EnviroCare

MicroMist Marine Scrubbers

Advanced Ship Scrubber Technology

Improving your bottom line

EnviroCare International

EnviroCare international, with headquarters in California, designs and manufactures pollution control systems across a wide range of maritime, industrial, and municipal applications for clients worldwide. Spanning a successful history of more than 30 years and more than 1,000 installations, each of our systems have been custom engineered and fabricated to meet the specifications of our clients and their individual requirements.

We offer advanced solutions for meeting the increasingly stringent maritime pollution control standards including, IMO, EPA, CARB and other maritime regulations. Through continuous research and development, we are expanding our product line with innovative technologies to meet current, future, and the ever-increasing pollution control regulatory climate.

EnviroCare established MictroMist Marine as a specialized division, dedicated to providing advanced technology scrubbers to help ship owners and operators lower CAPEX, while improving their ship's financial bottom line. Applying the technology and experience of EnviroCare, MicroMist Marine applies next generation, proven, innovative technologies focused upon safe, reliable operations. EnviroCare offers the potential for significant impact on improving your ship's financial performance.

The EnviroCare MicroMist Marine scrubber results show that:

- **Total sulfur emissions, including both SO_2 and sulfate particulate, on engines burning high-sulfur fuels, are easily reduced to emission levels below uncontrolled engines burning either 0.1% or 0.5% sulfur fuel.**

- **PM2.5 emissions on engines burning high-sulfur fuels can be reduced to levels below uncontrolled engines burning either 0.1% or 0.5% sulfur fuel.**

The IMO Annex VI regulations include caps on sulfur content of fuel oil as a measure to control SOx emissions and, indirectly, PM emissions. Special fuel quality provisions exist for SOx Emission Control Areas (SOx ECA or SECA). The sulfur limits and implementation dates are listed below.

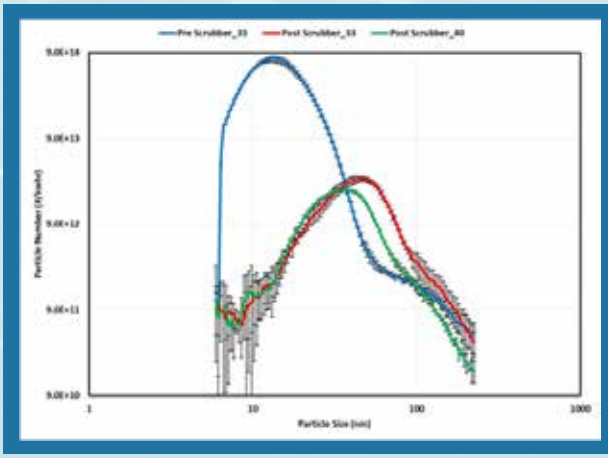
MARPOL Annex VI Fuel Sulfur Limits

Date	Sulfur Limit in Fuel (% m/m)	
	SOx ECA	Global
2000	1.5%	4.5%
2010	1.0%	
2012		3.5%
2015	0.1%	
2020		0.5%

Heavy fuel oil (HFO) is allowed provided it meets the applicable sulfur limit (there is no mandate to use distillate fuels).

The EnviroCare MicroMist Marine Scrubber contains progressive stages that treat and clean diesel exhaust gases. In the most general terms, fresh makeup water is introduced downstream, contacting the cleanest gases first. The water is then recirculated many times, working its way upstream until it comes in contact with the dirtiest gases in the quench. By the time the water is blown down (extracted), it has been allowed to cycle up in concentration with particulate and neutralized acid gases. The system has five stages: (1) Quench, (2) PM growth, (3) Venturi tubes, (4) Caustic treatment for acid gas capture and neutralization, and (5) mist elimination.

Current scrubber technologies typically provide minimal sulfate PM reduction and ~30% organic and black carbon PM reduction. The EnviroCare MicroMist Marine scrubber was found to perform substantially better. When using high sulphur diesel fuel SO_2 is often hydrolysed into very fine H_2SO_4 aerosols. These sulphates are actually created inside a typical marine wet scrubber and emitted as sulphate PM. The MicroMist Marine scrubber can absorb SO_2 efficiently and remove the created submicron sulphate PM. This provides a clean stack with no visible plume. EnviroCare nozzle and atomization technology is key component to the system efficiency and ability to capture fine particulate. The graph below shows the high concentration of submicron particulate.



Graph: MicroMist Marine Particulate Size Distribution before and after the scrubber, showing both the growth in particle size and reduction of submicron particulate

Elements of MicroMist Marine Scrubber

The MicroMist Marine Scrubber addresses the deficiencies of conventional scrubbers by dealing with their basic design flaws. The result is a patented technology that exhibits high collection efficiency on submicron particulate and condensables, with high turndown capabilities and excellent energy recovery. The scrubber can be oriented vertically or horizontally.

Separate Scrubber Effluents

The MicroMist Marine Scrubber differs from conventional designs in that it segregates the various stage effluents. In a very practical way, the system is designed with separate drains for the quencher and the MicroMist stage, allowing for greatly reduced water treatment requirements, efficient re-use of effluents, selective alkali scrubbing, and reduced toxic effluent processing.

STAGE ① Quench

To cool and saturate the engine exhaust gas, water is sprayed into the gas flow using a SpiralMist™ quench stage. In this stage, most of the coarse particulate and much of the acid gases are scrubbed from the gas stream. The water is recycled and concentrates with particulate and neutralized salts, typically between 8% and 12% (by weight).

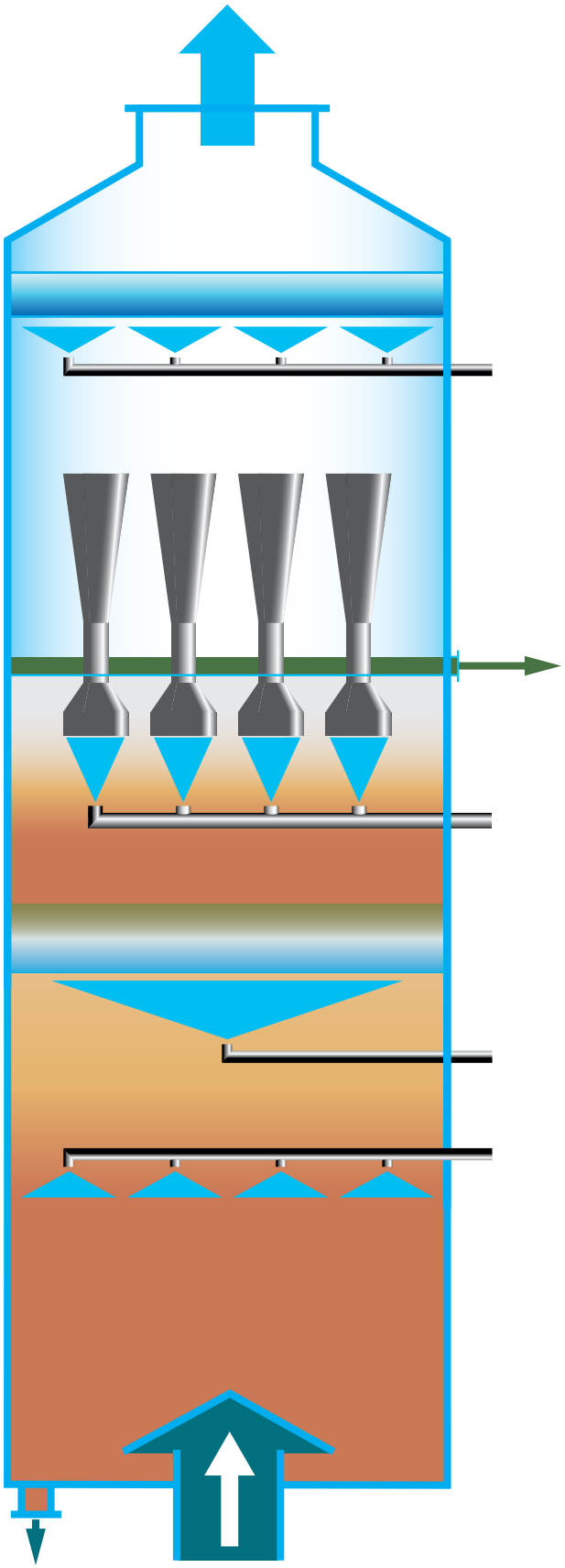
STAGE ② Particle Growth Stage

Downstream of the quench, an optional secondary quench can be installed. In this second quench, cleaner water is circulated using SpiralMist nozzles to further cool and humidify the gas flow. This process is used to assure that remaining submicron particulate are exposed to saturated gas, where particles can substantially grow in size through condensation. Larger particulates, which are mostly surrounded by water, are easier to capture downstream.

Even without a secondary quench, sufficient residence time must be provided to grow the PM through surface condensation.

The EnviroCare MicroMist Marine Scrubber

Typical General Arrangement



STAGE ④

Mist Elimination

After scrubbing, any remaining suspended water droplets are removed from the gas stream by a mist eliminator. Fresh (clean) water is continuously sprayed on the mist eliminator to catch and wash away dirty particles. Intermittently, a deluge from above is used to wash agglomerated particulate from the mist eliminator surfaces.

Acid Gas Scrubbing

Acid gases, predominantly SO_2, are captured in the scrubber water throughout the scrubber. Caustic (NaOH) is added to recirculating water with a pH feedback control mechanism to control SO_2 emissions. The reaction of caustic with SO_2 produces a stable salt (sodium sulfite), which is concentrated and stored for onshore processing and disposal. suspended water droplets are removed from the gas stream by a mist eliminator. Fresh (clean) water is continuously sprayed on the mist eliminator to catch and wash away dirty particles. Intermittently, a deluge from above is used to wash agglomerated particulate from the mist eliminator surfaces.

STAGE ③

MicroMist Venturi (MMV) Stage

Multiple parallel MicroMist Venturi (MMV) tubes are installed vertically across a diaphragm. The diaphragm forces the gas flow to accelerate through the tubes. The diffuser on the outlet side of the MMV tubes is aerodynamically designed to reduce the overall pressure drop, thereby reducing overall pressure drop.

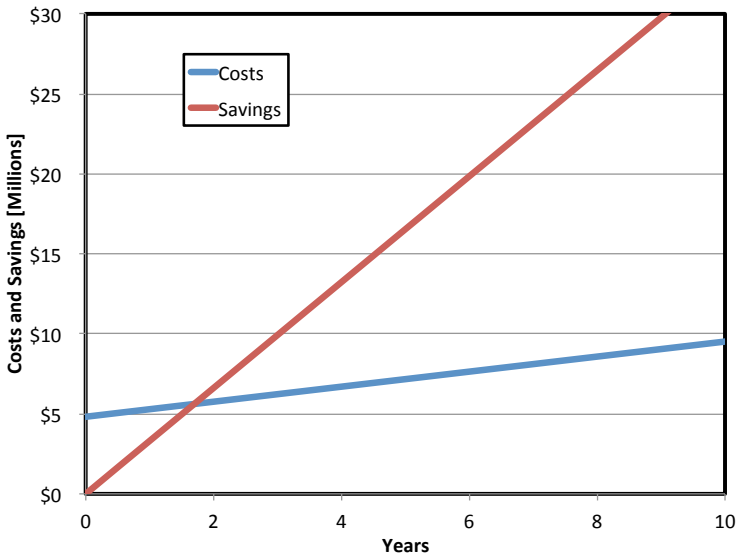
A MicroMist atomization nozzle is located at the entrance of each Venturi tube. The atomizers produce fine droplet sprays. In the MMV tube, gases interact with the particulate and droplets twice (acceleration and deceleration). This promotes fine particulate collisions with MicroMist droplets resulting in high capture efficiencies of submicron particulate.

The scrubbed gas and entrained droplets (with contaminants entrapped) enter the diverging section, where further collisions and agglomeration take place, creating larger drops which are easily removed from the gas stream and collected.

Benefits of Installing a MicroMist Marine Scrubber

There is a significant fuel cost savings after installing a MicroMist Scrubber so that the owner can use 3.5% sulfur fuel after the IMO 0.5% sulfur limit takes effect. The following cost analysis demonstrates this.

For a 12.5 MW engine burning high sulfur HFO ($280/ton) instead of 0.5% sulfur MGO ($520/ton), with a typical activity including 220 days at sea, a CapEx investment of $5M will produce roughly $3.3M in fuel savings each year. Including the O&M costs and caustic usage, the 10-year net present value of the scrubber investment exceeds $15M (with a 6% discount rate); and the IRR is nearly 60%. As shown in the figure below, the payback occurs within 20 months, with a 10-year fuel savings exceeding $30M.



Water Generation and Disposal

In order to provide a complete pollution solution, a scrubber water treatment system can be added to the MicroMist Marine Scrubber system. In the process of removing sulfur compounds, other contaminants such as particulates, soot, and unburned fuel are transferred from the exhaust gases into the scrubber water. The International Maritime Organization (IMO) regulations require Total Petroleum Hydrocarbon (TPH) concentrations <15 mg/L (ppm), normalized PAH concentrations <50 μg/L (ppb), and turbidity under 25 NTU in order to legally discharge this effluent overboard. (Turbidity is being used to quantify the PM in the scrubber water)

The water treatment system can be fully automated, combining both physical and chemical methods to reduce concentrations of the target contaminants. Coagulation and flocculation processes enable the clarifier (clarifier) to separate PM and contaminants from the water. The pH is adjusted automatically. Treated scrubber water is further processed through an automated filter for additional contaminant removal before going through monitors and overboard or into storage bins for off site treatment. PM with contaminants (Sludge) is sent to a sludge tank for later disposal.

To learn more about MicroMist Scrubber technology, contact:

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