Application of Actual Methane Slip Emission Factor (C_{slip}) under FuelEU Maritime and EU-ETS

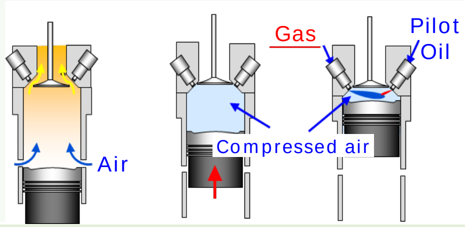
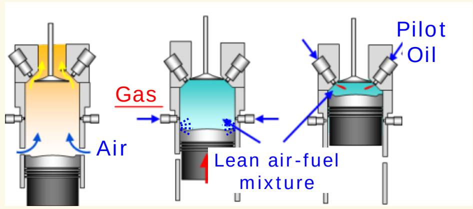
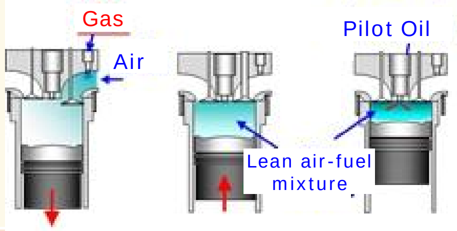
Ver. 1.0

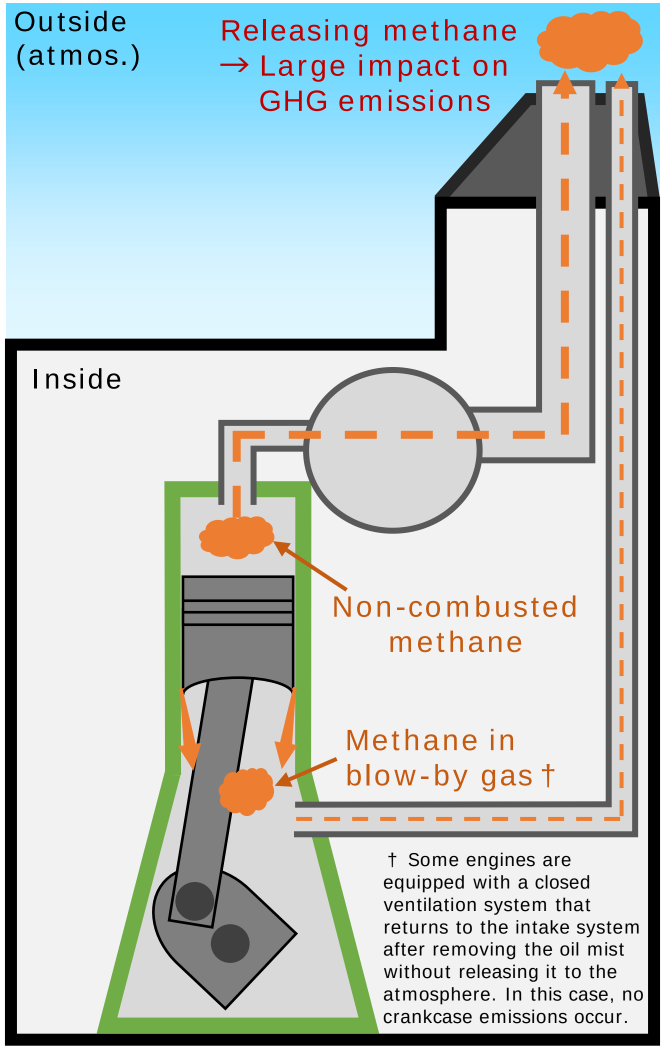
February 2026

Green Certification Department
ClassNK

What's "Methane Slip"

- Methane slip refers to a portion of LNG fuels (primarily methane) that escapes from engines without being oxidized.
- GWP* of methane is 25x for FuelEU Maritime / 28x for EU-ETS. Even a small slip significantly increases CO2-equivalent GHG emissions.
- Main pathways: "Non-combusted methane in exhaust" & "Crankcase emissions (blow-by)"
- Otto-cycle engines (lean-burn & low-pressure injection) generally have much higher methane slip rates than Diesel-cycle engines (high-pressure injection).

Type	Two-stroke (high-press.)	Two-stroke (low-press.)	Four-stroke
Thermodynamic Cycle	Diesel	Otto	
Combustion method	Diffusion combustion 	Premixed lean-burn 	
Gas injection press.	300 bar	16 bar	4 - 5 bar
Engine speed range	Slow	Slow	Medium
Major manufacturer	Everllence (ex. MAN): ME-GI (WinGD: X-DF-HP, from 2028)	WinGD: X-DF Everllence (ex. MAN): ME-GA	Yanmar, Daihatsu, Wärtsilä, etc.
Methane slip factor (default value)	0.2% ("Diesel-slow")	1.7% ("Otto-slow")	3.1% ("Otto-medium")



* GWP (Global Warming Potential): A coefficient that indicates how many times more greenhouse effect a substance has compared to CO_2. Under FuelEU Maritime, the reference is DIRECTIVE (EU) 2018/2001, and under EU-ETS, the reference is the IPCC AR5 values on a 100-year time horizon.

Reference: https://www.classnk.or.jp/classnk-rd/assets/pdf/seminar/2023/005_202307.pdf

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Treatment of Methane Slip in GHG Calculation

$$\text{GHG intensity}\left[\frac{\text{gCO2eq}}{\text{MJ}}\right] = f_{wind} \times (\text{WtT} + \text{TtW}) \quad \text{Equation (1)}$$

WtT	$\dfrac{\sum_i^{n\ fuel} M_i \times CO_{2eq\ WtT,\ i} \times LCV_i + \sum_k^c E_k \times CO_{2eq\ electricity,k}}{\sum_i^{n\ fuel} M_i \times LCV_i \times RWD_i + \sum_k^c E_k}$
TtW	$\dfrac{\sum_i^{n\ fuel}\sum_j^{m\ engine} M_{i,j} \times \left[\left(1 - \frac{1}{100} C_{slip\ j}\right) \times \left(CO_{2eq,\ TtW,i,\ j}\right) + \left(\frac{1}{100} C_{slip\ j} \times CO_{2eq\ TtW,\ slip,\ i,j}\right)\right]}{\sum_i^{n\ fuel} M_i \times LCV_i \times RWD_i + \sum_k^c E_k}$

- Basically, GHGs are calculated by multiplying fuel consumption by emission factors.
- GHG emissions from methane slip are calculated separately for LNG fuels.

C_{slip} (%): Non-combusted fuel (slipped) emission factor as a percentage of the mass of the fuel consumed

GHG emissions due to combusting fuels on board

$CO_{2eq,TtW}$: CO2eq. GHG factor for combusted fuels

$$CO_{2eq,TtWi,j} = (C_{fCO_2,j} \times GWP_{CO_2} + C_{fCH_4,j} \times GWP_{CH_4} + C_{fN_2O,j} \times GWP_{N_2O})_i$$

$C_{fCO_2,j} = 2.75$, $GWP_{CO_2} = 1$, $C_{fCH_4,j} = 0$, $GWP_{CH_4} = 25$, $C_{fN_2O,j} = 0.00011$, $GWP_{N_2O} = 298$

C_{fCO2}, C_{fCH4}, C_{fN2O}: GHG emission factors specified for each fuel

For LNG fuels, C_{fCH4} is set to zero since this term calculates the GHG emissions due to combusted fuels. Methane slip is caused by slipping non-combusted fuels.

GHG emissions due to slipping fuels on board

$CO_{2eq,TtW,slip}$: CO2eq. GHG factor for slipping fuels

$$CO_{2eq,TtWslip_{i,j}} = (C_{sfCO_2,j} \times GWP_{CO_2} + C_{sfCH_4j} \times GWP_{CH_4} + C_{sfN_2O,j} \times GWP_{N_2O})_i$$

$C_{sfCO_2,j} = 0$, $GWP_{CO_2} = 1$ → 0; $C_{sfCH_4j} = 1$, $GWP_{CH_4} = 25$ → 25; $C_{sfN_2O,j} = 0$, $GWP_{N_2O} = 298$ → 0

The relevant factors in the calculation are zero except for methane since this term calculates the GHG emission due to slipping fuels.
(CO2 and N2O are generated by fuel combustion.)

- There are many coefficients; however, most of them are fixed values. → C_{slip} is therefore a critical factor on methane slip emission.
- While default C_{slip} values are set for each engine type, actual values are also applicable instead of the default values.
  → The European Commission (EC) developed Guidelines* in October 2025.

* Guidelines for Reporting and Verification of Actual Methane Slip Tank-to-Wake Emission Factors from Marine Diesel Engines under the Scope of FuelEU Maritime Regulation

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Background of EC Guidelines

Current situation of IMO

- Currently, IMO-DCS, CII, and EEDI/EEXI do not count GHGs other than CO2, such as methane, N2O, etc.
- Methane slip will be accounted for in the new regulation, GFI (GHG Fuel Intensity); however, MEPC decided to delay adoption of GFI regulation by 1 year (Therefore, the GFI will not come into effect and be applied until 2028 at the earliest.)
  → Although discussions on methane slip are ongoing, it is just a future issue and not urgent for IMO.
- "Guidelines for test-bed and onboard measurements of methane (CH4) and/or nitrous oxide (N2O) emissions from marine diesel engines, Resolution MEPC. 402(83)" was adopted at MEPC 83 in April 2025, while discussions are still ongoing on Engine Load Monitoring (which will be detailed in a later slide), periodical verification methods, treatment of methane abatement aftertreatment devices, validity of test cycles for methane emissions, etc.

- EC already stipulated that methane and N2O should be counted as GHG (equivalent to CO2) in FuelEU Maritime and EU-ETS, and the specific rules were needed to be established urgently so that actual C_{slip} values can apply the regulations immediately.
- Therefore, the EC guidelines were developed with the aim at addressing the missing elements under discussion at IMO, even though these are interim solutions.
- Key Point: the EC guidelines adopted "Engine Load Monitoring (ELM)" and "Parameter check method" in advance of IMO.
- It is clearly stated that these are "interim guidelines". If international standards (e.g., IMO guidelines) will be established in the future, the guidelines may be revised to integrate them and/or refer to them.

Part of Introduction of the EC Guideline

> 1.4 FEUM entered into force on 1st January of 2025. It accounts for methane and/or nitrous oxide emissions, and for this reason an interim solution is required until international standards and certification references are developed for demonstration of actual tank-to-wake emission factors and accepted in the EU legislative framework. These Interim Guidelines aim at addressing the following missing elements under discussion at the IMO: onboard verification, monitoring the performance of methane abatement aftertreatment devices, and the validity of test cycles for methane emissions.

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Overall scheme for use of actual C_{slip}

Initial verification

- Perform the measurement of methane slip emissions at the specific load points on test bed or on board
- Prepare required documents and submit to the verifier

Only the first time
(or in case of major conversion)

During operation

- Monitor & record the engine load (ELM: Engine Load Monitoring)
- Record any adjustments and/or modifications of the engine(s) in the record book

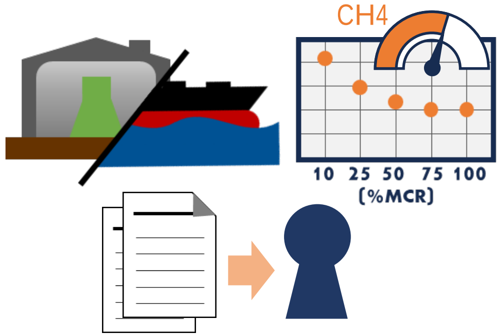
End of year

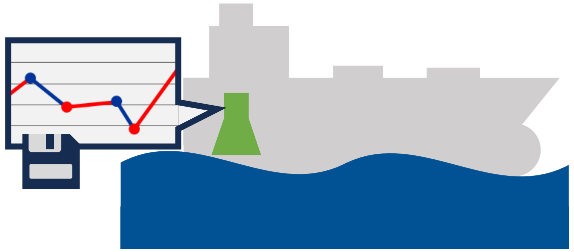
- Aggregate annual data (ELM data, LNG consumption, etc.) → Calculate C_{slip} for the year
- Prepare documents to be submitted to the verifier for the yearly verification

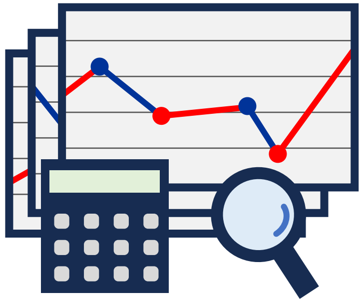
Yearly verification

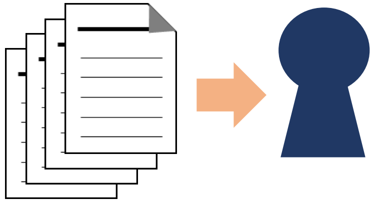
- Submit annual data, C_{slip} calculation results, record books, etc. to the verifier
- Parameter check (verification that no modifications/adjustments related to methane slip emissions have been made)

Repeating every year









Overall scheme for use of actual C_{slip}

To be performed in accordance with IMO Guidelines, Resolution MEPC.402(83)

Methane slip emissions vary depending on the engine load. (Generally, the lower the load, the higher the emissions.)
→ Engine Load Monitoring (ELM) should be conducted during operation continuously, and C_{slip} should be determined by a weighted average using the monitored engine load data.

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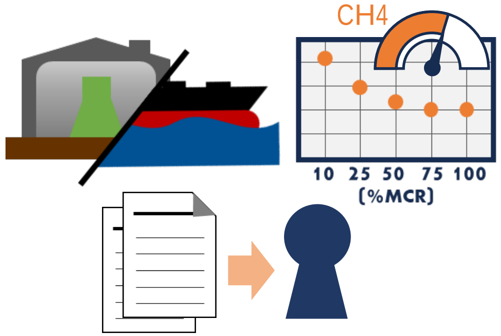

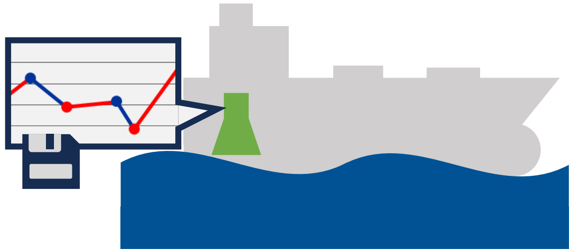

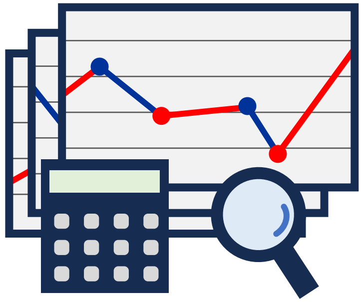

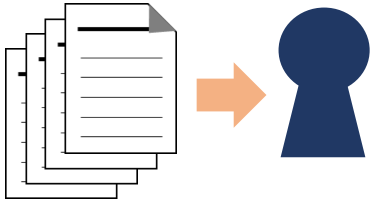

Methane Slip Emission Factor, C_{slip}

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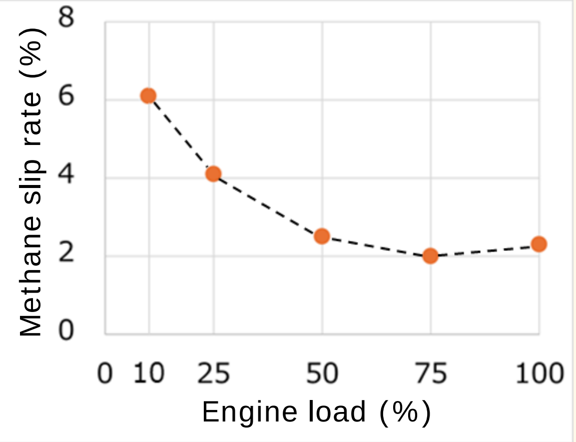
Procedure for determining C_{slip}

1st Process: Measurement of methane slip emission (test bed or on board)

- The measurement are performed at five (5) load points: 10% MCR (or the lowest load point of gas mode), 25%, 50%, 75%, and 100% MCR
- “Methane slip rate (%) at each load” is determined by the measurement results.
- Resolution MEPC.402(83) stipulates the method of the measurement.



2nd Process: Engine Load Monitoring (ELM) & C_{slip} calculation

1. During operation, engine load and gas fuel consumption are monitored continuously, and “average engine load” and “gas fuel consumption (kg)” are recorded at 30-minute intervals.
2. “Methane slip rate (%)” corresponding to each interval’s average load is determined by linear interpolation using the results of 1st Process.
3. “Amount of Methane slip (kg)” at each interval is determined by “methane slip rate (%)” x “gas fuel consumption (kg)”.
4. C_{slip} is determined by dividing “Total methane slip (kg)” by “ Total gas fuel consumption (kg)”.

Interval	Average engine power (monitored & recorded by ELM)	Gas fuel consumption (measured by flow meter)		Methane slip rate (determined by linear interpolation)		Methane slip emission (gas fuel consumption x slip rate)
12:00 - 12:30	15%	66.8kg	×	5.5%	=	3.7kg
12:30 - 13:00	55%	190kg		2.4%		4.6kg
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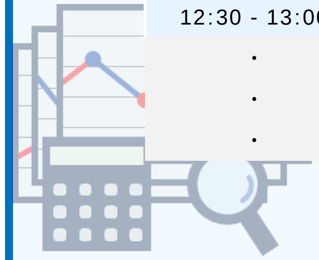
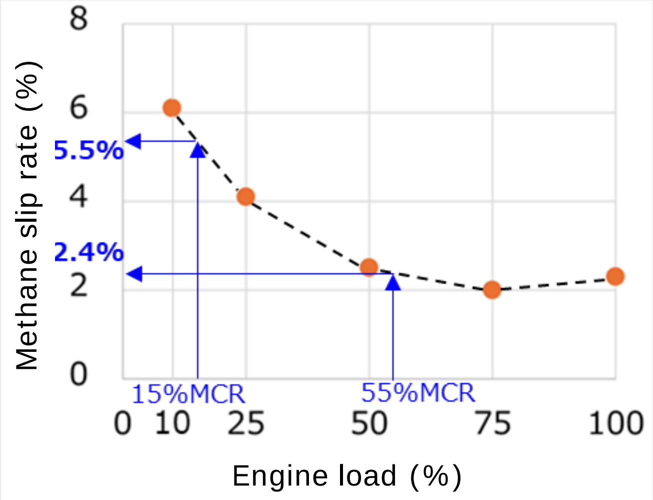
Σ ↓ Annual Total gas fuel consumption

Σ ↓ Annual Total methane slip





Methane Slip Emission Factor, C_{slip}

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■ Engine Load Monitoring (ELM)

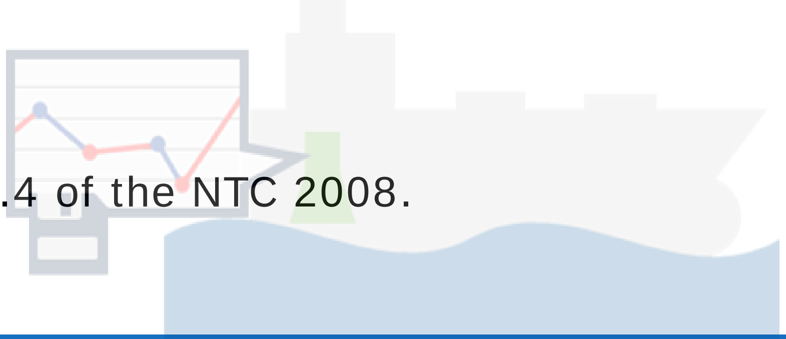
➢ Measurement & recording requirements

- Continuously monitor & record the engine load.
- Recording frequency: at least 0.0033 Hz (≈ every 5 minutes). If the load monitoring/recording is carried out without an automated data acquisition system, approval by the verifier or the flag State is required.
- Averaged in 30-minute intervals: calculate each interval's engine load as the average of the measured loads during the interval. (exclude fuel oil only operations.)
- If the range exceeds 10% of the rated power or rated speed of the engine, shorten the interval to the larger of:
  - A) the time in which the power/speed range is within ±10% of rated power/speed
  - B) the data recording & processing period
- If there are data gaps, provide the verifier with a methodology (e.g., proportional interpolation) to fill the missing period and obtain the verifier's assessment.

➢ Load measurement methods

Measure and determine the load based on one or a combination of the following:

- Direct load measurement signal;
- Torque flange and engine speed;
- Shaft strain gauge and engine speed;
- Calculated from generator output;
- Estimated load based on cylinder pressure, injection duration as in 6.4.3.4 of the NTC 2008.



Overall structure

1. Introduction
   - Purpose and scope of the Guidelines
   - Background of the FuelEU Maritime Regulation and the need for an interim solution due to the absence of international standards for methane emission factors
   - Use of IMO Resolution MEPC.402(83) and how to address elements not yet covered
   - Using Total Hydrocarbons (THC) as a proxy when methane is not measured; treatment of crankcase emissions for four-stroke engines

2. Documentation of the slip emission values
   - Information to be included in the Methane File
   - Preparation of the relevant record books

3. Verification of the methane emission values
   - Procedures for initial verification and yearly verification reporting

Annex I: Interim procedure for Engine Load Monitoring (ELM) and C_{slip} calculation
Annex II: Detailed yearly verification procedures
Annex III: Frequently Asked Questions (FAQ)

1. Introduction

- As of October 2025, IMO has adopted Resolution MEPC.402(83) which is the guidelines for measurement of methane slip. However, several elements are still under discussion (e.g., onboard verification such as ELM, monitoring the performance of methane abatement after-treatment devices, and the validity of test cycles for methane emissions). Therefore, the EC Guidelines serve as an interim approach applicable to FuelEU/ETS until acceptable international methods are established.
→ After further IMO Guidelines are established, the EC Guideline may be revised according to them.

- If methane emissions were not measured directly, THC (Total HydroCarbons) measured in accordance with MEPC.402(83) or the NOx Technical Code (NTC) may be used as a proxy for methane.
→ THC is usually measured in NOx measurement in accordance with NTC. Methane (CH_4) is a type of hydrocarbon and included in THC. However, since THC includes other hydrocarbons, the amount of THC is slightly higher than the amount of pure methane. (In LNG-fueled engines, methane often makes up >90% of exhaust THC.)

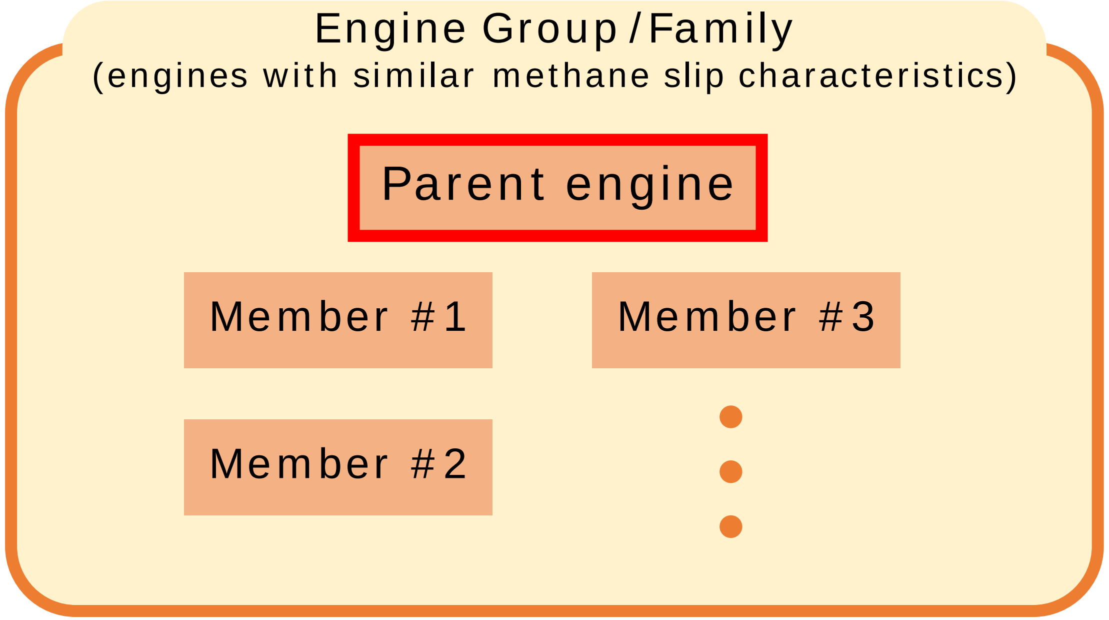
- Measurement at 10%MCR (or the lowest load point at which gas fuel is used) is mandatory
→ For E2/E3 cycle engines (often main engines), NOx measurement does not include 10%MCR.
For D2 cycle engines (often auxiliary engines), 10%MCR is included in NOx measurement, but it may have been conducted in fuel mode in the case where the lowest gas-mode load is higher than 10% (e.g., 15–20%). In that case, an additional measurement at the lowest gas-mode load is required even if THC is used as a proxy.

- For four-stroke engines without a closed crankcase ventilation system, crankcase emissions should be included.
→ Crankcase emissions should be based on measurements from the same or similar engines.
If such data are not available, a default emission value with technical justification should be used.
If a technically justified value cannot be established, the application of an actual C_{slip} may not be feasible.

2. Documentation of the slip emission values

- **Treatment of Engine Group / Family & Parent / Member**

  - The basic concept is the same as for NOx regulation. However, the group/family for methane slip may be different from that for NOx. (From the viewpoint of methane slip characteristics, a group/family consists of engines with similar methane slip characteristics, and the engine with the largest amount of methane slip is the parent.).
  - The results of methane slip measurement test for parent engines can also be applied to member engines (Technical justifications and documentations of the group/family are required.)
  - Onboard measurements may be accepted for an individual engine or an engine group represented by a parent engine, but not for an engine family without further justification.
  - Test-bed measurements may be accepted for an individual engine, an engine group, and also an engine family.



- Parent engine: the engine expected to produce the highest methane slip among all of the engines in the group/family.
- Member engines: the engines belonging to the same group/family other than the parent engine.
- Engine Group: typically, engines which may require adjustment after installation on board (e.g., two-stroke main engines).
- Engine Family: typically, engines which are not required adjustment after installation (e.g., four-stroke auxiliary engines).

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2. Documentation of the slip emission values

Preparation of Methane File

Resolution MEPC.402(83) requires the preparation of Methane File and specifies the information to be included. However, EC Guidelines add further requirement, as shown below.

Contents specified in Resolution MEPC.402(83)

- Detailed engine information
  - Model name and model
  - Rated power (kW) and rated speed (rpm)
  - NOx critical components and their settings
  - Other parts and settings that affect methane emissions
- Drawing of the exhaust system
  - Indication of exhaust gas sampling points
- Additional information for reporting methane slip
  - Details of how to calculate crankcase emissions, if included
- Test data and engine performance information
  - Conform to the test report format shown in Appendix 2
  - Methane emissions, measured at each load point
  - Measurement results including 10% load point in test cycle (E2/E3)
- Methane abatement aftertreatment device (if equipped)
  - Purpose of equipment, operating principle, main parts, set values
  - Information on consumables and operating conditions
  - If exhaust gas sampling is performed before and after the equipment, a description of the switching method

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Additional contents specified in EC Guidelines

- Treatment of crankcase emissions
  - If a four-stroke engine does not have closed ventilation, crankcase emissions shall be included.
  - Enter measured values, etc. for the same type of engine
- Allowable range of set and operating values
  - Allowable range of parameters that may increase methane slip
- Assessment of the influence of ambient conditions
  - Consider the effect of environmental conditions such as temperature and humidity on methane slip
- Engine group information and proof of representativeness
  - List of engines belonging to the same engine group
  - Technical description that the parent engine represents the target engine group
- Data collection and calculation procedures
  - Engine load monitoring (ELM) method
  - Calculation procedures for gas fuel consumption
  - Calibration certificates and validity periods for measuring instruments
- Parameter change recording procedures
  - Recording methods for parts and setting changes that affect methane slip (operation of record books)
- Verification procedure of methane slip emissions
  - Verification method (by Parameter check method or Measurement method)
  - In case of measurement method, measurement procedure considering the influence of ambient conditions
- Methane abatement aftertreatment device (if equipped)
  - Procedure to implement a maintenance record book

2. Documentation of the slip emission values

- Preparation of record books
  - Record book of changes that may increase methane slip emissions
    - Record any changes in engine components, settings or operating conditions that may increase methane slip emissions
    - Any such changes during the reporting period will invalidate the measurement results
  - Record books for the methane abatement aftertreatment device (if equipped)
    - Record the operating period and maintenance status of methane abatement aftertreatment device
    - Expected maintenance schedule should also be included
    - Procedure to implement this record book should be described in Methane File
- Additional information required for the annual report (FEUM Report)
  - Engine Load Monitoring (ELM) data and C_{slip} calculation results
  - Calibration certificates of instruments used for ELM
  - If a parameter checking method is applied, the records of changing engine parameters and settings. (“Parameter checking method” will be explained in a later slide.)

3. Verification of the methane emission values

- Initial verification

1. Prepare Methane File and submit it to the flag Administration or a recognized organization (RO) for approval.
2. Amend the FuelEU/ETS Monitoring Plan.
3. The FEUM verifier confirms and verifies at least the following:
   - Methane File:
     - ✓ The ship has the approved one;
     - ✓ It contains all required information;
     - ✓ It demonstrates with a reasonable assurance that the methane slip emissions were established in accordance with these guidelines.
   - Determine the application date of the actual C_{slip} :
     - ✓ the measurement of methane slip emissions should have been done prior to the end of the reporting for which the company intends to use actual C_{slip};
     - ✓ the engine's components, settings and/or operating values which may increase methane slip emissions have remained unchanged;
     - ✓ the monitoring procedures for engine load were in place from the beginning of the reporting period.

   NOTE: If any of the above conditions are not fulfilled, the actual C_{slip} can only apply from the date when all conditions are in place.

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■ 3. Verification of the methane emission values

● Yearly verification reporting

Includes the following information in the annual FEUM Report and verified by the FEUM verifier.

- Yearly ELM data and the corresponding emission factor calculations (Annex I).
- Results of the verification procedure (Parameter check method or Measurement method).
- For engines with methane abatement aftertreatment devices: the updated maintenance record book (as close as practical to the end of the reporting period).

Parameter check method for NOx regulation

- A method to verify compliance with NOx requirement during periodical surveys after delivery.
- Check that the parameters affecting NOx emission characteristics (e.g., components, setting/operating values, etc.) are the same as the initial verification or within the specific range. As a result of the checking, verify that the engine's NOx emission characteristics have not changed from the initial verification.
- The parameters are specified in NOx Technical File prepared by the manufacturer.
- When any changes related to the parameters are conducted, it should be recorded in the parameter record book.
- During periodical survey, the attending surveyor checks the parameter record book.
- Besides the parameter check method, two other periodical verification methods (simplified measurement method and direct measurement & monitoring method) are available. However, the parameter check method is generally adopted since it is the most practical method.

【Example of NOx parameters】

➢ Components constituting the engine (confirm each identification number)
  < Parts forming the combustion chamber >
  - Cylinder liner, piston crown, etc.
  < Fuel injection system >
  - Fuel injection pump, nozzle, etc.
  < Equipment/parts affecting air supply/scavenging >
  - Superchargers, air coolers, etc.

➢ Engine setting and operating values
  - Fuel injection timing, compression ratio, etc.
  - Maximum cylinder pressure, etc.

- For periodical verification of methane slip emissions, the parameter check method can be applied instead of onboard measurement.
- If a methane abatement aftertreatment device is equipped, the operation of the device should be checked as part of the parameter check.
- Refer to the next slide for the details of the parameter check method for methane slip emissions.

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3. Verification of the methane emission values

Procedure for “Parameter Check” for methane slip emissions

- For the yearly verification reporting, submit the following documents to the verifier to verify that any modifications or adjustments affecting methane slip emissions have not been made after the methane emission measurement.
  - Engine technical file (NOx Technical File, Methane File, etc.)
  - Record book of changes that may increase methane slip emissions
  - Record books for the methane abatement aftertreatment device (if equipped)
  - Engine parameter record book
  - Records of the past IAPP surveys in which NOx parameter checks were carried out

- The verifier determines if the documentation review allows for a reasonable assurance that the engine has not undergone any modifications or adjustments outside the options and ranges in the methane file that could cause the engines methane emissions to increase compared to the initially verified emission factors.
  → On-board inspection is not required if the verifier determines that the documentation review is sufficient.

- In the case where the verifier determines that the documentations are not sufficient, one of the following actions is required:
  - Carry out an on-board measurement, or
  - Carry out an on-board parameter check (i.e., checking each component’s ID number and setting/operation values of the engine directly by a surveyor) at IAPP periodical survey in parallel to NOx parameter check, and submit this inspection report issued by the flag/RO to the verifier.

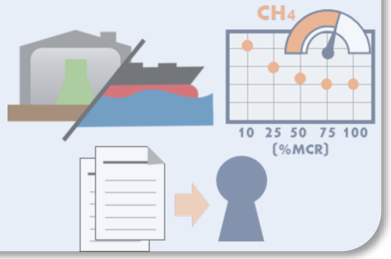
- Most parts of NOx parameters are also methane slip’s parameters. Therefore, the parameter check is limited to the additional parameters specific to methane slip emissions.

1. Overall process flow

Step 0.

Only the first time (or in case of major conversion)

- Measure methane slip emissions at 10%MCR (or the lowest load point of gas mode), 25%, 50%, 75%, and 100%MCR
  *THC measured in NOx test may be used as a proxy, or the parent engine results may be used for member engines. In such cases, all or part of the measurement may be omitted.)
- Initial verification: Submit the following documents to the verifier:
  - Methane File approved by Flag/RO
  - Prepared record books
  - FuelEU/ETS Monitoring Plan with partial modifications

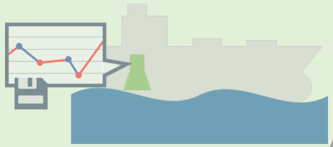


Repeating every year

Step 1.

During operation

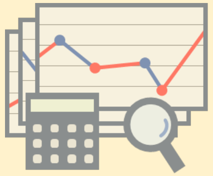
- Carry out ELM to monitor & record the data for C_{slip} calculation
- Implement the record books properly
- Perform maintenance of abatement aftertreatment devices as scheduled



Step 2.

End of the year

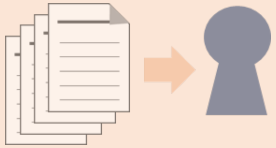
- Aggregate the monitored data and calculate C_{slip}
- Prepare documents which should be submitted to the verifier for the annual reporting (such as ELM data, updated record books, calibration certificates, documents for the parameter check)



Step 3.

Yearly verification

- Compile FEUM Report including all required documents and submit it to the verifier
- Basically, the parameter check is just a documentation review.



ClassNK

2. Measurement of methane slip emission

Key Point

- The measurement at 5 load points is required: 10%MCR (or the lowest load point of gas mode), 25%, 50%, 75%, and 100%MCR.
- THC (Total HydroCarbons) may be used as a proxy.
- Crankcase emissions must be included in case of four-stroke engines with open crankcase ventilation systems.

➢ If you do not want to use THC as a proxy:

- Methane slip emissions are not measured in shop test and NOx test; therefore, on board methane slip measurement at all 5 load points is necessary.
- For new-building engines, the measurement may be able to be carried out on test-bed (at the request of the shipowner since currently there is no MARPOL requirement mandating the methane slip measurement).

➢ If you use THC as a proxy:

THC is measured in NOx test, but…

- In the first place, there is a possibility that there are no available THC data if the parent/group/family are different on NOx and methane slip. NOx measurement (=THC measurement) is conducted for only NOx's parent engine in NOx's engine group/family.
- For E2/E3 cycle engines (often main engines), it is necessary to additionally carry out on board measurement at 10%MCR (or the lowest load point in gas mode) since NOx measurement test has only four load points (i.e, 25%, 50%, 75%, 100%).
  ⇒ The emission value at 10%MCR must be determined by measurement, and estimation by extrapolation is not allowed. If not measured, a default C_{slip} value should be used.
- For D2 cycle engines (often auxiliary engines), if the lowest load point in gas mode is more than 10%MCR, NOx measurement at 10%MCR was carried out in oil mode. In this case, it is necessary to carry out on board measurement at the lowest load point. Furthermore, if a closed ventilation system is not installed, the crankcase emissions should be determined.
  ⇒ The crankcase emissions should be based on measurements from the same or similar engines. If such data are not available, a default emission value with technical justification or default C_{slip} is to be used.

3. Engine Load Monitoring (ELM)

Key Point Requirements of ELM are as follows:

- Measurement & recording requirements
  - Continuously monitor and record the load of each engine.
  - Recording frequency: at least 0.0033 Hz (≈ every 5 minutes). If the load monitoring/recording is carried out without an automated data acquisition system, approval by the verifier or the flag State is required.
  - Use 30-minute intervals: calculate the interval load as the average of the measured loads during the interval. (exclude fuel oil only operations.)

- Load measurement methods

  Measure and determine the load based on one or a combination of the following:
  - Direct load measurement signal;
  - Torque flange and engine speed;
  - Shaft strain gauge and engine speed;
  - Calculated from generator output;
  - Estimated load based on cylinder pressure, injection duration as in 6.4.3.4 of the NTC 2008.

- First, it is necessary to confirm whether existing facilities and equipment can satisfy the above requirements
- Basically, data storage for one year is necessary. If it is not possible due to the capacity, it may be necessary to take operational measures (such as taking out data for each voyage and storing it separately. Details of the operation are described in Methane File.)
- Additional equipment may be necessary if it cannot be covered by existing facilities and equipment or operation.

4. Preparation of the required documents

The following documents are to be prepared:

- ✓ Methane File
- ✓ Record book of changes that may increase methane slip emissions
- ✓ Record books for the methane abatement aftertreatment device (if equipped)
- ✓ Record book of engine parameter for methane slip
- ✓ Modification of FuelEU/ETS Monitoring Plan

Key Point Methane File should be prepared jointly by the engine manufacturer and the company.

(Example)

Engine Manufacturer	Company
• Engine information • Drawing of the exhaust system • Methane emission measurement results • Evaluation of the influence of outside air conditions on methane slip • Crankcase emissions (if applicable) • Information on parameters on methane slip • Information and technical data related to engine groups and parent engines on methane slip • Verification procedure by parameter check method etc.	• Data collection and calculation procedures • Implementation procedure of record books etc. **Engine Manufacturer and/or Company** • Details of ELM • Calibration certificates and validity periods for measuring instruments etc.

↓

<u>Create Methane File by compiling all these data and submit it to Flag/RO for approval</u>

THANK YOU

for your kind attention

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