Status of Emission Control on Wärtsilä 2-stroke Sulzer RTA engines

Maritime Air Quality Technical Working Group

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**Actual status:**

**All** Sulzer RTA and RT-flex engines (approx. 200) installed on ships with keel-laying on or after the January 1st, 2000 comply with Regulation 13 of Annex VI to MARPOL 73/78 by the application of the so-called:

**Low $\text{NO}_x$ Tuning**

The elements are:

- Increased compression ratio
- Injection delay
- Changed exhaust valve timing
Future NO\textsubscript{X} reducing technology

Further NO\textsubscript{X} reduction measures:

- **Engine tuning**
  Measures as higher compression ratio and optimization of fuel injection have already been stressed out in order to comply with the Annex VI limits.

- **EGR**
  Applicable only in combination with 'clean fuels' (corrosion and fouling problems when running with residual fuel).
Future reduction of NO$_x$ emissions:

- Water addition
  - Humidification of intake air
  - Fuel/water emulsion
  - Direct water injection
Note: All methods using water require high amounts of water, which might not be available at low loads (produced by fresh water generators) or in coastal regions (sea water quality).

**Humidification of intake air**

Water injected into compressed scavenge air  
+ simple system  
- high amount of water amount (up to 2 times of fuel amount)  
- affecting oil film??

Note: Not yet tested on 2-stroke Sulzer RTA engines
Future NO$_x$ reducing technology

**Fuel/water emulsion**

Water mixed to fuel in emulsifier (load-dependent)

- simple system, if not high water amounts at 100% load required
- limited due to capacity of fuel pump, heating temperature of fuel system and stability of emulsion
- cavitation fuel pump??

Note: Some experience on stationary 2-stroke Sulzer engines with 'low' water amounts (15-18%).
Direct water injection

Water injected by a second, fully independent injection system

+ flexible timing
+ higher water amount can be injected (up to 70% of fuel amount)
- additional equipment (pump, pipes, rail, injectors)
- long-term behaviour??

Note: Tested on 2-stroke R&D engine on testbed at the moment (for Wärtsilä 4-stroke engines already available)
Selectiv Catalytic Reduction

**SCR state of the art:**

- Exhaust gas temperature
  \[ \approx 350°C \Rightarrow \text{before T/C} \]
- Urea consumption
  \[ \approx 25 \text{ l} / \text{MWh} \]
- NOx reduction
  \[ \geq 90\% \Rightarrow \leq 2 \text{ g/kWh} \]
- Investment costs
  \[ 40'000-60'000 \text{ US$} / \text{MW} \]
- Running costs (urea)
  \[ \approx 3.75 \text{ US$} / \text{MWh} \]
- Maintenance costs
  \[ \approx 0.9 \text{ US$} / \text{MWh} \]
Application for Diesel Engines

The **optimum working temperature** to get a good efficiency out of the SCR system is **around 350 °C**.

As the exhaust gas temperatures of 2- and 4-stroke engines are different, the SCR system is located different:

- **2-stroke engine:**
  
  SCR system to be placed before turbocharger

- **4-stroke engine:**
  
  SCR system to be placed after turbocharger
Reference Installation: Pre-turbo SCR arrangement

As applied for Sulzer 7RTA52U engine on heavy fuel operation

3 x RO-RO vessels for Wagenborg Shipping B.V.
CO and HC emissions

- Low due to high $O_2$ concentrations and efficient combustion process
- Of no legislative concern yet
- Reduction of HC with minisac nozzle, reduced lub.oil consumption, minimization of “dead volumes” in the combustion space and ring groves

$CO_2$

- Function of the quantity of fuel burned
- No regulation yet, but discussed on IMO board
- Reduction: higher propulsion efficiency
Derive directly from sulphur content of fuel
Limited by IMO to 4.5% sulphur content of the fuel;
SO\textsubscript{X} emission control areas (Baltic Sea, North Sea): 1.5%
Reduction measures: Higher propulsion efficiency, low sulphur fuel,
(Exhaust gas cleaning DeSO\textsubscript{X} (wet scrubbers) not suitable)

The most applicable method to reduce SO\textsubscript{X} is to run on low-sulphur-fuel. Desulphurisation of the bunkered fuel onboard or after-treatment of the exhaust gas is more expensive, requires additional space for the installation and the handling of the resulting waste products. Desulphurisation onboard nor after-treatment are not to be considered as viable methods at the moment at marine applications.
Smoke reduction measures

**Aim:** Reduce visible smoke

- Minisac nozzles (for 2-stroke engines; in development)
- Common rail
- Advanced injection timing ($\text{NO}_x \uparrow$)
- Increased scavenge air temp. ($\text{NO}_x \uparrow$)
- Fuel quality
- Lub.oil quality/quantity
- Exhaust gas cleaning: Not considered for marine applic. at the moment
Summary/Outlook

- Measures and certification procedures to comply with Annex VI NO\textsubscript{X} limit introduced successfully ⇒ today's standard

- 'International' character of this regulation facilitates introduction and application

- To guarantee compliance during lifetime of the engine ⇒ parameter check method according to NO\textsubscript{X} Technical Code (described in detail in the engine's Technical File)

- Measurements on board quite a challenge ⇒ Accuracy, repeatability (measurement of power, bsfc, emissions) ⇒ test cycle procedure (vessel out of service for several days)
Different **new emission reducing technologies** are in development at the moment.

As partly only testbed results from one engine type/rating is available, it should be kept in mind that the emission reducing potential and operational behaviour when applying to different engine types, ratings, operational conditions, etc. might differ from the (measured) reference and therefore further modifications (design, engine control) and time (!) might be necessary to adapt the technology to different engine types. First estimations of the potential of a measure or first results must therefore be handled carefully till long-term and wide-range experience is available.