Using Continuous Emission Monitoring on Ships

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IVL Swedish Environmental Research Institute Ltd

- Established in 1966
- Independent company
- 160 employees
- Offices in Stockholm and Göteborg
- Combining research and consultancy services

IVL activities/departments

- Environmental Engineering
- Work Environment and Environmental Management
- Environmental Effects and Atmospheric Chemistry
- Environmental Surveillance, Emissions and EIA
- IVL Analysis
- Water Resources and GIS
- Climate Change

- IVL have carried out emission measurements on board ships since 1989 (ca 50 ships and > 150 measurement campaigns).
- Both contract assignments (e.g. NO_X certifications, emission inventories) and research oriented projects (e.g. characterisation of emissions, measurement techniques).
- Follow international standards, e.g. IMO NO_X Tech. Code and ISO 8178. Accredited for NO_X certification measurements (SWEDAC)

Research

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1996 *Hydrocarbon, PAH and PCB emissions from ferries: a case study in the Skagerak-Kattegatt-Öresund region*

1999 *Predictive NO_x emission monitoring on board a passenger ferry*

2001 *Exhaust emissions from high speed passenger ferries*

2003 *Exhaust emissions from ships at berth*

Emission inventories

2002 *Quantification of emissions from ships associated with ship movements between ports in the European Community* (Entec UK Ltd and IVL)

2004 *Methodology for calculating emissions from ships – 1. Update of emission factors* (Swedish international reporting - fuel based)

Continuous Emission Monitoring

mainly for the purpose of reliable emissions trading or other flexible emission reduction schemes

2004 Feasibility of emission emissions trading at sea - DEMO project. (PricewaterhouseCoopers AB)

2005 Ship emissions: Assignments, abatement and market-based instruments. (ENTEC, EU-contract)

DEMO-project

(PricewaterhouseCoopers)

- Demonstration of continuous emission measurement of NO_x including verification procedures on *Manon* and *Stena Jutlandica*.
- Demonstration of continuous monitoring of fuel consumption and analysis of fuel on *Bro Atland* including verification procedures. (Simulation of fuel sulphur reduction verification)
- Continuous reporting to land of position and NO_x-emissions from *Stena Jutlandica* (C A Clase).

Results of DEMO-project Phase 1 and 2

- It is possible to continuously measure exhaust emissions reductions of NO_X and SO_2 in a way that enables future emission trading.
- Measurement uncertainty is a key issue for an emission trading system and depends on the choice of measurement strategy which in turn effects cost.
- Problems with the equipment may occur on ships with large vibrations and inclinations and during long time service when operating with HFO (maintenance costs).
- Future development of measurement equipment will likely reduce both measurement uncertainty and cost.

Parameters for NO_x monitoring and reporting

IMO Technical NOx code & ISO 8178

- NO_x Exhaust Concentration
- CO_2 Exhaust Concentration
- Air Intake Temperature
- Air Intake Humidity
- Barometric Pressure
- Charge Air Temperature
- Fuel Carbon Content
- Fuel Consumption and / or Engine Power

Global parameters:

- Time
- Position

Engine power measurement

- Direct measurement of output shaft torque
- Cylinder pressure registration
- Auxiliary engines and diesel electric propulsion can use electrical generator output.
- Indirectly from calibrated fuel pump index, charge air pressure, turbocharger speed etc. combined with engine test protocols
- Verifiable from fuel flow measurements or tank level soundings.

NO_x-monitoring instrument setup

Issues to consider for marine emission monitoring system

- What pollutants? (NH_3?)
- Emission sources? (Emergency engines?, Boilers?, Incinerators?)
- Geographical boundaries?
- Type of monitoring? (Continuous/Periodical)
- Logging frequency? Multiengine systems?
- Indirect methods? (PEMS & similar)
- Verification procedures?
- Third party requirements?
- Uncertainty? (Level? Principles for calculation?)
- Harmonisation with other standards?
- Data storage and reporting?
- Accounting principles?
- Downtime? Non-compliance?

- ***Different ships and different abatement methods have different requirements for emission monitoring and verification***
  - ***Flexible approach***

Finally:

- Continuous emission monitoring appears feasible considering:
  - Land based installations
  - Demonstrations by PwC, IVL & CA Clase
  - Existing systems for SCR process control
- Sealed system is <u>not yet</u> practical
  - Maintenance & frequent calibration
  - Sensor contamination
  - Immaturity of new NO_x sensors (developed for the truck sector)
- Requires:
  - Trained personnel
  - Auditing and verification
  - Unannounced inspections (Remote sensing)
- Long term operation on board ship has not been demonstrated

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