SOx-Scrubbing on Ships - Update

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Wärtsilä Finland Oy

Joint Short Sea Shipping and Motorways of the Sea Focal Points and Short Sea Promotion Centres Meeting

Brussels

21 November, 2012
1. Legislation
2. Economy
3. Technologies
4. References
Review of the 0.5% S global limit to be performed in 2018. In case readiness is not deemed to be sufficient by 2020, the introduction of the limit will be postponed to 2025.

Fuel type: Not regulated = both HFO and distillate are permitted
Exhaust gas cleaning: Permitted alternative under Regulation 4 to achieve any regulated limit
Particulate Matter (PM): No limit values
IMO SOx Emissions Control Areas are geographically defined areas where ships must limit their SOx emissions.

**SOx ECAs**

- Baltic Sea
- North Sea + English Channel
- North America
- US Caribbean area
North American SECA and NECA

North American SOx and NOx Emission Control Area.

- IMO adoption 2010, entry into force 1 August 2011, applicable 1 August 2012.
- 200 miles from coast.
- Fuel Sulphur: 1.00 % 1 August 2012, 0.10 % 1 January 2015, all ships.
- NOx: Tier III (Tier I minus 80 %) 2016, newbuildings.

Fuel sulphur limit applicable 12 months after entry into force of SECA, as per Regulation 14.7 of revised Marpol Annex VI.
Caribbean SECA and NECA

Caribbean SOx and NOx Emission Control Area.

- IMO adoption 2011, entry into force 1 January 2013, applicable 1 January 2014.
- Fuel Sulphur: 1.00 % 1 January 2014, 0.10 % 1 January 2015, all ships.
- NOx: Tier III (Tier I minus 80 %) 2016, newbuildings.

Fuel sulphur limit applicable 12 months after entry into force of SECA, as per Regulation 14.7 of revised Marpol Annex VI.
Scrubber documentation during certification

SECP
SHIP NAME
Main engine
Auxiliary engines
Oil-fired boilers
Ref. to statutory documents
Procedure for compliance

By shipowner, shipyard, contractor
Approved by Administration

SECC (A)
Scrubber
Make, type, serial number
ETM number

By Administration

“Exhaust Gas Declaration”
Engine
• Make, type, power, rpm
• Exhaust gas data (e.g. EIAPP cert.)

By engine maker or designer *
Approved by Administration

“Flue Gas Declaration”
Oil-fired boiler
• Make, type, capacity, pressure
• Flue gas data

By boiler maker or designer *
Approved by Administration

ETM
ETM number
Make, type, serial number
Capacity
SOx-reduction (A)
Installation requirements
Operational requirements
Maintenance requirements (A)
Survey procedures
Wash water characteristics

By manufacturer
Approved by Administration

OMM
Instrumentation issues
Gas and water monitoring
Device list (sensors, analysers)
Device positions
Service requirements
Maintenance, calibration
Survey procedures

By manufacturer
Approved by Administration

EGC Record Book
Log book for service and maintenance as per ETM & OMM.
Possibly in vessel PMS.

By manufacturer
Form approved by Administration

* Or another competent party

Scheme A and B unless otherwise stated

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**Survey Schemes**: Survey schemes for exhaust gas emission compliance:

<table>
<thead>
<tr>
<th>Item</th>
<th>Scheme A</th>
<th>Scheme B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance measurement campaign</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Monitoring of sulphur emissions</td>
<td>(Daily)</td>
<td>Continuous</td>
</tr>
</tbody>
</table>

| Monitoring of process parameters:                      |                   |                   |
| • Scrubbing water flow                                 | Continuous        | Daily             |
| • Scrubbing water pressure                             |                   |                   |
| • Scrubbing water pH                                   |                   |                   |
| • Exhaust gas pressure, scrubber inlet                 |                   |                   |
| • Exhaust gas pressure differential                     |                   |                   |
| • Exhaust gas temperature, scrubber inlet              |                   |                   |
| • Exhaust gas temperature, scrubber outlet             |                   |                   |
| • Combustion unit load                                 |                   |                   |

Survey schemes for water discharge compliance are identical under Scheme A and B.
* Details in Resolution MEPC.184(59)

**Surveying Bodies:**
- Flag state: Initial, Annual, Intermediate and Renewal Surveys
- Port state: Occasional Surveys
Technical safety approved.
Classification Society Involvement

1. Roles of classification societies in scrubber projects:
   • Safety related technical approval (all projects)
   • Marpol approval (when authorized to act on behalf of the flag Administration)
   • Risk assessment (in selected projects, when requested to act as advisor)

2. Some class societies have published scrubber related rules

3. Some class societies are expected to publish scrubber related rules soon

4. Cooperation between class societies and Exhaust Gas Cleaning System Association (EGCSA)
New Technology Qualification by DNV

Hybrid scrubber for cruise ship

Qualification Work Process

- Qualification Basis
- Technology Assessment
- Failure Mode Identification
- Develop Qualification Plan
- Analysis and Testing
- Performance Assessment

DNV deliverables

- Technology Assessment Report
- Technology Qualification Plan
- Technology Qualification Report
- Statement of Feasibility
- Statement of Endorsement
- Certificate of Fitness for Service

This work is at an advanced stage
Fuel prices, Rotterdam

\[ \Delta = 140\ldots700 \text{ $/ton} \]

MGO - HFO

Updated 12 November, 2012

Fuel prices (Rotterdam)

Source: bunkerworld.com
Cost comparison for 25 years
Total engine power: 10 MW
Annual fuel consumption: 9800 ton/a
Annual average load: 69%
Interest rate for NPV calculations: 5.0%
Fuel price inflation rate: 4.8% (1980-2010 average)
Currency rate: 1.27 US$/€
NaOH 50%: 200€/ton

Case 1: HFO 428 US$/ton, MGO 649 US$/ton
Case 2: HFO 244 US$/ton, MGO 646 US$/ton
Case 3: HFO 580 US$/ton, MGO 1282 US$/ton

*System delivery cost (not including installation)
Fuel prices are prices in Rotterdam
Case 1: 31.08.2010
Case 2: August 2008
Case 3: May 2008

Cost comparison for 25 years
Case 1 HFO 428 US$/ton, MGO 649 US$/ton
Case 2 HFO 244 US$/ton, MGO 646 US$/ton
Case 3 HFO 580 US$/ton, MGO 1282 US$/ton
SOx scrubbing technology

Scrubbing plant needed for removing sulphur oxides (SOx) from the exhaust gases of marine diesel engines and oil-fired boilers.

The product development covers scrubber design, performance, lifetime and economy, corrosion, scaling, the effect of scrubbing equipment on engine performance, installation requirements, discharge water criteria, ecological impact, sludge handling, exhaust plume quality, noise, chemicals, certification etc.

Target segments
• New buildings and retrofit installations.
• Diesel engines and oil-fired boilers.
• Two-stroke and four-stroke engines.
• Main and auxiliary engines.
• Any engine brand.
Neutralization takes place with appropriate pH, either by:
• dosing of alkali, or
• by using sufficient amounts of sea water.
Open sea alkalinity
Surface data (0… 15 m)
Data from 2001-2005
## Summary of Wärtsilä scrubbers

<table>
<thead>
<tr>
<th></th>
<th>Closed loop</th>
<th>Open loop</th>
<th>Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alkaline reactant</strong></td>
<td>NaOH</td>
<td>Sea water</td>
<td>NaOH / SW</td>
</tr>
<tr>
<td><strong>Operating modes</strong></td>
<td>Closed loop</td>
<td>Open loop</td>
<td>Closed / open loop</td>
</tr>
<tr>
<td><strong>Zero discharge mode</strong></td>
<td>Periodical</td>
<td>No</td>
<td>Periodical</td>
</tr>
<tr>
<td><strong>Scrubbing water flow, m³/MWh</strong></td>
<td>24</td>
<td>45</td>
<td>23/45</td>
</tr>
<tr>
<td><strong>Freshwater consumption, m³/MWh</strong></td>
<td>0.1…0.2</td>
<td>zero</td>
<td>zero</td>
</tr>
<tr>
<td><strong>Pumping power, % of engine power</strong></td>
<td>0.5</td>
<td>2.0</td>
<td>0.5/2.0</td>
</tr>
<tr>
<td><strong>Suitable certification scheme</strong></td>
<td>Scheme A or B</td>
<td>Scheme B</td>
<td>Scheme B</td>
</tr>
<tr>
<td><strong>Applications</strong></td>
<td>Low-alkalinity waters and for zero discharge</td>
<td>Ocean-going ships</td>
<td>Ships requiring full flexibility of operations</td>
</tr>
</tbody>
</table>

* In case of an Integrated Scrubber additionally fan power, load dependent, 0.1 – 0.5 %

** Refers to IMO Resolution MEPC.184(59)
Main features

- For diesel engines
- One scrubber unit for each combustion unit
- By-pass valve
- Scrubber unit back pressure 900 Pa

Ideal for

- Single engine cargo ships
Integrated scrubber

Benefits
• Completely avoid increased exhaust gas back pressure.
• Minimize the amount of equipment.

Main features
• One common scrubber unit
• Suction fans
• Suction branches with by-pass dampers
• Constant under-pressure prevents undue flow of gases.
• A wet sump minimises the needed vertical lifting height and therefore the power demand of the closed-loop pumps.
Closed loop scrubber process

Exhaust gas in

Exhaust gas fan

Exhaust gas out

Scrubber Unit

Buffer tank

Bleed-off treatment

Effluent monitoring

pH, PAH, Turb, T

Sea water
Scrubbing water
Fresh water
Alkali
Bleed-off
Effluent
Sludge

Alkali feed module

Cooling water

Fresh water System (lake water)

Sludge tank

Load

pH

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Bleed-off treatment

**Effluent**
Cleaned bleed-off
- **Disposal:**
  Can be discharged overboard
- **Storage:**
  In a buffer tank → possibility to operate in “zero discharge” mode

Permits cleaning of bleed-off anytime, also when scrubber is not operating

**Bleed-off**
Part of scrubbing water extracted to bleed-off treatment unit to remove contaminants
- **Disposal:**
  Never overboard
- **Storage:**
  In a buffer tank permitting:
  - Operation of scrubber with bleed-off treatment unit out of operation
  - Also vice versa

**Sludge**
- **Disposal:**
  In port, never overboard
- **Storage:**
  In ship’s sludge tank, possibly in same tank with separator and other sludge
Sea water scrubbing

Layout Seawater Scrubbing System – Basic Open Loop System

- Engine Exhaust Gas
- Scrubbed Exhaust Gas
- Possible Plume Control
- Laser Gas Analyser
- HMI Control Cabinet
- Water Monitor
- Scrubber Supply pump
- In-pit reaction water pump
- De-erosion reactor
- Optional Return pump
- Water treatment
- Sludge Tank
- Water monitoring
- Wash water discharge
- Seawater
- Seawater from Scrubber
- Sludge
- Control data
Marine scrubber milestones

1997: IMO adopts Marpol Annex VI
2004: Ratification of Marpol Annex VI
2005: Wärtsilä Marine Scrubber project started
2005: EU Directive
2005: Hamworthy scrubber on Pride of Kent
2007: Wärtsilä decision to install pilot scrubber
2008: IMO adopts Revised Marpol Annex VI:
   - stringent SOx-limits
   - scrubber permitted
   - effluent regulated
2008: Start of Wärtsilä pilot scrubber
2009: First certificate in the world (DNV, GL)
2010: Hamworthy contract for 20 scrubbers to Ignazio Messina
2012: EU Parliament and Council decision
2015: Drastic fuel savings with scrubbers in ECA
2020/2025: Drastic fuel savings with scrubbers globally
Large cruise vessel - Retrofit
<table>
<thead>
<tr>
<th>Vessel/Owner</th>
<th>Newbuilding or retrofit</th>
<th>Open loop</th>
<th>Closed loop</th>
<th>Hybrid</th>
<th>Scrubber delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS Pride of Kent / P&amp;O European Ferries Ltd.</td>
<td>Retrofit</td>
<td>x</td>
<td></td>
<td></td>
<td>2005</td>
</tr>
<tr>
<td>MS Zaandam / Carnival Corporation</td>
<td>Retrofit</td>
<td>x</td>
<td></td>
<td></td>
<td>2007</td>
</tr>
<tr>
<td>MT Suula / Neste shipping</td>
<td>Retrofit</td>
<td></td>
<td>x</td>
<td></td>
<td>2008</td>
</tr>
<tr>
<td>Containerships VII / Containership</td>
<td>Retrofit</td>
<td></td>
<td>x</td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td>APL England / APL</td>
<td>Retrofit</td>
<td>x</td>
<td></td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td>4 vessels / Ignazio Messina &amp; C.S.p.A</td>
<td>Newbuilding</td>
<td>x</td>
<td></td>
<td></td>
<td>2011 (2 vessels)</td>
</tr>
<tr>
<td>MV Tarago / Wilh. Wilhelmsen ASA</td>
<td>Retrofit</td>
<td>x</td>
<td></td>
<td></td>
<td>2012</td>
</tr>
<tr>
<td>8 vessels / Algoma</td>
<td>Newbuilding</td>
<td>x</td>
<td></td>
<td></td>
<td>2012 (4 vessels)</td>
</tr>
<tr>
<td>2 vessels / x*</td>
<td>Newbuilding</td>
<td>x</td>
<td></td>
<td></td>
<td>2013/2014</td>
</tr>
<tr>
<td>1 vessel / x*</td>
<td>Newbuilding</td>
<td>x</td>
<td></td>
<td></td>
<td>2013</td>
</tr>
<tr>
<td>HHI Hull 2516 and 2517 / Solvang</td>
<td>Newbuilding</td>
<td>x</td>
<td></td>
<td></td>
<td>2012/2013</td>
</tr>
</tbody>
</table>

* customer wants to remain anonymous

23 ships
Compliance with Marpol certified by DNV

DEUT NORSKE VERITAS
SECA COMPLIANCE CERTIFICATE
Certificate of Unit Approval for
Exhaust Gas-\(SO_x\) Cleaning Systems

Issued under the provisions of the Protocol of 1997 to amend the International Convention for the
Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 related thereto
under the authority of the Government of
FINLAND

by Det Norske Veritas AS

Particulars of Ship
Name of Ship: SUULA
Distinctive Number or Letters: OJKZ
Port of Registry: PORVOO
IMO Number: 9267560

THIS IS TO CERTIFY:
that the Exhaust Gas-\(SO_x\) Cleaning System (EGCS-\(SO_x\)) unit listed below has been surveyed in accordance with the
requirements of the specifications contained under Scheme A in the Guidelines for on-board exhaust gas-\(SO_x\) cleaning
systems - adopted by resolution MEPC.170(57) in line with regulation 14(4)(b) of MARPOL Annex VI.

This Certificate is valid only for the EGCS-\(SO_x\) unit referred to below:

<table>
<thead>
<tr>
<th>Unit manufacturer</th>
<th>Model/Type</th>
<th>Serial No.</th>
<th>EGC-(SO_x) Unit and Technical Manual approval number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wärtsilä Finland Oy</td>
<td>WM 125</td>
<td>0001</td>
<td>G-10117</td>
</tr>
</tbody>
</table>

A copy of this Certificate, together with the EGCS-\(SO_x\) Technical Manual, shall be carried onboard the ship fitted with this
EGCS-\(SO_x\) unit at all times.

This Certificate is valid for the life of the EGCS-\(SO_x\) unit subject to surveys in accordance with section 2 of the Guidelines and
regulation 5 of MARPOL Annex VI, installed in ships under the
authority of this Government.

Issued at Havik (Norway) on 2009-08-10

for Det Norske Veritas AS

Skevig Alf Roger
Head Of Marpol Section
MNBNA643
The first full-scale Wärtsilä SO\textsubscript{x} Scrubber

- Containerships VII, scrubber installed in August 2011.
- Main stream scrubber for Wärtsilä 7L64 main engine, 12600kW.
- Vessel built 2002 (Sietas, Hamburg).
- Operating area Baltic Sea and North Sea.
- Finnish flag, classification society GL.
Equipment locations

Scrubber “tower”

Equipment container

Engine room

Cargo area
Scrubber tower lifted onboard

Containerships VII
Containerships VII Scrubber Installed
Effluent Monitoring Module

• Dimensions:
  Height: 1370 mm
  Width:  810 mm
  Depth:  650 mm
  Weight: 300 kg

• Installed in equipment container.
BOTUs installed

Containerships VII

BOTU = Bleed-Off Treatment Unit
- In equipment container.
- Capacity 2 x 2.5 m³/h.
- 10 m³ holding tank capacity included.

UPGRADING
- New units will reduce effluent turbidity.
Containerships VII SOx measurements

- Fuel sulphur content 1.84%.
Algoma Fleet renewal project

New generation for Great Lakes Bulk Carriers

Energy efficiency & Environment

- Optimised hull form
- TIER II compliant engines
- Exhaust gas scrubbers
- Ballast water treatment
- Advanced waste water management
- Official Green Passport

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Algoma Scrubber arrangement

- Scrubber
- Wet sump
- Exhaust gas fans
- Exhaust gas by-pass dampers
- Exhaust gas inlet
Algoma Equinox class

Frame 8 Looking Forward

BRIDGE DECK 29100 a. BL
4TH CABIN DECK 26300 a. BL
3RD CABIN DECK 23500 a. BL
2ND CABIN DECK 20700 a. BL
1ST CABIN DECK 17900 a. BL
UPPER DECK 15000 a. BL
<table>
<thead>
<tr>
<th>#</th>
<th>ISSUE</th>
<th>CORRECTIVE ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scrubbing water pump jam</td>
<td>Pump modified</td>
</tr>
<tr>
<td>2</td>
<td>Scrubbing water pump cavitation</td>
<td>Sump level modified</td>
</tr>
<tr>
<td>3</td>
<td>Vibrations from ship hull</td>
<td>Sensitive equipment elastically mounted</td>
</tr>
<tr>
<td>4</td>
<td>Effluent turbidity sensor fouling</td>
<td>Automatic cleaning installed</td>
</tr>
<tr>
<td>5</td>
<td>Several other minor challenges</td>
<td>Corrected</td>
</tr>
<tr>
<td>6</td>
<td>Effluent turbidity</td>
<td>New Bleed-Off Treatment System</td>
</tr>
</tbody>
</table>
### Performance:
- 98% SOx Removal
- 60-80% Particulate Removal
- Up to 4.5% fuel sulphur content
- Prepared for main engine scrubbing

<table>
<thead>
<tr>
<th>Yard</th>
<th>DSME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel</td>
<td>Hull 4465/66/67/68</td>
</tr>
<tr>
<td>Size of SWS</td>
<td>4 x 2 MW auxiliary engine, 1 x 1 MW boiler</td>
</tr>
<tr>
<td>Installation type</td>
<td>New building</td>
</tr>
<tr>
<td>Delivery</td>
<td>January 2011, July 2011, January 2012, June 2012</td>
</tr>
</tbody>
</table>
Hamworthy Krystallon Ltd – Scrubbing Technology

Test station at Hamworthy Moss

- 1 MW Exhaust Gas Cleaning installation
- Tests run continuously
- Training for ships crew on Inert Gas Systems
- Future training on Exhaust Gas Cleaning Systems
- Demonstration for potential customers
Thank You!