MARPOL-VI compliance monitoring of ships in German waters – results from five years of operation

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Outline

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• Further development
Why do we measure?

MARPOL –VI regulation:
Inside an Emission Control Area (ECA) ships have to:
- Burn only low Sulphur fuel or must clean exhaust gas (Scrubber)
- Comply with TIER I-III regulations on NO\textsubscript{x} emissions (depending on ship age and type of engine)

→ Remote measurement of plumes to trigger compliance inspections
How does it work?

- Installation of fast and sensitive trace gas monitors, AIS receiver and meteorological station at frequented shipping lanes (Sniffer method)
- Automated analysis of plume measurement and ship allocation in near real-time (~1h)
- Reporting of suspicious ships to authorities for further inspection (E-Mail)
- Remote measurement give inspectors “clear ground” to take fuel samples
Where do we measure?

Map taken from www.marinetraffic.com
Where do we measure?
Wedel

• Start of measurement: September 2014
• 21 059 ship plumes analyzed (average compliance rate: 99.1%)
Where do we measure? Bremerhaven

- Start of measurement: August 2017
- 5,621 ship plumes analyzed (average compliance rate: 99.7%)
Where do we measure?

Kiel

• Start of measurement: May 2018
• 3210 ship plumes analyzed (average compliance rate: 97.2%)
Distribution of FSC and trends

- Significant decrease of observed FSC since 2015
- Non-compliance rate < 1% for Wedel and Bremerhaven (except 2015)
- Higher non-compliance rate in Kiel might be caused by difference in route section (ships often pass Kiel Canal but do not call a German port)
SO$_2$/NO$_2$ ratio suitable for Sulphur compliance monitoring?

- SO$_2$/NO$_2$ ratio > 1.0 often used as trigger to indicate non-compliance with MAX-DOAS measurements
- No correlation to FSC from Sniffer measurements found in Wedel

Wedel n=15254 2014-2019
SO$_2$/NO$_2$ ratio suitable for Sulphur compliance monitoring?

- More clear correlation with FSC from Sniffer measurements found in Kiel
SO$_2$/NO$_2$ ratio suitable for Sulphur compliance monitoring?

- Decreasing SO$_2$/NO$_2$ trigger level to 0.3 would double the fraction of reported non-compliant vessels and half the probability of reporting compliant vessels (false trues) (when assuming the Sniffer measurements are correct)

Probability of "false trues": 12.9%

Probability of not reported trues: 54.2%
NO\textsubscript{x}/CO\textsubscript{2} ratio suitable for NO\textsubscript{x} compliance monitoring (TIER I-III)?

NO\textsubscript{x} Emission factors from NO\textsubscript{x}/CO\textsubscript{2} ratio
(all sites all data: 2014 – 2019, n=29890)

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EF_{NOx}[g/kg\_fuel] = \frac{C_{NOx}[ppb]}{C_{CO2}[ppm]} \cdot 3.33[\%]
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NO\textsubscript{x}/CO\textsubscript{2} ratio suitable for NO\textsubscript{x} compliance monitoring (TIER I-III)?

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- > 80% are compliant with TIER I
- Only 9% are compliant with TIER III
- Shift to smaller EF is expected from 2021

Conversion of TIER I-III limits from g/kWh to g/kg fuel with specific fuel oil consumption factor of 160-180 g/kWh and engine rated speed 500-1500rpm
Further extension of monitoring network

- Up to six measurement sites
- Partly with additional aerosol monitoring
- Coordination with other states in EU and worldwide
International cooperation and projects

MeSmarT (2012-2019)
www.mesmart.de

CompMon (2015-2016)
www.compmon.eu

SCIPPER (2019-2022)
www.scipper-project.eu
Many thanks for your attention!

More information available at:
www.bsh.de
www.mesmart.de
www.scipper-project.eu

Contact: Andreas.Weigelt@bsh.de