SCRUBBER TECHNOLOGIES
(Open-closed, hybrid, single or multi-stream)

- Will an investment in scrubbers pay back?

Stavros Hatzigrigoris
Paraschos Liadis

Date: 14 November 2017
INDEX

1) Sulphur Cap 2020 Options for compliance
2) Technical factors for the selection of Scrubber type
3) Operational factors for the selection of Scrubber type
4) Retrofits SOx Scrubbers
5) New orders with SOx Scrubbers
6) Scrubber types (Based on Process Water)
7) Scrubber types (Based on the E/G inlet)
8) Configuration concepts (Based on the connected E/G Streams)
9) Scrubber payback time: Conventional HFO vs blended fuel (HFO & LSMGO 0.1%S)
10) Useful links
I. SULPHUR CAP 2020 COMPLIANCE OPTIONS

 Acrobat.com | Copyright © 2019

 Low sulfur HFO (0.5% S)
 - Produced by blending 75%-85% MGO and 15%-25% HFO or in a few cases by upgrading the refining process.
 - Lack of an appropriate ISO standard
 - Price most probably very close to MGO

 Low sulfur distillate fuels (MGO)
 - Lubricity issues
 - Higher fuel cost
 - One fuel onboard for general use outside ECA
 - No need for purification or heating

 LNG
 - Bunkering infrastructure
 - Very high CAPEX
 - It will come

 Alternative fuels (LPG, CNG etc.)
 - Bunkering infrastructure
 - Main engine design and testing

 Exhaust gas cleaning systems (SOx Scrubber)
2. TECHNICAL FACTORS FOR THE SELECTION OF SCRUBBER TYPE

Trading area

Electric load requirements
- Electric Load Analysis

Installation footprint
- dimensions
- engine casing modifications
- additional tanks, pumps
- sea water supply capacity
- interface with AMS (remote, local operations)

Note: Not in order of importance

Water/effluent requirements
- IMO criteria on: wash water turbidity, pH, polycyclic Aromatic Hydrocarbons (PAH) concentration, nitrate concentration.

Material specification of critical components.
- Scrubber body assembly
- NAOH supply line
- Rubber-lined valves
- Washwater processing tanks
- Polyethylene-lined or GRE water drainage lines
2. TECHNICAL FACTORS FOR
THE SELECTION OF SCRUBBER TYPE

Operating environment (water salinity)

Flag, Class, USCG Requirements
- IAPP certificate
- SECC (Sox Emissions Compliance Certificate), OMM (Onboard Monitoring Manual)
- EGC-SOx Notation (Optional)
- Under what scheme will the scrubbers be certified? Important to define at contractual stage.
- VGP sampling and monitoring obligations
- As per the MEPC there are two compliance routes:

**Scheme A**: based on initial emission performance certification obtained during shop test or commissioning together with continuous check of operating parameters and daily exhaust emission monitoring

**Scheme B**: based on continuous monitoring of operating parameters and exhaust emission
2. TECHNICAL FACTORS FOR THE SELECTION OF SCRUBBER TYPE

Maximum %S the scrubber is certified

- Certified value of SO2/CO2 ratio
- % Sulphur on exhaust gas after treatment

Commissioning, shop test, sea trials

- Testing environment. Important to test the scrubber in the water environment for which it is designed.
- Sea trial procedure specification

Note: Not in order of importance

Effect of scrubbing on O2 content of effluent gas of boilers used for inerting

- Backpressure and noise
- Sludge production and disposal
- Detailed inspection and planned maintenance procedure
3. OPERATIONAL FACTORS FOR THE SELECTION FOR SCRUBBER TYPE

 quieres:

Feedback from existing installations

Availability and continuity of fuel supply

Redundancy and safety
  - Safeguards/interlocks (high temperature in scrubber, high back pressure, low water pressure)
  - Alternative measures in case of failure. (Automatic by-pass ?)

Note: Not in order of importance

Familiarization and training requirements
  - Crew training
  - PSC inspectors familiarization

CAPEX/OPEX
  - Equipment and installation cost
  - Delivery time
  - Wear and tear parts
  - Consumables
  - Warranty
4. RETROFITS OF SOX SCRUBBERS

222 Ships (July 17)

- AEC Maritime: 8%
- Alfa Laval: 23%
- Clean Marine: 3%
- Couple Systems: 3%
- CR Ocean Eng: 9%
- DeltaLangh: 5%
- DuPont: 4%
- Ecospray: 3%
- Fuji Electric: 15%
- Gesab: 6%
- Green Tech Marine: 10%
- Hamworthy: 3%
- Kwang Sung: 3%
- MAN Diesel & Turbo: 6%
- Marine Exhaust Tech: 10%
- Mitsubishi: 3%
- Saacke: 3%
- Unknown: 10%
- Valmet: 3%
- Wartsila Moss: 15%

Source: Clarksons
5. NEW ORDERS WITH SOX SCRUBBER

75 Ships (July 17)

- Alfa Laval: 10%
- Clean Marine: 3%
- DuPont: 3%
- Ecospray: 1%
- Unknown: 49%
- Valmet: 3%
- Weihai Puyi: 11%
- Wartsila Moss: 11%
- Yara Marine Tech: 9%

Source: Clarksons
6. SCRUBBER TYPES (BASED ON PROCESS WATER)

Type of Installations

- Open Loop
- Closed Loop
- Hybrid
OPEN LOOP

- Efficiency dependable on water alkalinity
- Proper for vessel with no frequent calls in ports (VLCCs)
- No additional chemicals are required
- A few ports in Europe and US prohibit the discharge of wash water
- Crew is familiar due to resemblance with IGS Scrubber
- Lower CAPEX/OPEX than hybrid/closed loop
- Lower installation footprint than hybrid/closed loop
CLOSED LOOP

- Independent from water alkalinity
- Proper for low alkalinity waters (lakes, rivers)
- High installation footprint
- High CAPEX/OPEX
- Complicated operation
- Alkalinity reactant is necessary (Caustic soda-NAOH)
- Additional tanks: circulation tank, sludge tank, caustic soda storage tank, water holding tank
- Water cleaning unit is required
- 70 mt/day of fresh water are needed for a closed loop scrubber of a VLCC (higher FWG capacity)
6. SCRUBBER TYPES
(BASED ON PROCESS WATER)

HYBRID

- Proper for ships operating in both types of waters and requiring full flexibility of operation
- Can operate as closed loop and open loop
- Option of integrating GPS in the control system to switch automatically from “open loop” to “closed loop”
- Partial discharge is possible
- Complicated operation
- High CAPEX/OPEX
7. SCRUBBER TYPES
(BASED ON THE E/G INLET)

I-TYPE

- In Line with the exhaust gas pipe
- Challenging drain of the process water
- Simple installation
7. SCRUBBER TYPES
(BASED ON THE E/G INLET)

U-TYPE

- Venturi scrubbers
- Similar to the IGS scrubber
- Easier drain of the process water
8. CONFIGURATION CONCEPTS (BASED ON THE CONNECTED E/G STREAMS)

- Determined by the type/number equipment connected on the Scrubber’s Unit Stream

- The size of the Scrubber determines the amount of the flue gas that is treated

- Various concepts exist
8. CONFIGURATION CONCEPTS
(BASED ON THE CONNECTED E/G STREAMS)

SINGLE STREAM

- Scrubber has one exhaust gas entry from an individual unit.

- Possible to combine exhaust gas pipes from other combustion units to one main exhaust pipe before the Scrubber inlet.
MULTI- STREAM

- Multiple inlets, streams connected with valve.
- Suitable for diesel-electric ships
- Exhaust gas fans used to compensate additional back pressure
The average worldwide Sulphur level of HFO is 2.7%.

Main method for producing 0.5 % S HFO will be blending.

Based on Singapore supplied HFO with average 3.4 % Sulphur content, HFO will have to be mixed with 0.1 % distillates as per the formula: $3.4X + 0.1(100−X) = 0.5 \times 100$

If this is solved, it gives $X=12$ % i.e. 12 % HFO should be mixed with 88 % of 0.1 % distillates to produce 0.5 % HFO.

Based on the current Singapore prices the 0.5 % S blend will cost $300 \times 0.12 + 483 \times 0.88 = 461$ USD/MT.

This gives a differential of 461 - 300 = 161 USD/MT between HFO and 0.5 % S residual fuel.
9. SCRUBBER PAYBACK TIME: CONVENTIONAL HFO VS BLENDED FUEL (HFO & LSMGO 0.1%S)

A VLCC equipped with scrubber will save (260 days x 70 MT/Day x 163 USD/MT) 2.96 M USD per year.

For additional electrical power will spend (260 days x 3 MT/day x 300 USD/MT) 0.24 M USD/year and for maintenance 0.3 M USD/year.

Based on the above the estimated saving per year for a VLCC using scrubber is 2.42 M USD/year.

Payback time for an open loop scrubber with CAPEX=2.5 M USD is 1.03 years.
10. USEFUL LINKS

- Wartsila open-loop scrubber: [https://www.youtube.com/watch?v=drn1vl38qqo](https://www.youtube.com/watch?v=drn1vl38qqo)
- Wartsila retrofitting scrubber systems: [https://www.youtube.com/watch?v=GUWr1ukgm80](https://www.youtube.com/watch?v=GUWr1ukgm80)
- Clean Marine hybrid scrubber: [https://www.youtube.com/watch?v=OjdGjkPOOYs](https://www.youtube.com/watch?v=OjdGjkPOOYs)
- Alfa-Laval hybrid scrubber: [https://www.youtube.com/watch?v=pla6w9Tg-6A](https://www.youtube.com/watch?v=pla6w9Tg-6A)
- Saacke exhaust gas scrubbers: [https://www.youtube.com/watch?v=BIRDUskEnYs](https://www.youtube.com/watch?v=BIRDUskEnYs)
THANK YOU