

Spectral Sensing Tools Monitor Exhaust Emissions

How Ocean Optics and Danfoss IXA Enable Maritime Emissions Treatment



Background

At any given moment 100,000 transport ships are at sea. The movement of goods across our oceans accounts for almost 20% of conventional pollutant emissions. That number is growing rapidly as the transoceanic distribution of goods has increased by at least 4% year over year since the 1990s.

As governments and international regulators look to tackle the health risks of air pollution, offshore sources are the increasingly scrutinized elephant in the room.

Maritime shipping customers are seeking expertise and technological solutions to monitor and reduce emissions and optimize energy usage within an increasingly complex regulatory framework. Spectroscopy is one such solution.

Exhaust Emissions: Challenges

Prior spectroscopic methods for exhaust emission analysis required taking samples from the stack for remote analysis. Mass spectroscopy can be a slow technique to carry out, and may not respond as quickly as changes that occur in the exhaust emission spectral output. Even small savings in time and improvements can make enormous differences to emission controls and energy optimization. With today's modern optical spectroscopy devices, we believed we could engineer monitoring systems that functioned directly in the stack to measure the gases in situ.

Indeed, spectroscopy is well suited to emission monitoring, providing non-destructive, real-time measurements. As spectral devices have become faster, more powerful and easier to integrate into other devices, applications once considered impractical are now achievable. Bringing the spectrometer to the sample is critical for applications where real-time, in situ measurements help to analyze environmental conditions and to monitor important trends.

Maritime Emissions Analysis: Solutions

Ocean Optics partnered with Denmark-based Danfoss IXA to develop extremely robust sensor systems for the maritime environment. We customized the spectrometer assembly to withstand the high



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temperatures and vibration conditions experienced on cargo ships and in exhaust stacks (**Figure 1**).



Figure 1. An Ocean Optics spectrometer assembly has been integrated into a maritime emissions sensor for use at sea.

The Marine Emission Sensor created by Danfoss IXA leverages Ocean Optics UV absorption spectroscopy – more specifically, the differential optical absorbance spectroscopy (DOAS) technique.

With DOAS, UV light is directed into the gas and the spectrometer measures the amount of light absorbed by the gas. The sensor's computer contains a digital library with the "fingerprints" of the supported gases, allowing precise reporting of concentrations of each gas.

DOAS for Gas Analysis

DOAS is a method used to determine trace gas concentrations, by transmitting UV or visible light through an open path or fiber probe and measuring the unique absorption characteristics of each gas.

DOAS is a reliable technique for measuring gases that absorb in the UV. In addition to measuring exhaust emissions from ships, DOAS is used for environmental applications such as fenceline monitoring and volcanic gas monitoring. Fenceline monitoring involves deploying portable spectroscopic instrumentation to measure gas emissions that leak from industrial sites, creating potentially unsafe conditions. Volcanologists use DOAS to measure gases emitted from volcanoes including sulfur dioxide (SO₂), which is a major air pollutant associated with respiratory diseases and breathing problems (**Figure 2**).

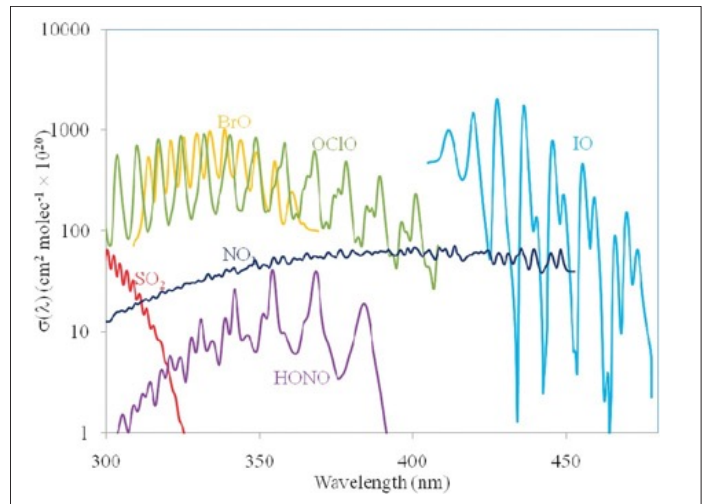


Figure 2. Differential optical absorbance spectroscopy is a common technique for measuring volcanic gas emissions.

Different applications of DOAS for ship exhaust emission monitoring may be employed. In some instances, land-based setups comparable to fenceline monitoring stations have been used for ambient air sampling at the harbor. Remote sensing from both helicopter and ship-based instruments also has been used, although these options have limitations including an inability to monitor conditions associated with ship operation at sea.

Ocean Optics-Danfoss IXA Collaboration: Results

The Danfoss Marine Emission Sensor continuously measures NO, NO₂ (NO_x), SO₂ and NH₃ directly (in situ) in the exhaust system. The sensor enables ship owners to comply with local and international emission regulations.

Beyond measurement and reporting, the Ocean Optics-Danfoss IXA collaboration is integral to automated dynamic engine control and emissions treatment systems like scrubbers and selective catalytic reduction (SCR) setups.

The Ocean Optics-Danfoss IXA solution helps to address a growing need in the maritime industry for timely and reliable data. Additional innovation awaits as industries invest in facilitating and accelerating continual improvement in efficiency, cost savings, environmental improvement and regulatory realities.