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# SCRUBBERS AS SHIPOWNERS' RESPONSE TO THE SULPHUR DIRECTIVE AND ITS IMPLICATIONS FOR THE WASTE MANAGEMENT IN BALTIC PORTS

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**Summary**

The paper investogates the recent developments in exhaust gas cleaning systems and the growing interests in scrubber installation among ferry and ro-ro shipowners operating on the Baltic Sea. This technology creates the need for reception of scrubber sludge, which is produced alongside with gas cleaning. The study states that the information about the disposal of scrubber waste is largely limited or vague and evaluates – on the basis of a questionnaire - the availability of port reception facilities for the disposal of waste from sulphur scrubbers at major Baltic Sea ports. The paper concludes that a review of current legislature on port reception facilities is absolutely necessary and expresses the hope that the situation will improve in the wake of recent environmental regulations.

**Keywords**: scrubber, scrubber sludge, Baltic Sea

## Introduction

Shipping is responsible for around 2-3% of total global $CO_2$ emissions and, in case of some of the non-GHG emissions, shares in the ranges of 5-10% and 17-31% of world's $SO_x$ and $NO_x$ emissions respectively[1]. Growing pressure put on the shipping industry to reduce air emission from ships provided the basis for international regulation, primarily the amendment Protocol of 1997 to MARPOL 73/78 Convention, where Annex VI was added and named Regulations for the Prevention of Air Pollution from Ships.

The Annex VI entered into force in 2005 and set the limits for $SO_X$ and $NO_X$, as well as introduced the $SO_X$ Emission Control Areas (SECA). The Baltic Sea was the first SECA to be fully implemented in 2006.

Amendments to Annex VI in 2008 introduced more stringent limits – in January 2015 the fuel's sulphur content limit within ECAs was reduced to less than 0.1% from previous 1%. Out-

[1] O. Merk, *Shipping Emmission in Ports*, Discussion Paper No. 2014-20, International Transport Forum, OECD, 2014.

side of ECAs, the sulphur limits are currently 3.5% and further reduction to 0.5% is planned for 2020 or 2025[2].

As an alternative to the use of low sulphur fuel, Regulation 14 of MARPOL Annex VI allows for the use of exhaust gas cleaning systems or any other alternative abatement technologies to limit $SO_X$ emissions which are at least as effective as low sulphur fuel.

## 1. Sulphur scrubbers on ships

To meet the requirements of EU sulphur directive and reduce $SO_X$ emission from ships, ship-owners may choose one from three options for sulphur removal:

– switching to low sulphur fuels,
– considering alternative fuel types such as e.g. LNG, methanol etc.,
– continue to operate on high sulphur fuel oil but install sulphur scrubbers on the ship board to wash the sulphur from the exhaust gases.

In search of alternatives, which all are worth considering, some ship-owners decided to invest in an abatement technology, mainly in exhaust gas cleaning systems (EGCS) – sulphur scrubbers. According to DNV-GL in the year 2000 there was only a single scrubber-equipped ship in operation, in 2010 there were 8 ships, and by 2014, in the anticipation of the forthcoming regulation, their numbers had increased to 77. Considering order books and trends, it is expected that a total of 200 ships with scrubbers on board will be exceeded in 2017[3]. (Figure 1)

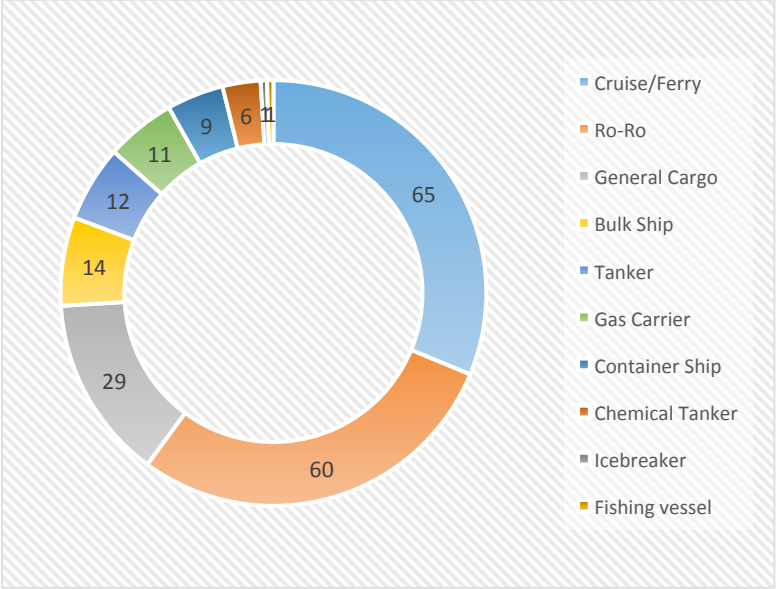


**Figure 1**. Number of scrubbers in order books.

Source: H. Mohn., *Ship owners' Compliance strategies: Dynamics, facts, figures*, presentation at BPO meeting: SECA is real now – first impressions of sulphur limits, Gdańsk, March 2015, Poland

Currently there are two main types of sulphur scrubbers: dry and wet scrubbers. The most popular are wet scrubbers using ambient seawater (open loop) or fresh water (closed loop) for gas scrubbing.

[2] The latter deadline will only be relevant, if an availability study in 2018 shows that sufficiently low sulphur fuel is not expected to be available by 2020.

[3] H. Mohn., *Ship owners' Compliance strategies: Dynamics, facts, figures*, presentation at BPO meeting: SECA is real now – first impressions of sulphur limits, Gdańsk, March 2015, Poland.

In *open loop scrubbers*, seawater is pumped from the sea through the scrubber, cleaned and then discharged back to sea. Wash water is not recirculated [4]. These systems are simpler and do not require large amounts of waste storage and on-board handling; however, there are issues concerning the water intake quality and many others [5].

*Closed loop scrubbers* use fresh water that is chemically treated (usually by caustic soda injection) to effect scrubbing. Most of the scrubbing agent is re-circulated with only minimal water intake and effluent discharge. These systems avoid the issues of waste water discharge but are more complex, more costly in operation, and create waste storage and handling issues on board. A variation of the closed loop system is a *hybrid system* which can operate as an open loop system while outside ECA[6].

*Dry scrubbers*, widely used in land-based industry, feed the exhaust gasses through a container filled with calcium hydroxide granulate. This calcium hydroxide has the ability to bind sulphur oxides by reacting with them to form calcium sulphate (gypsum). As of now, there is only a single ship plying on the European waters which is equipped with a dry scrubber.

EGC systems are a solution for both new constructions and retrofits. The installation choice depends on a number of factors such as cost of low sulphur fuels, capital expenditure, operating expenditure of the scrubber, or time spent in SECA. The share of each particular type of scrubber used by shipowners is presented in Figure 2.

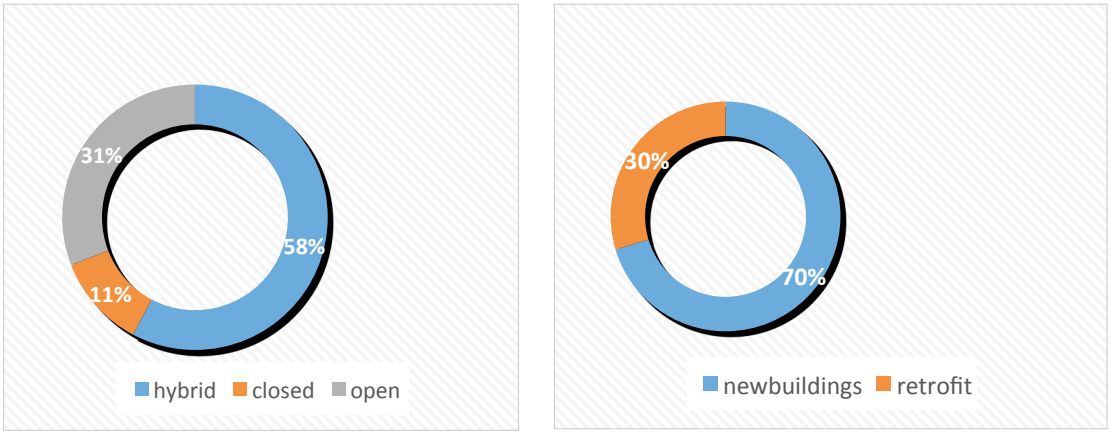


**Figure 2**. Scrubber type distribution in operations.

Source: H. Mohn, op. cit.

The aforementioned factors predetermined the installation of (or the decision to install) scrubbers on ships operating at the Baltic Sea on fixed routes – ferries, ro-ro and general cargo (feeder container ships) – which constitute almost three quarters of all ships equipped with scrubbers[7].

Judging by the shipowners' websites and companies' reports (as of 1st September 2015) some ferry/ro-ro operators have decided to retrofit almost a half of their fleets by installing scrubbers. The biggest investment in scrubber technology is planned by DFDS Seaways, which plans to complete the installation of scrubbers on 21 ships until 2017. Other shipping companies also have ongoing retrofit programmes, notably Finnlines and Transfennica. (Table 1).

[4] Lloyd's Register, Understanding exhaust gas treatment systems. Guidance for ship-owners and operators, June 2012.
[5] Bureau Veritas, Exhaust Scrubbers: What you need to know, date not provided.
[6] Ibidem.
[7] Mohn, op. cit.

**Table 1.** Solutions adopted by ferry and ro-ro shipowners operating on the Baltic in response to the sulphur directive.

| SHIPOWNER | SOLUTION |
|---|---|
| **Finnlines** | 14 out of 21 vessels are going to use scrubbers; other vessels will use MGO fuel (Marine Gas Oil). 10 installations have been completed already |
| **Polferries** | MGO fuel only |
| **Scandlines** | 4 ferries have been already equipped with scrubbing system; two new ships, which will use a hybrid propulsion system combined with a scrubber, have been ordered. |
| **Stena Line** | two ro-ro vessels will be retrofitted with closed-loop scrubber systems; one ferry is the first in the world running on methanol („Stena Germanica"). |
| **Tallink Silja Line** | ferries are running on MGO, no scrubber installation, one LNG-fueled ship has been ordered |
| **Transfennica** | 8 out of 15 operating vessels use scrubbers, the rest of the fleet is going to burn low sulphur fuels |
| **TT Line** | mainly MGO, 1 ro-pax with hybrid scrubber |
| **Unity Line** | MGO fuel only |

Source: own elaboration based on information provided by the shipowners (websites, newsletters, reports and personal communication).

## 2. Scrubber sludge from ships

Exhaust Gas Cleaning Systems are very effective at reducing sulphur oxides emissions (more than 90%). Moreover, they allow to capture the particulate matter and oil-based contaminants as well, with removal rates in excess of 80% possible[8].

Alongside exhaust cleaning, scrubbers produce different types of discharge fractions, depending on the type of scrubber system used:

1. Dry scrubber: the main residue is gypsum (calcium sulphate – $CaSO_4$) – a by-product that can be sold and re-used in other industries[9].
2. Wet scrubber:
   - sludge from an on-board wash water treatment plant (open-loop scrubber) or from the freshwater recirculation process (close-loop scrubber); in closed loop systems the amounts of waste generated can be quite considerable.
   - wash water – the scrubber's wash water itself can also be unloaded for on-shore treatment or can be discharged into the sea (closed loop scrubber in smaller volumes than the salt water scrubber).

There is no relevant or reliable literature/data available on sludge quantities and its composition (e.g. content of hazardous substances). Different suppliers provide inconsistent information, results from scrubbers' tests vary too.

Undoubtedly, fuel oil quality and the type of EGC system implemented are the factors that influence scrubber sludge quantity and quality. However, the amount of sludge not only

[8] J. Kjolholt et.al, *Assessment of possible impacts of scrubber water discharges on the marine environment*, Environmental Project No. 1431, 2012.

[9] EMSA, Discussion Paper – 1st Ad-Hoc Working Group on Scrubbing Technology Brussels, 3 June 2013.

depends on the amount of the particulates but also on the amount of water remaining mixed with it after treatment[10].

If a scrubber removes 70% of the PM, then approximately 500 kg of sludge may be expected for every 100 tonnes of residual fuel consumed by a diesel engine. This is dependent on the scrubber's removal rate and the efficiency of the washwater treatment, both in terms of removing PM and avoiding excess water output[11]. Wärtsillä, after testing the system on board of tanker "Suula", estimated the amount of ship generated sludge at approximately 0.1 to 0.4 kg/MWh[12]. Another supplier of EGCS, Alfa Laval, provides the following figures for the generated sludge quantities, summarised in Table 2.

**Table 2.** Estimated closed-loop scrubber's sludge amounts generated on ships.

| | **Engines** | **Total effect MW** | **HFO tonnes/year** | **Sludge tonnes/year** |
|---|---|---|---|---|
| **container ship** | 1 | 8 | 5800 | 1 |
| **tanker** | 1 | 13,74 | 5925 | 6 |
| **ro-ro ship** | 4 | 24,8 | 17534 | 14 |

Source: Nilson T., *Scrubbers. What do they mean to ports?,* presentation during BPO Environmental Seminar, Gdańsk, March 2014, Poland.

The waste that is generated during the entire scrubbing process can come in a variety of forms – from liquid to solid, packed or not – and needs to be handled properly. This multiplicity influences its reception at the port, handling and final disposal[13]. According to 2009 Guidelines for Exhaust Gas Cleaning Systems[14] § 10.4 residues generated by scrubbers should be delivered ashore to adequate reception facilities. It is not permitted to be incinerated on board or discharged at sea, hence requires separate storage for onshore disposal at port reception facilities (PRF). Moreover, each ship fitted with a scrubber unit "should record the storage and disposal of sludge in an EGC log, including the date, time and location of such storage and disposal".

## 3. Availability of PRF for scrubber sludge

One of the obligation of sea ports is to receive and handle ship generated waste. Regulation 17 of MARPOL Annex VI requires ports to implement reception facilities for scrubber residues. According to the EU Directive 2000/59/EC ports should ensure the availability of port reception facilities capable of receiving ship generated waste and cargo residues without causing undue delay to ships. However, waste originating from scrubbers is currently not within the scope of the Directive 2000/59/EC on port reception facilities.

Considering the growing interest in EGCS it is worth reviewing the availability of port reception facilities adequate for the needs of ships using scrubber systems. Information was gathered with the use of an online questionnaire powered by Google Forms, where some of the questions referred to the issue of scrubber sludge reception in ports. The questionnaire was sent out in August 2015 to the environmental departments of the eleven key Baltic ports. Only three ports (Sankt Petersburg, Gdańsk and Stockholm) have not answered the questionnaire. Table 3 summarizes the received responses.

[10] http://www.egcsa.com, website of Exhaust Gas Cleaning Systems Association (access date 11.08.2015)
[11] Lloyd's Register op. cit.
[12] Wärtsilä, Exhaust Gas Scrubber installed onboard MT "Suula". Public test report., 2010.
[13] Kjolholt *et al*., op. cit.
[14] MEPC.184(59), 2009 Guidelines for Exhaust Gas Cleaning Systems, Adopted on 17 July 2009.

**Table 3.** Selected Baltic ports and their PRF for scrubber waste.

| Port | Available information of reception of ships' sulphur scrubbers waste |
|---|---|
| **Stockholm** | According to port tariff, vessels that wish to deposit waste from scrubbers must give a 5 working days' notice before arrival at the port. Prices are available on request. |
| **Helsinki** | The port is preparing for the reception of the waste water generated by scrubbers. The handling of the waste water will be priced according to the actual costs. There is no reference to scrubber sludge. As most vessels calling in the port are in regular traffic, they do not use the PRF and have own contracts with waste management companies. |
| **Riga** | Port is ready to collect dry residues from scrubbers. All shipowners have an obligation to declare amount of scrubber waste 24 hours before calling the port. It is under discussion to include reception of scrubber waste in sanitary fee- the Port Authority will collect information on scrubbers residue (amount, chemical content etc.) and then will decide on special fee application. |
| **Rostock** | Reception of scrubber residues is included in the waste disposal fee. The fee imposed for the waste disposal depends on the result of its analysis carried out beforehand, and thus is contingent on the appropriate disposal method. Additionally, the port is under no obligation to accept the scrubber waste. |
| **Gdynia** | At the moment none of shipowners have reported the need for scrubber sludge disposal. Port tariff does not refer to this type of waste. PWMP (2012) describes scrubber waste as a marginal issue, which might be important in the future. |
| **Klaipeda** | The port is prepared for the reception of scrubber sludge not this is included in no-special-fee. However it is also possible to arrange sludge collection directly with external company. PWMP is being updated now and will include the scrubber sludge issues. |
| **Copenhagen** | The reception of scrubber sludge is not taken care of by the port – it is a matter directly between an approved contractor (vacuum truck service) and the vessel (owner). The port can provide assistance in contacting scrubber sludge collection services. Scrubber waste is collected in Y approved pallet tanks. |
| **Tallin** | Port offers reception of scrubber sludge. In 2015 the port received 595m$^3$ of scrubber wastes (from cruise ships only). Scrubber wastes are covered by no-special-fee scheme. |
| **Turku** | Port do not offer reception of scrubber sludge. At the moment it is a matter solely between the shipowner and external company. |
| **Szczecin/Świnoujście** | Port offers scrubber sludge reception; however, the price and conditions are negotiated directly with the receiving company. Because of its composition scrubber sludge was considered hazardous waste. |

Source: own elaboration based on responses to the questionnaire, ports' tariff and Port Waste Management Plans.

## Conclusions

The majority of shipowners operating on the Baltic Sea have decided to invest in an abatement technology, mainly in exhaust gas cleaning systems – scrubbers. The growing interest in EGC systems as well as growing number of ships with installed scrubbers will create the need for reception of scrubber sludge or wash water.

This study has revealed that official information regarding the possibility of reception of ships' sulphur scrubber waste in Baltic ports is generally limited, incomplete or even missing. Knowledge about scrubber sludge amounts and composition is insufficient. Scrubber sludge reception is covered by the no-special-fee scheme for ship-generated waste or has to be paid

separately. It has been frequently mentioned that the infrastructure for scrubber waste deposition in ports is not yet in place and that the port's responsibility to have such facilities is not clearly defined. However, in the case when shipowners report the need for scrubber sludge disposal, the ports are ready to fulfil their needs or are able to arrange such a service by external contractors.

To sum up, the growing number of ships with installed scrubbers have encouraged ports to reconsider their Waste Management Plans in terms of the new types of waste resulting from new environmental regulation in shipping. Correspondingly, the revision of the EU Directive 2000/59/EC on port reception facilities needs to be reconsidered as well.

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# SCRUBBER'Y JAKO ODPOWIEDŹ ARMATORÓW NA DYREKTYWĘ SIARKOWĄ I ICH IMPLIKACJE DLA GOSPODARKI ODPADAMI W PORTACH BAŁTYCKICH


## Streszczenie

Artykuł prezentuje rozwój systemów do oczyszczania spalin ze statków tzw. scrubber'ów i skalę ich stosowania przez armatorów promów i ro-ro na Bałtyku. Wskazuje także na towarzyszącą im potrzebę zagospodarowania osadu powstającego w procesie oczyszczania. W artykule podkreśla się ograniczoność informacji o sposobie zagospodarowania tych osadów, a w oparciu o wyniki przeprowadzonego badania ankietowego ukazuje stan przygotowania portów bałtyckich do ich odbioru oraz wyraża nadzieję, że sytuacja stopniowo będzie ulegać poprawie wraz z pojawianiem się nowych przepisów w zakresie ochrony środowiska. Wskazuje się także na potrzebę zmian obowiązujących przepisów dotyczących portowych urządzeń do odbioru odpadów.


**Słowa kluczowe:** scrubber, odpady ze scrubber'ów, Bałtyk

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