SCRUBBERS FOR THE MARITIME INDUSTRY

ANDRITZ SeaSOx
World’s first installation of dry desulphurization with a filter. ANDRITZ SeaSOx scrubber at the vessel “Prada” for La Méridionale in France.
ANDRITZ air pollution control

ANDRITZ is a globally leading supplier of plants, equipment, and services for various industries in the public, municipal, and private industrial sectors. The publicly listed technology Group is headquartered in Graz, Austria, and has a staff of around 29,000 employees.

ANDRITZ operates over 280 sites worldwide and is a leading global supplier of innovative air pollution control technologies. Our product range combines 35 years’ experience with the specific knowledge gained from hundreds of installations around the world. ANDRITZ offers high-end technologies and is a partner you can rely on.

CLEAN AIR IS THE BASIS OF A HEALTHY LIFE
Air pollution causes discomfort or harm to people and other living organisms. It is our mission to prevent air pollution from shipping fleets, power generation, and industrial processes. Thanks to our broad portfolio of air pollution control technologies and extensive experience from completed projects, ANDRITZ is able to handle any challenge your project may entail. Our product portfolio ranges from flue gas scrubbers (wet and dry), dust and soot separation, to SCR/DeNOx systems and complex flue gas cleaning equipment for waste-to-energy and industrial plants. Our wet scrubber technologies are tailor-made solutions developed for highest efficiencies and use either seawater, wet lime-stone suspensions or NaOH as absorption media. Our dry desulfurization technologies show the same high level of performance and are available for many different applications. ANDRITZ has numerous references for all technologies, and we are proud to say that all of our reference plants are working to the full satisfaction of our customers. The cutting-edge engineering tools used and global R&D collaboration with a network of recognized partners and universities are the foundation upon which we build our work.

Exhaust gas cleaning for shipping is a challenge that can be resolved perfectly with the know-how ANDRITZ has gained by designing and optimizing hundreds of installations around the world. Keeping in mind the demand for high availability, the simple but effective scrubber system is the ANDRITZ solution for efficient and reliable exhaust gas desulfurization on board maritime vessels. By identifying each client’s needs at an early stage, we can make a long-term contribution towards cleaner air and a clean environment. With offices in the USA, Europe, South America, and Asia, ANDRITZ is able to provide our well-proven solutions globally and has the dedicated personnel to meet all clients’ needs. A global service network is available for all of our products, so wherever you are – we are available to provide support to our clients.

Legislation and regulatory framework – the environmental impact

Exhaust gas emissions from marine diesel engines, mainly containing nitrogen oxides, sulfur oxides, carbon dioxides, and complex particulate matter (PM), are a big concern for human health and the environment. In response to these concerns, the International Maritime Organization (IMO) has introduced regulations for emission control under Annex VI of the MARPOL Convention. Annex VI imposes a framework of mandatory limits on emissions of sulfur oxides (SOx) and nitrogen oxides (NOx), both globally and within designated sea areas known as Emission Control Areas (ECA).

The regulations specify the sulfur content allowed in the fuel to limit the SOx emission. A ship may burn fuel with a higher sulfur content, providing that SOx emissions are controlled to a level that is not higher than the levels emitted when using compliant fuel. In order to comply with the new regulations, ships must either use expensive, low-sulfur fuel or install exhaust gas cleaning units. Based on the operating profile of maritime vessels, exhaust gas cleaning can secure enormous savings in fuel costs and thus provide payback periods of between one and three years. The ANDRITZ SeaSOx technology is the right answer to meet the new requirements and can be installed on all types of maritime vessels, either on a new build or retrofit basis thanks to its flexibility.
ANDRITZ SeaSOx\textsubscript{wet} process description

**OPEN LOOP MODE**
In open loop mode, seawater is used as a washing medium to clean the exhaust gas. This simple process makes use of the natural alkalinity of the seawater in chemical absorption of the SO\textsubscript{x}. For this reason, the washing medium is pumped from sea chests to the absorber, where the absorption process takes place by means of spray scrubbing. The treated exhaust gas can then be released to the environment, and the effluent is also discharged. Both the exhaust gas and the effluent have to meet several critical, environmental constraints, which are validated by continuous emission monitoring.

**CLOSED LOOP MODE**
If the natural alkalinity is too low or discharging of effluent is not allowed, SO\textsubscript{x} scrubbing is performed in closed loop mode. In this mode, the washing medium is recycled, and a neutralizing agent (50% wt. NaOH, Na\textsubscript{2}CO\textsubscript{3}, Mg(OH)\textsubscript{2}) is added in metered doses to obtain a certain absorption capacity. In order to control the absorption temperature and maintain the water balance, an inline heat exchanger is provided on request to cool the washing medium down. Consequently, the effluent has to be cleaned periodically depending on the engine load, the ship’s route, and its fuel specification. For this application, a washing water treatment unit is installed to separate the particles and salts from the washing medium, in accordance with the MARPOL Convention, before it is discharged into the sea. The sludge generated is collected in a separate tank, while the treated washing water is either stored in the holding tank or discharged into the sea, depending on local discharging restrictions.

**HYBRID MODE**
A combination of open and closed loop operations is called hybrid mode. In hybrid mode, it is possible to switch between these two processes depending on the predominant basic conditions (seawater alkalinity, discharge restrictions, etc.). This option provides high flexibility and enables customers to choose the best process, both economically and technically.

**ADVANTAGES**
- Simple and robust design suitable for inline and bypass installation
- Substantial noise reduction: The silencer can be removed if operated in the inline mode
- Exhaust gas can pass through safely, even when the absorber pumps are not operating
- Highest removal efficiencies with lowest operating costs, combining ANDRITZ proprietary FGDplus technology and optimized spray bank design
- Multiple inlets possible
- Smallest footprint due to rectangular design
**I-type\textsubscript{wet} (inline) scrubber, single or multiple-source scrubbing features:**

1. **DESIGN CONCEPT**
   Designed for the smallest footprint, inline funnel integration and run dry capabilities.

2. **MATERIAL SELECTION**
   The shell, internals and gas inlet are all made of alloys with high Cr, Ni and Mo content (SMD254 and ALLOY31) to perform under severe conditions:
   - Seawater/high chloride (wet mode)
   - Exhaust gases/high temperatures (dry mode)

3. **SQUARE DESIGN OPTION**
   ANDRITZ provides a square shell in order to maximize the internal volume required for the sulfur absorption process while minimizing the space demand and manufacturing costs.

4. **FGDPLUS LAYER**
   The patented FGDplus technology from ANDRITZ has proven its advantage over conventional mass transfer systems for power plants up to 600MW. It ensures even distribution and turbulent mixing of the exhaust gases and the seawater stream.

5. **PREVENTION OF BACK-FLOW**
   Beside class requirements, the patented ANDRITZ inlet was developed to minimize the pressure drop while providing an effective prevention of backflow to protect the exhaust gas ducts.

6. **OPEN-SPRAY SCRUBBING TOWERS**
   Open spray towers feature a slim design and the highest operational safety. As there are no obstacles in the absorber, there is no risk of clogging, blockages, or melting of internal parts.

7. **BOTTOM OR SIDE INLET DUCT**
   Inlet connections are available either at the side or at the bottom.

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**U-type\textsubscript{wet} (bypass) scrubber, single or multiple-source scrubbing features:**

1. **DESIGN CONCEPT**
   Designed for multiple source connections for highest flexibility and freedom of positioning inside or outside the existing funnel.

2. **MATERIAL SELECTION**
   Because of the bypass configuration, shell and internals are made of super-duplex alloys, while the gas inlet section requires high Cr, Ni and Mo alloys (ALLOY31).

3. **BY-PASS FEATURE**
   Existing exhaust gas ducts are maintained in place, while new duct branches are connected to the scrubber to maximize equipment positioning flexibility to match the specific ship’s arrangement.

4. **OPEN-SPRAY OR PACKED SCRUBBING TOWERS**
   Open spray towers feature a slim design and the highest operational safety. As there are no obstacles in the absorber, there is no risk of clogging, blockages, or melting of internal parts.

   Packed spray towers feature the lowest energy demand. The internal packing provides higher surface contacts, thus increasing the SOx absorption efficiency and reducing water consumption.
ANDRITZ SeaSOx\textsubscript{dry} process description

**DRY DESULFURIZATION PROCESS**
In the dry desulfurization process, sodium bicarbonate (NaHCO\textsubscript{3}) is injected as a dry powder into the existing exhaust pipe. Due to the prevailing high temperature and adequate residence time, the NaHCO\textsubscript{3} particles are activated, which increases the reactive surface by many times. This activation is necessary for the NaHCO\textsubscript{3} to react with the sulfur components. Such a process requires a temperature of at least 150 °C. If the temperature of the exhaust gas stream from the engines is higher than 250 °C, a quench is connected upstream to reduce the exhaust gas to the desired temperature by means of evaporative cooling. At the downstream dust filter, on which other particles (e.g. dust, soot ...) are also deposited in addition to the sodium bicarbonate, a filter cake builds up on the filter cloth, and this is where the decisive chemical reaction takes place. SO\textsubscript{2} reacts with NaHCO\textsubscript{3} to form Na\textsubscript{2}SO\textsubscript{4}, which is also present as a powder. After a defined period of time or due to the maximum permitted pressure loss, the dust filter is cleaned by means of a pulse-jet process. During operation, a short stream of air is introduced into the bag filter at high pressure, whereby the filter cake peels off and drops into a collecting funnel. From there, the product is carried off by compressed air and stored in a silo.

**ADVANTAGES**
- Low CAPEX (low-cost equipment, little installation work necessary)
- SO\textsubscript{2} removal possible with only 0.1% or 0.5% residue
- Low pressure drop (< 15 mbar)
- No waste water
- No plume due to hot process (tail-end SCR possible)
- No harmful sorbents (NaHCO\textsubscript{3} is also known as baking soda)
- Additional particulate removal > 99 %
- No need to install pumps, waste water treatment equipment, heat exchangers, filters, or tanks in the engine room
- Multiple inlets possible
Dry (bypass) scrubber, single or multiple-source scrubbing features:

The ANDRITZ Pulse Jet Fabric Filter (PJFF) technology has been developed as a result of the design and installation of more than 80 fabric filter systems worldwide. In applications for shipping, this provides many advantages:

1. **DESIGN CONCEPT**
   - Designed for single- or multiple-source connections with no liquid effluent produced and limited power demand.

2. **MATERIAL SELECTION**
   - The filter chamber is made of low-grade steel because of the dry absorption process. Austenitic steel alloys are not required anywhere, thus reducing costs and delivery time.

3. **MULTIPLE POLLUTANT REMOVAL**
   - Besides SO₂ abatement, soot and particulate emissions are drastically reduced, thus making your fleet future-proof. ANDRITZ dry scrubbing technology ensures abatement of particulate and fine particulate emissions at the highest extent.

4. **NO DRY DOCK ACTIVITIES REQUIRED**
   - Installation time is shortened, and there is no need for vessels to go into dry dock. Modifications to existing sea-chests: none Additional discharge outlet: none Additional sea water piping: none

5. **EASY FILTER BAG MAINTENANCE**
   - Maintenance or replacement of filter bags requires a very limited shutdown time because the chambers are easy to access and the internal design is modular.

ANDRITZ competences and key equipment

**AUTOMATED CONTROL**
- The close cooperation between ANDRITZ AUTOMATION and all business areas of the ANDRITZ GROUP creates significant advantages, such as concentration of the process know-how available throughout the Group and customer-focused solutions. In-house specialists at ANDRITZ AUTOMATION provide a complete control system for ANDRITZ SeaSOx applications, individually tailored to the specific characteristics of each vessel and able to communicate with the vessel’s main, higher-level control systems, also if installed as an upgrade.

**DATA FROM ANY EQUIPMENT CAN BE PROCESSED IN ORDER TO OPTIMIZE PROCEDURES:**
- The optimum water feed is supplied to pre-selected spray banks based on empirical knowledge.
- The emissions analysis also influences control of the circulation pump to comply with the MARPOL Convention.
- Data recording/trending of gas emissions and wash water
- Process simulation add-on increases efficiency during training, maintenance, and Factory Acceptance Test (FAT).
- Onboard performance, system diagnostics, as well as online remote service

**OPTIMIZING PROCEDURES**
- THE ANDRITZ SeaSOx CONTROL SYSTEM MAKES YOUR PLANT RELIABLE, EFFICIENT, AND ECONOMICAL.
LABORATORY TESTING
We have excellent R&D facilities for continuous optimization of our processes and products. A corporate laboratory with extensive test equipment, as well as access to technical centers and lab-scale plants at selected universities in combination with our own pilot plants put us in an excellent position to perform development work for our customers and ourselves.

The photo shows one of our test facilities for investigating seawater and NaOH scrubbing for SO2 reduction. A wide range of parameter variations, highly sophisticated measuring equipment, and the means of testing different types of absorption regimes (packings, spray scrubbing, FGDplus) help us to design and optimize the best suited scrubber configuration for each application.

CFD SIMULATION
Computational Fluid Dynamics (CFD) simulation provides local and/or time-resolved visualization of flow and transport in multiphase processes. For example, pollutant concentrations in apparatus can be pinpointed according to time and place. Over the years, CFD simulation has enabled us to improve our processes, using calculation models developed in-house.

CFD simulations for SO2 abatement technology on board maritime vessels is used to avoid maldistribution of the fluids. It is very important to prevent this in spray scrubbing systems.

Simulation is also important in verifying the pH value of the washing water, which can be discharged into the sea in open loop mode.

CFD simulations are admitted as evidence according to Annex VI to the MARPOL Convention (May 2015), and know-how on this application is necessary for the plant certification process.
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