DANFOSS IXA

White Paper (#1)

Introduction to MES 1001

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Doc no. 100347-REP – Rev. A - Rev. date 2016-07-06

Abstract

Today measurement of a ship's exhaust emissions requires expensive and complicated instrumentation. Danfoss IXA has developed the groundbreaking MES 1001 emission sensor, which deals with the disadvantages of today's emission monitoring equipment. The sensor measures in situ and supports NOx, SO_2 and NH_3.

The sensor has a fast response time (<10 seconds), which makes it ideal for regulation purposes like engine control or SCR control, where traditional extractive emission instrumentation is often complex and slow responding to changes in the exhaust. Also, the sensor in a feedback loop contributes to the optimum performance of your system. In addition, the sensor lives up the to the strict MARPOL requirements, which enables it to be used to document your ship's emissions. This way you will be ready to document compliance when port state control turns up unexpectedly on your vessel.

The sensor is very easy to install, operate and maintain, which means you save money on crew training. It is important to Danfoss IXA that the sensor can operate in the harsh marine environment, and it is therefore designed to be robust and reliable, which in return saves money on maintenance, repairs and spare parts. The MES 1001 holds a marine type approval certificate from DNV-GL.

This white paper gives an introduction to the application of the Danfoss IXA's MES 1001 marine emission sensor, including functionality, advantages and how you can move on with your emission sensing project

Background

The exhaust emission from ships has become an issue on the international agenda and, in particular, the reduction of NOx and SOx is very much being debated within the industry. The reason for this is that the International Maritime Organization (IMO) has posted legislation, which will reduce the emission from commercial ships. Some of the initiatives from IMO are already effective and have been for some years, and others will be effective in the near future. The important message is, however, that the course is set: The shipping industry can expect increasingly stricter regulations on the exhaust emissions in the years to come. This must be seen together with other initiatives like local and regional regulations, which are not in the hands of the IMO.

The IMO's regulations are defined by the International Convention for the Prevention of Pollution from Ships (MARPOL). The MARPOL document contains six technical annexes where Annex VI covers air pollution from ships, including the limitations for NOx and SOx.

NOx emission limits are set for diesel engines depending on the engine maximum operating speed as shown graphically in Figure 1. Tier I and Tier II limits are global, while the Tier III standards apply only in NOx Emission Control Areas.

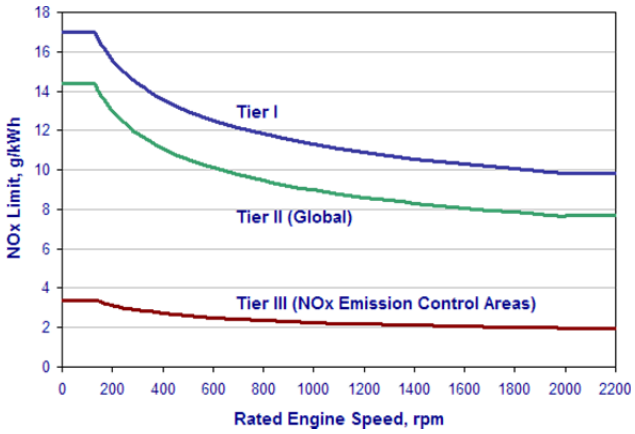

Figure 1 - MARPOL Annex VI NOx Emission Limits [www.dieselnet.com]

Tier II standards are typically met by combustion process optimization. The parameters which have been optimized by engine manufacturers include fuel injection timing, pressure, and rate (rate shaping), fuel nozzle flow area, exhaust valve timing, and cylinder compression volume.

Tier III standards require dedicated NOx emission control technologies such as various forms of water induction into the combustion process (with fuel, scavenging air, or in-cylinder), Exhaust Gas Recirculation (EGR), or Selective Catalytic Reduction (SCR).

Tier 1 came into force in 2000, Tier II in 2011, and Tier III 2016.

The SOx regulation deals with the maximum allowable sulfur content in the fuel. As shown in Figure 2 the regulation deals with two types of areas where different sets of limits apply: SOx ECAs and globally. The limits for SOx ECAs have already come fully into force whereas the last global step, which will supposedly be in 2020, is still yet to come. It is currently unknown whether the global sulfer cap is coming into force in 2020 or 2025, but the decision is expected to be taken by IMO in 2018. However, everything points in the direction that there is going to be a tighter limit on sulfur emissions on a global scale.

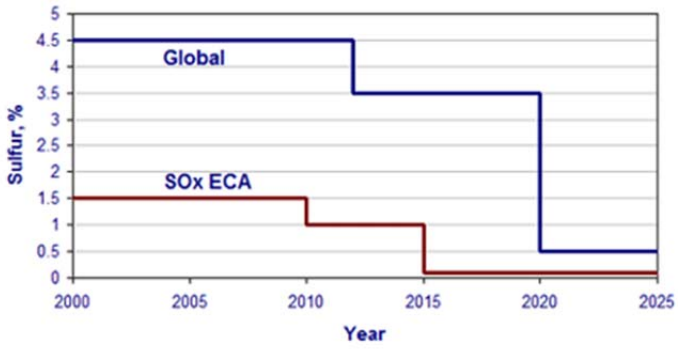

Figure 2 – MARPOL Annex VI Fuel Sulfur Limits [www.dieselnet.com]

Basically, there are only two ways to comply with the sulfur regulations: Sailing on Low-Sulfur Fuel or to have a scrubber system on board. Today the vast majority of ships perform fuel switching when going in or out of a SOx ECA, as scrubber systems are not very common technology on board. On a global scale, there are approximately 300 scrubbers installed or on order, and the interest in these systems seems to be increasing within the industry.

Existing Emission Control Areas include:

- Baltic Sea (SOx)
- North Sea (SOx)
- North American ECA, including most of US and Canadian coast (NOx & SOx)
- US Caribbean ECA, including Puerto Rico and the US Virgin Islands (NOx & SOx)

In addition to the IMO initiatives, local and regional initiatives are seen and more are expected. Currently we see China introducing its own set of rules on SOx emissions, and Hong Kong and Singapore have introduced a similar scheme. The picture is becoming increasingly blurred with respect to limits, enforcement and geographical coverages, as these initiatives may not be coordinated internationally. Future ECA discussions will cover Japan, Australia, the Mediterranean and Norway, which again emphasizes in which direction the trend is going [www.amnautical.com].

Danfoss IXA is proud to offer the MES 1001 marine emission sensor, which is capable of measuring environmentally harmful gasses and thereby enabling the ship to be in control of its emissions. The sensor stands out by being easy to install, easy to maintain, and easy to operate. Another great feature is that it measures in situ, which means that the response time is low making it suitable for various regulation purposes. The MES 1001 is compliant with the IACS E10 standard and is type-approved as well as MARPOL-recognized.

Sensor Overview and Technology

The new MES 1001 is designed for the maritime environment and offers an accurate and realtime measurement of the ship's emissions. Please refer to the overview below:

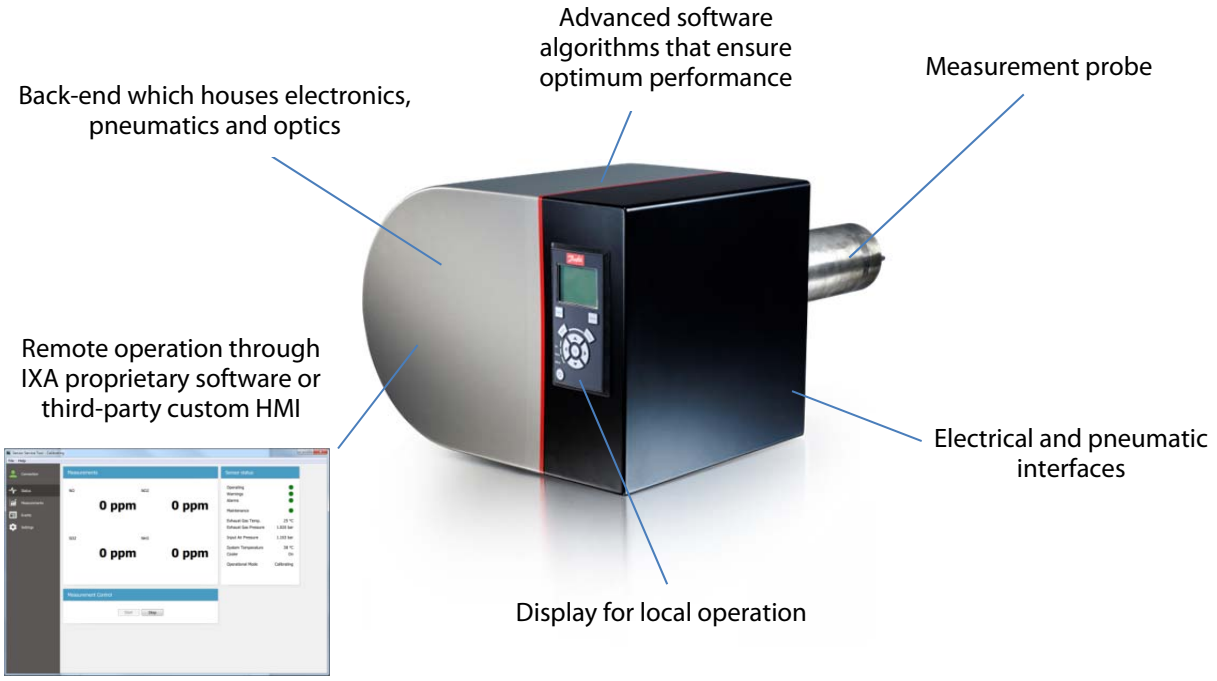

Figure 3 – Sensor Overview

The sensor works based on the principle of DOAS (Differential Optical Absorption Spectroscopy). When mounted on the exhaust stack, the exhaust will pass through the probe. An ultraviolet light source emits light into the probe where it is reflected and collected by a detector, which converts it into an electrical signal. The signal (spectrum) is then sampled and delivered to the computer inside the sensor.

The computer receives data from the detector, and through an advanced algorithm combined with proprietary gas reference library, the gaseous concentrations are calculated and delivered to the user (see Figure 4). The computer compensates for the exhaust gas pressure and the exhaust gas temperature provides a more accurate measurement.

The marine emission sensor is automatically calibrated at specific intervals to compensate for various potential sources of error. This is achieved by applying compressed air into the probe. This way the exhaust gas in the measurement path is evacuated and only clean compressed air will be present. The computer calculates a new reference and compressed air is removed bringing the marine emission sensor back to normal operation.

The computer also controls the interfaces for external communication with the marine emission sensor. Interfaces like CAN, Ethernet, Analog Out, RS-422, and discrete inputs/outputs are available and can be set up individually. The marine emission sensor can be operated locally through a display, but the user may also use a software-based service interface for remote access.

A Purge Air System ensures that the optics is not contaminated with soot and other particles during operation. The same system also provides compressed air for the calibration process.

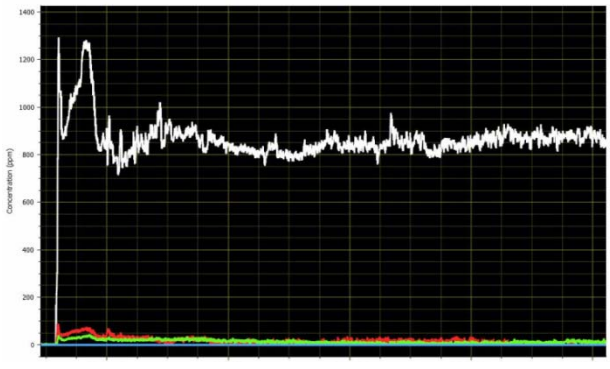

Figure 4 – Example of Measurement of NO (white), NO_2 (red) and SO_2 (green) over a 2-hour Period

Application

The sensor is very suitable for a number of applications. These include:

- Continuous Emission Monitoring (CEMS)
- Engine control
- Fuel switching monitoring
- SCR control including ammonia monitoring
- Big Data

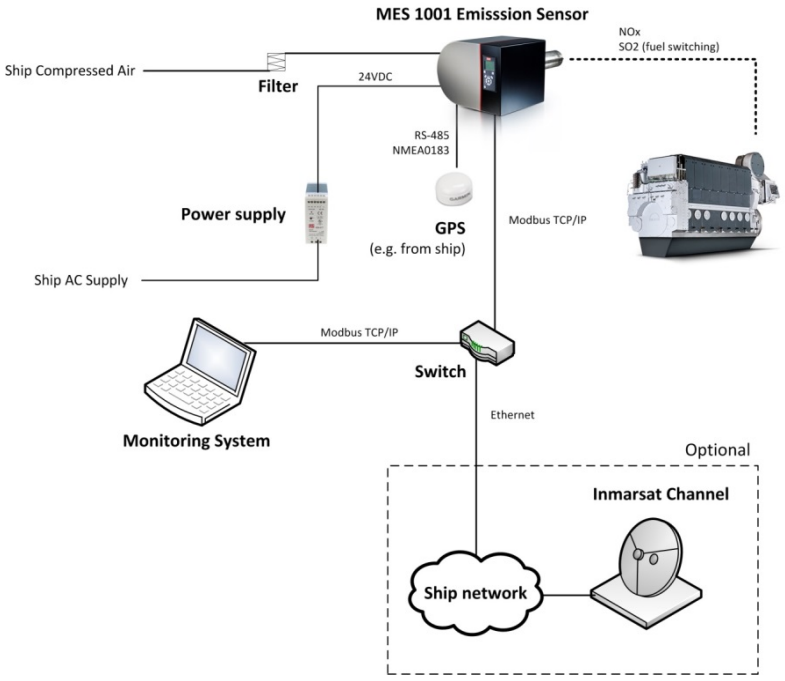

Figure 5 – Example of CEMS, Engine Control or Fuel Switching applications

The sensor is particularly suitable for CEMS as it delivers accurate realtime measurements of NOx and SOx. This will enable the ship to prove compliance in case the port state control requests this information. The data is stored in the sensor for future reference and in cases where the ship GPS is connected to the sensor, all measurement data is tagged with information about the position.

In applications with an advanced engine control, the sensor can with great advantage be used to feed back the NOx information to the engine control computer. This way the NOx signal can be combined with additional sensor information and thereby used to optimize engine parameters in a way that optimizes fuel consumption and emissions at the same time.

Sailing on routes where you go in and out of low sulfur emission zones requires that you are in complete control of your fuel switching process. The MES 1001 is capable of documenting the process so that questions raised on compliance can be fully addressed by means of accurate measurements and GPS positions.

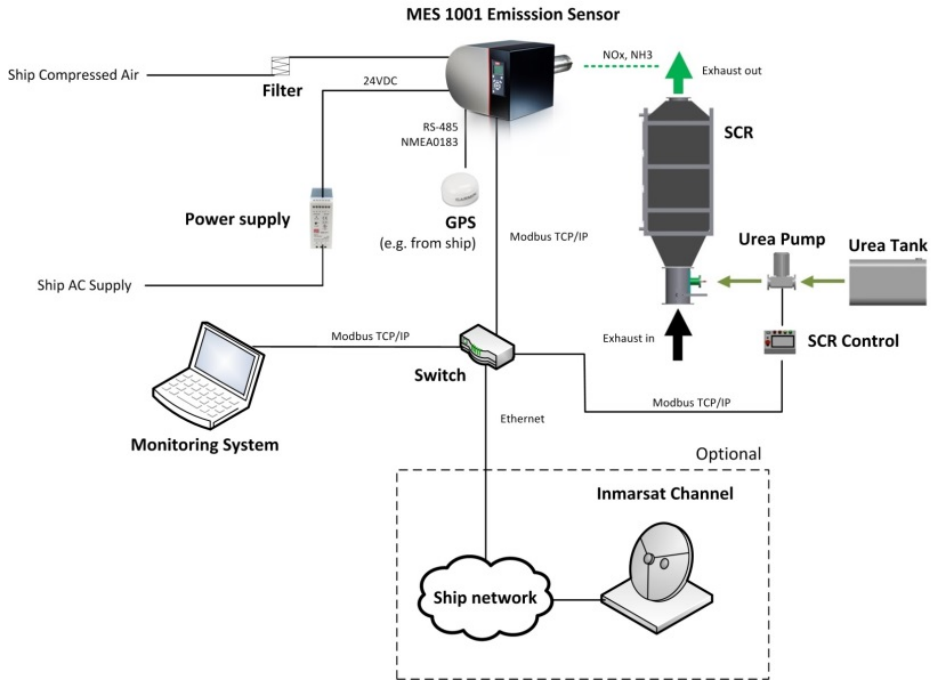

Figure 6 – Example of SCR Application

More and more engine manufacturers and ship owners are looking towards the SCR as a mean to reduce the NOx emissions. The traditional approach to controlling the SCR is by means of the engine load signal, where the amount of urea injected into the SCR is controlled as a function of the load. A novel approach is to install the MES 1001 after the SCR and feed back the NOx signal to the urea dosing controller. This way you can control the dosing of urea more accurately and obtain a better transient performance as the regulation is based on the exhaust out of the SCR. In addition, the sensor can measure an ammonia slip and thereby issue a warning, which will prevent damage to equipment further down the stack.

In case the ship holds a ship performance data system, it is particularly beneficial to connect the sensor's emission data to this system. This way the NOx measurement can be processed together with other valuable sensor information thus giving a more complete picture of the ship's performance, including an online presentation of how the engine is performing compared with the ideal Tier II or Tier III curves. Since data is stored by the ship performance system, it is possible to retrieve emission information from certain positions if port state control asks for proof of compliance. Over the past years, we have seen examples of significant fines and /or detainment of the ship in cases of non-compliance. Such incidents are extremely costly and create bad publicity.

Interfaces

Easy connection to the infrastructure around the sensor has been a key design parameter. The sensor connects to the stack through a circular flange with 8 bolts.

The sensor operates from 24 VDC and requires compressed air.

The MES 1001 offers a variety of physical interfaces, which enables the sensor to connect to the most common equipment in the industry. The sensor has analog out (4-20mA), CAN and Modbus TCP/IP for emission data. Two sets of discrete inputs and outputs are available for discrete commanding and sensor status. Finally, the sensor also offers an RS-485 serial interface for GPS data. The configuration of these interfaces can be set up individually by software.

Figure 7 – The Sensor in Operation

The sensor also connects to compressed air. The air plays a vital role in the calibration of the sensor as well as protecting the delicate sensor parts from being contaminated when operating in a harsh environment like an exhaust stack.

How to Move on with Your Project

At Danfoss IXA, *your trusted partner within emission instrumentation*, we are standing by to assist you on your next emission instrumentation application. We are ready to answer any questions you may have and to advise you on the selection of your next emission sensor. Please contact our professional sales and project team for further inquiries – we are pleased to conduct a meeting either at our headquarters or at your facility. You may also visit our website at www.danfoss-ixa.com.

Feel free to contact us now for a meeting, phone +45 7488 8500 or E-mail on ixa @danfoss.com.

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LEADING THE WAY
IN MARINE EMISSION GAS MEASUREMENT

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Doc no. 100347-REP – Rev. A - Rev. date 2016-07-06