EU MRV Regulation & Challenges for Ship-operators

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CO₂: EU Monitoring, Reporting & Verification

- EC published proposal for CO₂ emissions MRV Regulation on 28 June 2013
- Approved by EU Parliament on 29 April 2015 as Regulation (EU) 2015/757
- Entry into force: 1 July 2015
- Ships above 5,000 GT on voyages to, from and between EU ports

![Flowchart Diagram](chart.png)
ESSF Concept on Monitoring Plans

- Basic data - Identification of the ship - Company details
- Emission sources and fuel types used
- Fuel consumption of the ship
  - Methodology used to measure fuel consumption
  - Procedures for measuring fuel uplifts and fuel in tanks
  - Description of the measurement instruments involved
  - Determination of density
  - Procedures for recording, retrieving, transmitting and storing information
- Emission factors - Approaches for sampling and analyzing fuels
- List of voyages - Distance travelled - Time spent at sea
- Amount of cargo carried & number of passengers
- Quality and availability of data
  - Uncertainty assessment
  - Data gaps – Best practices for treatment of data gaps
- Management – Roles and Responsibilities
  - Data flow activities
  - Control activities
Emission sources and fuel types used

- Shipping companies will be asked to provide information about all emission sources which are installed onboard the ship.

<table>
<thead>
<tr>
<th>Emission source ref No</th>
<th>Emission source</th>
<th>Technical description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Main Engine</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>Aux. Engines</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Aux. Boilers</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>Inert Gas Generator(s)</td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>xxx</td>
<td></td>
</tr>
</tbody>
</table>

- Shipping company need to provide information on which fuel types according to ISO 8217 (or other standards, if permitted) are used by the ship.

<table>
<thead>
<tr>
<th>Fuel type ref</th>
<th>Fuel type (name, description)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFO</td>
<td>Heavy Fuel Oil (ISO 8217 Grades RME through RMK)</td>
</tr>
<tr>
<td>LFO</td>
<td>Light Fuel Oil (ISO 8217 Grades RMA through RM)</td>
</tr>
<tr>
<td>MDO/MGO</td>
<td>Diesel/Gas Oil (ISO 8217 Grades DMX through DMB)</td>
</tr>
<tr>
<td>HYBRID FUELS</td>
<td>HDME 50 (EXXONMOBIL), Fuel Oil (Chemoil), DMB (Chemoil), ULSFO (Shell), SK ULSFO (SK Energy, BP 0.1 RMD (BP), Eco Marine Fuel (Lukoil)</td>
</tr>
<tr>
<td>LPG</td>
<td>Liquefied Petroleum Gas (Propane/Butane)</td>
</tr>
<tr>
<td>LNG</td>
<td>Liquefied Natural Gas</td>
</tr>
</tbody>
</table>
Emission factors - Approaches for sampling and analyzing fuels

- Standard emission factors may be used:
  - Sample analysis in the case of:
    - alternative fuels not identified in table above or
    - in the case the company seeks improved accuracy
  - A list of laboratories accredited for the analysis according to EN ISO/IEC 17025

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>&quot;Default value (tonnes CO2 / tonne fuel)&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Fuel Oil (ISO 8217 Grades RME through RMK)</td>
<td>3.1144</td>
</tr>
<tr>
<td>Light Fuel Oil (ISO 8217 Grades RMA through RMD)</td>
<td>3.151</td>
</tr>
<tr>
<td>Diesel/Gas Oil (ISO 8217 Grades DMX through DMC)</td>
<td>3.206</td>
</tr>
<tr>
<td>Liquefied Petroleum Gas (Propane)</td>
<td>3.000</td>
</tr>
<tr>
<td>Liquefied Petroleum Gas (Butane)</td>
<td>3.030</td>
</tr>
<tr>
<td>Liquefied Natural Gas</td>
<td>2.750</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>69.3</td>
<td>44.3</td>
<td>3.070</td>
</tr>
<tr>
<td>Other Kerosene</td>
<td>71.9</td>
<td>43.8</td>
<td>3.149</td>
</tr>
<tr>
<td>Gas/Diesel Oil</td>
<td>74.1</td>
<td>43.0</td>
<td>3.186</td>
</tr>
<tr>
<td>Residual Fuel Oil</td>
<td>77.4</td>
<td>40.4</td>
<td>3.127</td>
</tr>
<tr>
<td>Liquefied Petroleum Gases</td>
<td>63.1</td>
<td>47.3</td>
<td>2.985</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>56.1</td>
<td>48.0</td>
<td>2.693</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of laboratory</th>
<th>Analytical procedures</th>
<th>Is the laboratory EN/ISO/IEC17025 accredited for this analysis?</th>
</tr>
</thead>
</table>
Fuel consumption of the ship – CO$_2$ Monitoring Approaches

- Four possible approaches to CO$_2$ emissions monitoring:
  - Bunker Delivery Note (BDN) and periodic stock takes of fuel tanks
  - Fuel tank monitoring
  - Flow meters for applicable combustion processes
  - Direct emission measurements

- The key challenge is the trade-off between:
  - Acceptable accuracy
  - Complexity
  - Corresponding relative through-life cost
BDN & Periodic Stock takes of Fuel Tanks

- Fuel consumption is calculated for each tank as:

\[ FQ_N = T_N + R_N - T_{N+1} - D_N \]
- \( FQ_N \) is the fuel consumed in tonnes for period “N”
- \( T_N \) is the total amount of fuel in the tank in tonnes at the start of period “N”
- \( T_{N+1} \) is the total amount of fuel in the tank in tonnes at the end of period “N”
- \( R_N \) is the fuel uptake in tonnes during period “N” (if applicable)
- \( D_N \) is the fuel debunkering in tonnes during period “N” (if applicable)

- The errors that are introduced with this method are associated mainly with the accuracy of:
  - BDNs
  - Bunker tanks measurements.

- The accuracy of the fuel tank readings vary depending on:
  - The means for measuring (i.e. dip tapes, automated systems)
  - External conditions (i.e., trim/heel, weather)
  - Calibration of the gauging system and the accuracy of tank tables
BDN & Periodic Stock takes of Fuel Tanks

- Fuel consumption combined uncertainty is calculated as:
  \[ u(y) = \sqrt{u^2(x_1) + u^2(x_2) + u^2(x_3) + u^2(x_4)} \]
  - \( u(x_1), \pm u(x_2), \pm u(x_3), \pm u(x_4) \) are the standard uncertainties of the measurements \( TN, RN, TN+1 \) and \( DN \) respectively

- To achieve a higher level of accuracy:
  - Follow bunkering and tank gauging procedures according to recognized standards.
    - criteria for at least three (3) consecutive gauges for each tank
    - free water checks, temperature checks, and checks on draught, trim and list
  - Calculate the delivered/received quantity
    - API Manual of Petroleum Measurement Standards MPMS – Chapter 12.1
  - Correct for impurities
    - ISO 8217 specifies the maximum impurities content for different grades of fuels
  - Check fuel tanks calibration tables
    - the steel reduction factor is generally 1.5 % of the total capacity
    - API Manual of Petroleum Measurement Standards MPMS – Chapter 2.8A
Fuel Tank Monitoring

- Fuel consumption is calculated for each tank as:
  \[ F_N = R_{N-1} - R_N \]
  - \( F_N \) = Fuel consumed for the period under consideration
  - \( R_{N-1} \) = Amount of fuel contained in ship’s tanks at the beginning of the period
  - \( R_N \) = Amount of fuel contained in ship’s tanks at the end of the period

- Fuel tank monitoring is based on fuel tank readings, which occur daily or at a defined time or geographical location, of all fuel tanks on-board
- More sensitive to inaccuracies as it relies only on fuel tank readings
- Discrepancies between the tank volume calculated and the actual volume consumed due to on-board fuel treatment processes
Fuel Tank Monitoring

- Fuel consumption combined uncertainty is calculated as:
  \[ u(y) = \sqrt{u^2(x_1) + u^2(x_2)} \]
  \[ \pm u(x1), \pm u(x2) \] are the uncertainties of the measurements RN-1, RN

- Uncertainty of tank monitoring data
  - For automatic systems
  - For manual bunkering measurement using look-up tables

- Factors influencing accuracy
  - Calibration of the automatic devices
  - Strike plate location
  - Dip tape properties
  - Accuracy of tables
  - Human error
  - Trim and heel
Flow Meters

- Fuel consumption is calculated as:
  \[ F_N = T_N - R_N \]
  - \( F_N \) = Fuel consumed for the period under consideration
  - \( T_N \) = Data from all flow meters linked to relevant engines
  - \( R_N \) = Data from all flow meters at the return lines from engines and fuel losses (i.e. filter backflush or engine leakage oil)

- Two typical arrangements:
  - Common line and flow meter prior to the mixing tube followed by branch for M/E and A/Es
  - Different lines for M/E and A/Es with separate flow meters installed

- Data from the various flow meters would be collated and combined to determine total fuel consumption for a specific period

- Increase in relative life cycle cost as well as additional maintenance and calibration requirements
Flow Meters

- Fuel consumption combined uncertainty is calculated as:
  \[ u(y) = \sqrt{u^2(x_1) + u^2(x_2)} \]
  - \( \pm u(x_1), \pm u(x_2) \) are the uncertainties of the measurements \( T_N, R_N \)

- Necessary for a 'fall-back' methodology in the event of failure of the primary flow-metering system

- Accuracy varies depending on:
  - The choice of flow-metering system
  - Improper operating environment
  - Installation and maintenance
  - Zeroing and calibration requirements
  - Operator competence

- Approach could be more accurate because it only accounts for the fuel consumed
Determination of Density

- Need to specify into the MP the method used. Actual density values unless not available and a standard density factor shall be applied.

- Actual density values:
  - Laboratory density is measured according to ISO 3675:1998. Another lab method is carried out with pyknometers (ISO 3838:1984).

- Standard density values:

- The volume and density must be for the same temperature:
  - The density measurement is specific to 15°C (e.g. from BDN). The volume measurement should be corrected to 15°C before the conversion to mass occurs.
  - The density measurement is corrected to the temperature of the fuel, then multiplied by the actual fuel volume to yield fuel mass.
BDN vs. FO Analysis

**BDN Density:** 989.6 kg/m\(^3\)

**FO Analysis Density:** 978.5 kg/m\(^3\)

**Difference in Density:** 11.1 kg/m\(^3\)

**Volume Delivered:** 303.5 m\(^3\)

**Fuel Mass (BDN):** \(303.5 \times 0.9896 = 300.28\) MT

**Fuel Mass (FO Analysis):** \(303.5 \times 0.9785 = 297\) MT

The BDN should be signed “for volume only”
Influence of Temperature

- BDN density: 989.6 kg/m\(^3\) and declared temperature: 50\(^\circ\)C
  - Corrected density = 967.4 kg/m\(^3\)
  - Actual Fuel Mass: 303.5 * 0.9674 = 293 MT

- FO Analysis density: 978.5 kg/m\(^3\) and actual temperature 55\(^\circ\)C
  - Corrected density = 953.4 kg/m\(^3\) (Difference: 14 kg/m\(^3\))
  - Actual Fuel Mass: 303.5 * 0.9534 = 289 MT

- Continuously monitored during bunkering:
  - Fuels’ tanks temperature
  - Temperature at manifolds
What about Sludge?

- Sludge is formed from water, asphaltenes, metals (such as rust particles), catalytic fines and other dirt with some of the oil base being carried over.

- Sludge generation is a direct function of:
  - Compatibility of fuel
  - Stability of fuel
  - The proper adjustment of separators

- Need to maintain data on sludge quantity vs. fuel oil consumption from oil record book (ORB)

- ISO 8217 specifies the maximum content for different grades of fuels

- The amount of fuel is determined by the correction factor (CF)

- \[ CF = \frac{100 - W(\%) - A(\%)}{100} \]
  - \( W(\%) \) is the water content in fuel,
  - \( A(\%) \) is the content of other inert material

- Typical sludge production 0.5 to 1% of daily fuel consumption

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Max. water content (% by vol)</th>
<th>Max. ash level (% by mass)</th>
<th>Max Al + Si (mg/kg)</th>
<th>Total aged sediment (% by mass)</th>
<th>Max Vanadium (mg/kg)</th>
<th>Max density @ 15°C (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMX</td>
<td>-</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>DMA</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>DM2</td>
<td>-</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>890</td>
</tr>
<tr>
<td>DMB</td>
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<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>900</td>
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<tr>
<td>RMA</td>
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<td>0.040</td>
<td>25</td>
<td>0.10</td>
<td>50</td>
<td>920</td>
</tr>
<tr>
<td>RMB</td>
<td>0.50</td>
<td>0.070</td>
<td>40</td>
<td>0.10</td>
<td>150</td>
<td>960</td>
</tr>
<tr>
<td>RMD</td>
<td>0.50</td>
<td>0.070</td>
<td>40</td>
<td>0.10</td>
<td>150</td>
<td>975</td>
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<tr>
<td>RME</td>
<td>0.50</td>
<td>0.070</td>
<td>50</td>
<td>0.10</td>
<td>150</td>
<td>991</td>
</tr>
<tr>
<td>RMG</td>
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<td>0.100</td>
<td>60</td>
<td>0.10</td>
<td>350</td>
<td>991</td>
</tr>
<tr>
<td>RMK</td>
<td>0.50</td>
<td>0.150</td>
<td>60</td>
<td>0.10</td>
<td>450</td>
<td>1010</td>
</tr>
</tbody>
</table>
Possible Causes for Fuel Measurement Inconsistencies

**POSSIBLE CAUSES**

**Equipment**
- Accuracy as function of capacity
- Data gaps due to software failure
- Data gaps due to hardware failure
- Un-calibrated equipment
- Lack precision due to fault installation
- Density
- Viscosity
- Enclosed impurities (i.e. Sludge)
- Mixing with air (during bunkering)

**Processes**
- Procedures not specific
- Not running controls on key assays
- Incorrect formulas and factors
- Not adequate measurement method
- Missing emission sources and fuels
- Temperature
- Vibration
- Rolling / Pitching
- Dust and dirt on measuring devices
- Trim / list

**People**
- Inconsistency of techniques
- Not familiar with measuring device
- Failure to follow procedures
- Erroneous data entry
- Not same level of training
- Job titles and roles not properly defined
- Reporting responsibilities not properly defined
- Monitoring responsibilities not properly defined
- Training and reviews not undertaken properly
- Not regular evaluation of the monitoring plan

**Environment**

**Management**

**EFFECT**
- Failure to measure fuel consumption correctly
Direct Emissions Measurement

- CO₂ emissions are determined by multiplying the CO₂ concentration of the exhaust gas with the exhaust gas flow.

- Direct measurement of CO₂ emissions is in its infancy within the maritime sector

- Direct emissions measurement will require substantially increased capital costs, on-board calibration and increased information technology (IT) infrastructure

- There will be greater requirements for on-board operator capability, together with the need for remote back-up systems
Data Gaps

- The MP should include a short description of the method to be used to estimate fuel consumption and other parameters if relevant data is missing:
  - Densities of fuels if a density analysis is not available
  - Correction for sludge if ORB data is not available
  - Emission factors if fuel analysis is not available
  - Missing data for fuel consumed at port
  - One or more flow meters fail during voyage
  - Missing data of date and hour of departure and arrival
  - Missing data on distance sailed
  - Missing data on cargo transferred

- The reasons why the data gap methodology has been applied and the quantity of emissions for which such approach is used shall be specified in the annual emissions report.
Data Flow

- Manually (through noon reports)
- Semi-automatically with human intervention
- Continuous real-time monitoring systems (ABS Nautical Systems VPMS)

**Onboard**
- Noon & Auto-Log data collection
- Data validation at source
- Reports & Dashboards
  - Engine Reports
  - Performance Reports
  - SEEMP

**Onshore**
- Fleet-wide comparative view of all assets
  - ME/Hull/Propeller Performance
  - Fuel Consumption
  - Environmental Compliance
  - Charter Party Compliance

Feedback
Data Replication
Three Steps for Data Flow and Control Systems

Create a logical sequence of data collection and processing

- Reading from instruments,
- Converting volume to mass
- Transferring data
- Processing, storing, retrieving

Assess the risks associated with this data flow and set up control measures

- Errors
- Misrepresentations
- Omissions

After the application of control measures, re-assess the risks

- Ensure Controls have been effectively applied.
- Remaining risks are sufficiently low

A well-defined data flow

- When and who takes which data
- From where and what does he do with these data
- Where he stores data thereafter

A set of control activities

- Search for duplicates
- Search for data gaps,
- Control check by an independent person

A risk assessment demonstrating risk reduced to an acceptably low level for

- Errors
- Misrepresentations
- Omissions
Establish Procedures for Control Activities

Quality assurance of the measurement equipment
- calibration schedules
- maintenance schedules
- availability of necessary parts

Quality assurance of the information technology system used.
- access to the systems
- backups
- recovery
- maintenance and security

Segregation of duties in the data flow and control activities
- four-eyes principle
- Cross checks

Internal reviews and validation of data
- comparison of data over time
- cross checks between different methods, etc.

Corrections and corrective actions
- replacement of a bad measurement instrument
- improvement of control activities, etc.

Control of out-sourced processes
- bunkering
- external laboratory analyses
- maintenance of equipment

Keeping records, documentation & document versions
Reporting

- Identify the ship and the company
- Identity of the verifier that assessed the emissions report
- Information on the monitoring method used and the related level of uncertainty
- Annual monitoring of following parameters:
  - Amount and emission factor for each type of fuel consumed in total
  - Total aggregate CO₂ emitted
  - Aggregated CO₂ emissions:
    - Voyages to/from EU ports
    - At berth within EU ports
  - Total distance travelled
  - Total time spent at sea
  - Total transport work
  - Average energy efficiency
Reporting

- **Excel template approach**
  - Several means of communication
  - MRV information through files (Excel, CSV, …)
  - Publication of information requires compilation of files
  - Harmonization through the use of templates
  - Version control of templates is required

- **Integrated web-based approach**
  - Communications centralized in one system
  - MRV information reported in predefined web-forms
  - Storage of information centralized in one system
  - Facilitated publication of information
  - Harmonization through the use of the web-based tool

Source: European Maritime Safety Agency
Verifiers shall be accredited by national accreditation body pursuant to Regulation (EC) No 765/2008.

Verifiers to ensure monitoring plans and emission reports are in compliance with the EU MRV Regulations.

Verifiers to assess the reliability, credibility and accuracy of the monitoring systems and reported data:
- Check data credibility by comparing reported data with estimated data based on ship tracking data and characteristics (estimates could be provided by the Commission).
- Check reported data are complete and free from inconsistencies.
- Check data sources and methodologies used in the calculations leading to the reported figures.
- Conduct spot-checks during verification process.
- Document all issues in the verification report.

Verifier issue the verification report.

Verifier issue Document of Compliance to be kept onboard.
Next Milestones

- ESSF sub-groups: monitoring/reporting & verification/accreditation
- Adoption of technical legislation
- Member States notify EC the system of penalties for non-compliance
- Start of monitoring

- July 2015
- 2015/2016
- End 2016
- Start 2017
- July 2017
- August 2017
- January 2018

- Preparation of supporting technical legislation
- Accreditation of verifiers
- Companies submit to the verifiers monitoring plans