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K-09

OXIDIZING CATALYTIC CONVERTER

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Foreword

China Classification Society (hereinafter referred to as CCS) Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.

This Guideline frees the users to adopt other test methods and requirements which are equivalent to or are stricter than this Guideline.

This Guideline is published and updated by CCS, and is released at <http://www.ccs.org.cn>. Your comments or suggestions are welcomed and may be sent to our email addressed service@ccs.org.cn.

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OXIDIZING CATALYTIC CONVERTER

1 Application

The Guideline applies to oxidizing catalytic converter products that are under application for approval and inspection by China Classification Society (hereinafter referred to as CCS).

2 Normative references

2.1 The approval and inspection bases referred to in this chapter are as follows:

2.1.1 Part 3, Chapter 9, Rules for Classification of Sea-going Steel Ships of China Classification Society

2.1.2 Chapter 7, Guidelines for Ships Using Methanol/Ethanol Fuel of China Classification Society

2.1.3 Chapter 7, Rules for Ship Using Natural Gas Fuel by China Classification Society,

2.2 The approval and inspection bases referred to in this chapter are as follows:

2.2.1 IMO MEPC.291(71) 2017 Guidelines Addressing Additional Aspects of the NO_x Technical Code 2008 with Regard to Particular Requirements Related to Marine Diesel Engines Fitted with Selective Catalytic Reduction (SCR) Systems and amendments such as MEPC.313(74)

2.2.2 IMO International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI

2.2.3 IMO MEPC.177 (58) NO_x Technical Code and its amendments

For dated references in the Guidelines, only the edition corresponding to that date applies. For undated references, the latest edition (including any amendments) applies.

3 Terms and definitions

3.1 Terms and definitions

- (1) Oxidizing catalytic converter (Oxidation catalyst): It refers to the device installed in the engine exhaust system, which can reduce the emission of pollutants such as carbon monoxide (CO) and total hydrocarbons (THC) in the exhaust through catalytic oxidation reaction.
- (2) Space velocity (SV) value: It refers to the ratio of the exhaust gas flow rate (m³/h) passing through the catalyst block to the total volume of the catalyst block in the oxidizing catalytic converter. Therefore, the unit of SV is 1/h. The exhaust gas flow volume refers to the volume defined at 0°C and 101.3 kPa.
- (3) Area velocity (AV) value: It refers to the ratio of the exhaust gas flow rate (m³/h) passing through the catalyst block to the total active surface area (m²) of the catalyst block in the oxidizing catalytic converter. The unit of AV value is m/h. The exhaust gas flow rate refers to the volume flow rate at 0°C and 101.3 kPa.

- (4) Linear velocity (LV) value: It refers to the ratio of the exhaust gas flow rate (m³/h) passing through the catalyst block to the cross-sectional area (m²) of the catalyst block in the direction perpendicular to the exhaust gas flow. The unit of LV is m/h. The exhaust gas flow rate refers to the volume flow rate at 0°C and 101.3 kPa.
- (5) Sample: It refers to the specimen selected from the oxidizing catalytic converter coated with catalyst according to certain specifications, which is used for relevant tests on the standard gas simulation test bench.
- (6) The ratio of the concentration change of a component in the exhaust gas pollutant before and after flowing through the catalyst to the concentration before the catalyst inlet is calculated as follows:

$$\text{Conversion efficiency of catalyst (i)} = \left[\frac{\text{Measured value of catalyst inlet pollutant (i)} - \text{Measured value of catalyst outlet pollutant (i)}}{\text{Measured value of catalyst inlet pollutant (i)}} \right] \times 100\%$$

Where: i respectively represents pollutants such as CO, HC, CH₄, and methanol.

- (7) Conversion efficiency curve: it shows the conversion efficiency of the oxidizing catalytic converter on the exhaust gas pollutant at different raw exhaust concentrations, temperatures and space velocities.
- (8) Fresh state: It refers to the state of the catalyst after pretreatment.
- (9) Aged state: It refers to the state of the catalyst after aging.
- (10) Modeling tool: It refers to the simulation calculation tool for calculating the conversion efficiency of HC and other exhaust gas pollutants using engine emission parameters and model test data.
- (11) Scheme A: It refers to a method of inspecting the emission compliance of the engine equipped with oxidizing catalytic converter through the bench test meeting the requirements of Chapter 5 of NTC2008 or the on-board test meeting all the requirements of the test bench in Chapter 5 of NTC2008 during the initial inspection and certification.
- (12) Scheme B: It refers to an inspection method to prove its emission compliance through modeling calculation and initial confirmation test on board. (Refer to MEPC.291(71))
- (13) Model test: It refers to providing data for modeling tool, so it is called "model test", which is referred to in Clause 6.1.1.3 of MEPC291(71). It can be carried out with full-size or scaled catalyst, and the mixture can be engine exhaust gas or simulated gas. (Refer to MEPC.291(71))
- (14) Deactivation rate: It refers to the change rate of conversion efficiency (or filtration efficiency) of a certain pollutant before and after the deactivation of the post treatment device.

$$\text{Deactivation rate} = \left[\frac{\text{Conversion efficiency of the device before deactivation (or filtration efficiency)} - \text{Conversion efficiency of the device after deactivation (or filtration efficiency)}}{\text{Conversion efficiency of the device before deactivation (or filtration efficiency)}} \right]$$

- (15) Precious metal content: It refers the mass of precious metal coated on unit volume of

- catalyst block, in grams per cubic decimeter (g/dm³).
- (16) Channels Per Square Inch (CPSI): It refers to the number of channels per square inch of the cross section of the catalyst.
- (17) NTC 2008 (NO_x Technical Code 2008): It refers the Technical Code for Nitrogen Oxides adopted by resolution MEPC.177(58).
- (18) Material Safety Data Sheet (MSDS) of catalyst: It refers to the document that provides information on the physical and chemical parameters and hazards of the catalyst for the reference of product users and helps safe operation.
- (19) Quality factor (Q): It is a quantity that characterizes the amplification characteristics at resonance.
- (20) Catalyst block: It refers to a certain size of block for exhaust gas to pass through, and its inner surface contains catalyst components that can reduce exhaust gas pollutant in the exhaust gas.
- (21) Block section: It refers to the cross-sectional area (m²) calculated according to the overall dimensions of the catalyst block.
- (22) Total volume of the catalyst block: It refers to the volume (m³) calculated according to the overall dimensions of the catalyst block.

4 Drawings and documents

The following drawings and documents shall be submitted for review.

4.1 The following drawings and documents shall be submitted to CCS for approval:

- (1) Oxidizing catalytic converter layout, including the installation layout of shell, catalyst (and/or support), bypass pipeline (if applicable), soot blowing device (if applicable), oxygen sensor, gasket and other components. And it should be able to reflect the relative position of the oxidizing catalytic converter and the engine, such as the arrangement before or after the turbocharger, the arrangement of the exhaust branch or header.
- (2) Schematic diagram of oxidizing catalytic converter system.
- (3) Materials and specifications of main components, including reaction device shell, catalyst, bypass pipeline (if applicable), soot blowing device (if applicable), etc.
- (4) The catalyst (and/or support) diagram shall include:
 - ① Catalyst (and/or support) structure diagram, including catalyst model, manufacturer, catalyst unit quality, etc.;
 - ② The installation layout of the internal catalyst support, including the quantity and arrangement of the supports, and the sealing arrangement between the support and the oxidizing catalytic converter reactor shell structure to prevent exhaust gas leakage;
 - ③ Catalyst support structure diagram, including dimensions, channels per square inch

(CPSI), structure and material of the support, etc.;

- ④ Type of catalyst coating, coating materials, total content and ratio of precious metals, and normal operating temperature (K) range of the catalyst.
- (5) Oxidizing catalytic converter system control strategy instructions, including at least: (if applicable)
- ① Control strategy flow chart, with the control mode (such as open loop or closed loop control, etc.) specified;
 - ② All control related input and feedback signals.
 - ③ The control unit shall be able to effectively monitor the working status of key components including the purge device (if any) and the exhaust gas heating device (if any), such as: bypass status, inlet and outlet pressure difference, soot blowing system status/purge pressure, exhaust gas heating device working status/ flame status/fuel pressure/air pressure/air volume, control unit power failure/communication failure/sensor failure.
- (6) Main performance specifications of the product, which shall include:
- ① Performance parameter table, i.e., applicable inlet and outlet boundary conditions and restrictions of the catalyst (and/or support), including at least the catalyst scaling range, exhaust gas flow rate range, space velocity and linear velocity range, exhaust gas pollutant concentration range, reaction device inlet temperature range, pressure loss, and other possible parameter ranges;
 - ② Type of catalyst coating, coating material, total content and ratio of precious metal, and normal operating temperature (K) range of the catalyst;
 - ③ The applicable fuel category, quality, standard and maximum allowable sulfur content shall be distinguished according to different engines, such as: dual fuel, micro-ignition;
 - ④ Factors related to the performance deactivation rate of the oxidizing catalytic converter, such as catalyst replacement conditions and recommended replacement time;
- (7) Type test outline (may be provided when applying for type approval).
- (8) Modeling tool instructions (for Scheme B only)
- (9) Modeling Calculation Report/Model Test Report (for Scheme B only)
- (10) Technical dossier of oxidizing catalytic converter (refer to the requirements of 9.1 in the Guideline, which can be provided when applying for type approval).

4.2 The following drawings and documents shall be submitted to CCS for reference:

- (1) Product manual;
- (2) Product nameplate, factory certificate and other samples;

- (3) Failure mode and effect analysis (FMEA);
- (4) The Material Safety Data Sheet (MSDS) of the catalyst, as well as the protective measures that shall be taken during the installation and replacement of the catalyst, and the waste recycling measures;
- (5) Auxiliary equipment drawings and documents, which shall include:
 - ① Bypass system structure diagram (if applicable);
 - ② Soot blowing device diagram and gas consumption calculation (if applicable);
 - ③ Waste gas heating device drawings and power calculation sheets (if applicable).

4.3 The approved drawings/data shall at least include the following:

- (1) Factory overview: factory name, address, production history, production capacity, technical and inspection personnel, main products, affiliation, product trademark, etc.;
- (2) Details of products under application;
- (3) List of main production equipment;
- (4) List of main testing equipment;
- (5) Brief production process of the product to be approved, such as catalyst manufacturing process. Adopt welded structure, the welding process shall be evaluated and approved according to the Material and Welding Specification of China Classification Society and the standard requirements accepted by CCS;
- (6) Quality management documents or quality system certificates;
- (7) Enterprise registration certificate;
- (8) Qualification certificate and/or production license, if applicable;
- (9) Sample of product quality certificate or conformity certificate;
- (10) Quality control plan, if applicable.
- (11) List of suppliers of raw materials / main parts and components.

5 Technical requirements

5.1 The design working conditions of the oxidizing catalytic converter shall meet the requirements of environmental conditions in Section 2 of Chapter 1 of Part 3 of CCS Rules for Classification of Sea-going Steel Ships.

5.2 The oxidizing catalytic converter installed upstream of the turbocharger, the shell of its catalyst (and/or support), and all equipment and exhaust pipes upstream of the reaction device shall be manufactured in accordance with the design requirements of the exhaust manifold of the supporting engine or the design requirements of the pressure vessel of the corresponding level .

And there shall be measures to prevent the catalyst from entering the turbocharger after being broken.

5.3 The oxidizing catalytic converter shall be designed, manufactured and installed in a reasonable way to prevent possible corrosion, oxidation and vibration during use; Safety in use shall be ensured, and measures such as thermal insulation protection shall be taken to prevent the surface temperature of the enclosure from exceeding 220 °C.

5.4 The oxidizing catalytic converter shall have sufficient capacity to treat exhaust gas pollutants such as CO, HC, CH₄, and methanol. During the approval and inspection of the oxidizing catalytic converter, the CO, HC and CH₄ limits shall meet the requirements of conventions and regulations; The emission limits of methanol and formaldehyde shall be recorded, and the conversion efficiency of the catalyst shall not be less than 80%. If there are the latest requirements for this limit in the convention and regulations, the requirements of conventions and regulations shall prevail.

5.5 Performance requirements of the oxidizing catalytic converter. The conversion efficiency curve of exhaust gas pollutants at different raw exhaust concentrations, temperatures and space velocity shall be provided. During the type approval test, this data shall be sampled according to the acceptance criteria of CCS, and shall meet the design requirements.

5.6 The total precious metal content test shall be carried out according to the CCS acceptance standard, and the test results shall be within 0.95~1.05 times of the manufacturer design value.

5.7 Deactivation index

The deactivation curve or catalyst life of the catalyst shall be obtained through testing or engineering application, or the deactivation resistance of the catalyst shall be verified through rapid aging test. The rapid aging test through the oxidizing catalytic converter according to the standards accepted by CCS shall be carried out and the deactivation rates after aging shall be: Not higher than 10% for CO and HC conversion efficiency, not higher than 40% for CH₄ conversion efficiency, and not higher than 30% for methanol conversion efficiency. The replacement conditions or replacement time of the catalyst blocks shall be considered.

5.8 The oxidizing catalytic converter shall be able to apply the fuel with a certain content of sulfur (S), and the applicable fuel category, quality, standard and maximum allowable sulfur content shall be specified. For dual-fuel engine, the bypass system shall be designed according to the fuel suitability.

6 Materials and components

6.1 The important components of the oxidizing catalytic converter shall be provided with a CCS marine product certificate or manufacturer certificate, and the relevant requirements of Chapter 3 of Part 1 of the Rules for Classification of Sea-going Steel Ships of CCS shall be followed.

6.2 The ID number or composition/type, structural form (such as CPSI) and manufacturer of the catalyst shall not be changed without the approval of CCS.

6.3 The materials used for each equipment component of the oxidizing catalytic converter shall be suitable for the intended temperature, pressure and medium. Such as shell, catalyst (and/or support), soot blowing device (if applicable), oxygen sensor, gasket.

6.4 Shell, pipeline, accessories and other parts and components in contact with methanol shall not use materials sensitive to methanol such as aluminum alloy, galvanized steel, lead alloy, or nitrile rubber, butyl rubber; Shell, pipeline, accessories and other parts and components in contact with ethanol shall not use materials sensitive to ethanol such as zinc, aluminum, brass, lead and lead-based alloys, or natural rubber, polyurethane, polyvinyl chloride, polyamide, methyl methacrylate plastic and polyester-bonded glass fiber laminates.

6.5 The metal materials that can be used include but are not limited to the following: Austenitic stainless steel, duplex stainless steel, etc. Non-metallic materials applicable: Polytetrafluoroethylene, ethylene propylene diene monomer (EPDM) and neoprene rubber can be used for methanol fuel system. For ethanol fuel systems, nitrile rubber, neoprene rubber, fluororubber, polypropylene, thermosetting reinforced glass fiber, etc. can be used. If new steels, such as high manganese austenitic steels, are used, the material compatibility statement shall be submitted to and approved by CCS.

6.6 The corrosively and swelling property of the fuel of the material of the piping system in direct contact with the engine fuel shall be taken into account. In addition to the requirements of this section, relevant requirements of CCS Rules for Materials and Welding and Rules for Construction and Equipment of Ships Carrying Hazardous Chemicals in Bulk shall also be met.

7 Type test

7.1 General requirements

7.1.1 For oxidizing catalytic converters with the same design but different specifications, if they are designed according to the principle of scaling, the whole series can be approved after the type test of typical samples. For the principle of scaling, refer to Clause 7.2 of this chapter.

7.1.2 Before the type test of the oxidizing catalytic converter is carried out, it shall be confirmed that the series of drawings and documents within its approved scope (refer to Clause 4 of the Guideline) have been approved by CCS.

7.1.3 The test equipment shall meet the relevant requirements of IMO MEPC.177(58) or GB15097.

7.2 Principle of scaling

7.2.1 The oxidizing catalytic converters designed based on the principle of scaling and applicable to different engine exhaust gas flow rates (rated working condition) shall meet the following requirements:

- (1) The AV value, SV value and LV value of each system shall be consistent or meet the applicable range.
- (2) Catalysts used in each system: The composition/type, catalyst block structure and manufacturer shall be consistent.
- (3) The control strategy design rules of each system shall be consistent. (If equipped with heaters)

7.3 Selection of typical samples

7.3.1 For initial approval, one set of equipment shall be selected for type test for each series of oxidizing catalytic converters. The selected prototype shall be typical in terms of technical parameters, structure and manufacturing process, reflecting the processing capacity and manufacturing level of the factory.

7.3.2 For the oxidizing catalytic converter system only used in Scheme A or used in both Scheme A and Scheme B, its performance test shall be verified by the method of engine + oxidizing catalytic converter according to the bench test of Scheme A, or in combination with the preliminary certification inspection of Scheme A.

7.3.3 The selection of engine + oxidizing catalytic converter for the performance test shall meet the following requirements:

- (1) The engine to be used for the test does not have to be the engine to be matched, and the oxidizing catalytic converter system may also be the equipment used for design and development.
- (2) The selection of the test engine + oxidizing catalytic converter shall ensure that the space velocity SV of the oxidizing catalytic converter catalyst under the rated operating conditions of the engine is not less than the maximum space velocity applicable for the oxidizing catalytic converter.
- (3) If the selection of a corresponding engine as a prototype is not available due to the fixed size and limited conditions of the catalytic reactor, and calculations or model calculations can prove that the design of the oxidizing catalytic converter can meet the requirements of the applicable maximum space velocity and that there is a surplus volume of catalyst blocks, the requirements of Paragraph (2) above may be lowered.
- (4) Considering that catalyst blocks of the same manufacturer and model may have different CPSI, the designer will take the AV consistency as an important design consideration, and the SV will be different. When selecting the performance test prototype, the maximum AV can be used as the selection parameter. However, this exception shall be limited to performance verification tests and does not apply to other items listed in 7.4.

7.4 Type test items

Table 7.4 Test Items

No.	Test items	Sample test	Integral test
1	Appearance and dimensions	-	×
2	Tightness test	-	×
3	Precious metal content of catalyst	×	-
4	Sulfur resistance of catalyst	×	-
5	Vibration test	-	×
6	Performance test	×	×
7	Rapid aging test	×	-

Note: "×" indicates "applicable", and "-" indicates "not applicable".

7.4.1 The test items of Scheme A and Scheme B shall not be less than: Sulfur resistance and vibration test, and rapid aging test of the catalyst. The sulfur resistance and rapid aging test of the catalyst can be verified by sample test under the same test environment; The vibration test shall be carried out as a whole (after packaging).

7.5 Sampling method

7.5.1 The oxidizing catalytic converter support shall be dissected into four quadrants by performing a longitudinal 1/2 cut and a transverse 1/2 cut, yielding the upper (lower) left or upper (lower)-right sections. Take any part and take a sample from the center of the support. The recommended sampling specification is $\Phi(20\sim 25)\text{mm}\times(45\sim 50)\text{mm}$. See Figure 7.5 for the schematic diagram of sampling. After sampling, purge and clean it with a compressed air. If the catalyst support is coated in zones, the sampling method shall be determined according to the coating process.

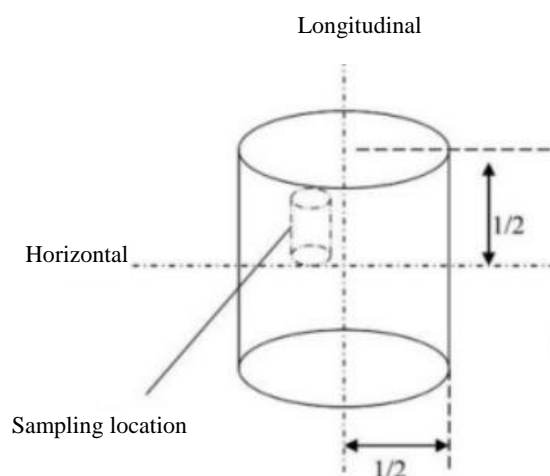


Figure 7.5 Schematic Diagram of Sampling

7.5.2 Pretreatment

7.5.2.1 Pretreatment of samples. The thermocouple for measuring the inlet temperature shall be installed on the centerline near 25 mm upstream of the oxidizing catalytic converter inlet end face. Under the simulated atmosphere of exhaust composition, the inlet temperature is $(550\pm 10)\text{ }^{\circ}\text{C}$, the space velocity is $(30000\pm 1500)\text{ h}^{-1}$, and the time is 1 h. After the pretreatment, close the reaction gas, introduce nitrogen, rapidly cool it down to be below $100\text{ }^{\circ}\text{C}$ and maintain stable conditions. It shall be carried out according to the technical requirements of the catalyst manufacturer's pretreatment design.

7.6 Test sequence

7.6.1 After inspections of appearance, size and tightness, take samples, and carry out other type tests for the samples in turn.

7.6.2 Three sets of samples may be used for the test. Precious metal content test shall be performed for the first set of samples; After inspections of appearance, size and tightness for the second set of samples, take samples, and conduct pretreatment, performance test and rapid aging test for the samples in turn; Vibration test shall be carried out for the third set of samples.

7.7 Type test requirements

7.7.1 Appearance and dimensions

The appearance of the oxidizing catalytic converter shall be visually inspected, and the outer

surface shall be smooth and free of scratches; The welds shall be flat and free of cold solder joints and solder skips. Internal and external structures, including the conformity of the package and the structural dimensions of the catalyst blocks, the number of units and their arrangements in the reaction device. The manufacturer's name, device model, factory number, manufacturing date, exhaust inlet and outlet flow directions shall be marked.

7.7.2 Tightness test

Generally, the air tightness test shall be carried out at the pressure 1.1 times the design pressure, or according to the factory requirements (whichever is higher).

7.7.3 Precious metal content of catalyst

According to different materials of the test sample supports, HJ 509 or QC/T 968 shall be selected for the precious metal content detection, and the results shall meet the requirements of 5.6.

7.7.4 Sulfur resistance of catalyst

- (1) The manufacturer shall provide sufficient theoretical basis or experimental data support for the sulfur resistance of its catalyst.
- (2) The minimum and maximum operating temperatures of the catalyst applicable to fuels with different sulfur contents shall be provided.

During the test, the sulfur poisoning duration shall be 10,000 hours or based on the requested worst-case cumulative exposure limit. The recommended space velocity is $(50000 \pm 400) \text{h}^{-1}$, and the inlet temperature of the gas atmosphere sample shall be configured to be $300 \pm 5^\circ\text{C}$ according to Table 7.7.4. Or after the test is carried out based on the CCS acceptance standard according to the fuel type, the conversion efficiency shall be measured according to the test conditions in Table 7.7.4, and the results shall meet the requirements of 5.4.

Table 7.7.4 Conditions for Sulfur Resistance Test

Component	SO ₂	H ₂ O	O ₂	N ₂
Concentration	20 ppm	(10-15%	8-12%	Balance gas

7.7.5 Vibration test

- (1) Catalyst blocks or reaction device samples of appropriate size can be selected as vibration test samples according to the conditions of the vibration test bench.
- (2) The vibration test parameters shall be in accordance with Table 7.7.5.

Table 7.7.5 Vibration Test Parameters

On-board installation method	Frequency (Hz)	Amplitude (mm)	Acceleration (m/s ²)
With independent support or base	2 (+3/0) ~13.2	±1.0	—
	13.2~100	—	±6.9 (0.7g)
Installed on the engine	2(+3/0) ~25	±1.6	—
	25~100	—	±39 (4.0g)

- (3) Test methods

- ① According to the frequency range and amplitude specified in Table 7.7.4 (2), scanning shall be conducted at a frequency sweep rate not exceeding 1 oct/min to check whether there is resonance;
- ② If there are no obvious resonance points, the vibration resistance test shall be carried out at 30Hz for 90min;
- ③ Perform the vibration resistance test for 90min at each recorded resonance frequency with an amplification $Q \geq 2$. If the measured resonance frequencies are close, the sweep frequency test can be adopted for the vibration resistance test, and the duration shall be 120min;
- ④ During the test, it is allowed to take measures to avoid dangerous frequencies or reduce the Q value, but the resonance inspection and vibration resistance test shall be carried out again;
- ⑤ The test shall be carried out on 3 mutually perpendicular axes.

7.7.6 Rapid aging test

The deactivation rates after rapid aging of the oxidizing catalytic converter shall be: Not higher than 10% for the conversion efficiency of CO and HC exhaust gas pollutants, not higher than 40% for CH₄ conversion efficiency, and not higher than 30% for methanol conversion efficiency. The rapid aging test utilizes samples for hydrothermal aging in a tube furnace or muffle furnace according to the accepted standard. The test conditions are shown in Table 7.7.6.

Table 7.7.6 Rapid Aging Test Conditions

Inlet temperature (°C)	Space velocity h ⁻¹	Aging duration (h)
650±10	≥30000 ⁽¹⁾	100
(1): If the hydrothermal aging is performed in an atmospheric muffle furnace, there is no requirement for space velocity.		

7.7.7 Performance test

(1) Conversion efficiency curve verification

- ① During the sample test, the oxidizing catalytic converter shall be operated at the designed space velocity, and the engine exhaust shall be used to bring the sample inlet temperature within the range of 200 °C to 500 °C. The temperature shall be gradually varied not exceeding 20 °C within the specified design temperature range. Before sampling emissions under each operating condition, the engine exhaust must be stabilized for at least 5 minutes. Subsequently, the concentrations of exhaust gas pollutants at the sample inlet and outlet shall be measured and recorded, along with the sample inlet temperature and bed temperature. Conversion efficiency curves for different exhaust gas pollutants shall be plotted with inlet temperature as the abscissa and conversion efficiency as the ordinate. The recorded conversion efficiencies shall cover the components specified in the technical specification.
- ② The bench test conditions shall follow the cycle conditions of the engine intended for matching. For spot checks, one additional working condition shall be randomly selected

from the cycle curve, excluding the original mode point conditions. If the test is conducted in conjunction with the preliminary certification inspection of Scheme A, one working condition shall be spot-checked from the curve of each test cycle.

(2) Catalyst's ability to deal with exhaust gas pollutant

- ① Verify the catalyst's conversion efficiency. Select at least one engine operating condition, and verify the catalyst's conversion efficiency curve based on the temperature and space velocity under that condition.
- ② The exhaust gas pollutant treatment capacity shall meet the requirements of Clause 5.4 of the Guideline.

(3) Validation of the rationality of control strategy design (if applicable)

- ① Spot check the operating conditions. Select an additional operating condition (excluding the original mode points of the E3 or D2 cycle) from the engine propulsion characteristic curve (E3 cycle curve) or D2 cycle curve (or within approximately 5% deviation). Under this condition, the conversion efficiency of exhaust gas pollutants, with an added 5% margin, shall not be lower than the interpolated conversion efficiency between the two adjacent mode points on the cycle curve. If the verification test is conducted in conjunction with the preliminary certification inspection of Scheme A, one operating condition shall be spot-checked from the curve of each test cycle.
- ② The exhaust gas pollutant treatment capacity shall meet the requirements of Clause 5.4 of the Guideline.

(4) Verification of the accuracy of modeling tool calculations and the rationality of scaling

- ① For the oxidizing catalytic converter system proposed for Scheme B, as Scheme B does not include a bench test for matching the engine with the oxidizing catalytic converter and the initial on-board confirmation test is a simplified confirmation method, the applicant shall complete the accuracy verification of the scaling approach and modeling tool before onboard installation, in order to reduce the risk of failure during the initial inspection.
- ② The applicant shall first submit the test report of the prototype oxidizing catalytic converter and the modeling calculation report, and verify the rationality of the scaling and the accuracy of the modeling calculations through testing.
- ③ The requirements for testing the oxidizing catalytic converter and the modeling tool shall be implemented with reference to MEPC.291(71).
- ④ The exhaust gas pollutant treatment capacity shall meet the requirements of Clause 5.4 of the Guideline.

(5) The verification test shall record at least the test data listed in Appendix 2.

(6) For the performance test, refer to the test bench NO_x emission measurement procedure in Chapter 5 of NTC 2008.

8 Unit/batch inspection

8.1 After obtaining the CCS type approval certificate, the oxidizing catalytic converter produced by the factory in accordance with the approval conditions may apply to CCS for single piece/single batch inspection.

8.2 The approved single piece/single batch inspection items shall meet the requirements of Table 8.2, and the corresponding test report shall be submitted upon completion of the inspection.

Table 8.2 Oxidizing Catalytic Converter Single-piece/Single-batch Inspection Items

No.	Test items	Test requirements
1	Appearance and dimension inspection	Clause 7.7.1 of the Guideline
2	Control software version number (if applicable)	Check the version number and other information of the control software
3	Identification verification of emission-related parts and components	For emission-related parts and components, refer to Clause 9.2 of the Guideline
4	Technical dossier approval of oxidizing catalytic converter	1) Confirm whether the product is suitable for the intended engine. 2) Meet the requirements of Clause 9 of the Guideline.

8.3 Upon completion of the single piece/single batch inspection, CCS shall issue the marine product certificate and approve the technical dossier of the oxidizing catalytic converter prior to issuance.

9 Technical dossier and parameter verification method for oxidizing catalytic converter

9.1 Technical dossier of the oxidizing catalytic converter;

9.1.1 A technical dossier shall be prepared for each oxidizing catalytic converter, and shall at least include the following contents:

- (1) Specifications of the catalyst block (and/or support) and its arrangement in the oxidizing catalytic converter. The detailed specifications of the catalyst block and the arrangement of the catalyst in the oxidizing catalytic converter may include, but are not limited to:
 - ① Installation of the catalyst block inside the oxidizing catalytic converter, including the quantity, layers and shell and frames of catalyst blocks to prevent waste gas leakage;
 - ② Geometrical dimensions of the catalyst block;
 - ③ Limiting features (e.g., CPSI) and ranges of physical parameters (such as SV, AV, LV), or part numbers or specification numbers designated by the applicant on the catalyst block;
 - ④ Materials of catalyst block: The materials can be identified by part number or specification number. Catalyst coating type, precious metal content and ratio shall also be included. Determine that the catalyst on board complies with the requirements in the technical dossier, and the method of specifying the part number or specification number by the applicant on the catalyst block shell or frame is acceptable;
 - ⑤ Arrangement of inspection ports. Inspection of the oxidizing catalytic converter is limited to ensuring the use of the correct catalyst block during the assembly stage. For inspections other than the initial assembly, it is acceptable to inspect the spare catalyst

blocks to prove compliance;

- (2) Inlet parameters, including the allowable exhaust gas temperature (maximum and minimum) at the inlet of the oxidizing catalytic converter.
- (3) Cross-unit parameters: The allowable pressure loss (Δp) between the inlet and outlet of the oxidizing catalytic converter, and across all components belonging to the oxidizing catalytic converter between the upstream and downstream of the reaction device.
- (4) Factors related to fuel quality that enable engines to continuously comply with applicable emission limits may include, but are not limited to:
 - ① Maximum allowable sulfur content of the fuel;
 - ② Description of fuel composition and fuel contaminants under operating conditions.
- (5) Factors related to the deactivation rate of oxidizing catalytic converter performance, such as the replacement conditions and recommended replacement time for the catalyst block in the oxidizing catalytic converter.
 - ① The applicant shall specify the correlation between catalyst block replacement criteria and the readings of the exhaust gas pollutant monitoring equipment, as well as the maintenance, overhaul, and calibration requirements of such equipment;
 - ② Evaluate catalyst conversion efficiency based on the guidelines provided by the applicant for periodic inspection or monitoring (if applicable); records shall be kept for use during annual, intermediate, and renewal inspections. The periodic inspection frequency shall be determined by the applicant according to the deactivation performance of the catalyst, but shall be carried out at least once after installation and every 12 months thereafter; and
 - ③ Other strategies for monitoring catalyst status/deactivation should be submitted for approval.
- (6) Control method and settings of the oxidizing catalytic converter, such as the model and specifications of the control equipment, including but not limited to the following:
 - ① Maintenance and/or replacement requirements;
 - ② If the engine system equipped with an oxidizing catalytic converter has different operating modes, the control logic for selecting different modes shall be provided, along with records of operating modes and switching methods; and
- (7) Parameter inspection method of the oxidizing catalytic converter (refer to Clause 9.2 of the Guideline).
- (8) Other parameters proposed by the applicant.
- (9) The technical dossier for certification of an engine equipped with an oxidizing catalytic converter shall also include: information on the engine family/group, as well as details of the engines within the family/group and their corresponding oxidizing catalytic converter systems.

9.2 Parameter verification method for oxidizing catalytic converter

9.2.1 The parameter verification methods for the oxidizing catalytic converter system mainly include the following:

- (1) Verification of identification numbers of emission-related components (refer to Clause 9.2.2 of this chapter).
- (2) Exhaust gas pollutant measurement (for periodic inspection, refer to Clause 9.2.3 of this chapter).
- (3) Parameter logbook, used to record changes in emission-related components and setting values.

9.2.2 All emission-related components shall be marked with their identification numbers, and the location of these numbers on the components shall be clearly indicated in the technical dossier. The emission-related parts and components of the oxidizing catalytic converter shall include but are not limited to the following:

- (1) Catalyst block (and/or support).
- (2) Software version of the oxidizing catalytic converter control system.

9.2.3 Exhaust gas pollutant measurement shall include the following:

- (1) Periodic inspection (at least once after installation and once every 12 months) or monitoring of exhaust gas pollutant concentrations downstream of the oxidizing catalytic converter under each operating mode.
- (2) Provide evaluation criteria that allow for easy determination of whether the processing efficiency of the oxidizing catalytic converter remains consistent with that at the time of certification.

Appendix 1 Operating Boundary Parameters of the Oxidizing Catalytic Converter

Parameter	Value
1. Catalyst	
Type	
Process (honeycomb, finned, or others)	
Main materials	
Cell density (CPSI of catalyst block)	
Manufacturer	
2. System parameters	
Maximum allowable pressure difference across the reaction device (at 100% load) kPa	
Applicable engine back pressure (at 100% load) kPa	
Applicable fuel quality and standard, and maximum fuel sulfur content %	
System temperature of the oxidizing catalytic converter °C	
Catalyst block replacement cycle	
Applicable scaling range	
Applicable exhaust gas flow rate range (at 100% load) kg/h	
Applicable space velocity range 1/h	
Face velocity m/h	
Linear velocity m/h	

Appendix 2 Verification Test Data Record

Mode	1	2	3	4	5	6	7	8
Power/torque %								
Rotational speed %								
Start time								
Environmental data								
Relative humidity %								
Ambient temperature °C								
Atmospheric pressure kPa								
Test condition parameter (fa)								
Engine data								
Fuel mass flow rate kg/h								
Exhaust mass flow rate (qmew) kg/h								
Charge air coolant inlet temperature °C								
Charge air temperature °C								
Charge air reference temperature °C								
Charge air pressure kPa								
Oxidizing catalytic converter data								
Oxidizing catalytic converter inlet exhaust gas temperature °C								
Oxidizing catalytic converter outlet exhaust gas temperature °C								
Oxidizing catalytic converter inlet exhaust gas pressure kPa								
Oxidizing catalytic converter outlet exhaust gas pressure kPa								
Oxidizing catalytic converter inlet and outlet pressure difference (ΔP) kPa								
Oxidizing catalytic converter housing surface temperature °C								
Emission data								
Oxidizing catalytic converter inlet	O ₂ concentration (dry/wet) %							
	CO concentration (dry/wet) ppm							
	CO ₂ concentration (dry/wet) %							
	HC concentration (dry/wet) ppm							
Oxidizing catalytic converter outlet	O ₂ concentration (dry/wet) %							
	CO concentration (dry/wet) ppm							
	CO ₂ concentration (dry/wet) %							
	HC concentration (dry/wet) ppm							
	Methanol concentration ppm							
	CH ₄ concentration ppm							
Other harmful pollutants ppm								