



GHGs emission mass flow monitoring system



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Regulatory background



• 1、Regulatory background



Global maritime trade volume

In recent years, the global maritime trade volume is relatively stable. Compared with other modes of transport, the demand for transporting goods by water is growing due to cost effectiveness and the safe way goods are transported. Economic reopening after the outbreak has also stimulated a surge in demand for goods and raw materials, with global maritime trade expected to reach 22,654.1 million tons in 2022.

The United Nations Conference on Trade and Development expects global seaborne trade to grow by 2.4 percent annually between 2022 and 2024.

• 1、Regulatory background



Related regulations

The IMO and regulations:

Since July 2018, the EU has required ship owners to provide information for EU-regulation 2015/757. This requires ship owners and operators to annually monitor, report, and verify CO₂ emissions for vessels larger than 5,000 GT and which call at any EU port on a per voyage basis. On January 1, 2025, the Fuel EU will implement a 2% reduction based on 91.16CO₂eq/MJ.

However, regulations covering a vessels fuel efficiency were introduced by the IMO in 2020 in the form of Carbon Intensity Indicators (CII). Regulations on mass emissions are increasing, with individual CII targets even being discussed in MEPC 75. Each year these regulations are discussed and heightened with the IMO's focus moving on from CO₂ to other emissions. With the growth of the LNG industry, methane slip is especially being considered, and greater regulation encouraged internationally.

Value:

With charterers under pressure to provide monthly figures for energy giants and their CSR reports, exact emissions measurement is a valuable tool. Currently, charterers estimate emission output based on fuel input, but with the RKMC-24GHG-HW providing accurate measurement of emissions output, overestimating is impossible, and shipowners are able to future proof against per-unit fees and emission credits.

The Environment:

Each year there is a growing emphasis on the collective greenhouse gas output of the shipping industry. Most notably by the European Commission to create a bench-marking system for the EU's policy for reducing domestic greenhouse gas emissions. The UN and it's internationally applicable Paris Agreement is also relevant in the regulation of greenhouse gas emissions by the maritime industry.

• 1、Regulatory background



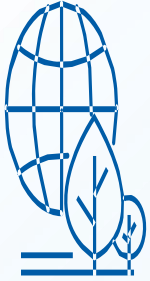
IMO passed the first phase standard in 1997, requiring that the NOx emissions from newly built ships must not exceed the limit;

IMO passed the second phase standard in 2008, requiring further reduction of NOx emissions from newly built ships and introducing restrictions on SOx emissions;

IMO passed the third phase standard in 2016. According to Annex VI of MARPOL 73/78, starting from January 1, 2016, when ships navigate within designated NOx emission control zones, they must comply with strict Tier III emission standards: the maximum limit for low-speed engines ($n < 130$) is 3.4g/kWh; The maximum limit for medium speed engines ($130 \leq n < 2000$) is $9 \times n - 0.2$ g/kw h; The maximum limit for high-speed machines ($n \geq 2000$) is 2.0 g/kw h. At present, the nitrogen oxide emission control areas include the North Sea emission control area and the United States and Caribbean Sea emission control areas. The Baltic Sea and North Sea, two future nitrogen oxide emission control areas, will be mandatory from January 1, 2021. If sailing outside the emission control zone, its NOx emissions must meet the requirements of IMO Tier II standards. The requirement for NOx emissions in Tier III standards is equivalent to reducing NOx emissions by 80% based on the original Tier I standards;

The 75th session of the IMO (MEPC 75) approved the draft amendment to Annex VI of the MARPOL Convention on short-term measures for reducing emissions in the shipping industry, including the existing Ship Energy Efficiency Index (EEXI) and Carbon Intensity Index (CII), which are expected to take effect on January 1, 2023. These key short-term measures were adopted at the MEPC 76 meeting in June 2021, consistent with the original goal of reducing the carbon emission intensity of all ships by 40% by 2030.

• 1、Regulatory background



In May 2023, the European Commission released

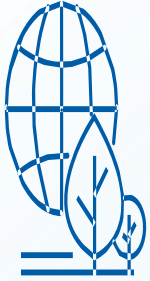
- The final revised texts of the EU Emissions Trading System (EUETS) Directive (EU2023/959) and the EU Monitoring, Reporting and Verification (MRV) Regulation (EU2023/957) require shipping companies operating in European territorial waters from 2025 to quantitatively verify their carbon emissions in accordance with the above regulations and directives. Ships exceeding 5000 gross tons must pay carbon quotas. From January 1, 2026, the EU Emissions Trading System will be expanded from carbon dioxide (CO₂) to include methane (CH₄) and nitrous oxide (N₂O) emissions. Starting from January 1, 2027, this regulation will apply to ocean engineering vessels of over 5000 gross tons.



**September 13, 2023, EU 2023/1805 Fuel EU Maritime
on the use of renewable and low-carbon fuels in maritime transport, and amending Directive 2009/16/EC**

- The limit referred to in paragraph 1 shall be calculated by reducing the reference value of 91,16 grams of CO₂ equivalent per MJ by the following percentage:
 - 2 % from 1 January 2025; 31 % from 1 January 2040;
 - 6 % from 1 January 2030; 62 % from 1 January 2045;
 - 14,5 % from 1 January 2035; 80 % from 1 January 2050.
- The GHG intensity of the energy used on board by a ship shall be calculated as the amount of GHG emissions per unit of energy in accordance with the methodology set out in Annex I.

• 1、Regulatory background



November 20, 2023, China Merchants Shipping

《The Third World Shipping Congress officially releases the fleet carbon emission monitoring tool "Ship Qi Carbon Intelligence Platform"》

- The first known digital carbon emission management platform at home and abroad, which includes carbon monitoring, carbon AI, and carbon visualization, comprehensively covers the collection, intelligent application, visualization, and exploration of industrial chain innovation of carbon asset data. Compared with fuel metering, the actual carbon dioxide measurement method reduced emissions by 7% in accounting





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GHGs emission mass flow monitoring system

2、GHGs emission mass flow monitoring system

To avoid large temperature fluctuations, high working humidity, and strong corrosiveness during navigation. The high intensity of navigation vibration leads to measurement errors caused by traditional CEMS optical path deviation, equipment corrosion, easy loosening of mechanical fixation, and detachment of equipment components. RKMC-24GHG-HW is equipped with imported high-precision sensors, no moving parts, and uses cold, hot, and wet methods to simultaneously measure 9 parameters and calculate mass concentration.



Equipment features

Relying on precise software information processing technology and GPS configuration, real-time monitoring and analysis of the quality of automatic monitoring data are carried out, establishing a three-point connection of "time location concentration"; And generate quality reports every second. Leave traces throughout the entire process to facilitate the submission of data from EU approved monitoring plan reports to EU certified MRV audit agencies for verification. It is difficult to track data and establish a three-point relationship of "time location concentration"; Convenient for shipping companies to manage fleet data.

• **2、 GHGs Introduction of the emission metering and monitoring system process**

GHGs Metering and Monitoring System

RKMC-24GHG-HW fully integrates into the vessels automation system or scrubber panel– RKMC-24GHG-HW was designed to fully integrate

into other shipboard systems using MODBUS. RKMC-24GHG-HW provides data to the vessels automation and alarm systems and can provide valuable data to vessel performance management software.

Comprehensive data reporting software provides instantaneous, specific and mass emissions – RKMC-24GHG-HW features the most comprehensive data suite of all marine CEM's systems. Specific (MARPOL) emissions, instantaneous measurements, mass emissions and along with a host of other engine performance data provides the owner with a huge amount of data to ensure compliance whilst providing valuable metric to enable optimisation of vessel performance

Methane Slip—RKMC-24GHG-HW can monitor methane slip in real time in ppm, g/kWh and additionally report the total mass output of methane in kg/tons.

MARPOL Annex VI, Regulation 13 Direct Measurement and Monitoring

Methane Slip

Mass Emissions Recording (Suitable for EU MRV)

Approved for monitoring all engine types engines (2-Stroke/4-Stroke

marine diesels), Boilers, Incinerators and Gas Combustion Units (GCU's)

MEPC.346(78) 8.DIRECT CO2 EMISSIONS MEASUREMENT

Resolution MEPC. 259 (68) - Guidelines for Exhaust Gas Cleaning Systems – Schemes A & B,

SO2/CO2 ratio method for measurement of SOx emissions;

Revised MARPOL 73/78 Annex VI Regulation 13 – Nitrogen Oxides (NOx) and the NOx Technical Code

2008, Chapter 6.4 - 'Direct measurement and monitoring method (DMM);

MEPC /Circ.471 - Interim Guidelines for Voluntary Ship CO2 Emission Indexing for Use In Trials –

Calculation of the CO2 emission index from operational data;

MEPC.271(69) - Amendments to the NOx Technical Code, 14 August 2017

MEPC.1/Circ.895 - UNIFIED INTERPRETATIONS TO THE NOX TECHNICAL CODE 2008, AS

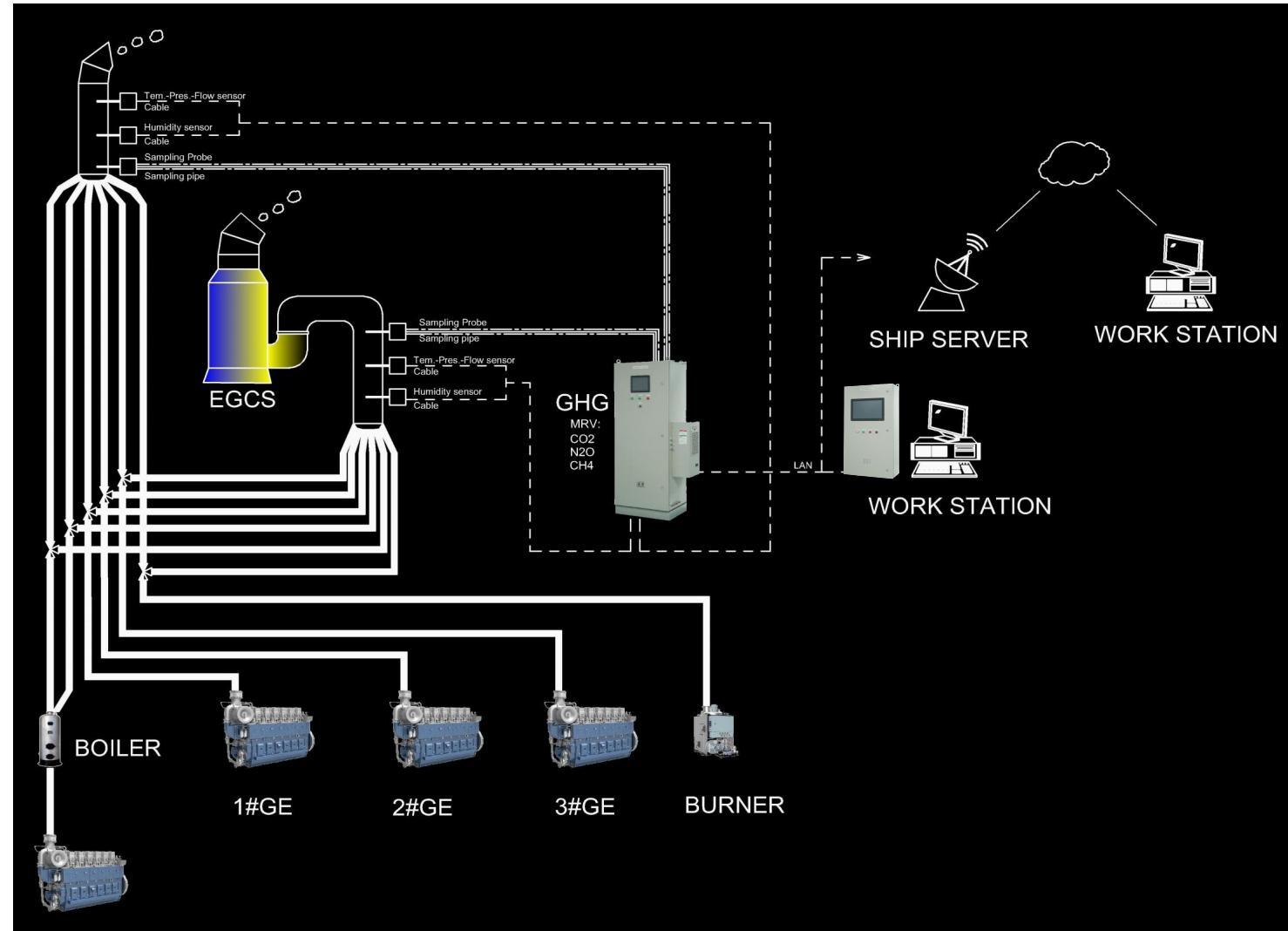
AMENDED, 9 July 2021

Resolution MEPC.340(77) - 2021 Guidelines for Exhaust Gas Cleaning Systems, adopted 26 November 2021.

• 2、GHGs Introduction of the emission metering and monitoring system process

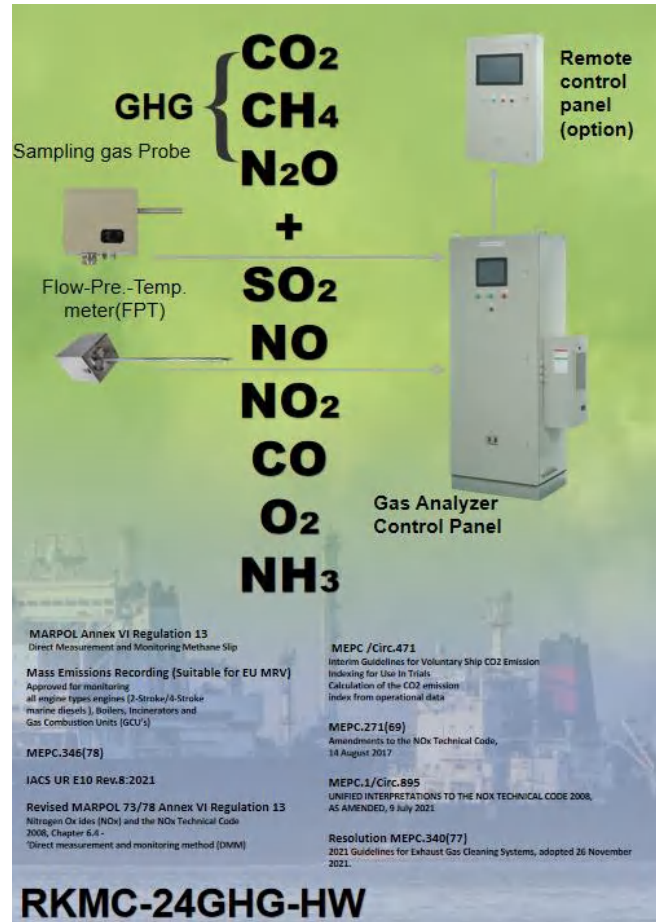
GHGs Metering and Monitoring System

We use wet heat method and cold dry method, advanced dust removal pretreatment system, high-precision non dispersive infrared absorption technology gas analyzer and ultraviolet differential technology to detect gases such as CO₂, CH₄, N₂O, SO₂, CO, NO, NO₂, NH₃, O₂ in flue gas. The flow measurement adopts differential pressure method. And generate a quality concentration report, And corresponding daily, monthly, and annual reports. Calculate the cumulative carbon emissions of the entire ship.



2、GHGs Parameters of the emission metering and monitoring system

GHGs measurement monitoring systems



Analysis of gas rest	CO ₂ 、 N ₂ O、 CH ₄ 、 O ₂ 、 CO、 NH ₃ 、 SO ₂ 、 NO、 NO ₂
Sensor principle	NDIR、 UV 、 EC
Range	CO ₂ :0-25%;N ₂ O: 0-500ppm CH ₄ : 0-10000ppm O ₂ :0~25%; NO ₂ :0-100-500ppm SO ₂ : 0-100-500ppm NO: 0-100-500ppm CO: 0-1000ppm NH ₃ : 0-500ppm (All range could be adjustable)
Precision	≤2 . 0% or ≤ 0.3% F.S.
zero-point drift	≤2. 0% F.S./24h
range drift	≤2. 0% F.S./24h
procedural parameter	
Measuring parameters	H ₂ O: 0-40% FLOW: 0-40m/S (differential pressure)
measuring technique	Differential pressure flowmeter
accuracy	H ₂ O: ± 5% ; FLOW: ± 1.5%F.S
Other parameters	
Sampling traffic	1.0L/min ±5%
export	1 road 485 1 road TCB 1 road Modbus
levels of protection	IP54
Working environment conditions	Environmental temperature: -20 °C -50 °C Environmental humidity: 0~90%Rh,
Equipment work requirements	source: AC 220V, 60HZ , GHGsMetering Unit :750W, Sampling tube: 50w/m, Sampling probe:500W
measurement	GHGs Metering Unit:L 700 x W 630 x H 1800mm (or customerized)

2、GHGs Introduction of the emission metering and monitoring system process

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Local control panel



Remote control panel

Remote control panel is based on the principle of DOAS and NDIR. The creative combination of heat and humidity and cold drying can detect up to 10 parameters. Through real-time measurement of the concentration of pollutants and the total exhaust emission of the ship, the total pollutant emission of the ship is calculated, Real time monitoring and analysis of the quality of automatic monitoring data, establishing a three-point connection of "time location concentration".

The local control panel adopts bidirectional measurement of cold dry and hot wet methods, which can directly measure NOX (NO, NO₂) without the need for a NO₂ converter to reduce operating costs. And since the measured concentration is NOX, there is no need to convert the dry wet coefficient when verifying the NOX of marine diesel engines. To verify the NOX emissions of the main engine (Khd temperature and humidity correction factors need to be provided by the ship), an equivalent differential pressure flowmeter (ISO 8178:2006 Part 1, Appendix D3) is used to generate a mass concentration report. It can monitor the escape of NOX (NO, NO₂), SO₂, CH₄, CO₂, N₂O, CO, NH₃, O₂, H₂O and other parameters at any time. Compliant with EU MRV CLASS D.

2、GHGs Introduction of the emission metering and monitoring system process



Sampling probe: L1282 x W 185 x H 328mm. (include the stainless sampling pipe) 4ea

- Temperature of Sample gas: $\leq 550^{\circ}\text{C}$
- Environmental conditions: $0^{\circ}\text{C}-70^{\circ}\text{C}$
- Stainless sampling pipe: about 970mm $\varnothing 25$ (Length can be customized)
- Counter flange: flange outer diameter- $\varnothing 160$; fixing hole-4 M10 in $\varnothing 130$ circle
- Outer diameter of connecting pipe: $\varnothing 8$
- Filter: $\varnothing 40 \times 140$
- The sealing material: Fluorine rubber
- Material :(the part through which sample gas pass) stainless steel.
- Painting color: Munsell No.7.5 BG 7/2
- Cable/pipe connection: Bottom

• 2、 Product introduction of the RKMC-24 GHG-HW monitoring system



Flow-Pressure-Temperature meter(FPT):

Size:W234 x H 232 x D 870 mm (will be confirmed later)

Used to measure the flow rate, pressure, and temperature parameters of exhaust gas, installed on the exhaust pipe near the sampling probe.

- Power:AC 220V
- Flow velocity measurement range:0~40 m/s
- Measurement accuracy:≤2%F.S.
- Resolution:0.1 m/s
- Response time:≤1s
- Pressure measuring range: (-2500~+2500)Pa
- Measurement accuracy:≤±1%
- Response time:≤1s
- Temperature measurement range: (0~500)°C
- Measurement accuracy:±3%°C
- Response time:≤1s
- Ambient Temperature:(0~+70)°C

- **2、GHGs Introduction of the emission metering and monitoring system process**

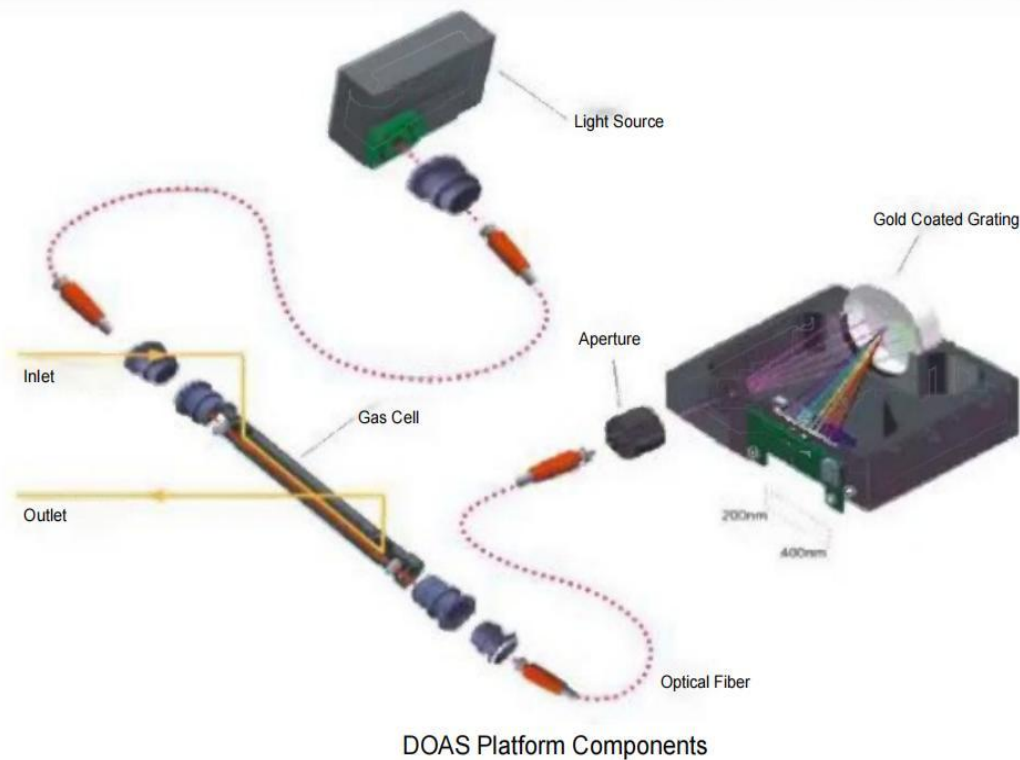
Non dispersive infrared spectroscopy (NDIR) technology For CO₂ CH₄ N₂O CO

Gases also have characteristic absorption of infrared radiation. When a gas is irradiated with an infrared light source, a portion of the radiation energy carried by the infrared radiation is absorbed by gas molecules, causing a change in the infrared spectrum. The absorbed gas is received by two detectors and converted into a measurement signal voltage that has already absorbed infrared light and a reference signal voltage that has not absorbed this infrared light. The concentration of sulfur dioxide is inverted using Lambert Beer's law. The non dispersive infrared absorption method can achieve accurate detection of gas content by calibrating experimental data and adding necessary constraints. Non dispersive infrared (NDIR) technology used for gas measurement targets wavelength absorption in infrared spectra as a method for identifying specific gases. NDIR technology is suitable for detecting air pollutants from emission sources, such as carbon monoxide (CO), carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), etc. One advantage of NDIR compared to other spectroscopic techniques is its low energy consumption. Infrared light sources with wavelengths ranging from 1-15 microns can operate at lower temperatures than other light sources.



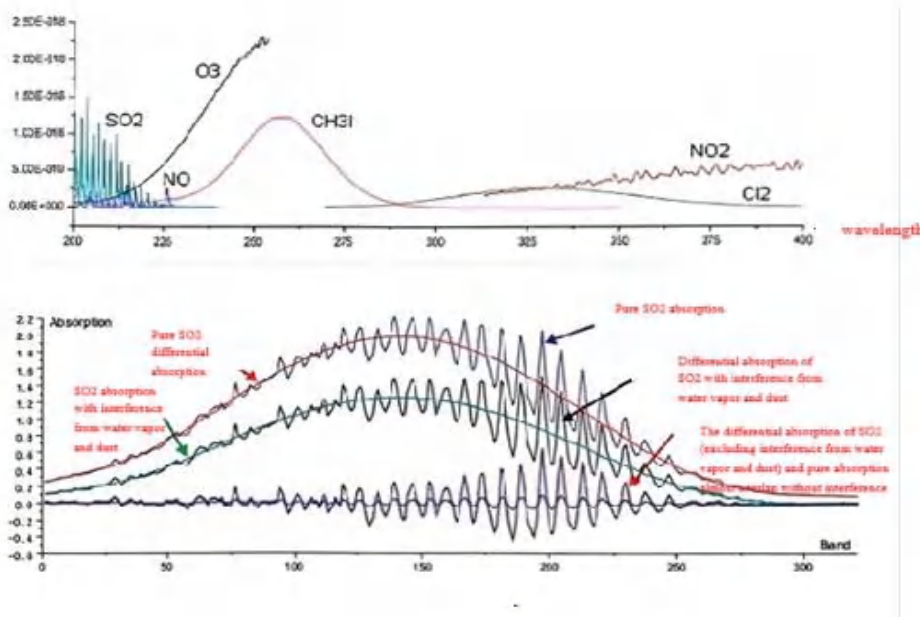
• 2、GHGs Introduction of the emission metering and monitoring system process

NO、NO₂、SO₂, The measurement adopts the (UV) ultraviolet differential absorption spectroscopy technique



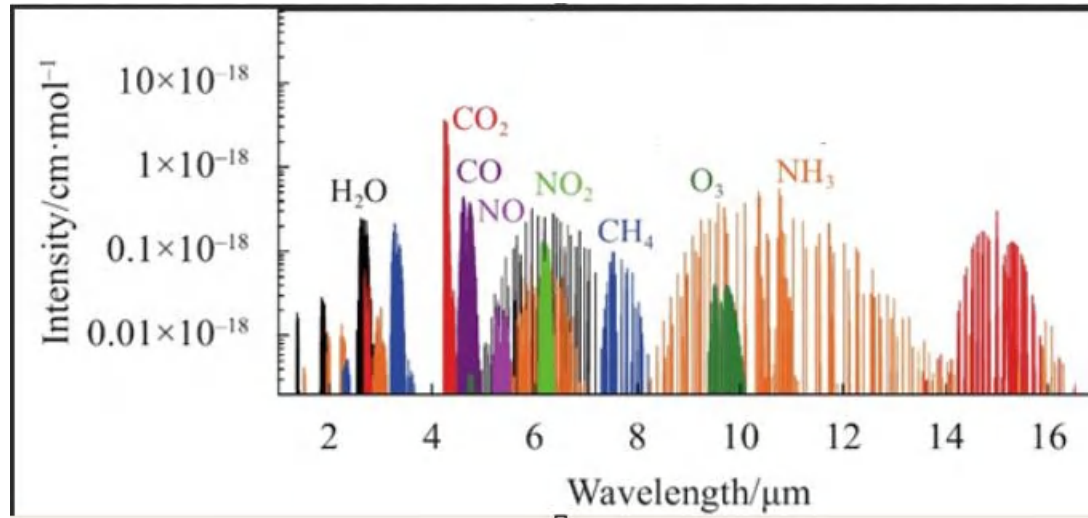
NO、NO₂、SO₂, The measurement adopts the ultraviolet differential absorption spectroscopy (UV) technique, which is a high-precision calculation of gas concentration using the absorption spectrum of gas molecules. According to the Beer Lambert law, the corresponding molecular concentration can be obtained by analyzing the absorption spectrum. This measurement technique can avoid measurement value fluctuations and drifts caused by factors such as dust interference, light source temperature drift or attenuation, and other gas interference.

• 2、GHGs Introduction of the emission metering and monitoring system process



Its core is to divide the absorption spectrum into two parts: fast changing and slow changing. The extinction effect caused by particle scattering and other factors changes slowly with wavelength. The part of absorption that changes rapidly with wavelength is only related to gas absorption, and corresponding calculations can be made to obtain the relevant gas concentration.

• 2、GHGs Introduction of the emission metering and monitoring system process

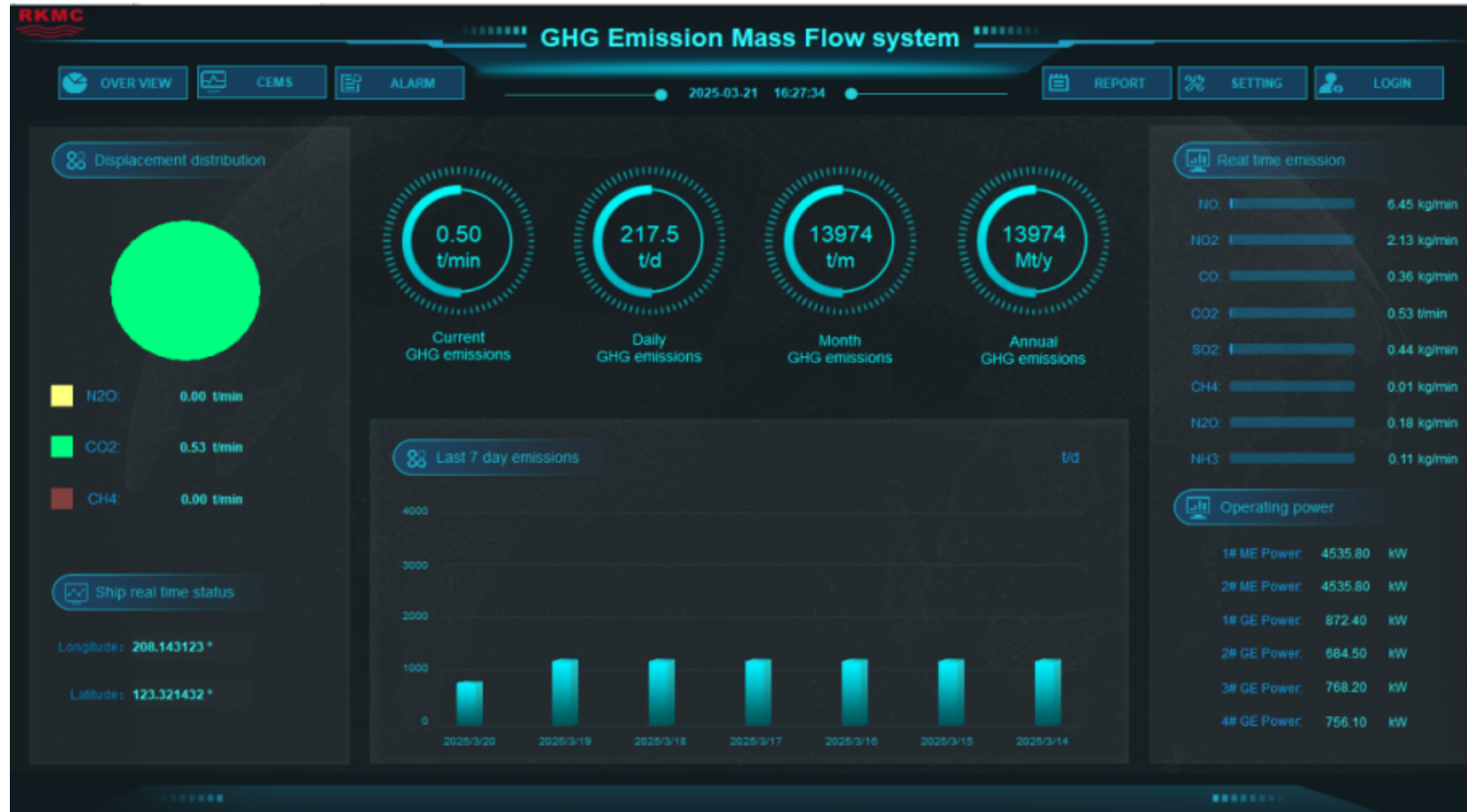


Infrared absorption spectroscopy: Molecules composed of different atoms have unique vibrational and rotational frequencies. When these molecules are exposed to infrared radiation at a specific frequency, infrared absorption occurs, resulting in changes in infrared intensity. By measuring this change, the gas concentration can be determined.

Lambert Beer's law: This law describes the relationship between light intensity and substance concentration. The higher the gas concentration, the greater the attenuation of light. Therefore, by measuring changes in light intensity, the concentration of gas can be calculated.

• 2、GHGs Introduction of the emission metering and monitoring system process

System interface (only for display reference, not actual)



• 2、GHGs Introduction of the emission metering and monitoring system process

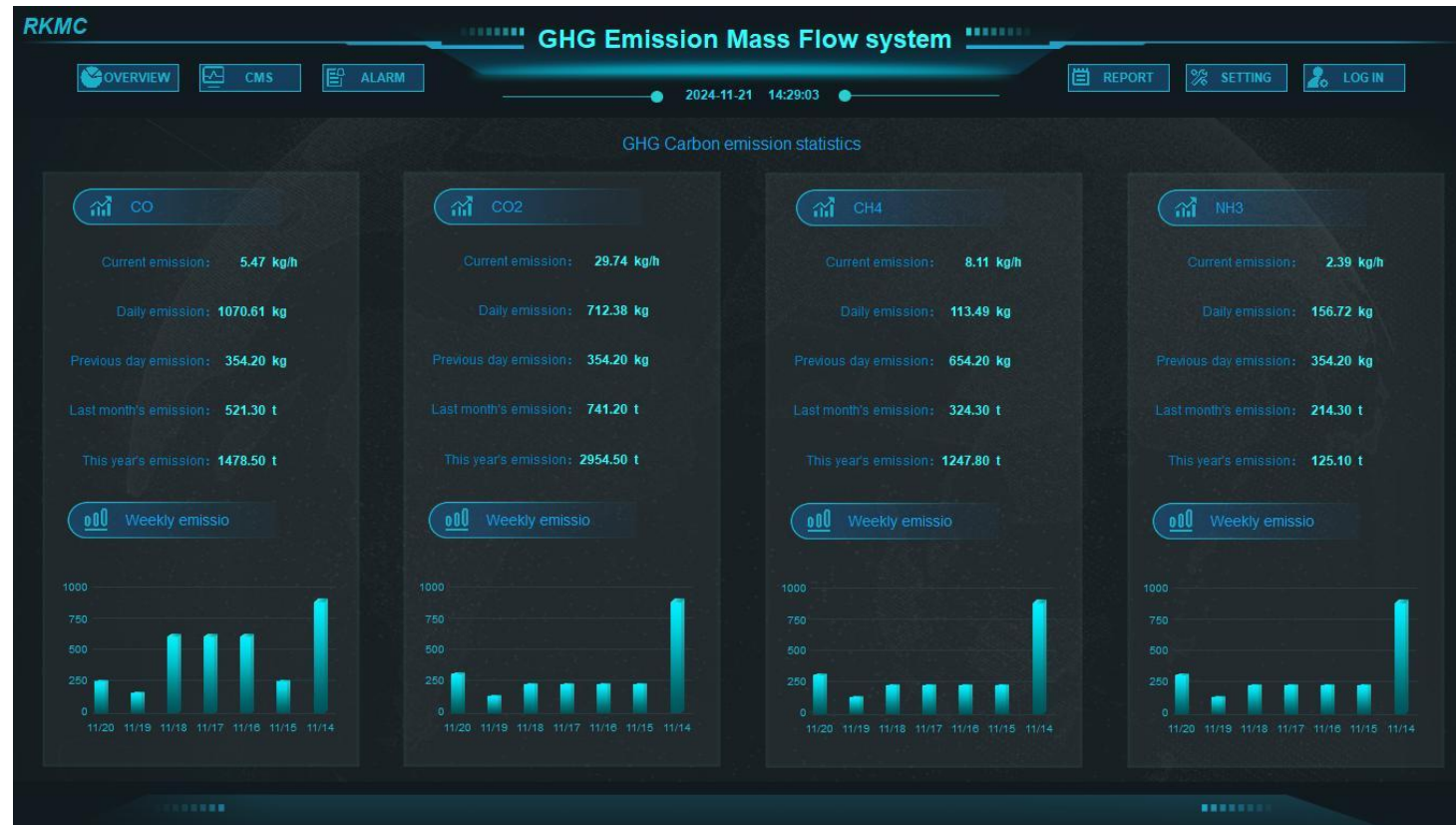
System interface (only for display reference, not actual)



• 2、GHGs Introduction of the emission metering and monitoring system process

System interface

(only for display reference, not actual)





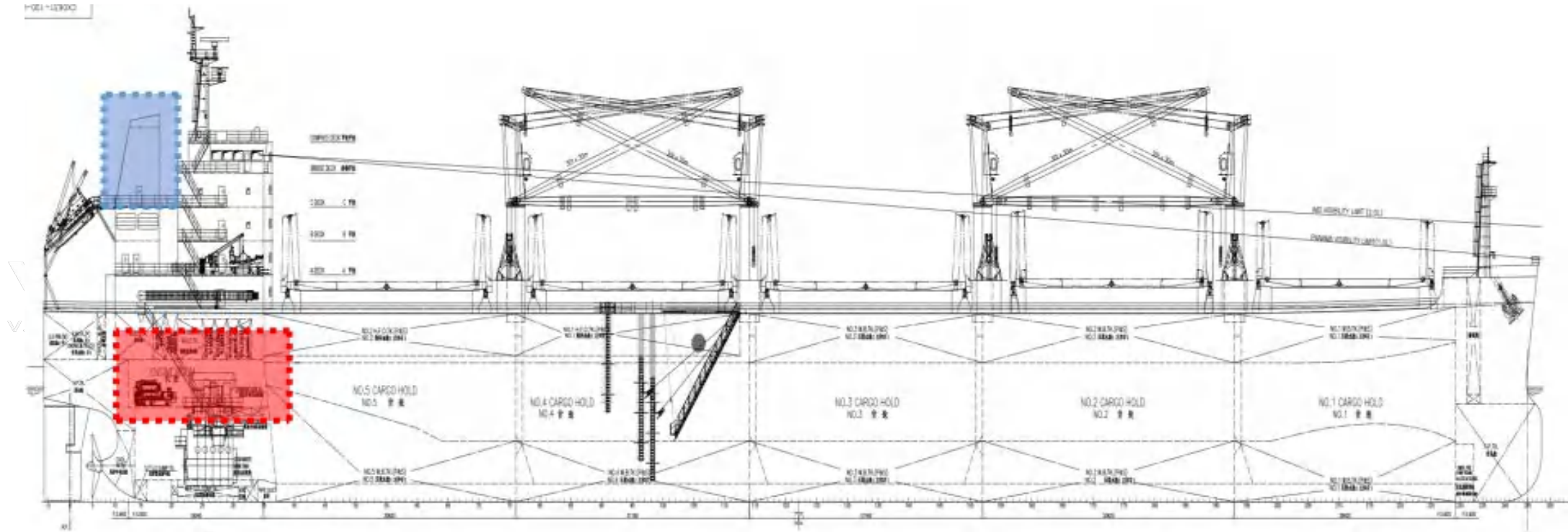
3

Selection of GHGs

• 3、GHGs Selection of emission metering and monitoring points

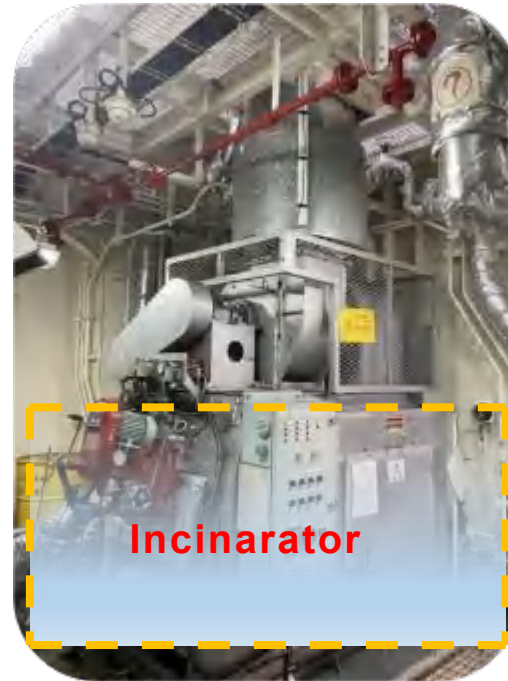
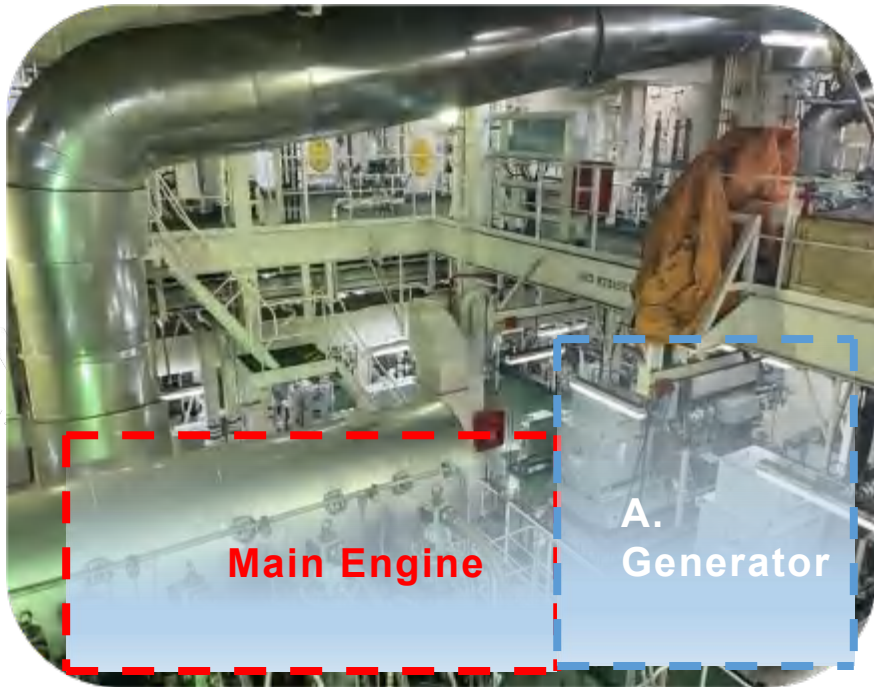
Ship surface drawing (example)

Waste gas production area GHGs Emission monitoring area



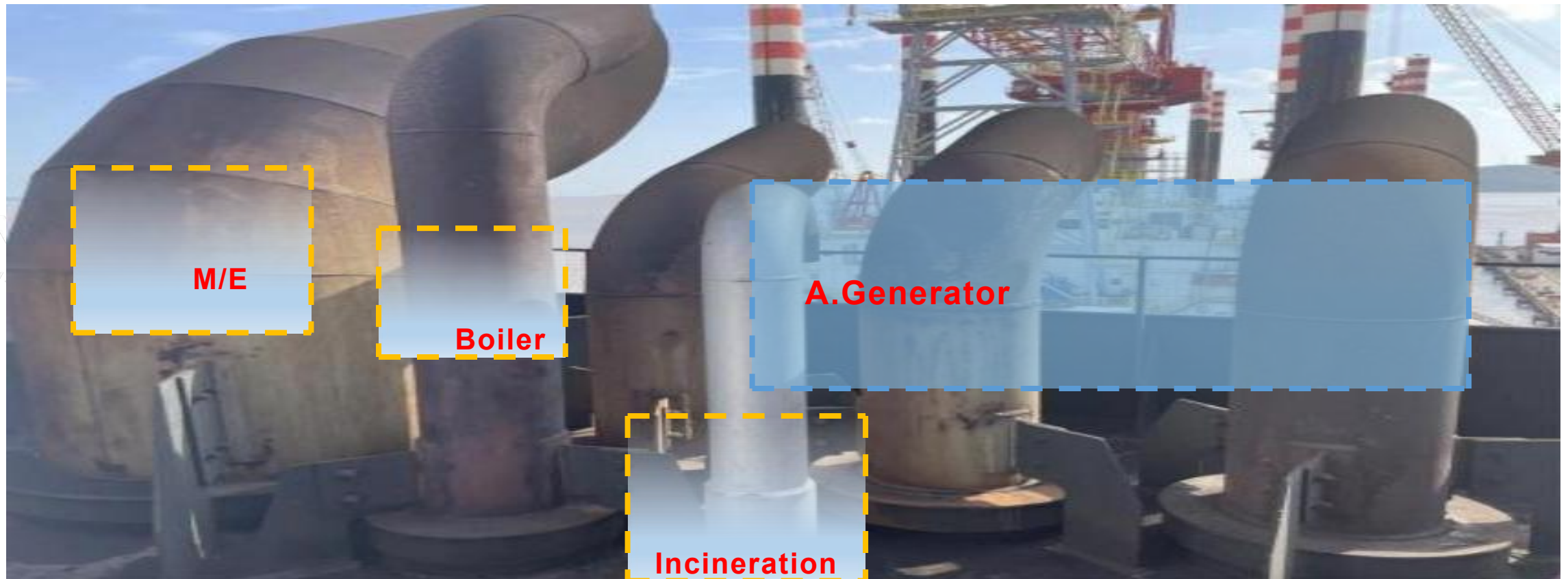
• 3、GHGs Selection of emission metering and monitoring points

Ship surface drawing (example)



- **3、 GHGs Selection of emission metering and monitoring points**

Monitoring point location (example)



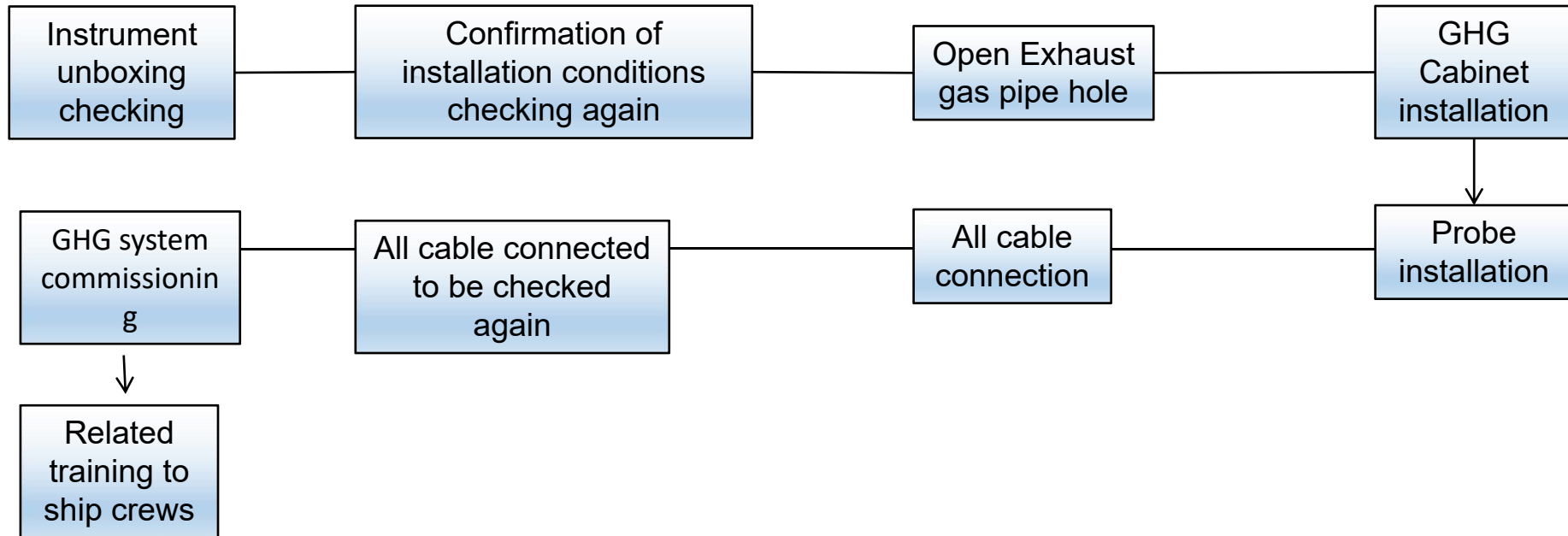


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Installation of ship GHGs emission monitoring points

• 4、 Installation of ship GHGs emission monitoring points

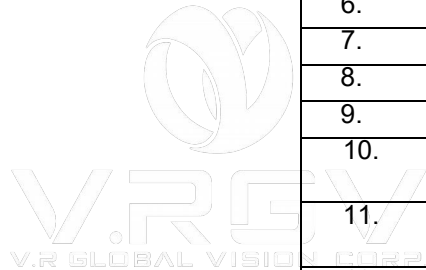
Equipment Installation Flowchart



• 4、 Installation of ship GHGs emission monitoring points

Work Interface Table

NO.	ITEMS	DISCRIPTION	Supplier's scope of supply	Buyer's scope of supply
1.	Equipment storage	After receiving the goods, store them in the warehouse for safekeeping		•
2.	Installation Guide	Telephone or on-site guidance	•	
3.	On site operation platform and ladder	Production and installation		•
4.	Smoke duct opening and flange welding			•
5.	Counterflanges	All system counterf-flange	•	
6.	Fixed platform equipment	Bracket and installation		•
7.	Cable tray	Materials and their installation		•
8.	Sampling pipeline		•	
9.	Sampling pipeline linstallation			•
10.	Cable	From the control room to the analysis cabinet		•
11.	Cable installation	From the control room to the analysis cabinet		•
12.	Cable	GHG system internal parts	•	
13.	Cable installation	GHG system internal parts		•
14.	Compressed air and pipelines	fittings and their installation		•
15.	GHG system internal parts such as cable and gas connection	Electrical wiring and gas connection	•	
16.	System trial operation		•	
17.	GHG system equipment startup and calibration		•	
18.	System commissioning		•	



• 4、 Installation of ship GHGs emission monitoring points

INSTALLATION REQUIREMENTS

Sampling point selection requirements

1. Located downstream of the fixed pollution source emission control equipment and upstream of the comparative monitoring section.
2. Priority should be given to vertical pipe sections and negative pressure areas in the flue, avoiding bends, sharp changes in cross-section, areas with induced fans, strong electromagnetic interference, and eddy current zones.

Explanation 1: For the sampling location, it should be set at ≥ 2 times the diameter of the downstream flue of elbows, valves, and reducers, and at 2 times the diameter of the upstream flue of the aforementioned components. If unable to meet the requirements, try to choose straight pipe sections as much as possible. 2. For a rectangular flue, its equivalent diameter $D=2AB/(A+B)$, In the formula, A B is the side length. The vibration amplitude of the flue should be minimized as much as possible, and not affected by environmental light and electromagnetic radiation.

3. The installation position should be leak proof to avoid interference from water droplets and mist in the smoke. If it cannot be avoided, suitable detection probes and instruments should be selected.

Installation location of system cabinet

Installation position: Installation position, height should be ≥ 2 m, place a cabinet with a volume of 1000 mm * 800 mm * 1800mm; And it is easy and convenient to open the door for instrument maintenance and installation environment: ambient temperature: -20 °C -55 °C; For installation locations with humidity $\leq 90\%$ and no condensation water, there should be no strong electromagnetic field interference nearby. Power supply: The distribution power should not be less than 5KW, and the specific amount should be based on the length of the on-site heat tracing pipeline. Separate air switches, leakage protectors, etc. should avoid sharing the same distribution cabinet with high-voltage equipment; Instrument air/gas source: Gas consumption: about 2.5 m³ /h; Export pressure: 0.6 Mpa~0.7 Mpa; Gas source quality: particle size $\leq 5 \mu m$, oil content $\leq$ maximum 1 mg/m³, pressure dew point not exceeding 3 °C, purity level: 3 (ISO 8573).

Lightning protection and insulation requirements

Grounding: The grounding cable should use a single core sheath system with a diameter greater than 4mm², a grounding resistance of less than 4 Ω , and can be shared with the lightning protection grounding wire; The lightning protection system of the ship's hull complies with relevant regulations. The parallel clearance between power lines, signal lines, and lightning rods is ≥ 1 m, and the cross clearance is ≥ 0.3 m.

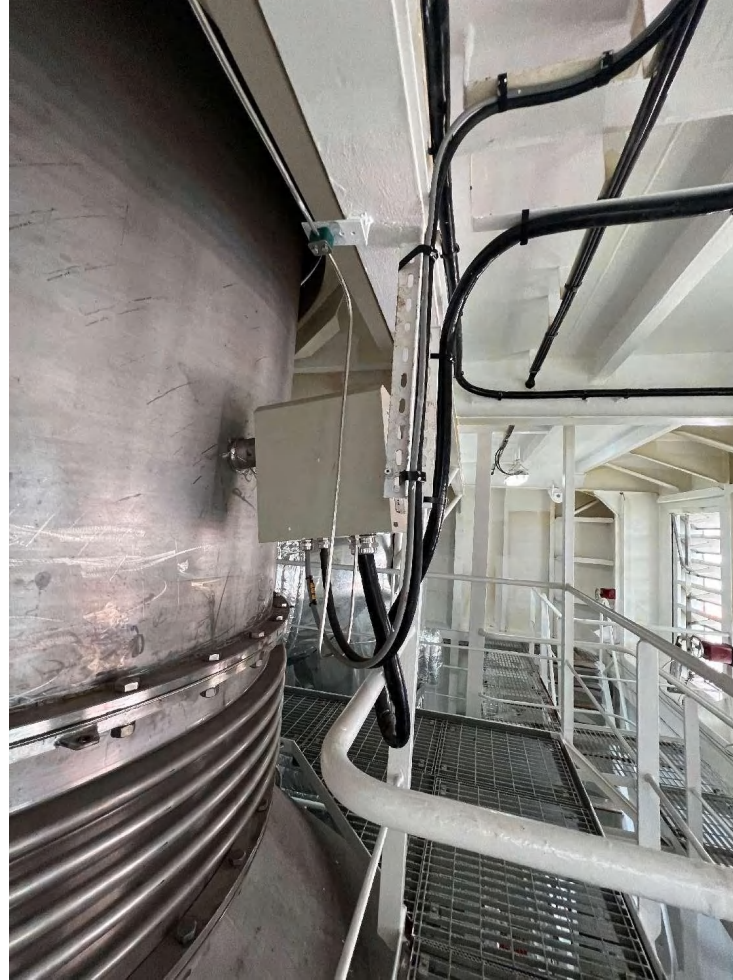


5

**Actual installation for
reference**

CEMS

5、 Actual installation for reference (CEMS SO₂/CO₂)





Thank You!!!



is the name changed from *Riken Marine China. Co.,Ltd.*
This change is only related to the name of the company.
All rights and obligations of the Old Contracts are undertaken by RKMC Co.,Ltd.

Factory and Products Type Approved By:

