

# **Guidance/Best practices document on monitoring and reporting of fuel consumption, CO<sub>2</sub> emissions and other relevant parameters pursuant to Regulation 2015/757 on monitoring, reporting and verification emissions from maritime transport**

This document is part of a series of documents prepared by experts gathered under two subgroups established under the umbrella of the "European Sustainable Shipping Forum (ESSF)": the MRV subgroup on monitoring and reporting and the MRV subgroup on verification and accreditation. These two MRV subgroups gathered for the period June 2015 to May 2017 in order to provide technical expertise in areas relevant for the implementation of Regulation (EU) 2015/757 (the MRV Shipping Regulation).

As indicated in their terms of reference, the two MRV shipping subgroups gathered relevant expertise and were mandated to identify guidance/best practices in areas relevant for the implementation of the MRV Shipping Regulation. The substance of this best practices document was unanimously endorsed by the representatives of the ESSF Plenary by written procedure ending on 30<sup>th</sup> of June 2017.

Guidance /best practices documents have been established in the following areas:

- Use of external ship's tracking data by verifiers
- Materiality and sampling;
- Recommendations for improvements issued by verifiers;
- Backward assessment of monitoring plans;
- Verification of emissions report;
- Assessment of monitoring plans by verifiers;
- Assessment of verifiers by National Accreditation Bodies in order to issue an accreditation certificate;
- Dealing with situations where the accreditation is suspended or withdrawn close to the planned issuing date of the Document of Compliance (DOC) by the verifier;
- Preparation of monitoring plans by companies;
- Monitoring and reporting of fuel consumption, CO<sub>2</sub> emissions and other relevant parameters

All guidance/best practice documents and other relevant documents can be downloaded from the Commission's website at the following address:

[https://ec.europa.eu/clima/policies/transport/shipping\\_en#tab-0-1](https://ec.europa.eu/clima/policies/transport/shipping_en#tab-0-1)

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## 1 INTRODUCTION

From 1<sup>st</sup> January 2018 companies are required to collect and later report verified annual data on CO<sub>2</sub> emissions and other relevant information for ships over 5 000 gross tons on voyages from and to EU ports. Furthermore, by 31 August 2017, for the ships concerned, companies have to submit to an accredited MRV shipping verifier a monitoring plan, consisting of complete and transparent documentation of the monitoring method and procedures to be applied for each of the ships under its responsibilities.

The legal framework is set by Regulation (EU) 2015/757 on monitoring, reporting and verification of carbon dioxide emissions from maritime transport and amending Directive 2009/16/EC ("the MRV Shipping Regulation")<sup>1</sup>.

Further technical legislation has been adopted by the European Commission to implement the requirements as regards monitoring and reporting. This includes:

- Commission Delegated Regulation (EU) 2016/2071 of 22 September 2016 on amending Regulation 2015/757 as regards the methods for monitoring CO<sub>2</sub> emissions and the rules for monitoring other relevant information<sup>2</sup>
- Commission Implementing Regulation (EU) 2016/1928 of 4 November 2016 on determination of cargo carried for categories of ship others than passengers ro-ro and container ships pursuant to Regulation (EU) 2015/757<sup>3</sup>
- Commission Implementing Regulation (EU) 2016/1927 of 4 November 2016 setting templates for monitoring plans, emissions reports and documents of compliance pursuant to Regulation (EU) 2015/757<sup>4</sup>

The present document has been compiled using working papers and reports prepared by dedicated Work Packages under the ESSF subgroup on MRV monitoring:

| Working Paper  | Work Package  | Coordinator   |
|--|---|---|
| Report of the ad-hoc taskforce on defining a robust cargo parameter for general cargo vessels under the EU MRV | Work Package 2 – Assessment of the concept of deadweight carried as cargo parameter/ cargo parameters for general cargo ships | Nick Lurkin (Royal Association of Netherlands Shipowners) |
| Report of the Ad-hoc expert group on recommendation for cargo parameter for Ro-Ro ships                        | Work Package 3 – Recommendation for cargo parameters for RoRo ships   | Poul Woodall (DFDS)                                       |
| Guidance on fuel monitoring  | Work Package 5 – Guidance on the monitoring of fuel consumption   | Torsten Mundt (DNV GL)                                    |
| Guidance on LNG – BoG  | Work Package 5 – Guidance   | Torsten Mundt   |

<sup>1</sup> [http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L\\_.2015.123.01.0055.01.ENG](http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2015.123.01.0055.01.ENG)

<sup>2</sup> [http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L\\_.2016.320.01.0001.01.ENG](http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2016.320.01.0001.01.ENG)

<sup>3</sup> [http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L\\_.2016.299.01.0022.01.ENG](http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2016.299.01.0022.01.ENG)

<sup>4</sup> [http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L\\_.2016.299.01.0001.01.ENG](http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2016.299.01.0001.01.ENG)

| <b>Working Paper</b>  | <b>Work Package</b>  | <b>Coordinator</b>                  |
|---|--|-------------------------------------|
| monitoring  | on the monitoring of fuel consumption  | (DNV GL)                            |
| Guidance for EIV arrangements   | Work Package 5 – Guidance on the monitoring of fuel consumption  | Torsten Mundt (DNV GL)              |
| Guidance on the determination of distance travelled and time spent at sea               | Work Package 6 – Guidance on the determination of distance travelled and time spent at sea               | Wolfram Guntermann (Hapag-Lloyd AG) |
| Guidance on monitoring methods for ships using the exemption from per-voyage monitoring | Work Package 8 – Guidance on monitoring methods for ships using the exemption from per-voyage monitoring | Carlos Pereira (EMSA)               |

This document provides best practices on how MRV companies should determine various parameters to be monitored and reported under the MRV Shipping Regulation. It has been written to support the implementation of the MRV Shipping Regulation by explaining its requirements in a non-legislative language and providing some examples. However, it should always be remembered that the MRV Shipping Regulation and the related Delegated and Implementing Regulations set the primary legal requirements.

## **2 DETERMINATION OF TECHNICAL EFFICIENCY**

According to Article 11 (3) and 21 (2) of the MRV Shipping Regulation and to part A, point 6 of the template for emissions reports, the technical efficiency of a ship is to be reported by using either the Energy Efficiency Design Index (EEDI) or the Estimated Index Value (EIV). This section provides to companies and verifiers best practices on how to derive the technical efficiency of the ship if the EEDI is not applicable.

### **2.1. Background and Scope**

The attained EEDI is to be reported where required by and in accordance with MARPOL Annex VI, Regulations 19 and 20.

Only for ships not covered by the EEDI, the Estimated Index Value (EIV) has to be reported for ship types as listed in:

- a) MEPC.231(65), paragraph 3: bulk carrier, gas carrier, tanker, containership, general cargo ship, refrigerated cargo carrier, combination carrier, ro-ro cargo ship, ro-ro cargo ship (vehicle), ro-ro passenger ship and LNG carrier.
- b) MEPC.233(65), paragraph 5: cruise passenger ships having non-conventional propulsion, including diesel-electric propulsion, turbine propulsion, and hybrid propulsion systems.

For the ship type which is not covered by the above guidelines, it is not required to report EIV, as "Not applicable".

Companies are encouraged to report voluntary EEDI values<sup>5</sup>, if available, instead of the EIV.

It is to be noted that EIV figures for determining ship type dependent reference lines within the EEDI framework have been calculated for a certain build period and have been fixed for this purpose.

The following section provides the calculation methodology and on how it could / may be applied to accommodate the legal reporting requirements on MRV.

### **2.2. Calculation of EIV**

To specify the calculation method for the EIV in the context of Shipping MRV, Commission Implementing Regulation (EU) 2016/1927 refers to IMO Resolution MEPC.215(63). This Resolution has been replaced by MEPC.231(65) – Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI) and more recently supplemented by MEPC.233(65). The calculation of the EIV is described in paragraphs 13 - 19 and 8 - 9, respectively:

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<sup>5</sup> certified independently by e.g. classification societies

The formula for calculating the EIV value for each ship (excluding containerships and ro-ro cargo ships (vehicle carrier), ro-ro cargo ships, ro-ro passenger ships and LNG carriers) is as follows:

$$\text{Estimated Index Value} = 3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{NME} P_{MEi} + 215 \cdot P_{AE}}{\text{Capacity} \cdot V_{ref}}$$

Specific formulae (and input parameters -  $P_{ME(i)}$  and  $P_{AE}$ ) for containerships and vehicle carriers<sup>6</sup>, ro-ro cargo ships, ro-ro passenger ships and LNG carriers are provided in MEPC.231(65).

For cruise passenger ships having non-conventional propulsion same information is provided in MEPC.233(65), remaining input parameters other than Capacity and  $V_{ref}$  are provided in MEPC.1/Circ. 866.

Data should be taken from available documents. If available, the reference speed can be obtained from the power-speed curves produced following sea trials at the time of delivery. These curves were submitted by the yard to the shipping company and they constitute an important document for the ship. Alternatively, data can potentially be obtained for vessels equipped with hull & fuel performance monitoring systems.

If no other values are available, the IHSF database should be used for EIV input parameters.

The importance of consistency of data sets for the three parameters  $P_{ME}$ , Capacity and  $V_{ref}$  has to be underlined.

### 2.3. Verification

Verification of the reported technical efficiency should focus on the correct use of attained EEDI values or on the correct calculation of EIV values including plausibility checks of input values.

In case of no changes in EIV values compared to previous emissions report for a ship, results of verification of previous emissions reports should be considered by the verifiers to avoid repetition of verification activities.

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<sup>6</sup> vehicle carrier is a sub-type of ro-ro cargo ships

### 3 MONITORING METHODS USED AND RELATED LEVEL OF UNCERTAINTY

The quantity determination is inherently subject to uncertainty. The Regulation requires specifying the uncertainty level within the Monitoring Plan (Art. 6.3.(f).(iv)) as well as in the emission report (Art. 11.3.(c)). Supplementary, uncertainty is further dealt with in Commission Implementing Regulation (EU) 2016/1927 (part C, point 3. of template for emissions reports) and Commission Delegated Regulation (EU) 2016/2072.

To deal comprehensively with the overall uncertainty figure with fuel monitoring on board a ship, it is to be noted that the measurement accuracy (uncertainty) of single equipment (e.g. flowmeters for receiving bunkers, density determination, storage in bunker tank,...) provide not the full picture of uncertainty levels for all processes of fuel oil handling on board.

By way of illustration, all process steps as mentioned in section 5.1 contribute to the overall “uncertainty level” to be stated according to the regulation. To serve as best practice within this document it is recommended (for the time being) to state an overall uncertainty level as follows:

| Monitoring Method acc.<br>Reg. EU 2015/757 | overall max.<br>uncertainty level |
|--|-----------------------------------|
| method A)                                  | ± 10%                             |
| method B)                                  | ± 10%                             |
| method C)                                  | ± 10%                             |

In case the uncertainty will be determined in more detail, the combined uncertainty should be calculated by using the following formula:

$$u_c(V) = \sqrt{u(V, \text{bunkering})^2 + u(V, \text{density})^2 + u(\dots)^2 + \dots}$$



## 4 PER-VOYAGE MONITORING

### 4.1. Consideration of voyages and ports of call for the monitoring of fuel consumption, CO<sub>2</sub> emissions, distance travelled, time spent at sea and cargo carried

A voyage is considered from the last berth or ship-to-ship transfer within a port of call<sup>7</sup> to the first berth or ship-to-ship transfer in the following port of call.

For the parameters to be monitored<sup>8</sup>, following scope applies:

| Parameter                 | During voyage | In EEA ports  | Total                         |
|---------------------------|---------------|---|-------------------------------|
| Fuel consumption          | Yes           | Yes*  | During voyages                |
| CO <sub>2</sub> emissions | Yes           | Yes (CO <sub>2</sub> emitted from arrival at 1 <sup>st</sup> berth until departure from last berth) | During voyages + in EEA ports |
| Distance travelled        | Yes           | No  | During voyages                |
| Time spent at sea         | Yes           | No  | During voyages                |
| Cargo carried             | Yes           | No  | During voyages                |

\* The monitoring of fuel consumption in EEA ports is required to determine the CO<sub>2</sub> emissions unless direct emissions monitoring is applied.

For the purpose of shipping MRV, specific situations and activities are considered as follows:

Ship-to-ship transfer of cargo or passengers:

- Part of voyage if carried out outside a port of call<sup>9</sup> (cargo carried needs to consider the amount of cargo before and after ship-to-ship transfer by calculating the weighted average for the entire voyage)
- If carried out within a port of call, ship-to-ship transfers are treated as cargo operations at berth: A ship-to-ship transfer within a port (prior to arrival at the first berth, if applicable) would be considered as the endpoint of the incoming voyage (and ship-to-ship transfer within a port after the last berth considered as start point of next voyage).

Anchoring:

- Considered as part of voyage if happening prior to arrival at port of call (arrival at 1<sup>st</sup> berth or 1<sup>st</sup> ship-to-ship transfer) or after departure from port of call (departure from last berth or last ship-to-ship transfer)

<sup>7</sup> To recall that the MRV Shipping Regulation defines 'port of call' as the port where a ship stops to load or unload cargo or to embark or disembark passengers.

<sup>8</sup> by measurement, calculation or estimation in accordance with the relevant provisions of the MRV Shipping Regulation

<sup>9</sup> Port limits are defined by the competent authority or body designated by Member States e.g. port Authority in each port.

- Excluded for determination of time spent at sea

#### Drifting

- Considered as part of voyage if happening prior to arrival at port of call or after departure from port of call

#### Tank cleaning:

- Considered as part of voyage if happening prior to arrival at port of call or after departure from port of call
- CO<sub>2</sub> emissions from movements to tank cleaning between the arrival at port of call and the departure from port of call (in the EEA) are considered as part of 'CO<sub>2</sub> emissions within EEA ports'

### **4.2. Monitoring methods for ships using the exemption from per-voyage monitoring**

In case of application of Article 9(2) of the MRV Shipping Regulation, following monitoring methods should be used:

#### *a) Determination of **distance travelled and time spent at sea***

- Use of standard distance considering routing elements such as avoiding shallow waters or an ECA transit
- Annual distance travelled: multiplying the distance travelled with the number of annual voyages (calculation per standard route and subsequent aggregation)
- Time spent at sea: use of scheduled time between scheduled port departure and scheduled port arrival
- Annual time spent at sea: multiplying the scheduled travel time with the number of annual voyages (calculation per standard route and subsequent aggregation)

#### *b) Determination of **cargo carried and transport work***

- Deviation from per-voyage monitoring possible in case of single standard routes (cargo and distance to be multiplied to calculate transport work)
- Use of commercial documents with aggregated cargo figures (either total annual or per standard route)

#### *c) Determination of **fuel consumption and CO<sub>2</sub> emissions***

- Fuel monitoring and recording should be carried out at the beginning of the monitoring period and at the end of the monitoring period for each fuel type and/or each storage tank and upon bunkering and de-bunkering.
- Companies may follow more frequent intervals according to their internal procedures.
- Fuel consumption (and subsequently CO<sub>2</sub> emissions) in ports may be calculated by multiplying the estimated hourly consumption while the ship is at berth with the average time spent at berth and the number of annual voyages.

Note: Unless all the performed voyages are of the exact same length, the need of having a parcel calculation (per-voyage monitoring derived) to obtain the annual reporting value will still remain.

## 5 DETERMINATION OF FUEL CONSUMPTION AND CO<sub>2</sub> EMISSIONS

### 5.1. Fuel oil consumption

This section provides best practices for onboard monitoring of fuel oil and recording of data for the purpose of monitoring of fuel consumption required by the MRV Shipping Regulation.

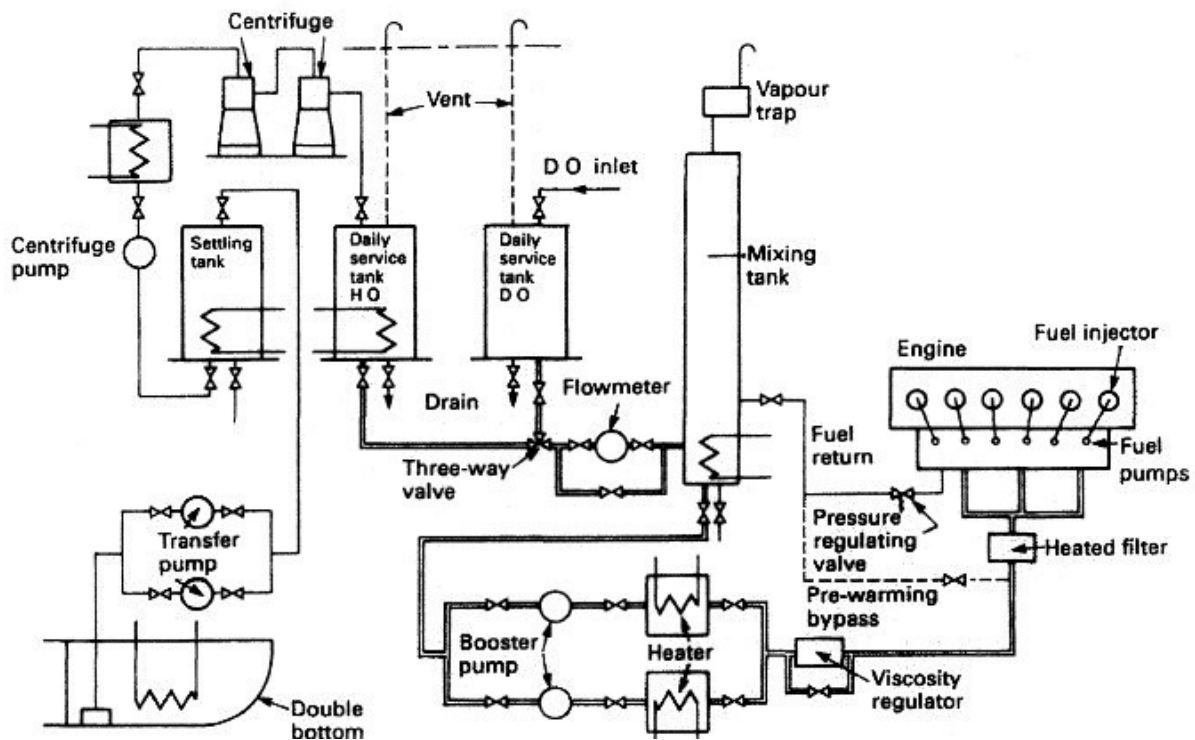
#### 5.1.1. RESPONSIBILITIES

The Master has ultimate responsibility for the monitoring of ship's bunker consumption and for reporting the data to the office as set by the company's procedures.

The Chief Engineer is responsible for the overall bunker operations, including the verification of bunker received, the sounding of the bunker tanks and calculation of the exact quantity of bunkers onboard.

#### 5.1.2. A GENERIC FUEL OIL SYSTEM ONBOARD

The following picture shows a generic ships fuel oil system.



Source: [www.machineryspaces.com](http://www.machineryspaces.com)

The diagram indicates that fuel oil onboard undergoes several process steps before being used. Own process steps are e.g.: bunkering, storage, heating, settling, cleaning (centrifuging) and in-between several transfers take place.

#### 5.1.3. TANKS SOUNDING FUEL OIL MEASUREMENT AND MONITORING

This is a generic guidance for fuel oil measurement through manual sounding/ ullage measurements. Depending on the situation onboard, it should be taken into account that not all ships may need to follow each step and the frequency of measurements provided below.

## **Fuel consumption “in port” and “at sea”**

For clarification, the fuel consumption “in port” is the total amount of fuel from the time the ship arrives at first berth of a port and up to the time the ship leaves the last berth of the port where commercial cargo operations or embarkation/disembarkation of passenger took place.

For example: a chemical tanker’s “in port” fuel consumption should include the total of the fuel consumed after the ship is securely moored at the first berth of a port including: fuel used for cargo operations to that berth and any other berth of the same port, fuel consumption used by the ship to move from one berth to another berth and fuel consumption used by the ship for moving out to sea for cargo tank cleaning and return to a berth of the same port.

The total fuel consumed “in port” can be:

- the difference between the fuel measured on board when the ship arrives at the first berth of a port and the fuel measured on board when the ship leaves the last berth of the port (eventual fuel bunkered during the stay in the port is not accounted for in this measurement) ; and
- when applicable, the fuel consumed while the ship was waiting at anchor or is carrying out ship-to-ship transfers within the port area

All other fuel consumption except the above should be considered as “at sea”.

## **Frequency**

The frequency of fuel tanks’ stock takings through soundings/ ullages should occur:

(1) For fuel monitoring method A)<sup>10</sup>:

- a) Upon bunkering and de-bunkering
- b) Upon arrival to the first berth of a port<sup>11</sup> and before leaving the last berth of the port where commercial cargo operations or embarkation/ disembarkation of passengers took place<sup>12</sup> prior to engaging on a voyage for a port outside the scope of the Regulation.
- c) For ships in short and regular trades and for ships using shore power while at berth the measurements may take place either upon arrival at the first berth or before leaving the last berth.<sup>2</sup>
- d) Allocation of all fuel consumption (for each fuel type) not under the scope of the regulation is needed as the sum is to be subtracted from the amount provided in the Bunker Delivery Note (BDN)

(2) For fuel monitoring method B)<sup>13</sup>:

- a) Upon bunkering and de-bunkering

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<sup>10</sup> Annex I, Although Method A is based on fuel data from BDN, ships need to measure fuel in tanks to make the balance at the end of the voyage or the end of the monitoring period...

<sup>11</sup> under the scope of the Regulation

<sup>12</sup> This may be applicable for fuel monitoring method B) as well.

<sup>13</sup> Annex I, B Methods for Determining CO<sub>2</sub> Emissions, (b) Bunker fuel tank monitoring on board

- b) Fuel tank readings for all bunker tanks onboard should occur daily when the ship is at sea<sup>14</sup>. These could be on a daily basis at 12:00 noon time, the start/end of a canal crossing, a voyage interruption, etc.
- c) While at sea passage prior entry and exit of a Sulphur Emission Control Area (SECA), if there is a fuel switch.

### **Calculating the volume of bunker in each tank**

The ship specific sounding/ calibration tables produced by shipyard for each individual bunker tank should be used to determine the volume of bunker in each tank taking into account the trim and list of the vessel.

ASTM D 1250-80 Standard Guide for Petroleum Measurement, table 54B, or equivalent tables or a substantiated software for temperature and atmospheric pressure corrections of density and mass calculations should be used.

The software could additionally be supported by dedicated ship specific software for trim, list and temperature corrections is available on board.

### **Density**

Density values to be used could be one of the following:

- (a) on-board measurement systems;
- (b) the density measured by the fuel supplier at fuel bunkering and recorded on BDN;
- (c) the density measured in a test analysis conducted in an accredited fuel test laboratory, where available.

The source of density values should be stated at all times. However, the fuel oil volumes recorded onboard after each monitoring may always be related to the standard temperature of 15°C<sup>15</sup>.

To cater for most practical handling onboard with the density issue – as an alternative to above- volume to mass conversion – may be done using standard conversion factors. The company may use bespoke conversion factors for the entire reporting period subject to criteria for establishing these have met the agreement of the verifier. The company may also use the following standard conversion factors:

- 0.96 when using RME180, RMG 180/380/500/700 or RMK 380/500/700
- 0.88 when using MGO/MDO

These standard conversion factors derive from ISO 8217 Fuel Standard figures after having been corrected with ASTM D1250 density temperature variation tables (using 60°C - 80°C for IFO/HFO and 40°C for MDO/MGO) and apply regardless of whether the volume measurements are made in the bunker tanks or at a volume flowmeter placed between the service tank and the engine inlet.

### **Density for commingled bunkers**

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<sup>14</sup> Fuel tank readings from tanks that have no transfer nor consumption can be omitted.

<sup>15</sup> reference is made to: ISO 8217; Specifications of Marine Fuels

When there are 2 types of fuels (or more) are mixed and stored in one fuel tank then the density volume to mass conversion factor of the fuel tank of the mixed oil should be calculated as per the below mentioned formula:

$$\frac{\text{'A' fuel volume} \times \text{Density (A)} + \text{'B' fuel volume} \times \text{Density (B)}}{\text{'A' fuel volume} + \text{'B' fuel volume}} = \text{mixed fuel Density}$$

**Density for blended fuels**

In the rare event that fuel types with different densities are blended in a tank, the weighted average density should be determined, unless a density analysis of the mixed fuel sample is available.

$$\rho_w = \rho_{add} \times \frac{m_{add}}{m_{total}} + \rho_{exist} \times \frac{m_{exist}}{m_{total}}$$

Where:

- $\rho_w$  : is the weighted average density of fuel in the tank after additions [ $t/m^3$ ]
- $\rho_{add}$  : is the density of the fuel added to the tank [ $t/m^3$ ]
- $m_{add}$  : is the amount of fuel added to the tank [ $t$ ]
- $m_{total}$  : is the total amount of fuel in the tank after addition [ $t$ ]
- $\rho_{exist}$  : is the density of the existing fuel in the tank before addition [ $t/m^3$ ]
- $m_{exist}$  : is the existing amount of fuel in the tank before addition [ $t$ ]

**Gauging equipment**

In general, there are several methods of gauging fuel tanks, e.g., manual soundings, gauges with audible noise when an oil interface is reached, pressure transducers, radar and so forth; each ship will adapt this part for description according to the equipment they use.

As back-up for fixed installed tank sounding/ gauging equipment, the method of determination of a tank’s sounding or ullage is suggested to be manual soundings. The tape or measuring device is to be graduated in feet, inches and fractions of an inch; or meters, centimetres, and millimetres.

Tapes which have been kinked or spliced or which contain illegible markings should not be used.

**Gauging criteria**

Vessel’s equipment used for gauging should always be substantiated for accuracies. This should be done by:

- Checking the condition and calibration (if applicable) of the instrumentation used for gauging the quantity of bunkers on board
- Recording the calibration certification (if applicable).
- Visual inspection of ullage tape to ensure there has been no damage to the tape and/or whether any repairs have been made that may alter readings.

Repeated measurements are taken for each tank to obtain at least two consistent readings. If two measurements are not similar then an average reading based on at least three measurements is recommended to do.

#### 5.1.4. CONTINUOUS FUEL OIL MONITORING

This procedure is for ships using flowmeters on consumers (e.g. main engines, auxiliary diesels, inert gas generators, boilers, etc.).

The data from all flow meters linked to fuel consumers minus the data from all flow meters at the return lines from the same consumers (if applicable) should be combined to determine fuel consumption over a period<sup>16</sup>.

Regardless if the fuel measurements are automatically recorded and transmitted, it is a good practice for ships engaged in long voyages when at sea to record daily measurements in the Engine Logbook. Depending on type of ship operation the master, chief engineer or the operator may follow other practice as per company SMS.

The validity of fuel flowmeters should be compared on a periodic basis through comparison with the fuel figures that derive from flowmeters and tank soundings. The ship operator's PMS should provide guidance on comparison frequency.

To ensure proper readings, fuel flowmeters onboard should be calibrated as per maker's recommendations or based on the ship's operational experience if flow meter is maintaining operational accuracy within manufactures suggested tolerances. Any records of manufacturer calibration should be maintained onboard and captured within the PMS onboard.

In the event that a fuel measurement cannot be made due to failure of a flow metering device the daily fuel consumption should be determined by utilising the tank soundings method<sup>17</sup>.

#### **Volume flowmeter**

The amount of fuel consumed is determined in units of volume, expressed in litres, and it is converted to mass by using the density values corrected for the applicable temperature by the use of the formula below:

$$M = \rho \times V$$

Where:

M: mass of fuel (*kg*)

V: volume of fuel (*l*)

$\rho$ : density at applicable temperature (*kg/l*).

Density values to be used should originate from BDN or provided through a fuel test analysis conducted in an accredited fuel test laboratory. Source of density values should be stated at all times.

ASTM D 1250-80 table 54B or equivalent tables or a substantiated software for temperature corrections of density should be used.

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<sup>16</sup> The need for a fuel meter in the return line may not be necessary depending on the arrangements, e.g. on where in the system the supply meter is fitted.

<sup>17</sup> means inherently that this is a fall-back solutions for filling (avoiding) data gaps for Methods A), B) and/ or C)

Temperature to be used for density corrections should be the fuel temperature at the flowmeters.

### **Mass flowmeters**

The mass flow meters measures directly the mass flow rate of the fuel and eliminates the need for further mathematical calculations to derive the mass of fuel consumed.

#### *5.1.5. FUEL OIL MONITORING AND RECORDING*

This section describes the different sequences of fuel oil handling onboard. This includes that fuel oil measurements on board ships are (or can be) done for different situations and purposes. The sequence and procedures in this chapter are generic and not each of them may apply to all the different ship types and ship trades we are faced with.

Ships may develop (or have) assessment procedures for dealing with possible mistakes or omissions that could occur and lay down control measures that are to be taken by the company to minimize this risk for data gaps.

Data flow charts for every fuel oil measurement method in use would be helpful to indicate the sequence of actions step by step along with the control activities.

### **Bunkering**

Bunkering should be covered by routine operational procedures. Therefore, in this paper a description of bunkering is not included as an own part / chapter. However, to just provide an info on what could / might be included in such descriptions, an own annex is attached for informational reasons.

### **“Noon report”**

As a matter of routine but on a voluntary basis only, ships engaged on long voyages do report the total amount of fuel on board on a daily basis<sup>18</sup>. The report is done at noon local time where the ship is located. This measurement provides also a daily monitor of the fuel consumption. The Officer in charge makes relevant entries in the Engine Log Book.

However, ships engaged in shorter voyages may not do this reporting.

### **Weekly measurement**

As a matter of best practice for good housekeeping but also to check and confirm proper function of mass flow meters, volumetric flow meters, ships may measure by manual tank sounding and make the balance of the fuel oil onboard on a weekly basis.

The procedure to follow was presented under section 5.1.3.

The Chief Engineer makes entries into the Engine Room log of the fuel oil remaining on board (ROB) and, comparing with the previous measurement results, could make the balance of the total fuel consumed during that week.

### **End of voyage measurement**

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<sup>18</sup> If you opt for monitoring Method B) it is required, for Method A) and C) it is a suggestion.



As a matter of best practice for easy monitoring and recording of the fuel consumption for each voyage, ships do measure the fuel oil ROBs at the end of each voyage or as determined by company SMS.

The procedure is similar to the one done as presented in section 5.1.3.

### **Fuel oil monitoring in ports**

A separated fuel oil monitoring / consumption analysis is required for ships in ports. Although ships may have various ways to monitor fuel consumption while in port, some ships may separately assess / calculate it using a method that with a reasonable accuracy establishes the mass of the individual fuel types consumed during the port stay(s).

#### *5.1.6. Emission factors for “Non-standard fuels”*

Since 1 January 2015, ships have been supplied with an increased number of Ultra Low Sulphur Fuel Oils (ULSFO) which are new products not yet categorised under the ISO 8217. In regard of the CO<sub>2</sub>-conversion factor of these fuels, it is that test results from accredited laboratories indicate that the large majority of these new products are within the RMA-RMD grades (i.e. residuals - light fuel oils) and only one or two are categorised as DMB grades (i.e. distillates).

For simplicity and consistency reasons, it is suggested that such new fuels (so-called “hybrid-fuels”) should use the standard CO<sub>2</sub> - conversion factors applied for light fuel oil (i.e. 3.151 when its viscosity is within RMA to RMD grades) and for distillates (i.e. 3,206 when similar to DMA or DMZ grades) as per this regulation.

| <b>Type of fuel</b>   | <b>Reference</b>                | <b>Emission factor (t-CO<sub>2</sub>/t-fuel)</b> |
|-----------------------|---------------------------------|--|
| Distillates (MGO/MDO) | ISO 8217 Grades DMA through DMZ | 3,206  |
| Light fuel oil (LFO)  | ISO 8217 Grades RMA through RMD | 3,151  |

The above assignment should not be seen as an exhaustive list as new products might be provided in the future.

#### *5.1.7. An example for a general description of bunkering procedures*

Chief Engineer or other appointed crew members<sup>19</sup> check ALL bunker tanks and complete the respective part of the “Bunkers Calculation” Form.

All quantities of bunkers (e.g. HFO, ULSHFO, MGO or other types of LSFOs) are recorded separately.

Common practice is to plan to receive new bunker in EMPTY bunker tanks. If not possible, comingling of different fuel batches may happen. In general, comingling is not favourable.

The appointed Engineer Officer has to implement the bunkering plan, supervise bunkering process and ensure that bunkering procedure is followed throughout the bunkering operations.

Relevant actions to secure correct assessment of the bunker received:

<sup>19</sup> or otherwise stated by company procedures

- carry out a pre-bunkering survey of the bunker barge, as per shipping company / bunker suppliers agreement, in order to determine exact quantity onboard together with the appointed Deck Officer of the watch.
- check ALL bunker tanks.
- witness the completion of the ullage report  
(for this purpose, the co-operation of bunker barge personnel should be secured)
- sign and obtain a copy of the completed ullage report;  
the copy should be attached to the Bunker Receipt Form.
- inform Master and request approval to start receiving bunkers when both quantity i.e. own vessel and bunker barge have been completed.
- upon completion of the bunkering, the Master and the Chief Engineer should arrange for a post bunkering survey (own vessel and bunker barge) similarly as with the “pre-bunkering survey procedures’ above.
- the Chief Engineer reviews the BDN and declaration of compliance with MARPOL Annex VI, presented by the bunker barge.
- during the review, Chief Engineer compares received quality and quantity against the Company’s bunkering information i.e. ordered regarding quality and quantity.
- both the Chief Engineer and the Master should sign for acceptance the Bunker Delivery Note issued by the bunker barge only if they agree with the figures received.

**Note :** The ship (i.e. the chief engineer on behalf of owner) issues a Letter of Protest in the following situations, but not limited to:

- shortage of bunker delivered,
- quality issues (e.g. failure of fulfilling ISO specifications)
- slow pumping rate,
- ship’s fuel samples not signed by the supplier
- lack of co-operation from bunker barge personnel to conduct mutual ullage inspections.

Upon completion of each bunkering, the following documentation is to be submitted to ships’ operational Head Office:

1. Bunkering Report Form.
2. Bunkers Quantity Calculation Form
3. Bunkering samples registration and consumption log Form
4. Bunkering pre-loading plan Form
5. Letter of Protest, if applicable
6. Ship-Barge Safety Checklist Form or Ship-Shore Safety Checklist Form, if bunkering by barge or terminal respectively.

The Chief Engineer should also maintain copies onboard. All relevant forms and checklists are kept on board for minimum 3 years.

Officer in charge makes relevant entries in the Engine Log Book and in the Oil Record Book.

## 5.2. LNG consumption – on-board monitoring of boil off gas (BoG)

This section provides best practices to the verifier and the company for the on-onboard monitoring of boil off gas (BoG) and recording of data for the purpose of monitoring of fuel consumption required by the MRV Shipping Regulation.

### 5.2.1. BACKGROUND

As required by the MRV Shipping Regulation, Annex-1 (Methods for monitoring CO<sub>2</sub> emissions), the company defines in the monitoring plan which monitoring method is to be used to calculate fuel consumption for each ship under its responsibility and ensure that once the method has been chosen, it is consistently applied. However, the 'Method A' states that "This method shall not be used when BDN are not available on board ships, especially when cargo is used as a fuel, for example, liquefied natural gas (LNG) boil-off"<sup>20</sup>. Since BDN cannot be used for the BoG, it is important for the verifier and the company to ensure that BoG measurement, calculation and documentation is in accordance with in fact use and is accurate, relevant and consistent.

LNG tankers are designed to carry natural gas in liquid form at a temperature of about -163°C, close to the vaporization temperature. Despite that tank insulation is designed to limit the admission of external heat, even a small amount of it will cause slight evaporation of the cargo. This natural evaporation, known as "natural boil-off" (NBoG) is unavoidable<sup>21</sup> and has to be removed from the tanks in order to control / limit the cargo tank pressure. Typical values are about 0.15%/day and below, recent projected LNG carriers are offered with a NBoR close to or even beneath 0.1%<sup>22</sup>.

Where insufficient NBOG volumes are available for propulsion, forced vaporization of LNG can be effected or otherwise liquid fuel (HFO /MDO/MGO) can supplement the additional energy demand. The force vaporized LNG is called Forced Boil Of Gas (FBOG). The NBOG and the FBOG will be collectively called BOG in this paper.

Boil-off gas (BoG) handling systems (known as Gas Management Systems) are typically used onboard LNG carriers as a means of pressure and temperature control. BoG is sent to the engine room via gas heaters by low capacity compressors and is burned by the main boilers or nowadays by dual fuel diesel engines as fuel.

On steam turbine powered vessels, the main boilers are capable of operating under different fuel combustion modes such as exclusively BoG mode (NBoG or NBoG + FBoG), combined BoG and fuel oil mode, and exclusively fuel oil mode. Although steam turbine systems have been the main form of propulsion used onboard LNG carriers and still comprise a large percentage of the operating LNG fleet, diesel engines capable of using BoG as fuel have become a preferred solution due to their higher operating efficiencies.

LNG carriers with diesel engines are required<sup>23</sup> to have a "Gas Combustion Unit" onboard. This GCU acts as a secondary means of controlling the tank pressure, in particular to cater for certain conditions like bad weather causing excessive NBoG generation, the temporary inability of the engines to burn gas or at engines' low load operation lower than what is

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<sup>20</sup> Use of cargo as fuel may apply to other low flash point hydrocarbons like ethane, LPG, etc.

<sup>21</sup> with the exception of vessels with re-liquefaction capability

<sup>22</sup> It may be noted that first boil-off phases contain almost exclusively nitrogen which has no calorific value for combustion.

<sup>23</sup> to fulfil the "historical 2 times 100% BoG capacity rule"

required to consume the available NBOG for propulsion and other services or when the vessel is idle. The flow to the GCU is to be included in the amount “consumed”. In general, GCU’s are equipped with flowmeters. However, there might be other uses for the GCU which may cause conflicts, e.g. when preparing for dry-dock, contaminated BoG / inert gas mixture is disposed off in this unit.

On the Steam LNG Carriers if the required energy for propulsion and other services drops below the energy available by the BOG, the main boilers continue to consume the available BOG and the excess steam generated is dumped directly into the condenser.

The natural Boil-off rate (BoR) is the amount of liquid that is evaporating from a cargo and expressed in % of total liquid volume per unit time.

It shall be noted that the MRV Shipping Regulation requires the reporting for LNG carries has to be done as follows:

- LNG cargo carried onboard to be reported in VOLUME units
- LNG consumed onboard as fuel to be reported in MASS units

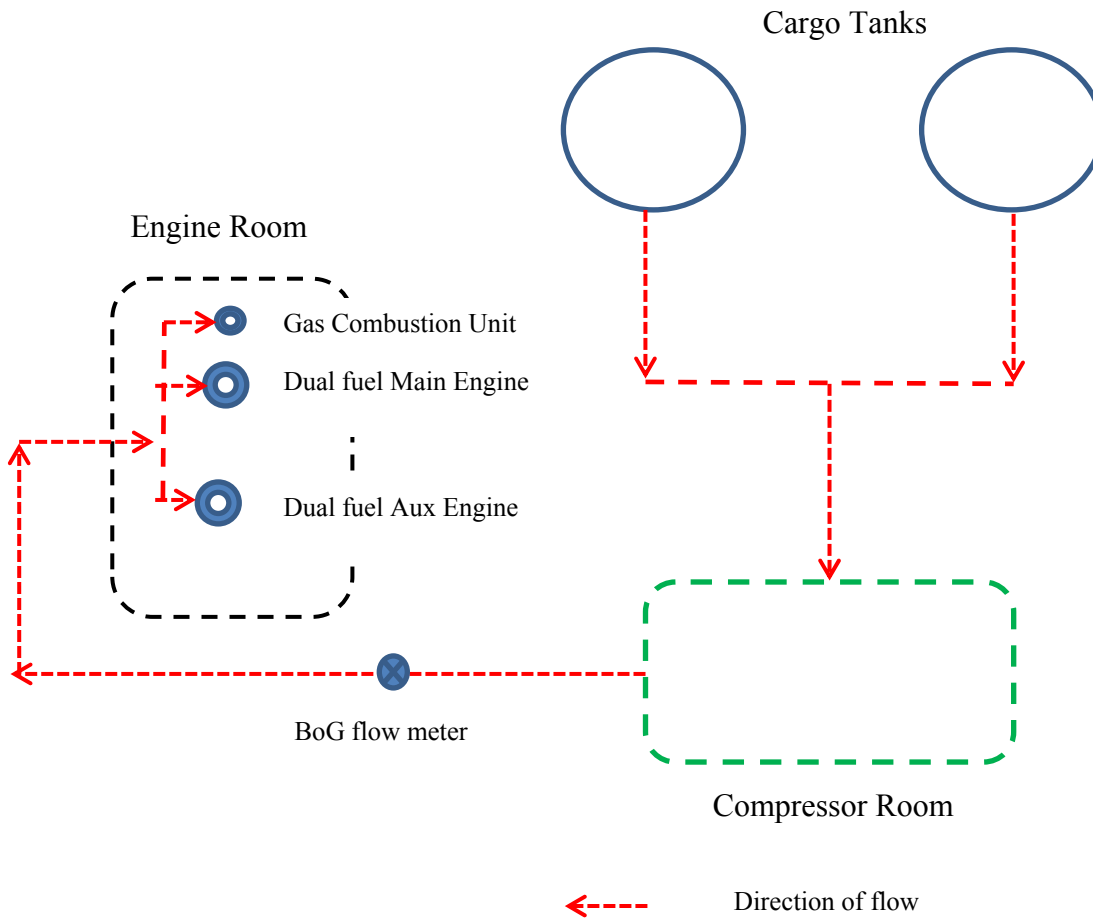
It should be noted that a number of LNG carriers are equipped with re-liquefaction systems which depending on the capacity can partially or fully re-liquefy the NBOG and send it back to the cargo tanks.

#### *5.2.2. RESPONSIBILITIES*

Usually the Master has overall responsibility for the monitoring of ship’s bunker consumption and BoG use/ consumption. This will be described in detail in company’s management procedures.

### 5.2.3. A GENERIC BoG HANDLING SYSTEM ONBOARD LNG VESSELS

The following diagram shows a generic ships BoG fuel oil system.



### 5.2.4. BoG MEASUREMENT AND MONITORING

The BoG can be measured by calculating the total LNG consumed for a voyage by custody transfer measurement system (CTMS) or by flow meters (onboard).

CTMS systems are the predominant systems available for all LNG carriers. They are used for determining the amount of cargo loaded or discharged and they have universally accepted with commercial relevance and are typically third-party verified.

#### a) Calculating BoG quantity by CTMS

Cargo consumed on the passage is calculated by using the “CTMS closing” (final volume on board at the loading terminal upon completion of loading) and “CTMS opening” (total volume upon arrival at the discharge terminal just before commencement of discharging) figures.

CTMS measures the volume of cargo in the tanks and further calculations convert the volume to weight / mass at the reference temperature. Therefore, the BoG is calculated as the difference between “CTMS closing” figure at the loading port and the “CTMS opening” figure at the discharging port.

In case of cargo discharge at several locations in a port of call, the discharged volumes have to be aggregated. In case of further discharges in other ports of call (in other words: during the subsequent voyages), the volumes discharged in these ports have to be added to the discharged volume, until new cargo is loaded.

On the ballast passage LNG carriers may maintain a comparatively small amount of LNG called “the heel” which can be used as fuel and/or for maintaining the cargo tanks in cold state ready to be loaded at the next loading port, using the same methodology as for the laden passage consumption.

b) Calculating BoG quantity by flow meters

If it is chosen to measure the BoG with flow meters instead of measuring through the CTMS, the BoG is measured either in volume and then converted to mass using appropriate density, pressure and temperature corrections or measured directly in mass (coriolis type flow meters).

Flow meters are typically installed on the BoG supply lines to the main boilers, diesel engines and the GCU as the case may be. The sum of all such flow meters determines the total BoG consumed.

In cases where the BoG is measured via onboard volume flow meters, the method to convert volume to weight (e.g. using the composition of the cargo at load port for deriving its density and converting volume to mass) will be decided by the company and described in the company’s management procedures. Bases on this method, the BoG used to fuel the ship during the voyage will be determined.

Shipping companies may determine the LNG vapour density for onboard flow meters using standard temperature of 15°C and at vapour space conditions  $P_v$  by the following calculation based upon ideal gas laws <sup>24</sup>:

$$\rho_{vt} = \frac{T_s}{T_v} \cdot \frac{P_v}{P_s} \cdot \frac{M_m}{I} \quad \left[ \frac{\text{kg}}{\text{m}^3} \right]$$

Where:

- $T_s$  is the standard temperature of 288 K (15°C)
- $T_v$  is the average temperature of vapour in degrees in Kelvin
- $P_v$  is the absolute pressure of vapour space in bar
- $P_s$  is the standard pressure of 1.013 bar
- $M_m$  is the molecular mass of vapour mixture in [kg/k mol] (provided from industry tables or from shore)
- $I$  is the ideal gaseous molar volume at standard temperature (288 K) and standard pressure (1.013 bar) = 23.645 [m<sup>3</sup>/k mol]

Note: An accurate knowledge of the vapour composition in deriving  $M_m$  is not necessary and the deviation of saturated liquid gas vapours from the ideal gas laws is usually ignored.

The amount of BoG consumed at berth may be derived by the flow meters installed on the piping supplying gas to the consumers (engines, boilers, etc.).

<sup>24</sup> The formula is derived from SIGTTO publication: 'Liquefied Gas Handling Principles on Ships and in Terminals' (LGHP4) 4<sup>th</sup> Edition, Section 8.5.2S

However, for the consumption in ports, the CTMS (opening and closing) might not in all cases reveal the full picture. Therefore, flow meters are the favourable alternative for port consumption. In particular, the shore meters of the vapour return line are useful to mention in this context as they are a commercial method which is applied, accurate and typically verified by a specialized 3<sup>rd</sup> party. Usually, the commercial calculation process does explicitly calculate the amount (the balance) consumed by the ship during the cargo operations.

#### 5.2.5. ACCURACY AND CALIBRATION OF MEASURING EQUIPMENT

All measuring equipment used for the monitoring should be maintained in good order and calibrated or certified for “fitness of purpose” in accordance with the maker’s guidance. Further information on maintenance procedures or in correlation with the PMS should be provided from the shipping company.

A copy of maintenance records and/ or the calibration certificate should be kept on board.

#### 5.2.6. Other relevant considerations

Existing EU legislation, namely the Directive (EU) 2016/802 relating to a reduction in the sulphur content of certain liquid fuels and more specifically the Commission Decision 2010/769/EU allow LNG carriers to use a specified BoG mixture as an equivalent abatement method to the low sulphur content oil-based fuels, i.e. for sulphur compliance reasons. For this purpose, it is required by Article 4 of Commission Decision 2010/769/EU that these ships are equipped with continuous monitoring and metering of the boil-off gas and marine fuel (i.e. pilot fuel) consumption.

More recently, the European Commission and EU Member States (through the Committee on Safe Seas and the Prevention of Pollution from Ships (COSS)) agreed, under certain circumstances (ship-specific design, operational profile & predefined BoG mixtures) on an extension to this equivalence also for propulsion purposes while sailing in the SECA.

Thus, it should be assumed that all the LNG carriers that would trade in the EU and planning to use BoG and marine fuel mixture as an abatement method, are already equipped with such continuous measuring/ metering devices plus related recording logs.

### 5.3. Assignment of fuel consumption and CO<sub>2</sub> emissions to passenger and freight transport (for ro-pax ships)

For ro-pax ships, Commission Implementing Regulation (EU) 2016/1927 requires a split of the total fuel consumption and CO<sub>2</sub> emissions in order to assign a part of the consumption/ emissions to passenger transport and the remaining part to freight transport (see part D, 1<sup>st</sup> section, points 7 and 8 of the template for emissions reports). This allows for better reflecting the nature of this ship type when expressing operational energy efficiency.

For the split of the total fuel consumption and CO<sub>2</sub> emissions it is recommended to use the methodology defined in EN 16258<sup>25</sup>.

EN 16258 allows the vessel’s total CO<sub>2</sub> to be split in a passenger and a freight element, in one of following two ways:

1. By mass

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<sup>25</sup> EN 16258:2012 Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers), Brussels: European Committee for Standardization (CEN)

## 2. By area

As regards the “mass” option, data should be taken for the determination of cargo carried (see section 1.1.7.2.2).

As regards the “area” option, all public passenger areas plus the part of the cargo decks used for passenger vehicles is allocated to “passengers” segment. All freight deck areas minus freight deck areas allocated to passenger vehicles is allocated to freight.

Following two issues should be considered when applying the area method:

### a) Hanging decks on ro-pax ships

Hanging decks could be understood as vertical moveable decks that enables a RoRo freight deck to be divided in to 2 or more decks enabling the vessel to accommodate more cargo with less height. Hanging decks may be split in to several sections each capable of being utilized independently.

For RoPax vessels fitted with hanging decks the company states, in the monitoring plan (MP), how many of these are to be included in the vessels freight capacity. The share of the hanging decks that is declared in the MP is to be substantiated based on either:

1. past performance
2. on the performance of a vessel serving the same trade
3. based on the company’s estimated use for the coming period
4. the actual utilization on hanging as recorded by the vessel<sup>26</sup>
5. based on such other method that satisfies the verifier.

The so declared capacity, including hanging decks, should remain unchanged for the monitoring period<sup>27</sup>. Should a fundamental change to the use of hanging decks be anticipated during a reporting period, a revision to the MP is to be made under Article 7 of Regulation (EU) 2015/757.

### b) How to allocate part of the freight deck to passenger car accommodation

The “passenger area” should include the area of the freight deck(s) allocated to passenger vehicles. A passenger vehicle is to be understood as “a vehicle whose sole purpose is to transport passengers and their personal luggage.”

The company should therefore in the monitoring plan state (in lanemeters or area) the area of the freight decks allocated to vehicles belonging to freight paying passengers. This so defined area should be part of the “passenger area” when spitting the vessels CO<sub>2</sub> emissions. This area should be declared in the MP and is to be substantiated by either:

1. based on past performance
2. on the performance of a vessel serving the same trade
3. based on the company’s estimated use for the coming period

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<sup>26</sup> In this case calculation of the vessels allocation of the CO<sub>2</sub> to passengers and freight will have to be calculated for each voyage being reported.

<sup>27</sup> unless method 4 is selected



4. the actual utilization as recorded by the vessel<sup>28</sup>
5. based on such other method that satisfies the verifier .

The so declared passenger area of the freight decks should remain unchanged for the monitoring period<sup>29</sup>.

Should a fundamental change to the use of freight decks for passenger vehicles be anticipated during a reporting period, a revision to the MP is to be made under Article 7 of the MRV Shipping Regulation.

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<sup>28</sup> In this case calculation of the vessels allocation of the CO<sub>2</sub> to passengers and freight will have to be calculated for each voyage being reported.

<sup>29</sup> unless method 4 is selected

## **6 DETERMINATION OF DISTANCE TRAVELLED AND TIME SPENT AT SEA**

For these two parameters following best practices are recommended:

- Distance travelled should be determined as distance over ground to follow the approach decided at IMO's MEPC 70.
- Should the vessel be adrift (i.e. while waiting for a berth) the distance should be included as the vessel is underway. Even if the main propulsion is temporarily not required, there will be still auxiliary generators and boilers in operation.
- Distances made for the purposes of tank cleaning operations should be included as the vessel is underway.
- Ship to Ship Transfer within defined limits of a port is considered as a port call.
- Unforeseen voyage deviations such as SAR (Search and Rescue), disembarkation of a sick crewmember, etc. should not result in an additional administrative burden for the carrier and verifier. Therefore it should be reported on a voluntary basis only.
- Since the EU Regulation stipulates that "time spent at sea" is to be calculated based on port departure and arrival information, it is recommended to use the arrival at the first berth and the departure of the last berth in a port where cargo operations have been conducted.
- Standard voyage distances and the use of scheduled time between scheduled port of departure and scheduled port of arrival for the monitoring of time spent at sea should be only considered for short fixed voyages such as for ro-ro/ ro-pax vessels. However, the usage of standard short voyages cannot be based exclusively on VTS distance, since distances and time spend at sea could be also subject to many factors such as avoiding shallow waters or an ECA transit.
- Given a high number of deviation scenarios, applying a "most direct route" (standard distance and time spent at sea) should be strongly discouraged, but could be used in order to fill data gaps subject to final approval by the verifier.
- It should be borne in mind that any correction factors have to be defensible and must be justifiable towards the verifier. There is a risk of wrongly estimating distances, (either as under or over estimation). It can create uncertainty in comparison to truly measured distances over ground and may result in an uneven, distorted playing field.

## 7 DETERMINATION OF CARGO CARRIED

### 7.1. Parameters for cargo carried

Parameters for 'cargo carried' are specified for 14 ship types and a category 'others' (in Annex II to the MRV Shipping Regulation, as amended, and in Commission Implementing Regulation (EU) 2016/1928). Furthermore, the emissions report template as specified by Commission Implementing Regulation (EU) 2016/1927 allows for the reporting of additional parameters on a voluntary basis.

The following table provides an overview of the ship categories, their definitions and the applicable cargo parameters:

| Ship type      | Definition in the context of the MRV Shipping Regulation   | Cargo parameter  | Remarks   |
|----------------|--|--|---|
| Passenger ship | -  | Number of passengers   | To be understood as ship with a passenger capacity above 12 persons but not carrying cargo. |
| Ro-ro ship     | A ship designed for the carriage of roll-on-roll-off cargo transportation units or with roll-on-roll-off cargo spaces. | Mass of the cargo on board, determined as <ul style="list-style-type: none"> <li>• the actual mass <i>or</i></li> <li>• as the number of cargo units (trucks, cars, etc.) multiplied by default values for their weight<sup>30</sup> <i>or</i></li> <li>• occupied lane meters multiplied by default values for their weight</li> </ul>  | To be understood as ro-ro cargo ships.  |
| Container ship | A ship designed exclusively for the carriage of containers in holds and on deck.                                       | <ul style="list-style-type: none"> <li>• Total weight in metric tonnes of the cargo or, failing that,</li> <li>• the amount of 20-foot equivalent units (TEU) multiplied by default values for their weight.</li> </ul> <p>Where cargo carried by a container ship is defined in accordance with applicable IMO Guidelines or instruments pursuant to the Convention for the Safety of Life at Sea (SOLAS Convention), that definition shall be deemed to comply with this Regulation.</p> |   |

<sup>30</sup> 'Weight' and 'mass' are to be considered as synonyms in the context of the Shipping MRV Regulation and in this document.

| <b>Ship type</b> | <b>Definition in the context of the MRV Shipping Regulation</b>  | <b>Cargo parameter</b>  | <b>Remarks</b>  |
|------------------|--|---|---|
| Oil Tanker       | A ship constructed or adapted primarily to carry crude oil or petroleum products in bulk in its cargo spaces, other than combination carriers, noxious liquid substances (NLS) tankers or gas tankers.   | Mass of the cargo on board  |   |
| Chemical tanker  | A ship constructed or adapted for the carriage in bulk of any liquid product listed in Chapter 17 of the International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk or a ship constructed or adapted to carry a cargo of NLS in bulk. | Mass of the cargo on board  | In addition to the monitoring and Additional voluntary reporting of annual average density of the cargoes transported |
| LNG carrier      | A tanker for the bulk carriage of liquefied natural gas (LNG) (primarily methane) in independent insulated tanks.  | Volume of the cargo on discharge, or if cargo is discharged at several occasions during a voyage, the sum of the cargo discharged during a voyage and the cargo discharged at all subsequent ports of call until new cargo is loaded. |   |
| Gas carrier      | A tanker for the bulk carriage of liquefied gases other than LNG.  | Mass of the cargo on board  |   |
| Bulk carrier     | A ship which is intended primarily to carry dry cargo in bulk, including types such as ore carriers as defined in Regulation 1 of Chapter XII of the 1998 International Convention for the Safety of Life at Sea (the SOLAS Convention), but excluding combination carriers.   | Mass of the cargo on board  | Additional voluntary reporting of annual average density of the cargoes transported                                   |

| Ship type               | Definition in the context of the MRV Shipping Regulation   | Cargo parameter  | Remarks   |
|-------------------------|--|--|---|
| General cargo ship      | A ship with a multi-deck or single-deck hull designed primarily for the carriage of general cargo excluding specialised dry cargo ships, which are not included in the calculation of reference lines for general cargo ships, namely livestock carrier, barge carrier, heavy load carrier, yacht carrier, nuclear fuel carrier. | Deadweight carried for laden voyages and zero for ballast voyages  | Mass of the cargo on board as additional voluntary parameter                        |
| Refrigerated cargo ship | A ship designed exclusively for the carriage of refrigerated cargoes in holds.   | Mass of the cargo on board   |   |
| Vehicle carrier         | A multi-deck roll-on-roll-off cargo ship designed for the carriage of empty cars and trucks.   | Mass of the cargo on board, determined as <ul style="list-style-type: none"> <li>the actual mass <i>or</i></li> <li>as the number of cargo units multiplied by default values for their weight <i>or</i></li> <li>occupied lane meters multiplied by default values for their weight</li> </ul>  | Deadweight carried as additional voluntary parameter                                |
| Combination carrier     | A ship designed to load 100 % deadweight with both liquid and dry cargo in bulk.   | Mass of the cargo on board   | Additional voluntary reporting of annual average density of the cargoes transported |
| Ro-pax ship             | A ship, which carries more than 12 passengers and which has roll-on/roll-off cargo space on board.   | <ul style="list-style-type: none"> <li>Number of passengers on board <i>and</i></li> <li>Mass of cargo on board, determined as <ul style="list-style-type: none"> <li>the actual mass or the number of cargo units (trucks, cars, etc.) multiplied by default values for their weight <i>or</i></li> <li>occupied lane meters multiplied by default values for their weight</li> </ul> </li> </ul> |   |

| Ship type                      | Definition in the context of the MRV Shipping Regulation                     | Cargo parameter   | Remarks  |
|--------------------------------|--|---|--|
| Container/<br>Ro-Ro cargo ship | A hybrid of a container ship and a ro-ro cargo ship in independent sections. | Volume of the cargo on board, determined as the <i>sum</i> <ul style="list-style-type: none"> <li>• of the number of cargo units (cars, trailers, trucks and other standard units) multiplied by a default area and by the height of the deck (the distance between the floor and the structural beam) <i>and</i></li> <li>• of the number of occupied lane-metres multiplied by the height of the deck (for other ro-ro cargo) <i>and</i></li> <li>• of the number of TEUs multiplied by 38,3 m<sup>3</sup></li> </ul> |  |
| Other ship types               | -  | <ul style="list-style-type: none"> <li>• Mass of the cargo on board <i>or</i></li> <li>• Deadweight carried for laden voyages and zero for ballast voyages</li> </ul>   | Other ship types not falling under any of the above categories |

## 7.2. Guidance on application of parameters for cargo carried

This section provides further guidance for some ship types to which more complex rules apply.

### 7.2.1. Determination of cargo carried for ro-ro ships

For ro-ro (cargo) ships, the company specifies in the monitoring plan (Table C.5.) which of the following options will be used for determining cargo carried:

1. Actual cargo weight
2. Actual loaded lanemeters multiplied with the default weight per lanemeter
3. Number and types of units multiplied by default weight per unit

Where options 2 or 3 are applied, the company lists in the monitoring plan (Table C.5.) the relevant default values to be used. These default values have to be representative for the trade in which the vessel is intended to trade and the so applied default value(s) have to be substantiated by the company to the satisfaction of the verifier. Such substantiation can be:

- past performance,
- on the performance of a vessel serving the same trade,
- based on the company's estimated use for the coming period,
- based on another method that satisfies the verifier.

The so declared default weights have to remain unchanged for the reporting period unless the monitoring plan is revised in accordance with Article 7 of the Shipping MRV Regulation to

reflect a fundamental change to the average weights per lanemeter or per unit during a reporting period.

#### *7.2.2. Determination of cargo carried for ro-ro passenger (ro-pax) ships*

For ro-pax ships, the company specifies in the monitoring plan (Table C.5.) which of the following options will be used for determining cargo carried:

1. Actual cargo weight
2. Actual loaded lanemeters multiplied with the default weight per lanemeter
3. Number and types of units multiplied by default weight per unit

Where options 2 or 3 are applied, the company lists in the monitoring plan (Table C.5.) the relevant default values to be used. These default values have to be representative for the trade in which the vessel is intended to trade and the so applied default value(s) have to be substantiated by the company to the satisfaction of the verifier. Such substantiation can be:

- past performance,
- on the performance of a vessel serving the same trade,
- based on the company's estimated use for the coming period,
- based on another method that satisfies the verifier.

The so declared default weights have to remain unchanged for the reporting period unless the monitoring plan is revised in accordance with Article 7 of the MRV Shipping Regulation to reflect a fundamental change to the average weights per lanemeter or per unit during a reporting period.

The passenger vehicle units loaded in the area allocated to passenger vehicles (which is included in the area allocated to the passenger area), must not be included in the calculation of cargo mass.

#### *7.2.3. Determination of cargo carried for vehicle carriers*

For vehicle carriers, the company specifies in the monitoring plan (Table C.5.) which of the following options will be used for determining cargo carried:

1. Actual cargo weight
2. Actual loaded lanemeters multiplied with the default weight per lanemeter
3. Number and types of units multiplied by default weight per unit

Where options 2 or 3 are applied, the company lists in the monitoring plan (Table C.5.) the relevant default values to be used. These default values have to be representative for the trade in which the vessel is intended to trade and the so applied default value(s) have to be substantiated by the company to the satisfaction of the verifier. Such substantiation can be:

- past performance,
- on the performance of a vessel serving the same trade,
- based on the company's estimated use for the coming period,
- based on another method that satisfies the verifier.

The so declared default weights have to remain unchanged for the reporting period unless the monitoring plan is revised in accordance with Article 7 of the MRV Shipping Regulation to reflect a fundamental change to the average weights per lanemeter or per unit during a reporting period.

In addition, on a voluntary basis, for vehicle carriers, cargo carried may also be determined as deadweight carried for laden voyages (and zero for ballast voyages).

#### 7.2.4. *Determination of cargo carried for general cargo ships*

Commission Implementing Regulation (EU) 2016/1928 specifies the parameter for cargo carried to be applied for general cargo ships as "*deadweight carried for laden voyages and zero for ballast voyages*".

For laden voyages, deadweight carried is calculated as follows:

*DWT carried = volume displacement x water density – ship's lightweight – fuel weight*

- DWT carried: expressed in metric tonnes
- Volume displacement: measured volume displacement of a ship at a load draught condition, determined as the volume of the moulded displacement of the ship, excluding appendages, in a ship with a metal shell, and means the volume of displacement to the outer surface of the hull in a ship with a shell of any other material, expressed in cubic metres
- Water density: relative water density at departure of the laden voyage concerned, expressed in metric tonnes per cubic metre
- Ship's lightweight: the actual weight of the ship with no fuel, passengers, cargo, water and other consumables on board, expressed in metric tonnes
- Fuel weight: weight of the fuel on board determined at the departure of the laden voyage concerned, expressed in metric tonnes

For the determination of the above parameters, following methods and sources should be used:

- Visual readings of the draught can be used to calculate the volume displacement with the help of a certified draft measurement scale. Digital readings could be used to validate the visual readings. For the ship's crew it will not be that burdensome, as the crew at almost all times already do visual reading. Draught measurements should be done just before departure/beginning of the voyage.
- The ship's lightweight should be taken from the stability booklet approved by the Administration or an organization recognized by it.
- To calculate the amount of fuel (by weight) the same three proposed monitoring methods (A, B and C) as for the fuel consumption should be used.

The methods applied to determine the volume displacement, the water density and the fuel weight have to be consistently applied during the entire reporting period and have to be specified in the monitoring plan (Table C.5.).

In addition, on a voluntary basis, for general cargo ships, cargo carried may also be determined as mass of the cargo on board.

#### 7.2.5. *Determination of cargo carried for container ships*

The Shipping MRV Regulation foresees two options to determine the amount for cargo carried which is expressed as mass of the cargo on board:

1. Actual cargo weight



2. Number of 20-foot equivalent units (TEU) multiplied by default values for their weight

The selected option is specified in the monitoring plan (Table C.5.) and applied consistently for the entire reporting period.

For option 1, the actual cargo weight should be determined using the verified gross mass information used under the new SOLAS regulations applicable to packed containers (reference is made to MSC.1/Circ.1475).

Where option 2 is applied, the company lists in the monitoring plan (Table C.5.) the relevant default values to be used. The use of a single default value of 12 tonnes per TEU is recommended as well as the use of a single default value of 2 tonnes per empty TEU.

It should be noted that the container industry uses a variety of standard container sizes, but standard default weights (consistent with the 12 tonne default figure per TEU and 2 tonnes per empty TEU) are easily calculated. The use of following standard conversion factors and default weights as noted below is recommended:

| <b>Container Size</b>                         | <b>TEU Conversion factor (TEU equivalents)</b> | <b>Default weight empty containers (in tonnes)</b> | <b>Default container weights (in tonnes)</b> |
|---|--|--|--|
| 20' ST TEU 8'6" plus 20' High Cube (HC)       | 1.0  | 2  | 12   |
| 40' ST FFE 8' 6" (forty-foot equivalent unit) | 2.0  | 4  | 24   |
| 40' High Cube (FFE 9'6") plus 45' and 48'     | 2.25   | 4.5  | 27   |

ST - Standard, TEU - twenty-foot equivalent unit, FFE – forty-foot equivalent, HC – high cube

#### 7.2.6. *Determination of cargo carried for LNG carriers*

Cargo carried for LNG carriers is determined as volume. LNG carriers often use boil off gas as a fuel. This means that the amount of LNG on board at the start of a voyage is larger than the amount of LNG discharged as cargo at the end of a voyage. Moreover, they often keep a small amount of LNG in the tank to maintain a low temperature. Therefore, for the determination of cargo carried, the amount of cargo is monitored at the discharge terminal.

The discharged volume of LNG is equal to the amount of cargo carried in case of discharge of the total amount at one single location. In case of discharge at several locations in a port of call, the discharged volumes have to be aggregated. In case of further discharges in other ports of call (in other words: during the subsequent voyages), the volumes discharges in these ports have to be added to the discharged volume, until new cargo is loaded.

For example, if an LNG carrier loads LNG at port A, then sails to port B where it discharges  $X \text{ m}^3$  and onwards to port C where it discharges  $Y \text{ m}^3$ , and finally returns to port A where it does not discharge any LNG, the amount of cargo on the voyage from A to B amounts to  $X+Y \text{ m}^3$ , the amount of cargo on the voyage from B to C amounts to  $Y \text{ m}^3$ , and the amount of cargo on the voyage from C to A is zero". This example also shows how to calculate the amount of cargo on voyages where no cargo is discharged.

To obtain information about discharged volumes of cargo, the Custody Transfer Management System (CTMS) should be used.

*7.2.7. Determination of cargo carried for chemical tankers, bulk carriers and combination carriers*

In addition to the monitoring and reporting of the amount of cargo carried, on a voluntary basis, the average density of the cargoes transported in the reporting period could be monitored and reported for chemical tankers, bulk carriers and combination carriers.

For that purpose, information about the methodology and procedures applied should be specified in the monitoring plan (Table C.5.) and applied consistently for the entire reporting period.

*7.2.8. Determination of cargo carried for other ship types*

For all other ships not covered by the definitions of one of the 14 categories, the company selects one of the two parameters:

- Mass of the cargo on board
- Deadweight carried for laden voyages and zero for ballast voyages

This choice is to be specified in the monitoring plan (Table C.5.) and applied consistently for the entire reporting period.

## Appendix: Abbreviations

|        |   |
|--------|---|
| BDN    | Bunker Delivery Note  |
| ESSF   | European Sustainable Shipping Forum                                 |
| BoG    | Boil off Gas which can be Natural NBoG or Forced FBoG               |
| BoR    | Boil-off rate   |
| COSS   | Committee on Safe Seas and the Prevention of Pollution from Ships   |
| CTMS   | Custody Transfer Measurement System                                 |
| EEDI   | Energy Efficiency Design Index                                      |
| EIV    | Estimated Index Value   |
| ESSF   | European Sustainable Shipping Forum                                 |
| FBoG   | Forced Boil off Gas   |
| GMS    | Gas Management Systems  |
| HFO    | Heavy Fuel Oil<br>(RME, RMG and RMK grades as per ISO 8217)         |
| IMO    | International Maritime Organisation                                 |
| LFO    | Light Fuel Oil<br>(RMA, RMB, RMD grades as per ISO 8217)            |
| IMO    | International Maritime Organisation                                 |
| LNG    | Liquefied Natural Gas   |
| MARPOL | International Convention for the Prevention of Pollution from Ships |
| MDO    | Marine Diesel Oil<br>(DMA, DMB, DMZ grades as per ISO 8217)         |
| MEPC   | Maritime Environmental Protection Committee                         |
| MGO    | Marine Gas Oil<br>(DMX, DMA grades as per ISO 8217)                 |
| MRV    | Monitoring, Reporting and Verification                              |
| NBoG   | Natural Boil off Gas  |
| NG     | Natural Gas   |
| PMS    | Plant Management System Planned Maintenance System                  |
| RO     | Recognised Organisation   |
| ROB    | Fuel Oil Remaining  |
| SECA   | Sulphur Emission Control Area                                       |
| SEEMP  | Ship Energy Efficiency Management Plan                              |
| SMS    | Safety Management System  |