Study EMIGREEN - DPF and SCR technology for maritime applications

Green Deal Validation

NETHERLANDS MARITIME TECHNOLOGY | iRO | TNO innovation for life | MARIN | Koninklijke Vereniging van Nederlandse Reders | Ministerie van Infrastructuur en Waterstaat | Ministerie van Economische Zaken en Klimaat

TNO has investigated the Emigreen Diesel Particulate Filter (DPF) and OEM SCR catalyst systems in the context of the Green Deal validation program.

The validation include the following elements:
- Environmental impact;
- Practical application and scalability;
- Economic aspects;
- Future proofness.

The investigations, which included emissions measurements on two dredger vessels with an ULEv notation, lead to the conclusions below.

Environmental impact

The measured DPF systems significantly reduce particle number (PN) and particle mass (PM) emissions from the exhaust stack. All measured systems reduced particulate emissions to levels well below the limit values for Stage V inland vessel engines applicable to the voluntary ULEv label. Filtered particulate matter emissions are kept stable across the entire engine load range. With an active regeneration strategy and regular in-situ and external cleaning of the DPF elements, no deterioration of the system performance is observed over a period of approximately 4 years.

The measured SCR systems on-board one of the measured vessels was capable to reduce NO_x emissions from the tailpipe to levels below the limit value for Stage V inland vessel engines applicable to the voluntary ULEv label and the limit values for Tier III marine engines. The SCR systems on-board this vessel were recently replaced according to the maintenance schedule. Although NOx emissions were reduced, NH_3 slip was measured partially offsetting the reduced NO_x emissions based on its acidification potential. Measurements on-board the second vessel showed highly dynamic NOx emission levels exceeding the limit value for Stage V inland vessel engines applicable to the voluntary ULEv label and significant NH_3 slip. SCR elements on-board this vessel were not replaced since commissioning of the vessel in 2019. After replacement of the SCR elements and calibration of the control strategy, emissions from this vessel also were at levels below the limit value for Stage V inland vessel engines applicable to the voluntary ULEv label and the limit values for Tier III marine engines. Measurements during this validation show the importance of timely maintenance and monitoring of emissions to ensure the continuous proper operation of SCR systems. Possible over injection of urea fluid should be avoided to prevent NH_3 slip from the catalyst. Additional monitoring on this pollutant could be necessary to safeguard this.

Practical application and scalability

Both DPF and SCR exhaust gas aftertreatment systems can be installed on all Dutch reference ships. As described above, especially the SCR system requires monitoring and regular maintenance to ensure continuous operation while the DPF system relies on automated regeneration and periodic cleaning events.

Note that SCR systems will not work at low exhaust gas temperatures, they therefore are only operational when the engine is under load. Both exhaust gas aftertreatment systems have proven to be capable in reducing particulate and NOx pollutant emissions to levels well below the acting limit values for marine vessels. This makes them a good option with respect to future regulatory updates.

Economic impact

Investment and operational costs of both aftertreatment systems are substantial. The investment costs for a combined SCR and DPF system on a new build vessel are expected to be around €112 to €131 per kW installed engine power. National policies and public contract requirements currently play a significant role in encouraging the use SCR systems, and to a much lesser extend the use of DPF systems. The MKI (Milieu-Kosten-Indicator) can serve as a financial incentive to reward lower emissions with higher contract prices for dredgers, especially for sensitive projects such as those near Natura 2000 sites. The results show that the discount of MKI may outweigh the investment and operational costs. However, the benefits are almost exclusively associated to NOx reduction, and are only relevant for certain government contracts.

Future proofness

Aftertreatment systems will remain important in the future. IMO MARPOL legislation for NO_x emissions will likely become more stringent in the future with respect to low load and real life emissions performance. This is due to the limited effectiveness of the current Tier III legislation. Use of a DPF system is less relevant under the current legislative framework. The importance of aftertreatment systems will remain with the transition to sustainable fuels, especially for the SCR NO_x reduction part. The Diesel Particulate Filter becomes less important, since the PM emissions are substantially lower with sustainable fuels like methane, methanol and ammonia. Also for biodiesel PM emissions generally lower. Methanol and methane (LNG) have lower NO_x emissions, but generally not enough to meet the Tier III legislation without aftertreatment.


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