.754	15.045	3
0.00	20.00	0.31	0.569	-0.003	20.00S	0.31A	17.190	15.058	3
0.00	30.00	0.24	1.106	0.003	30.00S	0.24A	16.300	14.666	3
0.00	45.00	0.19	-0.028	-0.002	45.00S	0.19A	14.325	13.005	4
0.00	60.00	0.15	-3.254	-0.004	60.00S	0.15A	11.183	10.124	5
0.00	75.00	0.19	-6.953	0.000	75.00S	0.19A	3.562	2.243	9

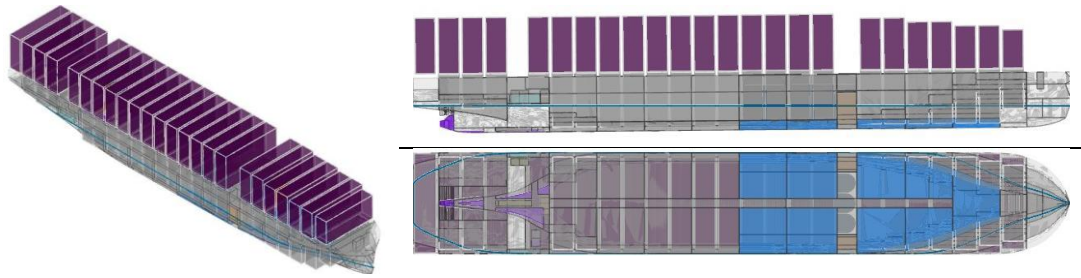
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	1,878	6,411	4,534	14,200S	50,378S	36,178H
22.200F	4,635	14,741	10,106	53,291S	183,440S	130,150H
51.100F	17,989	33,513	15,524	356,477S	859,033S	502,557H
76.800F	38,000	48,382	10,382	1,061,514S	1,883,470S	821,955H
105.700F	66,596	71,277	4,681	2,563,357S	3,593,690S	1,030,333H
134.600F	96,787	99,476	2,689	4,924,350S	6,043,770S	1,119,420H
163.500F	126,725	127,827	1,102	8,154,992S	9,312,000S	1,157,008H
178.657F	142,274	142,273	-2	10,193,787S	11,353,933S	1,160,147H
192.400F	156,281	156,180	-101	12,245,355S	13,399,635S	1,154,279H
221.300F	185,451	180,582	-4,868	17,184,310S	18,253,256S	1,068,945H
252.050F	216,027	207,388	-8,639	23,358,440S	24,215,303S	856,864H
264.050F	227,779	214,719	-13,060	26,021,410S	26,748,280S	726,870H
293.550F	255,811	245,519	-10,292	33,158,422S	33,515,648S	357,226H
322.450F	279,852	274,852	-5,000	40,913,118S	41,024,613S	111,495H
367.650F	300,023	300,651	628	54,104,153S	54,103,620S	534S
383.650F	302,558	302,384	-174	58,927,748S	58,929,402S	1,654H

LH₂ 9 MT Hold 6 MT Deck Max Design Departure

Trim and Stability Summary

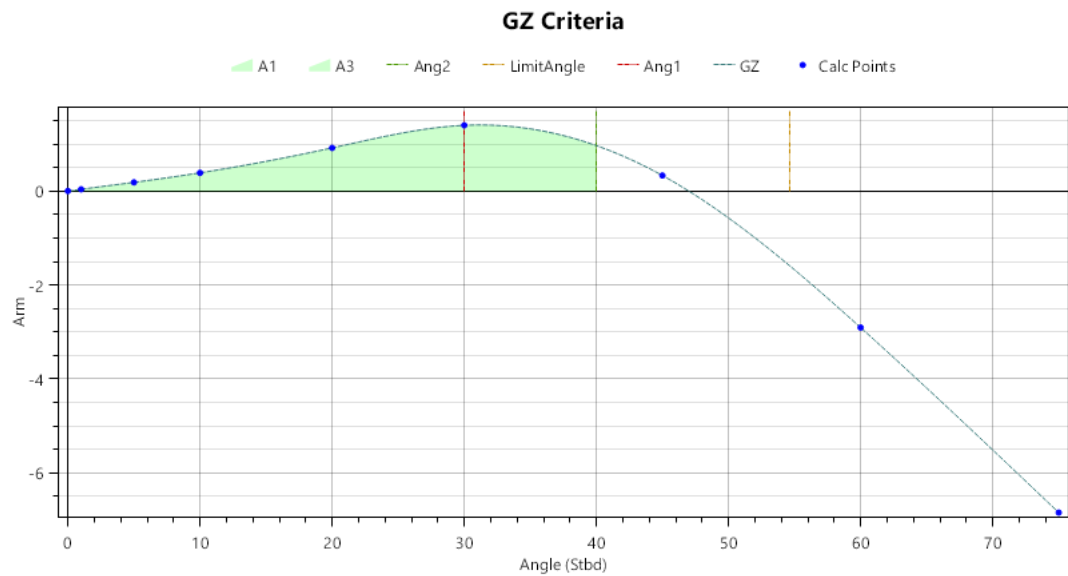


Loading					
Intact Displacement	259,647	MT	Sea Density	1.0250	MT/m ³
Deadweight	188,400	MT			
Available Deadweight	202	MT			
Stability			Trim		
KM0 Trans	31.450	m	Draft at LCF	14.691	m
VCG Upright	29.273	m-BL	LCF	179.798F	m-AP
GM0 Solid Trans	2.177	m	LCB	188.765F	m-AP
GM0 Trans	2.073	m	LCG	188.970F	m-AP
GMt Required	1.224	m	TPM	217.47	MT/cm
GMt Margin	0.849	m	MTM	5,633	m-MT/cm
GM at Equilibrium	2.303	m	Trim at Perps	4A	m
			Heel0	0.00	deg
			Propeller Immersion	152.92	%
Drafts - Perps			Drafts - Marks		
AP	16.413	m	Fwd	12.738	m
MS	14.526	m	Mid	14.552	m
FP	12.639	m	Aft	16.234	m
Bridge Visibility					
Visibility Distance	401.619	m	Visibility Distance Required	500.000	m
Calculation Notes					
Drafts from Keel					
Hull from Geometry					
GMt from GZ Curve Slope					
FSt Adjustment = SolidGMt-GMt					
37 Tanks from Geometry					
0 Tanks from Tables					
72 Empty Tanks					
GZ Curve from Geometry					
Downflood Angles from 3D Data					

Alarm Summary

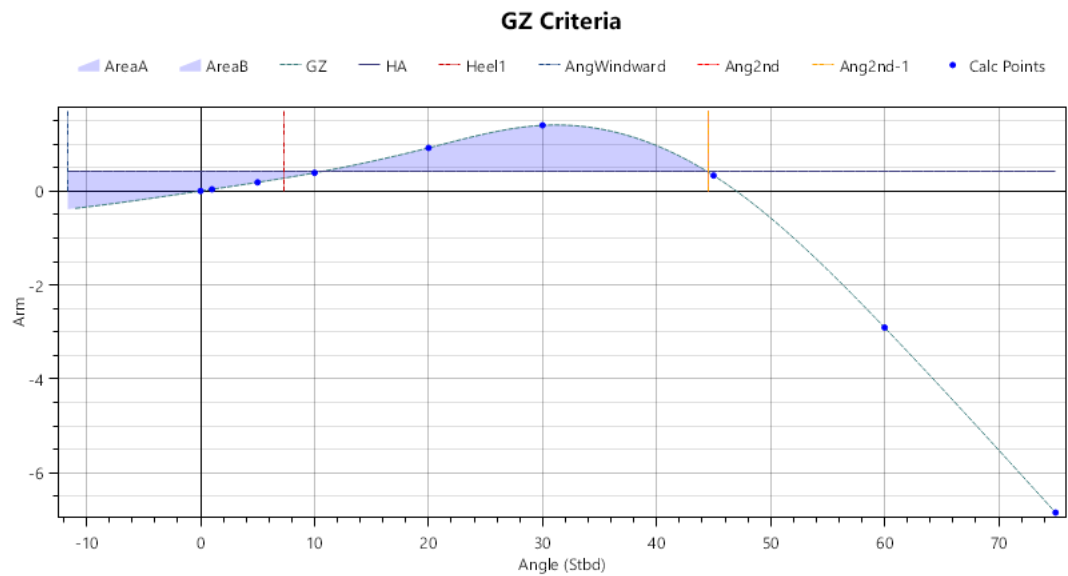
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	188,400 MT		232,909 MT
Pass	Propeller Immersion	152.92 %	100.00 %	
Pass	Visibility	401.619 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	2.073 m	1.224 m	
Pass	Design Deadweight	188,400 MT		188,602 MT

2008 IS Code 2.2 General Criteria



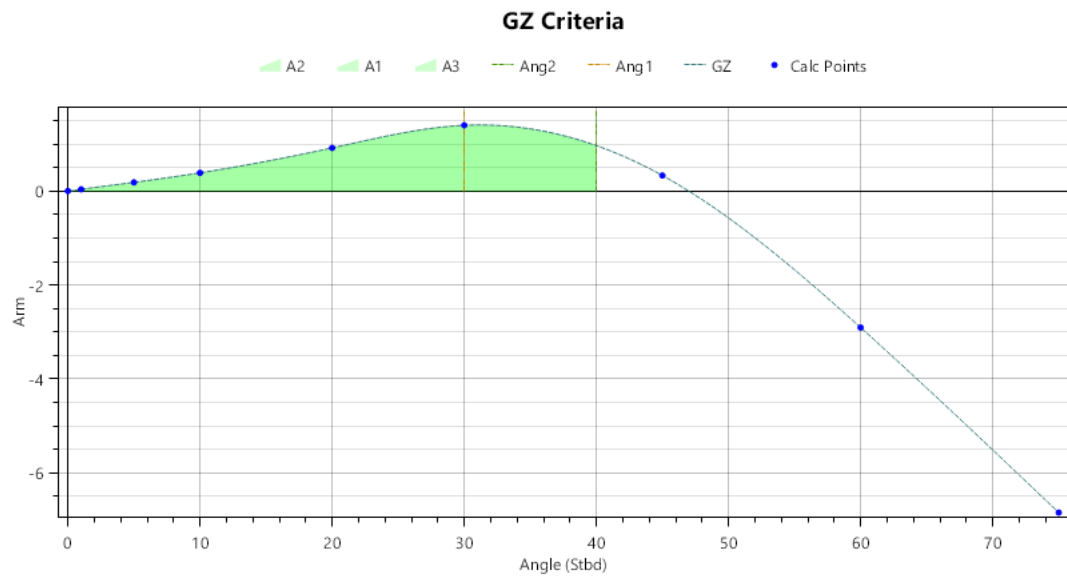
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.36 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.58 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.22 m-rad	0.03 m-rad	
	Angle to Downflooding	54.60 deg		
Pass	Angle at Maximum GZ	31.17 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.412 m	0.200 m	
Pass	Initial Metacentric Height	2.073 m	0.150 m	
	Range of Positive GZ	47.01 deg		

2008 IS Code 2.3 Weather Criteria



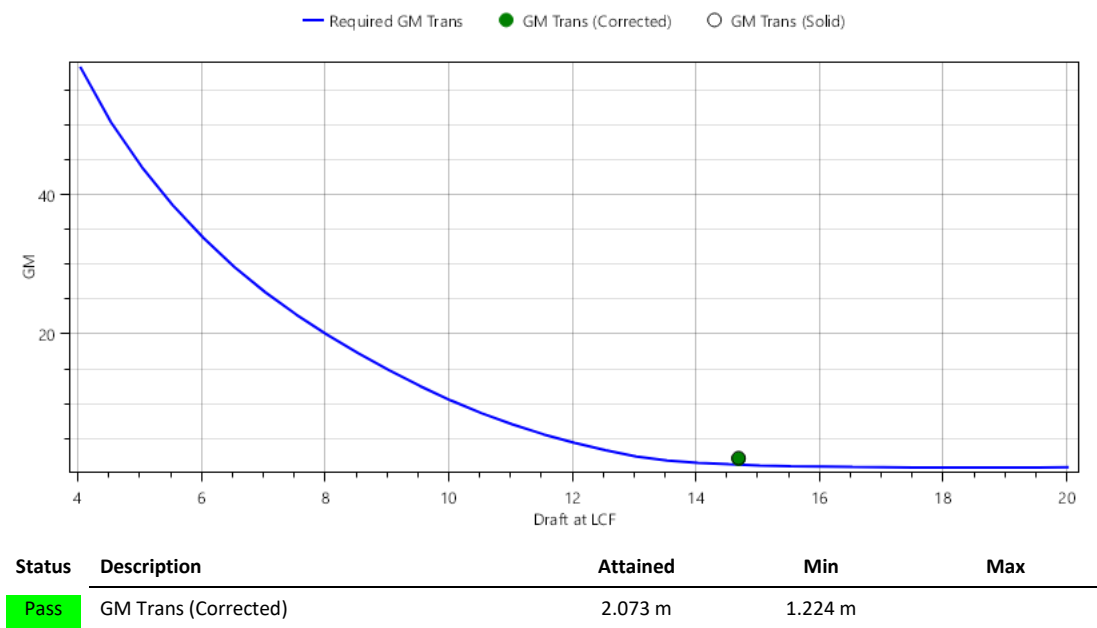
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2757844894		
	Steady Wind Heeling Lever LW1	0.276 m		
	80% Deck Edge Immersion Angle	15.35 deg		
Pass	Heeling Angle at LW1	7.27 deg		15.35 deg
	Gusty Wind Heeling Lever LW2	0.414 m		
	Heeling Angle at LW2	10.51 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	18.91 deg		
	Angle Windward	-11.64 deg		
	Second Intersect	44.48 deg		
	Limiting Angle	44.48 deg		
	Capsizing Area A	-0.16 m-rad		
	Righting Area B	0.35 m-rad		
Pass	Area Ratio B/A	2.1561674202	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0326642284		
Pass	Area to 30.00	0.36 m-rad	0.28 m-rad	
Pass	Area to 40.00	0.58 m-rad	0.49 m-rad	
Pass	Area 30.00 to 40.00	0.22 m-rad	0.18 m-rad	
Pass	Angle at Maximum GZ	31.17 deg	30.00 deg	
Pass	Maximum GZ	1.412 m	1.286 m	
Pass	Maximum GZ Above 30 Deg	1.412 m	1.010 m	
	Initial Metacentric Height	2.073 m		
	Range of Positive GZ	47.01 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	71,247	184.232F	22.571	0.000	0
	SEAWATER BALLAST	21,155	265.781F	2.155	0.122P	1,278
	DIESEL OIL	3,014	243.324F	13.196	0.000	789
	LUBE OIL	578	58.668F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	MISC TANKS	358	43.541F	2.887	2.286P	1,391
	LH2	3,034	229.938F	15.868	0.000P	1,277
	Containers In Hold	74,880	189.018F	19.704	0.000	0
	Containers On Deck	84,360	172.642F	51.520	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		259,647	188.970F	29.273	0.006P	4,914

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	71,247	184.232F	22.571	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT P	2,173	5.00	109	1.0250	111	1,278
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
MGO PILOT OIL TK S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT OIL TK P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,139
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

LH2

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
LH2 2 AFT C	6,373	85.00	5,417	0.0710	385	159
LH2 2 AFT P	6,373	85.00	5,417	0.0710	385	159
LH2 1FWD S	10,383	85.00	8,826	0.0710	627	267
LH2 1FWD C	10,383	85.00	8,826	0.0710	627	267
LH2 2 AFT S	6,373	85.00	5,417	0.0710	385	159
LH2 1FWD P	10,383	85.00	8,826	0.0710	627	267

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F

Bay 38	1,260	215.000F	0.000	18.618	0	0	48	0	48	208.700F	221.300F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	1,260	200.550F	0.000	18.618	0	0	70	0	70	194.250F	206.850F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 34	864	229.450F	0.000	18.115	0	0	70	0	70	223.150F	235.750F
Bay 30	1,260	243.900F	0.000	18.618	0	0	70	0	70	237.600F	250.200F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 22	3,432	287.250F	0.000	50.916	0	0	286	0	286	280.950F	293.550F
Stack 18	3,144	301.700F	0.000	49.621	0	0	262	0	262	295.400F	308.000F
Stack 14	3,144	316.150F	0.000	49.621	0	0	262	0	262	309.850F	322.450F
Stack 10	2,856	330.600F	0.000	48.326	0	0	238	0	238	324.300F	336.900F

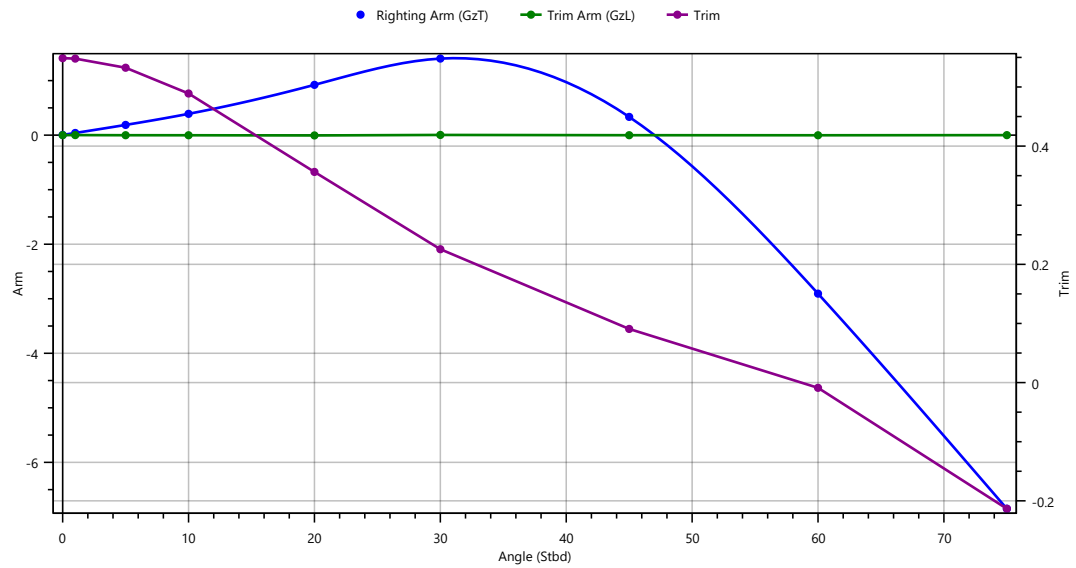
Stack 6	2,856	345.050F	0.000	48.326	0	0	238	0	238	338.750F	351.350F
Stack 2	2,352	359.500F	0.000	47.023	0	0	196	0	196	353.200F	365.800F
Stack 26	3,432	272.800F	0.000	50.916	0	0	286	0	286	266.500F	279.100F
Stack 30	3,720	243.900F	0.000	52.210	0	0	310	0	310	237.600F	250.200F
Stack 70	3,720	99.400F	0.000	52.210	0	0	310	0	310	93.100F	105.700F
Stack 38	3,720	215.000F	0.000	52.210	0	0	310	0	310	208.700F	221.300F
Stack 94	3,720	1.450F	0.000	52.210	0	0	310	0	310	4.646A	7.546F
Stack 90	3,720	15.900F	0.000	52.210	0	0	310	0	310	9.600F	22.200F
Stack 86	3,720	30.350F	0.000	52.210	0	0	310	0	310	24.050F	36.650F
Stack 34	3,624	229.450F	0.000	52.585	0	0	302	0	302	223.150F	235.750F
Stack 82	3,720	44.800F	0.000	52.210	0	0	310	0	310	38.500F	51.100F
Stack 74	3,720	84.950F	0.000	52.210	0	0	310	0	310	78.650F	91.250F
Stack 66	3,720	113.850F	0.000	52.210	0	0	310	0	310	107.550F	120.150F
Stack 62	3,720	128.300F	0.000	52.210	0	0	310	0	310	122.000F	134.600F
Stack 58	3,720	142.750F	0.000	52.210	0	0	310	0	310	136.450F	149.050F
Stack 54	3,720	157.200F	0.000	52.210	0	0	310	0	310	150.900F	163.500F
Stack 50	3,720	171.650F	0.000	52.210	0	0	310	0	310	165.350F	177.950F
Stack 46	3,720	186.100F	0.000	52.210	0	0	310	0	310	179.800F	192.400F
Stack 42	3,720	200.550F	0.000	52.210	0	0	310	0	310	194.250F	206.850F
Stack 78	3,720	70.500F	0.000	52.210	0	0	310	0	310	64.200F	76.800F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000

Stores Distributed	120	160.000F	27.200	0.000

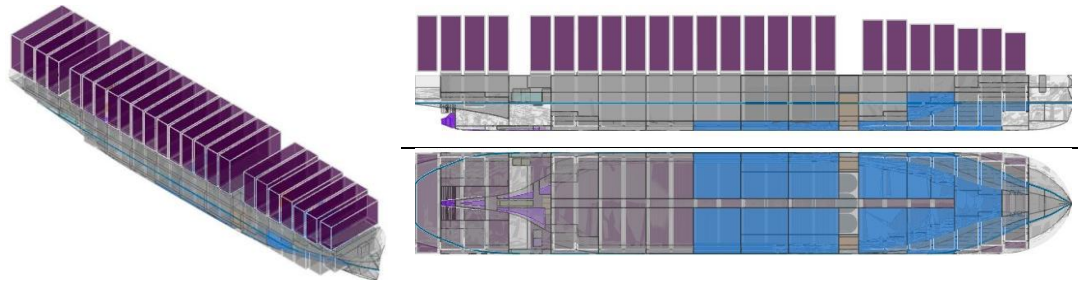
Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.55	0.004	0.000	0.00	0.55A	16.378	12.604	5
0.00	1.00	0.55	0.040	0.001	1.00S	0.55A	16.374	12.605	2
0.00	5.00	0.53	0.187	-0.001	5.00S	0.53A	16.295	12.633	3
0.00	10.00	0.49	0.391	-0.002	10.00S	0.49A	16.066	12.703	3
0.00	20.00	0.36	0.922	-0.006	20.00S	0.36A	15.270	12.820	3
0.00	30.00	0.23	1.404	0.004	30.00S	0.23A	14.001	12.450	3
0.00	45.00	0.09	0.335	-0.001	45.00S	0.09A	10.561	9.937	5
0.00	60.00	-0.01	-2.907	-0.002	60.00S	0.01F	4.934	4.995	7
0.00	75.00	-0.21	-6.851	0.000	75.00S	0.21F	-10.097	-8.629	9

LH₂ 10 Tier Deck Scantling Departure 9.6 MT Deck 9 MT Hold

Trim and Stability Summary



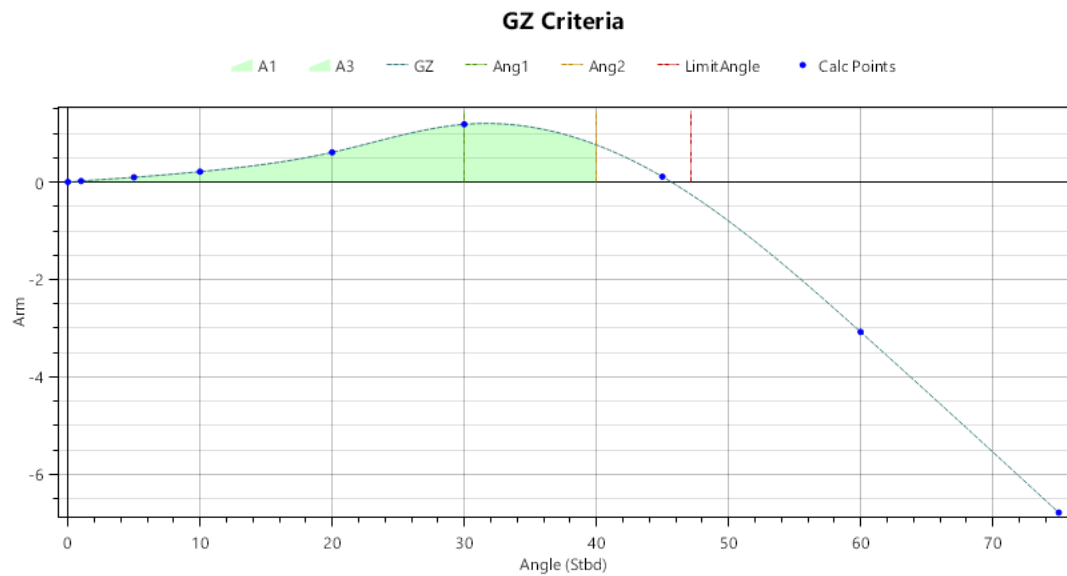
Loading					
Intact Displacement	297,494	MT	Sea Density	1.0250	MT/m ³
Deadweight	226,247	MT			
Available Deadweight	3,092	MT			
Stability			Trim		
KM0 Trans	29.902	m	Draft at LCF	16.399	m
VCG Upright	28.705	m-BL	LCF	182.145F	m-AP
GM0 Solid Trans	1.197	m	LCB	195.101F	m-AP
GM0 Trans	1.055	m	LCG	195.110F	m-AP
GMt Required	0.917	m	TPM	221.27	MT/cm
GMt Margin	0.138	m	MTM	5,898	m-MT/cm
GM at Equilibrium	1.218	m	Trim at Perps	0A	m
			Heel0	0.00	deg
			Propeller Immersion	153.90	%
Drafts - Perps			Drafts - Marks		
AP	16.443	m	Fwd	16.351	m
MS	16.396	m	Mid	16.397	m
FP	16.349	m	Aft	16.438	m
Strength					
Shear Min	-17,404	MT			
Shear Max	19,333	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,751,775H	m-MT			
Moment Max Sag	3,601S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	337.972	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
42 Tanks from Geometry
0 Tanks from Tables
67 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

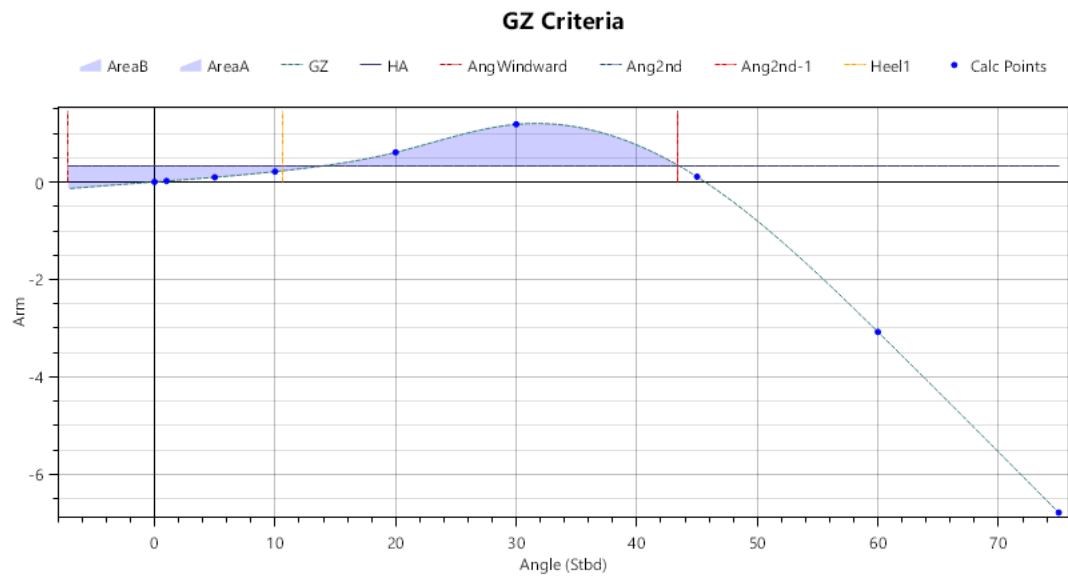
Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	226,247 MT		229,339 MT
Pass	Propeller Immersion	153.90 %	100.00 %	
Pass	Visibility	337.972 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.055 m	0.917 m	

2008 IS Code 2.2 General Criteria



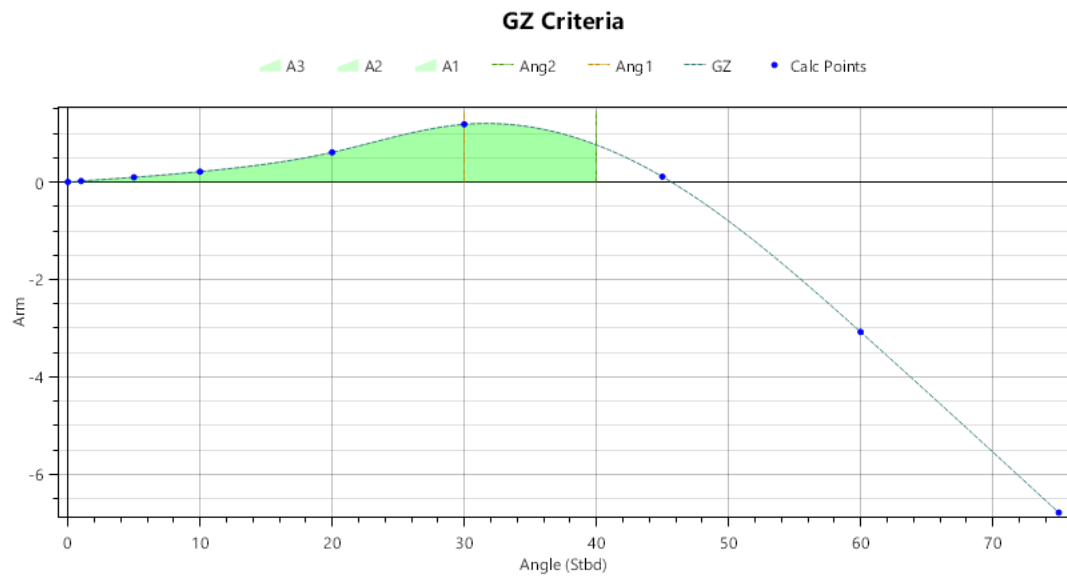
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.25 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.44 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.19 m-rad	0.03 m-rad	
	Angle to Downflooding	47.18 deg		
Pass	Angle at Maximum GZ	31.66 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.205 m	0.200 m	
Pass	Initial Metacentric Height	1.055 m	0.150 m	
	Range of Positive GZ	45.68 deg		

2008 IS Code 2.3 Weather Criteria



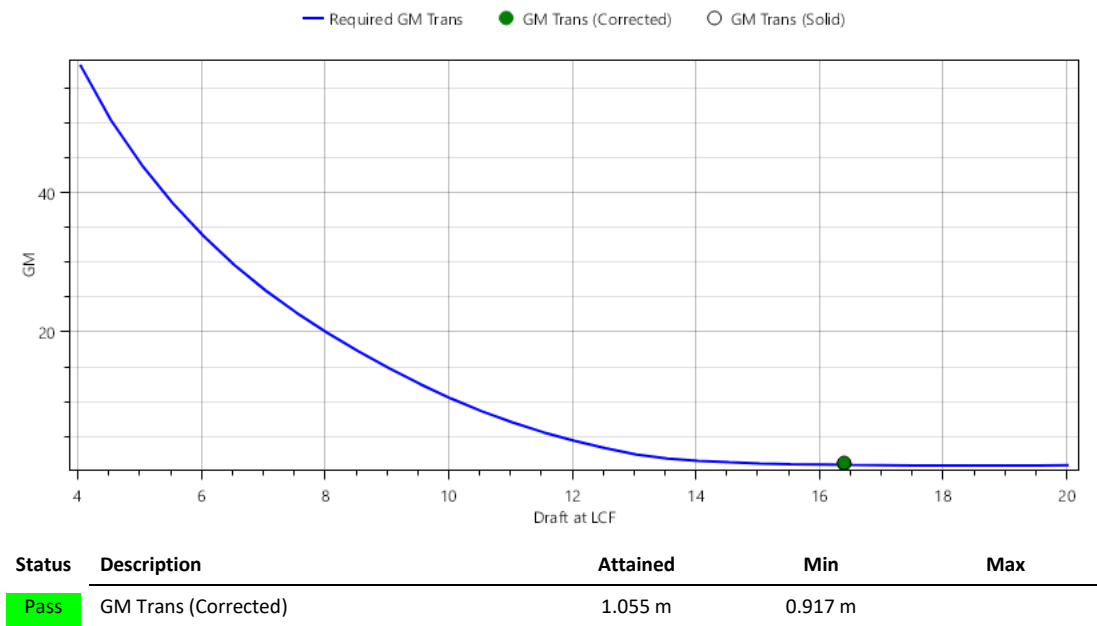
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2295842698		
	Steady Wind Heeling Lever LW1	0.230 m		
	80% Deck Edge Immersion Angle	15.18 deg		
Pass	Heeling Angle at LW1	10.58 deg		15.18 deg
	Gusty Wind Heeling Lever LW2	0.344 m		
	Heeling Angle at LW2	14.34 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.76 deg		
	Angle Windward	-7.18 deg		
	Second Intersect	43.43 deg		
	Limiting Angle	43.43 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.26 m-rad		
Pass	Area Ratio B/A	2.5825215282	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0393710392		
Pass	Area to 30.00	0.25 m-rad	0.23 m-rad	
Pass	Area to 40.00	0.44 m-rad	0.41 m-rad	
Pass	Area 30.00 to 40.00	0.19 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	31.66 deg	30.00 deg	
Pass	Maximum GZ	1.205 m	1.067 m	
Pass	Maximum GZ Above 30 Deg	1.205 m	0.838 m	
	Initial Metacentric Height	1.055 m		
	Range of Positive GZ	45.68 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	71,247	184.232F	22.571	0.000	0
	SEAWATER BALLAST	36,491	272.657F	5.164	0.065P	19,941
	DIESEL OIL	3,014	243.330F	13.196	0.000	789
	LUBE OIL	578	58.712F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	MISC TANKS	358	43.802F	2.885	2.319P	1,340
	LH2	3,034	229.974F	15.868	0.000P	1,278
	Containers In Hold	74,880	189.018F	19.704	0.000	0
	Containers On Deck	106,871	179.799F	48.117	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		297,494	195.110F	28.705	0.004P	23,526

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	71,247	184.232F	22.571	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	100.00	2,173	1.0250	2,227	0
2WWBT P	2,173	100.00	2,173	1.0250	2,227	0
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1 WWBT S	4,837	62.50	3,023	1.0250	3,099	10,858
1 WWBT P	4,837	65.00	3,144	1.0250	3,222	9,082
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14

NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
MGO PILOT OIL TK P	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT OIL TK S	1,645	98.00	1,612	0.8600	1,386	366

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
SSDG LO SETT TK	74	50.00	37	0.9000	33	13

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	29
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,093
ST CWT	140	100.00	140	1.0000	140	0
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
WASTE OIL TANK	138	10.00	14	1.0000	14	103

LH2

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
LH2 2 AFT S	6,373	85.00	5,417	0.0710	385	159
LH2 2 AFT C	6,373	85.00	5,417	0.0710	385	159
LH2 2 AFT P	6,373	85.00	5,417	0.0710	385	159
LH2 1FWD C	10,383	85.00	8,826	0.0710	627	267
LH2 1FWD P	10,383	85.00	8,826	0.0710	627	267
LH2 1FWD S	10,383	85.00	8,826	0.0710	627	267

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F

Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 34	864	229.450F	0.000	18.115	0	0	70	0	70	223.150F	235.750F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	1,260	200.550F	0.000	18.618	0	0	70	0	70	194.250F	206.850F
Bay 38	1,260	215.000F	0.000	18.618	0	0	48	0	48	208.700F	221.300F
Bay 30	1,260	243.900F	0.000	18.618	0	0	70	0	70	237.600F	250.200F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 18	4,493	301.700F	0.000	48.148	0	0	262	0	262	295.400F	308.000F
Stack 14	4,493	316.150F	0.000	48.148	0	0	262	0	262	309.850F	322.450F

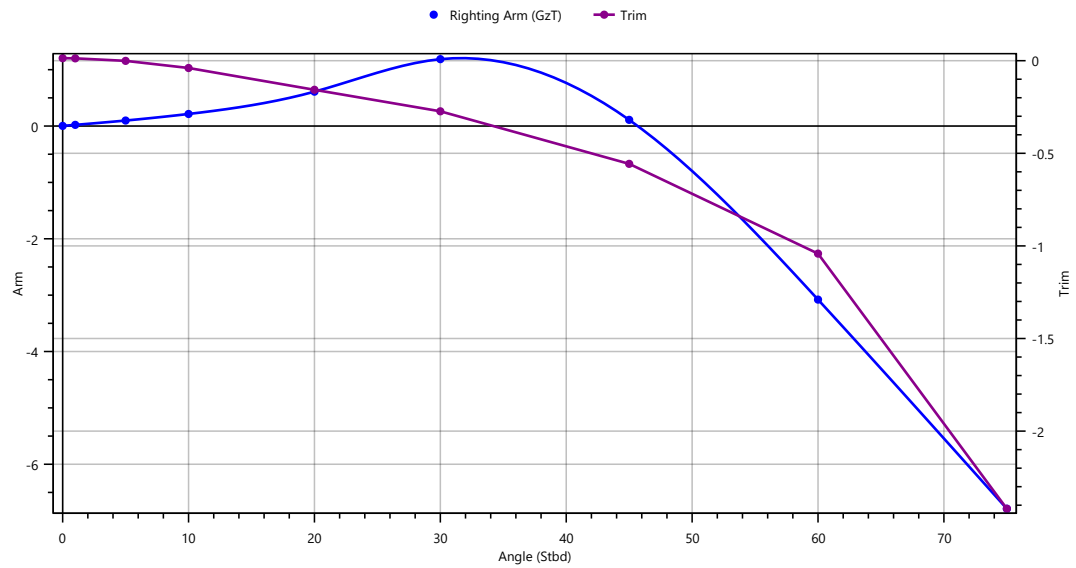
Stack 10	4,493	330.600F	0.000	48.148	0	0	238	0	238	324.300F	336.900F
Stack 6	4,493	345.050F	0.000	48.148	0	0	238	0	238	338.750F	351.350F
Stack 2	3,686	359.500F	0.000	46.832	0	0	196	0	196	353.200F	365.800F
Stack 22	4,493	287.250F	0.000	48.148	0	0	286	0	286	280.950F	293.550F
Stack 26	4,493	272.800F	0.000	48.148	0	0	286	0	286	266.500F	279.100F
Stack 66	4,493	113.850F	0.000	48.148	0	0	310	0	310	107.550F	120.150F
Stack 34	4,339	229.450F	0.000	48.505	0	0	302	0	302	223.150F	235.750F
Stack 94	4,493	1.450F	0.000	48.148	0	0	310	0	310	4.646A	7.546F
Stack 90	4,493	15.900F	0.000	48.148	0	0	310	0	310	9.600F	22.200F
Stack 86	4,493	30.350F	0.000	48.148	0	0	310	0	310	24.050F	36.650F
Stack 82	4,493	44.800F	0.000	48.148	0	0	310	0	310	38.500F	51.100F
Stack 78	4,493	70.500F	0.000	48.148	0	0	310	0	310	64.200F	76.800F
Stack 74	4,493	84.950F	0.000	48.148	0	0	310	0	310	78.650F	91.250F
Stack 70	4,493	99.400F	0.000	48.148	0	0	310	0	310	93.100F	105.700F
Stack 62	4,493	128.300F	0.000	48.148	0	0	310	0	310	122.000F	134.600F
Stack 58	4,493	142.750F	0.000	48.148	0	0	310	0	310	136.450F	149.050F
Stack 54	4,493	157.200F	0.000	48.148	0	0	310	0	310	150.900F	163.500F
Stack 50	4,493	171.650F	0.000	48.148	0	0	310	0	310	165.350F	177.950F
Stack 46	4,493	186.100F	0.000	48.148	0	0	310	0	310	179.800F	192.400F
Stack 42	4,493	200.550F	0.000	48.148	0	0	310	0	310	194.250F	206.850F
Stack 38	4,493	215.000F	0.000	48.148	0	0	310	0	310	208.700F	221.300F
Stack 30	4,493	243.900F	0.000	48.148	0	0	310	0	310	237.600F	250.200F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000

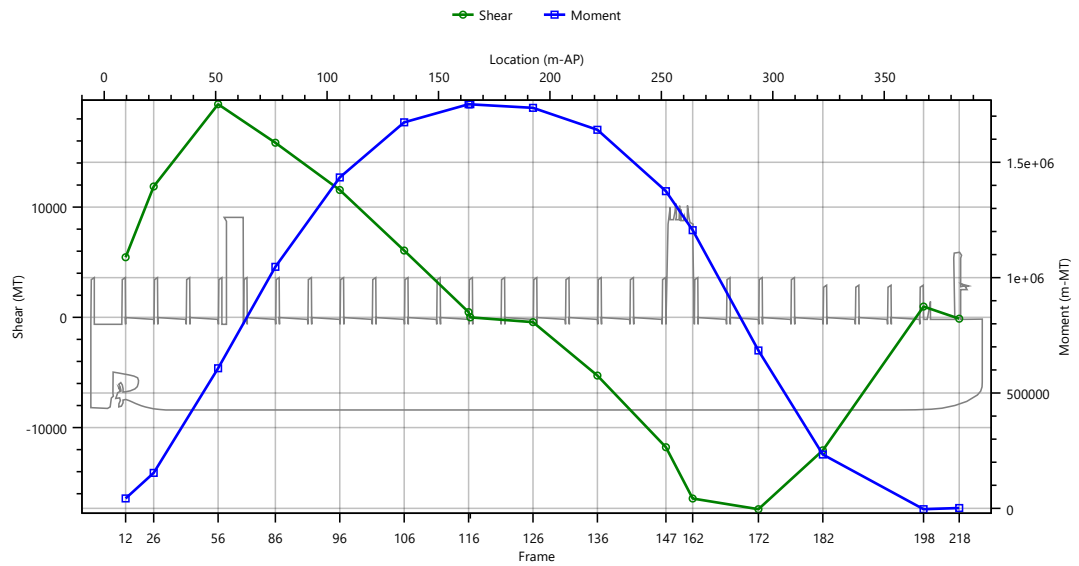
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.01	0.003	-0.004	0.00	0.01A	16.408	16.314	3
0.00	1.00	0.01	0.021	0.002	1.00S	0.01A	16.403	16.317	2
0.00	5.00	0.00	0.098	0.000	5.00S	0.00F	16.332	16.338	3
0.00	10.00	-0.04	0.214	0.000	10.00S	0.04F	16.122	16.393	3
0.00	20.00	-0.16	0.610	-0.002	20.00S	0.16F	15.402	16.482	3
0.00	30.00	-0.27	1.187	0.000	30.00S	0.27F	14.303	16.182	3
0.00	45.00	-0.56	0.110	-0.001	45.00S	0.56F	11.329	15.159	5
0.00	60.00	-1.04	-3.079	0.000	60.00S	1.04F	6.365	13.529	9
0.00	75.00	-2.42	-6.789	0.000	75.01S	2.42F	-7.000	9.645	17

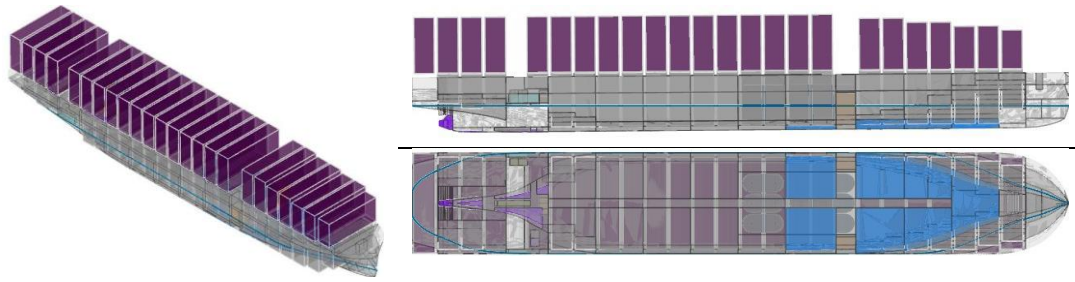
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	873	6,322	5,450	6,623S	49,653S	43,030H
22.200F	2,694	14,562	11,868	27,259S	181,033S	153,774H
51.100F	13,821	33,154	19,333	241,764S	849,058S	607,293H
76.800F	32,101	47,937	15,836	816,807S	1,863,707S	1,046,900H
105.700F	59,103	70,654	11,551	2,124,226S	3,558,659S	1,434,434H
134.600F	88,073	94,132	6,059	4,250,131S	5,923,447S	1,673,315H
163.500F	117,165	117,638	473	7,215,823S	8,967,423S	1,751,599H
164.266F	117,936	117,935	-2	7,305,904S	9,057,678S	1,751,775H
192.400F	146,248	145,812	-436	11,022,179S	12,758,178S	1,735,999H
221.300F	175,320	170,037	-5,283	15,668,871S	17,309,759S	1,640,888H
252.050F	206,202	194,419	-11,783	21,535,080S	22,909,896S	1,374,817H
264.050F	218,187	201,752	-16,436	24,081,481S	25,287,243S	1,205,762H
293.550F	247,068	229,664	-17,404	30,947,105S	31,631,463S	684,358H
322.450F	272,303	260,239	-12,064	38,465,652S	38,699,027S	233,375H
367.650F	294,193	295,170	977	51,358,208S	51,354,607S	3,601S
383.650F	297,027	296,903	-124	56,091,181S	56,092,698S	1,517H

LH₂ 10 Tier Deck Design Departure 8.15 MT Deck 9 MT Hold

Trim and Stability Summary



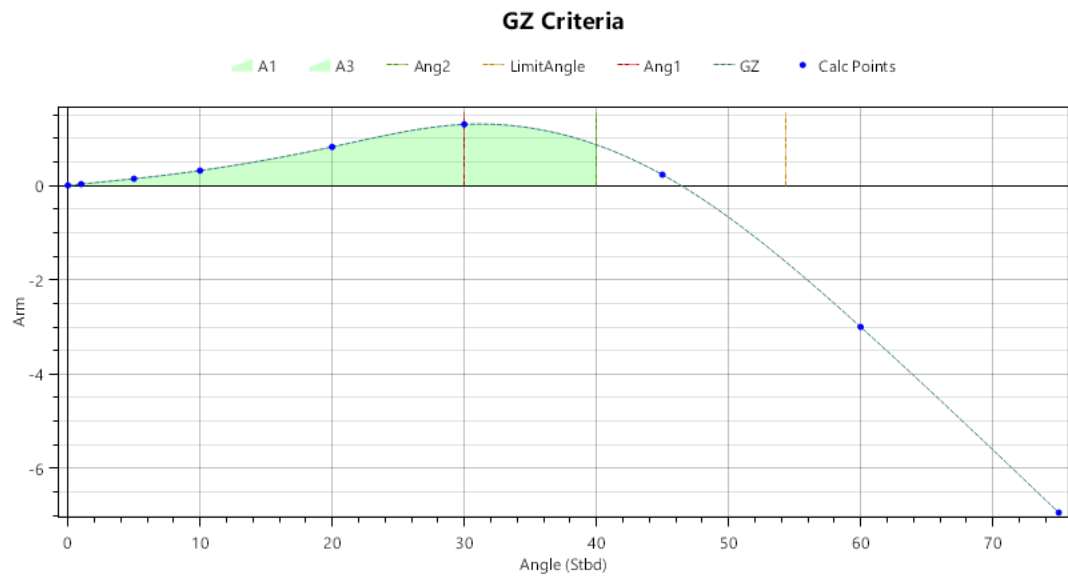
Loading					
Intact Displacement	259,206	MT	Sea Density	1.0250	MT/m ³
Deadweight	187,959	MT			
Available Deadweight	60	MT			
Stability			Trim		
KM0 Trans	31.343	m	Draft at LCF	14.661	m
VCG Upright	29.338	m-BL	LCF	180.805F	m-AP
GM0 Solid Trans	2.004	m	LCB	190.186F	m-AP
GM0 Trans	1.567	m	LCG	190.358F	m-AP
GMt Required	1.234	m	TPM	216.68	MT/cm
GMt Margin	0.333	m	MTM	5,573	m-MT/cm
GM at Equilibrium	1.797	m	Trim at Perps	3A	m
			Heel0	0.00	deg
			Propeller Immersion	150.06	%
Drafts - Perps			Drafts - Marks		
AP	16.103	m	Fwd	13.044	m
MS	14.532	m	Mid	14.554	m
FP	12.962	m	Aft	15.955	m
Strength					
Shear Min	-16,938	MT			
Shear Max	18,237	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,784,429H	m-MT			
Moment Max Sag	--	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	392.782	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
35 Tanks from Geometry
0 Tanks from Tables
74 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	187,959 MT		232,241 MT
Pass	Propeller Immersion	150.06 %	100.00 %	
Pass	Visibility	392.782 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.567 m	1.234 m	
Pass	Design Deadweight	187,959 MT		188,018 MT

2008 IS Code 2.2 General Criteria



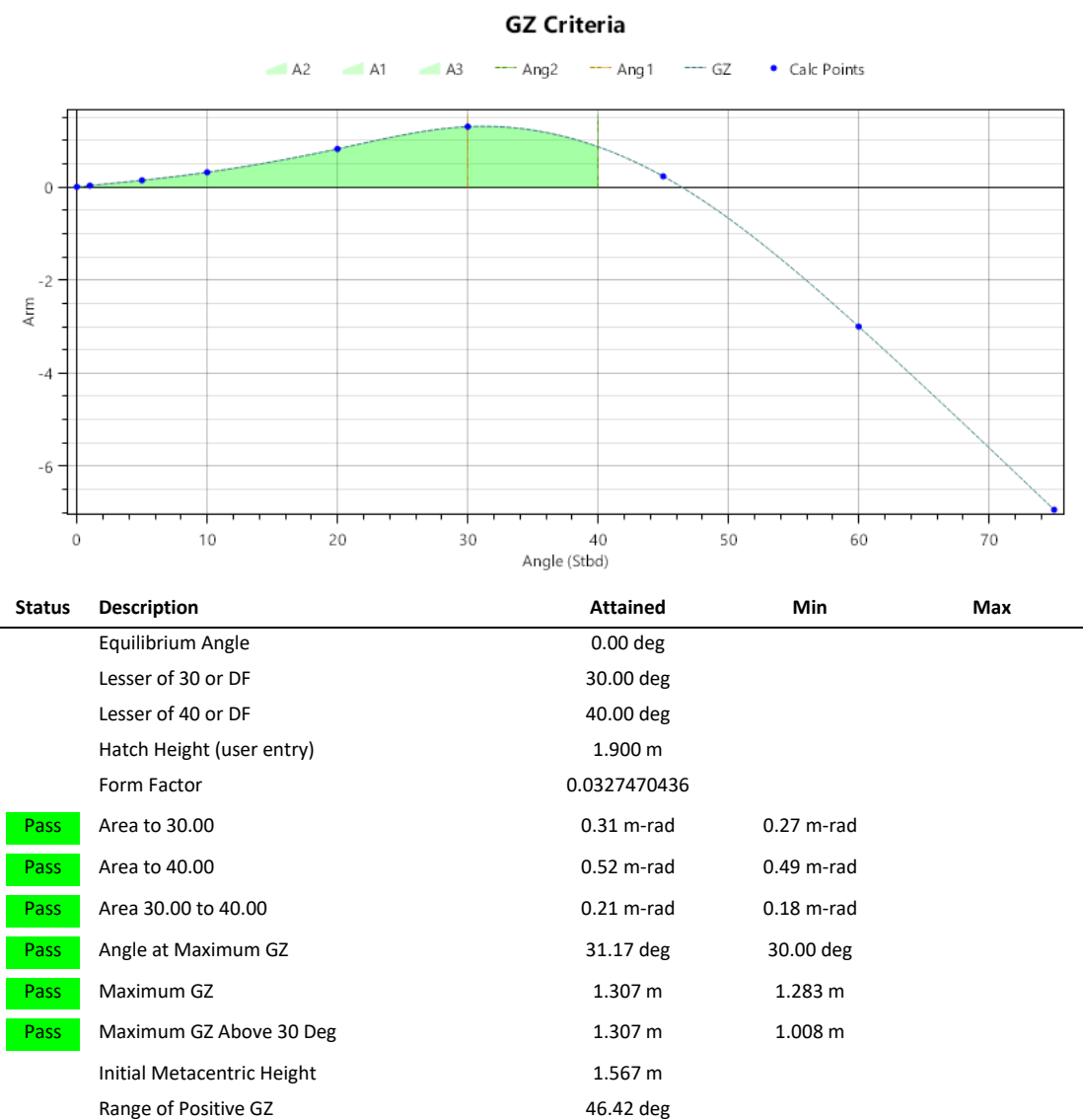
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.31 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.52 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.21 m-rad	0.03 m-rad	
	Angle to Downflooding	54.34 deg		
Pass	Angle at Maximum GZ	31.17 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.307 m	0.200 m	
Pass	Initial Metacentric Height	1.567 m	0.150 m	
	Range of Positive GZ	46.42 deg		

2008 IS Code 2.3 Weather Criteria

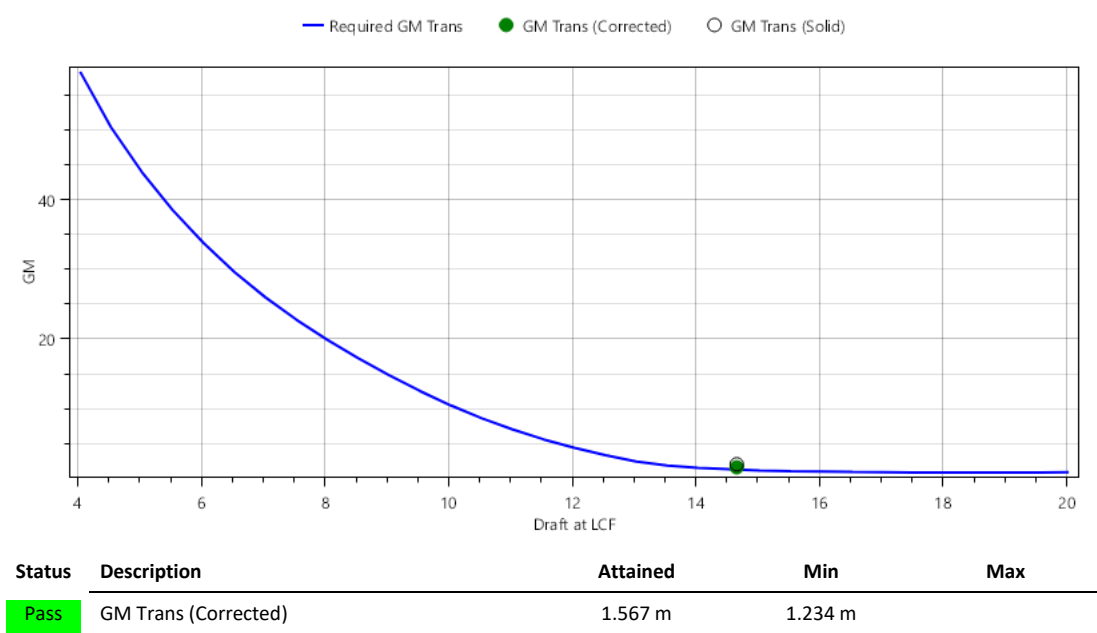


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2763957109		
	Steady Wind Heeling Lever LW1	0.276 m		
	80% Deck Edge Immersion Angle	15.92 deg		
Pass	Heeling Angle at LW1	8.92 deg		15.92 deg
	Gusty Wind Heeling Lever LW2	0.415 m		
	Heeling Angle at LW2	12.30 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	19.02 deg		
	Angle Windward	-10.10 deg		
	Second Intersect	43.76 deg		
	Limiting Angle	43.76 deg		
	Capsizing Area A	-0.15 m-rad		
	Righting Area B	0.29 m-rad		
Pass	Area Ratio B/A	2.0253476343	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	71,247	184.232F	22.571	0.000	0
	SEAWATER BALLAST	14,351	289.228F	2.128	0.180P	93,920
	DIESEL OIL	3,014	243.325F	13.196	0.000	789
	LUBE OIL	578	58.676F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	MISC TANKS	358	43.587F	2.886	2.292P	1,383
	LH2	3,034	229.944F	15.868	0.000P	1,277
	Containers In Hold	74,880	189.018F	19.704	0.000	0
	Containers On Deck	90,722	179.801F	48.117	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		259,206	190.358F	29.338	0.006P	97,549

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	71,247	184.232F	22.571	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT P	2,173	5.00	109	1.0250	111	1,281
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
4DBWBT P	2,406	56.76	1,366	1.0250	1,400	46,320
4DBWBT S	2,406	56.76	1,366	1.0250	1,400	46,320

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
MGO PILOT OIL TK S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT OIL TK P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT

SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,131
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

LH2

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
LH2 2 AFT S	6,373	85.00	5,417	0.0710	385	159
LH2 2 AFT C	6,373	85.00	5,417	0.0710	385	159
LH2 2 AFT P	6,373	85.00	5,417	0.0710	385	159
LH2 1FWD S	10,383	85.00	8,826	0.0710	627	267
LH2 1FWD C	10,383	85.00	8,826	0.0710	627	267
LH2 1FWD P	10,383	85.00	8,826	0.0710	627	267

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F

Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	4,716	171.650F	0.000	18.250	0	0	262	0	262	165.350F	177.950F
Bay 46	4,716	186.100F	0.000	18.250	0	0	262	0	262	179.800F	192.400F
Bay 42	1,260	200.550F	0.000	18.618	0	0	70	0	70	194.250F	206.850F
Bay 38	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 34	1,260	215.000F	0.000	18.618	0	0	48	0	48	208.700F	221.300F
Bay 30	864	229.450F	0.000	18.115	0	0	70	0	70	223.150F	235.750F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 22	1,260	243.900F	0.000	18.618	0	0	70	0	70	237.600F	250.200F
Bay 18	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 14	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 10	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 6	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 2	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

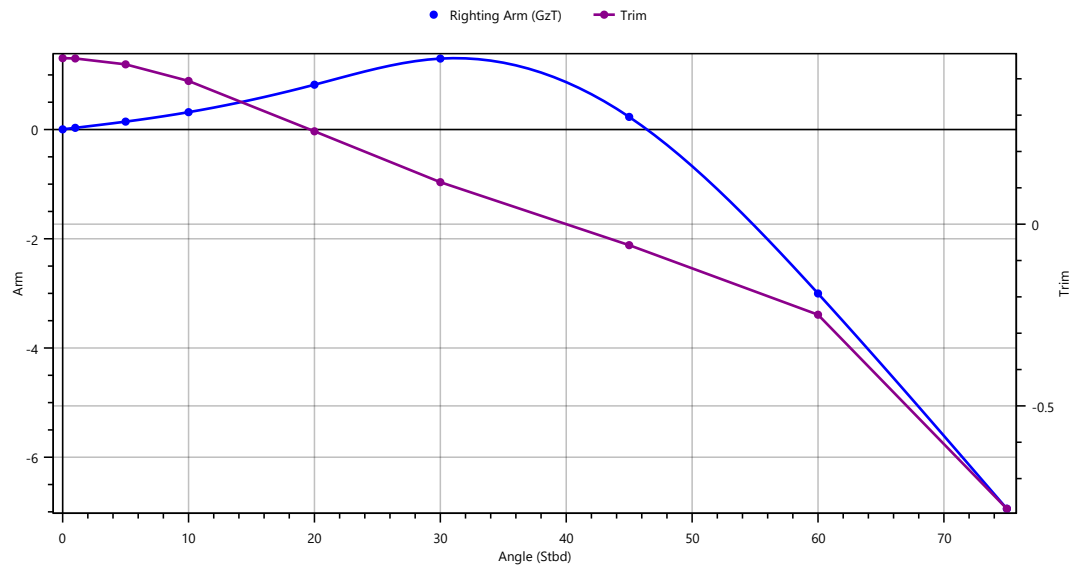
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 26	3,814	272.800F	0.000	48.148	0	0	286	0	286	266.500F	279.100F
Stack 22	3,814	287.250F	0.000	48.148	0	0	286	0	286	280.950F	293.550F
Stack 18	3,814	301.700F	0.000	48.148	0	0	262	0	262	295.400F	308.000F
Stack 14	3,814	316.150F	0.000	48.148	0	0	262	0	262	309.850F	322.450F
Stack 6	3,814	345.050F	0.000	48.148	0	0	238	0	238	338.750F	351.350F
Stack 2	3,130	359.500F	0.000	46.832	0	0	196	0	196	353.200F	365.800F

Stack 30	3,814	243.900F	0.000	48.148	0	0	310	0	310	237.600F	250.200F
Stack 34	3,684	229.450F	0.000	48.505	0	0	302	0	302	223.150F	235.750F
Stack 78	3,814	70.500F	0.000	48.148	0	0	310	0	310	64.200F	76.800F
Stack 42	3,814	200.550F	0.000	48.148	0	0	310	0	310	194.250F	206.850F
Stack 94	3,814	1.450F	0.000	48.148	0	0	310	0	310	4.646A	7.546F
Stack 90	3,814	15.900F	0.000	48.148	0	0	310	0	310	9.600F	22.200F
Stack 38	3,814	215.000F	0.000	48.148	0	0	310	0	310	208.700F	221.300F
Stack 86	3,814	30.350F	0.000	48.148	0	0	310	0	310	24.050F	36.650F
Stack 74	3,814	84.950F	0.000	48.148	0	0	310	0	310	78.650F	91.250F
Stack 70	3,814	99.400F	0.000	48.148	0	0	310	0	310	93.100F	105.700F
Stack 66	3,814	113.850F	0.000	48.148	0	0	310	0	310	107.550F	120.150F
Stack 62	3,814	128.300F	0.000	48.148	0	0	310	0	310	122.000F	134.600F
Stack 58	3,814	142.750F	0.000	48.148	0	0	310	0	310	136.450F	149.050F
Stack 54	3,814	157.200F	0.000	48.148	0	0	310	0	310	150.900F	163.500F
Stack 50	3,814	171.650F	0.000	48.148	0	0	310	0	310	165.350F	177.950F
Stack 46	3,814	186.100F	0.000	48.148	0	0	310	0	310	179.800F	192.400F
Stack 82	3,814	44.800F	0.000	48.148	0	0	310	0	310	38.500F	51.100F
Stack 10	3,814	330.600F	0.000	48.148	0	0	238	0	238	324.300F	336.900F

CONSTANT

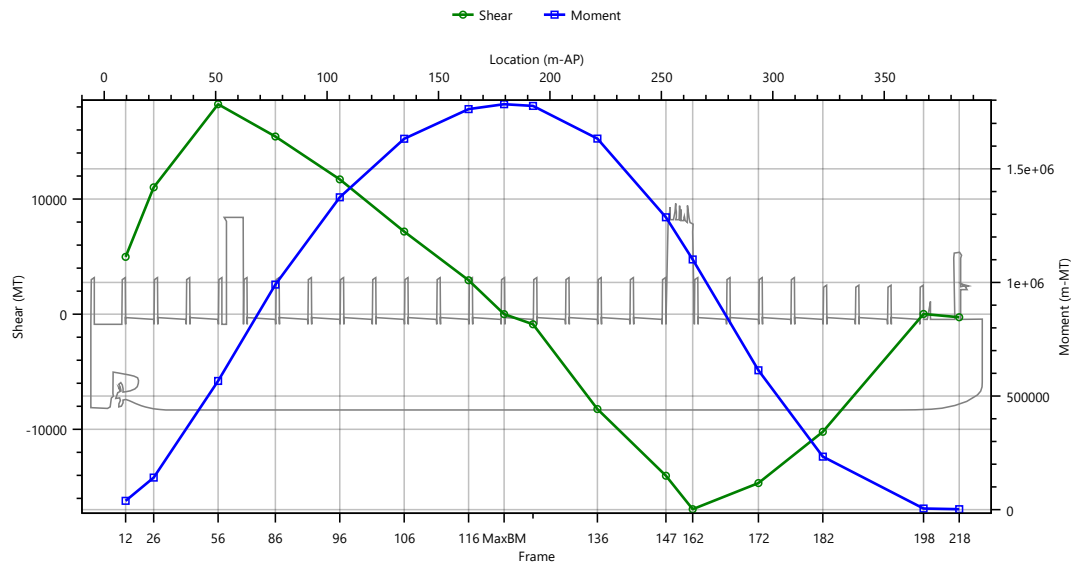
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.46	0.004	0.000	0.00	0.46A	16.068	12.927	5
0.00	1.00	0.46	0.031	0.001	1.00S	0.46A	16.064	12.928	2
0.00	5.00	0.44	0.145	-0.001	5.00S	0.44A	15.981	12.957	3
0.00	10.00	0.39	0.318	-0.002	10.00S	0.39A	15.743	13.033	3
0.00	20.00	0.26	0.821	-0.005	20.00S	0.26A	14.921	13.164	3
0.00	30.00	0.12	1.299	0.002	30.00S	0.12A	13.610	12.816	3
0.00	45.00	-0.06	0.231	-0.001	45.00S	0.06F	10.022	10.419	5
0.00	60.00	-0.25	-3.002	0.001	60.00S	0.25F	4.058	5.771	8
0.00	75.00	-0.78	-6.943	0.000	75.00S	0.78F	-12.189	-6.805	9

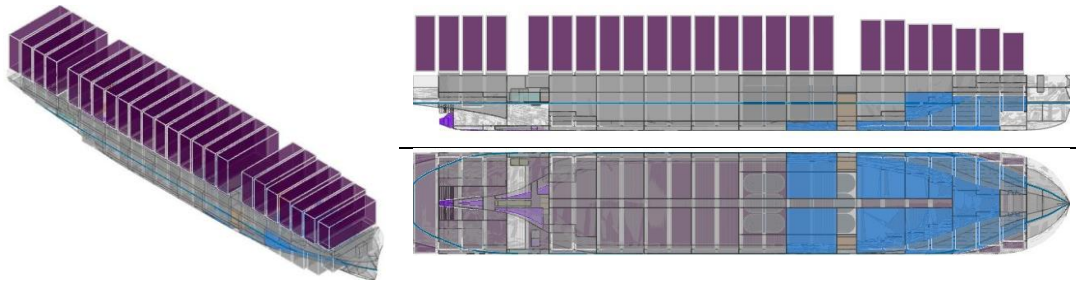
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	666	5,643	4,977	5,285S	44,119S	38,834H
22.200F	2,188	13,205	11,017	21,553S	162,666S	141,113H
51.100F	12,205	30,441	18,237	206,651S	773,095S	566,445H
76.800F	29,112	44,542	15,430	723,202S	1,713,748S	990,546H
105.700F	54,193	65,901	11,708	1,917,443S	3,292,217S	1,374,774H
134.600F	80,845	88,021	7,176	3,868,918S	5,501,276S	1,632,358H
163.500F	107,221	110,169	2,947	6,587,436S	8,350,277S	1,762,841H
179.434F	121,590	121,595	5	8,410,543S	10,194,973S	1,784,429H
192.400F	133,191	132,314	-877	10,062,383S	11,839,315S	1,776,932H
221.300F	158,751	150,510	-8,241	14,281,941S	15,914,958S	1,633,017H
252.050F	185,461	171,427	-14,033	19,575,670S	20,862,442S	1,286,771H
264.050F	195,696	178,758	-16,938	21,862,745S	22,963,892S	1,101,146H
293.550F	219,982	205,313	-14,670	27,998,119S	28,611,430S	613,310H
322.450F	240,402	230,186	-10,216	34,664,442S	34,897,747S	233,305H
367.650F	256,863	256,882	19	45,975,155S	45,980,074S	4,919H
383.650F	258,883	258,615	-268	50,103,578S	50,105,552S	1,974H

LH₂ 14 MT TEU HOMO 14400 TEU

Trim and Stability Summary



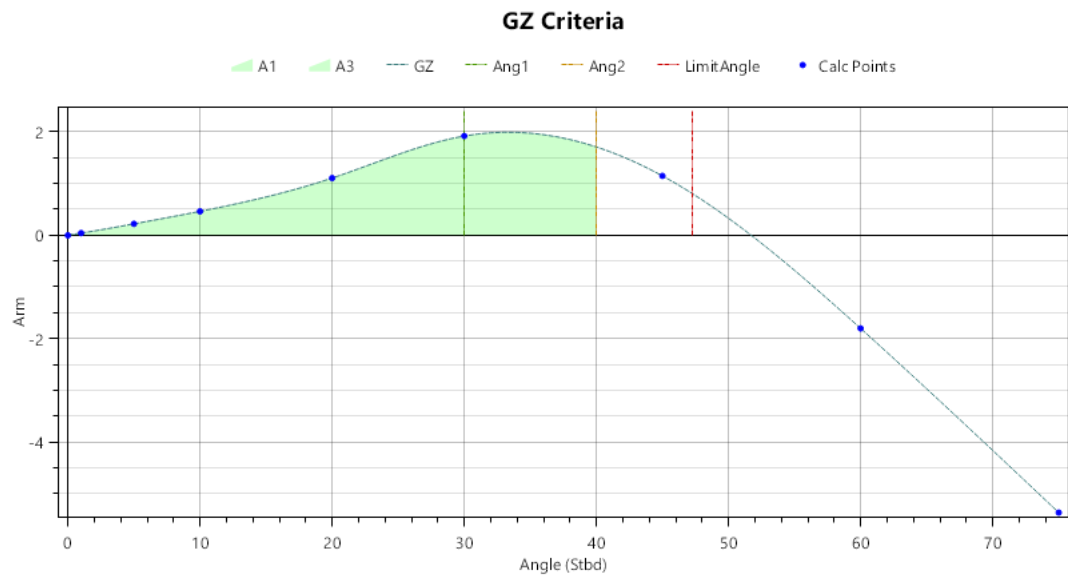
Loading					
Intact Displacement	297,004	MT	Sea Density	1.0250	MT/m ³
Deadweight	225,757	MT			
Available Deadweight	3,563	MT			
Stability			Trim		
KM0 Trans	29.908	m	Draft at LCF	16.377	m
VCG Upright	27.272	m-BL	LCF	182.210F	m-AP
GM0 Solid Trans	2.637	m	LCB	195.167F	m-AP
GM0 Trans	2.508	m	LCG	195.176F	m-AP
GMt Required	0.920	m	TPM	221.16	MT/cm
GMt Margin	1.588	m	MTM	5,900	m-MT/cm
GM at Equilibrium	2.170	m	Trim at Perps	0A	m
			Heel0	0.00	deg
			Propeller Immersion	153.60	%
Drafts - Perps			Drafts - Marks		
AP	16.410	m	Fwd	16.341	m
MS	16.375	m	Mid	16.375	m
FP	16.339	m	Aft	16.407	m
Strength					
Shear Min	-22,585	MT			
Shear Max	23,742	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	2,456,812H	m-MT			
Moment Max Sag	3,566S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	337.896	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
38 Tanks from Geometry
0 Tanks from Tables
71 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

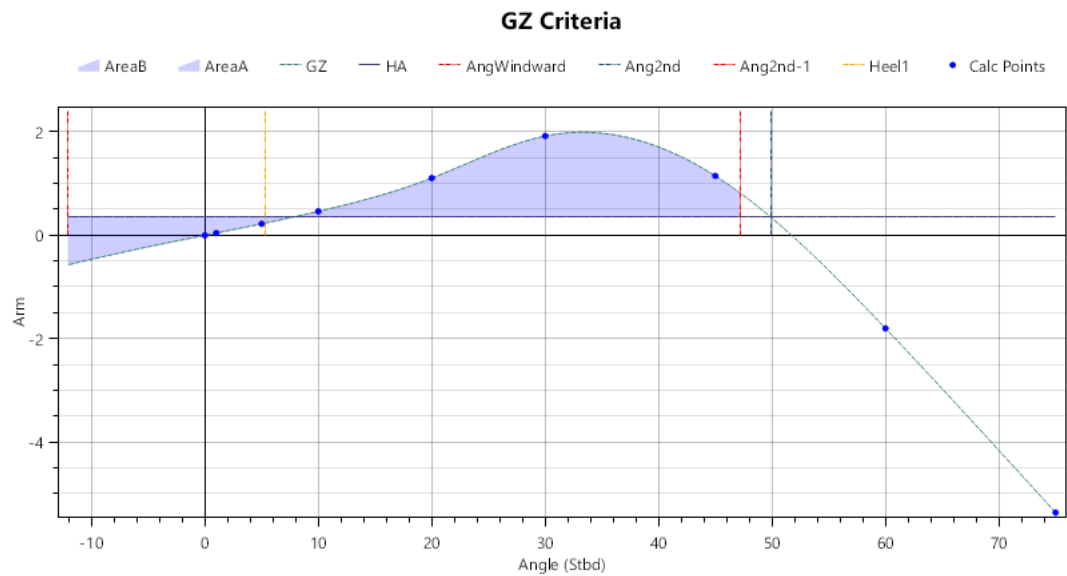
Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	225,757 MT		229,320 MT
Pass	Propeller Immersion	153.60 %	100.00 %	
Pass	Visibility	337.896 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	2.508 m	0.920 m	

2008 IS Code 2.2 General Criteria



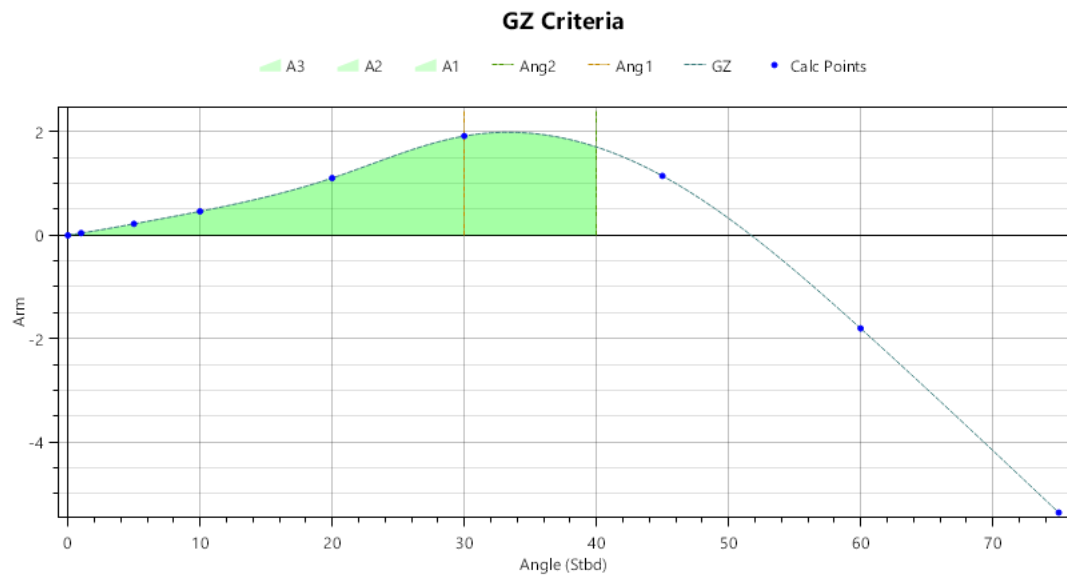
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.44 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.77 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.33 m-rad	0.03 m-rad	
	Angle to Downflooding	47.24 deg		
Pass	Angle at Maximum GZ	33.31 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.989 m	0.200 m	
Pass	Initial Metacentric Height	2.508 m	0.150 m	
	Range of Positive GZ	47.24 deg		

2008 IS Code 2.3 Weather Criteria



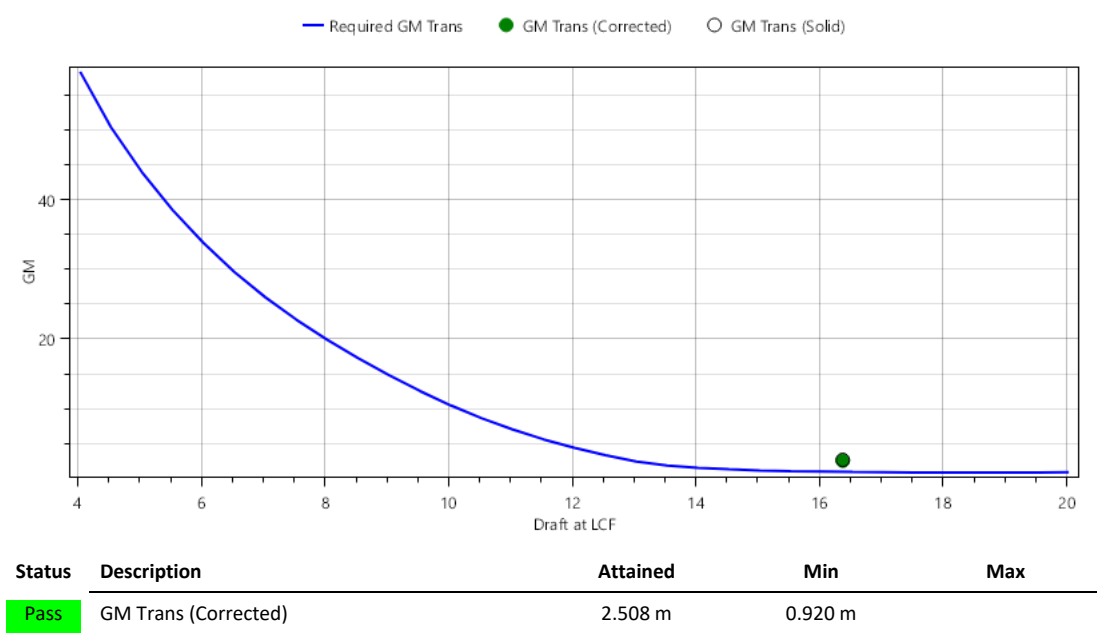
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2301131946		
	Steady Wind Heeling Lever LW1	0.230 m		
	80% Deck Edge Immersion Angle	15.23 deg		
Pass	Heeling Angle at LW1	5.29 deg		15.23 deg
	Gusty Wind Heeling Lever LW2	0.345 m		
	Heeling Angle at LW2	7.72 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.37 deg		
	Angle Windward	-12.08 deg		
	Second Intersect	49.90 deg		
	Limiting Angle	47.24 deg		
	Capsizing Area A	-0.16 m-rad		
	Righting Area B	0.68 m-rad		
Pass	Area Ratio B/A	4.3411094366	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0403257664		
Pass	Area to 30.00	0.44 m-rad	0.22 m-rad	
Pass	Area to 40.00	0.77 m-rad	0.40 m-rad	
Pass	Area 30.00 to 40.00	0.33 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	33.31 deg	30.00 deg	
Pass	Maximum GZ	1.989 m	1.042 m	
Pass	Maximum GZ Above 30 Deg	1.989 m	0.818 m	
	Initial Metacentric Height	2.508 m		
	Range of Positive GZ	51.70 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	71,247	184.232F	22.571	0.000	0
	SEAWATER BALLAST	29,256	303.472F	7.231	0.001P	14,046
	DIESEL OIL	3,014	243.330F	13.196	0.000	789
	LUBE OIL	578	58.712F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	MISC TANKS	358	43.804F	2.885	2.320P	1,340
	LH2	3,034	229.974F	15.868	0.000P	1,278
	Containers In Hold	77,560	184.910F	15.768	0.000	0
	Containers On Deck	110,936	180.487F	44.458	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		297,004	195.176F	27.272	0.004S	17,631

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	71,247	184.232F	22.571	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	100.00	2,173	1.0250	2,227	0
2WWBT P	2,173	100.00	2,173	1.0250	2,227	0
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1 WWBT S	4,837	85.00	4,111	1.0250	4,214	7,023
1 WWBT P	4,837	85.00	4,111	1.0250	4,214	7,023
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
MGO PILOT OIL TK S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT OIL TK P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	29
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,092
WASTE OIL TANK	138	10.00	14	1.0000	14	103
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

LH2

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
LH2 2 AFT S	6,373	85.00	5,417	0.0710	385	159
LH2 2 AFT P	6,373	85.00	5,417	0.0710	385	159
LH2 1FWD S	10,383	85.00	8,826	0.0710	627	267
LH2 1FWD C	10,383	85.00	8,826	0.0710	627	267
LH2 1FWD P	10,383	85.00	8,826	0.0710	627	267
LH2 2 AFT C	6,373	85.00	5,417	0.0710	385	159

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 82	3,192	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 90	3,360	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	3,808	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 78	1,848	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F

Bay 38	1,176	215.000F	0.000	12.603	0	0	48	0	48	208.700F	221.300F
Bay 70	4,312	99.400F	0.000	12.691	0	0	256	0	256	93.100F	105.700F
Bay 66	4,312	113.850F	0.000	11.901	0	0	262	0	262	107.550F	120.150F
Bay 62	4,312	128.300F	0.000	11.901	0	0	262	0	262	122.000F	134.600F
Bay 58	4,312	142.750F	0.000	11.901	0	0	262	0	262	136.450F	149.050F
Bay 54	4,312	157.200F	0.000	11.901	0	0	262	0	262	150.900F	163.500F
Bay 50	4,312	171.650F	0.000	11.901	0	0	262	0	262	165.350F	177.950F
Bay 46	4,312	186.100F	0.000	11.901	0	0	262	0	262	179.800F	192.400F
Bay 42	1,176	200.550F	0.000	12.603	0	0	70	0	70	194.250F	206.850F
Bay 74	4,312	84.950F	0.000	14.796	0	0	236	0	236	78.650F	91.250F
Bay 34	784	229.450F	0.000	11.638	0	0	70	0	70	223.150F	235.750F
Bay 30	1,176	243.900F	0.000	12.603	0	0	70	0	70	237.600F	250.200F
Bay 22	4,312	287.250F	0.000	13.217	0	0	250	0	250	280.950F	293.550F
Bay 26	4,312	272.800F	0.000	12.428	0	0	258	0	258	266.500F	279.100F
Bay 18	4,312	301.700F	0.000	13.744	0	0	246	0	246	295.400F	308.000F
Bay 14	4,200	316.150F	0.000	15.596	0	0	224	0	224	309.850F	322.450F
Bay 10	3,864	330.600F	0.000	18.040	0	0	190	0	190	324.300F	336.900F
Bay 6	3,136	345.050F	0.000	20.047	0	0	144	0	144	338.750F	351.350F
Bay 2	2,408	359.500F	0.000	24.508	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 26	4,648	272.800F	0.000	44.445	0	0	286	0	286	266.500F	279.100F
Stack 22	4,648	287.250F	0.000	44.445	0	0	286	0	286	280.950F	293.550F
Stack 18	4,648	301.700F	0.000	44.445	0	0	262	0	262	295.400F	308.000F
Stack 14	4,648	316.150F	0.000	44.445	0	0	262	0	262	309.850F	322.450F

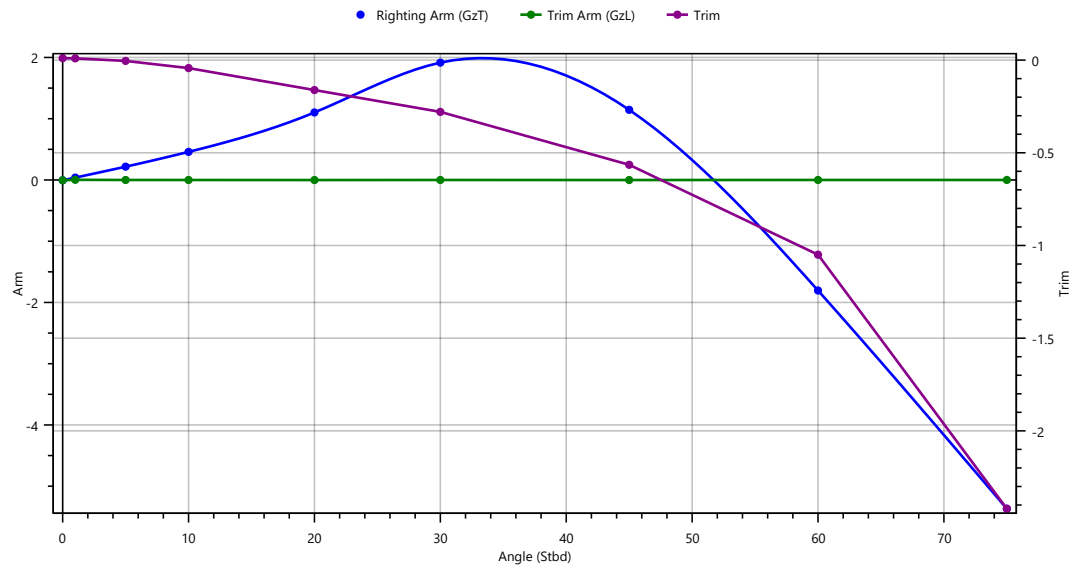
Stack 10	4,648	330.600F	0.000	44.445	0	0	238	0	238	324.300F	336.900F
Stack 2	4,256	359.500F	0.000	44.436	0	0	196	0	196	353.200F	365.800F
Stack 30	4,648	243.900F	0.000	44.445	0	0	310	0	310	237.600F	250.200F
Stack 34	4,424	229.450F	0.000	44.768	0	0	302	0	302	223.150F	235.750F
Stack 74	4,648	84.950F	0.000	44.445	0	0	310	0	310	78.650F	91.250F
Stack 42	4,648	200.550F	0.000	44.445	0	0	310	0	310	194.250F	206.850F
Stack 94	4,648	1.450F	0.000	44.445	0	0	310	0	310	4.646A	7.546F
Stack 90	4,648	15.900F	0.000	44.445	0	0	310	0	310	9.600F	22.200F
Stack 38	4,648	215.000F	0.000	44.445	0	0	310	0	310	208.700F	221.300F
Stack 86	4,648	30.350F	0.000	44.445	0	0	310	0	310	24.050F	36.650F
Stack 78	4,648	70.500F	0.000	44.445	0	0	310	0	310	64.200F	76.800F
Stack 70	4,648	99.400F	0.000	44.445	0	0	310	0	310	93.100F	105.700F
Stack 66	4,648	113.850F	0.000	44.445	0	0	310	0	310	107.550F	120.150F
Stack 62	4,648	128.300F	0.000	44.445	0	0	310	0	310	122.000F	134.600F
Stack 58	4,648	142.750F	0.000	44.445	0	0	310	0	310	136.450F	149.050F
Stack 54	4,648	157.200F	0.000	44.445	0	0	310	0	310	150.900F	163.500F
Stack 50	4,648	171.650F	0.000	44.445	0	0	310	0	310	165.350F	177.950F
Stack 46	4,648	186.100F	0.000	44.445	0	0	310	0	310	179.800F	192.400F
Stack 82	4,648	44.800F	0.000	44.445	0	0	310	0	310	38.500F	51.100F
Stack 6	4,648	345.050F	0.000	44.445	0	0	238	0	238	338.750F	351.350F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000

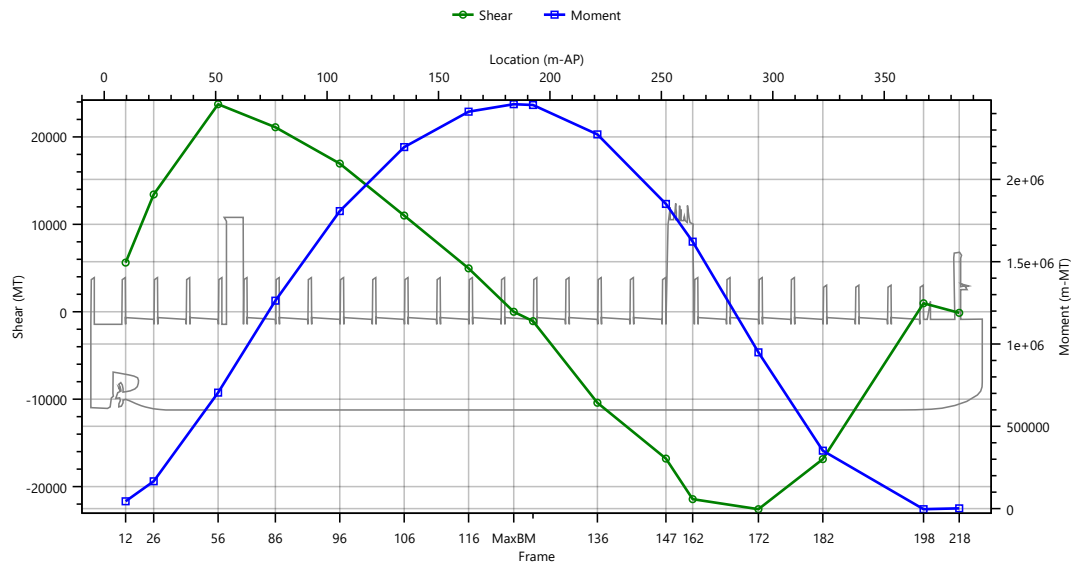
Provisions	7	258.450F	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.01	-0.005	-0.006	0.00	0.01A	16.375	16.304	3
0.00	1.00	0.01	0.038	0.002	1.00S	0.01A	16.370	16.307	2
0.00	5.00	0.00	0.217	0.000	5.00S	0.00F	16.298	16.329	3
0.00	10.00	-0.04	0.459	0.000	10.00S	0.04F	16.088	16.384	3
0.00	20.00	-0.16	1.102	-0.002	20.00S	0.16F	15.364	16.475	3
0.00	30.00	-0.28	1.916	0.000	30.00S	0.28F	14.258	16.178	3
0.00	45.00	-0.56	1.145	-0.001	45.00S	0.56F	11.264	15.148	5
0.00	60.00	-1.05	-1.805	0.000	60.00S	1.05F	6.274	13.493	9
0.00	75.00	-2.42	-5.368	0.000	75.01S	2.42F	-7.142	9.510	17

Strength Summary

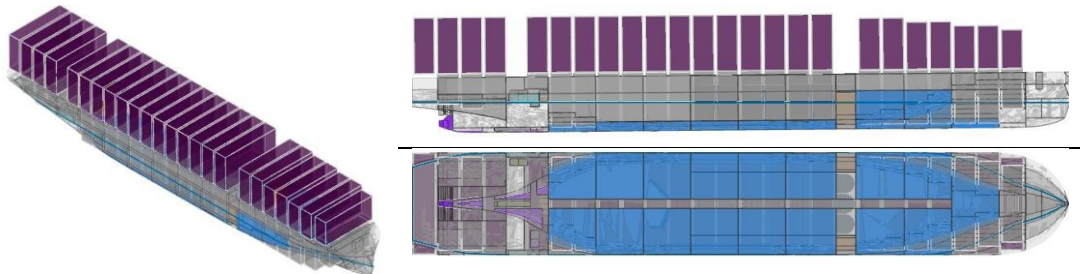


Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	855	6,477	5,623	6,495S	50,916S	44,421H
22.200F	2,657	16,072	13,416	26,786S	192,785S	165,999H
51.100F	13,732	37,474	23,742	239,468S	944,044S	704,576H
76.800F	31,965	53,072	21,107	811,611S	2,074,852S	1,263,240H
105.700F	58,918	75,867	16,949	2,114,388S	3,921,861S	1,807,473H
134.600F	87,842	98,847	11,005	4,234,271S	6,430,569S	2,196,298H
163.500F	116,890	121,855	4,964	7,192,645S	9,604,073S	2,411,428H
183.761F	137,253	137,251	-2	9,767,301S	12,224,113S	2,456,812H
192.400F	145,933	144,860	-1,073	10,990,472S	13,442,468S	2,451,996H
221.300F	174,967	164,556	-10,411	15,627,509S	17,900,960S	2,273,451H
252.050F	205,812	189,014	-16,798	21,482,305S	23,333,256S	1,850,951H
264.050F	217,785	196,347	-21,438	24,023,955S	25,645,745S	1,621,790H
293.550F	246,635	224,050	-22,585	30,877,241S	31,826,645S	949,404H
322.450F	271,843	254,986	-16,857	38,382,865S	38,734,787S	351,922H
367.650F	293,707	294,680	973	51,253,938S	51,250,372S	3,566S
383.650F	296,538	296,414	-125	55,979,107S	55,980,627S	1,520H

Compressed Hydrogen Condition Printouts

Comp H₂ 9 MT Hold 7.48 MT Deck Max Scantling Departure

Trim and Stability Summary



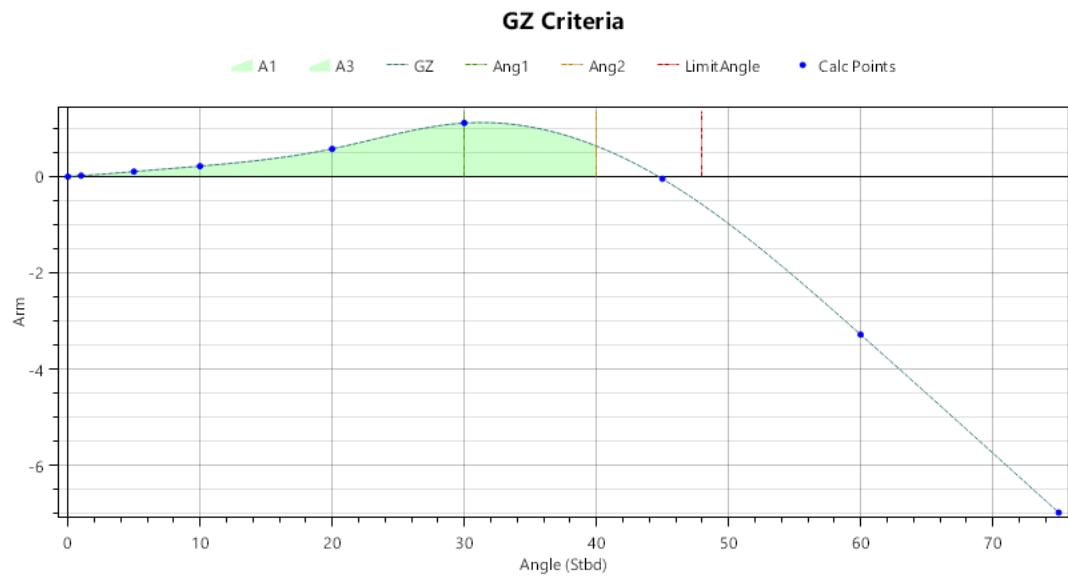
Loading					
Intact Displacement	303,858	MT	Sea Density	1.0250	MT/m ³
Deadweight	227,205	MT			
Available Deadweight	100	MT			
Stability			Trim		
KM0 Trans	30.178	m	Draft at LCF	16.701	m
VCG Upright	28.859	m-BL	LCF	178.320F	m-AP
GM0 Solid Trans	1.320	m	LCB	187.696F	m-AP
GM0 Trans	1.198	m	LCG	187.874F	m-AP
GMt Required	0.891	m	TPM	223.65	MT/cm
GMt Margin	0.307	m	MTM	6,067	m-MT/cm
GM at Equilibrium	0.865	m	Trim at Perps	4A	m
			Heel0	0.00	deg
			Propeller Immersion	171.32	%
Drafts - Perps			Drafts - Marks		
AP	18.323	m	Fwd	14.832	m
MS	16.531	m	Mid	16.556	m
FP	14.738	m	Aft	18.154	m
Strength					
Shear Min	-14,433	MT			
Shear Max	14,840	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,310,202H	m-MT			
Moment Max Sag	--	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	380.485	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
 Hull from Geometry
 GMt from GZ Curve Slope
 FSt Adjustment = SolidGMt-GMt
 51 Tanks from Geometry
 0 Tanks from Tables
 63 Empty Tanks
 GZ Curve from Geometry
 Downflood Angles from 3D Data

Alarm Summary

Status	Description	Attained	Min	Max
Pass	Calculation Status Calculations completed	Survived		
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	227,205 MT		227,305 MT
Pass	Propeller Immersion	171.32 %	100.00 %	
Pass	Visibility	380.485 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.198 m	0.891 m	

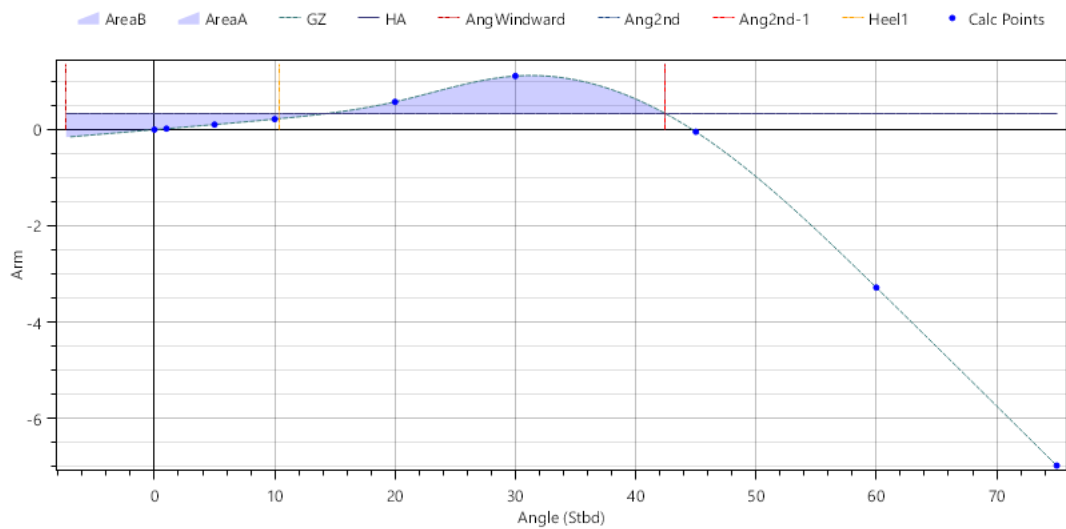
2008 IS Code 2.2 General Criteria



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.23 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.40 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.17 m-rad	0.03 m-rad	
	Angle to Downflooding	47.94 deg		
Pass	Angle at Maximum GZ	31.28 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.120 m	0.200 m	
Pass	Initial Metacentric Height	1.198 m	0.150 m	
	Range of Positive GZ	44.69 deg		

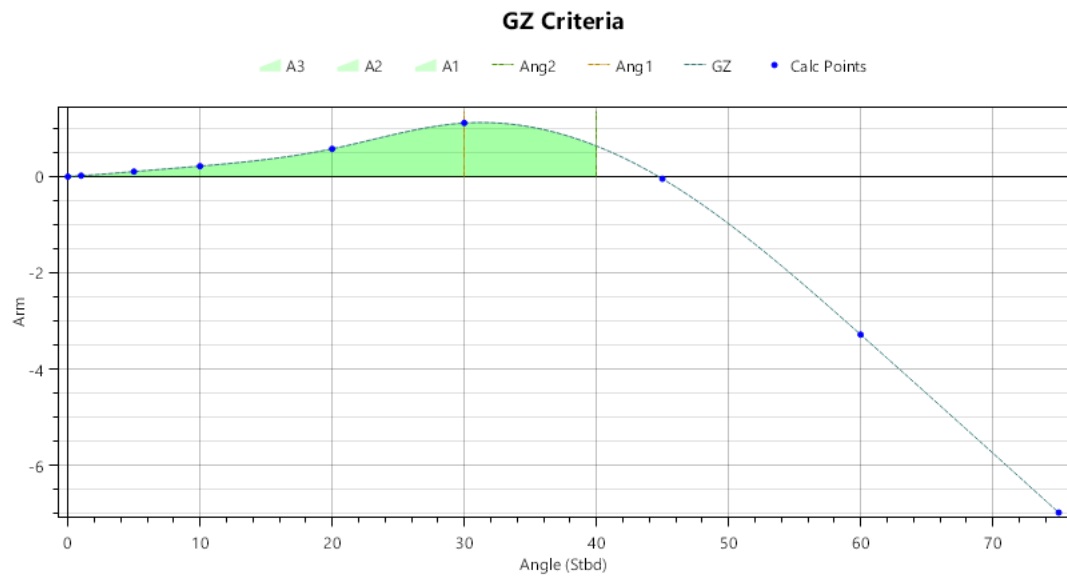
2008 IS Code 2.3 Weather Criteria

GZ Criteria



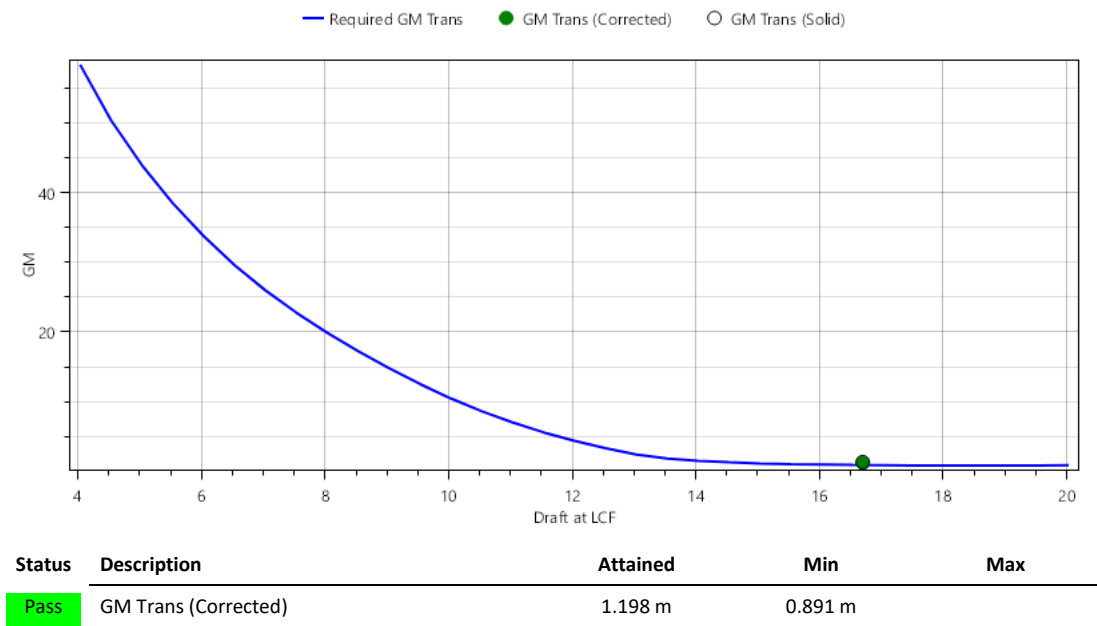
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2226752475		
	Steady Wind Heeling Lever LW1	0.223 m		
	80% Deck Edge Immersion Angle	11.86 deg		
Pass	Heeling Angle at LW1	10.38 deg		11.86 deg
	Gusty Wind Heeling Lever LW2	0.334 m		
	Heeling Angle at LW2	14.46 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.74 deg		
	Angle Windward	-7.36 deg		
	Second Intersect	42.44 deg		
	Limiting Angle	42.44 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.22 m-rad		
Pass	Area Ratio B/A	2.2554354545	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0399324276		
Pass	Area to 30.00	0.23 m-rad	0.23 m-rad	
Pass	Area to 40.00	0.40 m-rad	0.40 m-rad	
Pass	Area 30.00 to 40.00	0.17 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	31.28 deg	30.00 deg	
Pass	Maximum GZ	1.120 m	1.052 m	
Pass	Maximum GZ Above 30 Deg	1.120 m	0.826 m	
	Initial Metacentric Height	1.198 m		
	Range of Positive GZ	44.69 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	76,653	185.679F	22.241	0.000	0
	SEAWATER BALLAST	46,631	221.891F	3.860	0.000P	11,410
	DIESEL OIL	3,014	243.324F	13.196	0.000	789
	LUBE OIL	578	58.670F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	MISC TANKS	358	43.555F	2.886	2.288P	1,389
	H2	2,459	215.872F	15.870	0.000P	1,030
	Containers In Hold	67,968	190.049F	19.852	0.000	0
	Containers On Deck	105,176	172.639F	51.520	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		303,858	187.874F	28.859	0.004S	14,796

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	76,653	185.679F	22.241	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
9DBWBT S	2,199	85.00	1,869	1.0250	1,916	5,705
9DBWBT P	2,199	85.00	1,869	1.0250	1,916	5,705
8DBWBT S	2,216	100.00	2,216	1.0250	2,271	0
8DBWBT P	2,216	100.00	2,216	1.0250	2,271	0
7DBWBT S	2,277	100.00	2,277	1.0250	2,334	0
7DBWBT P	2,277	100.00	2,277	1.0250	2,334	0
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
3WWBT S	1,668	100.00	1,668	1.0250	1,710	0
3WWBT P	1,668	100.00	1,668	1.0250	1,710	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	100.00	2,173	1.0250	2,227	0
2WWBT P	2,173	100.00	2,173	1.0250	2,227	0
2DBWBT S	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0

DIESEL OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
MGO PILOT OIL TK S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT OIL TK P	1,645	98.00	1,612	0.8600	1,386	366

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,137
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

H2

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
H2 3 AFT C	6,373	85.00	5,417	0.0417	226	93
H2 3 AFT S	6,373	85.00	5,417	0.0417	226	93
H2 3 AFT P	6,373	85.00	5,417	0.0417	226	93
H2 2 AFT C	6,373	85.00	5,417	0.0417	226	93
H2 2 AFT P	6,373	85.00	5,417	0.0417	226	93
H2 1FWD S	10,383	85.00	8,826	0.0417	368	157
H2 1FWD C	10,383	85.00	8,826	0.0417	368	157
H2 1FWD P	10,383	85.00	8,826	0.0417	368	157
H2 2 AFT S	6,373	85.00	5,417	0.0417	226	93

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 50	1,260	171.650F	0.000	18.250	0	0	70	0	70	165.350F	177.950F
Bay 46	1,260	186.100F	0.000	18.250	0	0	70	0	70	179.800F	192.400F
Bay 42	1,260	200.550F	0.000	18.618	0	0	70	0	70	194.250F	206.850F
Bay 38	1,260	215.000F	0.000	18.618	0	0	48	0	48	208.700F	221.300F
Bay 34	864	229.450F	0.000	18.115	0	0	70	0	70	223.150F	235.750F
Bay 30	1,260	243.900F	0.000	18.618	0	0	70	0	70	237.600F	250.200F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

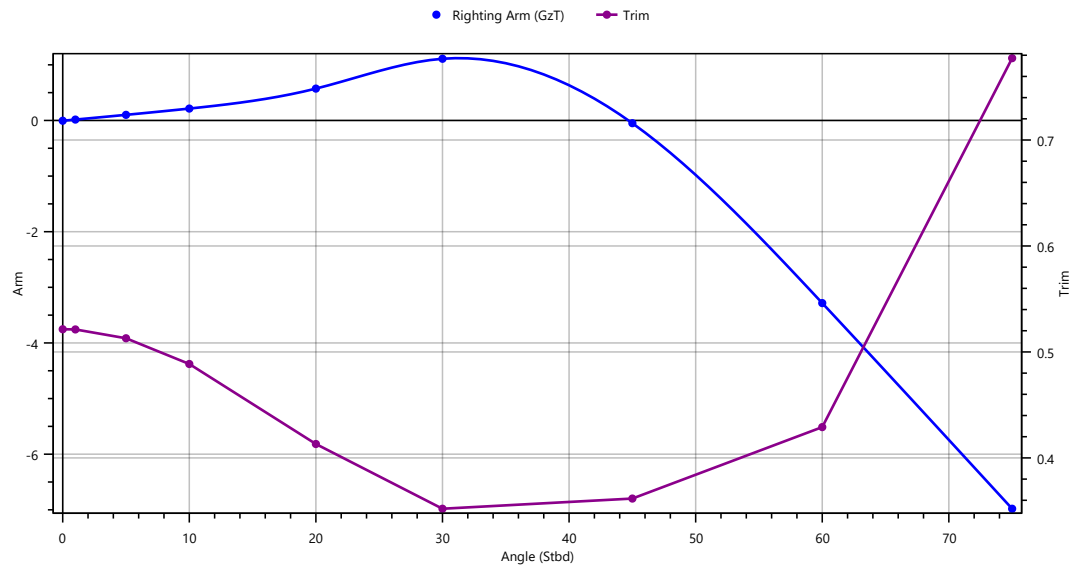
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 6	3,560	345.050F	0.000	48.326	0	0	238	0	238	338.750F	351.350F
Stack 2	2,932	359.500F	0.000	47.023	0	0	196	0	196	353.200F	365.800F
Stack 10	3,560	330.600F	0.000	48.326	0	0	238	0	238	324.300F	336.900F
Stack 14	3,920	316.150F	0.000	49.621	0	0	262	0	262	309.850F	322.450F
Stack 54	4,638	157.200F	0.000	52.210	0	0	310	0	310	150.900F	163.500F
Stack 22	4,279	287.250F	0.000	50.916	0	0	286	0	286	280.950F	293.550F
Stack 94	4,638	1.450F	0.000	52.210	0	0	310	0	310	4.646A	7.546F
Stack 90	4,638	15.900F	0.000	52.210	0	0	310	0	310	9.600F	22.200F
Stack 86	4,638	30.350F	0.000	52.210	0	0	310	0	310	24.050F	36.650F
Stack 82	4,638	44.800F	0.000	52.210	0	0	310	0	310	38.500F	51.100F
Stack 78	4,638	70.500F	0.000	52.210	0	0	310	0	310	64.200F	76.800F
Stack 18	3,920	301.700F	0.000	49.621	0	0	262	0	262	295.400F	308.000F
Stack 74	4,638	84.950F	0.000	52.210	0	0	310	0	310	78.650F	91.250F
Stack 66	4,638	113.850F	0.000	52.210	0	0	310	0	310	107.550F	120.150F
Stack 62	4,638	128.300F	0.000	52.210	0	0	310	0	310	122.000F	134.600F
Stack 58	4,638	142.750F	0.000	52.210	0	0	310	0	310	136.450F	149.050F
Stack 50	4,638	171.650F	0.000	52.210	0	0	310	0	310	165.350F	177.950F
Stack 46	4,638	186.100F	0.000	52.210	0	0	310	0	310	179.800F	192.400F
Stack 42	4,638	200.550F	0.000	52.210	0	0	310	0	310	194.250F	206.850F
Stack 38	4,638	215.000F	0.000	52.210	0	0	310	0	310	208.700F	221.300F
Stack 34	4,518	229.450F	0.000	52.585	0	0	302	0	302	223.150F	235.750F
Stack 30	4,638	243.900F	0.000	52.210	0	0	310	0	310	237.600F	250.200F
Stack 26	4,279	272.800F	0.000	50.916	0	0	286	0	286	266.500F	279.100F

Stack 4,638 99.400F 0.000 52.210 0 0 310 0 310 93.100F 105.700F
70

CONSTANT

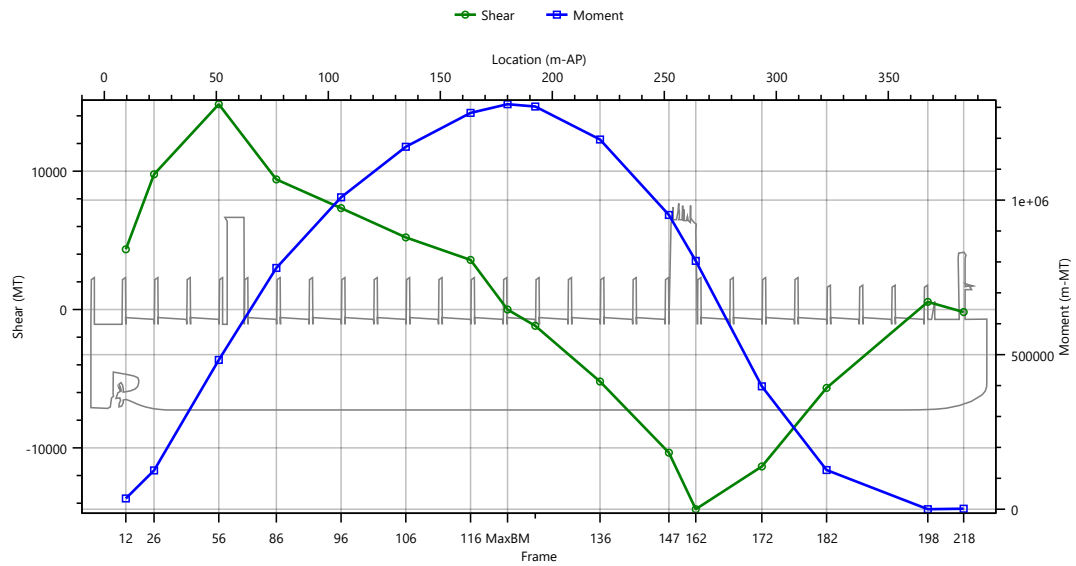
Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.52	-0.005	0.002	0.00	0.52A	18.288	14.703	6
0.00	1.00	0.52	0.016	0.000	1.00S	0.52A	18.287	14.702	2
0.00	5.00	0.51	0.101	-0.001	5.00S	0.51A	18.239	14.712	3
0.00	10.00	0.49	0.214	-0.002	10.00S	0.49A	18.093	14.733	3
0.00	20.00	0.41	0.573	-0.003	20.00S	0.41A	17.566	14.726	3
0.00	30.00	0.35	1.109	0.003	30.00S	0.35A	16.729	14.309	3
0.00	45.00	0.36	-0.049	-0.001	45.00S	0.36A	15.008	12.521	4
0.00	60.00	0.43	-3.284	0.004	60.00S	0.43A	12.344	9.393	6
0.00	75.00	0.78	-6.981	0.000	75.00S	0.78A	6.076	0.731	9

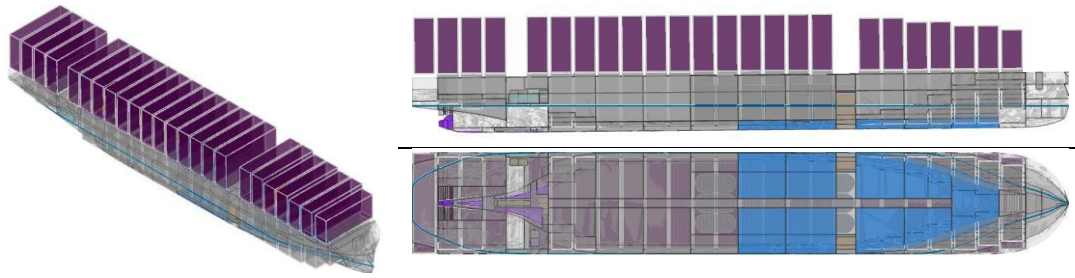
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	2,116	6,467	4,351	16,037S	50,835S	34,797H
22.200F	5,080	14,853	9,773	59,423S	184,955S	125,532H
51.100F	18,898	33,738	14,840	382,314S	865,304S	482,989H
76.800F	39,259	48,662	9,403	1,115,350S	1,895,866S	780,517H
105.700F	68,172	75,500	7,328	2,658,364S	3,667,376S	1,009,012H
134.600F	98,599	103,811	5,212	5,068,515S	6,241,019S	1,172,504H
163.500F	128,691	132,274	3,583	8,353,940S	9,636,048S	1,282,108H
180.015F	145,679	145,676	-3	10,619,787S	11,929,989S	1,310,202H
192.400F	158,319	157,139	-1,180	12,502,356S	13,805,048S	1,302,692H
221.300F	187,480	182,274	-5,205	17,500,275S	18,696,303S	1,196,028H
252.050F	217,957	207,609	-10,348	23,735,499S	24,687,457S	951,958H
264.050F	229,645	215,211	-14,433	26,421,253S	27,224,596S	803,344H
293.550F	257,460	246,116	-11,344	33,610,308S	34,007,898S	397,590H
322.450F	281,210	275,544	-5,666	41,408,610S	41,535,400S	126,789H
367.650F	300,984	301,534	551	54,651,067S	54,651,163S	97H
383.650F	303,452	303,267	-184	59,489,438S	59,491,081S	1,643H

Comp H₂ 9 MT Hold 6.1 MT Deck Max Design Departure

Trim and Stability Summary



Loading

Intact Displacement	259,560	MT	Sea Density	1.0250	MT/m ³
Deadweight	182,907	MT			
Available Deadweight	21	MT			

Stability

KM0 Trans	31.398	m	Draft at LCF	14.683	m
VCG Upright	29.428	m-BL	LCF	180.220F	m-AP
GM0 Solid Trans	1.970	m	LCB	189.405F	m-AP
GM0 Trans	1.853	m	LCG	189.596F	m-AP
GMt Required	1.227	m	TPM	217.17	MT/cm
GMt Margin	0.626	m	MTM	5,609	m-MT/cm
GM at Equilibrium	1.786	m	Trim at Perps	3A	m
			Heel0	0.00	deg
			Propeller Immersion	151.67	%

Drafts - Perps

AP	16.278	m
MS	14.534	m
FP	12.790	m

Drafts - Marks

Fwd	12.882	m
Mid	14.558	m
Aft	16.113	m

Bridge Visibility

Visibility Distance	397.541	m	Visibility Distance Required	500.000	m

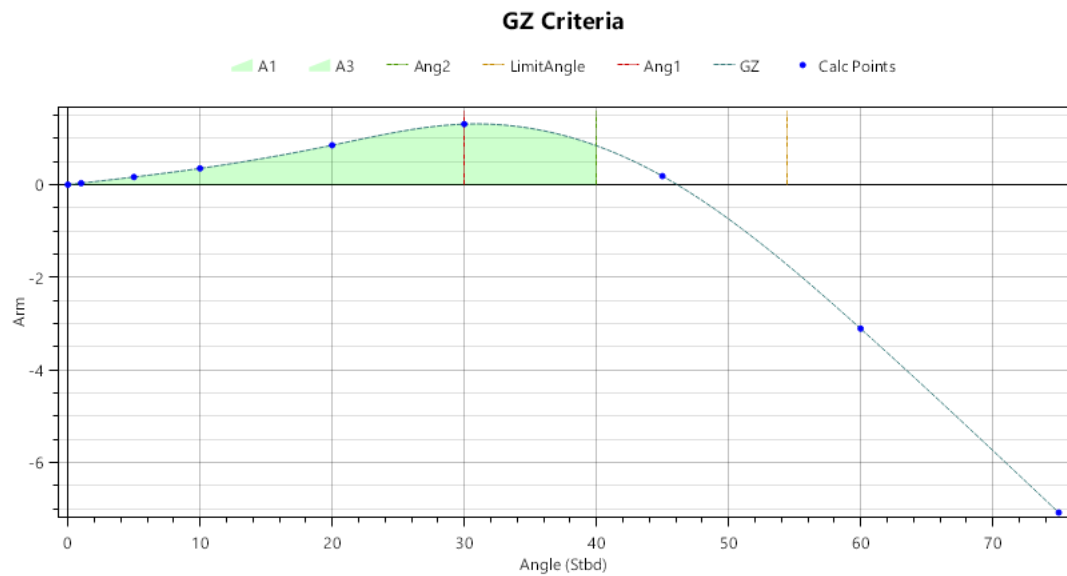
Calculation Notes

Drafts from Keel
 Hull from Geometry
 GMt from GZ Curve Slope
 FSt Adjustment = SolidGMt-GMt
 41 Tanks from Geometry
 0 Tanks from Tables
 73 Empty Tanks
 GZ Curve from Geometry
 Downflood Angles from 3D Data

Alarm Summary

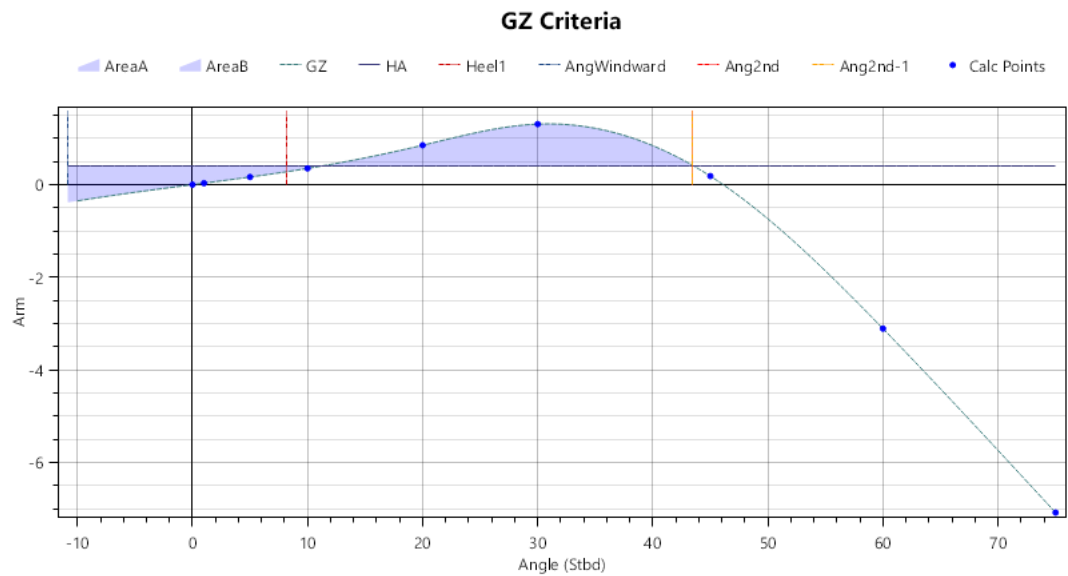
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	182,907 MT		227,199 MT
Pass	Propeller Immersion	151.67 %	100.00 %	
Pass	Visibility	397.541 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.853 m	1.227 m	
Pass	Design Deadweight	182,907 MT		182,928 MT

2008 IS Code 2.2 General Criteria



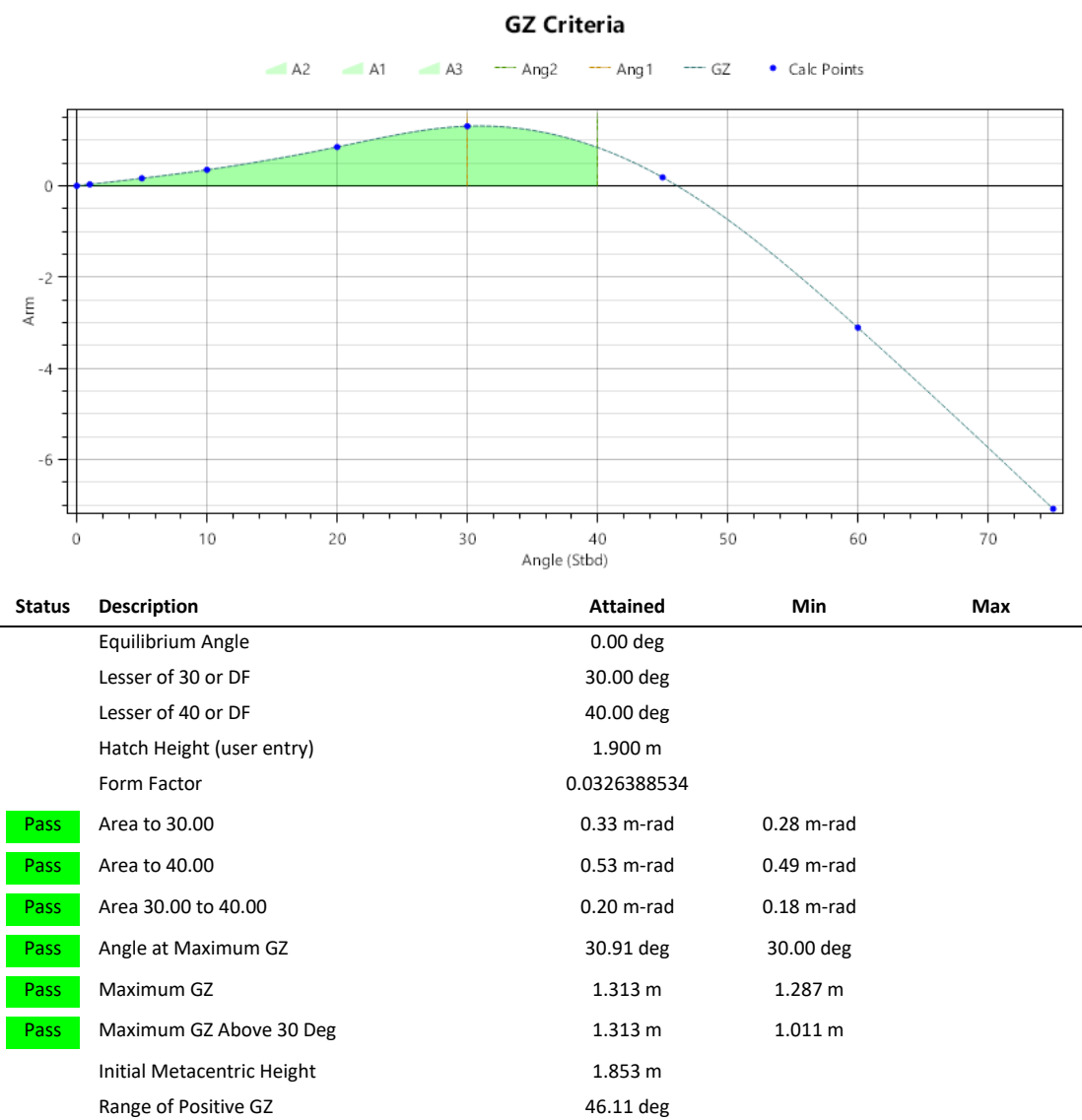
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.33 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.53 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.03 m-rad	
	Angle to Downflooding	54.39 deg		
Pass	Angle at Maximum GZ	30.91 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.313 m	0.200 m	
Pass	Initial Metacentric Height	1.853 m	0.150 m	
	Range of Positive GZ	46.11 deg		

2008 IS Code 2.3 Weather Criteria

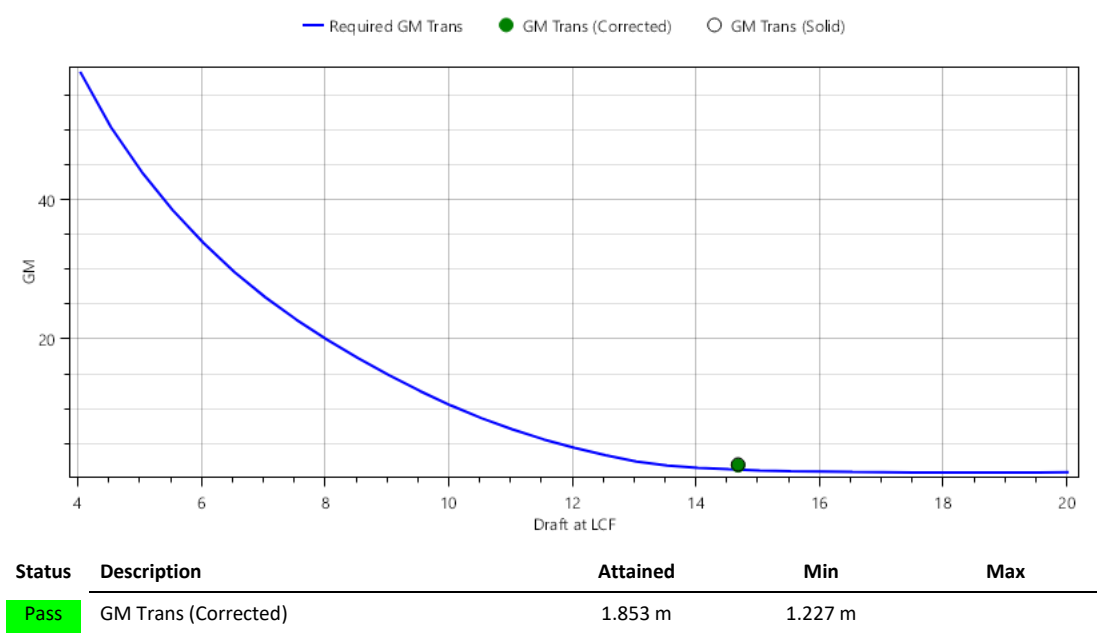


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2758970027		
	Steady Wind Heeling Lever LW1	0.276 m		
	80% Deck Edge Immersion Angle	15.59 deg		
Pass	Heeling Angle at LW1	8.12 deg		15.59 deg
	Gusty Wind Heeling Lever LW2	0.414 m		
	Heeling Angle at LW2	11.52 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	18.95 deg		
	Angle Windward	-10.83 deg		
	Second Intersect	43.48 deg		
	Limiting Angle	43.48 deg		
	Capsizing Area A	-0.16 m-rad		
	Righting Area B	0.30 m-rad		
Pass	Area Ratio B/A	1.9075278187	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	76,653	185.679F	22.241	0.000	0
	SEAWATER BALLAST	21,744	267.773F	2.275	0.063P	5,318
	DIESEL OIL	3,014	243.324F	13.196	0.000	789
	LUBE OIL	578	58.671F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	MISC TANKS	358	43.562F	2.886	2.289P	1,387
	H2	2,459	215.873F	15.870	0.000P	1,030
	Containers In Hold	67,968	190.049F	19.852	0.000	0
	Containers On Deck	85,765	172.641F	51.520	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		259,560	189.596F	29.428	0.001P	8,703

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	76,653	185.679F	22.241	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1 WWBT S	4,837	6.05	293	1.0250	300	2,519
1 WWBT P	4,837	8.07	390	1.0250	400	2,798
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
MGO PILOT OIL TK S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT OIL TK P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,135
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

H2

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
H2 3 AFT S	6,373	85.00	5,417	0.0417	226	93
H2 3 AFT C	6,373	85.00	5,417	0.0417	226	93
H2 3 AFT P	6,373	85.00	5,417	0.0417	226	93
H2 2 AFT C	6,373	85.00	5,417	0.0417	226	93
H2 2 AFT P	6,373	85.00	5,417	0.0417	226	93
H2 1FWD S	10,383	85.00	8,826	0.0417	368	157
H2 1FWD C	10,383	85.00	8,826	0.0417	368	157
H2 2 AFT S	6,373	85.00	5,417	0.0417	226	93
H2 1FWD P	10,383	85.00	8,826	0.0417	368	157

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F

Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 30	1,260	243.900F	0.000	18.618	0	0	70	0	70	237.600F	250.200F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	1,260	171.650F	0.000	18.250	0	0	70	0	70	165.350F	177.950F
Bay 46	1,260	186.100F	0.000	18.250	0	0	70	0	70	179.800F	192.400F
Bay 42	1,260	200.550F	0.000	18.618	0	0	70	0	70	194.250F	206.850F
Bay 38	1,260	215.000F	0.000	18.618	0	0	48	0	48	208.700F	221.300F
Bay 34	864	229.450F	0.000	18.115	0	0	70	0	70	223.150F	235.750F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 18	3,196	301.700F	0.000	49.621	0	0	262	0	262	295.400F	308.000F
Stack 14	3,196	316.150F	0.000	49.621	0	0	262	0	262	309.850F	322.450F

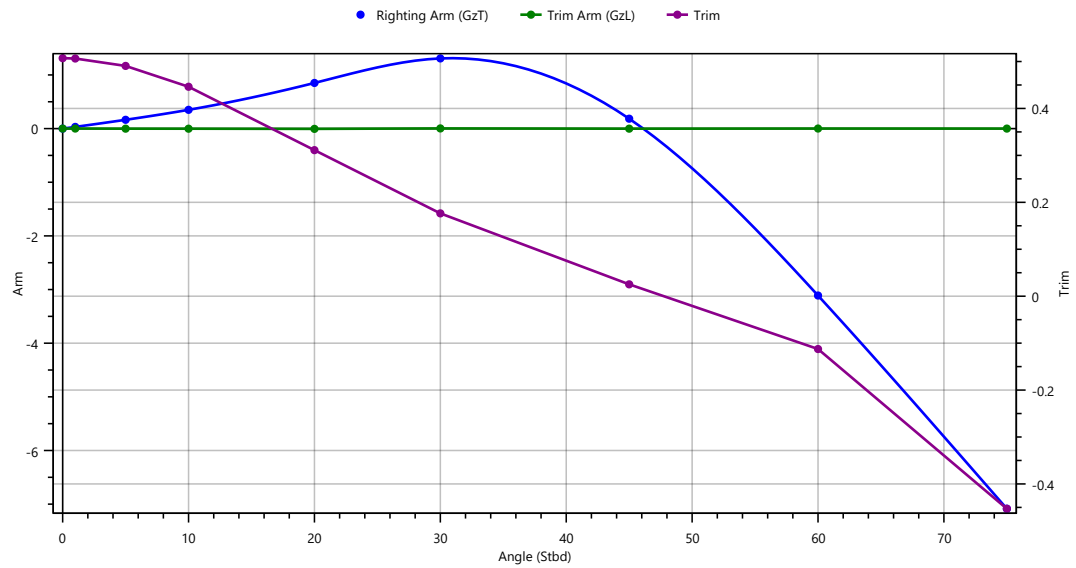
Stack 10	2,904	330.600F	0.000	48.326	0	0	238	0	238	324.300F	336.900F
Stack 6	2,904	345.050F	0.000	48.326	0	0	238	0	238	338.750F	351.350F
Stack 2	2,391	359.500F	0.000	47.023	0	0	196	0	196	353.200F	365.800F
Stack 22	3,489	287.250F	0.000	50.916	0	0	286	0	286	280.950F	293.550F
Stack 26	3,489	272.800F	0.000	50.916	0	0	286	0	286	266.500F	279.100F
Stack 66	3,782	113.850F	0.000	52.210	0	0	310	0	310	107.550F	120.150F
Stack 34	3,684	229.450F	0.000	52.585	0	0	302	0	302	223.150F	235.750F
Stack 94	3,782	1.450F	0.000	52.210	0	0	310	0	310	4.646A	7.546F
Stack 90	3,782	15.900F	0.000	52.210	0	0	310	0	310	9.600F	22.200F
Stack 86	3,782	30.350F	0.000	52.210	0	0	310	0	310	24.050F	36.650F
Stack 82	3,782	44.800F	0.000	52.210	0	0	310	0	310	38.500F	51.100F
Stack 78	3,782	70.500F	0.000	52.210	0	0	310	0	310	64.200F	76.800F
Stack 74	3,782	84.950F	0.000	52.210	0	0	310	0	310	78.650F	91.250F
Stack 70	3,782	99.400F	0.000	52.210	0	0	310	0	310	93.100F	105.700F
Stack 62	3,782	128.300F	0.000	52.210	0	0	310	0	310	122.000F	134.600F
Stack 58	3,782	142.750F	0.000	52.210	0	0	310	0	310	136.450F	149.050F
Stack 54	3,782	157.200F	0.000	52.210	0	0	310	0	310	150.900F	163.500F
Stack 50	3,782	171.650F	0.000	52.210	0	0	310	0	310	165.350F	177.950F
Stack 46	3,782	186.100F	0.000	52.210	0	0	310	0	310	179.800F	192.400F
Stack 42	3,782	200.550F	0.000	52.210	0	0	310	0	310	194.250F	206.850F
Stack 38	3,782	215.000F	0.000	52.210	0	0	310	0	310	208.700F	221.300F
Stack 30	3,782	243.900F	0.000	52.210	0	0	310	0	310	237.600F	250.200F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
Bosun Stores	40	385.000F	28.755	0.000

Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000

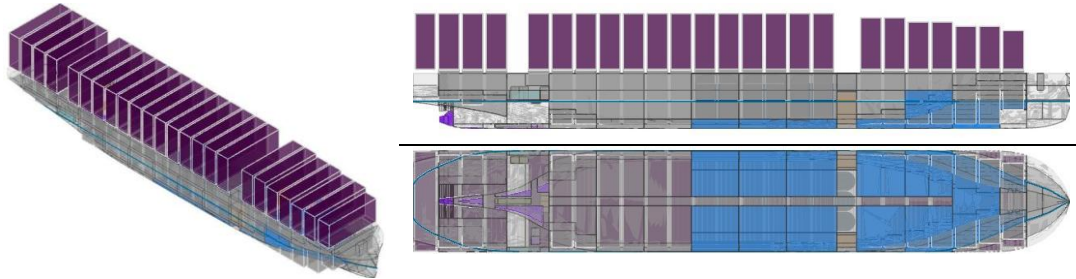
Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.51	-0.001	0.000	0.00	0.51A	16.243	12.755	5
0.00	1.00	0.51	0.031	0.001	1.00S	0.51A	16.239	12.757	2
0.00	5.00	0.49	0.164	-0.001	5.00S	0.49A	16.159	12.785	3
0.00	10.00	0.45	0.350	-0.002	10.00S	0.45A	15.925	12.857	3
0.00	20.00	0.31	0.851	-0.005	20.00S	0.31A	15.119	12.980	3
0.00	30.00	0.18	1.308	0.003	30.00S	0.18A	13.833	12.619	3
0.00	45.00	0.03	0.184	-0.001	45.00S	0.03A	10.348	10.174	5
0.00	60.00	-0.11	-3.112	0.001	60.00S	0.11F	4.641	5.416	8
0.00	75.00	-0.45	-7.086	0.000	75.00S	0.45F	-10.714	-7.600	9

Comp H₂ 10 Tier Deck Scantling Departure 9.6 MT Deck 9 MT Hold

Trim and Stability Summary



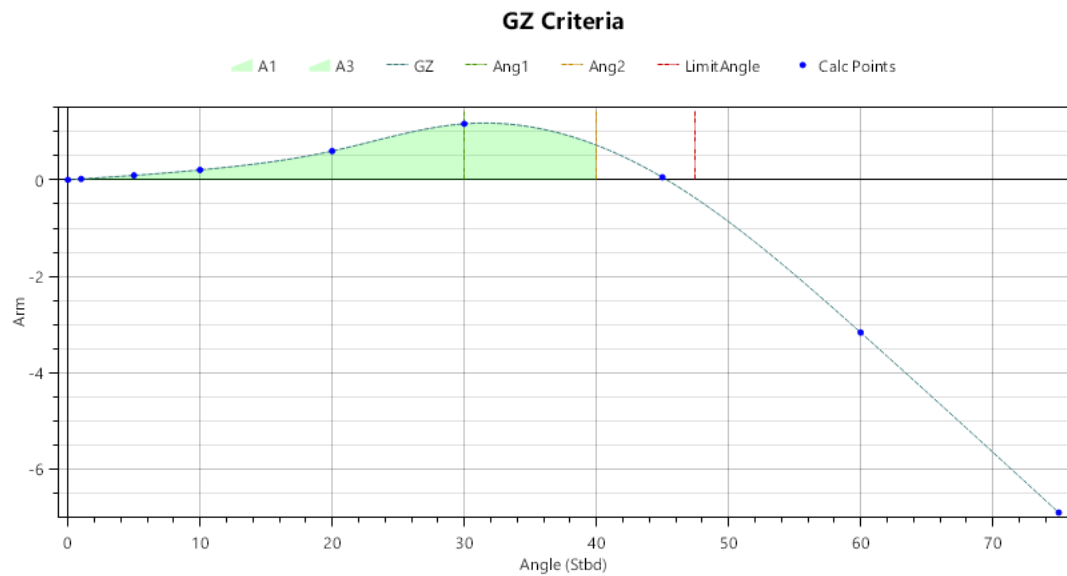
Loading					
Intact Displacement	295,165	MT	Sea Density	1.0250	MT/m ³
Deadweight	218,512	MT			
Available Deadweight	5,357	MT			
Stability			Trim		
KM0 Trans	29.936	m	Draft at LCF	16.294	m
VCG Upright	28.786	m-BL	LCF	182.428F	m-AP
GM0 Solid Trans	1.149	m	LCB	195.357F	m-AP
GM0 Trans	1.006	m	LCG	195.356F	m-AP
GMt Required	0.929	m	TPM	220.75	MT/cm
GMt Margin	0.077	m	MTM	5,859	m-MT/cm
GM at Equilibrium	1.134	m	Trim at Perps	0A	m
			Heel0	0.00	deg
			Propeller Immersion	152.57	%
Drafts - Perps			Drafts - Marks		
AP	16.303	m	Fwd	16.285	m
MS	16.294	m	Mid	16.294	m
FP	16.285	m	Aft	16.302	m
Strength					
Shear Min	-17,478	MT			
Shear Max	19,717	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,856,756H	m-MT			
Moment Max Sag	3,390S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	337.963	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
45 Tanks from Geometry
0 Tanks from Tables
69 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	218,512 MT		223,869 MT
Pass	Propeller Immersion	152.57 %	100.00 %	
Pass	Visibility	337.963 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.006 m	0.929 m	

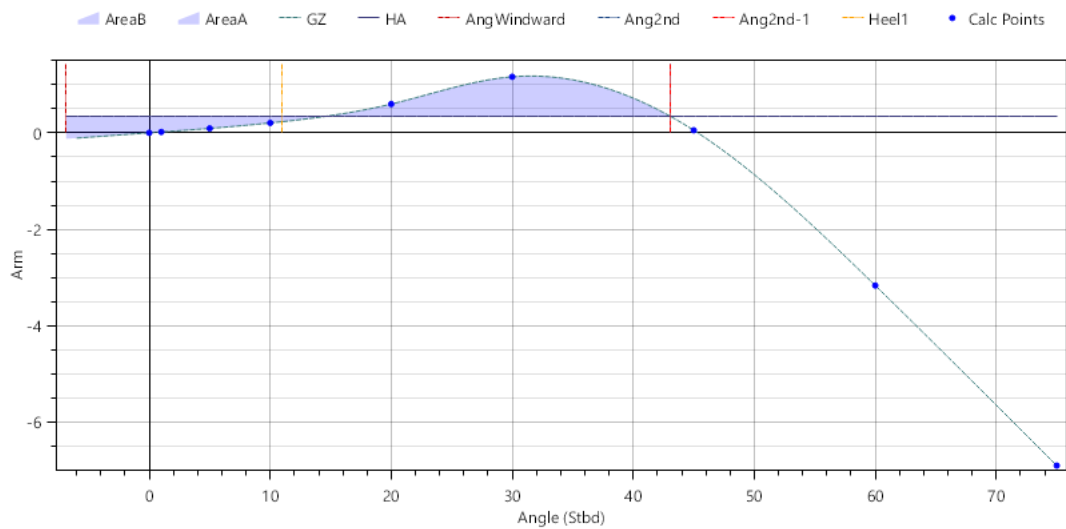
2008 IS Code 2.2 General Criteria



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.24 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.43 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.18 m-rad	0.03 m-rad	
	Angle to Downflooding	47.42 deg		
Pass	Angle at Maximum GZ	31.52 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.182 m	0.200 m	
Pass	Initial Metacentric Height	1.006 m	0.150 m	
	Range of Positive GZ	45.34 deg		

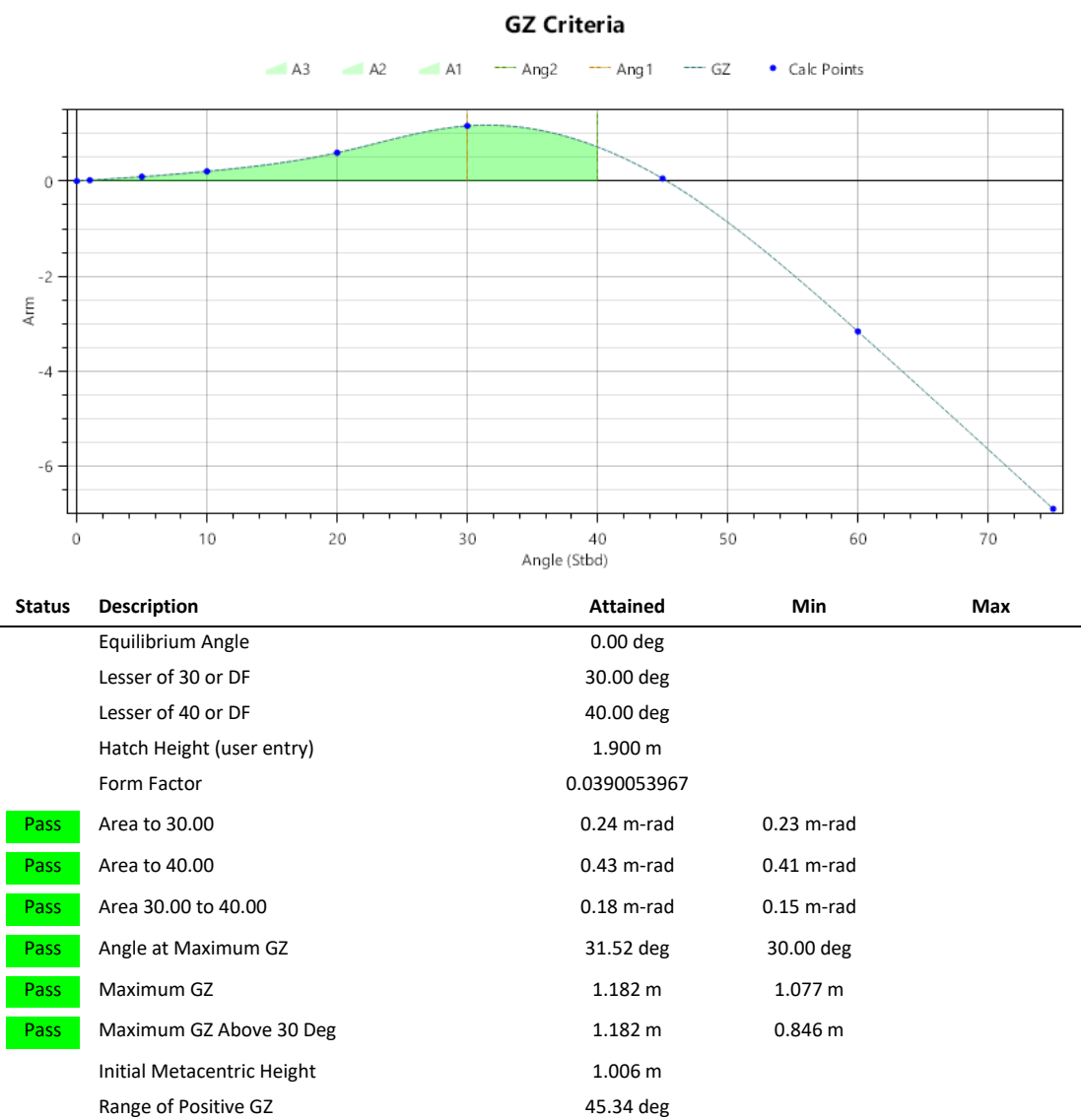
2008 IS Code 2.3 Weather Criteria

GZ Criteria

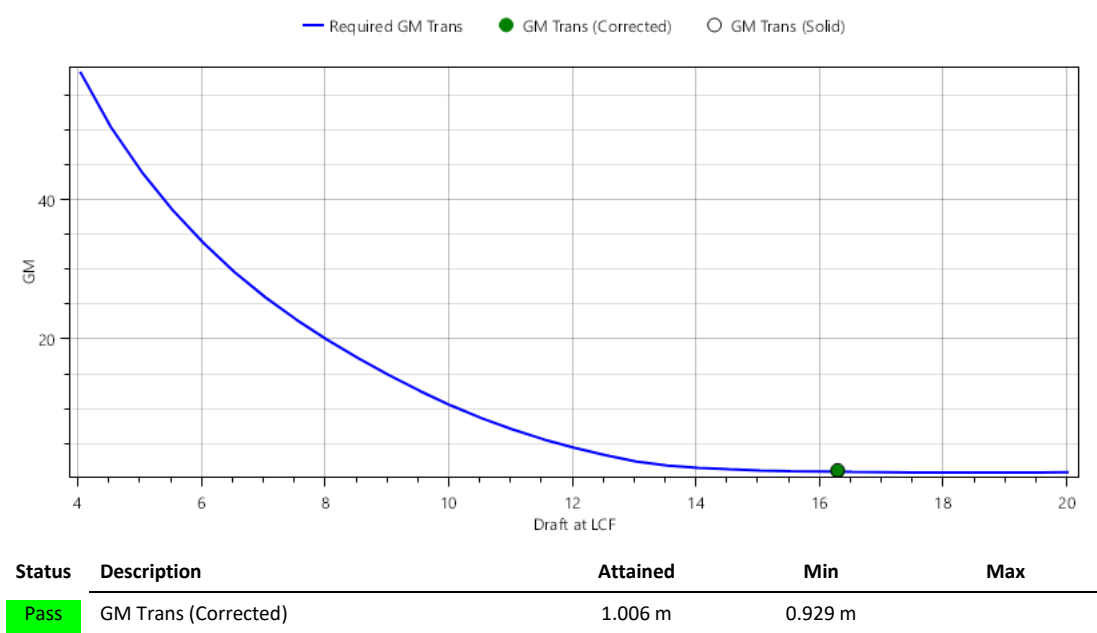


Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2321104849		
	Steady Wind Heeling Lever LW1	0.232 m		
	80% Deck Edge Immersion Angle	15.42 deg		
Pass	Heeling Angle at LW1	10.95 deg		15.42 deg
	Gusty Wind Heeling Lever LW2	0.348 m		
	Heeling Angle at LW2	14.69 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.84 deg		
	Angle Windward	-6.89 deg		
	Second Intersect	43.05 deg		
	Limiting Angle	43.05 deg		
	Capsizing Area A	-0.10 m-rad		
	Righting Area B	0.24 m-rad		
Pass	Area Ratio B/A	2.4486872064	1.0	

IMO IS Code 4.9 Containerships



INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	76,653	185.679F	22.241	0.000	0
	SEAWATER BALLAST	36,243	272.166F	5.082	0.061P	21,991
	DIESEL OIL	3,014	243.330F	13.196	0.000	789
	LUBE OIL	578	58.713F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	MISC TANKS	358	43.807F	2.885	2.320P	1,339
	H2	2,459	215.903F	15.870	0.000P	1,031
	Containers In Hold	67,968	190.049F	19.852	0.000	0
	Containers On Deck	106,871	179.799F	48.117	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		295,165	195.356F	28.786	0.004P	25,329

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	76,653	185.679F	22.241	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
6DBWBT S	2,279	100.00	2,279	1.0250	2,336	0
6DBWBT P	2,279	100.00	2,279	1.0250	2,336	0
5DBWBT S	2,278	100.00	2,278	1.0250	2,335	0
5DBWBT P	2,278	100.00	2,278	1.0250	2,335	0
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	100.00	2,173	1.0250	2,227	0
2WWBT P	2,173	100.00	2,173	1.0250	2,227	0
2DBWBT S	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1 WWBT S	4,837	60.00	2,902	1.0250	2,975	11,119
1 WWBT P	4,837	62.50	3,023	1.0250	3,099	10,872
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
MGO PILOT OIL TK P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14

NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14
MGO PILOT OIL TK S	1,645	98.00	1,612	0.8600	1,386	366

LUBE OIL

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO STOR TK	74	95.00	70	0.9000	63	13

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT S	275	100.00	275	1.0000	275	0
FWT P	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	29
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,092
WASTE OIL TANK	138	10.00	14	1.0000	14	103
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60

H2

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
H2 3 AFT S	6,373	85.00	5,417	0.0417	226	93
H2 3 AFT C	6,373	85.00	5,417	0.0417	226	93
H2 3 AFT P	6,373	85.00	5,417	0.0417	226	93
H2 2 AFT S	6,373	85.00	5,417	0.0417	226	93
H2 2 AFT C	6,373	85.00	5,417	0.0417	226	93
H2 1FWD S	10,383	85.00	8,826	0.0417	368	157
H2 1FWD C	10,383	85.00	8,826	0.0417	368	157
H2 1FWD P	10,383	85.00	8,826	0.0417	368	157
H2 2 AFT P	6,373	85.00	5,417	0.0417	226	93

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP

Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	1,260	171.650F	0.000	18.250	0	0	70	0	70	165.350F	177.950F
Bay 46	1,260	186.100F	0.000	18.250	0	0	70	0	70	179.800F	192.400F
Bay 42	1,260	200.550F	0.000	18.618	0	0	70	0	70	194.250F	206.850F
Bay 38	1,260	215.000F	0.000	18.618	0	0	48	0	48	208.700F	221.300F
Bay 34	864	229.450F	0.000	18.115	0	0	70	0	70	223.150F	235.750F
Bay 30	1,260	243.900F	0.000	18.618	0	0	70	0	70	237.600F	250.200F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

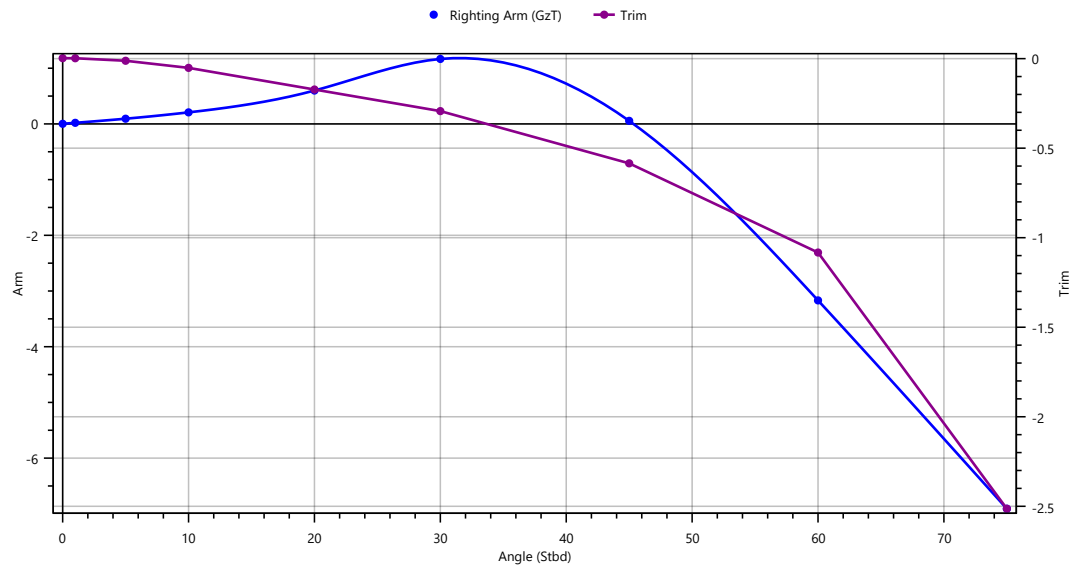
Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP

Stack 14	4,493	316.150F	0.000	48.148	0	0	262	0	262	309.850F	322.450F
Stack 10	4,493	330.600F	0.000	48.148	0	0	238	0	238	324.300F	336.900F
Stack 6	4,493	345.050F	0.000	48.148	0	0	238	0	238	338.750F	351.350F
Stack 2	3,686	359.500F	0.000	46.832	0	0	196	0	196	353.200F	365.800F
Stack 18	4,493	301.700F	0.000	48.148	0	0	262	0	262	295.400F	308.000F
Stack 22	4,493	287.250F	0.000	48.148	0	0	286	0	286	280.950F	293.550F
Stack 62	4,493	128.300F	0.000	48.148	0	0	310	0	310	122.000F	134.600F
Stack 30	4,493	243.900F	0.000	48.148	0	0	310	0	310	237.600F	250.200F
Stack 94	4,493	1.450F	0.000	48.148	0	0	310	0	310	4.646A	7.546F
Stack 90	4,493	15.900F	0.000	48.148	0	0	310	0	310	9.600F	22.200F
Stack 86	4,493	30.350F	0.000	48.148	0	0	310	0	310	24.050F	36.650F
Stack 82	4,493	44.800F	0.000	48.148	0	0	310	0	310	38.500F	51.100F
Stack 26	4,493	272.800F	0.000	48.148	0	0	286	0	286	266.500F	279.100F
Stack 78	4,493	70.500F	0.000	48.148	0	0	310	0	310	64.200F	76.800F
Stack 70	4,493	99.400F	0.000	48.148	0	0	310	0	310	93.100F	105.700F
Stack 66	4,493	113.850F	0.000	48.148	0	0	310	0	310	107.550F	120.150F
Stack 58	4,493	142.750F	0.000	48.148	0	0	310	0	310	136.450F	149.050F
Stack 54	4,493	157.200F	0.000	48.148	0	0	310	0	310	150.900F	163.500F
Stack 50	4,493	171.650F	0.000	48.148	0	0	310	0	310	165.350F	177.950F
Stack 46	4,493	186.100F	0.000	48.148	0	0	310	0	310	179.800F	192.400F
Stack 42	4,493	200.550F	0.000	48.148	0	0	310	0	310	194.250F	206.850F
Stack 38	4,493	215.000F	0.000	48.148	0	0	310	0	310	208.700F	221.300F
Stack 34	4,339	229.450F	0.000	48.505	0	0	302	0	302	223.150F	235.750F
Stack 74	4,493	84.950F	0.000	48.148	0	0	310	0	310	78.650F	91.250F

CONSTANT

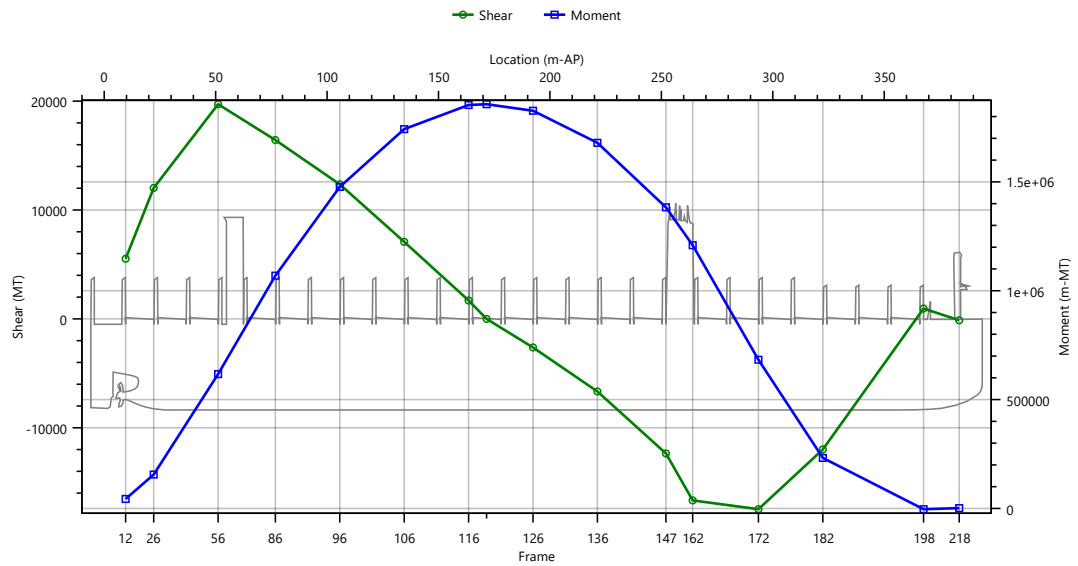
Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
Bosun Stores	40	385.000F	28.755	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.00	0.002	0.002	0.00	0.00A	16.268	16.250	4
0.00	1.00	0.00	0.020	0.001	1.00S	0.00A	16.265	16.250	2
0.00	5.00	-0.01	0.093	0.000	5.00S	0.01F	16.191	16.273	3
0.00	10.00	-0.05	0.207	0.000	10.00S	0.05F	15.977	16.331	3
0.00	20.00	-0.17	0.599	-0.001	20.00S	0.17F	15.241	16.427	3
0.00	30.00	-0.29	1.166	0.000	30.00S	0.29F	14.117	16.132	3
0.00	45.00	-0.58	0.055	-0.001	45.00S	0.58F	11.077	15.099	5
0.00	60.00	-1.08	-3.169	0.000	60.00S	1.08F	6.008	13.455	9
0.00	75.00	-2.51	-6.909	0.000	75.01S	2.51F	-7.726	9.570	17

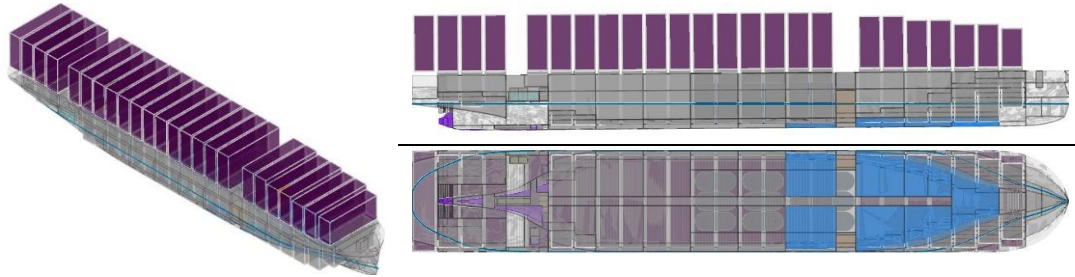
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	797	6,322	5,525	6,086S	49,653S	43,567H
22.200F	2,536	14,562	12,027	25,267S	181,033S	155,766H
51.100F	13,436	33,154	19,717	231,977S	849,057S	617,080H
76.800F	31,512	47,937	16,425	794,496S	1,863,705S	1,069,209H
105.700F	58,294	70,654	12,360	2,081,697S	3,558,657S	1,476,960H
134.600F	87,054	94,132	7,078	4,181,156S	5,923,444S	1,742,288H
163.500F	115,944	117,638	1,693	7,114,451S	8,967,420S	1,852,969H
171.570F	124,012	124,010	-3	8,082,691S	9,939,447S	1,856,756H
192.400F	144,836	142,213	-2,623	10,882,736S	12,709,492S	1,826,757H
221.300F	173,726	167,058	-6,668	15,485,961S	17,165,439S	1,679,478H
252.050F	204,424	192,067	-12,358	21,300,307S	22,683,420S	1,383,113H
264.050F	216,342	199,671	-16,671	23,824,969S	25,034,047S	1,209,078H
293.550F	245,061	227,583	-17,478	30,633,741S	31,316,878S	683,136H
322.450F	270,149	258,158	-11,991	38,092,126S	38,324,301S	232,174H
367.650F	291,890	292,841	951	50,883,440S	50,880,050S	3,390S
383.650F	294,704	294,574	-129	55,579,382S	55,580,879S	1,497H

Comp H₂ 10 Tier Deck Design Departure 8.24 MT Deck 9 MT Hold

Trim and Stability Summary



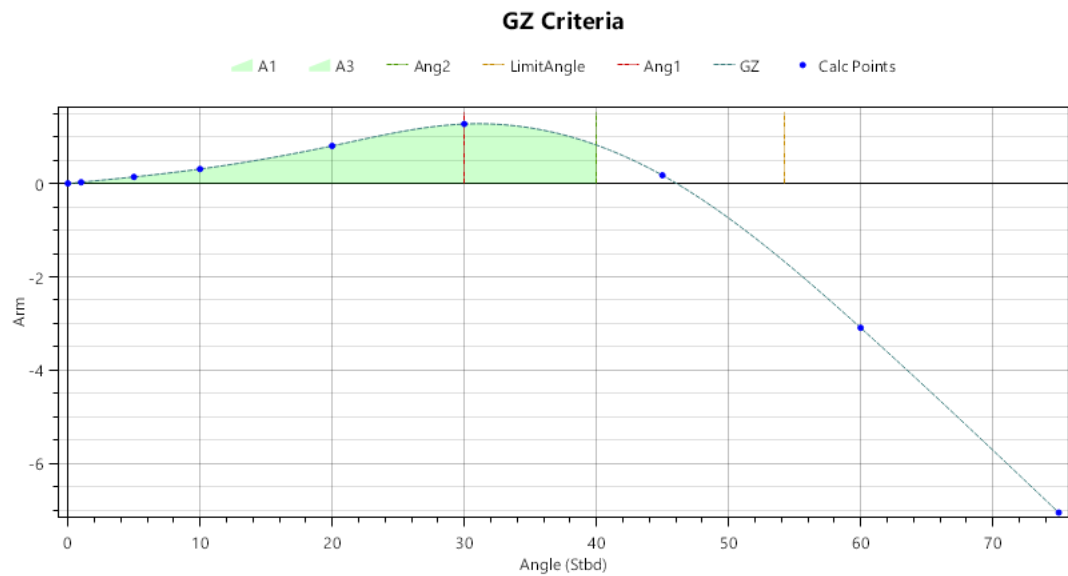
Loading					
Intact Displacement	259,022	MT	Sea Density	1.0250	MT/m ³
Deadweight	182,369	MT			
Available Deadweight	39	MT			
Stability			Trim		
KM0 Trans	31.303	m	Draft at LCF	14.650	m
VCG Upright	29.403	m-BL	LCF	181.234F	m-AP
GM0 Solid Trans	1.900	m	LCB	190.704F	m-AP
GM0 Trans	1.444	m	LCG	190.863F	m-AP
GMt Required	1.238	m	TPM	216.32	MT/cm
GMt Margin	0.206	m	MTM	5,544	m-MT/cm
GM at Equilibrium	1.659	m	Trim at Perps	3A	m
			Heel0	0.00	deg
			Propeller Immersion	149.00	%
Drafts - Perps			Drafts - Marks		
AP	15.988	m	Fwd	13.155	m
MS	14.533	m	Mid	14.554	m
FP	13.078	m	Aft	15.851	m
Strength					
Shear Min	-16,850	MT			
Shear Max	18,671	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	1,887,418H	m-MT			
Moment Max Sag	--	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	389.626	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
 $FSt \text{ Adjustment} = SolidGMt - GMt$
38 Tanks from Geometry
0 Tanks from Tables
76 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	182,369 MT		226,596 MT
Pass	Propeller Immersion	149.00 %	100.00 %	
Pass	Visibility	389.626 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	1.444 m	1.238 m	
Pass	Design Deadweight	182,369 MT		182,409 MT

2008 IS Code 2.2 General Criteria



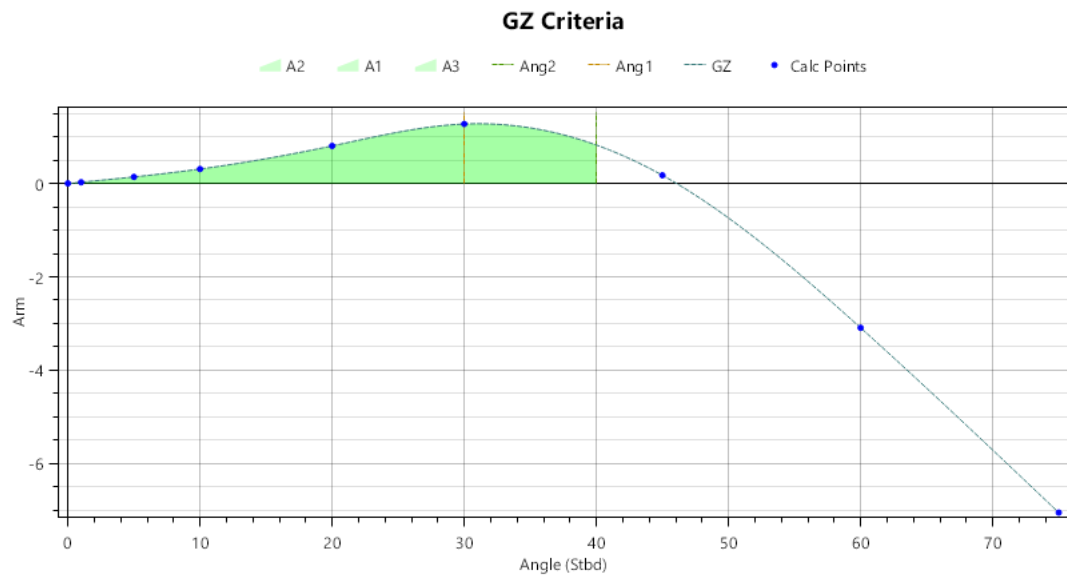
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.31 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.51 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.03 m-rad	
	Angle to Downflooding	54.19 deg		
Pass	Angle at Maximum GZ	31.04 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.285 m	0.200 m	
Pass	Initial Metacentric Height	1.444 m	0.150 m	
	Range of Positive GZ	46.09 deg		

2008 IS Code 2.3 Weather Criteria



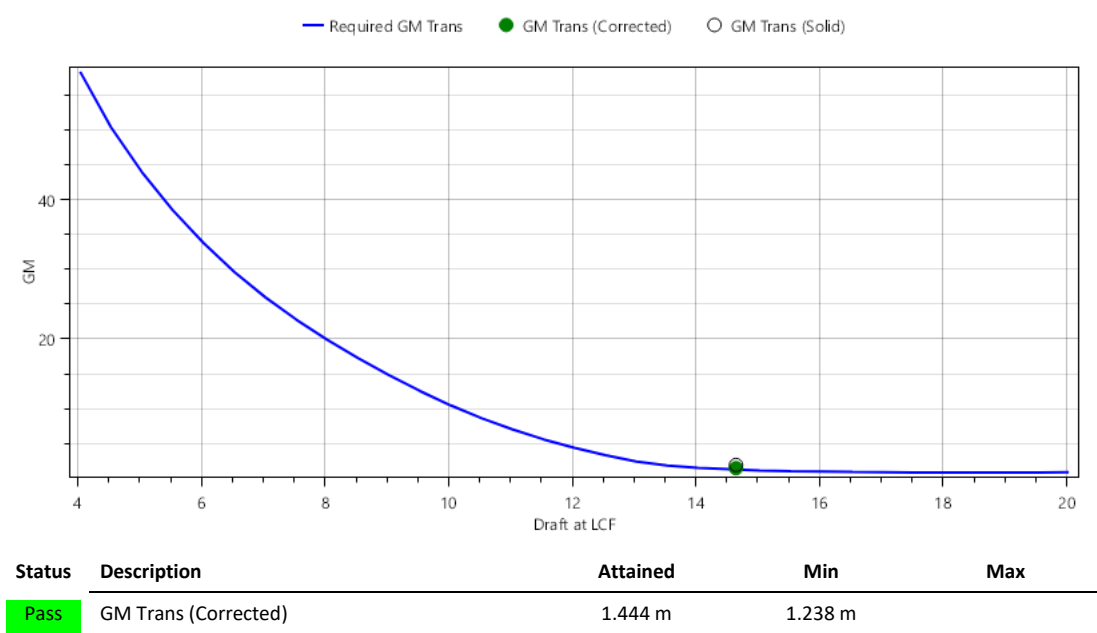
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2766604615		
	Steady Wind Heeling Lever LW1	0.277 m		
	80% Deck Edge Immersion Angle	16.13 deg		
Pass	Heeling Angle at LW1	9.05 deg		16.00 deg
	Gusty Wind Heeling Lever LW2	0.415 m		
	Heeling Angle at LW2	12.48 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	19.04 deg		
	Angle Windward	-10.00 deg		
	Second Intersect	43.41 deg		
	Limiting Angle	43.41 deg		
	Capsizing Area A	-0.14 m-rad		
	Righting Area B	0.28 m-rad		
Pass	Area Ratio B/A	1.9720865826	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0327731434		
Pass	Area to 30.00	0.31 m-rad	0.27 m-rad	
Pass	Area to 40.00	0.51 m-rad	0.49 m-rad	
Pass	Area 30.00 to 40.00	0.20 m-rad	0.18 m-rad	
Pass	Angle at Maximum GZ	31.04 deg	30.00 deg	
Pass	Maximum GZ	1.285 m	1.282 m	
Pass	Maximum GZ Above 30 Deg	1.285 m	1.007 m	
	Initial Metacentric Height	1.444 m		
	Range of Positive GZ	46.09 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	76,653	185.679F	22.241	0.000	0
	SEAWATER BALLAST	15,251	286.129F	2.129	0.169P	87,362
	DIESEL OIL	3,014	243.325F	13.196	0.000	789
	LUBE OIL	578	58.678F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	MISC TANKS	358	43.604F	2.886	2.294P	1,380
	H2	2,459	215.878F	15.870	0.000P	1,030
	Containers In Hold	67,968	190.049F	19.852	0.000	0
	Containers On Deck	91,720	179.800F	48.117	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		259,022	190.863F	29.403	0.006P	90,740

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	76,653	185.679F	22.241	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT P	2,173	5.00	109	1.0250	111	1,282
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
4DBWBT P	2,406	75.00	1,805	1.0250	1,850	43,040
4DBWBT S	2,406	75.00	1,805	1.0250	1,850	43,040

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT
MGO PILOT OIL TK S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT OIL TK P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14
NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m ³	%	m ³	MT/m ³	MT	m-MT

SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
ME LO STOR TK	110	95.00	104	0.9000	94	19
ME LO SUMP	117	50.00	58	0.9000	52	62
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	30
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	61
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,128
WASTE OIL TANK	138	10.00	14	1.0000	14	105
LO SLUDGE TANK	51	10.00	5	1.0000	5	56
ST CWT	140	100.00	140	1.0000	140	0

H2

Name	Capacity m ³	% Full %	Volume m ³	Density MT/m ³	Weight MT	FSMom Trans m-MT
H2 3 AFT S	6,373	85.00	5,417	0.0417	226	93
H2 3 AFT P	6,373	85.00	5,417	0.0417	226	93
H2 2 AFT S	6,373	85.00	5,417	0.0417	226	93
H2 2 AFT C	6,373	85.00	5,417	0.0417	226	93
H2 3 AFT C	6,373	85.00	5,417	0.0417	226	93
H2 1FWD S	10,383	85.00	8,826	0.0417	368	157
H2 1FWD C	10,383	85.00	8,826	0.0417	368	157
H2 1FWD P	10,383	85.00	8,826	0.0417	368	157
H2 2 AFT P	6,373	85.00	5,417	0.0417	226	93

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 82	2,052	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 90	2,160	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F
Bay 86	2,448	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 78	1,188	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F

Bay 38	1,260	215.000F	0.000	18.618	0	0	48	0	48	208.700F	221.300F
Bay 70	4,608	99.400F	0.000	18.640	0	0	256	0	256	93.100F	105.700F
Bay 66	4,716	113.850F	0.000	18.250	0	0	262	0	262	107.550F	120.150F
Bay 62	4,716	128.300F	0.000	18.250	0	0	262	0	262	122.000F	134.600F
Bay 58	4,716	142.750F	0.000	18.250	0	0	262	0	262	136.450F	149.050F
Bay 54	4,716	157.200F	0.000	18.250	0	0	262	0	262	150.900F	163.500F
Bay 50	1,260	171.650F	0.000	18.250	0	0	70	0	70	165.350F	177.950F
Bay 46	1,260	186.100F	0.000	18.250	0	0	70	0	70	179.800F	192.400F
Bay 42	1,260	200.550F	0.000	18.618	0	0	70	0	70	194.250F	206.850F
Bay 74	4,248	84.950F	0.000	19.431	0	0	236	0	236	78.650F	91.250F
Bay 34	864	229.450F	0.000	18.115	0	0	70	0	70	223.150F	235.750F
Bay 30	1,260	243.900F	0.000	18.618	0	0	70	0	70	237.600F	250.200F
Bay 22	4,500	287.250F	0.000	18.736	0	0	250	0	250	280.950F	293.550F
Bay 26	4,644	272.800F	0.000	18.500	0	0	258	0	258	266.500F	279.100F
Bay 18	4,428	301.700F	0.000	18.952	0	0	246	0	246	295.400F	308.000F
Bay 14	4,032	316.150F	0.000	19.655	0	0	224	0	224	309.850F	322.450F
Bay 10	3,420	330.600F	0.000	20.848	0	0	190	0	190	324.300F	336.900F
Bay 6	2,592	345.050F	0.000	21.828	0	0	144	0	144	338.750F	351.350F
Bay 2	1,620	359.500F	0.000	24.782	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 22	3,856	287.250F	0.000	48.148	0	0	286	0	286	280.950F	293.550F
Stack 18	3,856	301.700F	0.000	48.148	0	0	262	0	262	295.400F	308.000F
Stack 14	3,856	316.150F	0.000	48.148	0	0	262	0	262	309.850F	322.450F
Stack 10	3,856	330.600F	0.000	48.148	0	0	238	0	238	324.300F	336.900F

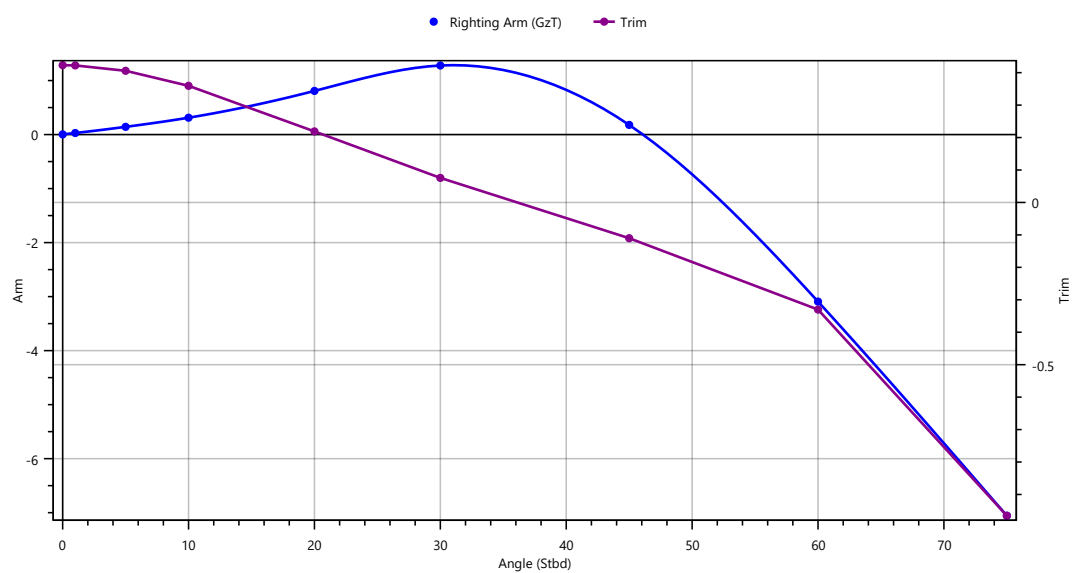
Stack 6	3,856	345.050F	0.000	48.148	0	0	238	0	238	338.750F	351.350F
Stack 2	3,164	359.500F	0.000	46.832	0	0	196	0	196	353.200F	365.800F
Stack 26	3,856	272.800F	0.000	48.148	0	0	286	0	286	266.500F	279.100F
Stack 30	3,856	243.900F	0.000	48.148	0	0	310	0	310	237.600F	250.200F
Stack 70	3,856	99.400F	0.000	48.148	0	0	310	0	310	93.100F	105.700F
Stack 38	3,856	215.000F	0.000	48.148	0	0	310	0	310	208.700F	221.300F
Stack 94	3,856	1.450F	0.000	48.148	0	0	310	0	310	4.646A	7.546F
Stack 90	3,856	15.900F	0.000	48.148	0	0	310	0	310	9.600F	22.200F
Stack 86	3,856	30.350F	0.000	48.148	0	0	310	0	310	24.050F	36.650F
Stack 34	3,724	229.450F	0.000	48.505	0	0	302	0	302	223.150F	235.750F
Stack 82	3,856	44.800F	0.000	48.148	0	0	310	0	310	38.500F	51.100F
Stack 74	3,856	84.950F	0.000	48.148	0	0	310	0	310	78.650F	91.250F
Stack 66	3,856	113.850F	0.000	48.148	0	0	310	0	310	107.550F	120.150F
Stack 62	3,856	128.300F	0.000	48.148	0	0	310	0	310	122.000F	134.600F
Stack 58	3,856	142.750F	0.000	48.148	0	0	310	0	310	136.450F	149.050F
Stack 54	3,856	157.200F	0.000	48.148	0	0	310	0	310	150.900F	163.500F
Stack 50	3,856	171.650F	0.000	48.148	0	0	310	0	310	165.350F	177.950F
Stack 46	3,856	186.100F	0.000	48.148	0	0	310	0	310	179.800F	192.400F
Stack 42	3,856	200.550F	0.000	48.148	0	0	310	0	310	194.250F	206.850F
Stack 78	3,856	70.500F	0.000	48.148	0	0	310	0	310	64.200F	76.800F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000
Bosun Stores	40	385.000F	28.755	0.000
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000

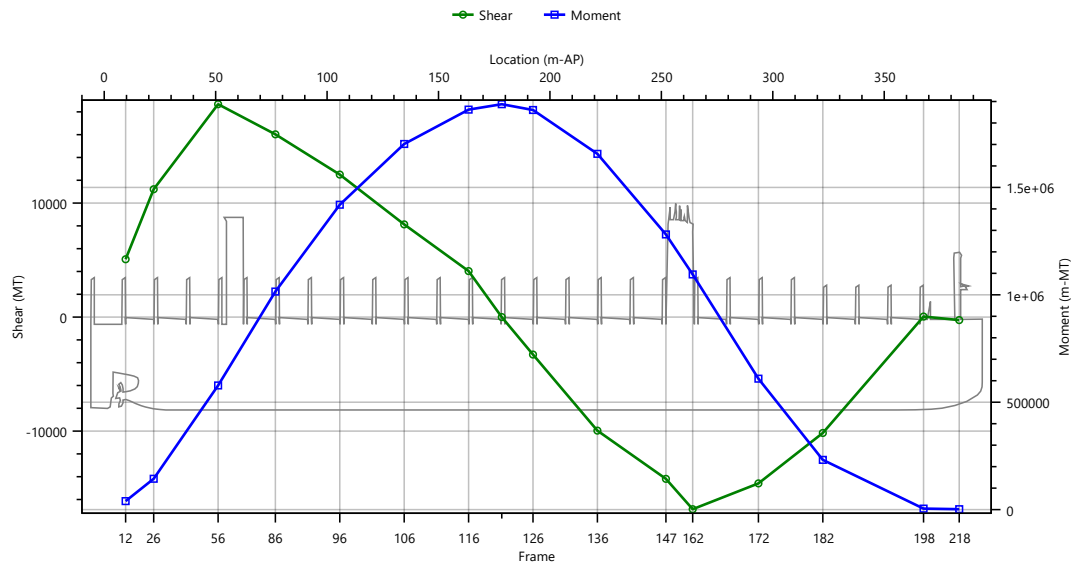
Stores Distributed	120	160.000F	27.200	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.42	0.004	0.000	0.00	0.42A	15.953	13.043	5
0.00	1.00	0.42	0.029	0.001	1.00S	0.42A	15.949	13.045	2
0.00	5.00	0.41	0.143	-0.001	5.00S	0.41A	15.865	13.075	3
0.00	10.00	0.36	0.312	-0.002	10.00S	0.36A	15.624	13.152	3
0.00	20.00	0.22	0.808	-0.005	20.00S	0.22A	14.793	13.287	3
0.00	30.00	0.08	1.279	0.002	30.00S	0.08A	13.467	12.947	3
0.00	45.00	-0.11	0.179	-0.001	45.00S	0.11F	9.845	10.603	5
0.00	60.00	-0.33	-3.092	0.002	60.00S	0.33F	3.829	6.099	8
0.00	75.00	-0.97	-7.057	0.000	75.00S	0.97F	-12.645	-6.004	9

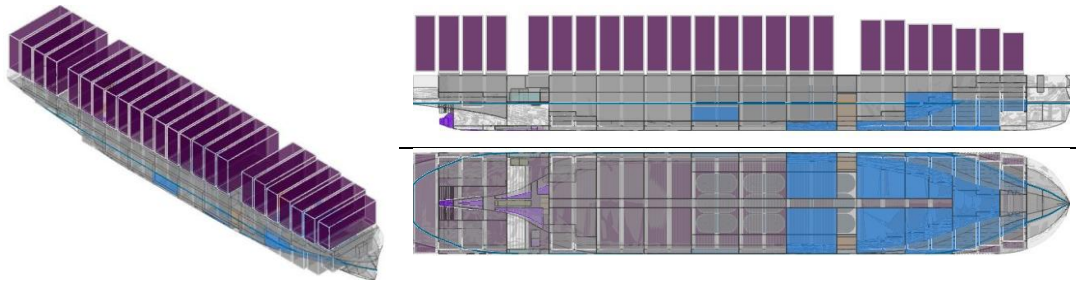
Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	613	5,685	5,072	4,921S	44,461S	39,540H
22.200F	2,075	13,289	11,213	20,157S	163,802S	143,645H
51.100F	11,938	30,609	18,671	199,778S	777,794S	578,015H
76.800F	28,723	44,752	16,029	707,869S	1,723,022S	1,015,153H
105.700F	53,696	66,195	12,499	1,889,242S	3,308,697S	1,419,455H
134.600F	80,270	88,399	8,130	3,825,138S	5,527,388S	1,702,250H
163.500F	106,597	110,631	4,034	6,526,239S	8,388,449S	1,862,210H
178.387F	120,013	120,013	0	8,213,139S	10,100,557S	1,887,418H
192.400F	132,549	129,261	-3,288	9,982,806S	11,843,302S	1,860,496H
221.300F	158,121	148,161	-9,959	14,183,893S	15,840,218S	1,656,326H
252.050F	184,876	170,686	-14,190	19,458,849S	20,739,950S	1,281,101H
264.050F	195,138	178,289	-16,850	21,739,065S	22,834,015S	1,094,950H
293.550F	219,514	204,927	-14,586	27,859,229S	28,468,846S	609,617H
322.450F	240,048	229,884	-10,163	34,513,622S	34,745,160S	231,537H
367.650F	256,653	256,698	45	45,812,001S	45,816,652S	4,651H
383.650F	258,696	258,432	-265	49,937,274S	49,939,198S	1,923H

Comp H₂ 14 MT TEU HOMO 14400 TEU

Trim and Stability Summary



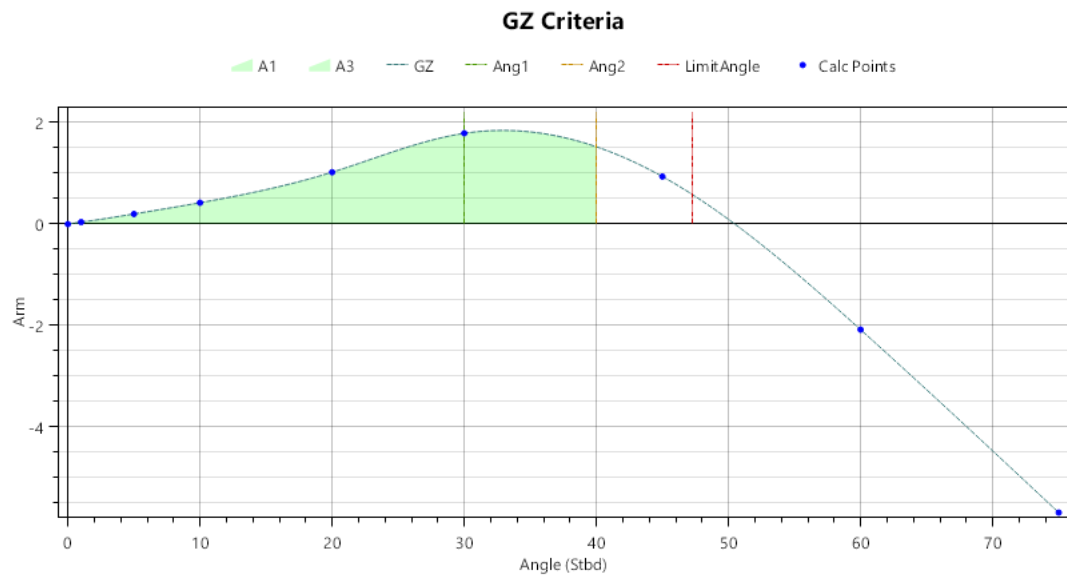
Loading					
Intact Displacement	296,436	MT	Sea Density	1.0250	MT/m ³
Deadweight	219,783	MT			
Available Deadweight	4,095	MT			
Stability			Trim		
KM0 Trans	29.913	m	Draft at LCF	16.352	m
VCG Upright	27.518	m-BL	LCF	182.313F	m-AP
GM0 Solid Trans	2.395	m	LCB	195.278F	m-AP
GM0 Trans	2.257	m	LCG	195.278F	m-AP
GMt Required	0.923	m	TPM	221.01	MT/cm
GMt Margin	1.334	m	MTM	5,887	m-MT/cm
GM at Equilibrium	1.917	m	Trim at Perps	0A	m
			Heel0	0.00	deg
			Propeller Immersion	153.17	%
Drafts - Perps			Drafts - Marks		
AP	16.365	m	Fwd	16.337	m
MS	16.351	m	Mid	16.351	m
FP	16.336	m	Aft	16.364	m
Strength					
Shear Min	-22,210	MT			
Shear Max	23,860	MT			
Shear at Max %Allow	--	MT			
Moment Max Hog	2,485,333H	m-MT			
Moment Max Sag	3,556S	m-MT			
Moment at Max %Allow	--	m-MT			
Bridge Visibility					
Visibility Distance	337.611	m	Visibility Distance Required	500.000	m
Calculation Notes					

Drafts from Keel
Hull from Geometry
GMt from GZ Curve Slope
FSt Adjustment = SolidGMt-GMt
43 Tanks from Geometry
0 Tanks from Tables
71 Empty Tanks
GZ Curve from Geometry
Downflood Angles from 3D Data

Alarm Summary

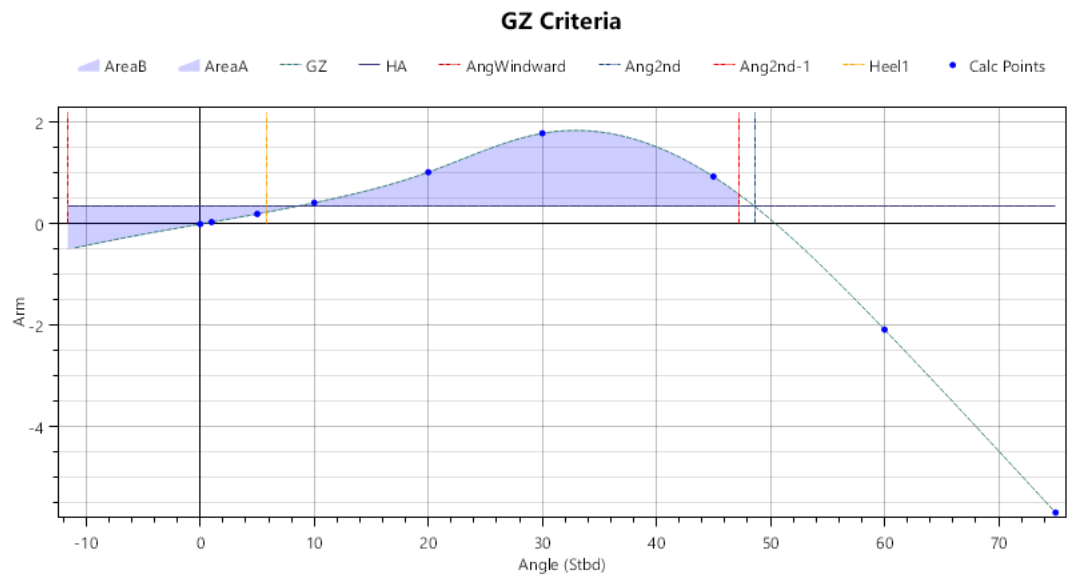
Status	Description	Attained	Min	Max
Pass	Calculation Status	Survived		
	Calculations completed			
Pass	2008 IS Code 2.2 General Criteria			
Pass	2008 IS Code 2.3 Weather Criteria			
Pass	Summer Deadweight	219,783 MT		223,878 MT
Pass	Propeller Immersion	153.17 %	100.00 %	
Pass	Visibility	337.611 m		500.000 m
Pass	IMO IS Code 4.9 Containerships			
Pass	INTACT MAX KG Required GM Trans	2.257 m	0.923 m	

2008 IS Code 2.2 General Criteria



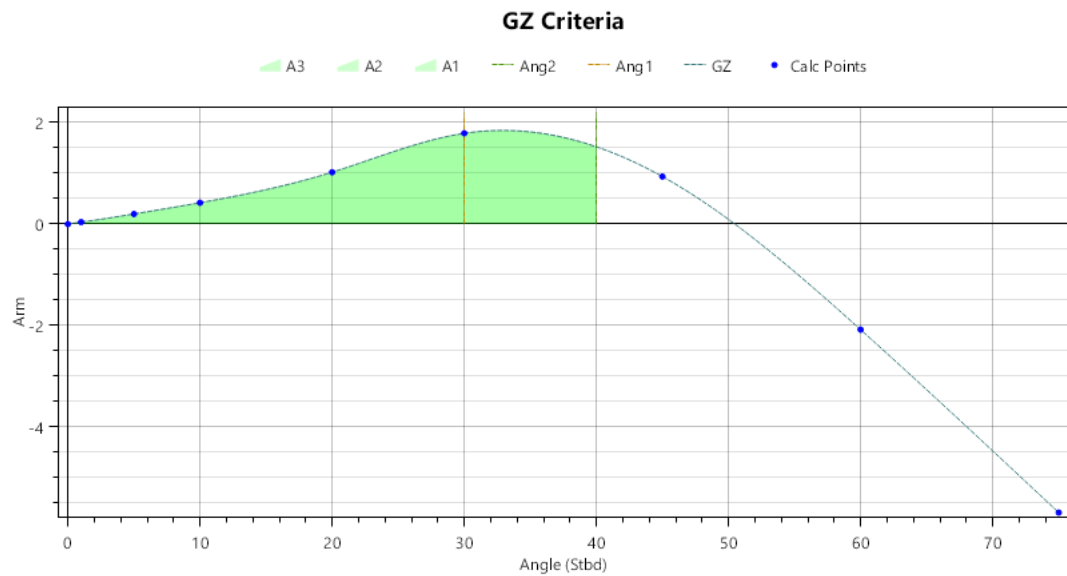
Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
Pass	Area to 30.00	0.41 m-rad	0.06 m-rad	
Pass	Area to 40.00	0.71 m-rad	0.09 m-rad	
Pass	Area 30.00 to 40.00	0.31 m-rad	0.03 m-rad	
	Angle to Downflooding	47.25 deg		
Pass	Angle at Maximum GZ	32.90 deg	25.00 deg	
Pass	Maximum GZ Above 30 Deg	1.841 m	0.200 m	
Pass	Initial Metacentric Height	2.257 m	0.150 m	
	Range of Positive GZ	47.25 deg		

2008 IS Code 2.3 Weather Criteria



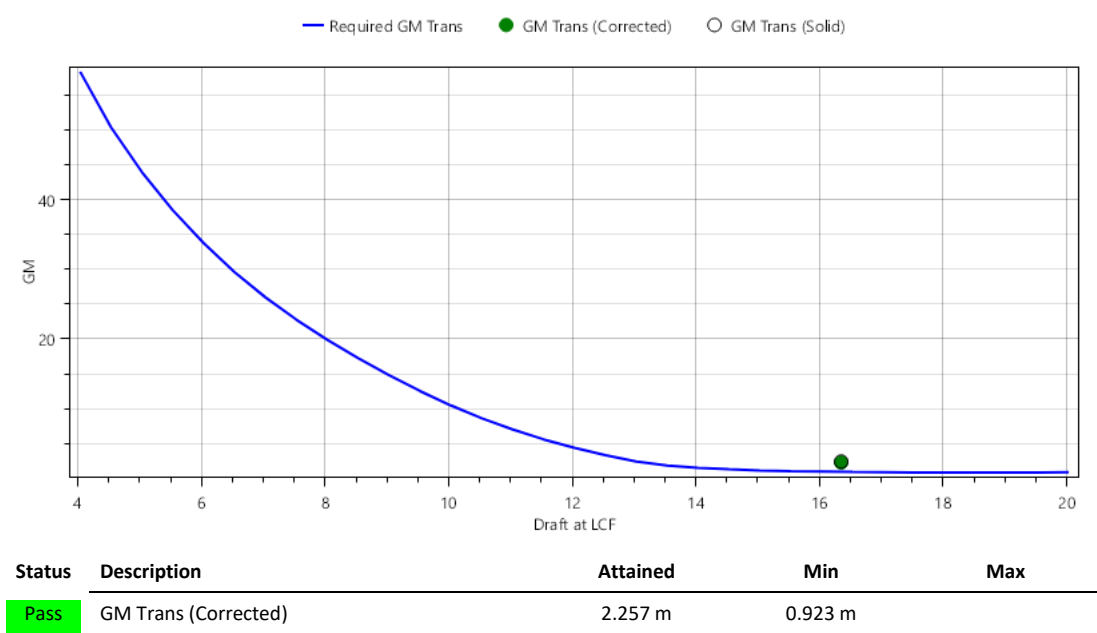
Status	Description	Attained	Min	Max
	Wind Heeling Arm Upright	0.2307324058		
	Steady Wind Heeling Lever LW1	0.231 m		
	80% Deck Edge Immersion Angle	15.31 deg		
Pass	Heeling Angle at LW1	5.85 deg		15.31 deg
	Gusty Wind Heeling Lever LW2	0.346 m		
	Heeling Angle at LW2	8.48 deg		
	Bilge Area	0.00 m ²		
	Roll Angle	17.46 deg		
	Angle Windward	-11.60 deg		
	Second Intersect	48.61 deg		
	Limiting Angle	47.25 deg		
	Capsizing Area A	-0.15 m-rad		
	Righting Area B	0.59 m-rad		
Pass	Area Ratio B/A	4.050172619	1.0	

IMO IS Code 4.9 Containerships



Status	Description	Attained	Min	Max
	Equilibrium Angle	0.00 deg		
	Lesser of 30 or DF	30.00 deg		
	Lesser of 40 or DF	40.00 deg		
	Hatch Height (user entry)	1.900 m		
	Form Factor	0.0400740928		
Pass	Area to 30.00	0.41 m-rad	0.22 m-rad	
Pass	Area to 40.00	0.71 m-rad	0.40 m-rad	
Pass	Area 30.00 to 40.00	0.31 m-rad	0.15 m-rad	
Pass	Angle at Maximum GZ	32.90 deg	30.00 deg	
Pass	Maximum GZ	1.841 m	1.048 m	
Pass	Maximum GZ Above 30 Deg	1.841 m	0.823 m	
	Initial Metacentric Height	2.257 m		
	Range of Positive GZ	50.46 deg		

INTACT MAX KG Required GM Trans



Weight Summary

	NAME	WT	LCG	VCG	TCG	FST
		MT	m-AP	m-BL	m-CL	m-MT
	Lightship	76,653	185.679F	22.241	0.000	0
	SEAWATER BALLAST	29,065	295.762F	6.716	0.001P	16,760
	DIESEL OIL	3,014	243.330F	13.196	0.000	789
	LUBE OIL	578	58.713F	18.954	3.418S	179
	FRESH WATER	549	62.003F	20.070	0.000	0
	MISC TANKS	358	43.806F	2.885	2.320P	1,340
	H2	2,459	215.903F	15.870	0.000P	1,031
	Containers In Hold	71,232	185.316F	16.099	0.000	0
	Containers On Deck	112,056	182.276F	44.572	0.000	0
	CONSTANT	473	179.784F	30.295	0.000	0
	Spaces	0				0
		296,436	195.278F	27.518	0.004S	20,098

Lightship

Name	Weight	LCG	VCG	TCG
	MT	m-AP	m-BL	m-CL
Lightship Constant	0	197.000F	0.000	0.000
Lightship	76,653	185.679F	22.241	0.000

SEAWATER BALLAST

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
6WWBT HEEL S	1,265	50.00	632	1.0250	648	41
6WWBT HEEL P	1,265	50.00	632	1.0250	648	41
4DBWBT S	2,406	100.00	2,406	1.0250	2,466	0
4DBWBT P	2,406	100.00	2,406	1.0250	2,466	0
3DBWBT P	2,316	100.00	2,316	1.0250	2,374	0
2WWBT S	2,173	100.00	2,173	1.0250	2,227	0
2WWBT P	2,173	100.00	2,173	1.0250	2,227	0
2DBWBTS	1,918	100.00	1,918	1.0250	1,966	0
2DBWBT P	1,918	100.00	1,918	1.0250	1,966	0
1 WWBT S	4,837	70.00	3,386	1.0250	3,470	8,339
1 WWBT P	4,837	70.00	3,386	1.0250	3,470	8,339
1DBWBT	2,693	100.00	2,693	1.0250	2,760	0
3DBWBT S	2,316	100.00	2,316	1.0250	2,374	0

DIESEL OIL

Name	Capacity	% Full	Volume	Density	Weight	FSMom Trans
	m³	%	m³	MT/m³	MT	m-MT
MGO PILOT OIL TK S	1,645	98.00	1,612	0.8600	1,386	366
MGO PILOT OIL TK P	1,645	98.00	1,612	0.8600	1,386	366
NO 2 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 1 MGO SERV TK	140	50.00	70	0.8600	60	14
NO 2 MGO SETT TK	140	50.00	70	0.8600	60	14

NO 1 MGO SETT TK	140	50.00	70	0.8600	60	14

LUBE OIL

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
ME LO SUMP	117	50.00	58	0.9000	52	62
ME LO STOR TK	110	95.00	104	0.9000	94	19
SSDG LO STOR TK	74	95.00	70	0.9000	63	13
ME LO SETT TK	74	50.00	37	0.9000	33	13
SSDG LO SETT TK	74	50.00	37	0.9000	33	13
NO 1 CYL OIL STOR TK	183	95.00	174	0.9000	157	31
NO 2 CYL OIL STOR TK	170	95.00	162	0.9000	146	29

FRESH WATER

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
FWT P	275	100.00	275	1.0000	275	0
FWT S	275	100.00	275	1.0000	275	0

MISC TANKS

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
BILGE HOLDING TANK	158	10.00	16	1.0000	16	29
ST CWT	140	100.00	140	1.0000	140	0
WASTE OIL TANK	138	10.00	14	1.0000	14	103
EGR BLEED WATER TK	331	50.00	165	1.0000	165	1,092
GRAY WATER HOLDING TANK	177	10.00	18	1.0000	18	60
LO SLUDGE TANK	51	10.00	5	1.0000	5	56

H2

Name	Capacity m³	% Full %	Volume m³	Density MT/m³	Weight MT	FSMom Trans m-MT
H2 3 AFT S	6,373	85.00	5,417	0.0417	226	93
H2 3 AFT C	6,373	85.00	5,417	0.0417	226	93
H2 3 AFT P	6,373	85.00	5,417	0.0417	226	93
H2 2 AFT S	6,373	85.00	5,417	0.0417	226	93
H2 2 AFT P	6,373	85.00	5,417	0.0417	226	93
H2 1FWD S	10,383	85.00	8,826	0.0417	368	157
H2 1FWD C	10,383	85.00	8,826	0.0417	368	157
H2 1FWD P	10,383	85.00	8,826	0.0417	368	157
H2 2 AFT C	6,373	85.00	5,417	0.0417	226	93

Containers In Hold

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Bay 74	4,312	84.950F	0.000	14.796	0	0	236	0	236	78.650F	91.250F
Bay 90	3,360	15.900F	0.000	25.564	0	0	120	0	120	9.600F	22.200F

Bay 86	3,808	30.350F	0.000	24.394	0	0	136	0	136	24.050F	36.650F
Bay 82	3,192	44.800F	0.000	25.856	0	0	114	0	114	38.500F	51.100F
Bay 78	1,848	70.500F	0.000	29.617	0	0	66	0	66	64.200F	76.800F
Bay 70	4,312	99.400F	0.000	12.691	0	0	256	0	256	93.100F	105.700F
Bay 30	1,176	243.900F	0.000	12.603	0	0	70	0	70	237.600F	250.200F
Bay 62	4,312	128.300F	0.000	11.901	0	0	262	0	262	122.000F	134.600F
Bay 58	4,312	142.750F	0.000	11.901	0	0	262	0	262	136.450F	149.050F
Bay 54	4,312	157.200F	0.000	11.901	0	0	262	0	262	150.900F	163.500F
Bay 50	1,176	171.650F	0.000	11.901	0	0	70	0	70	165.350F	177.950F
Bay 46	1,176	186.100F	0.000	11.901	0	0	70	0	70	179.800F	192.400F
Bay 42	1,176	200.550F	0.000	12.603	0	0	70	0	70	194.250F	206.850F
Bay 38	1,176	215.000F	0.000	12.603	0	0	48	0	48	208.700F	221.300F
Bay 34	784	229.450F	0.000	11.638	0	0	70	0	70	223.150F	235.750F
Bay 26	4,312	272.800F	0.000	12.428	0	0	258	0	258	266.500F	279.100F
Bay 66	4,312	113.850F	0.000	11.901	0	0	262	0	262	107.550F	120.150F
Bay 22	4,312	287.250F	0.000	13.217	0	0	250	0	250	280.950F	293.550F
Bay 18	4,312	301.700F	0.000	13.744	0	0	246	0	246	295.400F	308.000F
Bay 10	3,864	330.600F	0.000	18.040	0	0	190	0	190	324.300F	336.900F
Bay 14	4,200	316.150F	0.000	15.596	0	0	224	0	224	309.850F	322.450F
Bay 6	3,080	345.050F	0.000	19.883	0	0	144	0	144	338.750F	351.350F
Bay 2	2,408	359.500F	0.000	24.508	0	0	90	0	90	353.200F	365.800F

Containers On Deck

Name	Weight MT	LCG m-AP	TCG m-CL	VCG m-BL	# 20s	# 24s	# 40s	# 45s	# Containers	Aft m-AP	Fwd m-AP
Stack 14	4,648	316.150F	0.000	44.445	0	0	262	0	262	309.850F	322.450F
Stack 10	4,648	330.600F	0.000	44.445	0	0	238	0	238	324.300F	336.900F

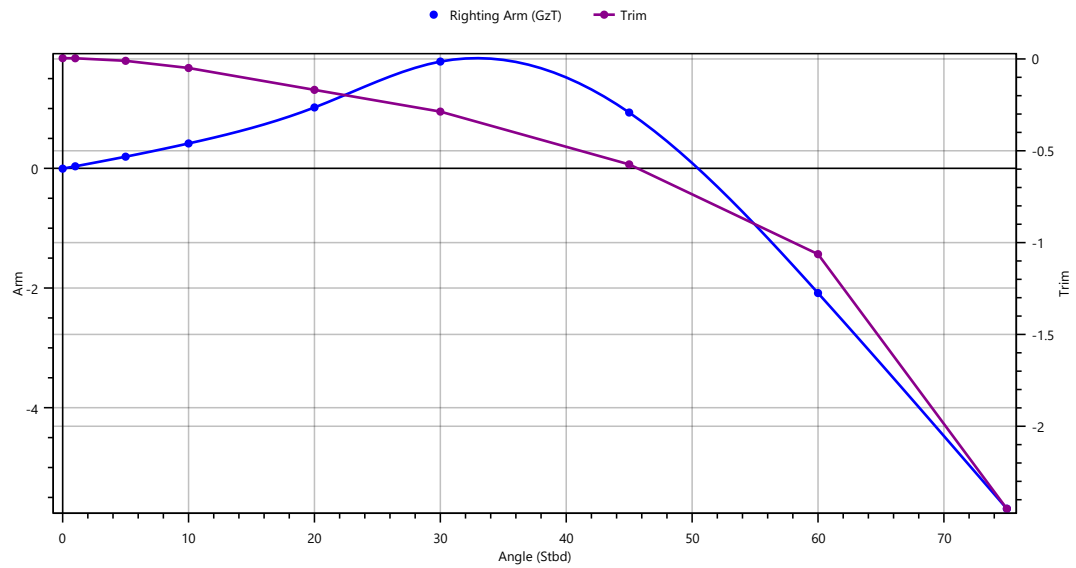
Stack 6	4,648	345.050F	0.000	44.445	0	0	238	0	238	338.750F	351.350F
Stack 2	5,376	359.500F	0.000	46.832	0	0	196	0	196	353.200F	365.800F
Stack 18	4,648	301.700F	0.000	44.445	0	0	262	0	262	295.400F	308.000F
Stack 22	4,648	287.250F	0.000	44.445	0	0	286	0	286	280.950F	293.550F
Stack 62	4,648	128.300F	0.000	44.445	0	0	310	0	310	122.000F	134.600F
Stack 30	4,648	243.900F	0.000	44.445	0	0	310	0	310	237.600F	250.200F
Stack 94	4,648	1.450F	0.000	44.445	0	0	310	0	310	4.646A	7.546F
Stack 90	4,648	15.900F	0.000	44.445	0	0	310	0	310	9.600F	22.200F
Stack 86	4,648	30.350F	0.000	44.445	0	0	310	0	310	24.050F	36.650F
Stack 82	4,648	44.800F	0.000	44.445	0	0	310	0	310	38.500F	51.100F
Stack 26	4,648	272.800F	0.000	44.445	0	0	286	0	286	266.500F	279.100F
Stack 78	4,648	70.500F	0.000	44.445	0	0	310	0	310	64.200F	76.800F
Stack 70	4,648	99.400F	0.000	44.445	0	0	310	0	310	93.100F	105.700F
Stack 66	4,648	113.850F	0.000	44.445	0	0	310	0	310	107.550F	120.150F
Stack 58	4,648	142.750F	0.000	44.445	0	0	310	0	310	136.450F	149.050F
Stack 54	4,648	157.200F	0.000	44.445	0	0	310	0	310	150.900F	163.500F
Stack 50	4,648	171.650F	0.000	44.445	0	0	310	0	310	165.350F	177.950F
Stack 46	4,648	186.100F	0.000	44.445	0	0	310	0	310	179.800F	192.400F
Stack 42	4,648	200.550F	0.000	44.445	0	0	310	0	310	194.250F	206.850F
Stack 38	4,648	215.000F	0.000	44.445	0	0	310	0	310	208.700F	221.300F
Stack 34	4,424	229.450F	0.000	44.768	0	0	302	0	302	223.150F	235.750F
Stack 74	4,648	84.950F	0.000	44.445	0	0	310	0	310	78.650F	91.250F

CONSTANT

Name	Weight MT	LCG m-AP	VCG m-BL	TCG m-CL
Stores Distributed	120	160.000F	27.200	0.000
Loose Fitting, Gear, Spares	200	180.000F	40.000	0.000
Bosun Stores	40	385.000F	28.755	0.000

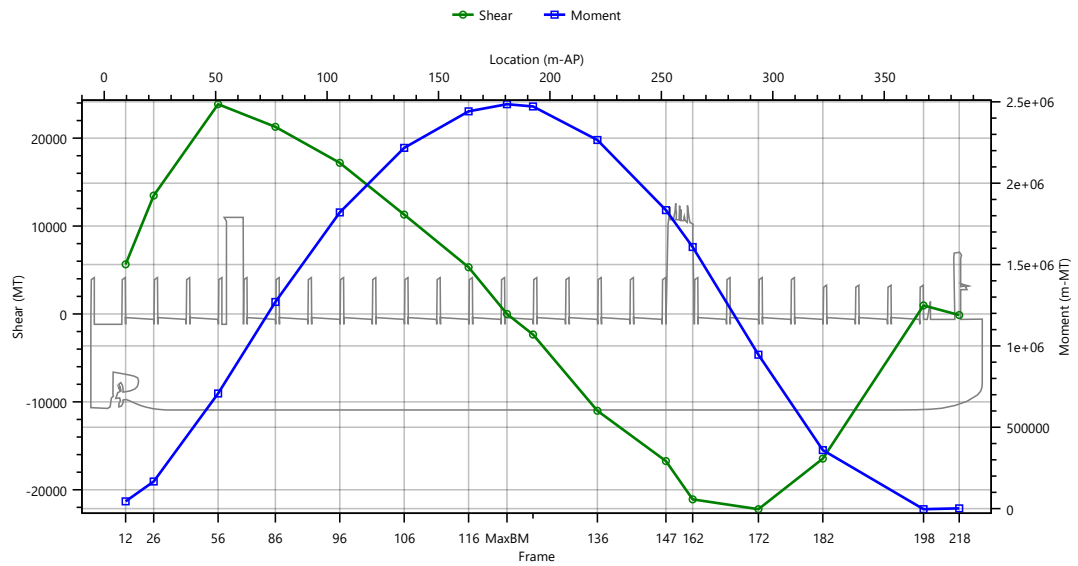
Water in Piping	50	160.000F	1.350	0.000
Crew & Effects	6	258.450F	55.000	0.000
Provisions	7	258.450F	40.000	0.000
ER Misc Tanks	50	62.350F	25.000	0.000

Righting Arm Summary



Heel Axis deg CCW-Fwd	Heel deg	Trim deg	GzT m	GzL m	Heel0 deg	Trim0 deg	Draft AP m	Draft FP m	Iterations
0.00	0.00	0.00	-0.005	0.002	0.00	0.00A	16.330	16.301	4
0.00	1.00	0.00	0.034	0.001	1.00S	0.00A	16.327	16.302	2
0.00	5.00	-0.01	0.195	0.000	5.00S	0.01F	16.254	16.324	3
0.00	10.00	-0.05	0.416	0.000	10.00S	0.05F	16.042	16.381	3
0.00	20.00	-0.17	1.018	-0.001	20.00S	0.17F	15.315	16.472	3
0.00	30.00	-0.29	1.784	0.000	30.00S	0.29F	14.204	16.175	3
0.00	45.00	-0.57	0.933	-0.001	45.00S	0.57F	11.214	15.163	5
0.00	60.00	-1.06	-2.084	0.000	60.00S	1.06F	6.243	13.554	9
0.00	75.00	-2.45	-5.689	0.000	75.01S	2.45F	-7.140	9.711	17

Strength Summary



Xfr m-AP	Buoyancy MT	Weight MT	Shear MT	Buoy Moment m-MT	Wt Moment m-MT	Moment m-MT
9.600F	831	6,477	5,646	6,323S	50,916S	44,593H
22.200F	2,607	16,072	13,465	26,159S	192,785S	166,626H
51.100F	13,614	37,474	23,860	236,434S	944,044S	707,610H
76.800F	31,787	53,072	21,285	804,766S	2,074,850S	1,270,084H
105.700F	58,677	75,867	17,190	2,101,484S	3,921,860S	1,820,376H
134.600F	87,544	98,847	11,303	4,213,576S	6,430,567S	2,216,991H
163.500F	116,541	121,855	5,314	7,162,577S	9,604,071S	2,441,495H
180.727F	133,826	133,823	-2	9,319,157S	11,804,490S	2,485,333H
192.400F	145,536	143,197	-2,339	10,949,598S	13,421,172S	2,471,574H
221.300F	174,529	163,514	-11,015	15,574,549S	17,839,990S	2,265,441H
252.050F	205,335	188,598	-16,737	21,415,245S	23,249,672S	1,834,427H
264.050F	217,294	196,202	-21,092	23,951,085S	25,558,679S	1,607,594H
293.550F	246,115	223,905	-22,210	30,789,441S	31,735,310S	945,869H
322.450F	271,299	254,842	-16,458	38,279,675S	38,639,272S	359,597H
367.650F	293,143	294,112	969	51,125,638S	51,122,082S	3,556S
383.650F	295,972	295,846	-126	55,841,763S	55,843,249S	1,486H