# Green Deal Validatieregeling

*Validation programme*

## Selective Catlytic Reduction (SCR) aftertreatment system

NETHERLANDS MARITIME TECHNOLOGY

TNO innovation for life

Ministerie van Economische Zaken en Klimaat

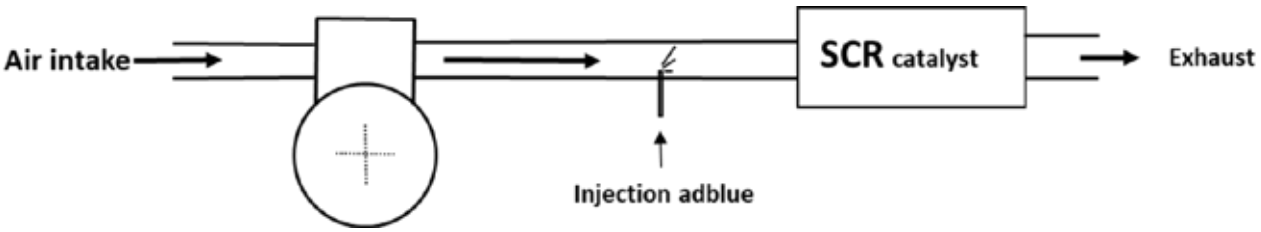
KONINKLIJKE VERENIGING VAN NEDERLANDSE REDERS

MARIN

Ministerie van Infrastructuur en Waterstaat

## Description

An SCR system is an emission control, aftertreatment, technology used to reduce $NO_X$ emissions during operation.




SCR aftertreatment is one of the most effective methods to reduce the level of $NO_X$ emissions. It is currently the mostly used $NO_X$ reduction option for diesel engines to achieve Tier III emissions. It is also suitable for other engines and fuel types such as LNG, methanol and ammonia engines to meet Tier III emission level.

$NO_X$ reduction is accomplished by adding urea to the exhaust gas and the emitted $NO_X$ (NO, $NO_2$) reacts with the ammonia from the urea and is reduced to its harmless counterpart: Nitrogen gas. To prevent ammonia emissions in the atmosphere, usually an ammonia slip catalyst is included in the SCR system which oxidizes the remaining ammonia.

The $NO_X$ reduction of an SCR system can deteriorate after time due to several reasons. This can be adsorption of sulphate or heavy hydrocarbons. This can be removed by temporarily heating up the catalyst, thereby restoring the catalyst efficiency. Secondly metal or inorganic additives or impurities in engine lubricant or fuel can also lead to deterioration which cannot be restored. The replacement of the catalyst may become necessary.

## Market readiness & availability

From both a technical and commercial point of view, this technology is mature (TRL 9) and already produced for many years. Additionally, the urea distribution infrastructure is already present and combined with normal bunker supply.

SCR systems for marine applications are readily available as suppliers are widely found on both the Dutch and the international maritime market.

## Applicability on reference ships

An SCR aftertreatment system can be implemented on all types of ships and marine engines, and in combination with any marine fuel oil.

| General cargo | Tug boat | Offshore supply | Crew tender catamaran | Dredger vessel | Super yacht |
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An SCR system can be integrated in the stack and funnel design, or located as a box in the engine room. Typical installations include a urea tank, a dosing unit, a catalyst, a control system and a mixing unit. Generally, the latter has a diameter of 50 cm and 2 to 6 meter in length, depending on the required engine power. Moreover, the dimensions of the SCR reactor are typically 1.5 to 3 $dm^3$ per kW engine power. Finally, an urea tank is needed. Typical volume: 5-8% of diesel volume for an ECA zone.

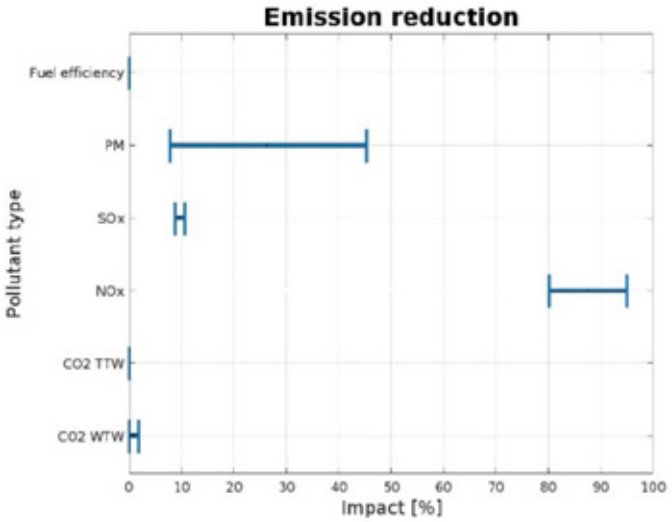
SCR can be combined with other emission control technologies, particularly:

- SCR + Scrubber: for ships that use high Sulphur fuel oil.
- SCR + diesel particulate filter: mostly used for port vessels or inland vessels, but also for example dredging vessels.

## Emission reduction effectiveness

In some cases, fuel consumption and GHG emissions can be reduced up to 10% by optimizing the engine for higher $NO_X$. The higher engine out $NO_X$ is reduced by the SCR catalyst to the required level (usually Tier III). This leads to a higher urea consumption, which lessens the advantages of the reduced fuel consumption to some extent.

In addition to $NO_X$, the SCR catalyst usually also reduces PM and HC emission due to the oxidative working of the SCR catalyst.




*GHG & pollutant reductions when using a SCR aftertreatment installation.*

## Operation and safety

Operation and training is not complex and can easily be added to engine room operation and maintenance training. No specific adverse safety or health aspects are associated with SCR systems.

The requirements of SCR systems are well described within IMO MARPOL Annex VI. Moreover, the design, compatibility, installation and monitoring requirements are described in guidelines for Application of Selective Catalytic Reduction (SCR) System Onboard Ships (2022) by CCS.

## Costs

SCR system and operating costs are well known.
Indicative values are:

- Investment costs:
  - €72 per KW installed engine power.
- Urea and maintenance costs: €3.5 per MWh engine output work (€18 per ton fuel consumed).

## Development prospect

SCR is one of the most well proven and widely applied technologies. In 2013, over 500 ships were already equipped with an SCR system. Over the last decade, the conventional SCR has been updated and integrated with other well established after treatment systems, such as scrubbers and diesel particulate filters, as complementary tools to reduce harmful emitters even further.

SCR systems are often not very effective at low engine load (below 25% load). This is also due to sulphate or HC poisoning. This can most likely be improved but also requires improved legislation. SCR is also a very suitable technology for $NO_X$ reduction for engines using other fuels such as methanol, LNG and Ammonia. $NO_X$ reduction potential of SCR can be increased to over 90% depending on test cycle and extend of integration with engine technology and fuel quality.