MTCC ASIA
Maritime Technology Cooperation Centre

GMN | The Global MTCC Network
A global network for energy-efficient shipping

GUIDELINES ON SHIP FUEL OIL CONSUMPTION DATA COLLECTION AND REPORTING

Maritime Technology Cooperation Centre for Asia (MTCC-Asia)

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Preface

The International Maritime Organization (IMO) and the European Commission (EC) reached an agreement in December 2015 to establish and seed-fund a global network of five Maritime Technology Cooperation Centres (MTCCs) in developing countries in the framework of the “Capacity Building for Climate Mitigation in the Maritime Shipping Industry” Project, with a funding contribution from the European Union (EU). The concept of establishing a global network of MTCCs to accelerate capacity building and technology transfer in the maritime field arose in response to a resolution (MEPC.229(65)) adopted by IMO in 2013, on “Promotion of Technical Co-operation and Transfer of Technology relating to the Improvement of Energy Efficiency of Ships”.

The overall objective of the Project is to support selected developing countries in limiting and reducing greenhouse gas (GHG) emissions from their shipping sector through technical assistance/capacity-building to promote low-carbon and energy efficient shipping technologies and operations. More specifically, the Project aims to establish five MTCCs one in each of the target regions (Asia, Africa, the Caribbean, Latin America and the Pacific), which would act as centres of excellence to promote the uptake of low-carbon technologies in maritime transport.

Shanghai Maritime University (SMU) was selected as the host institution of MTCC for Asia (MTCC-Asia) in December 2016. Funded by the European Union and implemented by the IMO, MTCC-Asia under the guidance of the IMO Project Coordination Unit (PCU) is making every endeavor to achieve the above-mentioned objectives through a number of actions including pilot projects, regional and national workshops, international conferences, technical seminars, postgraduate program, branch offices, and dissemination activities.

This publication is one of the outputs under the framework of the clearly

defined pilot project on “ship fuel oil consumption data collection and reporting”. The annual accurate amount of CO_2 emissions from ships is one of the most important bases for the international shipping sector to scientifically develop the strategy of reducing the GHG emissions from ships, assess the implementation effectiveness of current mandatory regulations and introduce new mandatory regulations.

However, due to the fact that ships engaged in international voyages are of great amounts, a great variety, complicated operational modes and high mobility, the traditional estimation approaches based on the global marine fuel sales, statistics analysis of global ship fleet database as well as statistics analysis of global ship navigational status are not the most accurate methods to calculate the annual cumulative amount of CO_2 emissions from ships. But if it is mandatorily required that each ship record and report its annual fuel consumption data to its flag state and the flag state accordingly reports the data collected from each ship to the IMO, then in principle the total amount of annual fuel consumption from ships may be most accurately determined.

In this regard, IMO adopted amendments to MARPOL Annex VI on data collection system for fuel oil consumption of ships through the resolution MEPC.278(70) in order to mandatorily implement the ship fuel consumption data collection and reporting scheme, which entered into force on 1 March 2018.

Besides the main purpose of providing overall knowledge and practices related to ship fuel consumption data collection and reporting, more importantly, this publication also aims to raise the awareness of each practitioner in the shipping sector of better understanding the mission and the international regulatory framework developed under leading role of the IMO for the reduction of GHG emissions from ships.

The contributions made towards the mission of reducing GHG emissions from ships rely not only on the marine regulators, maritime administrators and ship managers, but also on seafarers. As the front-line operator of a ship,

each seafarer can play a direct and significant role in limiting or reducing GHG emissions from ships. To facilitate readers, in particular seafarers, this publication is written in a user-friendly language through the avoidance of the complex terminology and formula as far as possible and is organized in five parts as follows:

- Chapter I presents the overall regulations developed and various actions conducted by IMO to enhance the energy efficiency and reduce GHG emissions from international shipping as a contribution to the global actions against climate change under the United Nations Framework Convention on Climate Change (UNFCCC).

- Chapter II provides the intent of and the mandatory requirements on the ship fuel consumption data collection and reporting.

- Chapter III introduces in detail principles, precautions and data submitted requirements of three data collection methods, i.e. method using bunker delivery notes (BDNs), method using fuel oil tanker monitoring on board and method using flow meters.

- Cases of ship fuel consumption data collection and reporting from containership, bulk carrier and oil tanker are presented in Chapter IV.

- Operational guidance for users’ reference on a simplified software of ship fuel consumption data collection and reporting is demonstrated in Chapter V.

Comments and observations are welcome to be sent to the feedback contact information shown on the back cover of this publication.

MTCC-Asia
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Abbreviations and Unit Symbols

℃	Celsius degree
BDNs	Bunker Delivery Notes
CBDR	Common But Differentiated Responsibilities
CFD	Computational Fluid Dynamics
CH_4	methane
CO_2	carbon dioxide
DWT	Deadweight Ton
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
GHG	Greenhouse Gas
GISIS	Global Integrated Shipping Information System
GloMEEP	Global Maritime Energy Efficiency Partnerships
GMN	Global MTCCs Network
GT	Gross Tonnage
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
kn	knot
kW	kilowatts
LFO	Light Fuel Oil
LNG	Liquefied Natural Gas

m	meter
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	Marine Environment Protection Committee
MBM	Market-based Mechanism
mt	million metric tons
N_2O	nitrous oxide
NT	Net Tonnage
RO	Recognized Organizations
PDF	Positive Displacement Flowmeters
ppb	part per billion
ppm	parts per million
SEEMP	Ship Energy Efficiency Management Plan
t	metric ton
UNFCCC	United Nations Framework Convention on Climate Change

Chapter I
Reduction of GHG Emissions from Ships

1.1 Climate change

Human activities, in particular the rising fossil fuel combustion, have directly emitted growing amounts of greenhouse gases (GHG) into the Earth's atmosphere. A cumulative rise of anthropogenic GHG such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) has led to in the Earth's atmosphere a rise of the heat from the sun that would in principle be rebounded back into space. The increase of his heat in the Earth's atmosphere has changed the natural climate variability, resulting in the climate change.

The direct impacts of climate change on the Earth can be summarized as follows:

- increases in the average global temperature (global warming),
- changes in cloud cover and precipitation particularly over land,
- melting of ice caps and glaciers and reduced snow cover, and
- increases in ocean temperatures and ocean acidity

Further, it is well recognized that the major threats caused by the global warming have had severe impacts on human sustainable survival and natural systems, including:

- the rise of the sea mean level,
- the biodiversity losses,
- more frequent and extreme weather events,
- the creation of new diseases,
- the famine aggravation, and
- the losses of traditional lifestyles.

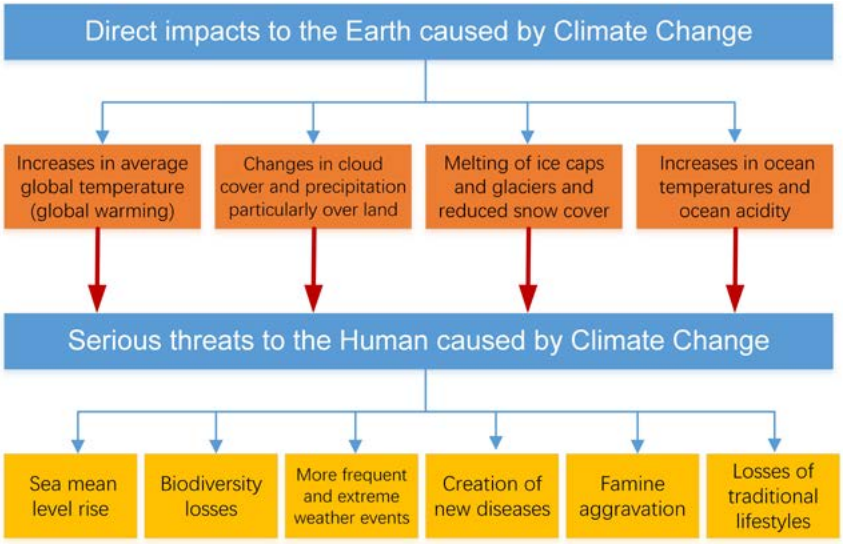

Figure 1-1 Direct impacts and threats to Human caused by climate change

1.2 Global mission in controlling GHG emissions

The study conducted by the Intergovernmental Panel on Climate Change (IPCC)[1] shows that over the last 160 years, atmospheric concentrations of CO_2, CH_4 and N_2O have increased from a pre-industrial value to 100 parts per million (ppm), 1,000 parts per billion (ppb) and 60ppb, respectively (see Figure 1-2), and globally the averaged surface temperature has a rise of 0.85 [0.65 to 1.06] °C from 1880 to 2012 (see Figure 1-3).

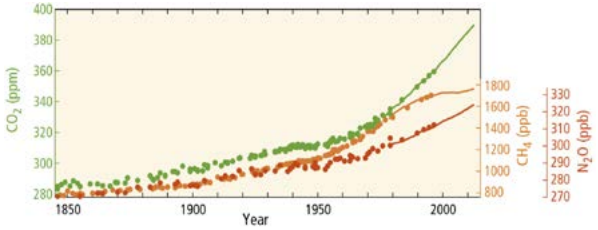

Figure 1-2 Change of global GHG average concentration[2]

In addition, it is projected based upon four global mitigation scenarios (Representative Concentration Pathways)[3] that the increase of the global mean surface temperature relative to 1986-2005 range from a minimum of 0.3°C to as much as 4.8°C rise.

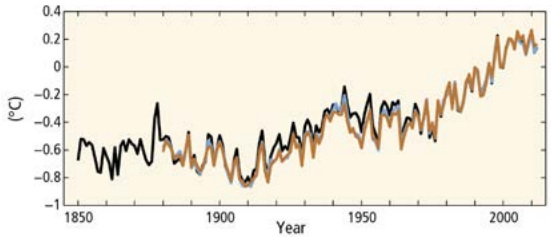

Figure 1-3 Change of global average temperature[4]

1.IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.
2.Ibid.
3.Ibid.
4.Ibid.

Limiting global warming would require all countries and sectors to take coordinated actions for the substantial and sustained reductions in the anthropogenic GHG emissions. In this regard, the United Nations Framework Convention on Climate Change (UNFCCC) has been internationally adopted in 1992, which set a goal to achieve stabilization of GHG Concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Then in 1997, the Kyoto Protocol to UNFCCC has set for the first time binding emissions targets for cleveloped countries, with a view to reducing their overall GHG emissions by 5.0% within 2008-2012 as compared to 1990. In 2012 this requirement was extended until 2020 by the Doha Amendment.

Further, the Paris Agreement to UNFCCC which was adopted in 2015 has reached a global target to maintain the average global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C.

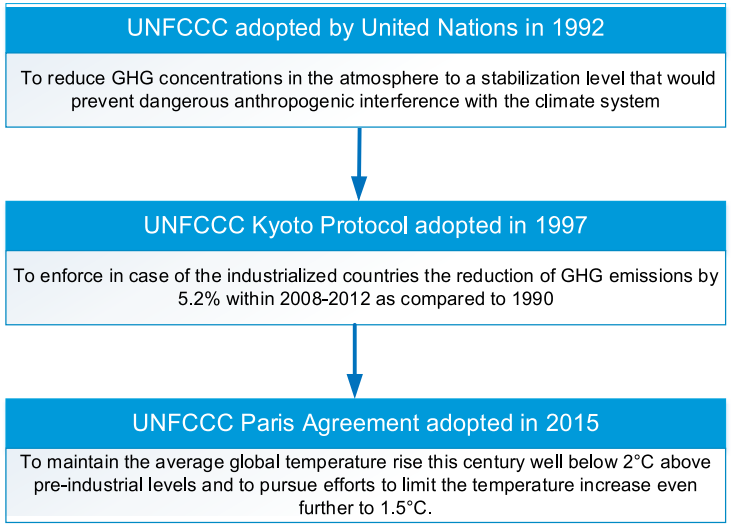

Figure1-4 Global mission in controlling GHG emissions

1.3 GHG emissions from international shipping sector

International shipping carries over 80% of all traded goods by volume and over 70% by value. About more than 50,000 merchant ships registered in over 150 nations are trading internationally. According to the Third IMO GHG Study 2014[5], international shipping has emitted 866 million tonnes of GHG (in CO_2 equivalent) per year on average between 2007 and 2012 which represented approximately 2.4% of global anthropogenic GHG emissions, and emitted 846 million tonnes of CO_2 emissions per year on average between 2007 and 2012, accounting for about 2.6% of global CO_2 emissions per year on average on the same period. Moreover, despite the amelioration through the technological and operational measures, the future CO_2 emissions from the international shipping sector are projected to rise by between 50% and 250% over the period 2012-2050 based on the business-as-usual (BAU) scenario that assumes a tripling in world trade.

Table 1-1 GHG and CO_2 emissions of international shipping sector from 2007 to 2012 (mt)[6]

Year	GHG	% of global	CO_2	% of global
2007	903	2.6%	885	2.8%
2008	940	2.6%	921	2.9%
2009	873	2.5%	855	2.7%
2010	790	2.1%	771	2.3%
2011	871	2.3%	850	2.4%
2012	816	2.1%	796	2.2%
Average	866	2.4%	846	2.6%

Consequently, it is indispensable that the international shipping industry shall take necessary actions to effectively limit and reduce the GHG emissions from ships in order to help achieve the goal in controlling the rise of global surface temperature which is laid down in the Paris Agreement to UNFCCC.

5.IMO GHG Study, 2014.
6.Ibid.

1.4 Control of GHG emissions from ships

1.4.1 Leading role of IMO in limiting GHG emissions from ships

The International Maritime Organization (IMO) is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. In September 1997, an international conference of parties to the International Convention for the Prevention of Pollution from Ships (MARPOL Convention), which adopted the Protocol of 1997 to amend the MARPOL Convention (MARPOL Annex VI), also adopted Conference resolution 8 on CO_2 emissions from ships. This resolution invited the Marine Environment Protection Committee (MEPC) to consider what CO_2 reduction strategies might be feasible in light of the relationship between CO_2 and other atmospheric and marine pollutants. The resolution also invited IMO, in cooperation with the UNFCCC, to undertake a study[7] of CO_2 emissions from ships for the purpose of determining the amount and relative percentage of CO_2 emissions from ships as part of the global inventory of CO_2 emissions.

Kyoto Protocol to UNFCCC calls upon that the parties included in its Annex I shall pursue limitation or reduction of emissions of GHG from marine bunker fuels working through the IMO. Even though the Paris Agreement neither explicitly mentions the international shipping industry in the global GHG emissions reduction targets nor specifically mentions that IMO should be acting as a body setting the international measures to restrict GHG emissions from the international shipping sector, the work regarding international shipping GHG emissions reductions is put, like in the Kyoto Protocol, on the shoulder of IMO in light of the fact that the leading role of IMO in limiting GHG emissions from international shipping industry has been well acknowledged, with its regular submission of reports on this issue, to the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA).

1.4.2 Two principles of reducing GHG emissions from ships

Since almost all merchant ships are propelled by fossil-fuel-powered marine

7.Study of Greenhouse Gas Emissions from Ships, IMO, 2000.

diesels, in principle, there are only two principles in limiting or reducing GHG emissions from ships:

- using less fossil fuels (also called the uptake of energy efficiency), and
- using alternative type of energy.

1.4.3 Three types of measures for reducing GHG emissions from ships

Guided by these two principles and considering the first IMO Study on GHG emissions from ships, in December 2003, the IMO Assembly adopted the resolution A.963(23) on IMO Policies and Practices related to the Reduction of Greenhouse Gas Emissions from Ships, which urged the IMO MEPC to identify and develop the mechanisms needed to achieve the limitation or reduction of GHG emissions from international shipping. There are mainly three types of measures to reduce GHG emissions from ships:

- technology-based measures,
- operation-based measures, and
- market-based measures.

(1) Technology-based measures

The most direct and efficient measure to limit or reduce GHG emissions from international shipping sector is naturally through the advanced technologies to design and build greener ships whose energy efficiency can be greatly promoted and GHG emissions be reduced accordingly. In order to encourage ship designers and builders to reduce CO_2 emissions by freely using the most cost-efficient solutions as well as to stimulate continual technological innovation and development influencing the energy efficiency of a ship, the Energy Efficiency Design Index (EEDI), a new index reflecting the ship's design energy efficiency, has been developed and established by IMO.

In July 2011, IMO adopted mandatory measures to improve the energy

efficiency of international shipping through resolution MEPC.203(62), representing the first-ever global mandatory energy efficiency standard for the international shipping sector, the first legally binding instrument adopted since the Kyoto Protocol to UNFCCC that addresses GHG emissions and the first global mandatory GHG-reduction regime for an international shipping sector.

The amendments adopted by resolution MEPC.203(62) added a new Chapter 4 entitled “Regulations on energy efficiency for ships” to MARPOL Annex VI. This technical requirement applicable to new ships of 400 Gross Tonnage (GT) and above is known as EEDI, which sets a minimum energy efficiency level for the work undertaken for different ship types and sizes, see Annex 1. These mandatory requirements entered into force on 1 January 2013.

EEDI is a non-prescriptive, performance-based mechanism that allows ship designers and builders to freely choose and use any technology for the uptake of a new individual ship’s energy efficiency as long as the attained energy efficiency level is in compliance with the regulations. EEDI is a quantified measure representing the amount of CO_2 generated by a ship while doing one tonne-mile of transport work. EEDI is able to be calculated for each newly-built ship using a complex formula consisting of a number of factors and coefficients, such as the ship’s deadweight, emissions and speed, and more technical parameters, to index the impact on environment from shipping vs the benefit to society from shipping. Lower EEDI figure means lower impact on environment from shipping and higher the benefit to society from shipping.

$$\text{EEDI} = \frac{\text{impact on environment from shipping}}{\text{benefit to society from shipping}}$$

$$= \frac{\text{amount of } CO_2 \text{ emissions from the ships}}{\text{ship's capacity} \times \text{ship's reference speed}}$$

Furthermore, EEDI requirements increase over time through successive phases with more and more stringent reduction factors, and that they are regularly reviewed to take into account the technological developments.

To date, EEDI requirements of 12 different types of ships are provided by regulations 20 and 21 of MARPOL Annex VI and are specified by various

IMO Guidelines, e.g. the 2018 Guidelines on the method of calculation of the attained EEDI for new ships (Resolution MEPC.308(73)).

Figure 1-5 Ship types that EEDI has been regulated

(2) Operation-based measures

The compulsory technology-based requirements of EEDI can only be observed by ship’s designers and builders as it is only applicable to new ships. This measure has optimized the world ship fleet in the future. However, there still needs some measures to limit or reduce the GHG emissions from existing ships. It is well recognized that a variety of efficient operations during ship’s sailing time, such as improved voyage planning, weather routing, just-in-time arrival at port, speed optimization, optimized shaft power and optimum trim, can also make a noticeable contribution to improving the ship energy efficiency if ship operators and seafarers adequately implement those operations.

Considering both the necessity of introducing efficient operations that can make an invaluable contribution to reducing global GHG emissions into the shipping

industry and the flexibility of allowing ship operators to freely decide what measures to adopt for ensuring the uptake of ship energy efficiency, regulation 22 of MARPOL Annex VI also stipulates the mandatory requirements for all ships of 400 GT and above engaged in international voyages to keep on board a specific Ship Energy Efficiency Monitoring Plan (SEEMP).

SEEMP is to establish a mechanism for ship operators to improve the energy efficiency of existing ships in a cost-effective manner. According to the relevant IMO guidelines[8], SEEMP "provides a possible approach for monitoring ship and fleet efficiency performance over time and some options to be considered when seeking to optimize the performance of the ship." This implies that shipping companies may establish the on-shore and on-board management procedure monitoring ship's energy efficiency performance by using a specific tool, such as the Energy Efficiency Operation Indicator (EEOI) and regularly reviewing new technologies and practices to improve ship's energy efficiency

Each SEEMP is unique to a specific ship and shall provide an approach to monitoring, evaluating and promoting this ship's energy efficiency. The efficient application of SEEMP is recommended by undertaking a four-stage continuous improvement cycle process: planning, implementation, monitoring, and self-evaluation and improvement.

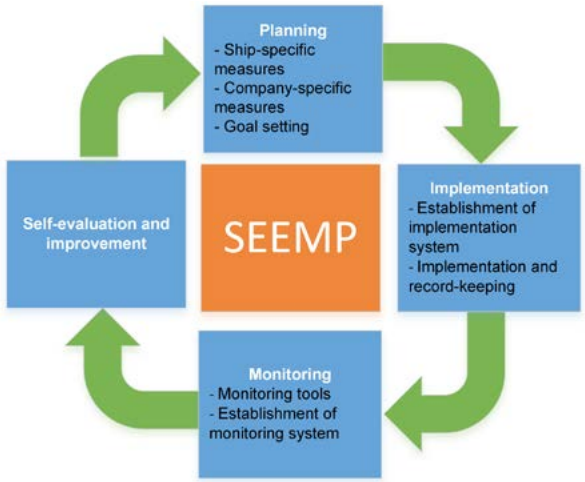

Figure 1-6 SEEMP application process

8.Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP), resolution MEPC.282(70), 2016.

(3) Market-based measures

Subject to the projected growth of world trade and fleet, market-based mechanisms (MBMs), in addition to the technical and operational measures, could be required to reduce substantially the GHG emissions from international shipping. The aim of an MBM is to put a price on carbon, in order to provide an economic incentive to invest in more efficient technologies or operate ships in a more energy efficient manner (in-sector reductions) and/or to offset emissions generated by ships in other sectors where the reduction of emissions is more economic (out-of-sector reductions).

MBMs have been considered by IMO since 2006. However, due to political divergences among member States and to many remaining technical uncertainties, such as the actual efficiency of such measures to reduce GHG emissions and their possible impacts on the economies of developing countries, these discussions have been suspended so far.The Initial IMO Strategy on reduction of GHG emissions from ships adopted in 2008 identifies the development of "new/innovative emission reduction mechanism(s), possibly including Market-Based Measures, to incentivize GHG emission reduction" as a candidate mid-term measure.

1.5 The Initial IMO Strategy on reduction of GHG emissions from ships

Despite the technical, operational and market-based measures which are applied or have been considered, there still remains in the international shipping sector a question on how much the GHG emissions from ships shall be further reduced in order to ensure that the maritime transport can satisfactorily contribute to the reduction of GHG emissions targets set out by the current global instruments, in particular the Paris Agreement.

In response to this challenge, IMO has adopted in April 2018 an Initial Strategy on reduction of GHG emissions from ships (resolution MEPC.304(72)).

1.5.1 Main content of the Initial Strategy

The Initial Strategy envisages for the first time a reduction in total GHG emissions from international shipping, representing a framework for the future vision for international shipping, the levels of ambition to reduce GHG emissions and guiding principles; and including candidate short-, mid- and long-term further measures with possible timelines and their impacts on States.

The "Vision" set out in the Initial Strategy confirms IMO's commitment to reducing GHG emissions from international shipping and, as a matter of urgency, to phasing them out as soon as possible in this century. Reference is made to the temperature goals of the Paris Agreement in the “Levels of ambition” with the aim to:

- strengthen the energy efficiency design requirements for ships with the percentage improvement for each phase to be determined for each ship type, as appropriate;
- reduce CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008; and
- peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 whilst pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO_2 emissions reduction consistent with the Paris Agreement temperature goals.

In the Initial Strategy, 13 types of candidate short-term measures such as establishment of an Existing Fleet Improvement Programme, 5 types of candidate mid-term measures such as development of a feedback mechanism to enable lessons learned on implementation of measures to be collated and shared through a possible information exchange on best practice, and 2 types of candidate long-term measures are listed, respectively.

As outlined in the Initial Strategy, the impacts on States of a measure should be assessed and taken into account as appropriate before adoption of the measure. In May 2019, MEPC 74 approved the MEPC.1/Circ.885 on Procedure for assessing impacts on States of candidate measures for reduction of GHG emissions from ships. The procedure identifies up to four steps (from an initial to a comprehensive impact assessment) in order to facilitate the best possible anticipation of the potential impacts of candidate measures before adoption.

1.5.2 Key stages based on the three-step approach for the adoption of a Revised Strategy in 2023

To consider further measures to enhance the energy efficiency of ships, a three-step approach was agreed by IMO in 2015 and included in the Initial Strategy:

- step 1: Data collection (2019-2021),
- step 2: Data analysis (2020-2021), and
- step 3: Decision step (2022-2023).

The data collection step involves the collection and reporting of data on ship fuel oil consumption. The data analysis conducted in 2020-2021 will be used to adjust and revise the Initial Strategy in 2023. Further data collection and analysis in the following years will contribute to the decision-making process in the implementation of the Revised Strategy. Figure 1-7 shows the roadmap for developing a comprehensive IMO strategy on reduction of GHG emissions from ships.

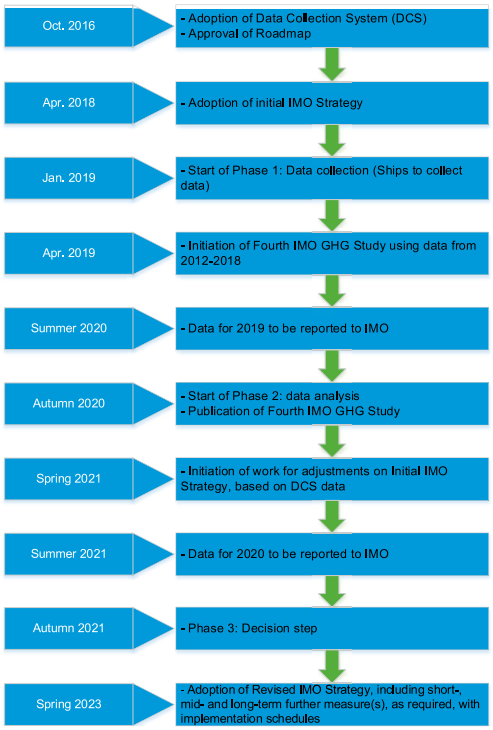

Figure 1-7 Roadmap for developing a comprehensive IMO strategy on reduction of GHG emissions from ships

1.6 Overview of the international regulatory framework for reducing GHG emissions from ships

The holistic structure of international regulatory regime on mitigating GHG emissions from ships from top to down is comprised by six levels: global target, IMO strategic direction, initial IMO strategy, MARPOL Convention, three specific measures and supportive activities, see Figure 1-8.

IMO has embarked on a strategic direction related to the response to the climate change to demonstrate its responsibility in addressing the global target set in the Paris Agreement. The adopted Initial IMO strategy on reduction of GHG emissions from ships represents a guiding framework for the future vision of the international shipping sector to reduce GHG emissions from ships, which

will be mainly achieved through the effective implementation of amendments to the Annex VI of MARPOL Convention and other relevant instruments developed by IMO. Two out of three specific measures, technology-based and operation-based, are already compulsorily implemented as required by MARPOL Convention while the MBMs have been considered. The additional activities including IMO 4th GHG Study, Model Course, technical cooperation and capacity building and a great deal of relevant technical guidelines provide excellent support in developing and implementing the international regulations on GHG emissions reduction from ships. The overall methodology to bridge Initial IMO strategy on reduction of GHG emissions from ships and supportive actions is guided under a three-step approach and the roadmap for developing a strategy on reduction of GHG emissions from ships.

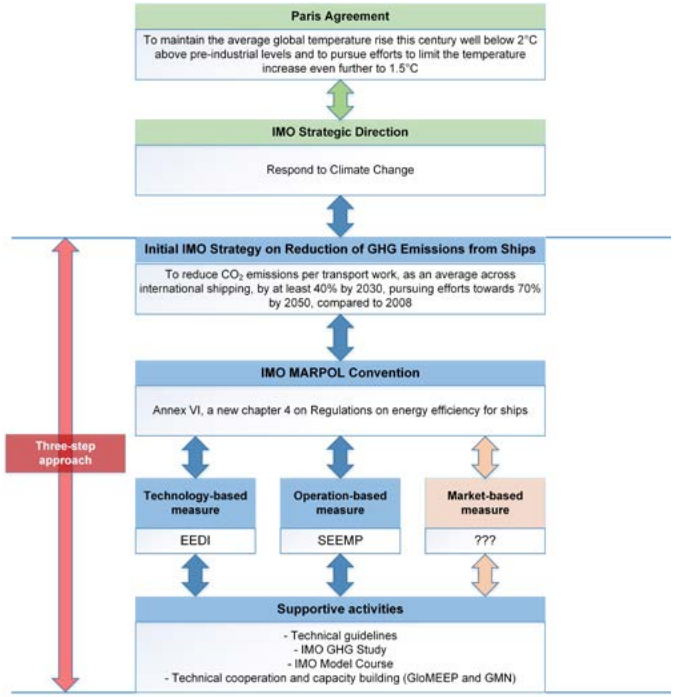

Figure 1-8 International regulatory framework of reducing GHG emssions from ships

As of December 2018, a total of 25 regulations related to the reduction of GHG emissions from ships have been published, as listed in Annex 2.

Chapter II Introduction of Ship Fuel Oil Consumption Data Collection and Reporting

2.1 Intent of ship fuel oil consumption data collection and reporting

The annual accurate amount of CO_2 emissions from ships is one of the most important bases for the international shipping sector to scientifically develop the strategy of reducing the GHG emissions from ships, assess the implementation effectiveness of current mandatory regulations and introduce new mandatory regulations. The amount of CO_2 emissions from a ship is able to be calculated based on the multiplication between ship's fuel consumption and fuel emission factor:

Amount of CO_2 emission=ship's fuel consumption × fuel emission factor

As the fuel emission factor of CO_2 varies from different types of fuel (see Table 2-1 in this chapter), the annual accurate amount of various types of ships' fuel consumption shall be firstly obtained before the annual accurate amount of CO_2 emissions from ships is calculated. However, due to the fact that ships engaged in international voyages are of great amounts, a great variety, complicated operational modes and high mobility, the traditional estimation approaches based on the global marine fuel sales, statistics analysis of global ship fleet database as well as statistics analysis of global ship navigational status are not the most accurate methods to calculate the annual cumulative amount of CO_2 emissions from ships.

In reality, it is a common practice that each ship records daily fuel consumption data and reports this data to the relevant parties such as its managers and charterers. Therefore, if it is mandatorily required that each ship record and report its annual fuel consumption data to its flag state and the flag state accordingly submit the data collected from each ship to the IMO, then in principle the total amount of annual fuel consumption from ships can be determined by the IMO and thus the total amount of annual CO_2 emissions from ships can also be calculated.

2.2 Mandatory regulations on ship fuel oil consumption data collection and reporting

In order to mandatorily implement the ship fuel consumption data collection and reporting scheme, IMO adopted amendments to MARPOL Annex VI on data collection system for fuel oil consumption of ships through the resolution MEPC.278(70) (see Annex 1), which entered into force on 1 March 2018. Under the amendments, the regulation 22A of collection and reporting of ship fuel oil consumption data, the Appendix IX on information to be submitted to the IMO Ship Fuel Oil Consumption Database and the Appendix X on Form of Statement of Compliance – Fuel Oil Consumption Reporting are added in the chapter 4 of MARPOL Annex VI.

The amendments require ships of 5,000 gross tonnage and above shall to collect consumption data for each type of fuel oil they use, as well as other, additional, specified data including proxies for transport work. The aggregated data shall be reported to the flag State after the end of each calendar year (the first calendar year begins from 1 January until 31 December inclusive 2019 within 3 months after the end of each calendar year) and the flag State, having determined that the data has been reported in accordance with the requirements, issues a Statement of Compliance to the ship no later than 5 months from the beginning of the calendar year. Flag States are required to subsequently transfer this data to an IMO Ship Fuel Oil Consumption Database. IMO will be required to produce an annual report to MEPC, summarizing the data collected. Before the process, on or before 31 December 2018, in the case of a ship of 5,000 gross tonnage and above, the SEEMP in its Part II shall include a description of the methodology that is used to collect the data and the processes that are used to report the data to the ship's flag State.

Requirements of ship fuel consumption data collection and reporting are a multi-parties process in which ships, flag States, Recognized Organizations (RO) and IMO Secretariat are technically involved. In terms of the developing progress of global ship information system, it directly requires IMO to develop and maintain a new Database on global Ship Fuel Consumption Data. The whole process

and corresponding descriptions on ship fuel consumption data collection are summarized in Figure 2-1.

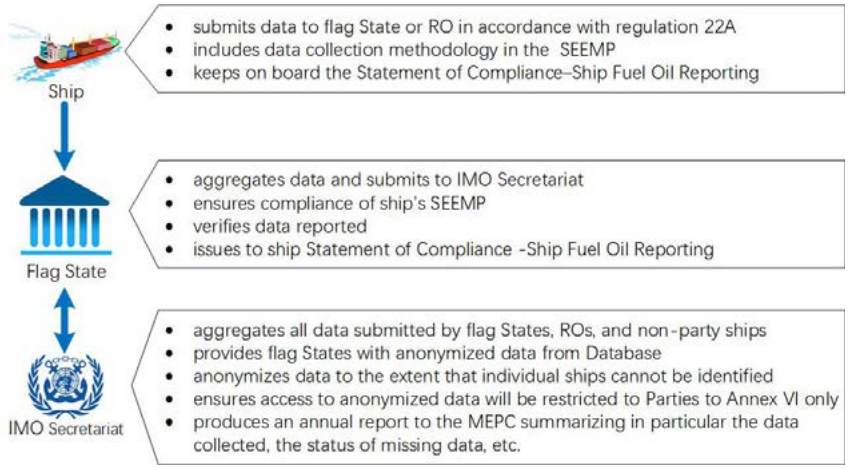

Figure 2-1 Process of ship fuel oil consumption data collection and reporting

Figure 2-2 shows the regulatory timeline of ship fuel oil data collection (with the year of 2019 as an example).

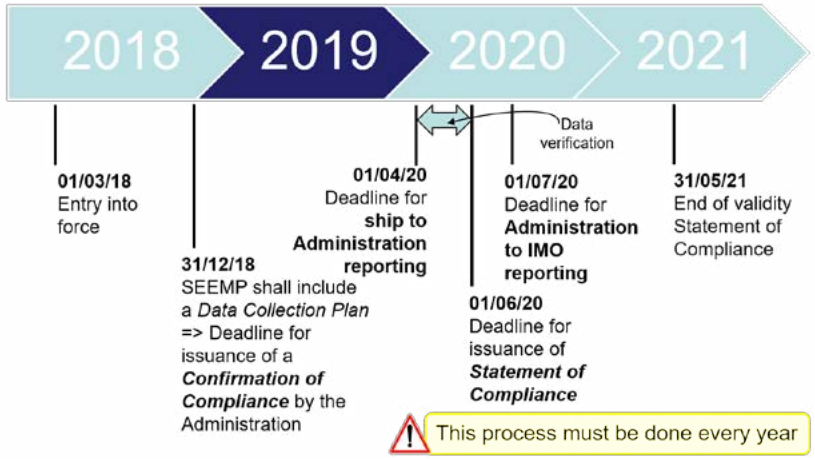

Figure 2-2 Regulatory timeline of ship fuel oil data collection

2.3 Ship fuel emission factor

Fuel emission factor is a non-dimensional conversion factor representing the relation between fuel consumption and its corresponding gas emissions. The emission factor of CO_2 for various types of fuel oil (CF) can be found in the 2018 Guidelines on the method of calculation of the attained EEDI for new ships (Resolution MEPC.308(73)), see Table 2-1.

Table 2-1 Emission factor of CO_2 for various types of fuel oil

Fuel oil type	CF (t-CO_2 / t-Fuel)
Diesel/Gas oil (e.g. ISO 8217 grades DMX through DMB)	3.206
Light fuel oil (LFO) (e.g. ISO 8217 grades RMA through RMD)	3.151
Heavy fuel oil (HFO) (e.g. ISO 8217 grades RME through RMK)	3.114
Liquefied petroleum gas (LPG) (Propane)	3.000
Liquefied petroleum gas (LPG) (Butane)	3.030
Liquefied natural gas (LNG)	2.750
Methanol	1.375
Ethanol	1.913

2.4 Data types of ship fuel oil consumption collection and reporting

Data related to collection and reporting of ship fuel oil consumption data are mainly divided into static data (ship basic data) and dynamic data.

2.4.1 Ship static data

In accordance with the appendix IX of MARPOL Annex VI and to the 2016 Guidelines for the development of a SEEMP (resolution MEPC.282(70)), in particular its appendix 3, the contents and requirements of the 8 types of ship static data to be recorded during the implementation of the ship fuel oil consumption data collection and reporting are shown in Table 2-2.

Table 2-2 Static data reporting format for the data collection system

No.	Ship static data	Requirement	
1	IMO number	In accordance with the IMO Ship Identification Number Scheme, adopted by the Organization by resolution A.1078(28).	
2	Ship type	As defined in regulation 2 of MARPOL Annex VI or other (to be stated).	
3	Gross tonnage	Gross tonnage should be calculated in accordance with the International Convention on Tonnage Measurement of Ships, 1969.	
4	Net tonnage	NT should be calculated in accordance with the International Convention on Tonnage Measurement of Ships, 1969. If not applicable, note "N/A".	
5	DWT	DWT means the difference in tonnes between the displacement of a ship in water of the relative density of 1025 kg/m^3 at the summer load draught and the lightweight of the ship. The summer load draught should be taken as the maximum summer draught as certified in the stability booklet approved by the Administration or an organization recognized by it.	
6	EEDI (if applicable)	EEDI should be calculated in accordance with the the appendix IX of MARPOL Annex VI and to the 2016 Guidelines for the development of a SEEMP (resolution MEPC.282(70)), in particular its appendix 3. If not applicable, note "N/A".	
7	Ice class (if applicable)	Ice class should be consistent with the definition set out in the International Code for ships operating in polar waters (Polar Code), adopted by resolutions MEPC.264(68) and MSC.385(94)). If not applicable, note "N/A".	
8	Power output(rated power) (kW)	Main Propulsion Power	Power output (rated power) of main and auxiliary reciprocating internal combustion engines over 130 kW (to be stated in kW). Rated power means the maximum continuous rated power as specified on the nameplate of the engine.
		Auxiliary Engine (s)	

2.4.2 Ship dynamic data

The contents and requirements of the 6 types of ship dynamic data to be recorded during the implementation of the ship fuel oil consumption data collection and reporting are shown in Table 2-3.

Table 2-3 Dynamic data reporting format for the data collection system

No.	Ship dynamic data		Requirements
1	Start date (dd/mm/yyyy)		The first day of a calendar year,for example, 1 January, 2019.
2	End date (dd/mm/yyyy)		The last day of a calendar year,for example, 31 December 2019.
3	Distance travelled (nm)		The distance travelled over ground while the ship is underway under its own propulsion shall be recorded in the log-book.
4	Hours underway (h)		The time period corresponding to the ship's distance travelled.
5	Fuel oil consumption (t)	HFO	Quantity in metric tonnes. Fuel oil consumption should include all the fuel oil consumed on board including but not limited to the fuel oil consumed by the main engines, auxiliary engines, gas turbines, boilers and inert gas generator, for each type of fuel oil consumed, regardless of whether a ship is underway or not.
		LFO	
		Diesel/Gas Oil	
		LPG (Propane)	
		LPG (Butane)	
		LNG	
		Methanol	
		Ethanol	
		Others	
6	Method used to measure fuel oil consumption		Methods used to measure fuel oil consumption: 1: method using BDNs 2: method using flow meters 3: method using bunker fuel oil tank monitoring

2.4.3 Data submitted to IMO by flag state

Upon completion and verification of the data collected by its ships, aggregated data of ships shall be submitted by the flag State or a Recognized Organization to IMO via the dedicated GISIS module in accordance with the User guidance on the ship fuel oil consumption GISIS module (IMO Ship fuel oil consumption database) (Circular letter No.3827).

Chapter III Methods Of Ship Fuel Oil Consumption Data Collection

In compliance with the 2016 Guidelines for the development of a SEEMP (resolution MEPC.282(70)), in particular Part II - data collection plan, the Data collection plan shall include a description of the methodology that will be used to collect ship fuel oil data.

3.1 Method using bunker delivery notes (BDNs)

3.1.1 Method description

According to Regulation 18 of MARPOL Annex VI, vessels of 400 GT and above as well as platforms and drilling rigs shall keep the bunker delivery notes (BDNs) on board for a period of not less than three years following the delivery. The BDN is issued by the ship and the bunker fuel suppliers. The BDN has to contain at least the information specified in Appendix V of MARPOL Annex VI, e.g. date and time of commencement of delivery, name of marine fuel oil supplier, oil type, temperature, density, viscosity, quantity, etc.

Annual fuel oil consumption would be the total mass of fuel oil used on board the vessel as reflected in the BDNs. In this method, the fuel oil quantities recorded in the BDNs would be used to determine the annual total amount of fuel oil consumption, plus the amount of fuel oil left over from the last calendar year period, less the amount of fuel oil carried over to the next calendar year period and less the amount of fuel oil offloaded during the calendar year.

The annual total amount of fuel oil consumption
= the BDN fuel oil quantities
+ the amount of fuel oil left over from the last calendar year period
- the amount of fuel oil carried over to the next calendar year period
- the amount of fuel oil offloaded during this calendar year

Where, the amount of fuel oil left over from the last calendar year period and the amount of fuel oil carried over to the next calendar year period can be determined by using bunker fuel oil tank reading on board at the start and end of the cycle.

The method using BDNs is shown in Figure 3-1.

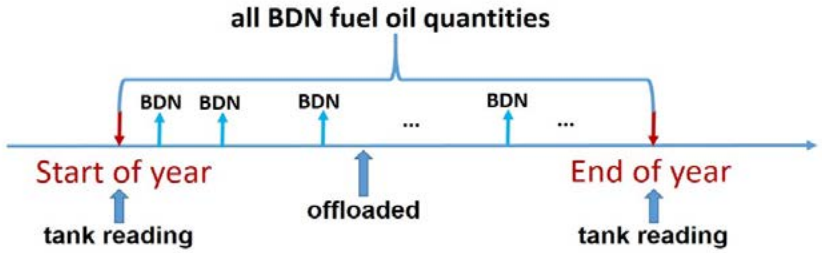

Figure 3-1 Method using bunker delivery notes

3.1.2 Precautions

The Data Collection Plan should set out how the ship will operationalize the summation of BDN information and conduct tank readings. When using BDN to determine the total fuel oil consumption of a ship in a calendar year. The following precautions should be taken:

- For voyages that span the data reporting period, stage fuel oil consumption should be performed by means of tank reading at the voyage starting port

and using the average number of voyage days.

- The tank monitoring should be carried out by using appropriate methods and should be clearly defined in the data collection plan.
- The accuracy of this method mainly depends on the accuracy of the amount of fuel oil recorded on BDNs.
- The tank monitoring method for determining the remaining tank oil quantity before and after the cycle should be read and calibrated according to the requirements.
- The annual amount of fuel oil offloaded shall be determined on the basis of the records in the Ship's Oil Record Book.
- Any supplementary data used for determining tank fuel discrepancies should provide supporting documentary evidence.
- A summary of annual BDNs shall be provided to flag state on the specified date.
- This method is not applicable for ships where there are no BDNs on board.
- If the ship uses shipborne cargo (such as LNG) as fuel, this method cannot be used alone.

3.1.3 Data submitted to flag state by ship

The total fuel oil consumption of the vessel for one calendar year can be determined by using the bunker delivery notes. Summary submitted to the flag state shall be in accordance with Table 3-1.

Table 3-1 Sample of the annual collected data summaries by using bunker delivery notes

Date of Operations (dd/mm/yyyy)	Fuel oil type/Mass(t)							Descriptions
	DO/ GO	LFO	HFO	LPG (P)	LPG (B)	LNG	Others	
Bunker delivery notes								
01/01/2019			150					
02/01/2019								
12/01/2019			300					
.....			0					
① Annual Supply Amount	0	0	450	0	0	0	0	
Correction for the tank oil remaining								
01/01/2019			400					
31/12/2019			-200					
② Correction for the tank oil remainings	0	0	200	0	0	0	0	
Other corrections								
03/01/2019								
15/08/2019								
③ Annual other corrections	0	0	0	0	0	0	0	
Annual fuel oil consumption								
Annual Fuel Oil Consumption (①+②+③)	0	0	650	0	0	0	0	

3.2 Method using bunker fuel oil tank monitoring on board

3.2.1 Method description

The fuel amount in oil tank is normally measured every day by seafarers to identify and record fuel oil consumption. Therefore, the annual fuel oil consumption on a ship will be identified by calculating all daily records.

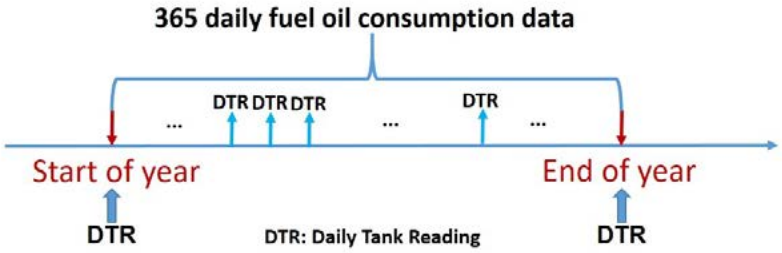

Figure 3-2 Method using bunker fuel oil tank monitoring on board

The rationale of method using bunker fuel oil tank monitoring is to detect the level of liquid (or ullage) in oil tank through the measurement devices, then the amount of fuel remaining and fuel consumption can be acquired via data conversions and corrections. At present, the means of using bunker fuel oil tank monitoring on ships can be categorized as manual, mechanical and electronic.

(1) Manual tank monitoring

Manual tank monitoring is carried out by the use of sounding tape, sounding pipe and oil tank conversion table. The oil level value can be directly acquired if the measurement is taken from fluid surface to the datum plate on the oil tank bottom. If the oil tank is too deep, the distance between the datum plate and fluid surface can be firstly measured to determine the ullage height, and then the oil level value can be acquired through conversion. The working principle of manual tank monitoring is shown as in Figure 3-3.

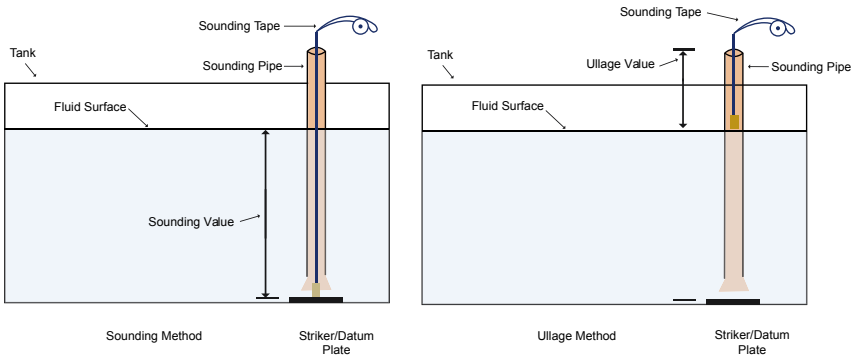

Figure 3-3 Working principle of manual tank monitoring

(2) Mechanical tank monitoring

Mechanical tank monitoring means mechanical detection is carried out in fuel tank, and the liquid level of fuel tank can be read directly by floating level sensor and its related system. In the fuel tank, the float ball is connected to the level gauge by pulley. The change of liquid level causes the change of float position, so that the pointer of the liquid level meter will change accordingly. The working principle of mechanical monitoring for fuel tank is shown in Figure 3-4.

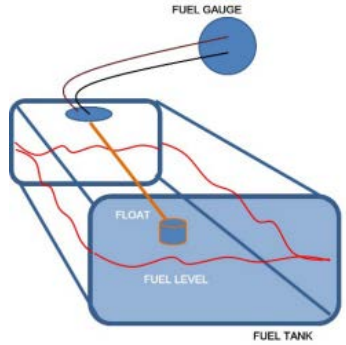

Figure 3-4 Working principle of mechanical tank monitoring

(3) Electronic tank monitoring

The electronic monitoring method for marine fuel tank is to use the sensors to detect the liquid or fuel tank pressure in the sounding tube and send the pressure signal to the receiver. The pressure signal is converted to the fuel volume of the tank and can be displayed by electric servo instrument. The working principle of electronic monitoring for fuel tank is shown in Figure 3-5.

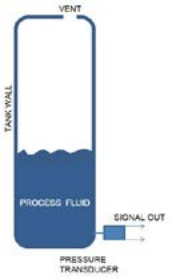

Figure 3-5 Working principle of electronic tank monitoring

3.2.2 Precautions

When using the manual tank reading method to measure the fuel oil consumption of the ship, precautions should be taken as follows:

- Before measuring, it should be clear whether to take sounding or ullage, and then identify the datum plate and the measurement point.
- The tape shall be qualified and within the validity period of use.
- The tape cannot be bent or damaged and connection between tape and weighted bob should not be loosened.
- The scale of tape should be clearly visible and the minimum division value should be no more than 1 mm.
- Generally, the 500grams bob is used for the measurement of light oil and 1000-gram bob for crude oil or heavy oil.
- When measuring light oil, the tape should be raised up and rolled back as long as the bob touches the bottom of the oil tank.
- When measuring heavy oil, the tape should be raised up and rolled back after the bob touches the bottom of the oil tank for about 5 seconds.
- When taking sounding, the tape should be rolled inside the oil tank stably so that the bob is able to touch the tank bottom lightly. It should be avoided that the liquid level sloshing caused by heavily rolling the tape inside the oil tank affects the measurement results.
- When reading, the tape should not be laid flat or inverted in order to prevent the liquid level from rising, and the line of sight should be vertical to the tape. The millimeter value should be read firstly followed by the centimeter, decimeter and meter.

- If the water mark or oil mark on the tape is not clear, the oil finding paste should be applied at the predicted value position. Then the reading should be based on the discoloration line on the tape.
- After the measurement is completed, the liquid remaining on the tape should be wiped off with a dry cloth while the tape is being rolled back, and the tape should be completely stowed in its drum.
- The accuracy of manual measurement is related to such factors as the position of datum plate, measuring tools, conversion tables, ship inclination, etc.
- Measuring tools should be calibrated and maintained regularly, and records of such calibrations and maintenance should be kept on board ships.
- The volume measured manually may differ from the actual volume.
- Manual tank reading method is not suitable for ships fueled by gas.

3.2.3 Data submitted to flag state by ship

When using bunker fuel oil tank monitoring on board to determine the total fuel oil consumption of the vessel for one calendar year, a summary should be submitted to the flag state in accordance with Table 3-2.

Table 3-2 Sample of the annual collected data summaries by using bunker fuel oil tank monitoring on board

Date from (dd/mm/yyyy)	Date to (dd/mm/yyyy)	Distance travelled (nm)	Hours underway (hh:mm)	Fuel oil consumption (Metric tons)						
				DO/GO	LFO	HFO	LPG (P)	LPG (B)	LNG	Others
01/01/2019		210	24:00	2	3	19	0	0	0	0
02/01/2019		283	24:00	2	0	20	0	0	0	0
03/01/2019		321	24:00	2	0	18	0	0	0	0
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
31/12/2019		213	24:00	1	1	17	0	0	0	0
Annual total										

3.3 Method using flow meters

3.3.1 Method description

This method determines the annual total amount of fuel oil consumption by measuring fuel oil flows on board by using flow meters. The fuel flow is often measured directly (by volume, velocity or mass) or indirectly by pressure. In principle, flow meters readings of marine energy equipment should be recorded daily and fuel consumption of the ship should be calculated daily.
Therefore, as long as the sum of the daily readings of the ship's flowmeter is recorded, the total fuel consumption for the ship's annual year can be determined.

Annual fuel oil consumption =

$\sum_{n=1}^{365}$ (Daily fuel oil consumption data measured by flow meters)

The method using flow meters is shown in Figure 3-6.

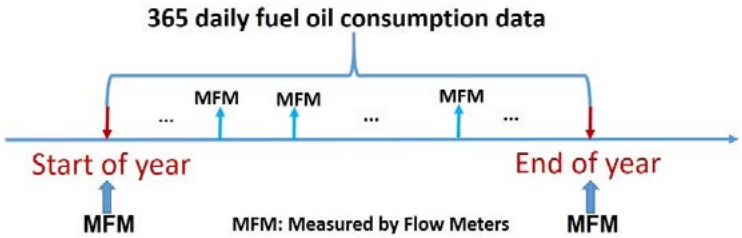

Figure 3-6 Method using flow meters

The Data collection Plan should set out information about the ship's flow meters and how the data will be collected and summarized and what alternative methods will be conducted in case of the breakdown of flow meters. According to its working principles, flow meters can be mainly categorized as Positive Displacement Flowmeter (PDF) and mass flowmeter.

(1) Positive Displacement Flowmeter

1) Working principle

The Positive Displacement Flowmeter (PDF) divides the fluid into single known volume part continuously using mechanical measurement elements and then measures total volume of the liquid flow based on the times of this known volume part filling and discharging the cavity successively and repeatedly. PDF is a hydraulic engine that absorbs a small amount of energy from the liquid in principle. The energy absorbed is used to overcome the rotation friction of flow detection elements and its accessories and meanwhile form a pressure drop at both ends of the meter's inflow and outflow.

PDF is usually composed of counter, magnetic coupling, outlet port, inlet port, measuring chamber, rotor, eccentric bearing, division plate and piston. Its working principle is shown in Figure 3-7. The liquid flowing into the meter from the inlet is divided by the outer wall and inner wall of measuring chamber, rotor and division plate into two parts (part A and part B as shown in Figure 3-7). The liquid in part A is connected to the inlet port, and the liquid in part B is connected to the outlet port. Part A is filled with high-pressure liquids, and part B is filled with low-pressure liquids. For each rotation of the rotor, there is liquid equivalent to the sum of the amount of part A and part B flowing through the meter. The rotation times of the rotor are transmitted to the counter for accumulation and displayed through magnetic coupling.

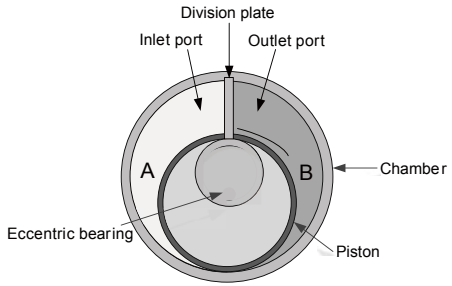

Figure 3-7. Working principle of positive displacement flowmeter

2) Advantages

The advantages of PDF are as follows:

- The highest accuracy of all flow meters;
- without external energy;
- direct reading mode;
- easy to operate;
- applicable to measuring high viscosity fluid.

3) Disadvantages

The disadvantages of PDF are as follows:

- complex structure, large size and bulky;
- large limitation and narrow application in terms of type of medium, working condition of medium and diameter;
- not generally suitable for high and low temperature occasions;
- only suitable for clean single-phase fluid.

(2) Mass flowmeter

1) Working principle

Mass flowmeter is an instrument for measuring mass flow. Mass flow is the mass of a liquid passing through a fixed point per unit of time. The common mass flowmeters are Coriolis flowmeter, Conveyor-based flowmeter and Thermal flowmeter. Among them, Coriolis flowmeter is a device that is able to

directly measure the mass flow by using Coriolis force, which is proportional to the mass flow rate when the fluid flows in the vibration pipeline. It is composed of flow detection elements and converters, and its working principle is shown in Figure 3-8.

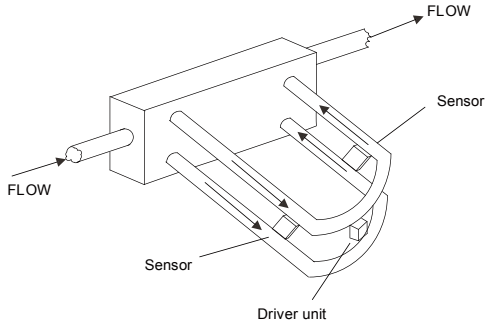

Figure 3-8 Working principle of the Coriolis flowmeter

2) Advantages

The advantages of Coriolis flowmeter are as follows:

- suitable for almost all liquids;
- not affected by the change of liquid density;
- able to measure flow rate with high accuracy;
- able to measure multiple media and parameters;
- able to ensure high accuracy and high stability in a wide range.

3) Disadvantages

The disadvantages of Coriolis flowmeter are as follows:

- very sensitive to external vibration interference and with high standard for installation and fixation;
- not used for larger pipe diameter;

- measurement accuracy affected by wear and corrosion of the inner wall of the measuring tube or deposition and scaling;
- with large pressure loss;
- with large weight and volume;
- relatively expensive.

3.3.2 Precautions

When using the flowmeter to measure the ship fuel oil consumption, the followings should be noted:

- If the flowmeter fails, manual tank reading or other alternative methods should be performed;
- The connection of the flowmeter to specific fuel consumer should be described in the data collection plan;
- Any fuel consumer not monitored by a flowmeter should be clearly identified and alternative fuel consumption measurement method shall be included;
- If the flowmeter is installed after the fuel oil daily tank, there is no need to correct the fuel oil measurement method due to the sludge, because the sludge will be removed before the fuel reaches the fuel oil daily tank;
- Calibration of flow meters shall be specified and records of calibration and maintenance shall be kept on board.

3.3.3 Data submitted to flag state by ship

When using flow meters to determine the total fuel oil consumption of the vessel for one calendar year, a summary should be submitted to the flag state in accordance with Table 3-3.

Table 3-3
Sample of the annual collected data summaries by using flow meters

Data from (dd/mm/yyyy)	Data to (dd/mm/yyyy)	Distance travelled (nm)	Hours underway (hh:mm)	Fuel oil consumption (Metric tons)						
				DO/GO	LFO	HFO	LPG (P)	LPG (B)	LNG	Others
01/01/2019		210	24:00	2	3	19	0	0	0	0
02/01/2019		283	24:00	2	0	20	0	0	0	0
03/01/2019		321	24:00	2	0	18	0	0	0	0
……	……	……	……	……	……	……	……	……	……	……
……	……	……	……	……	……	……	……	……	……	……
……	……	……	……	……	……	……	……	……	……	……
31/12/2019		213	24:00	1	1	17	0	0	0	0
Annual total										

3.4 Additional notes

When collecting and reporting ship fuel consumption data, the followings should also be noted:

- Whether the ship is underway or not, fuel consumption shall include all fuel consumers on board, and shall not be limited to the main engine, auxiliary engines, gas turbines, boilers and inert gas generators;
- Within the same reporting period, the same method should be applied to collect data on ship fuel consumption. If it is really necessary to change the method, necessary records and explanations shall be made;
- The daily fuel consumption data of ships should be recorded by electronic system in compliance with relevant requirements to avoid human errors and reduce the workload;
- The ship's daily noon report can be designed to cover the fuel consumption data types, and thus fuel consumption data collection can be completed through the work of daily report without increasing the additional workload;
- In order to verify the integrity, reliability and accuracy of the data, the flag state or the Recognized Organization may also require ships to provide copies of the ship's log book, engine log book, oil record book, BDNs, daily report, arrival and departure report, data collection plan, summaries of data, distance travelled and hours underway, information to demonstrate that the ship followed the data collection plan, etc.

Chapter IV Case Study

4.1 Containership

4.1.1 Data collection

Sets of data related to ship fuel oil consumption have been successfully collected from 5 demonstration containerships. Each set of data includes 11 information fields: date and time, status, hours travelled, distance travelled, speed, fuel consumption of main engine, fuel type of main engine, fuel consumption of auxiliary engine, fuel type of auxiliary engine, fuel consumption of boiler and fuel type of boiler. As the flow meters and their supportive electronic system are installed and working in normal conditions on 5 containerships, the data collected on these ships can be more frequent (every 15 minutes) and more accurate in an automatic manner compared to the manual daily data collected from below oil tankers and bulk carriers. Based on all data collected, the annual fuel consumption data is able to be produced. Figure 4-1 shows the example of annual data collected on a containership.

Date from	Date to	Distance Travelled...	Hours underway (hh...	DO/GO	LFO	HFO	LPG(P)	LPG(B)	LNG	Others
2018-08-30	2018-08-30	392.48	24:00	0.00	0.00	80.93	0.00	0.00	0.00	0.00
2018-08-31	2018-08-31	238.11	21:15	0.00	0.00	74.91	0.00	0.00	0.00	0.00
2018-09-05	2018-09-05	241.84	22:30	0.00	0.00	110.87	0.00	0.00	0.00	0.00
2018-09-06	2018-09-06	178.72	11:00	0.00	0.00	27.00	0.00	0.00	0.00	0.00
2018-09-07	2018-09-07	172.22	11:00	0.00	0.00	25.34	0.00	0.00	0.00	0.00
2018-09-08	2018-09-08	132.55	9:00	0.00	0.00	21.97	0.00	0.00	0.00	0.00
2018-09-10	2018-09-10	204.07	12:30	0.00	0.00	40.60	0.00	0.00	0.00	0.00
2018-09-11	2018-09-11	395.11	24:00	0.00	0.00	97.66	0.00	0.00	0.00	0.00
2018-09-12	2018-09-12	444.32	24:00	0.00	0.00	119.08	0.00	0.00	0.00	0.00
2018-09-13	2018-09-13	441.34	24:00	0.00	0.00	117.40	0.00	0.00	0.00	0.00
2018-09-14	2018-09-14	449.66	24:00	0.00	0.00	112.86	0.00	0.00	0.00	0.00
2018-09-15	2018-09-15	437.62	24:00	0.00	0.00	117.13	0.00	0.00	0.00	0.00
2018-09-16	2018-09-16	440.65	24:00	0.00	0.00	115.37	0.00	0.00	0.00	0.00
2018-09-17	2018-09-17	448.82	24:00	0.00	0.00	112.66	0.00	0.00	0.00	0.00
2018-09-18	2018-09-18	450.96	24:00	0.00	0.00	113.95	0.00	0.00	0.00	0.00
2018-09-19	2018-09-19	450.88	24:00	0.00	0.00	114.27	0.00	0.00	0.00	0.00
2018-09-20	2018-09-20	456.43	24:00	0.00	0.00	107.08	0.00	0.00	0.00	0.00
2018-09-21	2018-09-21	382.64	24:00	0.00	0.00	78.08	0.00	0.00	0.00	0.00
2018-09-22	2018-09-22	180.95	15:15	0.00	0.00	62.01	0.00	0.00	0.00	0.00
2018-09-24	2018-09-24	55.22	7:15	0.00	0.00	17.31	0.00	0.00	0.00	0.00
2018-09-25	2018-09-25	131.09	12:00	0.00	0.00	52.31	0.00	0.00	0.00	0.00
In total:		89129.95	5397:00	0.00	0.00	2749.35	0.00	0.00	0.00	0.00

Figure 4-1 Example of annual data collected on a containership

4.1.2 Aggregated data table

Thus based on the annual data, the aggregated data table can be automatically produced in accordance with regulation 22A and appendix IX of MARPOL Annex VI. Figure 4-2 shows the part of aggregated data table of a containership.

Identity of the ship:		
	IMO Number:	
Period of calender year for which the data is submitted:		
	Start date	2017-10-03
	End date	2018-07-01
Technical characteristics of the ship		
	Ship type:	Container ship
	Gross Tonnage:	114394
	Net Tonnage:	54951
	Deadweight Tonnage:	109968
	Main propulsion power(kW):	68640
	Auxiliary engine power output (kW)	4*3500 (kW)
	EEDI:	N/A
	Ice class:	N/A
Fuel oil consumption:		21854.35 MT
Fuel oil type:		
Distance travelled:		95286.7 n mile
Hours underway:		5743
Method used:		Method using flow meter

Figure 4-2 Part of aggregated data table of a containership

4.2 Bulk carrier

4.2.1 Data collection

Sets of data related to ship fuel oil consumption have been successfully collected from 5 demonstration bulk carriers. Likewise, each set of data includes 11 information fields: data and time, status, hours travelled, distance travelled, speed, fuel consumption of main engine, fuel type of main engine, fuel consumption of auxiliary engine, fuel type of auxiliary engine, fuel consumption of boiler and fuel type of boiler. As flowmeters and their supportive electronic system are not installed on 5 bulk carriers, the data collected on these ships can only be collected by seafarers after they use bunker fuel oil tank monitoring on board in daily interval. Based on all data collected, the annual fuel consumption data is able to be produced. Figure 4-3 shows the example of annual data collected on a bulk carrier by bunker fuel oil tank monitoring on board.

Date from	Date to	Distance Travelled (n.m)	Hours underway (hh:mm)	DO/GO	LFO	HFO	LPG(P)	LPG(B)	LNG	Others
2018-02-01	2018-02-01	150.70	9:09	2.50	0.00	0.00	0.00	0.00	0.00	0.00
2018-02-02	2018-02-02	346.20	24:00	0.32	0.00	20.70	0.00	0.00	0.00	0.00
2018-02-03	2018-02-03	81.20	6:00	0.00	0.00	23.17	0.00	0.00	0.00	0.00
2018-02-10	2018-02-10	234.60	17:00	1.50	0.00	3.10	0.00	0.00	0.00	0.00
2018-02-11	2018-02-11	244.10	24:00	0.40	0.00	22.70	0.00	0.00	0.00	0.00
2018-02-12	2018-02-12	237.50	21:24	0.00	0.00	23.50	0.00	0.00	0.00	0.00
2018-02-17	2018-02-17	269.70	23:10	1.00	0.00	12.70	0.00	0.00	0.00	0.00
2018-02-18	2018-02-18	273.60	24:00	0.00	0.00	23.70	0.00	0.00	0.00	0.00
2018-02-19	2018-02-19	274.60	24:00	0.00	0.00	23.60	0.00	0.00	0.00	0.00
2018-02-20	2018-02-20	300.10	24:00	0.00	0.00	23.65	0.00	0.00	0.00	0.00
2018-02-21	2018-02-21	249.90	24:00	0.00	0.00	23.80	0.00	0.00	0.00	0.00
2018-02-22	2018-02-22	80.20	6:00	0.00	0.00	17.11	0.00	0.00	0.00	0.00
2018-03-04	2018-03-04	258.10	21:20	0.20	0.00	8.30	0.00	0.00	0.00	0.00
2018-03-05	2018-03-05	285.30	24:00	0.00	0.00	23.60	0.00	0.00	0.00	0.00
2018-03-06	2018-03-06	214.10	24:00	0.00	0.00	23.40	0.00	0.00	0.00	0.00
2018-03-07	2018-03-07	230.70	24:00	0.10	0.00	23.70	0.00	0.00	0.00	0.00
2018-03-08	2018-03-08	80.60	7:25	0.20	0.00	14.45	0.00	0.00	0.00	0.00
2018-03-10	2018-03-10	175.60	14:44	2.70	0.00	1.50	0.00	0.00	0.00	0.00
2018-03-11	2018-03-11	364.10	24:00	0.10	0.00	19.70	0.00	0.00	0.00	0.00
2018-03-12	2018-03-12	279.80	22:15	0.00	0.00	21.95	0.00	0.00	0.00	0.00
2018-03-18	2018-03-18	184.20	18:36	0.90	0.00	5.30	0.00	0.00	0.00	0.00
2018-03-19	2018-03-19	295.80	24:00	0.00	0.00	23.10	0.00	0.00	0.00	0.00
2018-03-20	2018-03-20	212.60	24:00	0.00	0.00	22.90	0.00	0.00	0.00	0.00

Figure 4-3 Example of annual data collected on a bulk carrier

4.2.2 Aggregated data table

Thus based on the annual data, the aggregated data table can be automatically produced in accordance with regulation 22A and appendix IX of MARPOL Annex VI. Figure 4-4 shows the part of aggregated data table of a bulk carrier.

Identity of the ship:				
	IMO Number:			
Period of calender year for which the data is sub...				
	Start date	2018-02-01		
	End date	2018-08-27		
Technical characteristics of the ship				
	Ship type:	bulk carrier		
	Gross Tonnage:	39385		
	Net Tonnage:	24519		
	Deadweight Tonnage:	75181		
	Main propulsion power(kW):	10800		
	Auxiliary engine power output (kW)	610 (kW)		
	EEDI:	N/A		
	Ice class:	N/A		
Fuel oil consumption:	1633.86	0.00	33.34	0.00
Fuel oil type:	HFO	LFO	DO/GO	LPG(P)
Fuel oil consumption:	0.00	0.00	0.00	
Fuel oil type:	LPG(B)	LNG	Other	
Distance travelled:	22098.00			
Hours underway:	1887:23			
Method used:	Method using bunker oil tank monitoring			

Figure 4-4 Part of aggregated data table of a bulk carrier

4.3 Oil tanker

4.3.1 Data collection

Sets of data related to ship fuel oil consumption have been successfully collected from 5 demonstration oil tankers. Likewise, each set of data includes 11 information field: data and time, status, hours travelled, distance travelled, speed, fuel consumption of main engine, fuel type of main engine, fuel consumption of auxiliary engine, fuel type of auxiliary engine, fuel consumption of boiler and fuel type of boiler. As the flowmeters and their supportive electronic system are not installed on 5 oil tankers, the data collected on these ships can only be collected by seafarers after they use bunker fuel oil tank monitoring on board in daily interval. Based on all data collected, the annual fuel consumption data is able to be produced. Figure 4-5 shows the example of annual data collected on an oil tanker by bunker fuel oil tank monitoring on board.

Date from	Date to	Distance Travelled (n.m)	Hours underway (hh:mm)	DO/GO	LFO	HFO	LPG(P)	LPG(B)	LNG	Others
2017-05-21	2017-05-21	197.00	14:30	0.00	0.00	24.00	0.00	0.00	0.00	0.00
2017-05-26	2017-05-26	8.00	1:10	0.00	0.00	7.00	0.00	0.00	0.00	0.00
2017-05-28	2017-05-28	203.00	21:04	0.00	0.00	21.00	0.00	0.00	0.00	0.00
2017-05-31	2017-05-31	20.00	3:10	0.00	0.00	7.00	0.00	0.00	0.00	0.00
2017-06-01	2017-06-01	45.00	4:25	0.00	0.00	24.50	0.00	0.00	0.00	0.00
2017-06-02	2017-06-02	201.00	24:00	0.00	0.00	36.50	0.00	0.00	0.00	0.00
2017-06-03	2017-06-03	20.00	1:48	0.00	0.00	8.00	0.00	0.00	0.00	0.00
2017-06-04	2017-06-04	88.00	7:15	0.00	0.00	11.70	0.00	0.00	0.00	0.00
2017-06-05	2017-06-05	115.00	9:04	0.00	0.00	18.00	0.00	0.00	0.00	0.00
2017-06-06	2017-06-06	20.00	3:00	0.00	0.00	24.00	0.00	0.00	0.00	0.00
2017-06-07	2017-06-07	223.00	22:34	0.00	0.00	24.00	0.00	0.00	0.00	0.00
2017-06-09	2017-06-09	201.00	17:00	0.00	0.00	23.00	0.00	0.00	0.00	0.00
2017-06-12	2017-06-12	223.00	22:04	0.00	0.00	26.00	0.00	0.00	0.00	0.00
2017-06-16	2017-06-16	139.00	13:40	0.00	0.00	15.00	0.00	0.00	0.00	0.00
2017-06-17	2017-06-17	61.00	6:49	0.00	0.00	9.00	0.00	0.00	0.00	0.00
2017-06-21	2017-06-21	47.00	4:55	0.00	0.00	9.00	0.00	0.00	0.00	0.00
2017-06-22	2017-06-22	26.00	2:40	0.00	0.00	7.50	0.00	0.00	0.00	0.00
2017-06-23	2017-06-23	21.00	2:55	0.00	0.00	18.50	0.00	0.00	0.00	0.00
2017-06-24	2017-06-24	58.00	4:30	0.00	0.00	19.00	0.00	0.00	0.00	0.00
2017-06-25	2017-06-25	10.00	2:10	0.00	0.00	7.00	0.00	0.00	0.00	0.00
2017-06-26	2017-06-26	58.00	5:19	0.00	0.00	10.00	0.00	0.00	0.00	0.00
2017-06-27	2017-06-27	21.00	3:19	0.00	0.00	6.00	0.00	0.00	0.00	0.00
2017-06-28	2017-06-28	20.00	2:10	0.00	0.00	20.50	0.00	0.00	0.00	0.00

Figure 4-5 Example of annual data collected on an oil tanker

4.2.2 Aggregated data table

Thus based on the annual data, the aggregated data table can be automatically produced in accordance with regulation 22A and appendix IX of MARPOL Annex VI. Figure 4-6 shows the part of aggregated data table of an oil tanker.

Identity of the ship:				
	IMO Number:			
Period of calender year for which the data is sub...				
	Start date	2017-05-21		
	End date	2018-05-09		
Technical characteristics of the ship				
	Ship type:	Oil tanker		
	Gross Tonnage:	31004		
	Net Tonnage:	15326		
	Deadweight Tonnage:	52687		
	Main propulsion power(kW):	8748		
	Auxiliary engine power output (kW)			
	EEDI:	N/A		
	Ice class:	N/A		
Fuel oil consumption:	2986.00	0.00	2.70	0.00
Fuel oil type:	HFO	LFO	DO/GO	LPG(P)
Fuel oil consumption:	0.00	0.00	0.00	
Fuel oil type:	LPG(B)	LNG	Other	
Distance traveled:	16851.80			
Hours underway:	1934:30			
Method used:	Method using bunker oil tank moni...			

Figure 4-6 Part of aggregated data table of an oil tanker

4.4 Data analysis

4.4.1 Comparison of speed and unit fuel oil consumption per nautical mile

Figure 4-7 indicates the comparison of speed and unit fuel oil consumption per nautical mile for containership, bulk carrier and oil tanker. Compared to bulk carrier and oil tanker, containership clearly consumes the largest amount of fuel oil and produces the largest amount of CO_2 per nautical mile due to its fastest average speed of 15 kn and the highest portion of underway status. Due to the fact that the average speed of oil tanker is faster than bulk carriers, the oil tanker consumes more amounts of fuel oil and produces more amounts of CO_2 per nautical mile than bulk carrier. In a word, in terms of fuel oil consumption per nautical mile or production of CO_2 per nautical mile, containership is the largest consumer, followed by oil tanker. And the bulk carrier is least. Specifically, the containership consumes respectively 35.3% and 130.0% more fuel oil per nautical mile than the bulk carrier and the oil tanker, and the therefore emits more amounts of CO_2 in the same proportions.

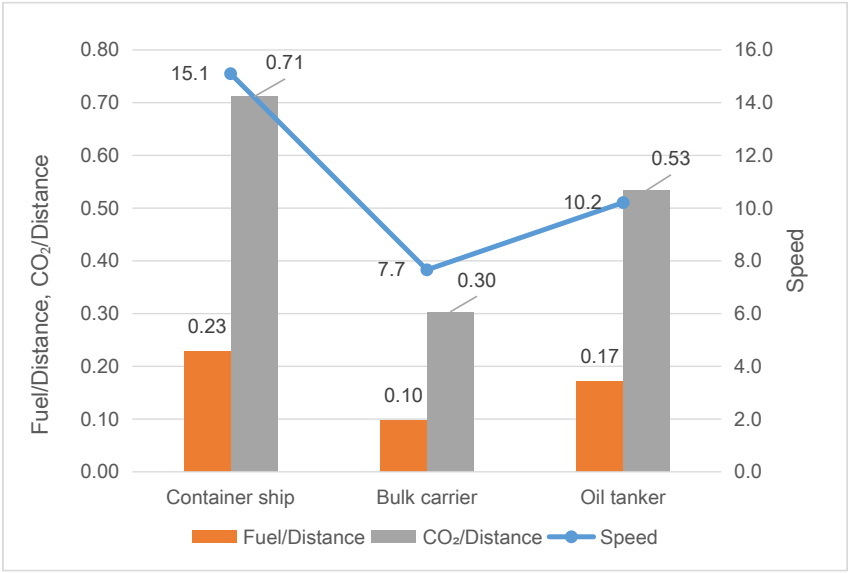

Figure 4-7 Comparison of speed and unit fuel oil consumption per nautical mile

4.4.2 Comparison of speed and unit fuel oil consumption per hour underway

Figure 4-8 indicates the comparison of speed and unit fuel oil consumption per hour underway for containership, bulk carrier and oil tanker. Compared to bulk carrier and oil tanker, containership clearly consumes the largest amount of fuel oil or produces the largest amount of CO_2 per hour due to its fastest average speed of 15kn. Due to the fact that the average speed of oil tanker is faster than bulk carriers, the oil tanker consumes more amounts of fuel oil or produces more amounts of CO_2 per hour underway than bulk carrier. In a word, in terms of fuel oil consumption per hour underway or production of CO_2 per hour underway, containership is the largest consumer, followed by oil tanker. And the bulk carrier is the least. Specifically, the containership consumes respectively 88.6% and 333.8% more fuel oil per hour underway than the bulk carrier and the oil tanker, and the therefore emits more amounts of CO_2 in the same proportions.

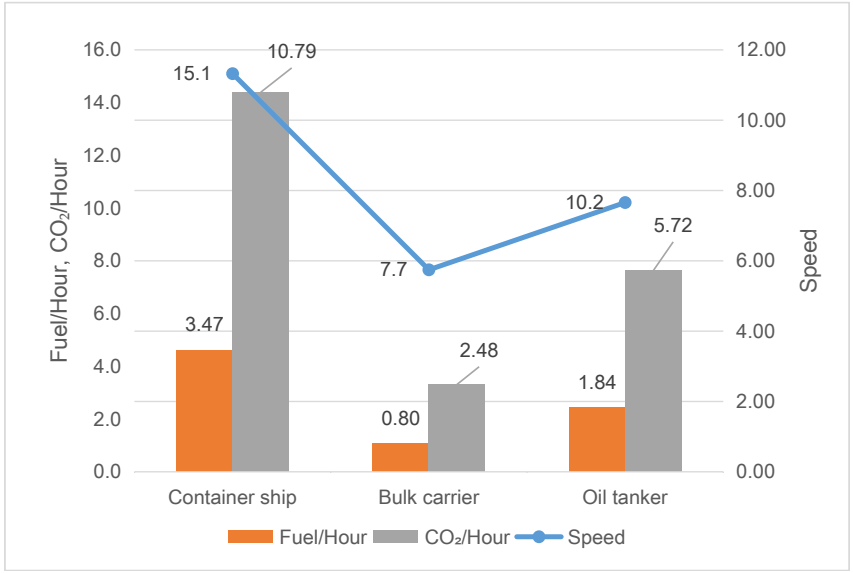

Figure 4-8 Comparison of speed and unit fuel oil consumption per hour

4.4.2 Comparison of EEOI

EEOI of each ship is able be calculated based on total fuel oil consumption in ton, total distance travelled in nautical mile and total loading cargo capacity (in TEU for containership and in ton for bulk carrier) during the data collection period. Figure 4-9 shows EEOIs of 5 containerships and 5 bulk carriers, respectively. On an average, EEOI of containerships is $25.1x10^{-6}$ (t/TEU • nm) while EEOI of bulk carriers is $21.2x10^{-6}$ (t/t • nm). Therefore, the containerships have higher EEOI than bulk carriers, which indicates that containerships consume more fuel and produce more CO_2 compared to bulk carriers.

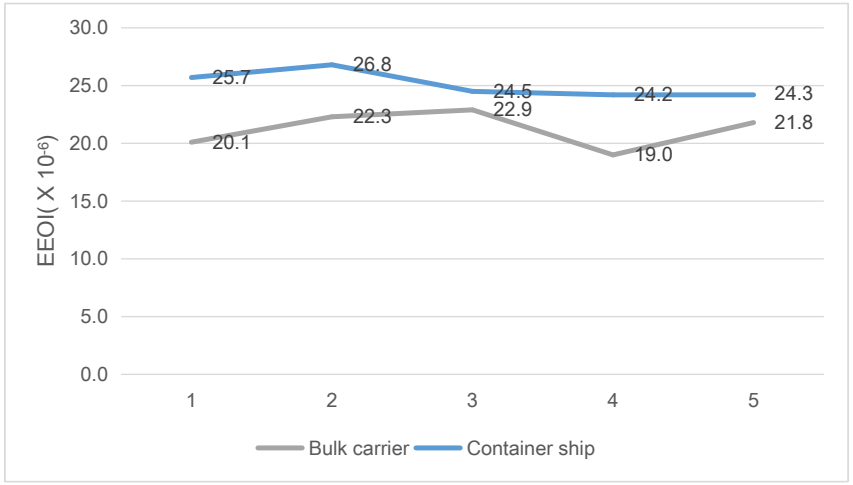

Figure 4-9 Comparison of EEOI between containership and bulk carrier

Chapter V Overview of the E-system for Voluntary Ship Fuel Oil Consumption Data collection and reporting

5.1 Introduction

A demo software of ship fuel consumption data collection and reporting is included in the folder E-system of Voluntary Ship Fuel Comsuption Data Collection and Reporting of the accompanying CD. The basic requirements of running this demo software is at least the operating system of 32-bit Windows 10. After double clicking the folder E-system of Voluntary Ship Fuel Comsuption Data Collection and Reporting , three files, ***ShipInfo.hch, Data input.exe*** and ***Data aggregated.exe*** can be found. The file of ***ShipInfo.hch*** is designed for inputting and storing the ship static data. The ***Data input.exe*** is designed for manually inputting the dynamic data related to the ship fuel consumption data collection and reporting. The ***Data aggregated.exe*** is used for searching the annual aggregated data.

It is suggested for effectively running this demo software to copy the folder E-system of Voluntary Ship Fuel Comsuption Data Collection and Reporting from CD to hard disc of a computer before starting the software.

5.2 Input of ship static data

Open the ***ShipInfo.hch*** by using the software of ***Notepad.exe*** installed in the Windows system and input the ship's name and other 8 static data according to the Table 2-2, see Figure 5-1.

```
Ship name:
IMO Number:
Ship type:
bulk carrier
Gross Tonnage:
64283
Net Tonnage:
35998
Deadweight Tonnage:
99761
Main propulsion power(KW):
13974
Auxiliary engine power output (kW):
680
EEDI:
N/A
Ice class:
N/A
```

Figure 5-1 Input of ship static data

5.3 Input of ship dynamic data

After the completion of ship static data input, close and save the file of ***ShipInfo.hch.*** Then double click the Data input.exe for inputting the dynamic ship data through the screen shown in the Figure 5-2.

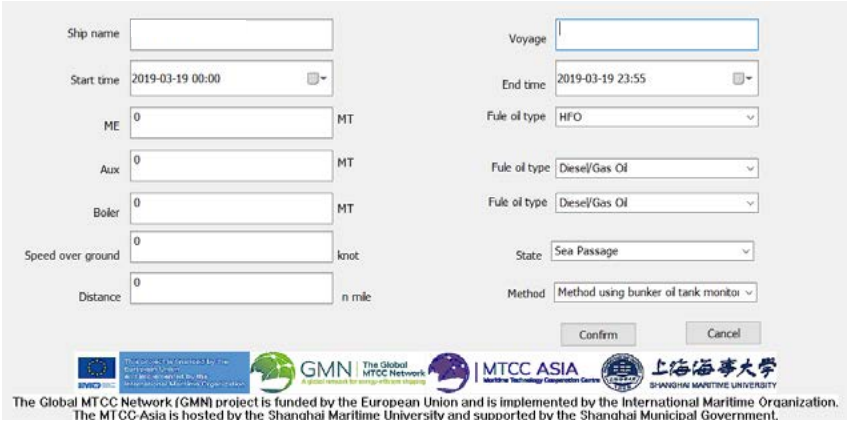

Figure 5-2 Input of ship dynamic data

The ***Ship name*** is automatically shown based on information in the file of ***ShipInfo.hch.*** The field of ***Voyage*** is optional and other data can be input

according to the Table 2-3. Once the completion of the data input and selection, click the button ***Confirm*** at the bottom right, then the ship dynamic data is sent to the onshore database if the radio communication network is available as well as stored locally at the same time.

5.4 Production of aggregated data

After the completion of ship dynamic data input, double click the Data aggregated.exe for producing annual ship aggregate data through the screen shown in the Figure 5-3.

Figure 5-3 Production of annual ship aggregated data

The ***Ship name*** is automatically shown based on information in the file of ***ShipInfo.hch.*** Once the date period is set by the ***Start date*** and ***End date***, and the ***Annual*** is selected in the field of ***Statistics***, the annual collected data summary which is required to be submitted to the flag state from ship can be automatically displayed in accordance with Table 3-1, Table 3-2 or Table 3-3, see Figure 5-4.

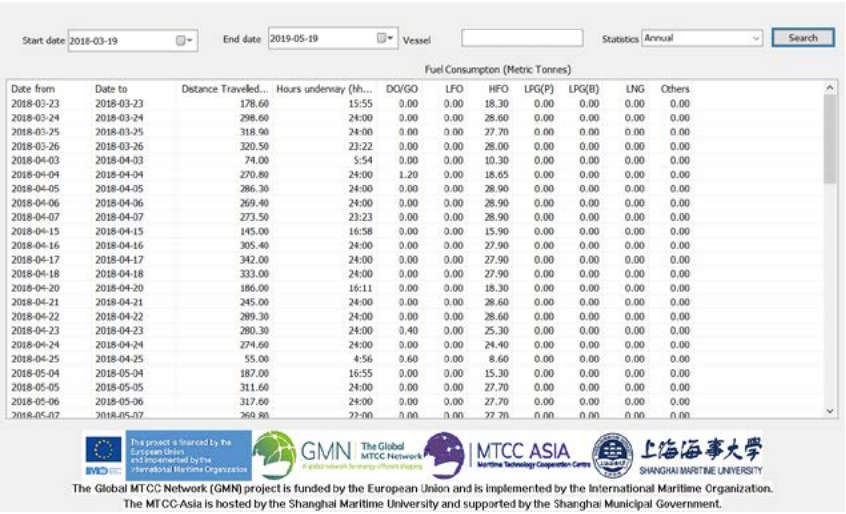

Figure 5-4 Annual collected data summary submitted to flag state

And if the ***Aggregated*** is selected in the field of Statistics, the annual aggregated data summary which is required to be submitted to the IMO from flag state can be automatically displayed in accordance with Table 2-4, see Figure 5-5.

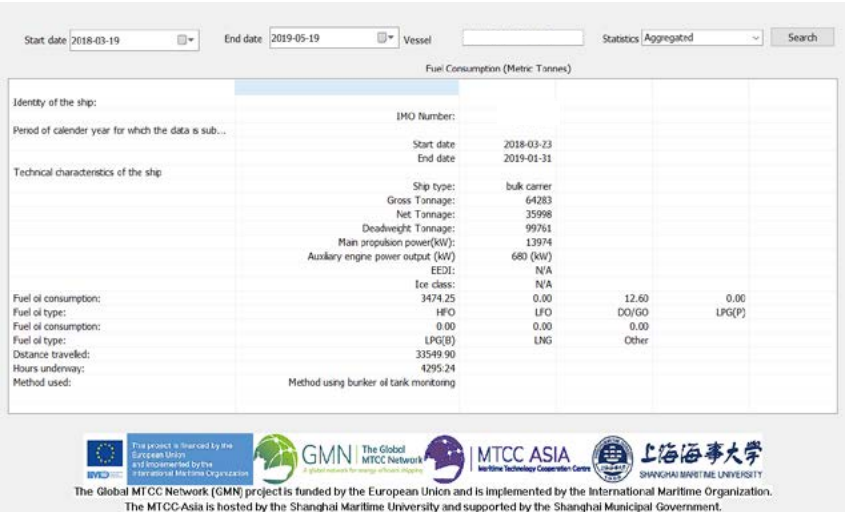

Figure 5-5 Annual aggregated data summary to IMO

Annex 1 Consolidated Chapter 4 of MARPOL Annex VI

Updated on 30 July 2019 including provisions entering into force on 1 September 2019

Chapter 4 – Regulations on energy efficiency for ships

Regulation 19

Application

1. This chapter shall apply to all ships of 400 gross tonnage and above.

2. The provisions of this chapter shall not apply to:

    1) ships solely engaged in voyages within waters subject to the sovereignty or jurisdiction of the State the flag of which the ship is entitled to fly. However, each Party should ensure, by the adoption of appropriate measures, that such ships are constructed and act in a manner consistent with the requirements of chapter 4 of this Annex, so far as is reasonable and practicable.

    2) ships not propelled by mechanical means, and platforms including FPSOs and FSUs and drilling rigs, regardless of their propulsion.

3. Regulations 20 and 21 of this Annex shall not apply to ships which have non-conventional propulsion, except that regulations 20 and 21 shall apply to cruise passenger ships having non-conventional propulsion and LNG carriers having conventional or non-conventional propulsion, delivered on or after 1 September 2019, as defined in paragraph 43 of regulation 2. Regulations 20 and 21 shall not apply to cargo ships having ice-breaking capability.

4. Notwithstanding the provisions of paragraph 1 of this regulation, the Administration may waive the requirement for a ship of 400 gross tonnage and above from complying with regulations 20 and 21 of this Annex.

5. The provision of paragraph 4 of this regulation shall not apply to ships of 400 gross tonnage and above:

    1) for which the building contract is placed on or after 1 January 2017; or

    2) in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction on or after 1 July 2017; or

    3) the delivery of which is on or after 1 July 2019; or

    4) in cases of a major conversion of a new or existing ship, as defined in regulation 2.24 of this Annex, on or after 1 January 2017, and in which regulations 5.4.2 and 5.4.3 of this Annex apply.

6. The Administration of a Party to the present Convention which allows application of paragraph 4, or suspends, withdraws or declines the application of that paragraph, to a ship entitled to fly its flag shall forthwith communicate to the Organization for circulation to the Parties to the present Protocol particulars thereof, for their information.

Regulation 20

Attained Energy Efficiency Design Index (Attained EEDI)

1. The attained EEDI shall be calculated for:

    1) each new ship;

    2) each new ship which has undergone a major conversion; and

3) each new or existing ship which has undergone a major conversion, that is so extensive that the ship is regarded by the Administration as a newly constructed ship,

which falls into one or more of the categories in regulations 2.25 to 2.35, 2.38 and 2.39 of this Annex. The attained EEDI shall be specific to each ship and shall indicate the estimated performance of the ship in terms of energy efficiency, and be accompanied by the EEDI technical file that contains the information necessary for the calculation of the attained EEDI and that shows the process of calculation. The attained EEDI shall be verified, based on the EEDI technical file, either by the Administration or by any organization duly authorized by it*.

2. The attained EEDI shall be calculated taking into account the guidelines developed by the Organization+.

Regulation 21

Required EEDI

1. For each:

1) new ship;

2) new ship which has undergone a major conversion; and

3) new or existing ship which has undergone a major conversion that is so extensive that the ship is regarded by the Administration as a newly constructed ship,

which falls into one of the categories defined in regulations 2.25 to 2.31, 2.33 to 2.35, 2.38 and 2.39 and to which this chapter is applicable, the attained EEDI shall be as follows:

Attained EEDI ≤ Required EEDI = (1-X/100) × reference line value

where X is the reduction factor specified in Table 1 for the required EEDI compared to the EEDI reference line.

2. For each new and existing ship that has undergone a major conversion which is so extensive that the ship is regarded by the Administration as a newly constructed ship, the attained EEDI shall be calculated and meet the requirement of paragraph 21.1 with the reduction factor applicable corresponding to the ship type and size of the converted ship at the date of the contract of the conversion, or in the absence of a contract, the commencement date of the conversion.

Table 1.
Reduction factors (in percentage) for the EEDI relative to the EEDI reference line

Ship Type	Size	Phase 0	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Jan 2025 and onwards
Bulk carrier	20,000 DWT and above	0	10	20	30
	10,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
Gas carrier	10,000 DWT and above	0	10	20	30
	2,000 – 10,000 DWT	n/a	0-10*	0-20*	0-30*
Tanker	20,000 DWT and above	0	10	20	30
	4,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
Container ship	15,000 DWT and above	0	10	20	30
	10,000 – 15,000 DWT	n/a	0-10*	0-20*	0-30*

*.Refer to the Guidelines for the authorization of organizations acting on behalf of the Administration (resolution A.739(18), as amended by resolution MSC.208(81)), and the Specifications on the survey and certification functions of recognized organizations acting on behalf of the Administration (resolution A.789(19), as may be amended).

+.Refer to 2018 Guidelines on the method of calculation of the Energy Efficiency Design Index (EEDI) for new ships (resolution MEPC.308(73)).

General Cargo ships	15,000 DWT and above	0	10	15	30
	3,000 – 15,000 DWT	n/a	0-10*	0-15*	0-30*
Refrigerated cargo carrier	5,000 DWT and above	0	10	15	30
	3,000 – 5,000 DWT	n/a	0-10*	0-15*	0-30*
Combination carrier	20,000 DWT and above	0	10	20	30
	4,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
LNG carrier***	10,000 DWT and above	n/a	10**	20	30
Ro-ro cargo ship (vehicle carrier)***	10,000 DWT and above	n/a	5**	15	30
Ro-ro cargo ship***	2,000 DWT and above	n/a	5**	20	30
	1,000 –2,000 DWT	n/a	0-5***	0-20*	0-30*
Ro-ro passenger ship***	1,000 DWT and above	n/a	5**	20	30
	250 –1,000 DWT	n/a	0-5***	0-20*	0-30*
Cruise passenger ship*** having non-conventional propulsion	85,000 GT and above	n/a	5**	20	30
	25,000 – 85,000 GT	n/a	0-5***	0-20*	0-30*

Note: n/a means that no required EEDI applies.

3. The reference line values shall be calculated as follows:

Reference line value = a·b-c

where a, b and c are the parameters given in Table 2.

*. Reduction factor to be linearly interpolated between the two values dependent upon ship size. The lower value of the reduction factor is to be applied to the smaller ship size.
**. Phase 1 commences for those ships on 1 September 2015.
***. Reduction factor applies to those ships delivered on or after 1 September 2019, as defined in paragraph 43 of regulation 2.

Table 2
Parameters for determination of reference values for the different ship types

Ship type defined in regulation 2	a	b	c
2.25 Bulk carrier	961.79	DWT of the ship	0.477
2.26 Gas carrier	1120.00	DWT of the ship	0.456
2.27 Tanker	1218.80	DWT of the ship	0.488
2.28 Container ship	174.22	DWT of the ship	0.201
2.29 General cargo ship	107.48	DWT of the ship	0.216
2.30 Refrigerated cargo carrier	227.01	DWT of the ship	0.244
2.31 Combination carrier	1219.00	DWT of the ship	0.488
2.33 Ro-ro cargo ship (vehicle carrier)	$(DWT/GT)^{-0.7} \cdot 780.36$ where DWT/GT<0.3	DWT of the ship	0.471
	1812.63 where DWT/GT≥0.3		
2.34 Ro-ro cargo ship	1405.15	DWT of the ship	
	1686.17*	DWT of the ship where DWT≤17,000* 17,000 where DWT > 17,000*	0.498
2.35 Ro-ro passenger ship	752.16	DWT of the ship	0.381
	902.59*	DWT of the ship where DWT≤10,000* 10,000 where DWT > 10,000*	
2.38 LNG carrier	2253.7	DWT of the ship	0.474
2.39 Cruise passenger ship having non-conventional propulsion	170.84	GT of the ship	0.214

4. If the design of a ship allows it to fall into more than one of the ship type definitions specified in table 2, the required EEDI for the ship shall be the most stringent (the lowest) required EEDI.

5. For each ship to which this regulation applies, the installed propulsion power shall not be less than the propulsion power needed to maintain the manoeuvrability of the ship under adverse conditions as defined in the guidelines to be developed by the Organization[1].

*. to be used from phase 2 and thereafter.
1. Refer to 2013 Interim guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions (resolution MEPC.232(65), as amended by resolutions MEPC.255(67) and MEPC.262(68); consolidated text: MEPC.1/Circ.850/Rev.2).

6. At the beginning of Phase 1 and at the midpoint of Phase 2, the Organization shall review the status of technological developments and, if proven necessary, amend the time periods, the EEDI reference line parameters for relevant ship types and reduction rates set out in this regulation.

Regulation 22

Ship Energy Efficiency Management Plan (SEEMP)

1. Each ship shall keep on board a ship specific Ship Energy Efficiency Management Plan (SEEMP). This may form part of the ship's Safety Management System (SMS).

SEE INTERPRETATION 4 of MEPC.1/Circ.795/Rev.4

2. On or before 31 December 2018, in the case of a ship of 5,000 gross tonnage and above, the SEEMP shall include a description of the methodology that will be used to collect the data required by regulation 22A.1 of this Annex and the processes that will be used to report the data to the ship's Administration.

SEE INTERPRETATION 13 of MEPC.1/Circ.795/Rev.4

3. The SEEMP shall be developed taking into account guidelines adopted by the Organization*.

SEE INTERPRETATION 13 of MEPC.1/Circ.795/Rev.4

Regulation 22A

Collection and reporting of ship fuel oil consumption data

1. From calendar year 2019, each ship of 5,000 gross tonnage and above shall collect the data specified in appendix IX to this Annex, for that and each subsequent calendar year or portion thereof, as appropriate, according to the methodology included in the SEEMP.

SEE INTERPRETATION 14 of MEPC.1/Circ.795/Rev.4

2. Except as provided for in paragraphs 4, 5 and 6 of this regulation, at the end of each calendar year, the ship shall aggregate the data collected in that calendar year or portion thereof, as appropriate.

3. Except as provided for in paragraphs 4, 5 and 6 of this regulation, within three months after the end of each calendar year, the ship shall report to its Administration or any organization duly authorized by it[2], the aggregated value for each datum specified in appendix IX to this Annex, via electronic communication and using a standardized format to be developed by the Organization[3].

4. In the event of the transfer of a ship from one Administration to another, the ship shall on the day of completion of the transfer or as close as practical thereto report to the losing Administration or any organization duly authorized by it[$$], the aggregated data for the period of the calendar year corresponding to that Administration, as specified in appendix IX to this Annex and, upon prior request of that Administration, the disaggregated data.

5. In the event of a change from one Company to another, the ship shall on the day of completion of the change or as close as practical thereto report to its Administration or any organization duly authorized by it[$$], the aggregated data for the portion of the calendar year corresponding to the Company, as specified in appendix IX to this Annex and, upon request of its Administration, the disaggregated data.

6. In the event of change from one Administration to another and from one Company to another concurrently, paragraph 4 of this regulation shall apply.

7. The data shall be verified according to procedures established by the Administration, taking into account guidelines to be developed by the Organization[4].

8. Except as provided for in paragraphs 4, 5 and 6 of this regulation, the disaggregated data that underlies the reported data noted in appendix IX to this Annex for the previous calendar year shall be readily accessible for a period of not less than 12 months from the end of that calendar year and be

*. Refer to 2016 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP) (resolution MEPC.282(70)).

2.Refer to Guidelines for the authorization of organizations acting on behalf of the Administration (resolution A.739(18), as amended by resolution MSC.208(81)), and the Specifications on the survey and certification functions of recognized organizations acting on behalf of the Administration (resolution A.789(19), as may be amended).

3.Refer to 2016 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP) (resolution MEPC.282(70)).

4.Refer to 2017 Guidelines for Administration verification of ship fuel oil consumption data (resolution MEPC.292(71)).

made available to the Administration upon request.

SEE INTERPRETATION 15 of MEPC.1/Circ.795/Rev.4

9. The Administration shall ensure that the reported data noted in appendix IX to this Annex by its registered ships of 5,000 gross tonnage and above are transferred to the IMO Ship Fuel Oil Consumption Database via electronic communication and using a standardized format to be developed by the Organization not later than one month after issuing the Statements of Compliance of these ships.

10. On the basis of the reported data submitted to the IMO Ship Fuel Oil Consumption Database, the Secretary-General of the Organization shall produce an annual report to the Marine Environment Protection Committee summarizing the data collected, the status of missing data, and such other relevant information as may be requested by the Committee.

11. The Secretary-General of the Organization shall maintain an anonymized database such that identification of a specific ship will not be possible. Parties shall have access to the anonymized data strictly for their analysis and consideration.

12. The IMO Ship Fuel Oil Consumption Database shall be undertaken and managed by the Secretary-General of the Organization, pursuant to guidelines to be developed by the Organization[5].

Regulation 23

Promotion of technical co-operation and transfer of technology relating to the improvement of energy efficiency of ships[6].

1. Administrations shall, in co-operation with the Organization and other international bodies, promote and provide, as appropriate, support directly or through the Organization to States, especially developing States, that request technical assistance.

2. The Administration of a Party shall co-operate actively with other Parties, subject to its national laws, regulations and policies, to promote the development

5.Refer to 2017 Guidelines for the development and management of the IMO Ship Fuel Oil Consumption Database (resolution MEPC.293(71)).
6.Refer to Promotion of technical co-operation and transfer of technology relating to the improvement of energy efficiency of ships (resolution MEPC.229(65)), and Model Agreement between Governments on technological cooperation for the implementation of the regulations in chapter 4 of MARPOL Annex VI (MEPC.1/Circ.861)

and transfer of technology and exchange of information to States which request technical assistance, particularly developing States, in respect of the implementation of measures to fulfil the requirements of chapter 4 of this Annex, in particular regulations 19.4 to 19.6.

Chapter 5 – Verification of compliance with the provisions of this annex

Regulation 24

Application

Parties shall use the provisions of the Code for Implementation in the execution of their obligations and responsibilities contained in this Annex.

Regulation 25

Verification of compliance

1. Every Party shall be subject to periodic audits by the Organization in accordance with the audit standard to verify compliance with and implementation of this Annex.

2. The Secretary-General of the Organization shall have responsibility for administering the Audit Scheme, based on the guidelines developed by the Organization*.

3. Every Party shall have responsibility for facilitating the conduct of the audit and implementation of a programme of actions to address the findings, based on the guidelines developed by the Organization*.

4. Audit of all Parties shall be:

   1) based on an overall schedule developed by the Secretary-General of the Organization, taking into account the guidelines developed by the Organization*; and

   2) conducted at periodic intervals, taking into account the guidelines developed by the Organization*.

*. Refer to the Framework and Procedures for the IMO Member State Audit Scheme (resolution A.1067(28)).

APPENDIX VIII

Form of International Energy Efficiency (IEE) Certificate

INTERNATIONAL ENERGY EFFICIENCY CERTIFICATE

Issued under the provisions of the Protocol of 1997, as amended, to amend the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention") under the authority of the Government of:

.....

(Full designation of the Party)

by .....

(Full designation of the competent person or organization authorized under the provisions of the Convention)

Particulars of ship*

Name of ship .....
Distinctive number or letters .....
Port of registry .....
Gross tonnage .....
IMO Number+ .....

THIS IS TO CERTIFY:

1. That the ship has been surveyed in accordance with regulation 5.4 of Annex VI of the Convention; and

2. That the survey shows that the ship complies with the applicable requirements in regulation 20, regulation 21 and regulation 22.

Completion date of survey on which this Certificate is based.....(dd/mm/yyyy)
Issued at .....

(Place of issue of certificate)

(dd/mm/yyyy): .....

(Date of issue) (Signature of duly authorized official issuing the certificate)

(Seal or stamp of the authority, as appropriate)

*.Alternatively, the particulars of the ship may be placed horizontally in boxes.
+.In accordance with IMO ship identification number scheme (resolution A.1078(28)).

Supplement to the International Energy Efficiency Certificate

(IEE Certificate)

RECORD OF CONSTRUCTION RELATING TO ENERGY EFFICIENCY

Notes:

1. This Record shall be permanently attached to the IEE Certificate. The IEE Certificate shall be available on board the ship at all times.

2. The Record shall be at least in English, French or Spanish. If an official language of the issuing Party is also used, this shall prevail in case of a dispute or discrepancy.

3. Entries in boxes shall be made by inserting either: a cross (x) for the answers "yes" and "applicable"; or a dash () for the answers "no" and "not applicable", as appropriate.

4. Unless otherwise stated, regulations mentioned in this Record refer to regulations in Annex VI of the Convention, and resolutions or circulars refer to those adopted by the International Maritime Organization.

1. Particulars of ship

1.1 Name of ship .....
1.2 IMO number .....
1.3 Date of building contract .....
1.4 Gross tonnage .....
1.5 Deadweight .....
1.6 Type of ship* .....

2. Propulsion system

2.1 Diesel propulsion .....
2.2 Diesel-electric propulsion .....
2.3 Turbine propulsion .....

* Insert ship type in accordance with definitions specified in regulation 2. Ships falling into more than one of the ship types defined in regulation 2 should be considered as being the ship type with the most stringent (the lowest) required EEDI. If ship does not fall into the ship types defined in regulation 2, insert "Ship other than any of the ship type defined in regulation 2".

2.4 Hybrid propulsion .....
2.5 Propulsion system other than any of the above .....

3. Attained Energy Efficiency Design Index (EEDI)

3.1 The Attained EEDI in accordance with regulation 20.1 is calculated based on the information contained in the EEDI technical file which also shows the process of calculating the Attained EEDI.....
The Attained EEDI is.....grams-CO_2/tonne-mile

3.2 The Attained EEDI is not calculated as:
3.2.1 the ship is exempt under regulation 20.1 as it is not a new ship as defined in regulation 2.23.....
3.2.2 the type of propulsion system is exempt in accordance with regulation 19.3.....
3.2.3 the requirement of regulation 20 is waived by the ship's Administration in accordance with regulation 19.4.....
3.2.4 the type of ship is exempt in accordance with regulation 20.1.....

4. Required EEDI

4.1 Required EEDI is:.....grams-CO_2/tonne-mile

4.2 The required EEDI is not applicable as:
4.2.1 the ship is exempt under regulation 21.1 as it is not a new ship as defined in regulation 2.23.....
4.2.2 the type of propulsion system is exempt in accordance with regulation 19.3.....
4.2.3 the requirement of regulation 21 is waived by the ship's Administration in accordance with regulation 19.4.....
4.2.4 the type of ship is exempt in accordance with regulation 21.1.....
4.2.5 the ship's capacity is below the minimum capacity threshold in Table 1 of regulation 21.2.....

5. Ship Energy Efficiency Management Plan

5.1 The ship is provided with a Ship Energy Efficiency Management Plan (SEEMP) in compliance with regulation 22.....

6. EEDI technical file

6.1 The IEE Certificate is accompanied by the EEDI technical file in compliance with regulation 20.1.....
6.2 The EEDI technical file identification/verification number .....
6.3 The EEDI technical file verification date .....

THIS IS TO CERTIFY that this Record is correct in all respects.

Issued at .....

(Place of issue of the Record)

(dd/mm/yyyy): .....

(Date of issue)

(Signature of duly authorized official issuing the Record)

(Seal or stamp of the authority, as appropriate)

APPENDIX IX

Information to be submitted to the IMO Ship Fuel Oil Consumption Database

Identity of the ship
IMO number

Period of calendar year for which the data is submitted
Start date (dd/mm/yyyy)
End date (dd/mm/yyyy)

Technical characteristics of the ship
Ship type, as defined in regulation 2 of this Annex or other (to be stated)
Gross tonnage (GT)[7]
Net tonnage (NT)[8]
Deadweight tonnage (DWT)[9]
Power output (rated power[10]) of main and auxiliary reciprocating internal combustion engines over 130 kW (to be stated in kW)
EEDI (if applicable)
Ice class[11]

Fuel oil consumption, by fuel oil type[12] in metric tonnes and methods used for collecting fuel oil consumption data

Distance travelled
Hours underway

SEE INTERPRETATION 14 of MEPC.1/Circ.795/Rev.4

7. Gross tonnage should be calculated in accordance with the International Convention on Tonnage Measurement of Ships, 1969.
8. Net tonnage should be calculated in accordance with the International Convention on Tonnage Measurement of Ships, 1969. If not applicable, note "N/A".
9. DWT means the difference in tonnes between the displacement of a ship in water of relative density of 1025 kg/m^3 at the summer load draught and the lightweight of the ship. The summer load draught should be taken as the maximum summer draught as certified in the stability booklet approved by the Administration or an organization recognized by it.
10. Rated power means the maximum continuous rated power as specified on the nameplate of the engine.
11. Ice class should be consistent with the definition set out in the International Code for ships operating in polar waters (Polar Code), (resolutions MEPC.264(68) and MSC.385(94)). If not applicable, note "N/A".
12. As defined in the 2018 Guidelines on the method of calculation of the Attained Energy Efficiency Design Index (EEDI) for new ships (resolution MEPC.308(73), as amended) or other (to be stated).

APPENDIX X

Form of Statement of Compliance – Fuel Oil Consumption Reporting

STATEMENT OF COMPLIANCE – FUEL OIL CONSUMPTION REPORTING

Issued under the provisions of the Protocol of 1997, as amended, to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention") under the authority of the Government of:

. . . . . .
(full designation of the Party)

by . . . . . .
(full designation of the competent person or organization authorized under the provisions of the Convention)

Particulars of ship[13]
Name of ship . . . . . .
Distinctive number or letters. . . . . .
IMO Number[14]. . . . . .
Port of registry . . . . . .
Gross tonnage. . . . . .

THIS IS TO DECLARE:

1. That the ship has submitted to this Administration the data required by regulation 22A of Annex VI of the Convention, covering ship operations from (dd/mm/yyyy) through (dd/mm/yyyy); and

2. The data was collected and reported in accordance with the methodology and processes set out in the ship's SEEMP that was in effect over the period from (dd/mm/yyyy) through (dd/mm/yyyy).

13. Alternatively, the particulars of the ship may be placed horizontally in boxes.
14. In accordance with IMO ship identification number scheme (resolution A.1078(28)).

This Statement of Compliance is valid until (dd/mm/yyyy). . . . . .

Issued at: . . . . . .
(place of issue of Statement)

Date (dd/mm/yyyy) . . . . . .

(date of issue) (signature of duly authorized official issuing the Statement)

(seal or stamp of the authority, as appropriate)

ANNEX 2

List of international regulations related to the reduction of GHG emissions from ships (as of December 2018)

No.	Regulations	Remarks
1	Carbon Dioxide (CO_2) emissions from ships	Adopted by resolution 8 of the International Air Pollution Conference of Parties to MARPOL 73/78 in September 1997
2	IMO Policies and Practices related to the Reduction of Greenhouse Gas Emissions from Ships	Adopted by resolution A.963(23) on 5 December 2003
3	Amendments to MARPOL Annex VI, inclusion of a new chapter 4 on regulations on energy efficiency for ships	Adopted by resolution MEPC.203(62) on 15 July 2011 and entered into force on 1 January 2013
4	Promotion of technical co-operation and transfer of technology relating to the improvement of energy efficiency of ships	Adopted by resolution MEPC.229(65) on 17 May 2013
5	2013 Guidelines for calculation of reference lines for use with the energy efficiency design index (EEDI)	Adopted by resolution MEPC.231(65) on 17 May 2013
6	2013 Guidance on treatment of innovative energy efficiency technologies for calculation and verification of the attained EEDI	Agreed by MEPC.1/Circ.815 on 17 May 2013
7	2013 Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI) for cruise passenger ships having non-conventional propulsion	Adopted by resolution MEPC.233(65) on 17 May 2013
8	2013 Interim guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions, as amended	Adopted by resolution MEPC.232(65) on 17 June 2013, as amended by resolution MEPC.255(67) on 17 October 2014 and resolution MEPC.262(68) on 15 May 2015, and a consolidated text circulated by MEPC.1/Circ.850/Rev.1 on 15 July 2015

9	2014 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships	Adopted by resolution MEPC.245(66) on 4 April 2014, as amended by resolution MEPC.263(68) on 15 May 2015
10	Amendments to MARPOL Annex VI and the NOx Technical Code 2008 (Amendments to regulations 2, 13, 19, 20 and 21 and the Supplement to the IAPP Certificate under MARPOL Annex VI and certification of dual-fuel engines under the NOx Technical Code 2008)	Adopted by resolution MEPC.251(66) on 4 April 2014
11	2014 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)	Adopted by resolution MEPC.254(67) on 17 October 2014, as amended by resolution MEPC.261(68) on 15 May 2015 and a consolidated text circulated by MEPC.1/Circ.855/Rev.1 on 8 October 2015
12	Model Agreement between Governments on technological cooperation for the implementation of the regulations in chapter 4 of MARPOL Annex VI	Approved by MEPC.1/Circ.861 on 22 April 2016
13	Recommendation on exemption of ships not normally engaged on international voyages from the requirements in chapter 4 of MARPOL Annex VI	Approved by MEPC.1/Circ.863 on 22 April 2016
14	2016 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP)	Adopted by resolution MEPC.282(70) on 28 October 2016
15	Roadmap for developing a comprehensive IMO strategy on the reduction of GHG emissions from ships	Approved by Annex 11 of MEPC 70/18/Add.1 on 28 October 2016
16	Amendments to MARPOL Annex VI related to the data collection system for fuel oil consumption of ships	Adopted by resolution MEPC.278(70) on 28 October 2016 and entered into force on 1 March 2018
17	2017 Guidelines for Administration verification of ship fuel oil consumption data	Adopted by resolution MEPC.292(71) on 7 July 2017
18	2017 Guidelines for the development and management of the IMO Ship Fuel Oil Consumption Database	Adopted by resolution MEPC.293(71) on 7 July 2017
19	Submission of data to the IMO data collection system of fuel oil consumption of ships from a State not Party to MARPOL Annex VI	Agreed by MEPC.1/Circ.871 on 7 July 2017
20	Sample format for the confirmation of compliance, early submission of the SEEMP part II on the ship fuel oil consumption data collection plan and its timely verification pursuant to regulation 5.4.5 of MARPOL Annex VI	Agreed by MEPC.1/Circ.876 on 13 April 2018
21	Amendments to MARPOL Annex VI (ECAs and required EEDI for ro-ro cargo and ro-ro passenger ships)	Adopted by resolution MEPC.301(72) on 13 April 2018
22	Initial IMO Strategy on reduction of GHG emissions from ships	Adopted by resolution MEPC.304(72) on 13 April 2018
23	2018 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships	Adopted by resolution MEPC.308(73) on 26 October 2018
24	Amendments to the 2014 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)	Adopted by resolution MEPC.309(73) on 26 October 2018 and a consolidated text circulated by MEPC.1/Circ.855/Rev.2 (including Resolution MEPC.254(67) MEPC.261(68) and resolution MEPC.309(73))
25	Programme of follow-up actions of the Initial IMO Strategy on reduction of GHG emissions from ships up to 2023	Approved by Annex 9 of MEPC 73/19/Add.1 on 5 December 2018

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The International Maritime Organization (IMO) and European Union (EU) reached an agreement in December 2015 to establish Maritime Technology Cooperation Centres (MTCCs) in five regions, i.e. Asia, Africa, Latin America, Caribbean and Pacific. The overall objective is to enhance capacity building in mitigating climate change through the effective adoption of global efficient energy measures by way of technical mentorship, professional training, data collection, regional coordination in adhering to international regulations on energy efficiency of ships. In December 2016, following the win of one-year bidding competition, Shanghai Maritime University (SMU) entered into an agreement with IMO as the host institution of MTCC-Asia, which was then inaugurated in 15th May 2017. The center serves as a promoting hub in Asia for IMO-EU MTCC projects by providing innovative technologies in curbing greenhouse gas, sharing of technical expertise and discovering innovative ways to reduce the carbon emission from ships through conferences, workshops, maritime education and training, and technological co-operations and transfer.

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