Selective Catalytic Reduction Systems

OCTOBER 2013
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CHANGES – CURRENT

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This is a new document.
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1 General

1.1 Scope
The DNV Type Approval scheme is a procedure for approval of design of a product type to be in conformity with a set of predetermined requirements. Reference is made to DNV Standard for Certification 1.2 “Type Approval”.

This Type Approval Program gives the requirements on which Det Norske Veritas bases its Type Approval of Selective Catalytic Reduction (SCR) systems complying with DNV Rules for ships and if applicable, Resolution MEPC.198(62) (hereinafter referred to as “MEPC.198(62)”) and the Revised MARPOL Annex VI (hereinafter referred to as “MARPOL Annex VI”), Regulation 13 and the NO\textsubscript{X} Technical code 2008 (hereinafter referred to as “NTC 2008”).

If the SCR system for the reduction of NO\textsubscript{X} is considered necessary to comply with MARPOL Annex VI Regulation 13, then the installed SCR system is considered as a mandatory installation. In this case shall the SCR system be considered as a part of the engine and “Engine system fitted with SCR system” certified according to the NTC 2008 and MEPC.198(62).

Where DNV is authorised to issue the IAPP certificate (under MARPOL Annex VI), the environmental performance of the system in accordance with MARPOL Annex VI Regulation 13 / NTC 2008 is considered to fall within the scope of the classification society and documents and manuals specified in MARPOL Annex VI Regulation 13 / NTC 2008 are subject to approval.

The procedure for assessment of conformity of manufactured products (production) and the installation on-board is not within the scope of the Type Approval Program. However, if during the Type Approval process, it is discovered that certain issues may affect on-board performance and satisfactory operation within limits and requirements given in this Program, then all these issues shall be clarified by the Manufacturer before the issuance of Type Approval Certificate.

In general the conditions outlined in this Program shall be fulfilled before the Type Approval Certificate is issued. The TA Applicant is committed to involve DNV in corrective actions whenever on-board confirmation test fails for SCR systems certified by DNV. Failing to involve DNV, or to carry out proper corrective actions, may result in withdrawal of the type approval as well as restrictions of future approvals and or certification.

1.2 Objective
The Type Approval of SCR systems are based upon the requirements in the following documents:

— DNV’s “Rules for Classification of ships”, Pt.4 Ch.1, Pt.4 Ch.6, Pt.4 Ch.8 and Pt.4 Ch.9
— Revised MARPOL Annex VI, Regulation 13/NO\textsubscript{X} Technical code 2008

This Type Approval Program is considered to be applicable for use of SCR installations intended for the Scheme B of the MEPC.198(62).

However, installations intended for Scheme A do not have to comply with the Scheme B emission specific requirements. The combined engine and SCR system shall then be documented and tested according to test bed measurement procedures of NTC 2008 Chapter 5.

2 Conformity assessment of design of product type

2.1 Procedure
The Type Approval procedure consists of the following elements:

— Application for Type Approval of the product
— Design Assessment
— Type Testing
— Initial Type Approval Assessment
— Issuance of Type Approval Certificate
— Periodical Assessment of Type Approval.

2.2 Documents to be submitted
Drawings and data showing all design details and materials are to be submitted together with application for Type Approval well in advance before the testing at the Manufacturer.

The product and system shall be declared free of asbestos (through ticking of the box in the Type Approval application form).
The following documentation is to be submitted to the local DNV office, either using a common electronic format (e.g. Adobe Acrobat(.pdf) or MS Word (.doc/.docx)) and protocol (Email or CD) or hard copies in paper. These documents will be evaluated in accordance with this document and other applicable rules.

2.2.1 Documentation of EIAPP

— Documentation for reason to apply for Scheme B approval, ref. MEPC.198(62) 3.1.1.
— Functional description.
— Arrangement and layout.
— Technical File, according to 3.2.1 of MEPC.198(62).
— Description of the required on-board NO\(_x\) verification procedure.
— Description of the required confirmation test procedure.
— Documentation of measures to minimize reduction agent slip.
— Documentation of calculation models for verification if scaling.
— Drawings of all NO\(_x\) relevant components.
— Type Test program and Schedule.
— Type Test report.

2.2.2 Documentation of Control, Monitoring and Safety system, ref. Pt.4 Ch.9

— Functional description (system requirement specification).
— System block diagrams.
— User interface documentation.
— Power supply arrangement.
— List of control and monitored points.
— Circuit diagrams.
— Test program for testing at the manufacturer.
— Data sheets with environmental specifications.
— Type Test report.

2.3 Design Requirements

The SCR system shall fulfil the following requirements.

— The system shall be fail to safe. This means that in case of failure of the system, the operation of the engine shall not be influenced in a way that can endanger the safe operation of the vessel.
— In case of single engine propulsion plants or single auxiliary engine plants, by-pass arrangement for the exhaust gas is required.
— The system shall be designed so that it minimizes the reduction agent slip.
— The equipment shall be fit for purpose in a machinery space.
— The system must be in compliance with SOLAS, e.g. surface temperatures, screening of pipe connections
— Depending of the principle of the SCR system, the design shall fulfil the relevant Appendix of this Program, (eg. App.A for systems using urea as reduction agent).

2.4 Product Marking

The product is to be provided with visible marking giving at least the following information:

— identification of manufacturer
— technical data necessary for the application
— type designation under which the product is Type Approved
— serial number.

The marking is to be carried out in such a way that it is visible, legible and indelible throughout the anticipated life of the product and that the marks can be traced back to the Type Approval Certificate.

The components that influence the NO\(_x\) emission shall be marked for identification as described to section 2.4 of the NTC 2008.

2.5 Installation Requirements and Testing

— According to MEPC.198(62).
— On-board confirmation test after installation, before issuing the IAPP Certificate for the ship.
— Depending of the principle of the SCR system, the design shall fulfil the relevant Appendix of this Program, (eg. App.A for systems using urea as reduction agent).

2.6 Elements of Type Approval

2.6.1 Application of Type Approval

The initial stage includes filling in a formal DNV application (DNV Form 90.01a) requesting Type Approval
of the product(s). The application form shall be forwarded to the local DNV station together with product documentation and proposed test programs.

2.6.2 Design Assessment
The Design Assessment is carried out to assess the requested documentation (stated in item [2.2]) and verifying that the design of the product is in conformity with given requirements (stated in item [2.3]).

2.6.3 Type Testing
The main objective of the Type Testing is to verify properties which cannot be verified by analysis and calculations with reasonable reliability. When the Design Assessment has been completed by DNV, including approval of all test procedures, the Type Testing may commence. This includes the following:

— visual inspection
— functional and performance Type Testing, including emission measurements as relevant for the system in question.

Visual inspection
The product is to be visually inspected for good workmanship, conformity with the manufacturer’s drawings and specifications.

Performance Type Testing
Tests shall be carried out to verify that the performance of the SCR system conforms to the applicable requirements.

— In case MEPC.198(62) chapter 6 applies, the performance tests specified in the MEPC.198(62) shall be the base for performance Type Testing of the SCR system.
— In case MEPC.198(62) does not apply, the performance tests shall be specified by the Manufacturer.

It is the manufacturer’s responsibility to make sure that the Type Testing is performed in accordance with approved test procedures.

The Type Testing is to be done in the presence of a DNV surveyor.

The SCR system will be Type Approved to be able to reduce NO\textsubscript{x} emission with a reduction ratio. The Type Test shall demonstrate that the reduction ratio is equal or higher than predicted according to scaling procedures used at the manufacturer. This means that prior to the Type Test, the predicted values shall be presented to DNV including details of the test such as:

— Type Test schedule and test bed set up
— preliminary generic Technical File
— exhaust composition, mass flow and temperature
— SCR chamber details such as catalyst block design and number of catalyst blocks used
— reduction agent injection rate/supply volume/flow.

The Type Test shall be carried out with exhaust gas, catalyst, reduction agent and injection system satisfying the following conditions:

1) Exhaust gas flow
   Exhaust gas flow rate for the test should be scaled accordingly to account for the dimension of the catalyst model.

2) Exhaust gas component
   Exhaust gas for the test should either be diesel engine exhaust gas or simulated gas.

3) Where diesel exhaust gas is used, the concentration for each emission species in terms of NO\textsubscript{x}, O\textsubscript{2}, CO\textsubscript{2}, H\textsubscript{2}O, and SO\textsubscript{2} to be within ±5% of the values that the SCR system shall be Type Approved for.

4) Where simulated gas is used, the concentration for each emission species in terms of NO, NO\textsubscript{2}, O\textsubscript{2}, CO\textsubscript{2}, H\textsubscript{2}O, and SO\textsubscript{2} to be within ±5% of the values that the SCR system shall be Type Approved for (balance N\textsubscript{2}).

5) Exhaust gas temperature
   The temperature of exhaust gas used for the test to be maximum 50°C above the minimum temperatures as stated in the Technical File for every load point, ensuring that the SCR chamber is activated, and that no ammonia bisulphate formation, or destruction of reduction agent, takes place.

6) Catalyst blocks, area velocity (AV), space velocity (SV) value
   The catalyst blocks used in the test should be representative of the catalyst blocks to be used in the SCR chamber in service. AV, SV or LV (linear velocity) value should, in the case of full scale tests, be within a
range of ±20% of the values that the SCR system shall be Type Approved for. In the case of scaled tests, values should be adjusted to correspond to the above. (for definitions of AV, SV and LV, please refer to MEPC.198(62), chapter 2.3)

7) Reduction agent

The reduction agent concentration should be representative of the reduction agent concentration injected into the exhaust gas during actual operation.

Final approval will only be given after verification of a full scale system, either on test bed or after successful on-board confirmation test following test of a downscaled SCR chamber as described in chapter 6.3 of MEPC.198(62).

However, modules of the Type Approved system may be added together to increase the total reduction ratio. Such increased capacity does not require re-approval as long as each module consists of the same components and has the same reduction ratio as the system, which was initially granted a Type Approval.

2.6.3.1 Test cell measurement equipment

Requirement of measurement equipment shall follow MEPC.198(62) and the NTC 2008 as found relevant.

2.6.4 Initial Type Approval Assessment

An initial TA Assessment may have to be carried out to confirm that the manufacturer has a production line and quality control for consistent production of the applicable product(s) for which TA is requested.

2.6.5 Type Approval Certificate

When the Design Assessment and Type Testing are successfully completed a Type Approval Certificate will be issued to the TA Applicant for the conformity of the design of the product type.

The Certificate is given a validity period of normally 4 years.

2.6.6 Periodical Assessment of Type Approval

The scope of the Periodical Assessment of TA is to verify that the conditions stipulated for the Type Approval is complied with and that no alterations are made to the product design or choice of materials. Periodical Assessment of TA will have to be carried out every second year.

The main elements of the Periodical Assessment of TA are:

— Review of Type Approval documentation.
— Review of possible changes in design, materials and performance.
— Ensure traceability between manufacturer's product type marking and Type Approval Certificate.

2.6.7 Renewal of Type Approval Certificate

At least three months before the period of validity expires, the TA applicant has to apply for renewal of the certificate.

Upon receipt of the request for renewal, DNV will perform a Periodical Assessment which has the same content as the Periodical Assessment of TA as stated in item [2.6.6].

The survey report will constitute the basis for renewal of the Type Approval and the issuance of a new certificate.

2.6.8 Design Changes

TA applicant shall inform DNV about any design changes that may have an influence on the performance data specified in the Type Approval Certificate. Additional performance tests shall be carried out if considered necessary.

3 Makers Certificate

The manufacturer shall furnish each unit with a certificate. The certificate shall contain:

— declaration that the design of the unit conforms to the basis for the Type Approval
— details of shop testing carried out (if applicable)
— reference to DNV Type Approval Certificate.
Appendix A
Requirements for urea SCR System

A.1 General
The scope of this appendix is to give design requirements to SCR systems based on urea as a reduction agent. Urea for use in SCR systems is not categorised according to the IBC code. By following the requirements given in this appendix, urea is allowed to be used in engine room.
The content of this appendix is as follows:

[A.1] General
[A.2] Document requirements
[A.3] Design requirements
[A.4] Certification requirements
[A.5] Arrangement requirements for information, not scope for Type Approval

A.2 Document requirements
The following diagrams need to be submitted for approval:

— System diagram (P&ID) Arrangement of exhaust gas system including SCR system.
— System diagram (P&ID) Arrangement of urea.
— System diagram (P&ID) Arrangement of systems for prevention of overheating of SCR components.
— System diagram (P&ID) Arrangement of systems for supporting media. (eg. injection air/air flow).
— System diagram (P&ID) Arrangement for catalyst cleaning system if applicable. (eg. soot blowing).

The plans shall be diagrammatic, and shall include the following particulars:

— outside diameters and wall thicknesses of pipes
— materials used in pipes, valve bodies and fittings
— pump type and capacity
— type of valves and fittings
— type of expansion elements
— maximum working pressure, if exceeding 7 bar, and temperature if exceeding 60°C
— hydrostatic test pressure after installation on-board, where required according to Pt.4 Ch.6.

For plastic pipes shown in system drawings the following information shall be given:

— fire endurance class
— conductive or non-conductive grade
— maximum working pressure and temperature.

A.3 Design requirements

A.3.1 Materials
The materials used in the SCR system exposed to exhaust shall be made of materials with a melting point above 925°C.
The exhaust piping shall be of stainless steel from the point where urea is injected into the exhaust gas and until it is fully vaporized.
Plastic pipes may be used where after special approval.

A.3.2 Piping system design
Urea supply system shall be separate from other piping systems on-board.
The SCR system shall be supplied by pumps of sufficient capacity for supplying the system at maximum load without interfering with any essential service on the ship.
Filters or strainers in systems serving the SCR system shall be arranged so that it is possible to clean the filters without interrupting the operation of system. Automatic filters shall be arranged with by-pass.
Interfaces to other ship systems shall be arranged to prevent the backflow of fluids or exhaust gas into such systems.
Where the design of the SCR system is considered to require additional means for cleaning (e.g. due to soot build up), such arrangements are subject to approval. The system shall be automatically operated.
Systems for cleaning of soot build up shall be provided where engines will be operated on heavy fuel oil.
By-pass valves and other valves arranged for remote or automatic operation shall be provided with position indication (both local and remote).
A.3.3 Control and monitoring systems

The control and monitoring system shall comply with the requirements of Pt.4 Ch.9. The control and monitoring system of a SCR system is considered to be an important control and monitoring system in the context of Pt.4 Ch.9.

An important control and monitoring system (hereafter called important system) is a system supporting services which need not necessarily be in continuous operation for maintaining the vessel's manoeuvrability, but which are necessary for maintaining the vessel's functions as defined in Pt.1 Ch.1 Sec.1 A200 of the Rules for Classification of Ships, or other relevant parts of the rules.

Exhaust gas cleaning units shall be monitored as listed below. Indicators and alarms shall be provided at the control station for the SCR system:

<table>
<thead>
<tr>
<th>Table A-1 Control and monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System</strong></td>
</tr>
<tr>
<td>Urea supply system</td>
</tr>
<tr>
<td>Supply pressure</td>
</tr>
<tr>
<td>Treatment fluid tank level 1)</td>
</tr>
<tr>
<td>Exhaust gas system</td>
</tr>
<tr>
<td>Pressure drop across SCR unit 2)</td>
</tr>
<tr>
<td>Temperature after unit 3)</td>
</tr>
<tr>
<td>Exhaust gas fans 4)</td>
</tr>
<tr>
<td>NOx emission value 5)</td>
</tr>
<tr>
<td>Ammonia slip 6)</td>
</tr>
<tr>
<td><strong>Power failure</strong></td>
</tr>
<tr>
<td>Control and Monitoring system</td>
</tr>
<tr>
<td>Safety system</td>
</tr>
<tr>
<td>Remote control system</td>
</tr>
</tbody>
</table>

1) Indicates intermediate tanks if installed. Applicable if supplied by SCR maker.
2) Alarm shall be activated before the backpressure exceeds the maximum allowable for the SCR system.
3) Indication of soot fire.
4) If fans are installed. Indication of operational status.
5) If compliance shall be demonstrated with direct measurement and monitoring method, ref. chapter 6.4 of NTC 2008.
6) Ref MEPC.198(62) - 3.3.1 Measures to prevent ammonia slip should be provided.

The SCR system shall be arranged for emergency stop from the control station of the SCR system. The emergency stop shall stop the supply of urea.

A.3.4 Electrical power supply

The electrical installation of SCR systems shall comply with the requirements of Pt.4 Ch.8.

A.4 Certification requirements

The following SCR system components are subject to certification:

<table>
<thead>
<tr>
<th>Table A-2 Certification requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component</strong></td>
</tr>
<tr>
<td>Urea transfer pumps 1)</td>
</tr>
<tr>
<td>Control and monitoring systems</td>
</tr>
<tr>
<td>Pipes and valves</td>
</tr>
<tr>
<td>Cables</td>
</tr>
<tr>
<td>Electro motors 3)</td>
</tr>
</tbody>
</table>

1) Not applicable for small system feeding pumps with capacity below 1 m³/h
2) Unless exception is given in DNV Type Approval Certificate when Control and monitoring system is Type Approved. Ref. Pt.4 Ch.9
3) Applicable only for electro motors above 100 kW
A.5 Arrangement requirements for information, not scope for Type Approval

Where DNV is authorised to issue the IAPP certificate under MARPOL Annex VI, testing of the environmental performance of the system in accordance with MARPOL Annex VI Regulation 13 / NTC 2008 is also considered to fall within the scope of the Society.

The IAPP certificate shall not be issued to a vessel before the On-board confirmation test has been carried out to verify that the SCR system is working as intended and documented in the EIAPP certificate.

Testing of piping systems shall be performed in accordance with Pt.4 Ch.6.

The exhaust gas cleaning system is subject to a functional test after installation on-board. The test shall include control and monitoring systems as well as the electrical power supply. The test shall be performed with all engine installations served in operation and in all relevant load conditions, including manoeuvring.

Exhaust pipes from multiple engine installations (i.e. main engines for propulsion, aux.engines for power generation, boilers etc.) are not to be connected, but shall have separate outlets, unless precautions are taken to prevent the loss of main function in the event of failure and to prevent the return of exhaust gases to a stopped engine installation.

Single main engine installations shall be equipped with the possibility to by-pass the SCR unit.

By-pass arrangements may be accepted provided the by-pass valves are remotely operated from the control station for the exhaust gas cleaning system. The valves shall fail to safe mode upon of loss of power supply.

The exhaust outlets from engine installations solely used for emergency operations are not required to comply with MARPOL Annex VI Reg.13 (e.g. emergency fire pump engines, emergency generator engines) and shall have independent exhaust outlets.

It shall be documented that the exhaust pressure drop in the exhaust gas system including the SCR system does not exceed the maximum allowable according to the engine and machinery component manufacturers. The pressure drop assessment shall be performed from the exhaust outlet of the engine installations to the exhaust outlet to open air. It shall include pressure drop from pipes and fittings as well as other components that contribute to pressure drop (e.g. silencers, exhaust gas boilers, SOX reduction units etc.). For cleaning systems where multiple exhaust sources are coupled to the same cleaning unit, the total pressure drop for all connected units shall be calculated. The pressure drop shall take into account the exhaust gas flow corresponding to maximum specified operating load of the engine installations.

Exhaust gas piping shall be arranged so as to prevent ingress of urea into the engine installations served. Exhaust collecting pipes shall be provided with a drainage system that is capable of draining when the unit is in operation. The drainage shall be led to a tank of suitable size.

In addition, bypass valves and other valves installed for the prevention of exhaust backflow into systems shall be provided with arrangements to prevent exhaust gas leakage.

If exhaust gas fans for the prevention of excessive back-pressure are needed, the SCR system shall be arranged with a bypass. Fans shall be arranged with redundancy if deemed necessary for safety of the system (control of pressure).

The exhaust piping and associated valves and fittings shall be of stainless steel from the point where urea is injected into the exhaust gas and until it is fully vaporized.

Tanks and piping systems for urea shall be designed in accordance with the requirements to fuel oil systems in Pt.4 Ch.6 with the following additional requirements:

— Materials in tanks and piping systems shall be suitable for storage and transportation of the urea.
— Air and sounding pipes to tanks shall be led to open air and shall terminate in such a location that possible spray does not represent a hazard to personnel.
— Tanks and piping systems shall be located in a well-ventilated space and shall not be led through accommodation, service spaces or control stations. If located in a separate space, ventilation capacities and leakage detection systems may be specially considered.
— Piping systems shall have all welded connections, except in way of valves or connections to equipment. Leakage sources shall be provided with spill trays leading to a closed tank. This also applies to bunker stations for urea. Leakage sources shall be screened so that possible spray does not endanger personnel.
— Valves fitted below the top of tanks shall for all tank sizes be arranged for quick acting shut-off from a central position outside the space where the tanks are located, and at a safe distance from openings to the same space.

Where a common supply system is serving multiple engine installations, the isolation arrangements for idle engines shall be so designed so that leaking isolation valves cannot result in ingress of urea into idle engines.