

HJ

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the People's Republic of China

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**Pollutant emissions control technical
requirements of non-road
diesel mobile machinery**

**Emissions control technical requirements of non-road
diesel mobile machinery**

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Foreword

The present Standards have been formulated to implement the "Environmental Protection Law of the People's Republic of China" and the "Air Pollution Prevention Law of the People's Republic of China," prevent and control environmental pollution caused by exhaust pollutants from non-road diesel mobile machinery, and improve ambient air quality.

The present Standards specify stage IV pollutant emission control technical requirements for non-road diesel mobile machinery and diesel engines. The present Standards supplement the contents of stage IV in GB 20891-2014 "Diesel engine exhaust pollutant emission limits and measurement methods for non-road mobile machinery (China stages III and IV)."

The present Standards have been revised using the technical contents relating to diesel engines for non-road mobile machinery in European Union (EU) Directive 97/68/EC (through revision 2012/46/EU) "Law on Coordinating Measures Adopted by Member States to Prevent and Control Gaseous Pollutants and Particulate Emissions from Diesel Engines for Non-road Mobile Machinery" and a portion of the technical contents in non-road stage V European regulations (EU) 2016/1628 "Requirements for Exhaust Pollutant Emission Limits for Compression Ignition Engines for Non-Road Mobile Machinery, the revisions to (EU) 1024/2012 and (EU) 167/2013, and the revisions and substitutions to 97/68/EC."

Addenda A-K of the present Standards are normative addenda.

This is the first publication of the present Standards.

Formulation of the present Standards has been organized by the Department of Atmospheric Environment and the Department of Regulations and Standards of the Ministry of Ecology and Environment.

The present Standards were principally drafted by the following work units: Jinan Automobile Testing Center Co., Ltd., the Chinese Academy of Environmental Sciences, and Weichai Power Co., Ltd.

The present Standards were approved by the Ministry of Ecology and Environment on December 28, 2020.

From the date of publication, information may be disclosed according to the Stage IV technical requirements set forth in the present Standards.

Beginning December 1, 2022, all non-road mobile machinery and diesel engines at or below 560 kW which are manufactured, imported, and sold shall be required to comply with the requirements of the present Standards.

The Stage IV implementation date for non-road mobile machinery above 560kW and diesel engines installed thereupon shall be published separately.

The present Standards shall be interpreted by the Ministry of Ecology and Environment.

Pollutant emission control technical requirements for non-road diesel mobile machinery

1 Scope of application

The present Standards specify the pollutant emission control technical requirements for stage IV non-road diesel mobile machinery (hereafter referred to as “machinery” or “machine(s)”), diesel engines installed thereupon, and second diesel engines installed on vehicles used to transport people (cargo) on roads.

The present Standards shall apply to (including but not limited to) the model inspection, production consistency inspection, emission compliance inspection, in-use compliance inspection, and durability requirements of machinery and diesel engines installed thereupon and operating at non-constant speeds, such as:

- Construction machinery (including excavation machinery, earth moving machinery, hoisting machinery, forklifts, compacting machinery, road construction and maintenance machinery, concrete machinery, tunneling machinery, piling machinery, aerial lifting machinery, and rock drilling machinery);
- Agricultural machinery (including tractors and combine harvesters);
- Forestry machinery;
- Airport ground handling equipment;
- Material loading and unloading machinery;
- Snow plowing equipment;
- Industrial drilling equipment.

The present Standards shall apply to the model inspection, production consistency inspection, emission compliance inspection, in-use compliance inspection, and durability requirements of the following (including but not limited to) machinery and diesel engines operating at constant speed installed thereupon, such as :

- Air compressors;
- Generator sets;
- Fishery machinery (aerators, pond excavators, etc.);
- Water pumps.

The present Standards shall apply to tri-wheel vehicles and diesel engines installed thereupon, ships with a rated net power of less than 37 kW and diesel engines installed thereupon.

2 Normative reference documents

The present Standards cite the following documents or sections therefrom. For all reference documents for which dates are not given, the most recent versions thereof shall apply to the present Standards.

GB 7258 Technical requirements for the operational safety of motor vehicles

GB 17691—2005 Vehicle compression ignition, gas fuel ignition engine and vehicle exhaust pollutant emission limits and measurement methods (China stages III,IV,V)

GB 17691—2018 Heavy-duty diesel vehicle pollutant emission limits and measurement methods (China stage VI)

GB 20891-2014 Non-road mobile machinery diesel engine exhaust pollutant emission limits and measurement methods (China stages III and IV)
 GB 29518—2013 Diesel engine nitrogen oxide reducing agent urea aqueous solutions (AUS 32)
 GB 36886—2018 Exhaust gas smoke limits and measurement methods for non-road mobile diesel machinery
 GB/T 1147.1 Small and medium power internal combustion engines Part 1: General technical conditions
 GB/T 25606 Earth-moving machinery - Product identification numbering system
 HJ 437—2008 Compression ignition and gas fuel ignition engines for vehicles and vehicle on-board diagnostics (OBD) System technical requirements
 ISO 13400 Road vehicles - Diagnostic communication based on Internet protocol (DoIP)
 ISO 15031 Communication between road vehicles and emission diagnosis related devices
 ISO 15765—4 Road vehicles - Diagnostics of controller area networks (CAN) Part 4: Emission-related system requirements
 ISO 27145 Road vehicles - Achieving unified communication requirements for on-board diagnostic systems (WWH-OBD) worldwide
 SAE J1939 Commercial vehicle control system local area network (CAN bus) communication protocol
 SAE J1939—73 Application layer – Diagnostics
 ASTM E 29—06B Use of important numbers in test data to determine applicability to specifications

3 Terms and definitions

The terms defined in GB 20891-2014 and the following terms and definitions shall apply to the present Standards.

3.1

Emission control strategy emission control strategy

An element or set of elements of design incorporated into the overall design of a diesel engine system or machine for the purpose of controlling exhaust emissions, including a base emission control strategy (BECS) and a set of auxiliary emission control strategies (AECS).

3.2

Base emission control strategy (BECS) base emission control strategy

An emission control strategy that works over the entire diesel engine speed and load range when the auxiliary emission control strategy has not been activated. Such as: Diesel engine timing characteristic diagram (engine timing map), EGR flow characteristic diagram (EGR map), SCR system reactant supply characteristic diagram (SCR catalyst reagent dosing map) etc.

3.3

Auxiliary emission control strategy (AECS) auxiliary emission control strategy

An emission control strategy that temporarily replaces or modifies the basic emission control strategy for one or more specific purposes, and under specific environmental conditions and (or) operating conditions (such as vehicle speed, diesel engine speed, gear, intake temperature or intake pressure, etc.).

3.4

Invalidation strategy defeat strategy

Emission strategies that do not meet the performance requirements of the basic emission strategy or auxiliary emission strategy specified in the present Standards.

3.5

Reagents

Media that are stored in a storage tank used by machinery, and provided to the exhaust aftertreatment system according to the needs of the exhaust control system.

3.6

deNO_x systems

Exhaust aftertreatment systems designed for use in reducing nitrogen oxides (NO_x) (such as active and passive lean burn diesel engine NO_xcatalytic converter, adsorption type NO_x catalytic converter and selective catalytic reduction (SCR) systems).

3.7

Combined nitrogen oxide reduction and particulate matter systems *combined deN O_x-particulate filter*

Exhaust aftertreatment systems designed for use in simultaneously reducing NO_x and particulate matter (PM).

3.8

Exhaust aftertreatment systems exhaust aftertreatment system

Catalytic converter (oxidation type catalyst (DOC), three-way catalyst and all gas catalysts), particulate matter aftertreatment system, nitrogen oxide reduction system, combined nitrogen oxide reduction-particulate matter system, and various other pollutant reducing devices installed downstream of the diesel engine.

3.9

Particle number (PN) particle number

According to the method described in Appendix BB, the total number of particles with a particle size exceeding 23 nm in the diluted exhaust gas from which volatile substances have been removed.

3. 10

Emission control system emission control system

A system of technical points or emission strategies developed or calibrated to control emissions.

3.11

NO_x Control diagnostic system (NCD) NO_x control diagnostic system

A computer information system, installed on a diesel engine, that is a pollution control device and has the following functions:

- a) Diagnostic NO_x control malfunction (NCM);
- b) Possible causes of a NO_x control malfunction can be found through information in memory and/or external communication information.

3. 12

NO_x Control malfunction (NCM) NO_x control malfunction

An attempt to tamper with the NO_x control system of a diesel engine or a malfunction caused by such an attempt that affects the NO_x control system. In the present Standards, a driver warning or driving performance limitation system shall be triggered once such a situation has been detected.

3.13

Diesel engine family *engine family*

A set of diesel engines designed by the manufacturer in accordance with the requirements of GB 20891—2014 Chapter 8 and the requirements of the present Standards 10.2 shall have similar exhaust emission characteristics; all diesel engines in the family must meet the same emission limits.

3.14

NCD Diesel engine family NCD engine family

A group of diesel engines with the same NCM monitoring and diagnosis methods.

3.15

Particulate control diagnostic system (PCD) particulate control diagnostic system

A computer information system, installed on a diesel engine, that is a pollution control device and has the following functions:

- a) Diagnostic particulate control malfunction (PCM);
- b) The ability to determine the cause of a particulate matter control malfunction by means of information stored in memory and/or external communication information.

3.16

Particulate control malfunction (PCM) particulate control malfunction

An attempt to tamper with the particulate matter control system of a diesel engine or a malfunction caused by such an attempt that affects the particulate matter control system. In the present Standards, a driver warning or driving performance limitation system shall be triggered once such a situation has been detected.

3.17

PCD Diesel engine family PCD engine family

A set of diesel engines with the same PCM monitoring and diagnostic methods

3. 18

Diagnostic trouble code (DTC) diagnostic trouble code

A group of numbers or a combination of letters and numbers that can represent or indicate a fault.

3. 19

Confirmed and active trouble code *confirmed and active DTC*

The DTC that is stored when the NCD and PCD confirm that there is a malfunction.

3. 20

Access *access*

Acquisition of all emission-related data through a standard diagnostic serial interface. This data shall include all trouble codes during the inspection, diagnosis, maintenance or repair of parts related to the emissions of machinery.

3.21

Unrestricted *unrestricted*

Access can be performed without relying on access codes or similar devices obtained from machinery manufacturers, or if the accessed information has not been standardized, access to the generated data can be performed without any unique decoding information.

3.22

Portable emissions measurement system (PEMS) *portable emissions measurement system*

A complete emission test system that can be installed on machinery to simultaneously measure exhaust flow, pollutant concentration, ambient temperature, humidity, and atmospheric pressure and measure or collect in real time parameters relating to diesel engine speed, torque, load, latitude and longitude, and altitude.

3. 23

On-board method PEMS method

The method of installing a PEMS on the machinery being tested to measure the exhaust pollutant emissions of the machinery during actual operation.

3.24

Word-based window *work-based window*

A continuous interval from the starting point to the ending point of the test. When the cumulative work in the interval is equal to the work done by the diesel engine in the transient cycle, the continuous interval is defined as a work base window.

3. 25

Window specific emissions *window brake-specific emissions*

The ratio of the total mass of mechanical exhaust pollutants discharged in the work base window to the amount of work done in the window; unit: g/kW·h.

3. 26

Work-based window method work-based window method

A method of evaluating mechanical emission compliance by comparing the specific emission of each power base window with the specific emission of diesel type testing.

3. 27

Average window power percentage average window power percentage

The percentage of the maximum net power of the diesel engine accounted for by the average diesel engine power in the power base window.

3. 28

Valid work-based window valid work-based window

A window with an average power percentage greater than 20%.

If the number of individual windows with an average power percentage of greater than 20% is less than 50% of all windows, the requirement of the average power percentage of the window of 20% can be gradually decreased in steps of 1%, but the minimum shall not be less than 15%.

3. 29

Valid data points valid data points

When the coolant temperature of the diesel engine is at or above 70°C, or when the change in the coolant temperature is less than 2°C within 5 min of the start of the PEMS test (whichever comes first, but not later than 20 min after the diesel engine starts), all test data points through the end of the test.

3.30

Operating process operating process

The continuous process consisting of starting up of the diesel engine, (mechanical) operation, stopping of the diesel engine, and the time from stopping of the diesel engine to the next start up of the diesel engine.

3. 31

Working process working process

A complete (or partial) actual operation process capable of reflecting the actual emission performance of the diesel engine installed on the machinery.

3. 32

Electronic fuel injection system electronic fuel injection system

A diesel engine electronic control system that can be used to make adjustments to change the injection parameters of the diesel engine.

3.33

Non-road steady cycle (NRSC) non-road steady cycle

According to the provisions of GB 20891-2014 Addendum B.1, test cycles comprising five working conditions, six working conditions, and eight working conditions.

3.34

Non-road transient cycle (NRTC) non-road transient cycle

According to the provisions of GB 20891-2014 Addendum B.1, a test cycle comprising 1,238 gradually changing working conditions.

3.35

Continuous regeneration continuous regeneration

An exhaust gas aftertreatment system regeneration process that occurs continuously or at least once in each hot state NRTC (or NRSC) test.

3.36

Periodic regeneration periodic regeneration

A regeneration process such that during normal operation of the diesel engine, the emission control device periodically regenerates within 100 h.

3.37

Non-volatile computer memory non-volatile computer memory

A random access memory that is still able to retain information when the power supply is interrupted (such as the mechanical battery being disconnected, the fuse of the control unit being removed). Generally, the non-volatility of a non-volatile memory is achieved using a backup battery provided in an onboard computer, or using an electronically erasable and programmable read-only memory chip.

3.38

Emission control device pollution control device

A device and its electronic control unit installed on machinery to control or limit the emission of pollutants by a diesel engine.

3.39

Wall flow diesel particulate filter (DPF) wall flow diesel particulate filter

A particulate aftertreatment system in which the two ends of adjacent honeycomb channels alternately block the holes, forcing air to flow through the porous wall, and trapping the particles in the wall holes and on the inlet wall.

3.40

Machine environmental identification numbers (MEIN) machine environmental identification

number

A set of character codes designated by machinery manufacturers and importers for each unit of machinery they produce and/or import in accordance with the requirements of this text to identify the machinery.

3.41

Full life full life

The full life cycle of machinery from production and use through to scrapping.

3.42

Machinery useful life useful life

A time period that is exactly the same as the effective life of a diesel engine installed on machinery.

3.43

Maximum net power maximum net power

The maximum net engine power value of a diesel engine measured at full engine load.

3.44

Tri-wheel vehicle tri-wheel vehicle

A freight-carrying vehicle having three wheels with a maximum design speed not exceeding 50 km/h in accordance with the provisions of BG 7258.

4 Pollution control requirements

4.1 Mechanical and diesel engine model inspection

4.1.1 General requirements

4.1.1.1 Machinery and diesel engine models falling within the scope of the present Standards shall be type tested in accordance with the requirements of section 5.2 of GB 20891-2014 and the requirements of section 5.2 of the present Standards.

4.1.1.2 Diesel engine models or diesel engine families can be used as an independent technical assembly for type testing.

4.1.1.3 For machinery equipped with diesel engines that have not been type-tested, the machinery or diesel engine shall be type-tested; for machinery equipped with diesel engines that have been type-tested, no additional machinery or diesel type testing shall be required.

4.1.1.4 When performing type testing, a standard fuel oil that meets the requirements of GB 17691—2018 Table D.1 shall be employed, and a urea aqueous solution that meets the requirements of GB 29518—2013 shall be employed (if applicable).

4.1.1.5 The diesel engine label shall be clear and readily visible, and may be supplemented with a QR code.

4.1.1.6 If, when the diesel engine is on the bench, the measured maximum net power and the rated net power are not in the same power segment, and the requirements of power deviation outlined in B.2 are not

met, stricter emission limits and technical requirements shall be implemented for the power segment.

4.1.2 Family (source engine) type testing

4. 1.2. 1 When inspecting a diesel engine type, a source engine that can represent the diesel engine type or family shall be selected. If the selected engine model does not fully represent the engine model or family described in GB 20891—2014Addendum A, a representative diesel engine shall be selected for testing.

4.1.2. 2 The source engine (machinery) shall have the poorest emission level in the family. It shall be possible to extend the type testing of the source engine (machinery) to all members of the family; it shall be unnecessary to conduct type testing of other members of the family.

4. 1.2. 3 The inspection agency shall seal the ECU of the diesel engine during a type testing for future reference, and shall not be required to retain it beyond 5 years after production of the diesel engine or machinery has been stopped.

4. 1.2. 4 The competent Department of Ecology and Environment shall be permitted to carry out and confirm inspections according to Addendum J.

4.2 Product type changes

No modification to a type-tested diesel engine model or machinery shall have an adverse effect on pollutant emissions, and all such modifications shall meet the requirements of the present Standards. If an item that has been changed falls under information that has been made public, the machinery manufacturer/importer shall disclose information on the contents of the product change; if the changed item could affect emission performance, corresponding type testing shall be carried out, and the contents of the product changes and type testing results shall be disclosed.

4.3 Information disclosure

4. 3.1 For machinery within the scope of the present Standards, the machinery manufacturer/importer shall disclose information in accordance with the requirements of Addendum A of GB 20891-2014 and Addendum A of the present Standards. The disclosure of relevant content involving the confidentiality of diesel engine manufacturers shall be permitted by the diesel engine company after technical processing.

4. 3.2 Each machine shall have an affixed environmental information label, and the environmental information label shall meet the requirements of Addendum I.

4. 3.3 Each machine shall have a unique mechanical environmental protection code, which shall meet the requirements of Addendum K.

4.4 Environmentally friendly production consistency and in-use compliance

4.4.1 Machinery and diesel engine manufacturers shall ensure the environmentally friendly production consistency of mass-produced machinery and diesel engines, and shall provide relevant production consistency guarantee materials in accordance with the requirements of Addendum F. Manufacturers shall ensure that new production machinery and diesel engine emissions meet the present Standards, and shall compile relevant materials for self-examination of new production machinery and diesel engine emissions in accordance with the requirements of Chapter 7. A competent Department of Ecology and Environment shall be permitted to conduct compliance supervision and random inspection of new production machinery and diesel engines in accordance with the requirements of Chapter 7.

4.4.2 Machinery and diesel engine manufacturers shall ensure the in-use compliance of production machinery and diesel engines, and prepare relevant in-use compliance self-inspection plans in accordance with the requirements of Addendum G. Manufacturers of machinery and diesel engines shall ensure that machinery emissions meet the standards in actual use in accordance with the provisions of the present Standards, and prepare in-use compliance self-examination reports in accordance with the requirements of Chapter 8. A competent Department of Ecology and Environment shall be permitted to conduct spot checks for in-use compliance supervision in accordance with Chapter 8.

4.4.3 Machinery and tri-wheel vehicles equipped with a diesel engine with a rated net power of 37kW or higher shall be subject to standard compliance inspection and in-use compliance inspection for new production machinery in accordance with the requirements of 5.7.6 and GB 36886-2018. Machinery and tri-wheel vehicles equipped with diesel engines with a rated net power of less than 37 kW shall be inspected for compliance of new production machinery and in-use compliance inspections in accordance with the requirements of GB 36886-2018. For machinery with multiple operating modes, compliance inspections of new production machinery and in-use compliance inspections shall be carried out for the various modes.

5 Technical requirements and testing

5.1 General requirements

5.1.1 Basic emission control strategy requirements

The basic emission control strategy shall be effective over the normal working range of the diesel engine and shall meet the relevant requirements of the present Standards.

5.1.2 Auxiliary emission control strategy requirements

5.1.2.1 The use of auxiliary emission control strategies on diesel engines or machinery shall be permitted in response to some specific environments and (or) operating conditions. The activation of a auxiliary emission control strategy shall be permitted, but permanent change to the basic emission control strategy shall not be permitted. The specific conditions are as follows:

- a) The activation of an auxiliary emission control strategy shall be permitted when the use conditions exceed the control conditions specified in 5.1.2.2 and meet the conditions of 5.1.2.3.
- b) When the conditions of use meet the conditions specified in 5.1.2.2; however, it shall be permissible to activate the auxiliary emission control strategy for the purposes of 5.1.2.3. When the activation conditions do not exist, the auxiliary emission control strategy shall no longer be effective.

5.1.2.2 Control conditions:

- a) An altitude not exceeding 1,700 m;
- b) An ambient temperature of from 266 K to 311 K (-7°C to 38°C);
- c) The temperature of the diesel engine coolant is not lower than 343 K (70°C).
- d) If the ambient temperature is lower than 275 K (2 °C and one of the following two conditions is met, regardless of the control conditions in 5.1.2.1, it shall be permissible to active the auxiliary emission control strategy of EGR in diesel engines equipped with exhaust gas recirculation EGR.

The intake manifold temperature is less than or equal to the temperature calculated by the following formula:

$$IMT_c = \frac{P_{IM}}{15.75} + 304.4$$

In the equation: IMT_c —Intake manifold temperature, K;

P_{IM} —Absolute intake manifold pressure, kPa.

The temperature of diesel engine coolant is not higher than the temperature calculated by the following formula:

$$ECT_c = \frac{P_{IM}}{14.004} + 325.8$$

In the equation: ECT_c — Diesel engine coolant temperature, K;

P_{IM} — Absolute intake manifold pressure, kPa.

5.1.2. 3 It shall be permissible to activate the auxiliary emission control strategy for the following purposes:

- a) To protect the diesel engine system (including protection of the intake system) and (or) machinery from damage, and only activation by on-board signals;
- b) For the purpose of operational safety;
- c) To prevent excessive emissions during cold start, warm-up or shutdown;
- d) Under certain environments or operating conditions, trade-offs shall be permitted and reduction in the control of a certain pollutant shall be permitted to maintain control of all other pollutants.

5. 1.2.4 Diesel engine manufacturers shall provide descriptions in accordance with the requirements of 5.1.3. Any auxiliary emission control strategy that is running during type testing shall meet the requirements of 5.1.2.

5. 1.2.5 The use of malfunction strategies that limit the effectiveness of emission control devices shall be prohibited.

5. 1.3 The machinery manufacturer shall include any technical key points of the machinery that affect emissions, diesel engine emission control strategies, and methods for the diesel engine system to directly or indirectly control emissions-related variables; in addition, the detailed descriptions of the driver warning system and the driving performance limitation system required in Addendum C and Addendum D shall be organized into a documentation package and meet the requirements of A.3.2.

5.1.4 Machinery equipped with vanadium-based SCR catalysts shall not leak vanadium-containing compounds into the atmosphere during any part of their life span; further, relevant materials (such as temperature control strategies and related test reports) shall be submitted during type testing to demonstrate that the inlet temperature of SCR is lower than 550°C under all working conditions during machinery use.

5. 1.5 Machinery manufacturers shall clearly inform users to add and use fuel and reactants that meet the requirements of the present Standards in time to ensure that the machinery meets the emission requirements of the present Standards in actual use.

5.1.6 Diesel engine manufacturers shall minimize the NO_x emissions of the original diesel engine (front end of the aftertreatment device), and explain the original engine NO_x emissions (data) and test methods to the competent Ecology and Environment Department.

5.2 Type testing items

The required type testing items when machinery and diesel engine models (family) undergo type testing according to the present Standards are shown in Table 1 (if applicable).

Table 1 Test items

Table 1 Test items		
Standard cycle	Non-road steady cycle (NRSC)	Gaseous pollutants
		Particulate matter (PM)
		Number of particles (PN ¹)
		Ammonia (NH ₃) concentration ²
		CO ₂
	Non-road transient cycle (NRTC) ⁵	Gaseous pollutants
		Particulate matter (PM)
		Number of particles(PN)
		Ammonia (NH ₃) concentration ²
CO ₂		
Non-standard cycle ⁶	Steady single point test	Gaseous pollutants
		Particulate matter (PM)
Durability		
NO _x control ^{2, 3}		
PM control ⁴		
Precious metal detection		
¹ PN measurement suited to 37kW<P _{max} <560kW diesel engines		
² Test items requiring use of reactant aftertreatment system;		
³ Test items requiring use of EGR system;		
⁴ Test items requiring use of particulate matter aftertreatment system;		
⁵ Does not apply to Pmax < 19 kW single-cylinder diesel engines;		
⁶ Applies to diesel engines with electronic fuel injection systems.		

5.3 Standard cycle emission requirements

5.3.1 Machinery equipped with diesel engines with a rated net power of 37 kW—560 kW shall be equipped with a wall-flow diesel particulate trap (DPF) or a more efficient particulate control device. When testing in accordance with the test procedures in GB 20891—2014 Addendum B and Addendum B of the present Standards, the number of particles shall be measured at the same time and the result multiplied by the degradation coefficient. This shall not exceed the limit specified in GB 20891—2014 Amendment Table 2. At the same time, it shall be ensured that no smoke is visible during regeneration of DPF.

5.3.2 When testing in accordance with GB 20891—2014 Addendum B and the test procedures of Addendum B of the present Standards, the diesel engine CO₂ emissions and fuel consumption level shall be simultaneously measured, and the measurement results recorded.

5.3.3 When testing in accordance with GB 20891—2014 Addendum B and the test procedures of Addendum B of the present Standards, if any reactant is used, the manufacturer shall ensure that the average emission value of NH₃ by the diesel engine in the NRTC and NRSC cycles does not exceed the limit requirements in GB 20891-2014 Amendment Table 2.

5.4 Non-standard recycling emission requirements

5.4.1 The non-standard cycle emission requirements shall apply to all diesel engines with electronic control fuel systems used in machinery.

5.4.2 According to the non-standard cycle emission requirements specified in Addendum B, the non-standard cycle emission test requirements shall be carried out after completing the steady-state test working conditions.

5.4.3 At least 3 random load and speed points shall be selected in the non-standard cycle discharge area for testing, and the operating sequence of the above test points shall be randomly determined. Tests shall be carried out in accordance with the requirements of the non-road steady cycle, but the specific emission of various pollutants (excluding PN) shall be calculated separately for each test point, and the specific emission at each test point shall not exceed 2 times the limit value of GB 20891-2014 Amendment Table 2.

5.5 Durability requirements

5.5.1 In addition to meeting the durability requirements of GB 20891—2014 Addendum BD, it shall also be necessary to meet the durability requirements of 5.5.2—5.5.4.

5.5.2 In the process of determining the degradation coefficient or the degradation correction value, the rated net power and maximum net torque of each test node shall meet the requirements of Addendum B.2.

5.5.3 The use of one of the two test cycles of GB 20891—2014 No. B.3.8.1 and B.3.8.2 (hot start cycle only) shall be permitted at each time node to determine the deterioration coefficient or the deterioration correction value, and the other test cycle shall require that an emission test be conducted at the beginning and end of the durability test. The determined degradation coefficient or degradation correction value shall apply to the two cycles, and no pollutant emission at any node in the durability test shall exceed the limit specified in GB 20891—2014 Table 2. Only a non-road steady cycle shall be required for a constant-speed diesel engine.

5.5.4 Diesel engine manufacturers shall be permitted to choose the deterioration coefficient specified in Table 2 as a substitute durability deterioration coefficient. The specific emissions of various pollutants shall be multiplied by the deterioration coefficients determined in Table 2, and the results shall not exceed the limits specified in GB 20891—2014 Table 2. For models that have passed type testing using the degradation coefficient specified in Table 2, if the manufacturer submits a written application, within one year of the application, it shall be permissible to use actual measurement to determine the deterioration coefficient or deterioration correction value, to substitute this for the deterioration coefficient in Table 2, and to change the type testing report.

Table 2 Specified degradation coefficient of each pollutant

Pollutant	CO	HC	NO _x	PM	PN	NH ₃
Specified degradation coefficient	1.3	1.3	1.15	1.05	1.0	1.0

5.6 NO_x Requirements for control measures and particulate matter control measures

5. 6.1 Machinery manufacturers shall provide detailed information to fully describe the functional characteristics of the emission control system.

5. 6.2 If the emission control system uses reactants, the machinery manufacturer shall specify the characteristics of the reactants, including type, concentration, and operating temperature.

5. 6.3 Machinery manufacturers shall ensure that the emission control system is capable of maintaining its emission control function under all normal conditions, especially under low temperature conditions.

5. 6.4 If a reactant tank is used in machinery, the reactant tank shall be readily accessible and permit ready sampling.

5.6.5 Diesel engine manufacturers shall:

- a) Provide written diesel engine maintenance instruction materials to machinery manufacturers;
- b) Provide diesel engine installation documents to machinery manufacturers, including installation documents for the emission control system as a component of the diesel engine;
- c) Provide machinery manufacturers with explanatory materials for driver warning systems, driving performance limitation systems, and reactant antifreeze systems (if applicable);

Ensure that the requirements of the relevant installation documents, driver warning system, driving performance limitation system and reactant antifreeze system in Addendum C and Addendum D of the present Standards are met.

5. 6.6 NO_x The normal operation of the control measures (if applicable) shall meet the requirements of Addendum C, and be tested and verified in accordance with the provisions of Addendum C. Companies shall be permitted to adopt stricter control strategies than Addendum C.

5. 6.7 The normal operation of particle control measures (if applicable) shall meet the requirements of Addendum D, and be tested and verified in accordance with the provisions of Addendum D. Companies shall be permitted to adopt stricter control strategies than those of Addendum D.

5. 6. 8 NCD and PCD information shall be acquired by means of a general diagnostic instrument, and the communication protocol shall satisfy at least one of the following standard protocols.

- a) ISO 27145 (based onCAN)based on ISO 15765—4 ;
- b) ISO 27145 (based onTCP/IP)based on ISO 13400 ;
- c) SAE J1939—73;
- d) ISO 15031.

5.7 Machinery technical requirements

5. 7.1 When a machinery manufacturer installs a diesel engine on a machine, they shall strictly follow the installation requirements specified in Chapter 6, and when performing verification in the actual operation process in accordance with Addendum E and GB 36886—2018, the corresponding technical requirements shall still be met.

5. 7.2 The emission control diagnostic system shall provide standardized interfaces and unrestricted access (limited to reading), and shall comply with the provisions of D.8.2, D.8.4, D.8.5, D.8.6 in HJ 437—2008. The diagnostic interface shall be in a location that is easy to find and access. If the diagnostic interface is in a specific equipment box, the door of the box shall open manually without tools, and the box shall be clearly marked "Emission Control Diagnostic System" to identify the diagnostic interface. If it is impossible to satisfy the above requirements in the structure of the cab, the use of an alternative location shall be permitted, provided such is readily accessible and accidental damage is prevented under normal use conditions. The machinery manufacturer shall disclose information on the alternative location.

5. 7.3 Tampering with the emission control system shall be prohibited. The machinery manufacturer shall be

responsible for preventing tampering with the emission control diagnosis system and emission control unit of the machine, and the machine shall have an anti-tampering function. If tampering occurs, the machinery manufacturer shall determine the reason, explain it to the competent Department of Ecology and Environment, provide a feasible tamper-proof technical solution, and take corresponding remedial measures in the production of new machinery.

5.7.4 Machinery equipped with a diesel engine with a rated net power of 37 kW or higher shall be equipped with a satellite navigation precision positioning system before leaving the factory, and shall meet the requirements of 5.7.7. Machinery manufacturers shall adopt necessary technical measures to achieve accurate positioning of the machinery by means of the satellite navigation precision positioning system during operation throughout its full service life. The positioning system shall meet the requirements of Addendum H. The manufacturer shall ensure that the machine transmits positioning information data according to the requirements of Addendum H. The competent Department of Ecology and Environment shall be permitted to perform positioning function inspections of the satellite navigation precision positioning system when inspecting the compliance of newly produced machinery and in-use compliance.

5.7.5 Construction machinery equipped with a diesel engine with a rated net power of 37 kW or more (if equipped with an SCR aftertreatment system, there shall be at least an NO_x sensor downstream from the SCR) shall be equipped with an on-board terminal system before leaving the factory, and shall meet the requirements of section 5.7.7. The machinery manufacturer shall adopt necessary technical measures to ensure that data is transmitted during operation over the full life of the machine according to the requirements of Addendum H. When conducting a compliance inspection of a newly produced machine or an in-use compliance inspection, the competent authority shall be permitted to perform a read of the uploaded information of Table H.7 with a general diagnostic instrument.

5.7.6 Exhaust emissions of 37 kW and above machinery shall be measured in accordance with the test procedures of Addendum E. Specific emissions of CO and NO_x in an effective work base window of 90% shall not exceed 2.5 times the power segment limit corresponding to GB 20891—2014 Table 2 (the NO_x specific emission of diesel engines with a rated net power of less than 56 kW shall be 2.5 times the HC+NO_x limit for that power segment). For constant speed and 560 kW and above machinery, the cumulative specific emissions shall be used to calculate pollutant emissions. Similarly, the specific emissions of CO and NO_x shall not exceed 2.5 times the power segment limit corresponding to GB 20891—2014 Table 2.

5.7.7 Machinery manufacturers shall possess anti-dismantling technical measures for vehicle-mounted terminals and precision positioning systems to ensure that vehicle-mounted terminals and precision positioning systems are not maliciously removed. When an on-board terminal and a precision positioning system malfunction or are removed, the machinery shall activate an alarm system and send a removal alarm to the management platform to the extent such is possible in accordance with the requirements of Tables H.2 and H.10. Alarm information shall include the dismantling status, dismantling time, and position latitude and longitude information. A system different from NCD or PCD may be employed in the alarm system.

5.7.8 The machinery manufacturer shall ensure that on-board terminals and precision positioning systems operate normally over the full life of the machinery.

5.8 Emission warranty period regulations

5.8.1 Machinery manufacturers shall ensure that the materials, manufacturing processes and product quality of emission-related parts and components are capable of ensuring normal functioning over the effective life of the machinery.

5.8.2 Under conditions of proper use by the user, if emission-related parts and components fail or are damaged due to quality problems of the parts and components during the warranty period, causing the emission control system to malfunction, or the emissions exceed the requirements of the present Standards, the machinery manufacturer shall adopt measures in accordance with Atmospheric Pollution Prevention and Control Law and other relevant legal requirements.

5.8.2.1 The machinery manufacturer shall clearly instruct the user to properly use and maintain the machine in accordance with the proper use and maintenance guide (manual) of the machinery, and to add oil and reactant in compliance with the provisions of the instructions and maintenance guide (manual).

5.8.2.2 The user shall employ an oil and reactant that meet standard requirements.

5.8.2.3 When it can be demonstrated that the breakdown of or damage to an emissions-related part or component has been caused by improper use or maintenance by the user, the manufacturer shall not be held liable under the relevant warranty.

5.8.3 The company shall make a commitment to providing emission-related components during the emission warranty period, which shall be no shorter than the period specified in Table 3, whichever shall expire first.

Table 3 Requirements for key environmental protection components during the emission warranty period

Diesel engine power segment (kW)	Rotational speed	Quality period ¹	
		Time (hours)	Years (years)
$P_{\max} \geq 37$	Any speed	3000	5
$19 \leq P_{\max} < 37$	Non-constant speed		
	Constant speed <3000		
	Constant speed >3000	1500	2
$P_{\max} < 19$	Any speed	1500	2

¹ Warranty period is calculated from the date of sale.

5.8.4 When the information is disclosed, the list of emission-related parts and their corresponding warranty periods shall be disclosed, and the above information shall be explained in the product manual.

6 Installation on machinery

6.1 For machinery within the scope of the present Standards, machinery manufacturers shall ensure that the state of the diesel engine as installed on the machine is exactly the same as the state of the diesel engine during type testing; companies shall not make any adjustments to the diesel engine.

6.2 The intake pressure drop shall not exceed the pressure drop specified in GB 20891—2014 Addendum A for diesel engines that have been type tested;

6.3 Exhaust back pressure shall not exceed the back pressure specified in GB 20891—2014 Addendum A for diesel engines that have been type tested;

6.4 The power absorbed by the auxiliary parts required for the operation of the diesel engine shall not exceed the power absorbed by the auxiliary parts specified in GB 20891—2014 Addendum A for diesel engines that have been type tested.

6.5 The characteristics of the exhaust gas aftertreatment system shall be consistent with those in the diesel engine type testing in GB 20891—2014 Addendum A.

6.6 For diesel engines that undergo type testing as an independent technical assembly, when installed on machinery, the emission control diagnostic system shall meet the requirements of the diesel engine manufacturer.

7 Newly produced machinery (diesel engine) emission compliance requirements and inspection

7.1 General requirements

7.1.1 Machinery manufacturers shall adopt measures to ensure production consistency in accordance with the requirements of Addendum F.

7.1.2 The production consistency inspections shall be carried out based on the information disclosure materials in Addendum A and GB 20891—2014 Addendum A].

7.1.3 The machinery used for the test shall be randomly selected, and the machinery manufacturer shall not make any adjustments to the selected machinery (including updating of ECU software).

7.1.4 In principal, machinery shall not be broken in. At the request of the machinery manufacturer, breaking in shall be permitted according to the breaking-in specifications, but this shall not exceed 5h, and no adjustments shall be made to the sampled machinery.

7.2 Self-inspection for compliance of new production machinery (diesel engine)

7. 2.1 Machinery manufacturers shall formulate procedures for conducting self-inspections for emission compliance of newly produced machinery by family, including self-inspection items, self-inspection methods, sampling methods, and sampling ratios, and shall disclose the self-inspection plans and self-inspection results.

7. 2.2 The self-inspection of machinery emissions shall be carried out in accordance with the provisions of Addendum E of the present Standards and GB 36886—2018.

7. 2.3 Machinery manufacturers shall keep detailed records and archives of machinery self-inspection tests; these record files shall be kept for at least 5 years. A competent Department of Ecology and Environment shall be permitted to check the test records as needed.

7. 2.4 Machinery manufacturers shall not be required to conduct self-inspection of every mechanical family, but a self-inspected mechanical family shall be sufficiently representative to ensure that other families also meet the standards. When disclosing information, a manufacturer shall conduct a reasonable engineering evaluation of the emission performance of each family under reasonable operational and applicable environmental conditions, and also declare that other machinery families also comply with the requirements of 5.7.6 of the present Standards.

7. 2.5 If it is difficult to conduct self-inspection of the machinery before leaving the factory, the reasons shall be explained. It shall be permissible for the self-inspection of newly produced machinery to be carried out during a period of use not exceeding 500 h, and an explanation shall be provided to a competent Department of Ecology and Environment.

7. 2.6 Newly produced diesel engines shall be subject to self-inspection of emission standards in accordance with the sampling and methods specified in GB 20891-2014 Section 6.2 and the test items specified in Section 5.2 of the present Standards.

7.3 Supervision and spot checks of compliance of newly produced machinery (diesel engines)

It shall be permissible for the supervision and random inspection of newly produced machinery by a competent Department of Ecology and Environment to include all or some portion of the following items.

7. 3.1 Verification of basic emission configuration

When verifying the basic emission configuration, if the key components or emission control strategies of the machine being inspected are inconsistent with the content of the information disclosure, that model shall be deemed to have failed the inspection.

7.3.2 Inspection of company's self-examination

The self-inspection plans, self-inspection process, self-inspection records and self-inspection results of machinery manufacturers shall be inspected.

7.3.3 Functional inspection of emission control strategy

Three units shall be randomly selected from mass-produced machinery. If two or more units meet the requirements of Addendum C (if applicable) and Addendum D (if applicable), the inspection shall be deemed to have been passed. If the diagnostic system of one or more units cannot be accessed effectively, or it is discovered that no diagnostic interface is present, the inspection shall be deemed to have been failed.

7.3.4 Pollutant discharge inspection

7. 3. 4.1 Spot checks of machine emissions shall be conducted.

7. 3. 4. 2 In a pollutant emissions inspection, an emissions test shall be conducted in accordance with the requirements of Addendum E or GB 36886—2018.

7. 3 . 4. 3 When conducting an emissions test on machinery according to Addendum E, three units shall be randomly selected from mass-produced machinery. If the pollutant specific emissions of the 3machines do not exceed 1.1 times the requirements of 5.7.6, and the average value does not exceed the requirements of 5.7.6, the environmental protection conformity inspection shall be deemed to have been passed; if the discharge results for two pollutants exceed 1.1 times the requirements of 5.7.6 for any one of the 3 machines, or the average value exceeds the requirement of 5.7.6, the environmental protection consistency inspection shall be deemed to have been failed.

7.3.4.4 When conducting an emissions test on machinery according to GB 36886—2018, three units shall be randomly selected from mass-produced machinery. If two or more units satisfy the requirements of the type II limits of GB 36886—2018, the test shall be deemed to have been passed; otherwise, it shall be deemed to have been failed.

7. 3.5 Supervision and random inspection of newly produced diesel engines

Supervision and random inspection of newly produced diesel engines shall be conducted according to the provisions of Chapter 6 of GB 20891-2014.

7.4 Factory inspection of newly produced machinery

It shall be ensured that newly produced machinery meets the requirements of category limits II in GB 36886—2018 Table 1 before leaving the factory.

8 In-use compliance requirements and inspection

8.1 General requirements

8.1.1 For machinery or diesel engines within the scope of the present Standards, measures shall be taken to ensure in-use compliance.

8.1.2 The technical measures adopted by a machinery manufacturer shall ensure that the exhaust pollutant emissions of the machinery can be effectively controlled under normal use conditions throughout the entire life cycle.

8.1.3 If an in-use compliance spot check is failed, the in-use compliance inspection shall be deemed to have been failed, and the relevant durability requirements shall be deemed to have been unmet.

8.2 In-use compliance inspections

In-use conformity shall be inspected under conditions of normal use and during the effective life in accordance with the provisions of Addendum G of the present Standards. The in-use conformity inspection shall include the self-inspection by a machinery and diesel engine manufacturer as specified in 8.2.1, and the supervision and random inspection by the Department of Ecology and Environment specified in 8.2.2.

8.2.1 Self-inspection by manufacturer

8. 2.1.1 Within 18 months following the first sale of machinery on which a diesel engine has been installed, the diesel engine manufacturer shall formulate an in-use compliance self-inspection plan, and disclose information on the self-inspection plan and self-inspection results. An in-use compliance self-examination by a diesel engine manufacturer shall be conducted on the basis of a diesel engine family. It shall not be necessary to conduct a self-examination of every family, but the family that is self-examined shall be sufficiently representative to ensure that the other families also meet the standards.

8. 2.1.2 The machinery manufacturer shall also formulate an in-use compliance self-inspection plan. The self-inspection plan shall be based on the machinery family. It shall not be necessary to conduct a self-examination of every family, but the family that is self-examined shall be sufficiently representative to ensure that the other families also meet the standards. When disclosing information, the manufacturer shall conduct a reasonable engineering evaluation of the emission performance of each family under reasonable operation and applicable environmental conditions, and declare that the other machinery families also comply with the requirements of 5.7.6 of the present Standards.

7. 2.1.3 The in-use compliance self-inspection plan shall include a test schedule, sampling plan, etc., and shall be prepared in accordance with the requirements of GB 20891—2014 Addendum A and Addendum A of the present Standards for supervision and inspection by a competent Department of Ecology and Environment.

8. 2.1.4 A diesel engine manufacturer shall conduct in-use compliance self-inspection according to the self-inspection plan, and shall select machines from different machinery manufacturers for testing to the extent possible. The information in the in-use compliance self-inspection report of the diesel engine family shall be disclosed and shall be permitted to serve as part of the in-use compliance self-inspection report by the machinery manufacturer.

8. 2.1.5 A machinery manufacturer shall conduct an in-use conformity self-inspection according to the self-inspection plan, and shall disclose the information in the self-inspection report on in-use conformity of the machinery.

8. 2.2 Supervision and spot checks by a competent Department of Ecology and Environment

8. 2.2.1 A competent department shall be permitted to supervise and spot check the in-use compliance of a certain engine model (diesel engine family) in accordance with the in-use compliance test procedures specified in Addendum G, and record purchase, maintenance, and manufacturer participation information.

8. 2.2.2 A competent department shall be permitted to perform functional inspection of vehicle terminals.

8. 2.2.3 If the competent department confirms that a certain engine model (diesel engine family) does not meet the requirements of the present Standards, the manufacturer shall take corrective measures in accordance with the provisions of 8.2.3 of the present Standards and Addendum G.5.

8.2.2.4 A competent environmental authority shall randomly select three units of machinery, and if the test results of two or more units satisfy the requirements of the type II limits of GB 36886—2018, the test shall be deemed to have been passed; otherwise, it shall be deemed to have been failed.

8.2.3 Non-compliance rectification measures

8. 2. 3.1 The manufacturer shall submit a rectification measure plan as required and implement it as planned.

8. 2. 3. 2 The rectification measures shall be applied to all diesel engines or machinery in use belonging to the same machinery (family), and be extended to diesel engine models (family) and machinery (family) that may be affected by the same defect at the manufacturer.

8. 2. 3. 3 The manufacturer shall keep the environmental protection recall, maintenance or modification records of each machine or diesel engine for at least 10 years.

9 Machinery environmental information labels

9.1 During manufacturing or before importing, the machinery manufacturer shall affix a machinery environmental protection information label to each unit of machinery, and the label shall meet the following requirements:

- a) It shall be impossible to remove the label without damaging the label or compromising the appearance of the machine;
- b) It shall remain clear and easy to read during the entire life of the machine;
- c) The parts for affixing the environmental protection information label on the machinery shall generally not need to be replaced during the entire life of the machinery;
- d) The location of the label shall be clearly visible.

9.2 The machinery environmental information label shall also satisfy the other requirements of Addendum I.

9.3 On a tri-wheeled vehicle, a list of the motor vehicle environmental protection information accompanying vehicles in accordance with the *Announcement on launching environmental protection information disclosure work for motor vehicles and machinery* (Guo-Huan-Gui-Da-Qi (2016) No. 3) shall be implemented.

10 Family

10.1 Machinery family

Machines simultaneously meeting the following conditions shall be regarded as belonging to the same mechanical family:

- a) The machines are manufactured by the same manufacturer;
- b) The engines belong to the same family; and
- c) The machines are of the same type—e.g. Excavators, loaders, forklifts, tractors, corn harvesters, etc.

10.2 Diesel engine families

When determining a diesel engine family, in addition to meeting the requirements of Chapter 8 of GB 20891-2014, the following conditions shall also be met.

10. 2. 1 Electronic control strategy

Whether an electronic control unit (ECU) is present shall be a basic parameter of a diesel engine family. For electronically controlled diesel engines, the manufacturer shall provide technical points explaining why a group of diesel engines has been placed in the same family, that is, why the group of diesel engines meets the same emission requirements. It shall be possible for the technical points to be calculations, simulations, estimations, descriptions of injection parameters, test results, etc.

Examples of control characteristics:

- a) Timing
- b) Fuel injection pressure
- c) Multi-point injection
- d) Pressurization
- e) VGT
- f) EGR

10. 2.2 Exhaust aftertreatment system

The functions and combinations of the following devices shall be the standards for members of the same diesel engine family:

- a) Oxidation catalyst
- b) Three-way catalytic converter
- c) DeNO_x and selective reduction NO_x (additional reducing agent)
- d) Other deNO_x systems
- e) Passive regenerative particulate matter trap
- f) Active regeneration particulate trap
- g) Other particulate matter traps
- h) Other devices

Addendum A
(Normative Addendum)
Type testing materials

A.1 Summary

The following materials shall be provided for machinery, and the information shall be disclosed by the machinery manufacturer or importer.

A.2 Basic information

A. 2.1 Machine model:

A. 2.2 Name of machine:

A. 2.3 Machine environmental protection code or vehicle identification number (VIN):

A. 2.4 Production date:

A.2.5 Trademark:

A. 2.6 Machine family:

A. 2.7 Machine category:

A. 2 . 8 Discharge stage:

A. 2 . 9 Machinery identification method and position:

A. 2 . 10 Location of machinery environmental protection information label:

A. 2. 11 Machine environmental protection code or VIN number marking position:

A. 2 . 12 Diagnostic interface location:

A. 2 . 13 Name of company that produced machinery:

A. 2 . 14 Address of machinery manufacturer:

A. 2.15 Name and address of legal entity of machinery manufacturer:

A. 2 . 16 Name of machinery import company (if applicable):

A. 2 . 17 Address of machinery import company (if applicable):

A. 2 . 18 Name and address of legal entity of machinery import company (if applicable):

A.3 Attached documents

A. 3.1 Basic characteristics of key components or systems relating to pollutants emitted by machinery (if applicable)

A. 3.2 Emission control strategy information

A. 3 . 2 . 1 The manufacturer or importer of machinery or diesel engines shall organize into a document package any machinery technical points that affect emissions, diesel engine emission control strategies, anti-tampering measures, methods for diesel engine systems to directly or indirectly control emissions-related variables, and detailed descriptions of the driver warning system and driving performance limitation system required by Addendum C and Addendum D. It shall be possible for the documentation package to comprise two parts:

- a) Official documents: Items to be disclosed to the competent Department of Ecology and Environment, which it shall be possible to provide to related parties as needed.
- b) Extended documents: Items to be kept secret. Extended documents shall be disclosed to the

competent Department of Ecology and Environment or kept by the machinery manufacturer; it shall be ensured that these documents can be inspected at any time when confirming the validity of the type testing.

A.3.2.2 The documents shall describe the functional operation of the driving performance limitation system required by Addendum C and Addendum D, including parameters required to retrieve system-related information. This material shall be disclosed to the competent Department of Ecology and Environment.

A.3.2.3 The extended documentation package shall include explanations of all auxiliary emission control strategies (AECS) and basic emission control strategy (BECS) operating information, including instructions for AECS revised parameters, AECS working boundary conditions, possible start AECS and BECS instructions, etc. The extended documents shall also include descriptions of the control logic of the fuel system, timing strategy and switching points during all operating conditions. They shall also include a complete description of the driving performance limitation system required in Addendum C and Addendum D, including relevant monitoring strategies.

A.3.2.4 A self-inspection plan for newly produced machinery compliance formulated in accordance with 7.2.1.

A.3.2.5 An in-use compliance self-inspection plan formulated in accordance with 8.2.1.1.

A.3.3 For diesel engine models or families undergoing type testing as an independent technical assembly, the following materials shall also be submitted:

- a) An explanation of provisions to prevent tampering and modification of the emission control electronic unit, including preventing the updating of equipment approved or calibrated by the machinery manufacturer;
- b) According to the production consistency assurance plan specified in GB 20891-2014 Addendum G;
- c) Other type testing documents (if applicable) used to extend the type testing or determine the deterioration coefficient.

A.3.4 See GB 20891—2014 Appendix FA and Appendix AA of the present Standards for the format of the type testing report.

A.3.5 See Appendix AB for the self-inspection report of newly produced machinery compliance and in-use conformity self-examination.

A.3.6 See Appendix AC for requirements of key emission parts and components.

A.3.7 For machines with multiple operating modes, technical documents shall be provided to explain the application characteristics of each operating mode.

A.3.8 List of other ancillary documents (if applicable).

Appendix AA
(Normative appendix)
Type testing report format

Type testing report type:

- ☐ Inspection report of source model type within diesel engine family
- ☐ Type testing report of each diesel model in the diesel engine family
- ☐ Type testing report on machinery equipped with diesel engine that has not been type inspected

AA.1 Part 1

AA.1.1 Brand (trademark of the manufacturer):

AA. 1.2 Model number:

AA.1.3 Name of manufacturer:

AA.1.4 Machine (or model) identification method and location (such as marking on the machine):

AA.1.5 Position and method of affixing label:

AA.1.6 The name and address of the assembly plant:

AA.1.7 The name and address of the legal entity of the production enterprise (if applicable):

AA.2 Part 2

AA.2.1 Additional information (if applicable):

AA.2.2 Inspection agency responsible for testing:

AA. 2. 3 Test report date:

AA. 2 . 4 Test report number:

AA. 2 . 5 Remarks (if applicable):

AA. 2 . 6 Date:

AA.3 Test report of inspection agency

AA. 3.1 Information relating to mechanical type testing of diesel engine

AA. 3. 1. 1 Brand of diesel engine (name of diesel engine manufacturer):

AA. 3. 1. 2 Type and product description (referring to various variants):

AA. 3. 1. 3 Diesel engine manufacturer code on diesel engine:

AA. 3. 1.4 Category: Diesel

AA.3.1.5 Name and address of diesel engine manufacturer:

AA. 3. 1. 6 Name and address of authorized representative of diesel engine manufacturer (if applicable):

AA. 3.2 The diesel engine mentioned in AA.3.1 as an independent technical assembly for type testing

AA. 3 . 2 . 1 Diesel engine/diesel engine family type testing number:

AA. 3. 2. 2 Diesel engine control unit (ECU) software calibration number:

AA. 3 . 3 Detailed instructions relating to the diesel engine (or family) type testing as an independent technical assembly (the mechanical installation conditions of the diesel engine shall also be considered)

AA. 3 . 3 . 1 Maximum and (or) minimum intake resistance:

AA. 3. 3. 2 Maximum allowable exhaust back pressure:

AA. 3. 3. 3 Exhaust system volume:

AA. 3. 3. 4 Limiting conditions (if present):

AA. 3. 3. 5 Aftertreatment installation position (position in the exhaust pipe and reference distance):

AA. 3. 4 Diesel engine/source engine emission level

Deterioration coefficient or deterioration correction value (DF): Calculated/set value

See the following tables for NRSC or NRTC test deterioration coefficient or deterioration correction value (DF) and emission value.

AA. 3. 4. 1 For NRSC test cycle emission results, see Table AA.1

Table AA. 1 NRSC Test cycle emission results

Pollutant	CO	HC	NO _x	PM	PN	NH ₃
DF value						
Pollutant	CO (g/kW·h)	HC (g/kW·h)	NO _x (g/kW·h)	PM (g/kW·h)	PN (#/kW·h)	NH ₃ (ppm)
Test results						
K _{r,u} multiplied/added ¹						
K _{r,d} multiplied/added						
DF Correction results						
CO ₂ Emissions: g/kW·h						
Fuel consumption: g/kW·h						

AA. 3. 4. 2 NRTC For test cycle emission results, see Table AA.2.

Table AA. 2 NRTC Test cycle emission result

Pollutant	CO	HC	NO _x	PM	PN	NH ₃
DF value						
Pollutant	CO (g/kW-h)	HC (g/kW-h)	NO _x (g/kW-h)	PM (g/kW-h)	PN (#/kW · h)	NH ₃ (ppm)
Cold start						
Hot start without regeneration						
Hot start with regeneration						
K _{r,u} multiplied/added ¹						
K _{r,d} multiplied/added						
Weighted test results						
DF correction results						
NRTCcycle work (kW · h)						
CO ₂ emissions: g/kW-h						
Fuel consumption: g/kW-h						

AA. 3. 4. 3 For emission results at non-standard cycle emission test points, see Table AA.3.

¹Those that do not apply shall be crossed out

Table AA.3 Emission results at non-standard cycle emission test points

Non-standard cycle emission test points						
Emission at test points	Diesel engine speed (rpm)	Load (%)	CO (g/kW · h)	HC (g/kW · h)	NO _x (g/kW · h)	PM (g/kW · h)
Test point1						
Test point2						
Test point3						

AA. 3 . 4. 4 Power measurement

AA. 3. 4. 4. 1 For diesel engine power test on a test bench, see TableAA.4.

Table AA . 4 Diesel engine power test on a test bench

Measured diesel engine speed (rpm)										
Measured fuel flow rate (g/h)										
Measured torque (Nm)										
Measured power (kW)										
Atmospheric pressure (kPa)										
Water vapor partial pressure (kPa)										
Intake air temperature (K)										
Power correction factor										
Corrected power (kW)										
Accessory power (kW)										
Maximum net power (kW)										
Maximum net torque (Nm)										
Corrected fuel consumption (g/kW · h)										

AA. 3. 4. 4. 2 Additional data

AA. 3. 4. 5 For source engine NRSC test cycle emission results, see Table AA.5

AA.5 NRSC test cycle emission results

Pollutant	CO (g/kW · h)	HC (g/kW · h)	NO _x (g/kW · h)	PM (g/kW · h)
Test results				

AA. 3. 4. 6For source engine NRTC test cycle emission results, see Table AA.6

AA.6 NRTC Test cycle emission results

Pollutant	CO (g/kW · h)	HC (g/kW · h)	NO _x (g/kW · h)	PM (g/kW · h)
Test results				

Appendix AB
(Normative appendix)
In-use compliance self-inspection report

AB.1 General requirements

- AB.1.1 Name and address of machinery manufacturer
- AB.1.2 Assembly factory address
- AB.1.3 Name, address, telephone number, fax number, and email address of machinery manufacturing plant
- AB.1.4 Type and commercial use description (involving various variants)
- AB.1.5 Diesel engine family
- AB. 1. 6 Source engine
- AB.1.7 Diesel engine family members/machinery family members
- AB.1.8 Machinery environmental protection code or VIN number
- AB.1.9 Location and marking method of identification plates and nameplates
- AB.1.10 Diagnostic interface location
- AB.1.11 Category of machinery
- AB.1.12 Machinery family
- AB. 1. 13 Fuel type
- AB. 1. 14 Number of type testings applicable to this engine mode/machinery; when applicable, further include all extensions and maintenance/numbers of recall areas
- AB.1.15 Detailed information on diesel engine/machinery type testing extensions, maintenance/recall areas provided by machinery manufacturer
- AB. 1. 16 When diesel engine/machinery manufactured

AB.2 Diesel engine/machinery selection

- AB. 2. 1 Method of installation of machinery or diesel engine
- AB. 2. 2 Machinery, machinery family, diesel engine, diesel engine family selection standards
- AB. 2. 3 Geographic area of machinery manufacturer calling for testing of machinery

AB. 3 Equipment

- AB. 3. 1 PEMS Equipment, trademark and model
- AB. 3. 2 PEMS Equipment calibration
- AB. 3. 3 PEMS Equipment power supply
- AB. 3. 4 Data analysis software and version number
- AB. 3. 5 Smoke device, trademark, model
- AB. 3. 6 Smoke device calibration

AB. 4 Test data

- AB. 4. 1 Test date and time
- AB. 4. 2 Detailed information on test points and route
- AB. 4. 3 Environmental conditions (such as temperature, humidity, altitude)
- AB. 4. 4 Test conditions for each machine

- AB. 4. 5 Technical parameters of test fuel
- AB. 4. 6 Technical parameters of reactants (if applicable)
- AB. 4. 7 Technical parameters of lubricants
- AB. 4. 8 Results of emission test conducted in accordance with Addendum E
- AB. 4. 9 Results of emission test conducted in accordance with GB 36886—2018

AB. 5 Diesel engine information

- AB. 5. 1 Information disclosure number
- AB. 5. 2 Diesel engine manufacturer
- AB. 5. 3 Diesel engine model number
- AB. 5. 4 Diesel engine manufacturing date
- AB. 5. 5 Diesel engine number
- AB. 5. 6 Diesel engine displacement (L)
- AB. 5. 7 Number of cylinders
- AB. 5. 8 Rated net power of diesel engine (kW rpm)
- AB. 5. 9 Maximum torque of diesel engine (Nm rpm)
- AB. 5. 10 Idle speed (rpm)
- AB. 5.11 Effective full load torque curve provided by diesel engine manufacturer (Yes/No)
- AB. 5.12 Reference values of effective full load torque curve provided by diesel engine manufacture
- AB. 5. 13 Type of NO_x reduction system (eg: EGR, SCR)
- AB. 5. 14 Catalytic converter type (such as: DOC)
- AB. 5. 15 Type of particulate matter trap (such as: DPF)
- AB. 5. 16 Aftertreatment system installation location:
- AB. 5. 17 Information on diesel engine ECU (software calibration number)
- AB. 5. 18 Work done in non-road transient cycle (NRTC) in hot state

AB. 6 Machinery information

- AB. 6.1 Owner
- AB. 6. 2 Category
- AB. 6. 3 Machinery manufacturer
- AB. 6. 4 Machinery environmental protection code or VIN number
- AB. 6. 5 Registration number and place of registration (if applicable)
- AB. 6. 6 Machinery model number
- AB. 6. 7 Manufacturing date
- AB. 6. 8 Discharge stage
- AB. 6. 9 Gearbox type (if applicable)
- AB. 6.10 Machinery application
- AB. 6.11 Diesel engine running time before start of test (h)
- AB. 6.12 Maximum total design mass of machinery (kg)
- AB. 6.13 Exhaust pipe diameter (mm)
- AB. 6.14 Fuel tank volume (L)
- AB. 6. 15 Number of fuel tanks

AB. 6.16 Volume of reactant tank (L) (if applicable)

AB. 6.17 Number of reactant tanks (if applicable)

AB. 7 Characteristics of test conditions

AB. 7.1 Duration (s)

AB. 7.2 Average environmental conditions (calculated based on instantaneous measurement data)

AB. 7.3 Environmental condition sensor information (type and sensor location)

AB. 7.4 Ineffective work incident ratio

AB. 8 Instantaneous measurement data

AB. 8.1 NO_x Concentration (ppm)

AB. 8.2 CO Concentration (ppm)

AB. 8.3 CO₂ Concentration (%)

AB. 8.4 Exhaust flow (kg/h or L /min)

AB. 8.5 Exhaust temperature (°C)

AB. 8.6 Ambient temperature (°C)

AB. 8.7 Ambient atmospheric pressure (kPa)

AB. 8.8 Ambient humidity (g/kg or %)

AB. 8.9 Diesel engine torque (Nm)

AB. 8.10 Diesel engine speed (rpm)

AB. 8.11 Diesel engine fuel consumption rate (g/s)

AB. 8.12 Diesel engine coolant temperature (°C)

AB. 8.13 Latitude (°)

AB. 8.14 Longitude (°)

AB. 8.15 Altitude (m)

AB. 9 Instantaneous data calculation

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AB. 9.2 CO mass (g/s)

AB. 9.3 CO₂ mass (g/s)

AB. 9.4 NO_x cumulative mass (g)

AB. 9.5 CO cumulative mass (g)

AB. 9.6 CO₂ cumulative mass (g)

AB. 9.7 Calculated value of fuel consumption rate (g/s)

AB. 9.8 Diesel engine power(kW)

AB. 9.9 Diesel engine work (kW · h)

AB. 9.10 Duration of power base window (s)

AB. 9.11 Average power percentage of diesel engine in power base window (%)

AB. 10 Data averaging and integration

AB. 10.1 NO_x average concentration (ppm)

AB. 10.2 CO average concentration (ppm)

AB. 10.3 CO₂ average concentration (ppm)

AB. 10.4 Average exhaust mass flow rate (kg/h)

AB. 10 . 5 Average exhaust temperature (°C)

AB. 10.6 NO_x emissions (g)

AB. 10.7 CO emissions (g)

AB. 10.8 CO₂ emissions (g)

AB.11 Test result determination

AB. 11.1 The minimum, maximum, and 90th percentile in the effective work-based window

AB.11.1.1 Work-based window method NO_x emission results (g/kW-h)

AB. 11. 1. 2 Work-based window method CO emission results (g/kW · h)

AB. 11.2 Work-based window: Minimum and maximum average window power

AB. 11.3 Work-based window: Effective window percentage (%)

AB.11.4 Smoke measurement results (m⁻¹)

AB.12 Test confirmation

AB. 12.1 Before and after test, NO_x analyzer zero point, full scale and evaluations results

AB.12.2 Before and after test, CO analyzer zero point, full scale and evaluation results

AB.12.3 Before and after test, CO₂ analyzer zero point, full scale and evaluation results

AB.12.4 Smoke meter evaluation results before and after test

AB.13 More necessary appendices

AB. 13.1 Photo of test machinery after completion of mechanical loading and PEMS system installation (at least 2 photos)

AB. 13. 2 Electronic files recording original data of all emission tests.

Attachment AC
(Normative attachment)
Requirements for key emission components

AC. 1 Key emission components

AC. 1.1 Machinery and diesel engine components (if any) relating to the following systems, but not including components requiring regular replacement within effective life (such as: consumable parts such as filter elements):

AC. 1.1.1 Intake system

AC. 1.1.2 Fuel system

AC. 1.1.3 Exhaust gas recirculation system

AC. 1.2 Emission control related parts, but excluding the consumables required for DPF metal removal, ash maintenance operations, etc.

AC. 1.2.1 Aftertreatment device

AC. 1.2.2 Sensors

AC. 1.2.3 Electronic control unit

Addendum B
(Normative Addendum)
Bench test procedure

B.1 Summary

This addendum specifies the measurement methods of exhaust pollutants from machinery and diesel engines installed thereupon in the scope of application, including standard circulation and non-standard circulation. This addendum is an effective supplement to GB 20891—2014 Addendum 1 } B.

-- Non-road steady cycles (NRSC), including five working condition, six working condition and eight working condition cycles, shall apply to the measurement of stage IV diesel engine exhaust pollutants.

-- Non-road transient cycles (NRTC), including 1238 transient working conditions that change second to second, shall apply to the stage IV measurement of exhaust pollutants from 19 kW—560 kW non-constant speed diesel engines (excluding marine diesel engines) and non-constant speed multi-cylinder diesel engines of 19kW and below (excluding marine diesel engines).

B.2 Determination of dynamometer setting value

The setting values of the intake pressure drop and exhaust back pressure shall be adjusted to the upper limits specified by the diesel engine company in accordance with the provisions of GB 20891—2014 Section B.2.3 and Section B.2.4.

The power and torque curves at full load (except for constant-speed diesel engines and 4.5 kW and lower variable-speed diesel engines) shall be determined by testing to calculate torque values for the test working conditions specified under the net power state in accordance with the provisions of GB 20891—2014 Appendix AA.7.2. Used to examine whether the performance of the diesel engine being tested is consistent with the specifications of the diesel engine manufacturer. In diesel engine type testing, relative to the value specified by the diesel engine manufacturer, the difference in the speed of the diesel engine shall be within $\pm 1.5\%$, and the difference in the rated net power shall not exceed $\pm 2\%$ (for 37 kW or lower, this shall be $\pm 4\%$); the difference in maximum net torque shall not exceed $\pm 4\%$ (for 37 kW or lower, this shall be $\pm 8\%$). In a production consistency examination and durability test, relative to the value specified by the diesel engine manufacturer, the difference of the diesel engine speed shall be within $\pm 5\%$, and the difference between the rated net power and the maximum net torque shall not exceed $\pm 5\%$ (for 37 kW or lower, this shall be $\pm 10\%$). Diesel engines with overload power shall meet the requirements of GB/T 1147.1—2017 Standard 3.3.3. The setting value of the dynamometer under each test condition shall be calculated according to the following formula:

If the test is being conducted under the net power state:

$$S = P_{(a)} \times \frac{L}{100}$$

If the test is being conducted under non-net power state:

$$S = P_{(a)} \times \frac{L}{100} + (P_{(a)} - P_{(b)})$$

If $\frac{P_{(b)} - P_{(a)}}{P_{(n)}} \geq 0.03$, then the manufacturer shall provide a written description of the value of $(P_{(b)} - P_{(a)})$.

In the equation:

S—Dynamometer setting value, kW;

$P_{(n)}$ —Net power, kW, specified in GB 20891—2014 Appendix AA.7.2;

L— Load percentage, %, specified in GB 20891—2014 Addendum B.3.8.1;

$P_{(a)}$ —Power, kW, absorbed by auxiliary components installed, specified in GB 20891—2014 Appendix AA.5.1;

$P_{(b)}$ —Power, kW,, absorbed by auxiliary components to be removed, specified in GB 20891—2014 Appendix AA.5.2;

B. 3 Non-standard cycle emission test requirements

B. 3.1 The test shall be carried out as follows:

- a) This test shall be started after the end of the non-road steady cycle specified in GB 20891-2014 Addendum B.3.8;
- b) The test shall be conducted in accordance with the requirements of GB 20891—2014 Addendum B.3.8, and each test point shall be tested with a piece (pair) of filter paper;
- c) An emission value shall be calculated for each test point, g/kW-h;
- d) The same calculation method as for the non-read steady cycle shall be adopted to calculate the emission value;
- e) When calculating gaseous pollutants, the number of working conditions shall be set to 1, and the weighting factor shall be 1;
- f) When calculating particulate matter, the number of working conditions shall be set to 1, and the weighting factor shall be 1.
- g) The full load torque curve of non-standard cycle emission diesel engines shall be determined in accordance with the requirements of B.2.

B. 3.2 Diesel engine non-standard cycle emissions

B. 3 . 2 . 1 Requirements for non-standard cycle emissions of diesel engine with $P_{\max} \geq 19$ kW

Speed range: speed A to maximum speed;

Wherein:

$$A = n_{l0} + 15\% \times (n_{hi} - n_{l0}) ;$$

The high speed n_{hi} is the speed at maximum net power $P_{(n)}$ 70%, and the maximum net power $P_{(n)}$ is determined from GB 20891—2014 Appendix AA.7.2. The maximum speed of the diesel engine corresponding to this power on the power curve is defined as n_{hi} .

The low speed n_{l0} is the speed at maximum net power $P_{(n)}$ 50%, and the maximum net power $P_{(n)}$ is determined by GB 20891—2014 Appendix AA.7.2. The lowest speed of the diesel engine corresponding to this power on the power curve shall be defined as n_{l0} .

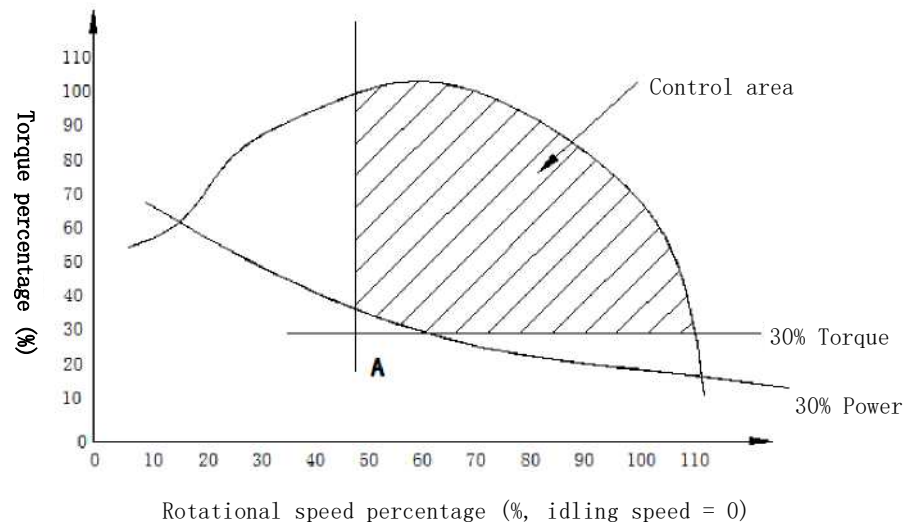


Figure B. 1 Non-standard cycle emissions of diesel engine greater than or equal to 19 kW

The following diesel engine operating areas shall be excluded during the test:

- Operating area below 30% of maximum torque;
- Operating area below the torque curve corresponding to 30% of maximum net power.

For details, see Figure B.1, non-standard cycle emissions of diesel engines greater than or equal to 19 kW.

B. 3. 2. 2 $P_{\max} < 19$ kW non-standard cycle emissions requirements

- The particulate matter non-control area. If the speed $C < 2400$ rpm, at a speed of B, taking the point of 30% of maximum torque or the point of 30% of maximum net power (adopting the greater of the two), and connecting it to the point of 70% of the maximum net power at high speed to form a zone, the points on the right side or beneath; see Fig. B.2.
- The particulate matter non-control area. If the speed $C < 2400$ rpm, at a speed of B, taking the point of 30% of maximum torque or the point of 30% of maximum net power (adopting the greater of the two), connecting it with the point of 50% of maximum net power at a speed of 2400 rpm and the point of 70% of maximum net power at high speed to form a zone, the points on the right side and or beneath; see Fig. B.3.

Wherein:

$$B = n_{lo} + 50\% \times (n_{hi} - n_{lo}),$$

$$C = n_{lo} + 75\% \times (n_{hi} - n_{lo}) \circ$$

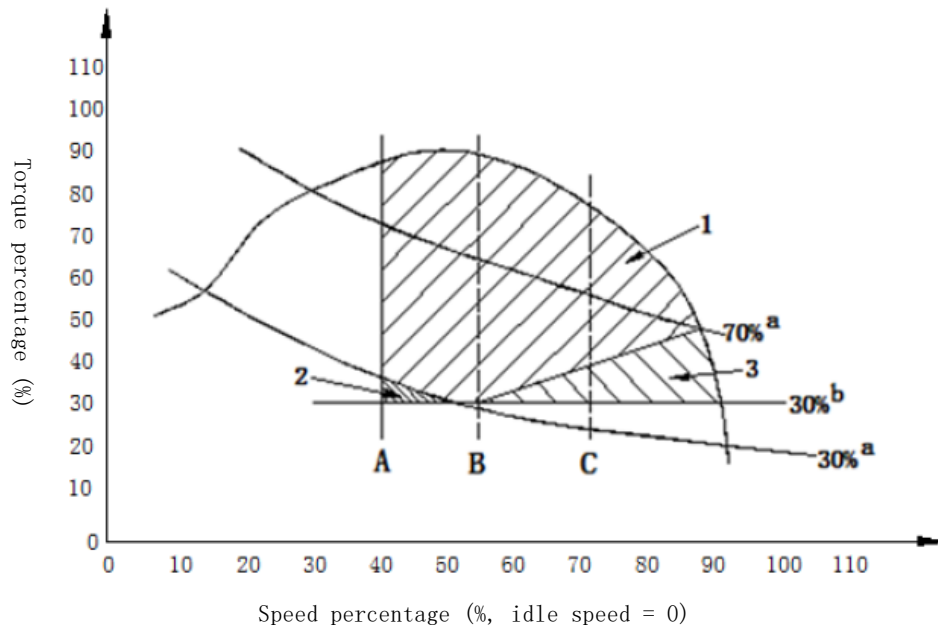


Fig. B.2 Non-standard cycle emissions of a diesel engine at less than or equal to 19 kW and a speed of $C < 2400$ rpm

Figure: 1—Non-standard cycle emissions of diesel engine

2—Non-control area for all pollutants

3 —PM non-control area

a — Percentage of maximum net power

b — Percentage of maximum torque

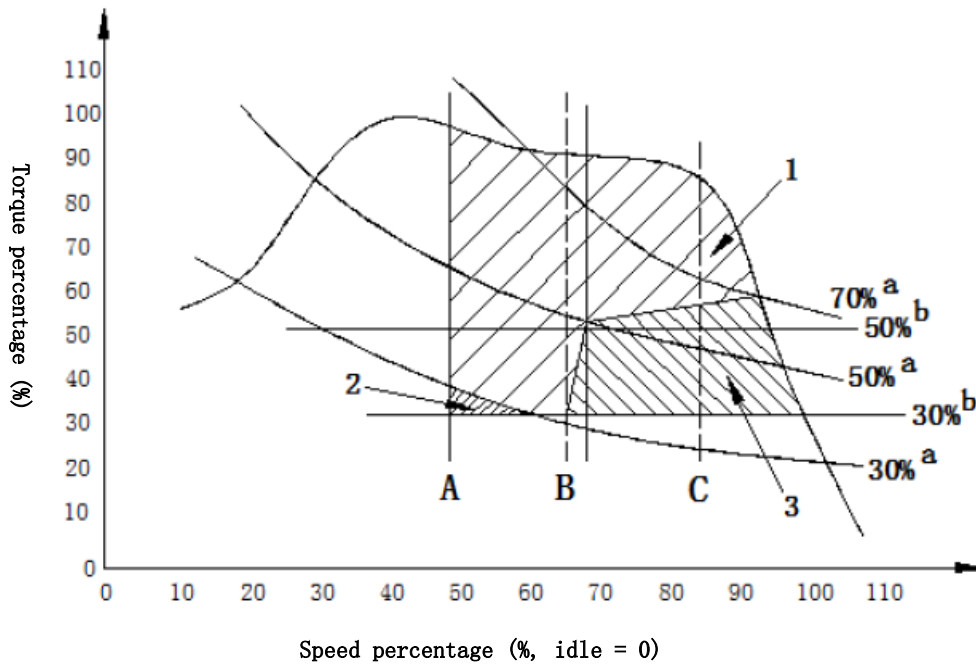


Fig. B.3 Non-standard cycle emissions of a diesel engine at less than or equal to 19 kW and a speed of $CN2400$ rpm

Figure: 1— Non-standard cycle emissions of diesel engine

2 — Non-control area for all pollutants

3— PM Non-control area

a — Percentage of maximum net power

b — Percentage of maximum torque

B. 3. 2. 3 Non-standard cycle emissions of diesel engines tested in accordance with five operating conditions or six operating conditions

Diesel engines tested under five operating conditions or six operating conditions mainly run at design speeds, with non-standard cycle emissions being defined as follows:

Speed: 100%

Torque range: 50%—100% of torque at maximum power point

B. 3.3 If the measured diesel engine speeds A, B, C and the diesel engine speed declared by the diesel engine manufacturer are within $\pm 3\%$, then the speed declared by the diesel engine manufacturer shall be used. If any test speed exceeds the tolerance range, the actual measured diesel engine speed shall be used.

B.3.4 Exclusion points

If the diesel engine manufacturer can prove that it is impossible for the diesel engine to reach the operating conditions of such operating points on any machinery, the diesel engine manufacturer may request that certain non-standard cycle emission areas specified in Article B.3.2 be excluded.

B. 4 Test cycle

B.4.1 Non-road stable cycle (NRSC)

The test shall be conducted adopting the test cycle of GB 20891—2014 Addendum B.3.8.1. Before the test, a simulation test of pretreatment of the diesel engine and exhaust system shall be carried out according to the requirements of the company. Measurement of the number of particles shall be sampled at the end of each working condition to the extent possible, and the sampling time shall not be less than 60 s.

B.4.2 Non-road transient cycle (NRTC)

B. 4. 2.1 The non-road transient cycle NRTC specified in GB 20891—2014 Appendix BE shall be adopted and testing shall be carried out in accordance with the test procedures specified in the Appendix BA. If the actual measured reference speed is within $\pm 3\%$ of the value declared by the diesel engine manufacturer, the value declared by the diesel engine manufacturer shall be used. Otherwise, the actual measured values shall be used.

B.4. 2.2 Following the emission test, a recheck shall be performed with zero gas and the same span gas. If the difference in the inspection results before and after the test is less than 2% of the span gas, the test shall be deemed valid.

B.4.2.3 At the request of the diesel engine manufacturer, before the measurement cycle, it shall be permissible to carry out a simulation test designed to pre-treat the diesel engine and exhaust system to check the diesel engine, test room and emission system.

B.5 Diesel engine exhaust aftertreatment system

B. 5.1 General requirements

B. 5. 1. 1 If the diesel engine is equipped with an exhaust after-treatment device, the diameter of the exhaust pipe and heat preservation measures shall be consistent with actual use. The distance from the flange of the exhaust branch pipe or the outlet of the turbocharger to the exhaust after-treatment device shall be consistent with the configuration of the machine, or within the distance range specified by the diesel engine manufacturer. Exhaust back pressure or resistance shall follow the same guidelines as above and be set by the exhaust back pressure valve. For aftertreatment systems with varying back pressure, the maximum back pressure upper limit value shall be the back pressure value under the conditions (such as degree of aging and regeneration or load level) of the aftertreatment system as specified by the diesel engine manufacturer. If the upper limit of the exhaust back pressure does not exceed 5kPa, the back pressure shall be controlled to within ± 1 kPa of the specified upper limit. If the upper limit of exhaust back pressure is greater than 5 kPa, the back pressure shall be controlled to within 80%—100% of the specified upper limit. When conducting simulation tests and diesel engine transient performance curve tests, it shall be permissible to remove the aftertreatment shell and replace it with a shell containing an inactive catalyst carrier.

B. 5. 1.2 If the diesel engine is equipped with an exhaust aftertreatment device, the emission value tested in the test cycle shall be able to represent the emission value in actual use. The diesel engine manufacturer shall provide written instructions on the type of reactant required for the test and the quantity of reactant consumed.

B. 5. 1.3 Diesel engines equipped with a continuous regeneration after-treatment system do not need to undergo special tests, but they need to be verified for the regeneration process in accordance with the provisions of B.5.2.

B. 5.1.4 Diesel engines equipped with a periodic regeneration aftertreatment system shall be tested in accordance with the requirements of B.5.3, and the emission results shall be corrected taking regeneration into account. In such situations, for the part of the test where regeneration occurs, the average emissions shall depend on how often regeneration occurs.

B. 5.1.5 For diesel engines with a net rated power of 560 kW and above and constant power diesel engines, replace the NRTC cycle with NRSC cycle, and conduct B.5.2 and B.5.3 test verification.

B.5.2 Continuous regeneration

For exhaust aftertreatment systems with continuous regeneration, pollutant emissions shall be measured after the aftertreatment system has stabilized. At least

one regeneration test shall occur during a hot state NRTC test cycle, and the diesel engine manufacturer shall state the conditions (particle load, temperature, exhaust back pressure, etc.) under which regeneration occurs.

To verify the continuous regeneration process, at least 3 NRSC cycles or hot state NRTC cycles shall be carried out. When the diesel engine is in a hot state NRTC test cycle, the engine shall be heated according to BA.4.4, heat soaking shall be conducted according to BA.4.9.6, followed by the first hot state NRTC, with the other two NRTC tests also being conducted after heat soaking in accordance with the requirements of BA.4.9.6. During the test, the exhaust temperature and pressure (temperature before and after post-treatment, exhaust back pressure, etc.) shall be recorded.

If the test demonstrates the regeneration conditions specified by the diesel engine manufacturer, and the 3 NRSC cycles or NRTC cycles of particulate matter mass ratio emission results and the deviation in the 3 time average value are less than 25% or 0.005 g/kW-h (whichever is greater), then the exhaust gas aftertreatment system shall be deemed to be continuously regenerated, and testing shall be conducted

according to the test specifications specified in the NRSC cycle specified in GB 20891—2014 Addendum B.3 or BA.4.9 of the present Standards.

If the exhaust aftertreatment system has a safe mode that can be transformed into a periodic regeneration mode, it shall be tested according to B.5.3. In this special case, the emissions may exceed the emission limit, and the emissions will not be weighted in the calculation.

B.5.3 Periodic regeneration

For periodically regenerated exhaust aftertreatment systems, emissions shall be measured in at least 3 hot state NRTC cycles, of which: during at least 1 regeneration process, other than the 2 regeneration processes, and shall be a test cycle after the exhaust aftertreatment system has been stabilized, with the measurement results ultimately being weighted based on formula B.5.3.

Periodic regeneration shall occur at least once during the test cycle. It shall be permissible to equip the diesel engine with a switch to prevent or allow regeneration to occur, but this technology shall not affect the calibration of the original diesel engine.

Diesel engine manufacturers shall explain the general parameter conditions for regeneration (such as particle load, temperature, exhaust back pressure, etc.), regeneration cycle and regeneration frequency. The determination of regeneration period and regeneration frequency shall be based on sound engineering experience.

Diesel engine manufacturers shall provide a post-treatment system that is close to regeneration conditions to achieve regeneration during the NRSC or hot state NRTC test. When conducting the NRTC test, the engine shall be heated in accordance with BA.4.4, heat soaking shall be performed according to BA.4.9.6, and a hot state NRTC shall be performed. Regeneration shall not occur during the engine heating stage.

The average specific emission levels between regenerations shall be determined as the arithmetic average of several approximate NRTC or hot state NRTC test results. It is recommended that at least one NRSC or hot state NRTC test be conducted before regeneration occurs and as close to regeneration as possible. After regeneration, pretreatment shall be performed according to the requirements of the manufacturer, but 5h shall not be exceeded before performing another NRSC or hot state NRTC test. As an alternative, diesel engine manufacturers shall be permitted to provide data to demonstrate that the deviation between the test results and the average value of the three times between two regenerations is less than $\pm 25\%$ or 0.005 g/kW-h (whichever is greater). In this case, only one hot state NRTC test shall be required.

During regeneration, all data used for monitoring regeneration shall be recorded (such as: CO or NO_x emissions, temperature before and after the aftertreatment system, exhaust back pressure, etc.).

The emission measurement results during the regeneration process can exceed the emission limit. However, the weighted emissions of a regeneration cycle (e_w) shall meet the emission limit requirements.

A schematic diagram of the test process is shown in Figure B.4.

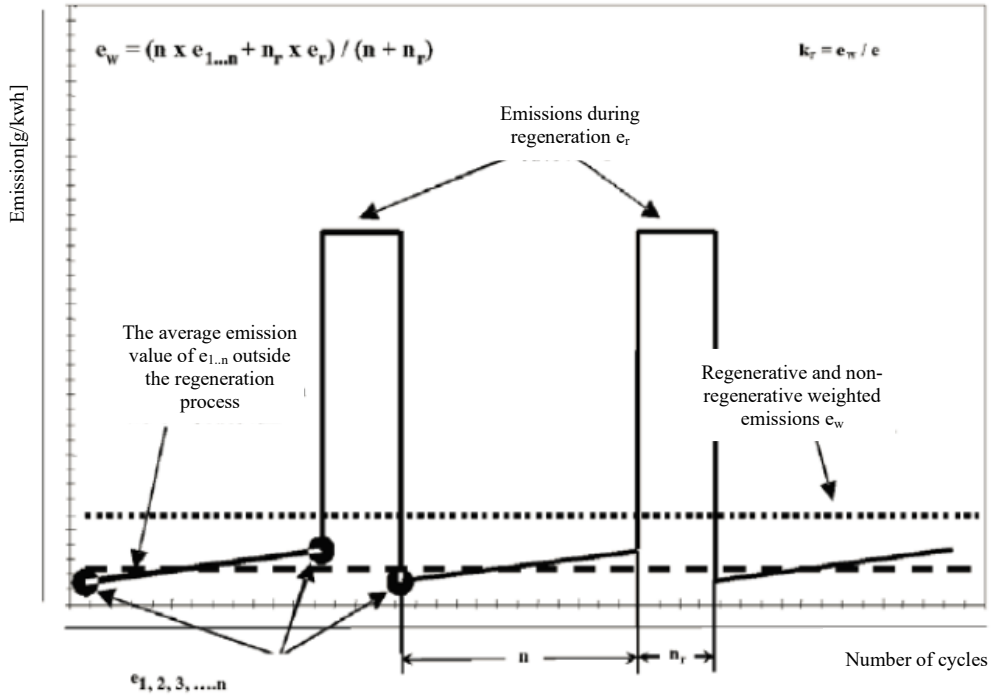


Figure B.4 Schematic diagram of regeneration process test

The weighted emission results are:

$$e_w = \frac{n \times \bar{e} + n_r \times \bar{e}_r}{n + n_r}$$

In the equation:

n —Number of test cycles between two regenerations;

n_r —Number of test cycles at which regeneration occurs (at least 1);

e —Average specific emission between two regenerations, g/kW-h or #/kW·h;

e_r — The average specific emission during regeneration, g/kW-h or #/kW·h.

When determining the %, the following terms shall apply:

- a) If regeneration cannot be completed during the test, a complete test cycle shall be carried out continuously without stopping or heat soaking until the regeneration has been completed. The average of all test cycles shall be determined.
- b) If the regeneration ends during an NRSC or NRTC test process, it shall still be necessary to complete the testing of the test cycle.

B. 5.4 Regeneration factors

Based on sound engineering experience, it shall be permissible to correct the results by the regeneration factor of formula a) or b).

a) Calculation formula of multiplied regeneration factors:

$$k_{r,u} = \frac{e_w}{e}$$

$$k_{r,d} = \frac{e_w}{e_r}$$

- b) Calculation formula of added regeneration factors:

$$k_{r,u} = e_w - \bar{e}$$

$$k_{r,d} = e_w - \bar{e}_r$$

In the calculation of specific emissions specified in BA.6.1.2.4, the regeneration factor shall be applied in accordance with the following provisions:

- c) In a test without regeneration, the specific emission results of BA.6.1.2.4 shall be multiplied by or added to the regeneration factor $k_{r,u}$;
- d) In a test in which regeneration occurs, the specific emission results of BA.6.1.2.4 shall be multiplied or added to the regeneration factor respectively;

At the request of the diesel engine manufacturer, the regeneration factor can be applied to the following terms:

- e) Other diesel engines within the family;
- f) Other families in which similar aftertreatments are installed, and the inspection agency identifies diesel engines with similar emission levels based on technical data provided by the diesel engine manufacturer.

B. 6 Carbon balance calibration of exhaust flow

The carbon balance method specified in GB 20891-2014 Appendix CA.5.1.7 shall be used to calibrate the exhaust flow. The deviation between the results of the air displacement measured by the flowmeter and the results of the air displacement measured by the carbon balance method shall be within $\pm 5\%$ (within $\pm 10\%$ for single-cylinder engines).

B.7 NRTC The measurement, sampling and calibration procedures of the test cycle are shown in Appendix BA.

B. 8 See the Appendix BB for the particle number measurement procedure.

B.9 See Appendix BD for the NH_3 test procedure.

Appendix BA
(Normative appendix)
Non-road transient cycle (NRTC)

BA. 1 Summary

This appendix specifies in detail the determination sampling procedure, data evaluation, and calculation of the NRTC.

BA.2 NRTC determination procedure**BA. 2. 1 Determination of the speed range of diesel engine transient performance**

To be able to carry out the NRTC test cycle in the test chamber, the transient performance of the diesel engine shall be tested before the test cycle to obtain a speed-torque curve for the diesel engine. The minimum and maximum transient performance speeds are defined as follows:

Minimum transient performance speed = idle speed;

Maximum transient performance speed = $n_{hi}1.02$ or the speed at the oil reduction point, whichever is lower.

BA. 2. 2 Measurement of diesel engine transient performance power

In accordance with the recommendations of the diesel engine manufacturer and seasoned engineering experience, the diesel engine shall be warmed up to the rated net power state to stabilize the diesel engine parameters. Once the diesel engine parameters have stabilized, the power measurement of the transient performance of the diesel engine shall be carried out in the following steps:

- a) The diesel engine shall be unloaded and run at idle speed;
- b) The diesel engine shall be operated at the full load setting of the fuel injection pump and the minimum transient performance speed;
- c) The average increase rate of the diesel engine from the minimum transient performance speed to the maximum transient performance speed shall be 8 ± 1 (rpm)/s, or a constant rate shall be used to allow the minimum transient performance speed to increase to the maximum transient performance speed within 4-6 minutes. The speed and torque of the diesel engine shall be recorded at a sampling rate of at least one point per second.

BA. 2. 3 Formation of a diesel engine transient performance curve

Linear interpolation shall be used to connect all the data points recorded in BA.2.2, and the torque curve obtained shall be the transient performance curve of the diesel engine. This curve shall be used to convert the standard percentage value specified by the NRTC cycle into an actual torque value, as described in BA.3.

BA. 2. 4 Alternative performance measurement

If the diesel engine manufacturer believes that the above-mentioned diesel engine transient performance curve measurement technology is unsafe or does not represent the diesel engine, they shall be permitted to adopt an alternative diesel engine transient performance curve measuring technique. The alternative diesel engine transient performance curve measurement technique shall satisfy the purpose of the specified diesel engine transient performance curve measurement procedure, that is, to determine the maximum effective torque that the diesel engine is capable of generating over the entire allowable speed range. For reasons of safety or representation, if the transient performance curve measurement technique for diesel engines that is specified in this article is not adopted, approval shall be obtained from the inspection agency and a reasonable basis for the alternative method used shall be explained. For turbocharged or

governor-controlled diesel engines, the method of continuously decreasing the speed of the diesel engine shall not be used.

BA. 2. 5 Repeat testing

It shall be unnecessary to measure a transient performance curve for the diesel engine before each test cycle. However, if any of the following situations occurs, the transient performance curve of the diesel engine shall be remeasured before the test cycle:

—Determined based on engineering experience, it has been too long since the latest transient performance curve of the diesel engine has been measured.

Or

—A change or recalibration of parts may have affected the performance of the diesel engine.

BA.3 Formation of a benchmark test cycle

The non-road transient cycle shall be as described in GB 20891-2014 Appendix BE. The standard percentage values of torque and speed shall be converted into actual values according to the following method to form a reference cycle.

BA.3.1 Actual speed

The following formula shall be used to convert the GB 20891—2014 Appendix BE standard speed percentage value into an actual value:

$$\text{actual speed} = \% \text{speed} \times \frac{\text{reference speed} - \text{idle speed}}{100} + \text{idle speed}$$

The reference speed (n_{ref}) refers to the actual speed value of the 100% relative speed point specified by the diesel engine dynamometer specifications of GB 20891—2014 Appendix BE. It shall be calculated by the following method:

$$n_{\text{ref}} = n_{\text{lo}} + 95\% \times (n_{\text{hi}} - n_{\text{lo}})$$

In the equation:

High speed n_{hi} — The highest speed at 70% of the maximum net power $P_{(n)}$;

Low speed n_{lo} — The lowest speed at 50% of maximum net power $P_{(n)}$.

BA. 3. 2 Actual torque

The torque of GB 20891—2014 Appendix BE is the standard percentage of the maximum torque at various speeds. For the torque value of the reference cycle, the actual value shall be used, and the transient performance curve of the diesel engine shall be determined according to BA.2.3; for the actual corresponding individual speeds determined in BA.3.1, the actual torques shall be calculated using the following formula:

$$\text{Actual torque} = \frac{\% \text{torque} \times \text{maximum torque}}{100} \text{ for generating a reference cycle.}$$

BA. 3. 3 Example of converting standard percentage value to actual value

As an example, the standard percentage values of the following test points are converted into actual values:

$\% \text{speed} = 43$

$\% \text{torque} = 82$

Assuming the following values:

Reference speed (n_{ref}) = 2200 rpm

Idle speed=600 rpm

Calculation gives:

$$\text{Actual speed} = \frac{43 \times (2200 - 600)}{100} + 600 = 1288 \text{ rpm}$$

$$\text{Actual torque} = \frac{82 \times 700}{100} = 574 \text{ Nm}$$

In the equation:

700 Nm is the maximum torque value of the diesel engine at a speed of 1,288 rpm on the transient performance measurement curve.

BA.4 Emission test operation

BA. 4.1 For a flowchart of the test sequence, see Fig. BA.1:

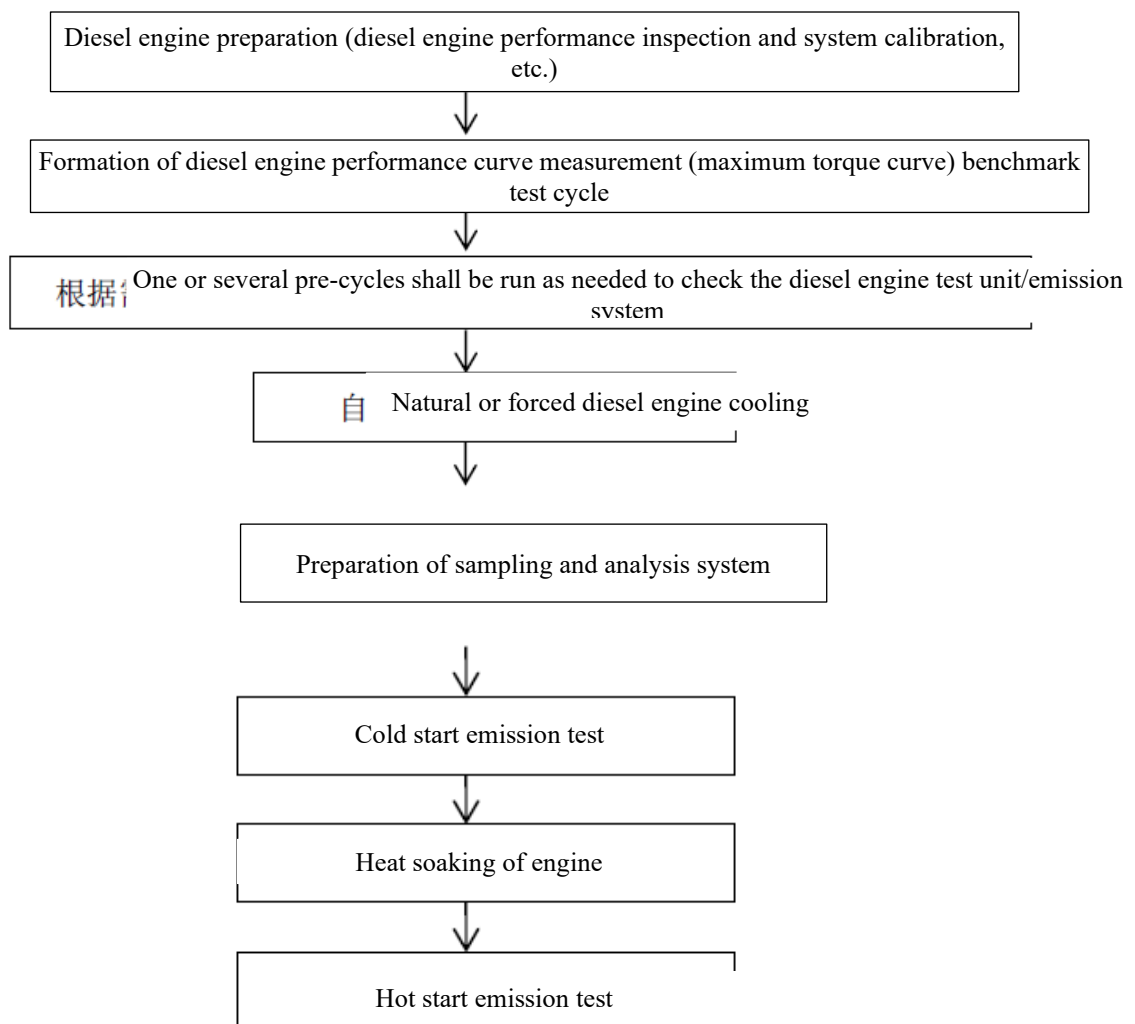


Figure BA.1 Test flow chart

BA. 4. 2 Preparation of sampling filter paper

At least 1h before the test, each piece (pair) of filter paper shall be placed in a closed but not sealed

petri dish, and placed in the weighing chamber for stability. Following stabilization, the net weight of each piece (pair) of filter paper shall be weighed and recorded. The piece (pair) of filter paper shall then be stored in a closed but unsealed petri dish or a sealed filter paper holder until needed for the test. If the piece (pair) of filter paper is not used within 8 h after being taken out from the weighing chamber, it must be pre-processed and weighed again before use.

BA. 4. 3 Installation of measurement equipment

The instruments and sampling probe shall be installed as required. The exhaust tail pipe of the diesel engine shall be connected to the particulate dilution system.

BA. 4. 4 Starting the dilution system and diesel engine

In accordance with the recommendations of the diesel engine manufacturer and seasoned engineering experience, the dilution system and the diesel engine shall be started and preheated until all the temperatures and pressures are stable at the rated net power.

BA. 4. 5 Starting the particulate sampling system

The particulate matter sampling system shall be activated and carried out under a bypass. The background value of the dilution air in the particulate test can be measured by passing the dilution air through the particulate filter. If filtered dilution air is used, it can be measured only once before or after the test. If the dilution air is not filtered, it shall be measured at the beginning and end of the cycle, and the average value shall be adopted.

BA. 4. 6 Adjusting the dilution system

The total flow rate of the diluted exhaust shall be set so that water vapor does not condense in the system, and the temperature of the filter paper surface is between $320\text{ K} \pm 5\text{ K}$ ($47\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$).

BA. 4. 7 Examining the analyzer

The zero point and span point of the emission analyzer shall be calibrated. If a sampling bag is used, the sampling bag shall be emptied.

BA. 4. 8 Cooling requirements

It shall be permissible to employ natural cooling or a forced cooling method. When forced cooling is used, sound engineering judgment shall be exercised in setting up the system so that cooling air is sent to the diesel engine, cooling lubricating oil is sent to the diesel engine lubrication system, and the diesel engine cooling system is used to remove heat from the coolant and exhaust gas aftertreatment system. In forced aftertreatment cooling, the cooling air shall not be used until the aftertreatment system has cooled to below the catalytic activity temperature. It shall be forbidden to use any cooling procedures that result in unrepresentative emission results.

Once the diesel engine has been cooled, the temperature of the lubricating oil, coolant and aftertreatment device shall be stabilized at 20°C to 30°C and this shall be maintained for at least 15 min before starting a cold start cycle emission test.

BA. 4. 9 The test cycle

BA. 4. 9. 1 The cold start cycle

Once all the cooling requirements in BA.4.8 have been satisfied, the cold start cycle shall be started. A diesel engine shall be started using a starter motor or dynamometer according to the start-up procedures recommended by the diesel engine manufacturer in the user manual. Once it has been determined that the diesel engine has started, it shall be operated in "no-load idling," and the NRTC cycle shall be started at $23\text{ s} \pm 1\text{ s}$.

The test shall be performed according to the reference cycle specified in GB 20891-2014 Appendix BE. Diesel engine speed and torque command set points shall be issued 5 times or more/second (10

times/second is recommended). During the test cycle, the feedback signal of the diesel engine speed and torque shall be recorded at least once per second, and the signal can be electronically filtered.

BA. 4. 9. 2 Analyzer response

If entering the test cycle directly from pretreatment, when the diesel engine or the test cycle starts, the measuring equipment shall be started at the same time:

- Equipment for collecting or analyzing dilution air shall be started;
- Equipment for collecting or analyzing diluted exhaust gas shall be started;
- The diluted exhaust volume measuring device (CVS) and the required temperature and pressure measuring equipment shall be started;
- The equipment recording the dynamometer speed and torque feedback data shall be started.

HC and NO_x in the dilution duct shall be continuously measured at a frequency of 2 times/ second. The average concentration shall be obtained by integrating the concentration measurement signal of the analyzer over the entire test cycle. The system response time shall not exceed 20 s. If necessary, it shall be adjusted according to the flow fluctuation of the CVS and deviation in the sampling time / test cycle. CO, CO₂, and HC shall be determined by integrating or analyzing the gas concentration collected by the sampling bag throughout the cycle. The concentration of gaseous pollutants in the dilution air shall be determined by integration or by the gas collected in the background air bag. All other values shall be recorded at least once per second.

BA. 4. 9. 3 Sampling of particulate

If the cycle starts directly from pretreatment, when the diesel engine or the test program is started, the particulate matter sampling system shall be switched from bypass to particulate matter collection. If flow compensation is not used, the sampling pump shall be adjusted so that the flow through the particle sampling probe or conveying pipe is kept within $\pm 5\%$ of the set value. If flow compensation is used (that is, the sample gas flow rate is controlled proportionally), it shall be demonstrated that the ratio of the main dilution air duct flow rate to the particulate matter sample gas flow rate does not exceed $\pm 5\%$ of the set value (excluding the first 10 seconds following the start of sampling).

Note: For two-stage dilution, the sample gas flow is the net difference between the flow passing through the sample gas filter and the air flow at the second stage of dilution.

The average temperature and pressure at the inlet of the flow meter or flow instrument shall be recorded. If too much particulate matter accumulates on the filter paper and the set flow cannot be maintained within $\pm 5\%$ throughout the cycle, the test shall be invalid. The test shall be repeated with a lower flow rate and/or larger diameter filter paper.

BA. 4. 9 . 4 Diesel engine stalling during cold start test cycle

If the diesel engine stalls at any stage of the cold start test cycle, the diesel engine shall be pre-conditioned and the cooling procedure shall be repeated, and ultimately, the diesel engine shall be restarted and the test repeated. If any necessary test equipment fails during the test cycle, the test shall be invalid.

BA. 4. 9 . 5 Diesel engine operation after cold start cycle

Once the test has been completed, measurement of the volume of the diluted exhaust gas, gas sampling of the sampling bag and sampling of the particulate matter by the sampling pump shall all cease. For the integral analysis system, sampling shall continue until the system response time ends. If a sampling bag is used, in all cases, the concentration shall be analyzed as soon as possible within 20 min after the end of the test cycle.

After the emission test, the analyzer shall be rechecked with zero gas and the span gas. If the error of the two measurement results before and after the test is within 2% of the span gas value, the test shall be

considered valid.

Once the test has been completed, the particulate filter paper shall be returned to the weighing room within 1 h, and placed in a closed but not sealed petri dish for at least 1 h before weighing. The total weight of the filter paper shall be recorded.

BA. 4. 9 . 6 Heat soaking the engine

Once the diesel engine has been turned off, if a cooling fan is being used on the diesel engine, the cooling fan shall be turned off immediately; if an intake air conditioner and a CVS fan are also being used, they shall also be turned off immediately.

Keep the diesel engine in a heat-soaked state for $20 \text{ min} \pm 1 \text{ min}$. Prepare for a hot start test of the diesel engine and dynamometer. Connect an emptied sampling bag to the dilution exhaust and dilution air sampling system. Start CVS (if using CVS /if CVS has not been started) or connect the exhaust system to CVS (if it has been disconnected). Start the sampling pumps (except the particulate matter sampling pump), diesel engine cooling fan and data acquisition system.

Before the test begins, the heat exchanger of the constant-volume sampler (if used) and any heated parts of the continuous sampling system (if applicable) shall be preheated to their designated operating temperatures.

Adjust the sample flow rate to the desired level and set the CVS flow measurement device to zero. Carefully install clean particulate filter paper into each filter paper holder, and install the assembled filter paper holders into the sample flow pipeline.

BA. 4. 9 . 7 The hot start cycle

Once the diesel engine is determined to have started, start the "no-load idling" operation, and start the transient diesel engine cycle at 23 ± 1 seconds.

The test shall be performed according to the reference cycle specified in GB 20891-2014 AppendixBE. Diesel engine speed and torque command set points shall be issued 5 times or more/second (10 times/second is recommended). During the test cycle, the feedback signal of the diesel engine speed and torque shall be recorded at least once per second, and electronic filtration of the signal shall be permitted.

Repeat the procedures in BA.4.9.2 and BA.4.9.3.

BA.4.9.8 Diesel engine stalling during hot start test cycle

If the diesel engine stalls at any stage of the hot start cycle, the diesel engine can be turned off and engine heat soaking can be repeated for 20 minutes. The hot start cycle can then be rerun.

BA.4.9.9 Diesel engine operation after hot start cycle

Once the test has been completed, measurement of the volume of the diluted exhaust gas, gas sampling of the sampling bag and sampling by the particulate matter sampling pump shall all be ceased. For the integral analysis system, sampling shall continue until the system response time ends. If a sampling bag is being used, in all cases, the concentration shall be analyzed as soon as possible within 20 minutes of the end of the test cycle.

After the emission test, the analyzer shall be rechecked with zero gas and the span gas. If the error of the two measurement results before and after the test is within 2% of the span gas value, the test shall be considered valid.

Once the test has been completed, the particulate filter paper shall be returned to the weighing room within 1h, and placed in a closed but unsealed petri dish for at least 1 h before weighing. The total weight of the filter paper shall be recorded.

BA.4. 10 Verification of test runs

BA. 4.10.1 Data conversion

In order to minimize the impact of deviation due to a time lag in the feedback signal relative to the reference cycle, the entire diesel engine speed and torque feedback signal sequence can be advanced or delayed relative to the corresponding reference speed and torque sequence in time. If the feedback signal is converted, both torque and speed shall be converted to the same sequence value in the same direction.

BA.4.10.2 Calculation of cycle work

Use each pair of feedback speed and torque of the diesel engine to calculate actual cycle work $W_{act}(kW \cdot h)$. The actual cycle power W_{act} shall be compared to the reference cycle power W_{ref} and shall be used to calculate the braking power ratio emissions (See Attachment BA.6). The same method shall be used to calculate the reference power and actual power of the diesel engine. If determination of the value between two adjacent reference values (or measured values) is desired, linear interpolation shall be employed.

When calculating the reference power and actual cycle power by integration, all negative torque values shall be included and set to zero. If the integration is performed at a frequency of less than 5 Hz and within a given time period the torque changes from positive to negative or from negative to positive, the negative torque component shall be set to zero for calculation. The positive torque part shall be included in the integral value.

The deviation of W_{act} shall be between $-15\%W_{ref}$ and $+5\%W_{ref}$.

BA. 4.10. 3 Statistics confirming the validity of the test cycle

Perform linear regression analysis based on the feedback value of the reference value on the speed, torque and power. If a linear regression method is used, linear regression shall be required for all the feedback data conversions of the operation. The least squares method shall be used; the most suitable equation being:

$$y = mx + b$$

In the equation:

y—Speed(rpm), torque (Nm) or power(kW) (actual) feedback value;

m—Slope of regression line;

x—Speed (rpm), torque (Nm), or power(kW) reference value;

b—y intercept of regression line.

For each regression line, the standard deviation (SE) and correlation coefficient (r^2) of the estimated value of y based on x shall be calculated.

The recommended analysis frequency is 1 Hz. All negative reference torque values and their corresponding feedback values shall be deleted from the statistical calculations of cycle torque and cycle power validity. Only when the statistical results are in conformity with the standard values in Table BA1. will the test be considered valid.

Table BA.1 Regression line tolerance

	Speed	Torque	Power
Standard deviation of estimated value (SE) of y relative to x	$\leq 5.0\%$ of maximum test speed	$\leq$ maximum of 10.0% of maximum diesel engine torque in power curve distribution graph	$\leq$ maximum of 10.0% of maximum diesel engine power in power curve distribution graph
Slope of regression line, m	0.95-1.03	0.83-1.03	0.89-1.03
Correlation coefficient, r^2	Minimum is 0.970	Minimum is 0.850	Minimum is 0.910
Regression line yintercept, b	$\leq 10\%$ of idle speed	± 20 Nm or $\pm 2\%$ of maximum torque, take the greater of the two	± 4 kW or $\pm 2\%$ of rated net power, take the greater of the two

Before regression calculation, some points can be deleted based on Table BA.2 (only for regression calculation purposes). However, these points must not be deleted when calculating cycle work and emissions. The idle speed point is defined as the point where both the standardized reference torque and the standardized reference speed are 0%. It shall be permissible to delete test points from the entire cycle or part of the cycle.

Table BA.2 Points that can be deleted in regression analysis (deleted points need to be noted)

Throttle position	Working condition (n = diesel engine speed, T = torque)	Deletable points
Minimum throttle (Idle speed point)	$n_{ref} = n_{idle}$ and $T_{ref} = 0$ and $T_{act} > (T_{ref} - 0.02 T_{maxmappedtorque})$ and $T_{act} < (T_{ref} + 0.02 T_{maxmappedtorque})$	Speed and power
Minimum throttle	$n_{act} \leq 1.02 n_{ref}$ and $T_{act} > T_{ref}$ or $n_{act} > n_{ref}$ and $T_{act} \leq T_{ref}$ ¹ or $n_{act} > 1.02 n_{ref}$ and $T_{ref} < T_{act} \leq (T_{ref} + 0.02 T_{maxmappedtorque})$	Power and torque or speed
Maximum throttle	$n_{act} < n_{ref}$ and $T_{act} \geq 3 T_{ref}$ or $n_{act} \geq 0.98 n_{ref}$ and $T_{act} < T_{ref}$ or $n_{act} < 0.98 n_{ref}$ or $T_{ref} > T_{act} \geq (T_{ref} - 0.02 T_{maxmappedtorque})$	Power and torque or speed

n_{ref} refers to reference speed
n_{idle} refers to idle speed
n_{act} refers to actual (measured) speed
T_{ref} refers to reference torque
T_{act} refers to actual (measured) torque
$T_{maxmappedtorque}$ refers to maximum torque value on full load torque curve obtained based on BA2.3.

BA.5 Measurement and sampling procedures

BA. 5. 1 Introduction

The gaseous pollutants and particulate matter emitted by the test diesel engine that are submitted by the diesel engine manufacturer shall be measured according to the method in GB 20891-2014 Addendum C. The method of GB 20891-2014 Addendum C introduces the recommended gas emission analysis system and the recommended particulate matter dilution and sampling system.

BA. 5. 2 Dynamometer and test room equipment

The following equipment shall be used for testing the emissions of a diesel engine connected to a dynamometer:

BA. 5. 2 . 1 Diesel engine dynamometer

The selected diesel engine dynamometer shall have all the functions required to perform the test cycle in this addendum. Torque and speed measuring instruments shall have the capability of measuring power within the specified limits. Additional calculations can be performed. Regarding the accuracy of the measuring equipment, the measured value shall not exceed the maximum tolerance specified in Table BA.3.

BA. 5. 2 . 2 Other instruments

Measuring instruments for measuring fuel consumption, air consumption, coolant and lubricant temperature, exhaust pressure and intake manifold vacuum, exhaust temperature, intake temperature, atmospheric pressure, and humidity and fuel temperature shall be used as needed. These instruments shall meet the requirements in Table BA.3:

Table BA. 3 Measurement instrument precision

Serial number	Measurement instrument	Precision
1	Diesel engine speed	$\pm 2\%$ of the reading or $\pm 1\%$ of the maximum value of the diesel engine, whichever is greater
2	Torque	$\pm 2\%$ of the reading or $\pm 1\%$ of the maximum value of the diesel engine, whichever is greater
3	Fuel consumption	$\pm 2\%$ of maximum value of diesel engine
4	Air consumption	$\pm 2\%$ of the reading or $\pm 1\%$ of the maximum value of the diesel engine, whichever is greater
5	Exhaust flow	$\pm 2.5\%$ of the reading or $\pm 1.5\%$ of the maximum value of the diesel engine, whichever is greater
6	Temperature ≤ 600 K	± 2 K, absolute value
7	Temperature > 600 K	$\pm 1\%$ of reading
8	Exhaust pressure	± 0.2 kPa, absolute value
9	Intake vacuum	± 0.05 kPa, absolute value
10	Atmospheric pressure	± 0.1 kPa, absolute value

11	Other pressure	±0.1 kPa, absolute value
12	Absolute humidity	±5 % of reading
13	Dilution air flow	±2% of reading
14	Dilution exhaust flow	±2% of reading

BA. 5. 2. 3 Original exhaust flow

In order to calculate the emission of the original exhaust gas and control the split dilution system, it is necessary to understand the exhaust mass flow rate. In order to determine the exhaust mass flow rate, either of the following two methods can be selected.

In calculating the emission value, the response time of the following two methods shall not exceed the response time requirement of the analyzer specified in BD.4.

In terms of controlling the split dilution system, a faster response time is required. For a diversion dilution system that is controlled on-site, the response time shall be ≤ 0.3 s. For a pre-controlled split dilution system, the response time of the exhaust flow measurement system shall be ≤ 5 s, and the rise time shall be ≤ 1 s. The system response time shall be specified by the instrument manufacturer. The response times of the exhaust flow rate and the split dilution system is shown in BA.5.3.6.

Direct measurement method:

Direct measurement of the instantaneous exhaust flow can be realized by the following system:

- Differential pressure equipment, such as flow nozzles;
- Ultrasonic flowmeter;
- Vortex flowmeter.

Measures shall be taken to prevent measurement errors that affect emission results. Such measures shall include careful installation of measurement equipment in the diesel engine exhaust system based on the recommendations of the test equipment manufacturer and sound engineering practices. In particular, the performance and emission levels of diesel engines shall not be affected by equipment installation.

The flowmeter shall achieve the accuracy specified in Table BA.3.

Air and fuel measurement method:

This method requires the use of suitable flow meters to measure air flow and fuel flow. The calculation formula for the instantaneous exhaust flow is as follows:

$$G_{\text{EXHW}} = G_{\text{AIRW}} + G_{\text{FUEL}} \quad (\text{used for wet base exhaust mass})$$

In the equations:

G_{EXHW} — Instantaneous exhaust mass flow, kg/s;

G_{AIRW} — Wet base intake air mass flow rate, kg/s;

G_{FUEL} — Fuel mass flow rate, kg/s.

The flowmeter shall achieve the accuracy specified in Table BA.3, but shall also have sufficient accuracy to meet the accuracy specifications for exhaust flow measurement.

Tracer measurement method:

This method measures exhaust flow by measuring the concentration of tracer gas in the exhaust.

A known amount of inert gas (such as pure helium) will be injected into the exhaust as a tracer gas. The gas will mix with the exhaust gas and be diluted by the exhaust gas, but will not react in the exhaust pipe. The gas concentration is then measured in the exhaust gas sample.

To ensure that the tracer gas is fully mixed, the exhaust gas sampling probe shall be placed at least 1m or 30 times the diameter of the exhaust pipe downstream of the tracer gas injection point (whichever is greater). Comparing the tracer gas concentration with the reference concentration (the concentration when the tracer gas is injected upstream of the diesel engine) permits verification of whether the mixing is sufficient; at this time, the exhaust gas sampling probe can be placed closer to the injection point.

The tracer gas flow rate shall be set so that the concentration of the tracer gas after mixing at the idle speed of the diesel engine does not exceed the full range of the tracer gas analyzer.

The instantaneous exhaust flow shall be calculated as follows:

$$q_{mew,i} = \frac{q_{It} \cdot \rho_e}{10^{-6} \cdot (c_{mix,i} - c_b)}$$

In the equation:

$q_{mew,i}$ —Instantaneous exhaust flow rate, kg/S;

q_{It} —Tracer gas flow rate, m³/s;

$C_{mix,i}$ —Instantaneous concentration of tracer gas after mixing, ppm;

P_e —Exhaust gas density, kg/m³;

C_b —Background concentration of tracer gas in intake air, ppm.

The background concentration of the tracer gas ($conc_a$) can be measured based on the average of the measured values of the background concentration before and after the test.

If the background concentration is less than 1% of the mixed tracer gas concentration ($conc_{mix}$) when the exhaust gas flow reaches the maximum value, it shall be permissible to ignore the background concentration.

Air flow and air fuel ratio measurement method:

This method calculates exhaust gas quality by measuring air flow and air-fuel ratio. The instantaneous exhaust gas mass flow shall be calculated as follows:

$$G_{EXHW} = G_{AIRW} \times \left(1 + \frac{1}{A/F_{st} \times \lambda}\right)$$

In the equation:

$A/F_{st}=14.5$ —Air/fuel stoichiometric ratio, kg/kg;

λ —Air/fuel ratio.

$$\lambda = \frac{\left(100 - \frac{conc_{co} \cdot 10^{-4}}{2} - conc_{HC} \cdot 10^{-4}\right) + \left(0.45 \cdot \frac{1 - \frac{2 \cdot conc_{co} \cdot 10^{-4}}{3.5 \cdot conc_{co2}}}{1 + \frac{conc_{co} \cdot 10^{-4}}{3.5 \cdot conc_{co2}}}\right) \cdot (conc_{co2} + conc_{co} \cdot 10^{-4})}{6.9078 \cdot (conc_{co2} + conc_{co} \cdot 10^{-4} + conc_{HC} \cdot 10^{-4})}$$

In the equation:

$conc_{co2}$ —CO₂ dry base concentration, %;

concco-----CO dry base concentration, ppm;

conchc-----HC concentration, ppm.

Note: The fuel oil to which the above calculation formula applies has a hydrocarbon ratio equal to 1.8.

The air flow meter shall comply with the accuracy specifications in Table BA.3, and the CO₂ analyzer shall comply with the specifications in BA.5.3.3.2. The overall system shall satisfy the accuracy specifications of exhaust flow.

In addition, an air-fuel ratio measuring device that meets the specifications of BA.5.3.4, such as a zirconia sensor, can also be used to measure the air-fuel ratio.

BA. 5. 3 Measurement of gas composition

BA. 5. 3 . 1 Analyzer specifications

The measurement range of the analyzer shall be suited to the accuracy requirements for measuring the concentration of exhaust gas components (BA.5.3.1.1). It is recommended that an appropriate method of operation be used so that the measured concentration will be between 15% and 100% of the full scale of the analyzer. During the test, the range of emission analysis shall not be switched.

If the full scale does not exceed 155 ppm (or ppm C) or the reading system (computer, data logger) still provides enough accuracy and resolution at 15% below the full scale, the measured concentration will still meet requirements at 15% below the full scale of the analyzer. In this case, additional calibration shall be required to ensure the accuracy of the calibration curve.

The equipment shall have good electromagnetic compatibility (EMC) to minimize additional errors.

BA. 5. 3. 1. 1 Measurement error

The total measurement error of the analyzer, including cross-effects on other gases, shall not exceed $\pm 2\%$ of the reading or $\pm 0.3\%$ of the full scale, whichever is greater. For concentrations below 100 ppm, the measurement error shall not exceed ± 4 ppm.

BA. 5. 3. 1.2 Repeatability

Definition of repeatability: 2.5 times the standard deviation of the response value for 10 repetitions of a given calibration gas or span gas. For a calibration gas or span gas at greater than 155 ppm (or ppm C), repeatability shall not exceed $\pm 1\%$ of the full-scale concentration of the range, and for a calibration gas or span gas at less than 155 ppm (or ppm C), it shall not exceed $\pm 2\%$ of the full-scale concentration of the range.

BA.5.3.1.3 Response value

With regard to all measurement ranges in use, the arbitrary 10 s-period peak-to-peak response value of the analyzer in the case of zero air, calibration gas, or span gas may not exceed 2% of the full range.

BA. 5. 3. 1.4 Zero drift

With regard to the lowest measurement range in use, the 1 h-period zero drift must be smaller than 2% of the full range of the measurement range used. Zero drift is defined as: After the analyzer has stabilized, the average response (including the response value) to zero air within a 30s interval.

BA. 5. 3. 1.5 Span gas drift

With regard to the lowest measurement range in use, the 1 h-period span drift must be smaller than 2% of the full range. Span drift is defined as: After the analyzer has stabilized, the average response (including the response value) to the span gas within a 30s interval.

BA. 5. 3. 2 Gas drying

The selected gas drying apparatus must have the smallest impact on the concentration of the gas being measured; chemical drying agents may not be used to eliminate moisture from the sample gas.

BA.5.3.3 Analyzer

The following instruments shall be used to analyze the gas being measured.

BA. 5. 3. 3.1 Carbon monoxide (CO) analysis

The carbon monoxide analyzer must be the nondispersive infrared (NDIR) absorption type.

BA. 5. 3. 3. 2 Carbon dioxide (CO₂) analysis

The carbon dioxide analyzer must be the nondispersive infrared (NDIR) absorption type.

BA. 5. 3. 3. 3 Hydrocarbon (HC) analysis

The hydrocarbon analyzer must be a heated flame ionization detector (HFID). The analyzer's detector, valves, and tubing, etc. must be heated, which will cause the gas temperature to remain at $463\text{ K} \pm 10\text{ K}$ ($190\text{ }^{\circ}\text{C} \pm 10\text{ }^{\circ}\text{C}$).

BA. 5. 3. 3. 4 Nitrogen oxide (NO_x) analysis

If nitrogen oxides are measured on a dry basis, a chemoluminescence analyzer (CLD) with an NO₂/NO converter or a heated chemoluminescence analyzer (HCLD) must be used. If nitrogen oxides are measured on a wet basis, an HCLD with a converter able to maintain a temperature above 328 K (55 °C), and which can meet moisture quenching fluorescence examination needs, must be used.

In the case of CLD and HCLD, the wall temperature of the sampling channel must be kept between 328 K and 473 K (55 ° to 200 °C); the wall temperature must be maintained all the way to the location of the converter when taking dry basis measurements, and must be maintained to the location of the analyzer when taking wet basis measurements.

BA. 5. 3. 4 Air-fuel ratio measurements

In the case of air-fuel ratio measurement equipment determining exhaust gas flow as specified in BA.5.2.3, a broadband air-fuel ratio sensor or zirconia 1 oxygen sensor shall be employed. The sensor must be mounted directly on the exhaust pipe, and the high temperature of the exhaust can prevent moisture from condensing.

The precision of electrical sensor elements must comply with the following requirements:

When $\lambda < 2$, $\pm 3\%$ in the reading;

When $2 < \lambda < 5$, $\pm 5\%$ in the reading;

When $5 < \lambda$, $\pm 10\%$ in the reading;

In order to satisfy the foregoing precision requirements, the sensor must be calibrated in accordance with the instrument manufacturer's instructions.

BA. 5. 3. 5 Sampling exhaust gas emissions

BA. 5. 3. 5.1 Raw exhaust gas flow

The gaseous pollutant sample probe must installed at an upstream location at least 0.5 m from the exhaust system outlet or 3 times the diameter of the exhaust pipe (whichever is greater). Whenever possible, the probe shall be somewhat distant, but must be close enough to the diesel engine to ensure that the exhaust temperature at the exhaust temperature is $\geq 343\text{ K}$ (70 °C).

In the case of a multi-cylinder diesel engine with a branching exhaust manifold, to ensure that the sample gas is representative of average exhaust pollutants from all cylinders, the probe inlet must be located sufficiently far downstream. If a multi-cylinder diesel engine has separate exhaust manifolds, as in the case of a V diesel engine, it is permissible to take samples separately from each manifold, and calculate average exhaust emissions. Other methods similar to the foregoing methods may also be used. The calculation of exhaust emissions must employ the total exhaust mass flow.

If an exhaust gas aftertreatment system has been installed on a diesel engine, exhaust gas must be sampled downstream from the exhaust gas aftertreatment system.

BA. 5. 3. 5. 2 Dilute exhaust gas flow

If a full flow dilution system is used, it must comply with the following specifications.

The exhaust pipe from the diesel engine to the full flow dilution system must comply with the requirements of Annex C in GB 20891-2014.

The exhaust gas emission sampling probe must be installed within the dilution tunnel at a location where the dilution air and exhaust are sufficiently mixed, and must be close to the particulate matter sampling probe.

Two sampling methods are generally employed:

- a) A sampling bag is used to perform sampling of pollutants throughout the full test cycle, and measurement is performed after testing has been completed;
- b) Continuous sampling of pollutants throughout the full test cycle, and use of integration to calculate pollutant values; the measurement of HC and NO_x must employ this method.

A sampling bag must be used in the upstream part of the dilution tunnel to perform sampling of the background pollutant concentration of the air, and the background concentration subtracted from the measured emission values as prescribed in Appendix BA.6.2.3.

BA. 5. 3. 6 Measurement of particulate matter

The measurement of particulate matter may employ a partial flow dilution system or full flow dilution system to perform dilution. When the ecological and environmental competent authority performs supervision and inspection, a full flow dilution system must be employed when testing under 560 kW diesel engines. The flow capacity of a dilution system must be sufficient to completely eliminate the condensation of water in the dilution and sampling system, and the dilute exhaust temperature at an upstream location close to the filter paper retainer must be $320\text{ K} \pm 5\text{ K}$ ($47\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$). It is permissible to dehumidify the dilution air before it enters the dilution system (particularly when the dilution air is relatively humid), and the dilution air temperature must be $298\text{ K} \pm 5\text{ K}$ ($25\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$).

The particulate matter sampling probe must be installed in a location close to the exhaust gas emission sampling probe, and the installation method must comply with the requirements of BA.5.3.5.

To determine the mass of particulate matter, a particulate matter sampling system, particulate matter sampling filter paper, microgram balance, and a weighing room with controlled technology and humidity must be employed.

BA. 5. 3. 7 Particulate matter sampling filter paper

The particulate matter sampling filter paper must comply with the technical requirements of GB 20891—2014 Appendices BA.1.5.1.1 and BA.1.5.1.2.

BA. 5. 3. 8 Specifications of weighing room and analytical balance

The specifications of the weighing room and analytical balance must comply with the technical requirements of GB 20891—2014 Appendix BA.1.5.2.

BA.6 Data assessment and calculations

This section introduces the two measurement principles below that can be used to assess NRTC cycle pollutant emissions:

- a) Real-time measurement of the composition of the raw exhaust gas, and use of a partial flow dilution system to measure particulate matter;
- b) Use of a full flow dilution system (CVS system) to measure gas composition and particulate matter.

BA.6.1 Calculation of raw gas emissions in the raw exhaust and calculation of particulate matter emissions when a partial flow dilution system is used

BA.6. 1.1 Introduction

The mass of emissions can be calculated by multiplying the instantaneous concentration signals for gaseous components by the instantaneous exhaust gas flow rate. The exhaust mass flow rate can be measured directly, and the method in BA.5.2.3 can also be used to perform calculations (measurement of intake air and fuel flows, tracer method, measurement of intake air and air/ fuel ratio). Special attention must be paid to the response times of different instruments, and such time differences must be eliminated by performing time synchronization of signals.

When measuring particulate matter, the exhaust mass flow rate signals must be used to control the partial flow dilution system so that it takes individual samples that are proportional with the exhaust mass flow rate. Use the method in BA.5.3.6 to perform regression analysis of the sample flow rate and exhaust gas flow rate, and thereby determine whether the ratio meets requirements.

BA.6.1.2 Measurement of gas composition

BA.6.1.2.1 Calculation of mass emissions

Instantaneous mass emissions must be measured (based on the original pollutant concentrations), and the u values in Table BA.4, exhaust mass flow rate (after conversion and time synchronization), and the integrated instantaneous values throughout the full test cycle employed to determine the mass of pollutants $M_{\text{gas}}(\text{g/test})$. Wet basis concentration measurement shall be performed as a first priority. If dry basis concentration is measured, dry/wet correction of instantaneous concentration values must be performed in accordance with the content of BA.6.1.2.2 before any further calculations are performed.

Table BA.4 Coefficient u of different exhaust components--Wet basis values

Gas	u	Conc.
NO _x	0.001587	ppm
co	0.000966	ppm
HC	0.000479	ppm
cO ₂	15.19	Percentage

HC density is calculated according to an average carbon-to-hydrogen ratio of 1:1.85.

Use the following formula:

$$M_{\text{gas}} = \sum_{i=1}^n (u \cdot \text{conc}_i \cdot G_{\text{EXHW},i} \cdot \frac{1}{f}) \quad (\text{in g / test})$$

Where:

u —Density of exhaust components and exhaust density ratio;

conc_i --- instantaneous concentration of each component in the raw exhaust, ppm;

$G_{\text{EXHW},i}$ ----- instantaneous exhaust mass flow rate, kg/s;

f — data sampling rate, Hz;

n —— number of measurements.

When calculating NO_x, the humidity correction coefficient k_H in BA.6.1.2.3 should be used.

If the measured instantaneous concentration is not the wet basis concentration, conversion must be performed using the formula in BA.6.1.2.2.

BA.6.1.2.2 Dry/wet correction

If the measured instantaneous concentration is the dry basis concentration, dry/wet conversion must be performed using the following formula:

$$\text{conc}_{\text{wet}} = K_W \cdot \text{conc}_{\text{dry}}$$

Where:

$$K_{W,r} = \left(\frac{1}{1 + 1.88 \cdot 0.005 \cdot (\text{conc}_{\text{CO}} + \text{conc}_{\text{CO}_2})} \right) - K_{W2}$$

Where:

$$K_{W2} = \frac{1.608 \cdot H_a}{1000 + (1.608 \cdot H_a)}$$

conc_{co} ——CO₂ dry basis concentration, %;

conc_{co} ——CO dry basis concentration, %;

H_a ----- intake air humidity, g/kg (moisture/dry air).

$$H_a = \frac{6.220 \cdot R_a \cdot P_a}{P_B - P_a \cdot R_a \cdot 10^{-2}}$$

Where:

R_a ——Relative humidity of intake air, %;

P_a ----- Saturated vapor pressure of intake air, kPa;

P_B ----- atmospheric pressure, kPa.

Note: H_a can be calculated using the general formula after performing relative humidity measurements, or dew point and vapor pressure measurements, or dry/wet bulb measurements.

BA. 6. 1.2.3 NO_x humidity and temperature correction

NO_x emissions are connected with the ambient air conditions. The coefficient k_H from the following formula shall be used to perform correction of the NO_x concentration:

$$k_H = \frac{1}{1 - 0.0182 \cdot (H_a - 10.71) + 0.0045 \cdot (T_a - 298)}$$

Where:

T_a ——Intake air temperature, K;

H_a ----- intake air humidity, g/kg (moisture/dry air).

$$H_a = \frac{6.220 \cdot R_a \cdot P_a}{P_B - P_a \cdot R_a \cdot 10^{-2}}$$

Where:

R_a ——Intake air relative humidity, %;

P_a -----Intake air saturated vapor pressure, kPa;

P_B ----- Atmospheric pressure, kPa.

Note: H_a can be calculated using the general formula after performing relative humidity measurements, or dew point and vapor pressure measurements, or dry/wet bulb measurements.

BA. 6. 1. 2. 4 Calculation of specific emissions

The specific emission (g/kW · h) of each component should be calculated using the following formula:

$$\text{Individual Gas} = \frac{(1/10)M_{\text{gas.cold}} + (9/10)M_{\text{gas.hot}}}{(1/10)W_{\text{gas.cold}} + (9/10)W_{\text{gas.hot}}}$$

Where:

$M_{\text{gas, cold}}$ —Total mass of gaseous pollutants in cold start cycle, g;

$M_{\text{gas, hot}}$ —Total mass of gaseous pollutants in hot start cycle, g;

$W_{\text{act, cold}}$ —Actual total work done in cold start cycle, measured in accordance with BA.3.9.2, kW-h;

$W_{\text{act, hot}}$ — Actual total work done in hot start cycle, measured in accordance with BA.3.9.2, kW-h

BA. 6. 1. 3 Measurement of particulate matter

BA 6 1 3 1 Calculation of mass emissions

Either one of the following two methods may be used to calculate the mass of particulate matter

$M_{\text{PT, cold}}$ and $M_{\text{PT, hot}}$ (g/test) :

a)

$$M_{\text{PT}} = \frac{M_f}{M_{\text{SAM}}} \cdot \frac{M_{\text{EDFW}}}{1000}$$

Where:

M_{PT} --- cold/ hot start cycle $M_{\text{PT.cold}}/M_{\text{PT.hot}}$;

M_f —Mass of particulate matter collected during full cycle, mg;

M_{EDFW} —Mass equivalent of dilute exhaust during full cycle, kg;

M_{SAM} —Mass of dilute exhaust passing through particulate matter collection filter, kg.

The dilute exhaust mass equivalent during the full cycle shall be calculated using the following formula:

$$M_{\text{EDFW}} = \sum_{i=1}^n G_{\text{EDFW},i} \cdot \frac{1}{f}$$

$$G_{\text{EDFW},i} = G_{\text{EXHW}} \cdot q_i$$

$$q_i = \frac{G_{\text{TOTW},i}}{(G_{\text{TOTW},i} - G_{\text{DILW},i})}$$

Where:

$G_{\text{EDFW},i}$ —Instantaneous equivalent mass flow rate of dilute exhaust, kg/s;

$G_{\text{EXHW},i}$ -----Instantaneous mass flow rate of exhaust, kg/s;

q_i — instantaneous dilution ratio;

$G_{\text{TOTW},i}$ — Instantaneous mass flow rate of dilute exhaust through dilution tunnel, kg/s;

$G_{\text{DILW},i}$ —Instantaneous mass flow rate of dilution air, kg/s;

f—Data sampling rate, Hz;
 n—Number of measurements.
 b)

$$M_{PT} = \frac{M_f}{r_s \cdot 1000}$$

Where:

M_{PT} -- cold/hot start cycle $M_{PT, cold}/M_{PT, hot}$;

M_f —Mass of particulate matter collected during full cycle, mg;

r_s —Average sample ratio during the full cycle.

Where:

$$r_s = \frac{M_{SE}}{M_{EXHW}} \cdot \frac{M_{SAM}}{M_{TOTW}}$$

M_{SE} —Mass of exhaust sampled during full cycle, kg;

M_{EXHW} —Total exhaust flow during full cycle, kg;

M_{SAM} — Mass of dilute exhaust passing through particulate matter collection filter, kg;

M_{TOTW} —Mass of dilute exhaust passing through dilution tunnel, kg.

Note: In the case of a full-amount sampling system, the M_{SAM} and M_{TOTW} values should be identical.

BA. 6. 1. 3. 2 Particulate matter humidity correction coefficient

A diesel engine's particulate matter emissions will depend on the humidity of the ambient air. The coefficient k_p in the formula below to perform correction of particulate matter measurement results.

$$k_p = \frac{1}{(1 + 0.0133 \cdot (H_a - 10.71))}$$

Where:

H_a — intake air humidity, g/kg (moisture/dry air);

$$H_a = \frac{6.220 \cdot R_a \cdot p_a}{p_B - p_a \cdot R_a \cdot 10^{-2}}$$

Where:

R_a —Intake air relative humidity, %;

p_a ----- Intake air saturated vapor pressure, kPa;

p_B ----- Atmospheric pressure, kPa.

Note: H_a can be calculated using the general formula after performing relative humidity measurements, or dew point and vapor pressure measurements, or dry/wet bulb measurements.

BA. 6. 1. 3. 3 Calculation of specific emissions

Calculate specific emissions (g/kW-h) using the following formula:

$$P_T = \frac{(1/10)K_{p,cold} \cdot M_{PT,cold} + (9/10)K_{p,hot} \cdot M_{PT,hot}}{(1/10)W_{act,cold} + (9/10)W_{act,hot}}$$

Where:

$M_{PT, cold}$ —Mass of particulate matter during cold start cycle, g/test;

$M_{PT, hot}$ —Mass of particulate matter during hot start cycle, g/test;

$K_{p, cold}$ —Humidity correction coefficient for particulate matter during cold start cycle;

$K_{p, hot}$ —Humidity correction coefficient for particulate matter during hot start cycle;

$W_{act, cold}$ —Actual cycle work done during cold start cycle, measured in accordance with BA.4.10.2, kW-h;

$W_{act, hot}$ —Actual cycle work done during hot start cycle, measured in accordance with BA.4.10.2, kW · h.

BA. 6. 2 Measurement of gaseous components in particulate components in a full flow dilution system

The dilute exhaust mass flow rate must be understood before dilute exhaust emissions can be calculated. Full cycle total dilute exhaust flow M_{TOTW} (kg/test) must be calculated on the basis of the full cycle measured values and the calibration data for the flow measurement device (PDP is V_0 , CFV is K_V , SSV is C_d): The method introduced in BA.6.2.1 may be used. If the total mass of particulate matter and gaseous pollutant samples (M_{SAM}) exceeds 0.5% of total CVS flow (M_{TOTW}), CVS flow must be corrected on the basis of M_{SAM} , or the particulate matter samples sent to a CVS before any backflow measurement equipment.

BA 6 2 1 Measurement of dilute exhaust gas flow

PDP-CVS system

If a heat exchanger is used to ensure that variation in the temperature of the full cycle dilute exhaust temperature does not exceed ± 6 K, the following cycle exhaust mass calculations should be performed:

$$M_{TOTW} = \frac{1.293 \cdot V_0 \cdot N_P \cdot (P_B - P_1) \cdot 273}{101.3 \cdot T}$$

Where:

M_{TOTW} —Wet basis mass of dilute exhaust during the cycle;

V_0 —Volume of exhaust expelled with each revolution of a positive displacement pump under experimental conditions, m^3/rev ;

N_P —Total number of revolutions in each experiment;

P_B —Atmospheric pressure in the test room, kPa;

P_1 —Pressure drop at the pump inlet, kPa;

T —Average temperature of dilute exhaust during full cycle, K.

If the system uses flow compensation (i.e., no heat exchanger is used), the full cycle instantaneous exhaust mass must be calculated and integration performed. Under these conditions, the instantaneous mass of dilute exhaust shall be calculated as follows:

$$M_{TOTW,i} = \frac{1.293 \cdot V_0 \cdot N_{P,i} \cdot (P_B - P_1) \cdot 273}{101.3 \cdot T}$$

Where:

$N_{P,i}$ —Number of pump revolutions within each time interval.

CFV-CVS system

If a heat exchanger is used to keep variation in the temperature of full cycle dilute exhaust within ± 11 K, the cycle exhaust mass shall be calculated as follows:

$$M_{TOTW} = \frac{1.293 \cdot t \cdot K_V \cdot P_A}{T^{0.5}}$$

Where:

M_{TOTW} —Cycle wet basis dilute exhaust mass;

t —Cycle time, s;

K_V —Calibration coefficient of critical flow Venturi tube under standard conditions;

P_A — Absolute pressure at the inlet to the Venturi tube, kPa;

T — Absolute temperature at the inlet to the Venturi tube, K.

If the system uses flow compensation (i.e., no heat exchanger is used), the full cycle instantaneous exhaust mass must be calculated and integration performed. Under these conditions, the instantaneous mass of dilute exhaust shall be calculated as follows:

$$M_{TOTW,i} = \frac{1.293 \cdot \Delta t_i \cdot K_V \cdot P_A}{T^{0.5}}$$

Where:

Δt_i —time interval, s;

SSV-CVS system

If a heat exchanger is used to keep variation in the temperature of full cycle dilute exhaust within ± 11 K, the cycle exhaust mass shall be calculated as follows:

$$M_{TOTW} = 1.293 \cdot Q_{SSV} \cdot \Delta t$$

Where:

$$Q_{SSV} = \frac{A_0}{60} d^2 C_d P_A \sqrt{\left[\frac{1}{T} (r^{1.4286} - r^{1.7143}) \cdot \left(\frac{1}{1 - \beta^4 r^{1.4286}} \right) \right]}$$

A_0 —Combined constant and units: 0.005692;

d —SSV throat diameter, mm;

C_d —SSV flow coefficient;

P_A — Absolute pressure at the inlet to the Venturi tube, kPa;

T —Temperature at the inlet to the Venturi tube, K;

r —Ratio of SSV throat to inlet under absolute static pressure = $1 - \frac{\Delta P}{P}$;

p —Ratio of SSV throat diameter d to inner diameter of the inlet tube = $\frac{d}{D}$.

If the system uses flow compensation (i.e., no heat exchanger is used), the full cycle instantaneous exhaust mass must be calculated and integration performed. Under these conditions, the instantaneous mass of dilute exhaust shall be calculated as follows:

$$M_{TOTW,i} = 1.293 \cdot Q_{SSV} \cdot \Delta t_i$$

Where:

$$Q_{SSV} = A_0 d^2 C_d P_A \sqrt{\frac{1}{T} (r^{1.4286} - r^{1.7143}) \cdot \left(\frac{1}{1 - \beta^4 r^{1.4286}} \right)}$$

Δt_i —time interval, s.

Real-time calculations must begin employing a reasonable C_d value, such as 0.98, or a reasonable Q_{SSV} value. If the calculations begin from Q_{SSV} , the initial value of Q_{SSV} must be used to calculate the Reynolds number (Re).

BA.6.2.2 NO_x humidity correction

NO_x emissions are connected with the ambient air conditions. The coefficient K_H from the formula below must be used to perform correction of the measured NO_x concentration.

$$K_H = \frac{1}{1 - 0.0182 \cdot (H_a - 10.71) + 0.0045 \cdot (T_a - 298)}$$

Where:

T_a —Air temperature, K;

H_a —Intake air humidity, g/kg (moisture/dry air).

$$H_a = \frac{6.220 \cdot R_a \cdot p_a}{p_B - p_a \cdot R_a \cdot 10^{-2}}$$

Where:

R_a —Intake air relative humidity, %;

p_a —Saturated vapor pressure of intake air, kPa;

p_B —Atmospheric pressure, kPa.

Note: H_a can be calculated using the general formula after performing relative humidity measurements, or dew point and vapor pressure measurements, or dry/wet bulb measurements.

BA. 6.2.3 Calculation of exhaust mass flow rate

BA. 6.2.3.1 Use of a constant mass flow rate system

When the system employs a heat exchanger, the pollutant mass M_{gas} (g/test) shall be calculated using the following formula:

$$M_{\text{gas}} = u \cdot \text{conc} \cdot M_{\text{TOTW}}$$

Where:

u —Ratio of density of exhaust components to the dilute exhaust density;

conc —Full cycle average background correction concentration, calculated using integration (NO_x and HC are required) or measured using a sampling bag, ppm;

M_{TOTW} —Measured total mass of full cycle dilute exhaust, kg.

NO_x emissions depend on ambient air conditions. The coefficient k_m from BA.6.2.2 must be used to perform correction of the measured NO_x concentration.

If the dry basis concentration is measured, it must be converted to the wet basis concentration in accordance with BA.6.1.2.2.

BA 6 2 3 1 1 Measurement of the background correction concentration

To obtain net pollutant concentrations, the average background concentration of dilute air pollutants must be subtracted from the measured concentrations. Average background concentration values can be obtained using the sampling bag method or via integration of the results of continuous measurements. The following formula shall be used.

$$\text{conc} = \text{conc}_e - \text{conc}_d \cdot \left(1 - \frac{1}{D}\right)$$

Where:

conc —Concentration of each pollutant in dilute exhaust after correction for the background concentration, ppm;

conc_e —The measured concentration of each pollutant in dilute exhaust, ppm;

conc_d —The measured concentration of each pollutant in the dilution air, ppm;

D —Dilution coefficient.

The following formula is used to calculate the dilution coefficient:

$$D = \frac{13.4}{\text{conc}_{e\text{CO}_2} + (\text{conc}_{e\text{HC}} + \text{conc}_{e\text{CO}}) \cdot 10^{-4}}$$

BA. 6.2.3.1.2 Systems using flow compensation

In the case of systems not equipped with a heat exchanger, pollutant mass M_{gas} (g/test) must be determined via calculation of instantaneous exhaust mass and integration of instantaneous values throughout the test cycle. In addition, background correction must be performed directly on the instantaneous concentration values. Use the following formula:

$$M_{\text{gas}} = \sum_{i=1}^n ((M_{\text{TOTW},i} \cdot \text{conc}_{e,i} \cdot u)) - (M_{\text{TOTW}} \cdot \text{conc}_d \cdot (1 - \frac{1}{D}) \cdot u)$$

Where:

conce, i ----- The measured instantaneous concentration of each pollutant in dilute exhaust, ppm;

concd----- The measured concentration of each pollutant in dilution air, ppm;

u—Ratio of the density of exhaust components to density of dilute exhaust;

M_{TOTW, i}----- instantaneous mass of dilute exhaust, kg;

M_{TOTW}—Total mass of full cycle dilute exhaust, kg;

D—Dilution coefficient.

NO_x emissions are connected with the ambient air conditions. The coefficient k_m in BA.6.2.2 must be used to perform correction of the NO_x concentration.

BA. 6. 2. 4 Calculation of specific emissions

The specific emission (g/kW · h) of component shall be calculated using the following formula:

$$\text{Individual Gas} = \frac{(1/10)M_{\text{gas, cold}} + (9/10)M_{\text{gas, hot}}}{(1/10)W_{\text{gas, cold}} + (9/10)W_{\text{gas, hot}}}$$

Where:

M_{gas, cold}—Total mass of gaseous pollutants during cold start cycle, g;

M_{gas, hot}—Total mass of gaseous pollutants during hot start cycle, g;

W_{act, cold} -Actual total work done in cold start cycle, measured in accordance with BA.4.10.2, kW-h;

W_{act, hot} Actual total work done in hot start cycle, measured in accordance with BA.4.10.2, kW · h.

BA. 6. 2. 5 Calculation of particulate matter emissions

BA. 6. 2. 5. 1 Calculation of mass flow rate

The following formula shall be used to calculate the mass of particulate matter M_{pT, cold} and M_{pT, hot} (g/test):

$$M_{PT} = \frac{M_f}{M_{SAM}} \cdot \frac{M_{TOTW}}{1000}$$

Where:

M_{pT} ----- cold/ hot start cycle M_{pT, cold}/M_{pT, hot} ;

M_f—Mass of particulate matter collected during full cycle, mg;

M_{TOTW}—Total measured mass of dilute exhaust during full cycle, kg;

M_{SAM}—Mass of dilute exhaust passing through particulate sampling filter in dilution tunnel, kg.

M_f ----- M_{f, p} + M_{f, b}, if weighed separately, mg;

M_{f, p}—Mass of particulate matter collected by main filter, mg;

M_{f, b}—Mass of particulate matter collected by backup filter, mg.

If a secondary dilution system is used, the mass of secondary dilution air shall be subtracted from the total mass of secondary dilute exhaust passing through the particulate filter.

$$M_{SAM} = M_{TOT} - M_{SEC}$$

Where:

M_{TOT}—Mass of secondary dilute exhaust passing through the particulate filter, kg ;

M_{SEC}—Mass of secondary dilution air, kg.

Background correction must be performed to the mass of particulate matter. Under these conditions, the following formula shall be used to calculate the mass of particulate matter $M_{pT, cold}$ and $M_{pT, hot}$ (g/test):

$$M_{PT} = \left(\frac{M_f}{M_{SAM}} - \left(\frac{M_d}{M_{DIL}} \cdot \left(1 - \frac{1}{D} \right) \right) \right) \cdot \frac{M_{TOTW}}{1000}$$

Where:

M_{PT} ---- cold/ hot start cycle $M_{PT.cold}/M_{PT.hot}$;

M_{DIL} ——Mass of chief dilution air collected in the background particulate matter sampling filter, kg;

M_d ——Mass of background particulate matter collected from chief dilution air, mg;

D ——Measured dilution coefficient.

See text above for explanation of M_f , M_{SAM} , M_{TOTW} .

BA. 6. 2. 5. 2 Particulate matter humidity correction coefficient

Particulate matter emissions from diesel engines are connected with ambient air humidity. The coefficient k_p from the following formula shall be used to perform correction of particulate matter measurement results.

$$k_p = \frac{1}{(1 + 0.0133 \cdot (H_a - 10.71))}$$

Where:

H_a ----- intake air humidity, g/kg (moisture/dry air).

$$H_a = \frac{6.220 \cdot R_a \cdot p_a}{p_B - p_a \cdot R_a \cdot 10^{-2}}$$

Where:

R_a —Relative humidity of intake air, %;

p_a ----- Saturated vapor pressure of intake air, kPa;

p_B ----- Atmospheric pressure, kPa.

Note: H_a can be calculated using the general formula after performing relative humidity measurements, or dew point and vapor pressure measurements, or dry/wet bulb measurements.

BA. 6. 2. 5. 3 Calculation of specific emissions

Specific emissions shall be calculated using the following formula (g/kW-h):

$$PT = \frac{(1/10)K_{p,cold} \cdot M_{PT,cold} + (9/10)K_{p,hot} \cdot M_{PT,hot}}{(1/10)W_{act,cold} + (9/10)W_{act,hot}}$$

Where:

$M_{PT,cold}$ ——Mass of particulate matter during NRTC cold start cycle, g/test;

$M_{PT,hot}$ —— Mass of particulate matter during NRTC hot start cycle, g/test;

$K_{p,cold}$ ——Humidity correction coefficient for particulate matter during cold start cycle;

$K_{p,hot}$ —— Humidity correction coefficient for particulate matter during hot start cycle;

$W_{act,cold}$ ——Actual total work done in cold start cycle, measured in accordance with BA.4.10.2, kW-h;

$W_{act,hot}$ —— Actual total work done in hot start cycle, measured in accordance with BA.4.10.2., kW · h.

Appendix BB
(normative appendix)

Particle count measurement regulations

BB.1 Sampling

Particle count emissions can be continuously sampled and measured using the dilution system described in Annex C.1.2.1 of GB 20891-2014.

BB.1.1 Filtration of dilution air

The dilution air used in primary and secondary dilution systems (if needed) must flow through the air filter specified in Annex C.1.2.1 of GB 20891-2014. To reduce and stabilize the hydrocarbon concentration of the dilution air, the dilution air may be first filtered through activated carbon before passing through the filter paper of the air filter. It is recommended that additional coarse particulate filter paper be placed before the filter paper of the air filter and after the activated carbon brush (if used).

BB.2 Particle count sampling compensation- full flow dilution system

In order to compensate for the mass flow rate removed from the particle count sampling dilution system, the removed mass flow (which has undergone filtration) must be returned to the dilution system. As an alternative, the total mass flow rate of the dilution system can be used to perform mathematical correction of the removed particle count sampling flow. If the sum total mass flow rate of sample gas removed from the dilution system for use in measurement of particle count and mass of particulate matter is less than 0.5% of the total dilute exhaust gas flow in the dilution tunnel (q_{med}), correction or return to the dilution system can be omitted.

BB. 3 Particle count sampling compensation- partial flow dilution system

BB. 3. 1 In the case of a partial flow dilution system, the exhaust gas flow removed from the dilution system for use in determination of particle count must be accounted for in the control sampling ratio. The dilution system upstream from the flow measurement device can be used to return the sample gas flow used for measurement of the particle count or mathematical correction in accordance with BB.3.2 employed. With regard to an overall sampling partial flow dilution system, correction of the exhaust gas flow removed for particle count sampling shall also be performed as prescribed in BB.3.3 when particulate matter mass calculations are performed.

BB. 3. 2 Correction for transient exhaust gas flow (q_{mp}) input to the dilution system to control the sampling ratio shall be performed using one of the following methods:

- a) If the sampled particle count sampling flow is discarded, the following formula must be used:

$$q_{mp} = q_{mdew} - q_{mdw} + q_{ex}$$

Where:

q_{mp} —Exhaust gas flow in the partial flow dilution system, kg/s;

q_{mdew} —Dilute exhaust mass flow rate, kg/s;

q_{mdw} —Mass flow rate of dilution air, kg/s;

q_{ex} —Particle count sampling mass flow rate, kg/s.

Regardless of the time, the q_{ex} signal sent by the partial flow system controller must be precise to within 0.1% of q_{mdw} . The signal transmission frequency may be no lower than 1 Hz.

- b) When the sampled particle count sampling flow is partially or completely discarded, but an equal air flow flows back to the dilution system upstream of the air flow measurement device, the following formula must be used:

$$q_{\text{mp}} = q_{\text{mdew}} - q_{\text{mdw}} + q_{\text{ex}} - q_{\text{sw}}$$

Where:

q_{mp} —Exhaust sampling flow in the partial flow dilution system, kg/s;

q_{mdew} —Dilute exhaust mass flow rate, kg/s;

q_{mdw} —Dilution air mass flow rate, kg/s;

q_{ex} —Particle count sampling mass flow rate, kg/s;

q_{sw} —Mass flow rate used for particle count sampling for which compensation was performed and which was sent back into the dilution tunnel, kg/s.

Regardless of the time, the difference between q_{ex} and q_{sw} sent to the partial flow system controller must be precise to within 0.1% of q_{mdw} . The signal transmission frequency may be no lower than 1 Hz.

BB. 3.3 PM Measurement correction

When particle count measurement sample gas is removed from the overall partial flow dilution system, in view of the effect of the removed gas, correction of the mass of particulate matter (m_{PM}) calculated as shown in Appendix

BA. 6.1.3.1 shall be performed using the following method. Correction must also be performed when gas flow removed after filtration is returned to the partial flow dilution system.

$$m_{\text{PM,cor}} = m_{\text{PM}} \times \frac{m_{\text{sed}}}{(m_{\text{sed}} - m_{\text{ex}})}$$

Where:

$m_{\text{PM, cor}}$ —Mass after correction of particulate matter resulting from particle count sampling, g/test;

m_{PM} —BA.6.1.3.1 Measured mass of particulate matter, g/test;

m_{sed} —Total mass of dilute exhaust passing through dilution tunnel, kg;

m_{ex} —Total mass of dilute exhaust used in particle count sampling removed from the dilution tunnel, kg.

BB. 3.4 Partial flow dilution sampling ratio

In order to determine particle count, exhaust mass flow rate measured using any of the methods specified in BA.5.2.3 is used to control proportional exhaust sampling from the partial flow dilution system. The specific ratio shall be determined by regression analysis of samples and exhaust flow in accordance with BA.5.3.6.

BB. 4 Confirmation of particle count

BB. 4.1 Data conversion

In the case of a partial flow dilution system, data conversion shall be performed on the particle count signal and test cycle and exhaust mass flow rate in order to eliminate lag time from the particle count sampling and measurement system. The particle count sampling and measurement system conversion time

shall be determined in accordance with Appendix BC.1.4. Confirmation of particle count in a partial flow dilution system

BB. 4.2 Determining particle count in a partial flow dilution system

If a partial flow dilution system is used to perform sampling of particle count, the particle count of test cycle exhaust shall be calculated using the following formula:

$$N = \frac{M_{EDFW}}{1.293} \cdot k \cdot \bar{c}_s \cdot \bar{f}_r \cdot 10^6$$

Where:

N—Particle count of test cycle emissions, #;

M_{EDFW} —Equivalent dilute exhaust mass of the cycle confirmed in accordance with BA.6.1.3.1, kg/test;

k—Calibration coefficient. Calibration coefficient used to correct the particle counter to the standard measurement equipment. Not applicable to particle counters with internal calibration; when internal calibration is performed, $k=1$ particle count;

$\bar{c}_s$ —Average concentration of particles in dilute exhaust corrected to standard conditions (273.2 K, 101.33 kPa), number of particles per cm^3 ;

$\bar{f}_r$ —Average particle concentration attenuation coefficient of the volatile particle remover with a dilution setting at the time of testing.

$\bar{c}_s$ Calculated in accordance with the following formula

$$\bar{c}_s = \frac{\sum_{i=1}^{i=n} c_{s,i}}{n}$$

Where:

$c_{s,i}$ —Correction of particle count concentration (number of particles per cm^3) in dilute exhaust measured non-continuously by the particle counter to standard conditions (273.2 K, 101.33 kPa);

n—Number of measurements of particle count concentration during testing.

BB. 4.3 Measurement of particle count using a full flow dilution system

When using a full flow dilution system to perform sampling for particle count measurement, the particle count in test cycle exhaust shall be calculated using the following formula:

$$N = \frac{M_{ed}}{1.293} \cdot k \cdot \bar{c}_s \cdot \bar{f}_r \cdot 10^6$$

Where:

N—Test cycle particle count, #;

M_{ed} —Total calculated mass of dilute exhaust during the test cycle, kg/test;

k—Calibration coefficient. Calibration coefficient used to correct the particle counter to the standard measurement equipment; not applicable to particle counter with internal calibration. When there is internal calibration, $k=1$;

$\overline{c_s}$ — Average concentration of particles in dilute exhaust corrected to standard conditions (273.2 K, 101.33 kPa),

number of particles per cm^3 ;

$\overline{f_r}$ — Average particle concentration attenuation coefficient of the volatile particle remover with a dilution setting at the time of testing.

$\overline{c_s}$ must be calculated using the following formula

$$\overline{c_s} = \frac{\sum_{i=1}^{i=n} c_{s,i}}{n}$$

Where:

$c_{s,i}$ — Correction of particle count concentration (number of particles per cm^3) in dilute exhaust measured non-continuously by the particle counter to standard conditions (273.2 K, 101.33 kPa);

n — Number of measurements of particle count concentration during testing.

BB. 4. 4 Test results

BB. 4. 4. 1 Calculation of specific emissions

In the case of each individual hot start NRTC and cold start NRTC cycle, particle count specific emissions are calculated using the following formula:

$$e = \frac{N}{W_{\text{act}}}$$

Where:

N — Total particle count, #

e — Particle count specific emissions, #/kW · h;

W_{act} — Actual cycle work specified in BA.4.10.2, kW · h.

When NRSC has been adopted, particle count specific emissions are calculated using the following formula:

$$e = \frac{\sum_{i=1}^{N_{\text{mode}}} (N_i^g \cdot W_{Fi})}{\sum_{i=1}^{N_{\text{mode}}} (P_i \cdot W_{Fi})}$$

Where:

P_i — Diesel engine power under operating condition i [kW] ;

W_{Fi} — Weight coefficient under operating condition i [-] ;

N_i^g — Particle count under operating condition i [# / h] .

When periodic regeneration of a diesel engine occurs (see Annex B.5), specific emissions must be corrected using a suitable multiplied or added regeneration factor. If periodic regeneration does not occur

during the testing period, the upward coefficient ($k_{r, u}$) shall be employed. If periodic regeneration occurs during the testing period, the downward coefficient ($k_{r, d}$) shall be employed.

The final test results must also be corrected employing the deterioration coefficient in 5.5.

BB. 4. 4. 2 Exhaust gas aftertreatment systems with a periodic regeneration function

In the case of a diesel engine equipped with a periodic regeneration aftertreatment system, follow the general requirements of B.5.3. Hot NRTC emissions must be weighed in accordance with the formula in B.5.3, where $\bar{e}$ is the average particle count (#/kW · h) without regeneration, and $\bar{e}_r$ is the average particle count (#/kW · h) with regeneration. The regeneration adjustment factor shall be calculated using the corresponding formula in B.5.4.

BB. 4. 4. 3 NRTC test results after taking the weighted average.

In the case of NRTC, the weighted average of the final test results shall be taken using one of the following formulas depending on whether there is cold start or hot start (including related periodic regeneration).

- a) Multiplicative regeneration adjustment factor or diesel engine without periodic regeneration aftertreatment:

$$e = k_r \left[\frac{(0.10 \times N_{\text{cold}}) + (0.90 \times N_{\text{hot}})}{(0.10 \times W_{\text{act, cold}}) + (0.90 \times W_{\text{hot}})} \right]$$

- b) Additive regeneration adjustment factor:

$$e = k_r + \left[\frac{(0.10 \times N_{\text{cold}}) + (0.90 \times N_{\text{hot}})}{(0.10 \times W_{\text{act, cold}}) + (0.90 \times W_{\text{hot}})} \right]$$

Where:

N_{cold} —Particle count of NRTC cold cycle emissions, #/kW-h;

N_{hot} —Particle count of NRTC hot cycle emissions, #/kW-h;

$W_{\text{act, cold}}$ —Actual cycle work of NRTC cold test cycle calculated as specified in BA.4.10.2, kW-h;

$W_{\text{act, hot}}$ —Actual cycle work of NRTC hot test cycle calculated as specified in BA.4.10.2, kW-h;

k_r —Regeneration factor obtained as specified in B.5.3; $k_r=1$ in the case of diesel engines with no periodic regeneration aftertreatment.

BB. 4. 4. 4 Significant digits in test results

In accordance with the requirements of ASTM E 29—06B, NRSC test results and weighted average NRTC test results shall preserve 3 significant digits. Intermediate values used in the calculation of final specific emissions need not be rounded to a certain number of significant digits.

BB.5 Determination of background particle count

BB. 5. 1As requested by the diesel engine manufacturer, background particles in the dilution tunnel can be sampled before or after testing; to facilitate calculation of the background particle count in tunnel, the sampling point must be downstream of the dilution air filter.

BB. 5. 2Determination of tunnel background particle count may not be omitting when performing type testing. If it can be proven that the effect of the background particle count in the tunnel is significant, it must be subtracted from the actual dilute exhaust measurements during consistency testing.

Appendix BC
(normative appendix)

Particle count emissions measurement equipment

BC.1 Technical requirements

BC.1.1 System overview

BC. 1.1.1 The particulate matter sampling system shall obtain samples of homogeneously mixed air from a dilution system described in GB 20891—2014 Annex C.1.2.1 through a sampling tube or sampling probe, which must be installed on the volatile particle remover (VPR) upstream of the particulate counter (PNC) and must include a suitable transfer tube.

BC. 1.1.2 It is recommended that a particle diameter pre-separator (such as a cyclone separator or action type) be installed before the volatile particle remover (VPR). A sampling probe with an appropriate particle diameter classification function may be used instead of a particle diameter pre-separator. In the case of a partial flow system, particulate matter mass and particle count sampling may use the same pre-separator, and particle count sampling may be performed in the dilution system downstream from the pre-separator. As an alternative, an independent pre-separator may also be used, and particle count sampling performed in the dilution system upstream from the particulate matter mass pre-separator.

BC.1.2 General requirements

BC. 1.2.1 The particle sampling point must be inside the dilution tunnel.

The particle transfer system (PTS) shall jointly comprise the sampling probe or needle (PSP) and the particle transfer tube (PTT). Sample gas diverted by the particle transfer system (PTS) shall enter the volatile particle remover (VPR) inlet through the dilution tunnel. The particle transfer system (PTS) must satisfy the following criteria:

In the case of a partial flow dilution system or a full flow dilution system performing partial sampling, sampling tube must be installed near the centerline of the dilution tunnel, and must be located a distance of from approximately 10 times to 20 times the tunnel diameter downstream from the gas inlet; it must be positioned to face the direction of gas flow, and the central axis of the sampling probe must be parallel with the central axis of the dilution tunnel. The sampling probe must be installed within the dilution tunnel so as to ensure that a homogeneous mixture of dilution air and exhaust is sampled.

In the case of a partial flow system performing full sampling, the particulate matter sampling point or sampling probe must be installed within the particulate matter transfer tube, and must be upstream from the filter paper retainer, flow measurement device, and any sampling/bypass branch points. The location of the sampling points or sampling tube must ensure that the dilution air and exhaust are thoroughly mixed. The specifications and dimensions of the particulate matter sampling tube may not affect the normal operation of the partial flow dilution system.

Sample gas in the particle transfer system must satisfy the following criteria:

In the case of a full flow dilution system, the air flow Reynolds number must be $Re < 1700$;

In the case of partial flow systems, the air flow Reynolds number in the transfer tube downstream from the sampling probe or sampling point must be $Re < 1700$;

The residence time within the particle transfer system must be $\leq 3s$.

If it can be proven that particles with a diameter of 30nm have equivalent transmissibility, a particle transfer sampling system with some other construction can be accepted.

The outlet tube (OT) diverting dilute sample gas from the volatile particle remover (VPR) into the particle counter inlet must have the following characteristics:

The inner diameter must be $\geq 4\text{mm}$;

The residence time of sample gas passing through the outlet tube must be $\leq 0.8\text{s}$.

If it can be proven that particles with a diameter of 30nm have equivalent transmissibility, an outlet tube with some other sampling structure can be accepted.

BC. 1.2.2 The volatile particle remover (VPR) must include a sample gas dilution device and volatile particle removal device.

BC. 1.2.3 Whenever they are in contact with raw exhaust or dilute exhaust, the design of all parts of the dilution system and sampling system between the exhaust pipe and particle counter (PNC) must minimize precipitation of particles. All parts must be made from electrically-conducting materials, which may not react with any exhaust components; the system must be grounded to prevent static electrical effects.

BC. 1.2.4 The particle sampling system must be effectively paired with aerosol sampling characteristics, such as by avoiding sharp bends and sudden changes in cross-section, and it must have smooth inner surfaces; the sampling tube must be as short as possible. Gradual changes in cross-section are permitted.

BC. 1.3 Detailed requirements

BC. 1.3.1 The particle sample gas may not pass through a sampling pump before passing through the particle counter.

BC. 1.3.2 It is recommended that a sampling pre-separator (PCF) be used.

BC. 1.3.3 The sampling pre-treatment must:

BC. 1.3.3.1 be able to single or multiple dilution of the sample gas, ensuring that the particle count concentration is lower than the upper limit of the particle counter's particle count module, and also ensuring that the temperature at the inlet to the particle counter is lower than 35°C .

BC. 1.3.3.2 include an initial heating dilution process that can output sample gas with a temperature of from 150°C to 400°C , and has a dilution multiple of at least 10.

BC. 1.3.3.3 control the temperature through the heating stage to the constant working, this temperature must be within the range specified in BC.1.3.3.2, and may have a permissible variation of $\pm 10^{\circ}\text{C}$.

BC. 1.3.3.4 use indicator data to display whether the correct working temperature has been reached during the heating stage. The concentration attenuation coefficient (f_r (di)), see definition in BC.2.2.2) for particulate matter with an electronic mobility diameter of 30nm and 50nm may not exceed 30% and 20% respectively. With regard to the volatile particle remover (VPR) as a whole, the amplitude of the particulate matter concentration attenuation coefficient corresponding to particulate matter with an electronic mobility diameter of less than 100nm may not exceed 5%.

BC. 1.3.3.5 can cause the rate of vaporization of 30nm tetracontane ($\text{CH}_3(\text{CH}_2)_{38}\text{CH}_3$) particles with an inlet concentration of $\geq 10,000\text{ cm}^{-3}$ to reach $>99.0\%$ via heating and reduction of tetracontane ($\text{CH}_3(\text{CH}_2)_{38}\text{CH}_3$) partial pressure.

BC. 1.3.4 Particle counter (PNC)

BC. 1.3.4.1 operate under full flow conditions.

BC. 1.3.4.2 In accordance with the principle of traceability, count precision must be $\pm 10\%$ from 1 cm^{-3} to the upper limit of a single particle counting module. If the average measured value of particle concentration is less than 100 cm^{-3} during a prolonged sampling period, a higher statistical degree of confidence may be required to verify the accuracy of the particle counter (PNC).

BC. 1.3.4.3 The resolution must be at least 0.1 cm^{-3} when the particle concentration is less than 100 cm^{-3} .

BC. 1. 3. 4. 4 A single particle counting module must have linear response to particle concentration within the full measurement range.

BC. 1. 3. 4. 5 The data refresh frequency must be greater or equal to 0.5Hz.

BC. 1. 3. 4. 6 The T_{90} response time of the measurement range may not exceed 5s.

BC. 1. 3. 4. 7 When there is a coincidence correction function with a maximum of 10%, the method in BC.2.1.3 can be used to determine the correction coefficient, but no other algorithm may be used to perform correction or define counting performance.

BC. 1. 3. 4. 8 Must have particle counting performance of 50% ($\pm 12\%$) and greater than 90% in the case of particles with electronic mobility diameter of 23nm ($\pm 1\text{nm}$) and 41nm ($\pm 1\text{nm}$) respectively. This counting performance can be achieved via internal methods (such as control of instrument design) or external methods (such as use of a particle pre-separator).

BC. 1. 3. 4. 9 If the particle counter uses a working fluid, it must be replaced in accordance with the replacement frequency specified by the instrument manufacturer.

BC. 1. 3. 4.10 If a known constant flow is maintained within the controllable range of the particle counter (PNC), the pressure and/or temperature at the particle counter inlet must be measured and recorded in order to correct particle concentration measurements to standard conditions.

BC. 1. 3. 4. 11 The sum of residence time of particulate matter in the particulate matter transfer system (PTS), volatile particle remover (VPR), and outlet tube (OT) and the t_{90} response time of the particle counter response may not exceed 20s.

BC. 1. 3. 4. 12 The transmission time of the particulate matter counting and sampling system as a whole (transport system, volatile particle remover, outlet tube, and particle counter) shall be determined by the aerosol conversion rate at the inlet to the particulate matter transfer tube. Aerosol conversion must be completed within 0.1sec. Aerosol used for testing must be able to cause concentration changes of at least 60% of full range.

BC. 1. 3. 4. 13 The tracer gas concentration must be recorded. To facilitate matching of the particle count concentration and exhaust gas flow signal time, the transmission time shall be defined as 50% (t_{50}) of the time interval from the start of change (t_0) to the final reading.

BC.1.4 Description of recommended system

The following clauses consist of the recommended operating procedures for particle count measurement. Any system meeting the performance standards in BC.1.2 and BC.1.3 can background accepted.

Fig. BC.1 and Fig. BC. 2 are schematic diagrams of the recommended partial flow and full flow particle count sampling systems.

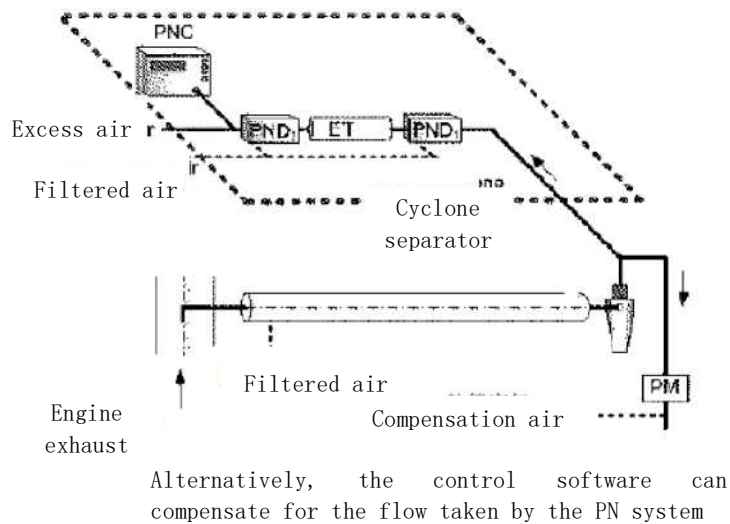


Figure BC.1 Schematic diagram of recommended particle count sampling system — Partial flow sampling

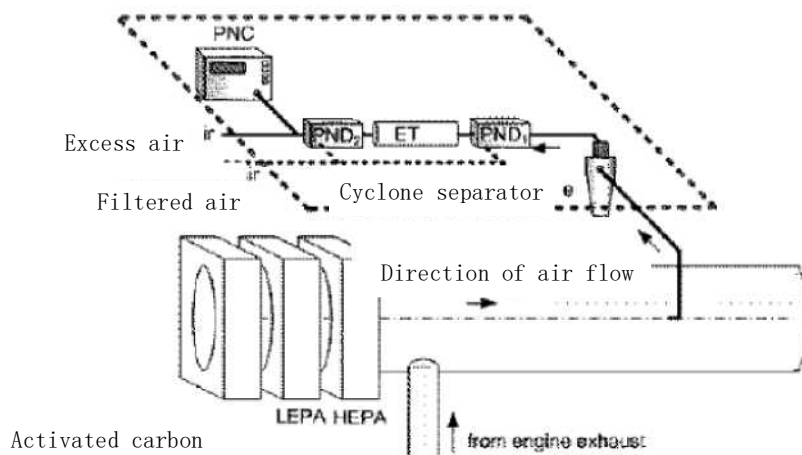


Figure BC.2 Schematic diagram of recommended particle count sampling system — Full flow sampling

BC. 1.4.1 Description of sampling system

BC. 1. 4. 1. 1 The particulate matter sampling system shall consist of a sampling probe or needle in the dilution tunnel, a particle transfer tube (PTT), particle diameter pre-classifier (PCF), and volatile particle remover (VPR) located upstream of the particle count concentration measurement (PNC) unit. The volatile particle remover (VPR) must include sample dilution devices (particle count dilution devices: primary particle count dilution device (PND₁) and secondary particle count dilution device (PND₂) and particle evaporation device (evaporation tube ET). The sampling probe or needle for the gas to be measured must be installed in the dilution tunnel, which will facilitate the taking of representative gas samples of the thoroughly mixed air and exhaust. The sum of the residence time of particulate matter in the sampling system and the T₉₀ response time of the particle counter may be no greater than 20s.

BC. 1. 4. 2 Particle transfer system

The sampling probe or needle and particle transfer tube (PTT) shall jointly constitute the particulate matter transmission system (PTS).

In the case of partial and full flow dilution systems, the sampling tube must be installed near the centerline of the dilution tunnel, and must be located a distance of from approximately 10 times to 20 times the

tunnel diameter downstream from the gas inlet; it must be positioned to face the direction of gas flow, and the central axis of the sampling probe must be parallel with the central axis of the dilution tunnel. The sampling probe must be installed within the dilution tunnel so as to ensure that a homogeneous mixture of dilution air and exhaust is sampled.

In the case of a partial flow system performing full sampling, the particulate matter sampling point or sampling probe must be installed within the particulate matter transfer tube, and must be upstream from the filter paper retainer, flow measurement device, and any sampling/bypass branch points. The location of the sampling points or sampling tube must ensure that the dilution air and exhaust are thoroughly mixed. The specifications and dimensions of the particulate matter sampling tube may not affect the normal operation of the partial flow dilution system.

Sample gas in the particle transfer system shall meet the following conditions:

In the case of a full flow dilution system, the air flow Reynolds number must be $Re < 1700$;

The residence time within the particle transfer system must be $\leq 3s$.

If it can be proven that particles with a diameter of 30nm have equivalent transmissibility, a particle transfer sampling system with some other construction can be accepted.

The outlet tube (OT) diverting dilute sample gas from the volatile particle remover (VPR) into the particle counter inlet must have the following characteristics:

The inner diameter must be $\geq 4mm$;

The residence time of sample gas passing through the outlet tube must be $\leq 0.8s$.

If it can be proven that particles with a diameter of 30nm have equivalent transmissibility, an outlet tube with some other sampling structure can be accepted.

BC. 1.4.3 Particle diameter pre-separator (PCF)

It is recommended that a particle diameter pre-separator be installed upstream from the volatile particle remover. Under the volume flow selected for particle count emissions sampling, the diameters of particles separated by the pre-separator (classification performance must be 50% of the particle diameter) must range from 2.5 μm to 10 μm . The pre-classifier shall permit 99% of particulate matter with a mass concentration of 1 μm particulate matter to enter, and shall allow it to exit with the volume flow selected for particle count emissions sampling. In the case of a partial flow system, particulate matter mass and particle count sampling may use the same pre-separator, and particle count sampling may be performed in the dilution system downstream from the pre-separator. As an alternative, an independent pre-separator may also be used, and particle count sampling performed in the dilution system upstream from the particulate matter mass pre-separator.

BC. 1.4.4 Volatile particle remover (VPR)

The volatile particle remover shall comprise a primary particle count dilution device (PND₁), evaporation tube (ET), and secondary dilution device (PND₂) in series. The effect of dilution shall be to reduce the sample gas count concentration when the gas enters the particle concentration measurement unit, cause the concentration to be lower than the upper limit of a single particle counting module, and inhibit nucleation and condensation of the sample gas. The VPR shall display whether the working temperature of the PND₁ and ET is normal.

The volatile particle remover must cause the rate of vaporization of 30nm tetracontane ($CH_3(CH_2)_{38}CH_3$) particles with an inlet concentration of $> 10,000\text{ cm}^{-3}$ to reach $> 99.0\%$ via heating and reduction of tetracontane ($CH_3(CH_2)_{38}CH_3$) partial pressure.

The particle concentration attenuation coefficient (f_r) must reach: With regard to the volatile particle remover (VPR) as a whole, the attenuation coefficient of particles with an electronic mobility diameter of

30nm and 50nm may not exceed 30% and 20% respectively, and the attenuation coefficient of particles with an electronic mobility diameter of less than 100nm may not exceed 5%.

BC. 1. 4. 4. 1 Primary particle count dilution device (PND₁)

The design of the primary particle count dilution device must allow it to dilute the particle count concentration, and operate with a wall temperature of from 150°C to 400°C. The wall temperature set point must be maintained at a constant level below the nominal operating temperature, with an error within $\pm 10^\circ\text{C}$, and may not exceed the evaporation tube (see BC.1.4.4.2) temperature. The dilution gas must pass through an air filter, and the dilution coefficient must be adjustable from 10 times to 200 times.

BC. 1. 4. 4. 2 Evaporation tube (ET)

The temperature of the evaporation tube wall must be controlled so that it is greater than or equal to that of the primary particle count dilution device, and the wall temperature must be maintained at a constant value within the range of from 300°C to 400°C, with an error of less than $\pm 10^\circ\text{C}$.

BC. 1. 4. 4. 3 Secondary particle count dilution device (PND₂)

The design of the secondary particle count dilution device must allow the dilution of particle count concentration. The dilution device must be connected by an air filter, and it must be possible to select a dilution coefficient of 10-fold to 30-fold. The dilution coefficient of the secondary particle count dilution device must be selected within a range of from 10 times to 15 times, must ensure that the downstream particle count concentration is lower than the upper limit of a single particle counting module in the particle counter, and must ensure that the gas temperature is lower than 35 °C before the gas enters the particle counter.

BC. 1. 4. 5 Particle counter (PNC)

The particle counter must satisfy the requirements of BC.1.3.4.

BC.2 Calibration and verification of the particle count sampling system

BC. 2. 1 Calibration of the particle counter

BC. 2. 1. 1 The inspection organization must ensure that the particle counter has a traceable inspection certificate, and that certificate must be within its 12-month period of validity during testing.

BC. 2. 1. 2 If any major maintenance is performed on the particle counter, calibration must be performed again, and a new inspection certificate obtained.

BC. 2. 1. 3 A standard traceable calibration method must be employed:

- a) When sampling standard particles with static classification F, calibration may be performed by comparing the response of a particle counter with calibrated and uncalibrated air electrometers; or
- b) a second particle counter (this counter must have undergone direct calibration employing the foregoing method) may be used, and calibration performed by comparing the response of the particle counters.

At least 6 standard concentration values must be used when calibrating the electrometer, and these values must be evenly distributed across the particle counter's range as much as possible. These values must include the nominal zero point generated by the high-efficiency air filter (must be at least grade H13 specified in EN1822: 2008) installed at the inlet of each instrument. When the particle counter does not use a calibration coefficient in the calibration process, measurement results for each of the concentration values used may not exceed $\pm 10\%$ of the standard concentration value, with the zero point values as an exception, and otherwise the particle counter shall not pass calibration. The linear regression slope of the two sets of data shall be calculated and recorded. When performing calibration, the calibration coefficient shall be the reciprocal of the slope. Use the squares of the Pearson product-moment correlation coefficients (r^2) for the

two sets of data to calculate the response linearity; this value must be greater than or equal to 0.97. When calculating the linear regression slope and r^2 value, the slope must be forced to pass through the origin (the zero point concentration values of the two instruments).

When using the standard particle counter method, at least 6 standard concentration values distributed across the particle counter's range must be used in calibration. At least 3 of these values must be lower than the concentration value of 1000 cm^{-3} , and the remaining concentration values must be linearly distributed between 1000 cm^{-3} and the upper limit of each single particle counter module. These values must include the nominal zero point concentration value generated by the high-efficiency air filter (must be at least grade H13 specified in EN1822:2008 or have equivalent performance) installed at the inlet of each instrument. When the particle counter does not use a calibration coefficient in the calibration process, measurement results for each of the concentration values used may not exceed $\pm 10\%$ of the standard concentration value, with the zero point values as an exception, and otherwise the particle counter shall not pass calibration. The linear regression slope of the two sets of data shall be calculated and recorded. When performing calibration, the calibration coefficient shall be the reciprocal of the slope. Use the squares of the Pearson product-moment correlation coefficients (r^2) for the two sets of data to calculate the response linearity; this value must be greater than or equal to 0.97. When calculating the linear regression slope and r^2 value, the slope must be forced to pass through the origin (the zero point concentration values of the two instruments).

BC. 2. 1.4 Inspection must also be conducted in accordance with the requirements of BC.1.3.4.8 when performing calibration, and the counting performance of the particle counter shall be checked using particles with an electronic mobility diameter of 23nm. It is not necessary to check the counting performance for particles with a diameter of 41 nm.

BC. 2. 2 Volatile particle remover Calibration and verification

BC. 2. 2. 1 After any major maintenance is performed to the volatile particle remover and equipment, the particle concentration attenuation coefficient of the volatile particle remover must be calibrated over the full range at the working temperature recommended by the instrument manufacturer. The regular inspection requirements for the particle concentration attenuation coefficient of the volatile particle remover require inspection only at a single preset time (in the case of typical applications such as use on diesel engines equipped with particulate matter aftertreatment systems). The inspection organization must confirm that the volatile particle remover is within its 6-month inspection validity period at the time of testing. If the volatile particle remover has a temperature monitoring and alarm function, a 12-month inspection validity period is permissible.

Solid particles with an electronic mobility diameter of 30 nm, 50 nm, and 100 nm must be used to express the particle concentration attenuation coefficient of the volatile particle remover.

The concentration attenuation coefficient (f_r ; (di)) of particles with electronic mobility diameters of 30 nm and 50 nm may not exceed 30% and 20%, and the concentration attenuation coefficient of particles with an electronic mobility diameter less than 100 nm may not exceed 5%.

For confirmation, the average value of the particle concentration attenuation coefficient must be within $\pm 10\%$ of the particle concentration attenuation coefficient ($\overline{f_r}$) at the time of initial calibration of the volatile particle remover.

BC. 2. 2. 2 Suspended particles used in testing the particle concentration attenuation coefficient of a volatile particle remover must be solid particles with electronic mobility diameters of 30 nm, 50 nm, and 100 nm, and the minimum concentration at the inlet to the volatile particle remover must be 5000 cm^{-3} . Particle concentration must be measured at locations upstream and downstream of the volatile particle remover.

The following formula shall be used to calculate the particle concentration attenuation coefficient (f_r)

(d_i) for various particle diameters

$$f_r(d_i) = \frac{N_{in}(d_i)}{N_{out}(d_i)}$$

Where:

$N_{in}(d_i)$ —Upstream particle count concentration for particles with a diameter of d_i ;

$N_{out}(d_i)$ —Downstream particle count concentration for particles with a diameter of d_i ;

d_i -----Electronic mobility diameter (30 nm, 50 nm or 100 nm).

$N_{in}(d_i)$ and $N_{out}(d_i)$ must be correlated to the same basis.

The following formula shall be used to calculate the average particle concentration attenuation coefficient ($\bar{f}_r$) for a given dilution setting

$$\bar{f}_r = \frac{f_r(30\text{nm}) + f_r(50\text{nm}) + f_r(100\text{nm})}{3}$$

It is recommended that the volatile particle remover be calibrated and confirmed as a single unit.

BC. 2. 2. 3 The inspection organization must ensure that the volatile particle remover's volatile particle removal efficiency inspection certificate is within its 6-month period of validity during testing. If the volatile particle remover has a temperature monitoring and alarm function, a 12-month inspection validity period is permissible. It must be verified that the volatile particle remover can remove more than 99% of tetracontane ($\text{CH}_3(\text{CH}_2)_{38}\text{CH}_3$) particles with an electronic mobility diameter of 30 nm at the lowest dilution setting, the manufacturer's recommended working temperature, and an inlet concentration of $\geq 10000 \text{ cm}^{-3}$.

BC. 2. 3 Particle counting system inspection procedures

BC. 2. 3.1 Before testing, when a high-efficiency air filter (must be at least grade H13 specified in EN1822 or have equivalent performance) is installed at the entrance to the particle sampling system as a whole (volatile particle remover and particle counter), the measured concentration value displayed by the particle counter must be less than 0.2 cm^{-3} .

BC. 2. 3. 2 A calibrated flow meter must be used to check the particle counter on a monthly basis; the difference between particle counter flow measurements and the nominal values may not exceed 5%.

BC. 2. 3. 3 Before testing, when a high-efficiency air filter (must be at least grade H13 specified in EN1822 or have equivalent performance) is installed at the particle counter inlet, the measured concentration value displayed by the particle counter must be $\leq 0.2 \text{ cm}^{-3}$. After removing the filter and switching to use of ambient air, the measured concentration value displayed by the particle counter must at least increase to 100 cm^{-3} ; when a high-efficiency air filter is installed again, the measured concentration must return to $\leq 0.2 \text{ cm}^{-3}$.

BC. 2. 3. 4 Prior to testing, it must be confirmed that the evaporation tube, which is the measurement system's key element, has reached its normal working indicator temperature.

BC. 2. 3. 5 Before each testing session, it must be confirmed that the measurement system's PND₁ has reached its normal working indicator temperature.

BC. 2. 3. 6 After each testing session, the analyzer's zero point and span points must be inspected to ensure that the instrument manufacturer's requirements have been met.

Appendix BD
(normative appendix)
NH₃ testing regulations

BD.1 Overview

This Appendix specifies NH₃ testing regulations. A linearization circuit may be used in the case of nonlinear analyzers.

BD.2 Measurement principles

NH₃ measurement principles must comply with the requirements of BD.2.1 or BD.2.2; a gas dryer may not be used in the NH₃ measurement process.

BD. 2. 1 Diode laser spectrometer (LDS)**BD. 2.1.1 Measurement principles**

LDS employs the principle of single-path spectrometry, and determines the absorption spectrum lines of NH₃ by scanning the near infrared spectrum using a single-path laser diode.

BD. 2. 1. 2 Installation

The analyzer is installed directly on the exhaust pipe (original location) or in the analyzer sampling cabinet, and must perform sampling in accordance with the manufacturer's recommendations. If installed in an analyzer sampling cabinet, the sampling line(sampling tube, coarse filter, and valve) must be made of stainless steel or polytetrafluoroethylene (PTFE) material, and must be heated to at least 463K±10K (190°C±10°C), which will serve to reduce loss of NH₃ and impact on sampling. In addition, the sampling tube should be as short as possible in view of the actual situation.

The effect of exhaust temperature and pressure, the installation environment, and vibration on measurements should be kept as minimal as possible, or compensation methods adopted. If applicable, the protective gas connected with in situ measurements and used to protect the instrument may not influence measurement of the concentration of any exhaust components downstream of the equipment; if there is any influence, other exhaust component sampling points must be installed upstream of this equipment.

BD. 2. 1. 3 Interference inspection

Interference from other substances in exhaust must be reduced to a minimum, the resolution of laser spectroscopy must be within 0.5 cm⁻¹.

BD. 2. 2 Fourier transform infrared spectroscopic (FTIR) analyzer**BD.2.2.1 Measurement principles**

FTIR employs the principles of broadband infrared spectrometry. It can perform synchronous simultaneous testing of multiple types exhaust components with standard spectra within the instrument. The absorption spectra of the various components (intensity/wavelength) shall be obtained from interference figures (intensity/time) calculated using the Fourier transform method.

BD.2.2.2 Installation and sampling

FTIR shall be installed in accordance with equipment manufacturer's requirements. Selection of NH₃ wavelength for analysis. If installed in an analyzer sampling cabinet, the sampling line(sampling tube, coarse filter, and valve) must be made of stainless steel or polytetrafluoroethylene (PTFE) material, and must be heated to at least 463K±10K (190°C±10°C), which will serve to reduce loss of NH₃ and impact on sampling. In addition, the sampling tube should be as short as possible in view of the actual situation.

BD.2.2.3 Interference inspection

In order to reduce interference from other substances in exhaust to a minimum, the NH_3 wavelength resolution must be less than 0.5 cm^{-1} .

BD. 3 Exhaust testing regulations and assessment

BD.3.1 Analyzer inspection

An analyzer range must be selected prior to exhaust testing. Analyzers with an automatic or manual range switch function may be used, but the analyzer's range may not be changed during the testing process.

If the regulations in BD.3.4.2 are not applicable to the instrument, zero air and span gas response times must be determined. With regard to the span gas response, an NH_3 standard gas complying with BD.4.2.7 must be used. Use of a testing room containing NH_3 span gas is permitted.

BD. 3. 2 Collection of exhaust-related data

NH_3 data must be collected simultaneously with the start of the test cycle. The NH_3 concentration must be measured continuously throughout the testing process, and concentration data must be saved with a frequency of at least 1 Hz.

BD. 3. 3 Procedures after testing

After the conclusion of testing, sampling shall continue until the conclusion of the system's response time. Analyzer drift should be measured in accordance with BD.3.4.1 only when the requirements of BD.3.4.2 cannot be satisfied.

BD. 3. 4 Analyzer drift inspection

BD. 3. 4.1 Analyzer zero air and span gas drift inspection shall be performed as soon as possible 30 minutes after the conclusion of the hot soak stage or test cycle. Error before and after testing must be less than 2% of full range.

BD. 3. 4. 2 Analyzer drift inspection is not required under the following circumstances:

- a) If the zero point and span gas drift specified by the manufacturer in BD.4.2.3 and BD.4.2.4 satisfy the requirements of BD.3.4.1;
- b) If the zero point and span gas drift time specified by the manufacturer in BD.4.2.3 and BD.4.2.4 exceed the test cycle.

BD. 3. 5 Data processing

The NH_3 concentration shall be calculated additively from all instantaneous values in the cycle. The calculation formula is as follows:

$$C_{\text{NH}_3} = \frac{1}{n} \sum_{i=1}^{i=n} C_{\text{NH}_{3,i}}$$

Where:

C_{NH_3} ----- The instantaneous concentration of NH_3 in exhaust, ppm;

n——Measurement frequency.

BD. 3. 5. 1 The final NRTC cycle test results are calculated using the following formula:

$$C_{\text{NH}_3} = (0.10 \times C_{\text{NH}_{3,\text{cold}}}) + (0.90 \times C_{\text{NH}_{3,\text{hot}}})$$

Where:

$C_{\text{NH}_3, \text{ cold}}$ —Average concentration of NH_3 during cold start cycle, ppm;

$C_{\text{NH}_3, \text{ hot}}$ —Average concentration of NH_3 during hot start cycle, ppm.

BD.3.5.2 The final NRSC cycle test results are calculated using the following formula:

$$C_{\text{NH}_3} = \sum_{i=1}^{N_i} \bar{C}_{\text{NH}_{3,i}} \cdot \text{WF}_i$$

Where:

$\bar{C}_{\text{NH}_{3,i}}$ — Average NH_3 concentration under operating condition i ;

N_i —Number of test operating conditions;

WF_i —Weight coefficient under operating condition i .

BD.4 Analyzer technical parameters and calibration

BD. 4.1 Calibration requirements

At least every 3 months or when system maintenance or modification may affect calibration, the analyzer must be subjected to linearity inspection in accordance with the requirements of Appendix BB.1.5 of GB 20891-2014. If it has been verified that equivalent precision can be achieved, the number of data points used in calibration may be less than 10. The NH_3 used in linearity inspection must comply with the requirements of BD.4.2.7. Use of a testing room containing NH_3 span gas is permitted. Linearity inspection shall be performed in accordance with the requirements of internal inspection procedures and the equipment supplier's recommended standards.

BD. 4. 2 Analyzer technical parameters

The analyzer's measurement range and response time must satisfy steady-state and transient cycle NH_3 concentration measurement precision requirements.

BD. 4. 2. 1 Minimum measurement limit

Under all testing conditions, the analyzer inspection limit must be < 2 ppm.

BD. 4. 2. 2 Accuracy

Analyzer reading and standard value error may not exceed $\pm 3\%$ of the reading or ± 2 ppm, whichever is the greatest.

BD. 4. 2. 3 Zero drift

Zero air response drift and relevant time intervals must comply with the instrument manufacturer's standards.

BD. 4. 2. 4 Span gas drift

Calibration gas response drift and relevant time intervals must comply with the instrument manufacturer's standards.

BD. 4. 2. 5 System response time

The system response time shall be ≤ 20 s

BD. 4. 2. 6 Rise time

Analyzer rise time shall be ≤ 5 s

BD. 4. 2. 7 NH₃ standard gas

Must be a mixed gas with the following chemical composition.

NH₃ and purchase nitrogen.

The actual concentration of the standard gas must be within $\pm 3\%$ of the nominal value. The NH₃ concentration shall be a volumetric ratio (% or ppm).

The standard gas validity date specified by the manufacturer must be recorded.

BD.5 Alternative systems

If another system or analyzer can achieve the same "results" as those specified in 5.2.1 of GB 20891-2014, it may also be used by the inspection organization. "Results" refer to the average value of NH₃ during the cycle.

Annex C
(normative annex)

CORRECT OPERATING REQUIREMENTS FOR NO_x control measures

C.1 Overview

This Annex specifies technical requirements ensuring the correct operation of NO_x control measures. This Annex is applicable to pollutant control systems that may have any impact on NO_x emissions, such as SCR, EGR systems.

C.2 General requirements

Diesel engine systems must be equipped with an NCD, which is used to identify the NCM specified in this Annex. All NCD system designs, structures, and installations must satisfy requirements under normal operating conditions within its service life.

C. 2.1 Necessary information

C. 2.1.1 If an exhaust control system requires a reagent, the diesel engine manufacturer must explain the reagent type, provide information concerning the concentration of the reagent in a dissolved state, and specify characteristics including the use temperature conditions, composition and mass, and reference standards, etc.

C. 2.1.2 During type testing, the diesel engine manufacturer must provide a detailed written explanation explaining the functionality of the driver alarm system specified in C.4, and must provide a detailed explanation of the functionality of the driving performance restriction system activation specified in C.5.

C. 2.1.3 The diesel engine manufacturer shall provide installation documents, and these documents must include detailed technical requirements and regulations needed for correct installation of the diesel engine (software, hardware, and information) on machinery.

C. 2.2 Operating conditions

C. 2.2.1 The NO_x control and diagnostic system must operate under the following conditions:

- a) An ambient temperature of from 266K to 311K (-7°C to 38°C);
- b) An elevation above sea level not exceeding 1700m;
- c) A diesel engine cooling fluid temperature above 343K (70°C).

Reagent level monitoring shall not be limited to the foregoing conditions; whenever technically feasible, reagent level monitoring shall be performed under all conditions. If a liquid reagent is employed, monitoring of reagent level shall be performed under all conditions as long as the reagent is not frozen.

C.2.3 Reagent freezing prevention

C. 2.3.1 A heated or unheated reagent tank and reagent metered injection system may be used. Heating systems must comply with the requirements of C.2.3.2, and unheated systems must comply with the requirements of C.2.3.3.

C. 2.3.1.1 Instructions must explain unheated reagent tanks and injection systems to the machinery's owner.

C. 2.3.2 Reagent tanks and reagent metered injection systems with heating systems

C. 2.3.2.1 If the reagent has frozen, the enterprise should ensure that reagent can be used normally at an ambient temperature of 266K (-7°C) within 70 min of diesel engine operation.

C. 2.3.2.2 Demonstration testing

- C. 2. 3. 2. 2.1 The reagent tank and reagent metered injection system must sit at a temperature of 255K (-18 °C) for 72 h or until the reagent has solidified, whichever comes first.
- C. 2. 3. 2. 2. 2 After the end of the sitting period in C.2.3.2.2.1, the diesel engine shall be started at a temperature of 266K (-7 °C) or below, be allowed to idle for 10 to 20 min, and then operate for no more than 50 min at no greater than 40% load.
- C. 2. 3. 2. 2. 3 After the end of the testing procedures in C.2.3.2.2.2, the reagent metered injection system must be able to operate normally.
- C. 2. 3. 2. 3 The machine or representative parts installed on the machine may be testing in a low-temperature chamber or on-site.
- C. 2. 3. 3 Activation of unheated system driver alarm and driving performance restriction system
- C. 2. 3. 3. 1 If there is no reagent supply at a temperature of 266K (-7 °C) and below, the driver alarm system specified in C.4 must be activated.
- C. 2. 3. 3. 2 If there is no reagent supply at a temperature of 266K (-7 °C) and below, the strict driving performance restriction system specified in C.5.4 must be activated within 70 min of the start of diesel engine operation.
- C. 2. 4 Diagnostic requirements
- C. 2. 4. 1 The NCD must be able to identify the NCM specified in this Annex on the basis of the DTC saved in the system, and must transmit the saved information at the time of offline identification.
- C. 2. 4. 2 Diagnostic fault code record requirements
- C. 2. 4. 2. 1 The NCD system must record one DTC for each different NCM.
- C. 2. 4. 2.2 When the diesel engine has been operating for less than 60 min, the NCD system must be able to diagnose whether any potential faults exist. If potential faults exist, the system must save "Confirmed and activated" fault code, and activate the driver alarm system specified in C.4.
- C. 2. 4. 2. 3 If any monitoring items require the diesel engine to operate for more than 60 min. In order to accurately detect and confirm an NCM (such as when the monitoring item employs a statistical model or is based on the machine's fluid consumption), after the diesel engine manufacturer has verified the need for a relatively long time, a longer monitoring time may be permitted (for instance, use of technical principles, test results, and internal experience, etc.).
- C. 2. 4. 3 Diagnostic fault code erasure requirements
- C. 2. 4. 3. 1 Except when the DTC fault has already been corrected, the DTC and related information may not be erased directly from the system by the NCD system.
- C. 2. 4. 3.2 The NCD system may erase all DTC in accordance with diagnostic or maintenance tools provided by the diesel engine manufacturer, or using the code provided by the diesel engine manufacturer.
- C. 2. 4. 4 Within the diesel engine's full service life, the NCD system may not have any code or other designs that are partially or wholly deactivated on the basis of the machine's service life; and may not have any algorithm or strategy that may degrade NCD system performance within the engine's full service life.
- C. 2. 4. 5 Alteration of any modifiable computer code or NCD system working parameters must be prevented.
- C. 2. 4. 6 NCD Diesel engine family

The diesel engine manufacturer shall bear responsibility for confirming composition of the NCD diesel engine family. Diesel engine system subgroups within a NCD family must be judged on the basis of

sound engineering experience; diesel engines that do not belong to the same diesel engine family may still be classified as being in the same NCD diesel engine family. C. 2. 4. 6.1 Definition of NCD diesel engine family parameters

The basic design parameters of any one NCD diesel engine family must be identical. The following basic design parameters must be similar in the case of different diesel engine families belonging to a single NCD family must:

- a) Emission control system;
- b) NCD monitoring method;
- c) NCD monitoring principles;
- d) Monitoring parameters (such as sampling frequency).

The diesel engine manufacturer must employ relevant engineering proof or other legitimate procedures to verify these similar basic parameters.

If changes in the configuration of a diesel engine system cause minor differences in the NCD system's monitoring/ diagnostic methods, but the diesel engine manufacturer believes that the control strategy is the same, and the reason for the difference is solely to comply with the specific characteristics of parts or components (such as dimensions, exhaust gas flow, etc.), or the similar control strategies are based on sound engineering judgment, the manufacturer may apply to the inspection organization for a NCD diesel engine family.

C. 3 Maintenance and service requirements

In accordance with the requirements of Appendix CC, the machinery company must provide a written introduction to relevant aftertreatment control systems and their normal introduction to the final user of the machine.

C. 4 Driver alarm system

C. 4.1 Driver alarm systems that must be installed on machines. When the system detects a low reagent level, reagent quality fault, interrupted injection, or fault specified in C.9.3, if the problem is not promptly corrected, the driving performance restriction system shall be activated. The driver alarm system must notify the driver using a visible alarm signal. After the driving performance restriction system specified in C.5 is activated, the driver alarm system must remain in an activated condition.

C.4.2 Although the same alarm system may be used, the alarm light must be different from other warning signals indicating faults or need for diesel engine maintenance. If the cause of the alarm being triggered is not corrected, it shall not be possible to use diagnostic tools to turn off the alarm system or visual alarm.

C.4.3 The driver alarm system may include one or several alarm lights, or may display short messages. Short messages must clearly display the following information; if alarm lights are employed, the following text content is not required:

- a) Remaining time until primary and/or severe restriction system activation;
- b) Primary and/or severe restriction system parameters, such as torque restriction;
- c) Driving performance restriction system erasure conditions.

When information is displayed, the system displaying this information may be a system used for other maintenance purposes.

C.4.4 If required by the machine manufacturer, the driver alarm system may include an audible alarm element used to notify the driver, and the driver shall have the right to turn off the audible alarm.

C.4.5 The driver alarm system shall variously be activated as required in C.2.3.3.1, C.6.2, C.7.2, C.8.3, and C.9.3.

C.4.6 When at activation conditions no longer exist, the driver alarm system must cancel activation. If a problem causing system activation is not corrected, driver alarm system shall be unable to cancel activation.

C.4.7 If other alarm signals containing important safety information occur, this alarm system may be temporarily interrupted.

C. 4. 8 This Annex's Appendix CB specifies the driver alarm system's activation and deactivation methods in detail.

C.4.9 As part of type testing, the diesel engine manufacturer must verify the driver alarm system's operating processes as required in Appendix CB.

C.5 Driving performance restriction system

C.5.1 The machine must comply with one of the following two principles when equipped with a driving performance restriction system:

C. 5. 1. 1 In the case of a two-level driving performance restriction system, the system shall activate the severe restriction system (effectively restricting machine operation) after the primary restriction system (performance restriction) has been activated.

C. 5. 1.2 In the case of a single-level severe restriction system (effectively restricting machine operation), activation shall comply with the requirements of C.6.3.2, C.7.3.2, C.8.4.2 , and C.9.4.2.

C.5.2 Diesel engines may be equipped with a device to prevent use of the driving performance restriction system in emergency situations; the activation of such a device shall be performed by the company. After such a device has been activated, a counter must record the device's operating time, and the device must upload data at one-second intervals as required by Annex H.6.4.5.2. When an emergency situation no longer exists, the device shall no longer operate, and the counter shall stop and save event record data; in addition, the ecological and environmental competent authority must be able to use a general-purpose diagnostic device to read this information. If the device is subsequently activated again, it shall maintain cumulative records after activation from the previous recorded data point. Keeping the device in an activated state for an extended period of time is prohibited; each instance of activation may not exceed 120 h.

C.5.3 Primary restriction system

C. 5. 3.1 The primary restriction system must be activated when any one of the conditions specified in C.6.3.1, C.7.3.1, C.8.4.1, or C.9.4.1 is met.

C.5. 3.2 Between a diesel engine's maximum torque speed and its rated speed (as shown in Fig. C.1), the primary restriction system shall, within the diesel engine's speed range, at least gradually reduce engine speed to 25% of the diesel engine's maximum usable torque. After the primary driving performance restriction system has been activated, torque in the diesel engine's speed range below maximum torque speed may not exceed maximum torque after torque restriction has been implemented. The torque restriction of speed must be at least 1% per minute.

C. 5. 3. 3 If it is verified to the ecological and environmental competent authority that other restriction measures have an equivalent or more severe level of restriction, those restrictive measures may be employed.

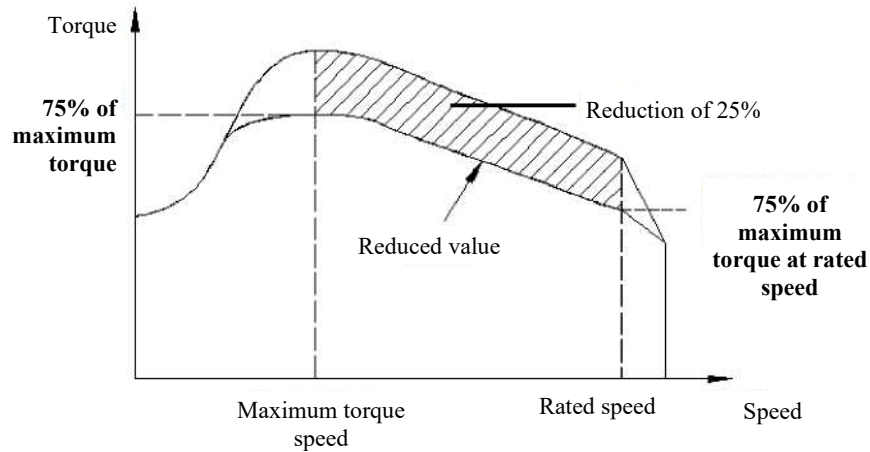


Figure C.1 Primary restriction system plan

C. 5.4 Severe restriction system

C.5.4.1 The severe restriction system must be activated when any one of the conditions specified in C.2.3.3.2, C.6.3.2, C.7.3.2, C.8.4.2, or C.9.4.2 are met.

C. 5. 4. 2 Severe restriction systems must reduce machine performance to a point where the driver is forced to correct the problems specified in sections C.6 to C.9. Severe restriction systems must employ the following strategy:

C. 5. 4. 2.1 Between a diesel engine's maximum torque speed and its rated speed, the diesel engine's torque must be gradually reduced from the primary restriction torque shown in Fig. C.1 at a rate of no less than 1% of speed per minute to 50% of maximum torque or an even lower level; while torque is being reduced, the speed of the diesel engine (apart from constant speed diesel engines) must gradually fall to 60% of the rated speed or even lower (as shown in Fig. C.2).

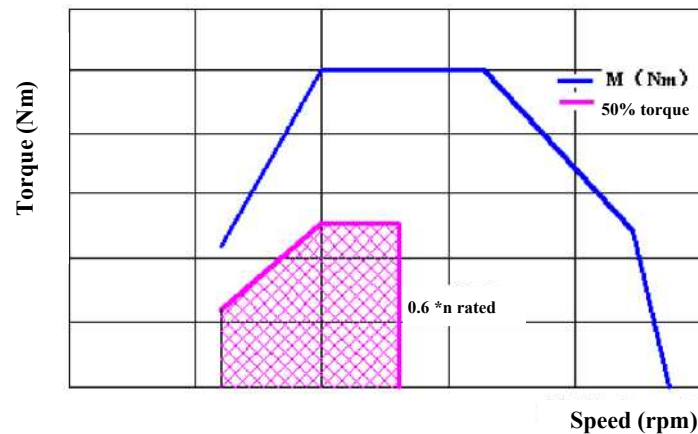


Figure C.2 Severe restriction system plan

C. 5. 4. 2.2 If it is verified to the ecological and environmental competent authority that other restriction measures have an equivalent or more severe level of restriction, those restrictive measures may be employed.

C.5.5 If self-repair diagnosis is permitted due to safety considerations, temporary disabling of the driving performance restriction system is permitted, but must comply with the following conditions:

- a) Time in an activated state may not exceed 30 min on each occasion, and;
- b) the driving performance restriction system may not be activated more than 3 times during the

system activation period.

C. 5.6 When conditions for activation no longer exist, activation of the driving performance restriction system must be canceled. If the problem causing system activation is not corrected, the driving performance restriction system shall not automatically cancel activation.

C. 5.7 This Annex's Appendix CB provides detailed regulations concerning driving performance restriction system activation and deactivation methods.

C. 5.8 As part of type testing, the diesel engine manufacturer shall verify the operating processes of the driving performance restriction system in accordance with the requirements of this Annex's Appendix CB. In consideration of safety factors, the machine may turn on the driving performance restriction system after stopping and then restarting.

C.6 Reagent supply

C. 6.1 Reagent level indicator

Machinery shall be equipped with indicators to clearly inform the driver of the level of reagent in the reagent storage tank. When the driver alarm system specified in C.4 is activated, the indicator should at least be able to continuously indicate the reagent level. The indicator may have a simulated volume or numeric volume display, or may express the reagent level as a proportion of tank capacity, or may display remaining reagent or estimated time of continued operation.

C. 6.2 Activation of the driver alarm system

C. 6.2.1 The driver alarm system specified in C.4 shall be activated when the reagent level is less than 10% of tank capacity or a higher proportion specified by the diesel engine manufacturer.

C. 6.2.2 The driver alarm system's alarm signal and the reagent indicator display must be clear and unambiguous, so as to enable the driver to know when the reagent level is low. If the driver alarm system is equipped with an information display system, the visual alarm shall display low reagent level information (such as "Low urea level," "Low AdBlue level," or "Low reagent level").

C. 6.2.3 The driver alarm system does not need to be continuously activated from the time of starting (for instance, alarm information does not need to be displayed continuously), but when reagent will soon be used up and the reagent level is close to the driving performance restriction system's activation point (for instance, when the alarm light is flashing rapidly), the intensity of activation should be progressively raised, which shall ultimately result in continuous activation. When the level specified by the diesel engine manufacturer has been reached, driver alarm system shall notify the driver using some compelling method, which shall attract the driver's attention even more strongly than the first activation of the driving performance restriction system specified in C.6.3.

C. 6.2.4 A continuous alarm should not be easily turned off or ignored. If the driver alarm system is equipped with an information display system, it must clearly display alarm information (such as "Add urea," "Add AdBlue," or "Add reagent"). If another alarm signal bearing important safety information occurs, it must be possible to temporarily interrupt the continuous alarm.

C. 6.2.5 Unless reagent has already been added to a level sufficient to cancel activation, the driver alarm system should not be turned off.

C.6.3 Activation of the driving performance restriction system

C. 6. 3. 1 If the reagent level is lower than 2.5% of nominal tank capacity or a higher proportion specified by the diesel engine manufacturer, the primary driving performance restriction system specified in C.5.3 shall be activated.

C. 6. 3. 2 If the reagent tank has become empty (when the injection system cannot pump reagent from the tank) or the reagent level is lower than 2.5% of nominal tank capacity or a proportion specified by the diesel engine manufacturer, the severe restriction system specified in C.5.4 shall be activated.

C.6. 3. 3 Except when the circumstances are permitted by C.5.5, unless reagent has been added to a level at which the system cancels activation, the primary or severe driving performance restriction system may not be turned off.

C.7 Monitoring of reagent quality

C. 7.1 The diesel engine or machine must be equipped with a method able to detect unacceptable reagent.

C. 7. 1. 1 The diesel engine manufacturer must specify the minimum acceptable reagent concentration

CD_{min} , and must provide an explanation in publicly-disclosed information; this concentration must ensure that NO_x emissions in tail gas do not exceed 2.25 times the limit for that power level specified in Table 2 in GB 20891—2014; diesel engines with rated net power less than 56 kW shall have emissions not exceeding 2.25 times the HC+NO_x limit for that power level.

C. 7. 1. 1. 1 The CD_{min} concentration value must be verified using the procedures specified in Appendix C B.6 during the type testing period, and must be recorded in accordance with the requirements of A.3 in the enlarged portfolio.

C. 7.1.2 In accordance with the requirements of C.7.1, all reagent with a concentration lower than CD_{min} must be detected, and shall be considered unacceptable reagent.

C. 7.1.3 Must be equipped with a counter measuring reagent quality (reagent quality counter). This counter must record operating time during which the diesel engine uses unacceptable reagent. Or, the diesel engine manufacturer may assign reagent quality faults to a single counter together with one or several of the faults listed in C.8 and C.9.

C. 7. 1.4 This Annex's Appendix CB explains reagent quality counter activation and deactivation standards and mechanisms in detail.

C. 7. 2 Activation of the driver alarm system

If the monitoring system confirms unacceptable reagent quality, the driver alarm system specified in C.4 shall be activated. When the alarm system is equipped with an information display system, it must display alarm cause information (for instance, “Unacceptable urea detected,” “Unacceptable AdBlue detected,” or “Unacceptable reagent detected”).

C. 7. 3 Activation of the driving performance restriction system

C. 7. 3. 1 After activation of the driver alarm system specified in C.7.2, if reagent quality is not corrected during a cumulative total of 10h of diesel engine operation, the primary restriction system specified in C.5.3 shall be activated.

C. 7. 3. 2 After activation of the driver alarm system specified in C.7.2, if reagent quality is not corrected during a cumulative total of 20h of diesel engine operation, the severe restriction system specified in C.5.4 shall be activated.

C. 7. 3. 3 If faults occur repeatedly, the mechanism specified in this Annex's Appendix CB shall reduce the hours of operation required to activate the driving performance restriction system.

C. 8 Monitoring of reagent injection operation

C. 8. 1 The diesel engine's NCD system must have a method of confirming the interruption of injection.

C. 8. 2 Reagent injection operation counter

C. 8. 2. 1 Must be equipped with a counter detecting reagent injection operation (injection operation counter). This counter must record the diesel engine's hours of operation during which reagent injection operation has been interrupted. If the diesel engine's electrical control unit (ECU) has requested the interruption of reagent injection, the diesel engine's hours of operation does not need to be recorded (because the machine's emissions performance does not require reagent injection under these operating conditions).

C. 8. 2. 1. 1 The diesel engine manufacturer may assign reagent injection faults to a single counter together with one or several of the faults listed in C.7 and C.9.

C. 8. 2. 2 This Annex's Appendix CB explains reagent injection operation counter activation and deactivation standards and mechanisms in detail.

C. 8. 3 Activation of the driver alarm system

In accordance with the requirements of C.8.2.1, if the injection operation counter begins recording the interruption of injection, the driver alarm system specified in C.4 shall be activated. When alarm system is equipped with an information display system, this system shall display information concerning the cause of the alarm (for instance, "Urea injection fault," "AdBlue injection fault," or "Reagent injection fault").

C.8.4 Activation of the driving performance restriction system

C. 8. 4. 1 After activation of the driver alarm system specified in C.8.3, if the reagent injection fault is not corrected during a cumulative total of 10h of diesel engine operation, the primary restriction system specified in C.5.3 shall be activated.

C. 8. 4. 2 After activation of the driver alarm system specified in C.8.3, if the reagent injection fault is not corrected during a cumulative total of 20h of diesel engine operation, the severe restriction system specified in C.5.4 shall be activated.

C. 8. 4. 3 If faults occur repeatedly, the mechanism specified in this Annex's Appendix CB shall reduce the hours of operation required to activate the driving performance restriction system.

C.9 Monitoring of faults caused by tampering

C.9.1 Except when the level in the reagent tank is low or a reagent quality or reagent injection fault has occurred, the anti-tampering system shall monitor the following faults possibly attributable to tampering:

- a) EGR valve sticking;
- b) NCD system fault specified in C.9.2.1.

C.9.2 Monitoring requirements

C. 9. 2.1 An NCD system equipped with SCR shall employ an NO_x concentration sensor to detect the complete removal of the SCR aftertreatment system carrier. At the same time, the system must also detect faults in the NCD system's circuits, and detect the removal or disabling of any sensors or actuators that may cause the NCD system to lose its diagnostic functions in C.6 through C.8.

C. 9. 2. 2 EGR valve counter

C. 9. 2. 2.1 Must be equipped with a counter able to detect EGR valve sticking. The EGR valve counter must record the diesel engine's hours of operation after DTC confirmation and activation associated with EGR valve sticking. Or the diesel engine manufacturer may assign EGR valve sticking faults to a single counter together with one or multiple of the faults listed in C.7, C.8, or C.9.2.3.

C. 9. 2. 2.2 This Annex's Appendix CB explains EGR valve sticking counter activation and deactivation standards and mechanisms in detail.

C. 9. 2. 3 NCD system counter

C. 9. 2. 3.1 A counter must be provided for each of the monitored faults specified in C.9.1 b). The NCD system counter must record the diesel engine's hours of operation after

DTC confirmation and activation associated with NCD system faults. Several faults may be assigned to the same counter. Or, the diesel engine manufacturer may assign NCD system faults to a single counter together with one or multiple of the faults listed in C.7, C.8, and C.9.2.2.

C. 9. 2. 3.2 This Annex's Appendix CB explains NCD system counter activation and deactivation standards and mechanisms in detail.

C. 9. 3 Activation of the driver alarm system

When a fault specified in C.9.1 occurs, the driver alarm system specified in C.4 shall be activated, and shall display a reminder that emergency maintenance is needed. When the alarm system is equipped with an information display system, this system shall display information concerning the cause of the alarm (for instance, "Reagent injection valve disconnection" or "Severe emissions fault").

C.9.4 Activation of driving performance restriction system

C. 9. 4. 1 After the driver alarm system specified in C.9.3 has been activated, if the fault specified in C.9.1 has not been corrected within 36h of cumulative diesel engine operation, the primary restriction system specified in C.5.3 shall be activated.

C. 9. 4. 2 After the driver alarm system specified in C.9.3 has been activated, if the fault specified in C.9.1 has not been corrected within 100h of cumulative diesel engine operation, the severe restriction system specified in C.5.4 shall be activated.

C. 9. 4. 3 If the fault occurs repeatedly, the mechanism specified in this Annex's Appendix CB shall reduce the number of operating hours required before the driving performance restriction system is activated.

Appendix CA
(normative appendix)
Verification testing requirements

CA. 1 Overview

This appendix specifies testing requirements for verification of NCD system driver alarm activation and driving performance restriction activation and diesel engine NCD family differentiation.

CA.2 Verification items

Prior to type testing, the following methods must be employed to verify compliance with the requirements of this Annex; see Table CA.1 and this appendix for specific verification item requirements:

- a) Verification of driver alarm system activation;
- b) Verification of primary restriction system activation (if applicable);
- c) Verification of severe restriction system.

Table CA.1 Explanation of verification processes specified in Annex C.4 and C.5

Item	Verification items
Activation of driver alarm system specified in CA.4	• Two activation tests (including insufficient reagent) • Verification items added when the situation requires (if applicable)
CA.5.5	• Two activation tests (including insufficient reagent) • Additional verification items as appropriate (if applicable) • One torque reduction test
Activation of the severe restriction system specified in CA.5.6	• Two activation tests (including insufficient reagent) • Additional verification items as appropriate (if applicable) • One torque reduction test

CA.3 Diesel engine family and NCD diesel engine family

Testing of one diesel engine from a certain family can be performed to verify that the diesel engine family or NCD family meets the requirements of Annex C, but the diesel engine manufacturer must verify to the ecological and environmental competent authority that the monitoring system meeting the requirements of Annex C is similar throughout that family.

CA. 3.1 The submission of materials including calculations and functional analysis to the ecological and environmental competent authority shall be the means of verifying that the monitoring systems of other diesel engines in the NCD family are similar.

CA. 3.2 The diesel engine selected for testing by the diesel engine manufacturer may or may not be the parent engine of that family.

CA. 3. 3 If a diesel engine within a certain diesel engine family belongs to an NCD family (see Fig. CA.1) that has already received type testing as required by CA.3.1, it shall be deemed that the compliance of this diesel engine family had already been verified, and does not require additional verification; however, the diesel engine manufacturer must verify to the ecological and environmental competent authority that the monitoring systems complying with the requirements of Annex C are similar throughout the diesel engine family and NCD family.

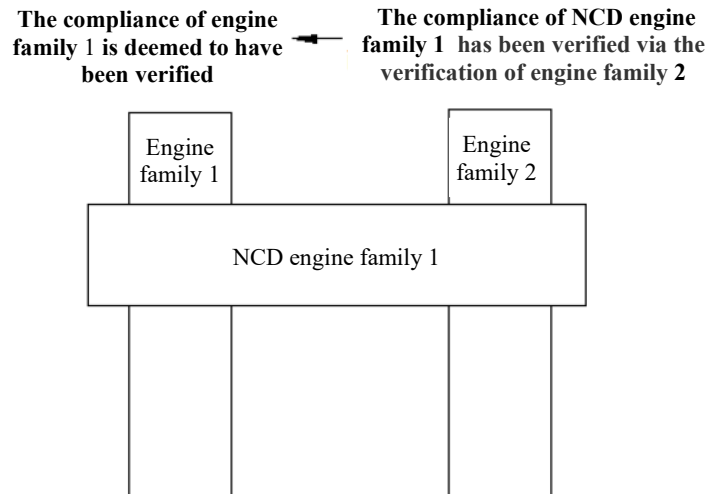


Figure CA. 1 When an NCD diesel engine family can be considered verified

CA. 4 Verification of driver alarm system activation

CA. 4. 1 Two tests are employed to verify whether driver alarm system activation complies with requirements: Insufficient reagent and anyone type of fault specified in C.7 through C.9.

CA. 4. 2 Selection of test fault

CA. 4.2.1 In order to verify driver alarm system activation attributable to reagent quality error, one type of reagent must be selected as required in C.7, and the active components of that reagent must be diluted at least until the level specified by the diesel engine manufacturer.

CA. 4.2. 2 In order to verify driver alarm system activation attributable to a fault caused by tampering (as specified in C.9), a test fault shall be selected in accordance with the following requirements:

CA. 4. 2. 2.1 The diesel engine manufacturer shall provide a list of potential faults of this type to the ecological and environmental competent authority.

CA. 4. 2. 2. 2 The ecological and environmental competent authority shall select test faults from this list in accordance with the requirements of CA.4.2.2.1.

CA. 4. 3 Verification

CA. 4. 3. 1 For the purpose of verification, each of the faults specified in CA.4.1 shall be tested independently.

CA. 4. 3. 2 In the testing process, apart from the fault to be verified, other faults may not occur.

CA. 4. 3. 3 Prior to the start of testing, all diagnostic fault code (DTC) must be erased.

CA. 4. 3. 4 In accordance with the diesel engine manufacturer's requirements, and insofar as this does not affect other functions, the fault being tested may be simulated.

CA. 4. 3. 5 Testing of faults other than insufficient reagent

With regard to faults other than insufficient reagent, the fault must be tested in accordance with the following requirements as soon the fault has been induced or simulated:

CA. 4. 3. 5. 1 In accordance with the requirements of this Appendix, the NCD system must respond to the induction of the fault selected by the ecological and environmental competent authority. In accordance with the requirements of CA.4.3.7, if activation occurs during two continuous NCD test cycles, this shall be considered verification.

If specifically explained in the description of monitoring that a specific monitoring item requires more

than two NCD test cycles to complete monitoring, the number of NCD test cycles may be increased.

During the verification testing process, the diesel engine may be stopped between each independent NCD test cycle. During the period before the engine is restarted, any monitoring actions performed after the diesel engine has stopped and any necessary conditions occurring during monitoring after the engine has been restarted must be taken into consideration.

CA. 4.3.5.2 After the conclusion of each verification testing session conducted in accordance with CA.4.2.1, if the driver alarm system has been confirmed to have been activated and the DTC of the selected fault is displayed as "Confirmed and activated," it can be determined that driver alarm system activation verification has been completed.

CA. 4.3.6 Test of insufficient reagent supply

In order to verify driver alarm system activation due to insufficient reagent supply, as required by the engine manufacturer, one or more NCD test cycles of the diesel engine system shall be run.

CA. 4.3.6.1 When performing verification testing, the reagent level shall be that level determined by the diesel engine manufacturer and inspection organization through mutual consultation, but may not be less than 10% of the tank's nominal capacity.

CA. 4.3.6.2 If the following conditions are satisfied simultaneously, it can be determined that the driver alarm system is operating in a normal fashion:

- a) When the reagent level is equal to or higher than 10% of the nominal capacity of the reagent tank, the driver alarm system has already been activated;
- b) When the reagent level is equal to or higher than the value set by the diesel engine manufacturer in accordance with the requirements of Annex C.6, the "continuous" driver alarm system is already been activated.

CA. 4.3.7 NCD test cycle

CA. 4.3.7.1 A hot NRTC cycle serving as the NCD test cycle used to verify NCD system performance is applicable to non-constant-speed diesel engines with rated net power of 19 kW—560 kW, and an NRSC cycle shall be used to test other types of diesel engines.

CA. 4.3.7.2 As required by the diesel engine manufacturer, an alternative NCD test cycle (apart from NRTC and NRSC cycles) may be used to test any specific monitoring item. The diesel engine manufacturer must provide key technical reference, simulation, and test results information, etc. to assist verification:

- a) The test cycle used for verification of fault monitoring must have actual operating conditions;
- b) NCD test cycles specified in CA.4.3.7.1 have been proven to be relatively unsuitable for this monitoring.

CA. 4.4 After the conclusion of each verification testing session conducted as required in CA.4.3, if the driver alarm system has been confirmed to have been activated, it can be determined that driver alarm system activation verification has been completed.

CA.5 Verification of restriction system activation

CA. 5.1 Restriction system activation verification testing must be conducted on a diesel engine test bench. All parts, components, and auxiliary systems that must be additionally installed on a diesel engine for verification testing, including but not limited to ambient temperature sensors, level, sensors, and driver alarm and information systems, must be physically or virtually connected with the diesel engine system, and must satisfy the ecological and environmental competent authority's requirements.

CA. 5.2 These test procedures shall verify restriction system activation when reagent is insufficient and any one of the faults defined in C.7, C.8, or C.9 occurs.

CA. 5.3 For the purpose of verification:

- a) Apart from insufficient reagent, one of the faults defined in C.7, C.8, or C.9 that has already been used in driver alarm system verification may be selected for use in verification.
- b) Insofar as this does not affect other functions, the diesel engine manufacturer may use simulation to speed up testing by achieving a specific operating duration.
- c) When the restriction of torque is required in activation of the primary restriction system, this verification may be performed simultaneously with general diesel engine performance approval procedures required by these regulations. Under these circumstances, no independent torque measurements are required when performing restriction system verification.
- d) Severe restriction verification shall be performed in accordance with the requirements of

CA.5.6 of this Annex.

CA. 5.4 With regard to those faults defined in C.7, C.8 or C.9 of this Annex but not selected for use in the verification testing specified in CA.5.1 through CA.5.3, the diesel engine manufacturer shall also verify restriction system activated when these faults occur.

These supplementary verifications can be completed through the submission of technical cases, including calculations, functional analysis, and past test results to the ecological and environmental competent authority.

CA. 5.4.1 When conducting these supplementary verifications, explicit verification that the diesel engine's ECU includes the correct torque restriction mechanism must be provided to the ecological and environmental competent authority.

CA. 5.5 Primary restriction system verification testing

CA. 5.5.1 When the driver alarm system or "continuous" driver alarm system is activated by the fault selected by the ecological and environmental competent authority, verification of the primary restriction system may begin.

CA. 5.5.2 When checking the system's response to insufficient reagent in the storage tank, the diesel engine system shall run continuously, until the reagent level reaches 2.5% of the tank's nominal capacity or the value set by the diesel engine manufacturer in accordance with the requirements of C.6.3.1 of this Annex, and the primary restriction system must be activated when this level is reached.

Insofar as this does not affect other functions, regardless of whether the diesel engine is running or stopped, the diesel engine manufacturer may draw reagent from the tank for use in simulation of the diesel engine's continuous operation process.

CA. 5.5.3 When inspecting the system's response to faults other than insufficient reagent system in the tank, the diesel engine system must operate continuously for the duration shown in Table C B.3 in Appendix CB or specified by the diesel engine manufacturer, until the relevant counter reaches the primary restriction system activation value.

CA. 5.5.4 At the end of every verification testing session conducted as required in CA.5.5.2 and CA.5.5.3, if the diesel engine manufacturer verifies to the ecological and environmental competent authority that the diesel engine's ECU already has an activation torque restriction strategy, it shall be determined that primary restriction system verification has been completed.

CA. 5.6 Verification testing of the severe restriction system

CA. 5. 6. 1 Verification of the severe restriction system may begin after completion primary restriction system activation, and may be handled as an extension of verification testing of the primary restriction system.

CA 5 6 2 When checking the system's response to insufficient reagent in the storage tank, the diesel engine system shall run continuously, until the reagent is used up or the reagent level reaches 2.5% of the tank's nominal capacity, and this percentage shall be the severe restriction activation level set by the diesel engine manufacturer.

Insofar as this does not affect other functions, regardless of whether the diesel engine is running or stopped, the diesel engine manufacturer may draw reagent from the tank for use in simulation of the diesel engine's continuous operation process.

CA.5.6.3 When inspecting the system's response to other faults apart from insufficient reagent in the tank, the diesel engine system must operate continuously for the duration shown in Table C B.3 in Appendix CB or specified by the diesel engine manufacturer, until the relevant counter reaches the severe restriction system activation value.

CA. 5. 6. 4 At the end of every verification testing session conducted as required in CA.5.6.2 and CA.5.6.3, if the diesel engine manufacturer verifies to the ecological and environmental competent authority that the severe restriction mechanism specified in this Annex has been activated, it shall be determined that severe restriction system verification has been completed.

Appendix CB
(normative appendix)

Driver alarm and driving performance restriction system activation and cancellation

CB.1 Overview

This Appendix specifies driver alarm and driving performance restriction system activation and deactivation mechanism requirements in detail.

CB.2 Driver alarm system activation and cancellation

CB. 2. 1 When the system's DTC triggered by any NCM displays a status shown in Table CB.1 in this Appendix, the driver alarm system shall be activated.

Table CB.1 Driver alarm system activation

Fault type	DTC status of alarm system
Unsatisfactory reagent quality	Confirmed and activated
Interruption in metered injection of reagent	Confirmed and activated
EGR valve sticking	Confirmed and activated
Monitoring system failure	Confirmed and activated
NO _x limit (if applicable)	Confirmed and activated

CB. 2. 2 When the diagnostic system judges that the fault connected with an alarm no longer exists, or DTC information connected with a fault causing system activation is erased by a diagnostic tool, the driver alarm system shall cancel activation.

CB. 2. 2.1 “NO_x control information” erasure requirements

CB. 2. 2. 1. 1 When requested by a diagnostic tool, the following data shall be erased from the system (as shown in Table C B.2) or reset as the value specified in this Appendix.

Table CB.2 “NO_x control information” erased/reset by a diagnostic tool

NO _x control information	Can be erased	Can be reset
All diagnostic trouble code (DTC)	√	
Counter reading showing the maximum value of diesel engine operating duration		√
Diesel engine operating duration recorded by the NCD counter		√

CB. 2. 2. 1.2 Disconnection of the machine's storage battery may not cause NO_x control information to be erased.

CB. 2. 2. 1.3 NO_x CONTROL INFORMATION MAY ONLY BE ERASED WHEN THE DIESEL ENGINE HAS STOPPED IN A STATE WITH UNINTERRUPTED POWER.

CB. 2. 2. 1.4 When erasing NO_x control information including DTC, any counter readings in this Annex connected with a fault may not be erased, but must be reset as the value specified in the corresponding section of this Annex.

CB. 3 Driving performance restriction system activation and deactivation mechanism

CB. 3.1 After the driver alarm system has been activated, and the counter reading connected with the type of NCM causing this activation to reach the value specified in Table CB.3 of this Appendix, the driving performance restriction system shall be activated.

CB. 3.2 When the system no longer detects the fault causing activation, or the DTC information connected with the NCM causing activation is erased by a diagnostic or maintenance tool, the driving performance restriction system shall cancel activation.

CB. 3.3 After assessment of the reagent level in the reagent tank, the driver alarm and restriction system shall immediately be activated or deactivated as required in Annex C.6, and the activation and deactivation mechanisms shall not depend on any relevant DTC status.

CB.4 Counter mechanism**CB. 4. 1 General requirements**

CB. 4. 1. 1 As required by Annex C, the system shall include at least 4 counting units serving to record the diesel engine's operating duration after any of the following faults are detected by the system: The diesel engine manufacturer may use one or several counters to handle subgroups of the following faults.

- a) Reagent quality error;
- b) Interruption in reagent injection;
- c) EGR Valve sticking;
- d) NCD system fault specified in section C.9.1 b) of this Annex.

CB. 4. 1. 2 Unless the counter's permissible zeroing conditions have been satisfied, each counter must accumulate each hour's 2-byte value until the maximum value has been reached, and must stay at this value.

CB. 4. 1. 3 The diesel engine manufacturer may use one or several NCD system counters. Each counter may record the cumulative number of hours for 2 or more different faults associated with the counter type; the cumulative numbers of hours for these faults may not exceed the maximum time that may be displayed by a single counter.

CB. 4. 1. 3. 1 If a diesel engine manufacturer decides to use multiple NCD system counters, the system may assign faults to the counter of a specific monitoring system in accordance with the requirements of this Annex and match with the counter's type.

CB. 4. 2 Counter mechanism principles

CB. 4. 2. 1 All counters must operate in accordance with the following principles:

CB. 4. 2. 1. 1 If a counter starts from 0, as soon as any faults associated with that counter are detected, and the DTC status is shown in Table CB.1, that counter must begin counting.

CB. 4. 2. 1. 2 If repeated faults occur, in accordance with the diesel engine manufacturers requirements, one of the following regulations shall be applicable:

- a) If a single event occurs and the fault recorded by the originally activated counter is not detected, or the fault had been erased by a diagnostic or maintenance tool, the counter shall stop counting, and stay at the current value. When the severe restriction system is in an activated state, if the counter stops counting, the counter shall remain frozen at the value specified in Table CB.3 of this Appendix, or at a value greater than or equal to the reading of the severe restriction counter after subtracting 30 min;

- b) The counter shall remain frozen at the value specified in Table C B.3 of this Appendix, or a value greater than or equal to the reading of the severe restriction counter after subtracting 30 min.

CB. 4. 2. 1.3 With regard to the counter of each individual monitoring system, if the NCM associated with that counter has already been detected, and its DTC displays “Confirmed and activated” status, that counter shall continue counting. If the NCM causing counter activation had not been detected, or all faults associated with that counter had been erased by a diagnostic or maintenance tool, the counter shall stop counting, and stay at the value specified in C B.4.2.1.2.

Table CB.3 Counters and limit

	DTC status at time of first counter activation	Primary restriction system counter value	Severe restriction system counter value	Frozen value maintained by counter
Reagent quality counter	Confirmed and activated	≤ 10 h	≤ 20 h	$\geq 90\%$ of severe restriction system counter value
Injection counter	Confirmed and activated	≤ 10 h	≤ 20 h	$\geq 90\%$ of the severe restriction system counter value
EGR valve counter	Confirmed and activated	≤ 36 h	≤ 100 h	$\geq 95\%$ of the severe restriction system counter value
Monitoring system counter	Confirmed and activated	≤ 36 h	≤ 100 h	$\geq 95\%$ of the severe restriction system counter value
NOx limit (if applicable)	Confirmed and activated	≤ 10 h	≤ 20 h	$\geq 90\%$ of the severe restriction system counter value

CB. 4. 2. 1.4 As soon as the counter reading is frozen, if any of the counter's relevant monitoring items has implemented at least one full monitoring cycle without detecting any faults, and no faults associated with the counter have been detected during 40h of diesel engine operation since the previous stopping of the counter, the counter must be zeroed (as shown in Fig. CB.1).

CB. 4. 2. 1.5 If any faults associated with the counter are detected within a certain period of time after the counter froze, the counter shall continue counting from the frozen value (see Fig. C B.1).

CB. 4. 2. 1.6 When the disabling function of a driving performance restriction system specified in C.5.5 is activated, the counter shall stop counting and retain its value at that time; when the function specified in C.5.5 is deactivated, the counter shall continue counting from the frozen value.

CB. 5 Explanation of activation and deactivation and counter mechanisms

CB. 5. 1 This section explains activation, deactivation, and counter mechanisms in some typical situations. The figures and description in sections CB.5.2, CB.5.3, and CB.5.4 are only for use in the explanation in this Annex, and shall not be taken as examples of the requirements of these regulations or authoritative statements concerning the processes involved. The number of hours on the counters in Fig. CB.3 and Fig. CB.4 represent the maximum severe restriction value in Table CB.3. For simplicity, the fact that the driver

alarm system must also be activated when the restriction system is activated, etc. is not mentioned in relevant explanation.

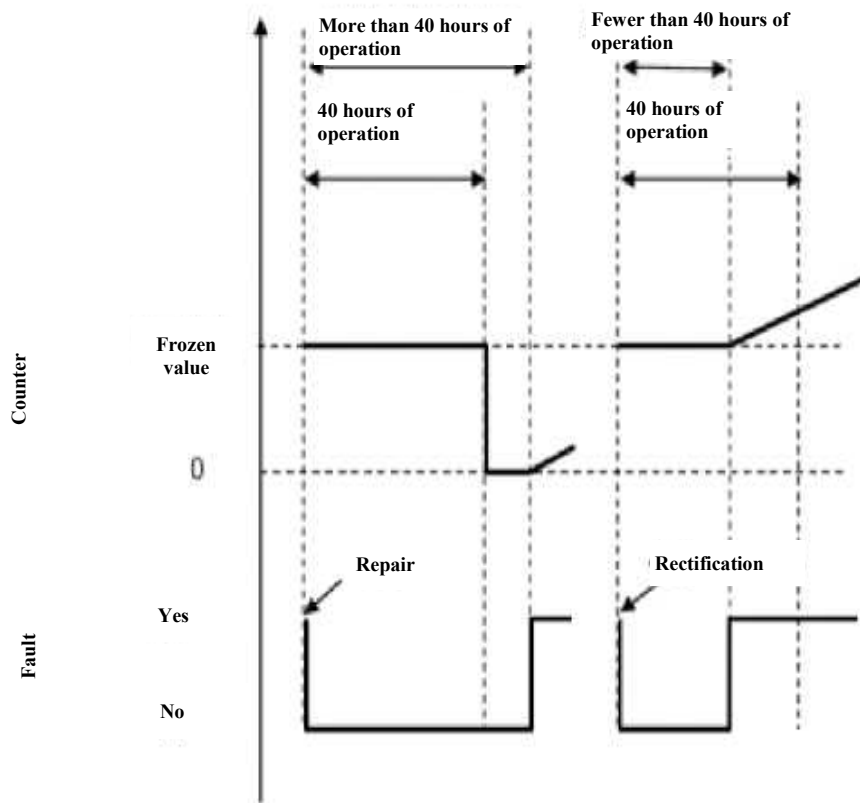


Figure CB.1 Re-activation and zeroing after the counter reading has been frozen for a period of time

CB. 5. 2 Fig. CB.2 presents 5 cases involving the functioning of activation and deactivation mechanisms when different reagent levels have been detected:

Use case 1: The driver ignores the alarm and continues to operate the machine, until the machine can no longer operate;

Fill-up case 1 (“sufficient” filling): Reagent added by the driver exceeds 10% of the supply limit; activation of alarm and restriction is cancelled;

Fill-up cases 2 and 3 (“insufficient” filling): The driver alarm system is activated; the alarm level depends on the reagent level;

Fill-up case 4 (“extremely insufficient” filling): The primary restriction system is immediately activated.

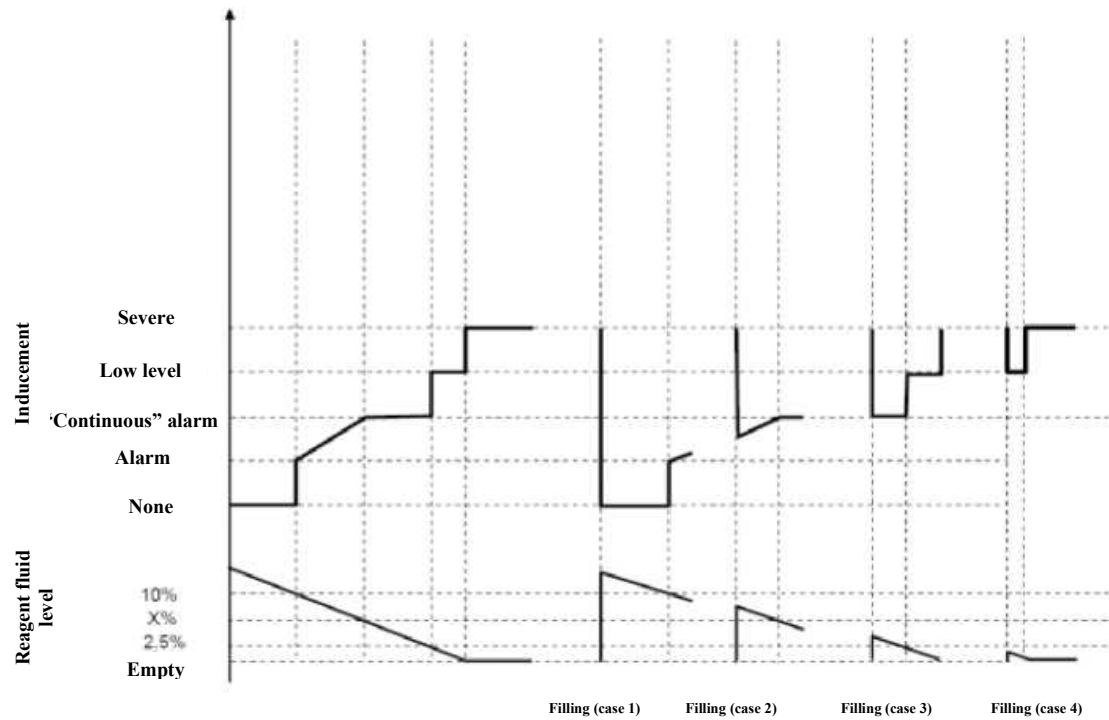


Fig. CB.2 reagent supply

CB. 5.3 Fig. CB.3 explains three cases involving poor reagent quality:

Use case 1: The driver ignores the alarm and continues to operate the machine, until the machine can no longer operate.

Rectification case 1 ("incorrect" or "false" rectification): After use of the machine is prohibited, the driver changes the reagent quality, but the reagent quality quickly deteriorates. After the diesel engine is operated for 2h, the restriction system is immediately activated, and operation is prohibited.

Rectification case 2 ("correct" rectification): After use of the machine is prohibited, the driver corrects the reagent quality. But after a period of time, poor-quality reagent is again added. The alarm, restriction, and counting process begin again from 0.

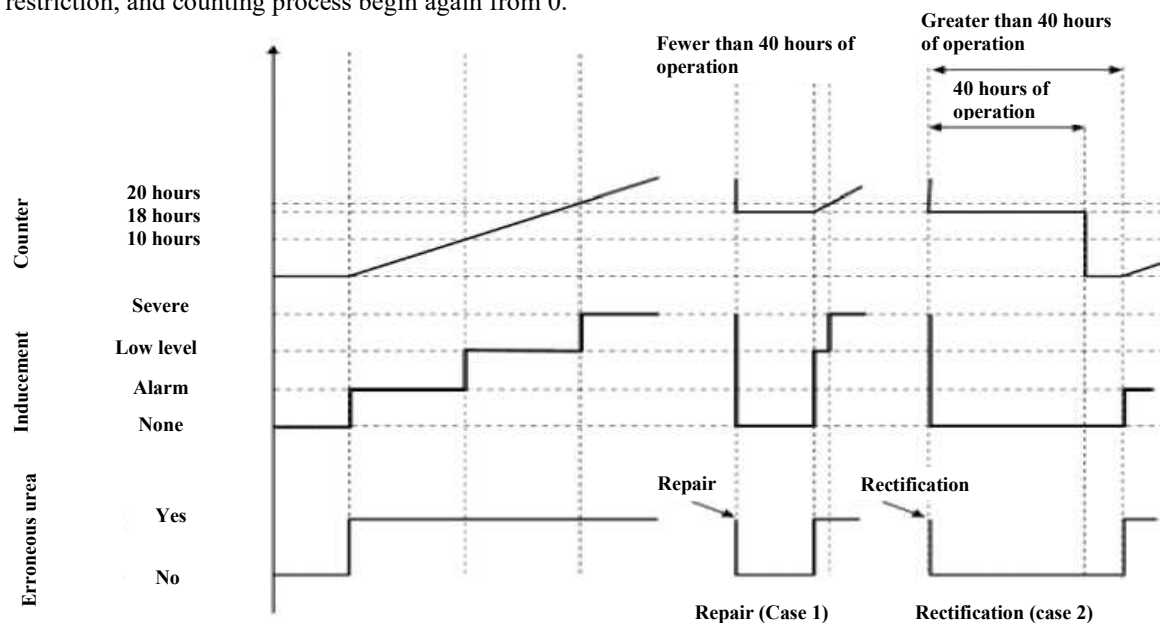


Figure CB.3 Filling with poor-quality reagent

CB. 5. 4 Fig. CB.4 presents three cases involving urea injection system malfunctions, and also explains the fault monitoring process applied in Annex C.9.

Use case 1: The driver ignores the alarm and continues to operate the machine, until the machine can no longer operate.

Rectification case 1 (“correct”) rectification: After use of the machine is prohibited, driver rectifies the injection system. However, after a period of time, the injection system again suffers a malfunction. The alarm, restriction, and counting processes begin again from 0.

Rectification case 2 (“incorrect”) rectification: During the primary restriction period (restricted torque), the driver rectifies the injection system. However, the injection system soon suffers another malfunction. The primary restriction system is immediately reactivated, and the counter again begins counting from the value at the time of rectification.

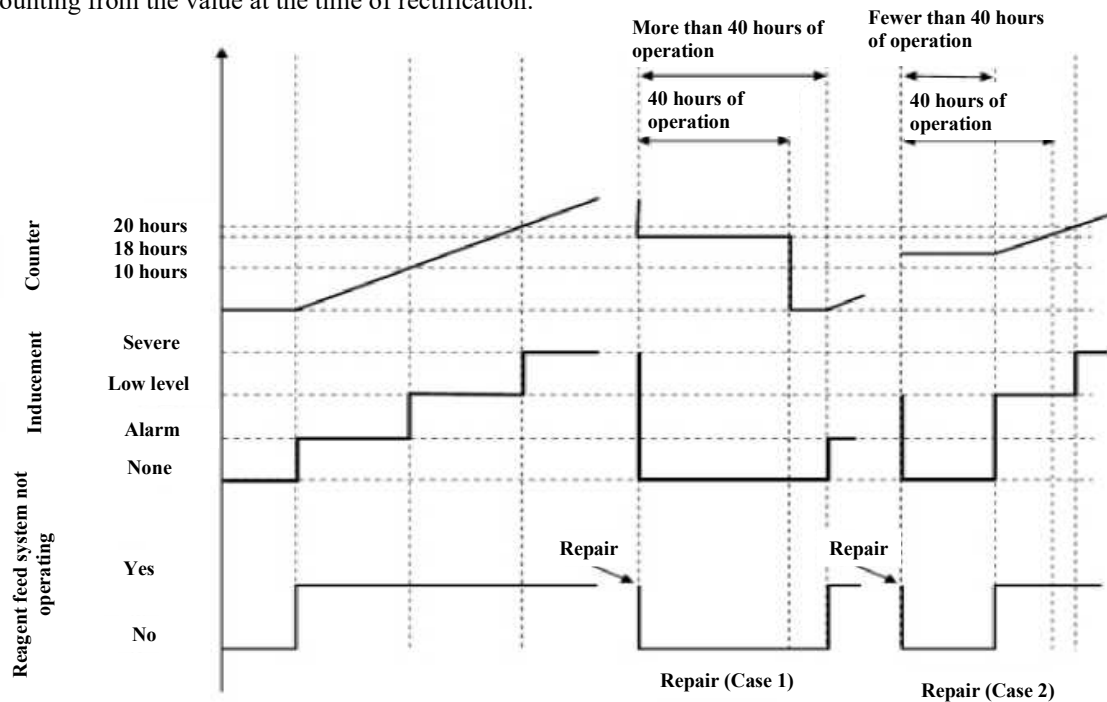


Figure CB.4 Reagent injection system malfunction

CB. 6 Verification of the minimum acceptable reagent concentration CD_{min}

CB. 6. 1 The manufacturer shall employ an NCD test cycle to verify the correct value of CD_{min} at the time of type testing; an NRSC test cycle shall be employed in verification in the case of constant-speed and over-560kW diesel engines.

CB. 6.2 Pre-treatment shall be performed in accordance with a suitable NCD test cycle or the manufacturer's definition; a closed-cycle NO_x control system may be used to satisfy reagent quality requirements at the CD_{min} concentration. The pre-treatment cycle of a variable-speed diesel engine of 560 kW or less shall not exceed 9 NRTC cycles, and the pre-treatment cycles of other diesel engines shall not exceed 9 NRSC cycles. Prior to commencement of the pretreatment cycle, it shall be ensured that ammonia storage remaining in the SCR system and normal concentrations of urea remaining in the system have been eliminated.

CB. 6. 3 Pollutant emissions may not exceed the requirements of section C.7.1.1 of this Annex.

CB. 6. 4 Reporting requirements

Reports must seek to record verification of the minimum acceptable reagent concentration. The report shall:

- a) The failure inspected;
- b) A description of the verification methods used, including the test cycle used;
- c) Verification that the pollutant emissions in testing did not exceed the requirements in

section C.7.1.1 of this Annex.

Appendix CC
(normative appendix)

Detailed information and explanation provided to the final user

CC. 1 Overview

This Annex specifies that the machine manufacturer must provide information and necessary explanation concerning the correct use of the diesel engine to the final user, which must facilitate ensuring that the diesel engine's gaseous pollutants and particulate matter are consistently within the limits of the type test diesel engine type or family. Explanation intended to facilitate achievement of this goal must be clearly marked for the final user.

CC. 2 Instructions for the final user:

CC. 2. 1 Clear and non-technical methods must be used to provide descriptions in the same language used in instructions for the final user of the machinery;

CC. 2. 2 Must be provided in paper form, or in a commonly-used electronic format;

CC. 2. 3 Should constitute part of the instructions for the final user of the machinery, or be an additional document;

CC. 2. 3. 1 When separate from the instructions for the final user of the machinery, must be provided in the same form.

CC. 3 Information and explanation to be provided to the final user:

CC. 3.1 Must explain operation, use, and maintenance of the diesel engine, including the emissions control system, in accordance with instructions for the final user, and ensure that the emissions performance of the diesel engine continues to satisfy the requirements for the applicable diesel engine type;

CC. 3.2 Must state that intentional tampering with or misusing the diesel engine emission control system is prohibited, especially failure to use or maintain the EGR or reagent injection system;

CC. 3.3 Must state that immediate measures must be taken in the case of the alarms in CC.3.4 and CC.3.5 to correct the incorrect operation, use, or maintenance of the emission control system;

CC. 3.4 Must explain in detail how incorrect installation, use, or maintenance of the diesel engine may possibly cause the emission control system to malfunction, and also explain relevant alarm signals and the corresponding corrective measures;

CC. 3.5 Must explain in detail incorrect use of the machinery that may cause the diesel engine's mission control system to malfunction, and also explain relevant alarm signals and the corresponding corrective measures;

CC. 3.6 Must provide information concerning the unheated reagent tank and injection system that may be used (if applicable);

CC. 3.7 In the case of machinery with a driver alarm system, must state that the driver will receive in alarm from the driver alarm system when the mission control system is not operating normally;

CC. 3.8 In the case of machinery with a driving performance restriction system, must state that ignoring and alarm from the driver alarm system will activate the driving performance restriction system, which will cause the functions of the machinery to be disabled;

CC. 3.9 Must explain how the driver alarm and restriction system operate, including performance, fault

records, and the consequences of ignoring alarm system signals, failing to fill reagent, and failing to correct problems (if applicable);

CC. 3.10 In the case of machinery allowing the driving performance restriction system to be cancelled, information and statements concerning the operation of this function must note that this function may be activated only in the case of an emergency, all activation information will be recorded in onboard memory, and the ecological and environmental competent authority can use a general-purpose diagnostic instrument to read this information;

CC. 3.11 Must state information concerning fuel specifications needed to maintain the emission control system's performance;

CC. 3.12 Must state information concerning lubricant specifications needed to maintain the emission control system's performance;

CC. 3.13 When the emission control system must use a reagent, must state reagent characteristics, including reagent type, concentration of reagent in solution, working temperature conditions, reagent composition, and quality; these reference standards must comply with the specifications listed for diesel engine type testing;

CC. 3.14 Must explain how the driver must add reagent at normal maintenance intervals, and must explain how the driver should add reagent to the reagent tank and the expected frequency of filling in accordance with the usage of the machinery (if applicable);

CC. 3.15 Must state the need to use and add reagent in accordance with the machine's specifications in order to maintain the diesel engine's emission performance.

CC. 3.16 Information on the specifications of the fuel and reagent needed to maintain the emission control system's performance must be consistent with these standards.

Annex D
(normative annex)

Correct particulate matter control measure implementation requirements

D.1 Overview

This Annex specifies correct operating requirements for particulate matter control measures, and this applicable to DPF aftertreatment systems affecting particulate emissions.

D.2 General requirements

Diesel engines must be equipped with PCDs, which are used to identify the particular aftertreatment system malfunctions considered in this Annex. The design, configuration, and installation of all PCD systems shall satisfy relevant requirements associated with normal use over its full life.

D. 2.1 Necessary information

D. 2.1.1 If an emission control system requires a reagent, such as the fuel needed in a post-injection fuel DPF regeneration system, fuel catalyst, reagent characteristics such as reagent type, concentration of reagent solution, and reaction temperature conditions, and quality specified by the diesel engine manufacturer, must be explained in detail in the product instructions.

D. 2.1.2 At the time of type testing, written materials providing a detailed description of the functions, operation, and characteristics of the driver alarm system and driving performance restriction system must be provided in accordance with standard requirements.

D. 2.1.3 The diesel engine manufacturer shall provide installation documents, and these documents shall contain the detailed technical requirements and regulations needed for correct installation of the diesel engine (software, hardware, and information) on machinery.

D. 2.2 Working conditions

D. 2.2.1 The PCD system should be able to operate under the following conditions:

- a) An ambient temperature of from 266 K to 311 K (-7°C to 38°C);
- b) An elevation not exceeding 1700 m above sea level;
- c) A diesel engine cooling fluid temperature higher than 343 K (70°C).

D. 2.3 Diagnostic requirements

D. 2.3.1 General requirements

D. 2.3.1.1 The PCD must be able to rely on the DTC stored in the computer system to identify PCMs considered in this Annex, and transmit the data saved while offline when required.

D. 2.3.1.2 Whenever conditions for diagnosis are met, must perform continuous diagnosis. If monitoring is not performed continuously, the manufacturer must explicitly inform the ecological and environmental competent authority, must explain the conditions for monitoring to occur, and employ reasonable technical means (such as sound engineering practice) to verify this proposal.

D. 2.3.2 Diagnostic trouble code (DTC) record requirements

D. 2.3.2.1 The PCD system must record a DTC for each different PCM.

D. 2.3.2.2 The PCD system shall inspect whether any malfunction information has occurred within the diesel engine operating cycles shown in Table D.1. At the same time, it must also save a "Confirmed and activated DTC," and activate the driver alarm system specified in D.4.

D. 2.3.2.3 When more time than the operating cycles listed in Table D.1 is needed to detect and confirm a

PCM (if the inspected item employs a statistical model or is based on the machine's fluid consumption), if the diesel engine manufacturer can confirm that a longer cycle is needed, and this will meet diagnostic requirements, a longer inspection time may be permitted.

Table D.1 Inspection types and cycles needed to save a “Confirmed and activated” DTC

Inspection type	Must be able to save to the cumulative operating time of the “Confirmed and activated” DTC
Removal of particulate matter aftertreatment system	Non-idling operation of the diesel engine for 60 min
Particulate aftertreatment system functional deficiency	Non-idling operation of the diesel engine for 240 min
PCD system malfunction	Diesel engine operation for 60 min

D. 2. 3. 3 Diagnostic trouble code (DTC) erasure requirements

- Unless a DTC malfunction has already been corrected, the DTC and related information may not be directly erased from the system by the PCD system;
- The PCD system shall be able to erase all DTC as required by the diagnostic or maintenance tools provided by the diesel engine manufacturer, or using the password provided by the diesel engine manufacturer;
- Confirmed and activated DTC event records saved to non-volatile memory as required in D.6.2 may not be erased.

D. 2. 3. 4 Within the diesel engine's full life, the PCD system may not have program code or other design performing partial or full disabling based on the machinery's service life. This system also may not use any algorithms or strategies that may degrade the PCD system's performance within the engine's full life.

D. 2. 3. 5 All PCD modifiable computer code or PCD system operating parameters must prevent tampering.

D. 2. 3. 6 PCD diesel engine family

The diesel engine manufacturer shall bear responsibility for confirming the compensation of each PCD diesel engine family. Determination of an individual PCD diesel engine system must be based on sound engineering judgment; diesel engines that do not belong to the same diesel engine family may belong to a single PCD diesel engine family. D. 2. 3. 6.1 Parameters for determination of a PCD diesel engine family

The characteristics of basic design parameters must be common to all diesel engines within the same PCD family.

If the diesel engines used are assigned to the same PCD diesel engine family, the following basic design parameters must be similar:

- Emission control system;
- Operating principles of the particulate aftertreatment system (such as machine type, aerodynamics, dispersal effect, inertial principles, periodic regeneration, and continuous regeneration, etc.);
- PCD monitoring method;
- PCD monitoring principles;
- Monitoring parameters (such as sampling frequency).

The diesel engine manufacturer must employ relevant engineering proof or other normal procedures to verify these similar parameters.

If changes in the configuration of a diesel engine system cause minor differences in the PCD system's monitoring/ diagnostic methods, but the diesel engine manufacturer believes that the provided methods are similar, and the reason for the difference is solely to comply with the specific characteristics of parts or

components (such as dimensions, exhaust gas flow, etc.), or the similar control strategies are based on sound engineering judgment, the manufacturer may apply to the inspection organization for a PCD diesel engine family.

D.3 Maintenance requirements

The machine manufacturer must in accordance with the requirements of Appendix CC provide to or arrange for the machine's final user a written introduction to relevant aftertreatment control systems and their normal operation.

D.4 Driver alarm system

D.4.1 Machinery must be equipped with a driver alarm system. After the system detects the faults in D.7, D.8, and D.9, if the faults are not corrected immediately, the system will activate the driving performance restriction system. At the same time, the driver alarm system will notify the driver employing a visible alarm signal. When the driving performance restriction system specified in D.5 is activated, the driver alarm system shall remain in an activated state.

D.4.2 The driver alarm system may comprise one or several indicator lights, or may display short messages. The system used to display these messages may also be used for other maintenance or NCD purposes; text content need not be included if alarm lights are employed. If the cause of the alarm being activated has not been corrected, it shall not be possible to use diagnostic tools to shut down the alarm system or visual alarm.

The driver alarm system must be able to explicitly require emergency maintenance. When the alarm system includes a display system, it must display a line of information indicating because of the alarm (such as sensor disconnection or severe emissions malfunction).

D.4.3 If required by the machine manufacturer, the alarm system may be equipped with an audible alarm component able to warn the driver, and the driver shall have the right to turn off the audible alarm.

D. 4. 4 The driver alarm system shall be activated in accordance with the requirements of D.2.3.2.2.

D. 4. 5 When the conditions for activation no longer exist, the driver alarm system must cancel activation. If a problem causing system activation is not corrected, the driver alarm system will not be able to perform automatic deactivation.

D.4.6 When other alarm signals bearing important safety information occur, it must be possible to temporarily interrupt this alarm system.

D. 4. 7 During type testing, the diesel engine manufacturer shall verify the driver alarm system's operating processes as required by D.10.

D.5 Driving performance restriction system

D.5.1 The machine must comply with one of the following two principles when equipped with a driving performance restriction system:

D. 5. 1. 1 In the case of a two-level driving performance restriction system, the system shall activate the severe restriction system (effectively restricting machine operation) after the primary restriction system (performance restriction) has been activated;

D. 5.1.2 A severe restriction system (effectively restricting machine operation) shall be activated in accordance with the requirements of D.5.3 on the basis of the primary restriction system conditions.

D.5.2 Diesel engines may be equipped with a device to prevent use of the driving performance restriction system in emergency situations; the activation of such a device shall be performed by the company. After such a device

has been activated, a counter must record the device's operating time, and the device must upload data at one-second intervals as required by Annex H.6.4.5.2. When an emergency situation no longer exists, the device shall no longer operate, and the counter shall stop and save event record data; in addition, the ecological and environmental competent authority must be able to use a general-purpose diagnostic device to read this information. If the device is subsequently activated again, it shall maintain cumulative records after activation from the previous recorded data point. Keeping the device in an activated state for an extended period of time is prohibited; each instance of activation may not exceed 120 hours.

D.5.3 When the system detects a fault in D.7, D.8, and D.9, if the fault has not been corrected within 36h of cumulative diesel engine operation, the primary restriction system specified in C.5.3 shall be activated. If the fault has not been corrected within 100h of cumulative diesel engine operation, the severe restriction system specified in C.5.4 shall be activated.

D.5.4 During type testing, the diesel engine manufacturer must verify the driving performance restriction system's operating processes as required by D.10.

D. 5. 5 If self-repair diagnosis is permitted due to safety considerations, temporary disabling of the driving performance restriction system shall be permitted, but must comply with the following conditions:

- a) Time in an activated state may not exceed 30 min on each occasion, and;
- b) the driving performance restriction system may not be activated more than 3 times within each period of time.

D. 6 Activation information storage system

D.6.1 The PCD system shall include non-volatile memory storage or a counter, which shall be used to store diesel engine operating events at the time of DTC confirmation and activation, and shall ensure that information is not intentionally deleted.

D.6.2 The PCD system shall save confirmation and activation DTC. When the driver alarm system has been activated for more than 20 h of diesel engine operating time, or a shorter time selected by the manufacturer, and the DTC is still in an activated state, the PCD system shall store the total number of PCD events and total cumulative operating time in non-volatile memory.

D. 6. 3 The ecological and environmental competent authority shall be able to use a general-purpose diagnostic instrument to read these records.

D.7 Detecting removal or blockage of the particulate aftertreatment system

The PCD system must be able to detect the removal or blockage of the particulate aftertreatment system, including sensors used to monitor, activate, reset, or adjust other actions.

D.8 Requirements of particulate aftertreatment systems using liquid reagent (such as fuel additive-type catalysts)

D.8.1 If particulate aftertreatment system removal DTC has been confirmed and activated reagent injection must be interrupted immediately; normal injection must be restored after the malfunction has been eliminated.

D. 8. 2 When the level in the tank storing liquid reagent is lower than minimum value specified by the diesel engine manufacturer, activation must be performed as required in D.4 and D.5 .

D.8.3 The use of fuel additive-type catalysts containing metal ions is prohibited.

D.9 Malfunctions induced by tampering

D. 9.1 Malfunctions induced by tampering include:

a) Loss of particulate aftertreatment system function, as specified in D.9.2;

b) PCD system malfunctions, as specified in D.9.3.

D.9.2 Monitoring of particulate aftertreatment system function

A particulate emission control device PCD shall be able to detect the complete removal of the particulate aftertreatment system carrier. Under these conditions, the outer shell of the particulate aftertreatment system and sensors used to monitor, activate, reset, or adjust other actions must still exist. D.9.3 PCD system monitoring malfunctions.

D. 9.3 Detection of failure of PCD system

D. 9. 3. 1 The system must also detect faults in the PCD system's circuits, and prevent the removal of any sensors or actuators used to monitor the faults specified in D.7 and D.9.2.

D.9. 3.2 If the malfunction, removal, or failure of any individual sensor or actuator in the PCD system will not affect monitoring in D.7 and D.9.1 a), there is no need to activate the driver alarm system and restriction system, and there is no need to store the event in the driver alarm system.

D.10 Verification requirements

D.10.1 General requirements

When performing type testing, compliance with the requirements of this Annex must be verified as required in Table D.2.

Table D.2 Explanation of particulate matter control system verification content

Items	Verification items
Driver alarm system activation as specified in D.4	— Two activation tests (including particulate aftertreatment system removal) — Verification items added when the situation warrants (if applicable)
Driving performance restriction system activation as specified in D.5	— Two activation tests (including particulate aftertreatment system removal) — Verification items added when the situation warrants (if applicable) — One torque reduction test (including primary restriction system and severe restriction system)

D.10.2 Diesel engine family and PCD diesel engine family

Testing of one diesel engine from a certain family can be performed to verify that the diesel engine family or PCD family meets the requirements of Annex D, but the diesel engine manufacturer must verify to the ecological and environmental competent authority that the monitoring system meeting the requirements of Annex D is similar throughout that family.

D.10. 2.1 The submission of materials including calculations and functional analysis to the ecological and environmental competent authority shall be the means of verifying that the monitoring systems of other diesel engines in the PCD family are similar.

D.10. 2.2 The diesel engine selected for testing by the diesel engine manufacturer may or may not be the parent engine of that family.

D. 10. 2. 3 If a diesel engine within a certain diesel engine family belongs to an PCD family (see Fig. D.1) that has already received type testing as required by D.10.2.1, it shall be deemed that the compliance of this diesel

engine family had already been verified, and does not require additional verification; however, the diesel engine manufacturer must verify to the ecological and environmental competent authority that the monitoring systems complying with the requirements of Annex D are similar throughout the diesel engine family and PCD family.

D. 10. 3 Verification of activation of the driver alarm system and the driving performance limitation system

D. 10. 3. 1 Compliance of the driver alarm system and the driving performance limitation system shall be demonstrated by two tests: loss of the particulate aftertreatment system function and a failure category described in D.7 and D.9.3 of this annex.

D. 10. 3. 2 Selection of test failure

The diesel engine manufacturer shall provide a list of these potential failures to the competent environmental authority, and the verification test shall be selected from the potential failures provided by the diesel engine manufacturer.

D. 10. 3.3 Verification

D. 10. 3. 3.1 This verification is intended to provide independent testing of any loss of function in the particulate aftertreatment system specified in D.9.2 and the faults specified in D.7 and D.9.3. Loss of function in the particulate aftertreatment system shall include the complete removal of matrix from the particulate aftertreatment system shell.

D. 10. 3. 3. 2 Apart from those faults being tested, no other faults may appear during the testing process.

D. 10. 3. 3. 3 Prior to the start of testing, all DTC must be erasable.

D. 10. 3. 3. 4 When requested by the diesel engine manufacturer, and this will not affect other functions, fault testing may be simulated.

D. 10. 3. 3.5 Fault detection

D. 10. 3. 3. 5.1 In accordance with the requirements of this Annex, the response of the PCD system to the fault selected by the ecological and environmental competent authority shall be tested. If it is activated during the consecutive PCD test cycles specified in Table D.3, the verification shall be considered successful.

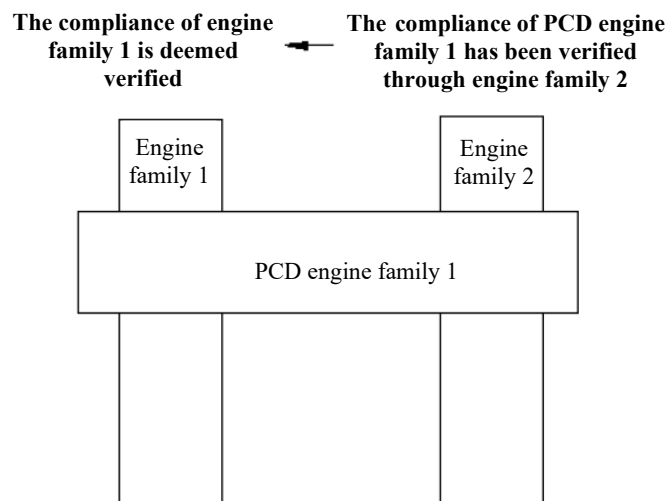


Figure D.1—PCD engine family deemed to be verified

If achieving the failures mentioned in the test description requires more PCD test cycles than indicated in D.3, the PCD test cycles may be increased by up to 50%.

During the verification test, each individual PCD test cycle may be separated by an engine shutdown. The time before the engine restart shall be considered in any monitoring that may occur after engine shutdown and the necessary conditions for monitoring to occur after the next engine restart.

Table D.3—Monitoring modes and number of PCD test cycles with “confirmed and active” DTCs stored

Monitoring mode	Number of PCD test cycles with “confirmed and active” DTCs stored
Removal of the particulate aftertreatment system	2
Loss of the particulate aftertreatment system function	8
PCD system failure	2

D.10. 3. 3.6 PCD test cycle

D.10. 3. 3. 6.1 The PCD test cycle used for verifying the proper performance of the particulate aftertreatment system specified in D.9 is the hot NRTC cycle for variable speed diesel engines with a rated net power of 19 kW to 560 kW; other types shall be verified using the NRSC cycle.

D.10. 3. 3. 6.2 Alternative PCD test cycles (e.g. other than the NRTC or NRSC) may be used for specific tests as requested by the engine manufacturer. The request shall include verification of the following elements (technical considerations, simulations, test results, etc.):

- a) The test cycle requested for verifying failure monitoring shall be the actual working conditions;
- b) The applicable PCD test cycle specified in D.10.3.3.6.1 is not applicable to the considered monitoring.

D.10. 3. 3. 7 Configuration for verification of the operator warning system activation

D. 10. 3. 3. 7. 1 Verification of the operator warning system activation shall be completed by tests performed on an engine test bench.

D. 10. 3. 3. 7. 2 All parts or ancillary systems that need to be additionally installed on the engine system for the performance of the verification test, including but not limited to ambient temperature sensors, level sensors, and operator warning and message systems, shall be connected to the engine system or simulated to meet the test requirements.

D.10. 3. 4 At the end of each verification test performed in accordance with D.10.3.3, if the operator warning system and the restriction system are able to be properly activated and the DTC of the selected failure is confirmed and active, the verification of the operator warning system activation is deemed complete.

D.10.3.5 If a particulate aftertreatment system that uses a fuel born catalyst is subjected to a verification test for functional loss or removal of the particulate aftertreatment system, it shall also be confirmed that the fuel borne catalyst dosing is stopped.

D.11 Removal of operator warning system and operating performance restriction system

For activation and deactivation of the PCD operator warning system and operating performance restriction system, refer to Annex CB.

If a PCD system failure described in D.7-D.9 occurs repeatedly, the number of operating hours before the activation of the operating performance restriction system shall be reduced. Refer to Annex CB for the counter mechanisms, and Table D.4 for the PCD counters and limits.

D.4—Counters and limits

	DTC status at the first activation of the counter	Counter value for the primary restriction system	Counter value for the critical level restriction system	Freeze value held by the counter
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Removal and blockage of the particulate aftertreatment system	Confirmed and active	≤ 36 h	≤ 100 h	$\geq 95\%$ of the counter value for the critical restriction system
Failure of the particulate aftertreatment system	Confirmed and active	≤ 36 h	≤ 100 h	$\geq 95\%$ of the counter value for the critical restriction system
PCD system failure	Confirmed and active	≤ 36 h	≤ 100 h	$\geq 95\%$ of the counter value for the critical restriction system

Annex E
(Normative)
PEMS Method Test Procedures and Requirements

E.1 Overview

This annex specifies the test procedures and calculation methods for pollutant emissions from machines using a portable emissions measurement system (PEMS).

E.2 Test requirements**E. 2.1 General requirements**

The machine manufacturer shall disclose a test plan on an information disclosure platform. The plan shall contain the working process, load, and break-in methods for machines (diesel engines) to ensure that the selected conditions are sufficiently representative.

- E. 2.1.1 The ambient temperature shall be between 283 K and 311 K (10°C and 38°C).
- E. 2.1.2 The altitude shall be not higher than 1,700 m during the test.
- E. 2.1.3 Before the test, the mechanical parameters shall be recorded in detail in accordance with E.5.
- E. 2.1.4 If a periodic regeneration event occurs during the PEMS test, the test may be considered invalid and may be repeated once as requested by the manufacturer. The occurrence of regeneration during the test can be determined on the basis of ECU signals or relevant information such as exhaust temperature and CO₂ and O₂ measurements. All test results shall be corrected by means of a regeneration factor obtained in the emission type approval test of an engine equipped with a periodic regeneration system.

The manufacturer shall ensure that, before the second test, the regeneration of the machine has been completed and proper pretreatment has been carried out. If regeneration occurs again when the test is being repeated, the pollutants emitted during the repeated test shall be included in the emission evaluation results.

E. 2.2 Preparation of machine

- E. 2.2.1 The machine's engine shall be within its effective lifetime, and the machine shall have been properly used and maintained and be free from any modification. The machine's pollution control device works properly and has not had any warning or failure affecting its normal operation, e.g. a cylinder misfire in the engine, a damaged sensor in the pollution control device, etc.
- E. 2.2.2 The emission control diagnostic system of the machine shall comply with the provisions of 5.7.2. The following data can be obtained by means of a standard diagnostic serial interface: coolant temperature, engine speed, torque, engine fuel consumption rate, etc. The data shall be acquired at a frequency of 1 Hz.
- E. 2.2.3 The PEMS test shall be carried out under normal operating conditions of the machine. The test shall represent the load characteristics of the machine in actual operating conditions.
- E. 2.2.4 The test shall use a fuel or reagent that meets the type approval test requirements of this standard.
- E. 2.2.5 For the emission compliance inspection of newly-manufactured machines, machine break-in should not be carried out in principle. If requested by the machine manufacturer in writing, break-in may be carried out in accordance with the relevant break-in specifications; however, the break-in period shall last no longer than 5 hours, and no changes shall be made to the machine.
- E. 2.2.6 For in-use compliance tests, the cumulative operating hours of the engine installed on the

machine shall be within the effective lifetime required by GB 20891-2014.

E. 2. 2.7 The machines being tested shall be loaded according to actual operating requirements, and shall not be tested without being loaded.

E. 2. 2. 8 During the test, if necessary, samples of fuel, lubricating oil, and aftertreatment reagents shall be collected from the machines being tested.

E. 2.3 Measurement items

E. 2. 3.1 The portable emissions measurement system shall be fixed on the machine to measure and collect the data listed in Table E.1 in real time during the working process. The data shall be acquired at a frequency of 1 Hz. When it is not possible to directly measure the exhaust flow using an exhaust flowmeter (EFM), the exhaust flow may be calculated using the carbon balance method if it can be demonstrated that there is no difference from the EFM test result.

Table E.1—Measurement items

Measurement item	Unit	Measurement instrument
NO _x concentration ¹	ppm	Analyzer
CO concentration ¹	ppm	Analyzer
CO ₂ concentration ¹	ppm	Analyzer
Exhaust flow	kg/h (or L/min)	EFM
Exhaust temperature	°C	EFM
Ambient temperature	°C	Sensor
Ambient atmospheric pressure	kPa	Sensor
Ambient relative humidity	%	Sensor
Engine speed	r/min	ECU data reading device
Engine torque ²	Nm	ECU data reading device
Engine fuel consumption rate	g/s	ECU data reading device
Engine coolant temperature	°C	ECU data reading device
Longitude	°	Navigation satellite precision positioning system
Longitude	°	Navigation satellite precision positioning system
Altitude	m	Navigation satellite precision positioning system

¹ Wet concentration obtained by direct measurement or corrected according to the provisions of E.2.3.2.

² According to standard protocols such as SAE J1939, ISO 15765-4, and ISO 15031, the engine torque shall be the net torque of the engine or the net torque calculated from the engine's actual torque percentage, friction torque, and reference torque; net torque = reference torque × (actual torque percentage - friction torque percentage).

E. 2. 3. 2 Dry-wet basis correction

If the pollutant concentration is measured on a dry basis, the measured dry concentration shall be converted to a wet concentration.

$$C_{\text{wet}} = k_w \times C_{\text{dry}}$$

Where:

C_{wet} —concentration of the pollutant on a wet basis, in ppm (or ppmC) or volume percentage;

C_{dry} —concentration of the pollutant on a dry basis, in ppm (or ppmC) or volume percentage;

k_w —dry-wet basis correction factor.

k_w may be calculated with the following formula:

$$k_w = \left(\frac{1}{1 + \alpha \times 0.005(c_{CO_2} + c_{CO})} - k_{w1} \right) \times 1.000$$

Where:

$$k_{w1} = \frac{1.608 \times H_a}{1000 + (1.608 \times H_a)}$$

Where:

H_a —absolute humidity of intake air, g H₂O/kg dry air;

C_{CO_2} —dry CO₂ concentration, %;

C_{CO} —dry CO concentration, %;

α —molar hydrogen ratio.

E. 2.4 Test conditions

E. 2.4.1 The test shall be carried out during the actual operation of the machine.

E. 2.4.2 If the machine manufacturer provides an explanation to the competent environmental authority indicating that the requirements of E.2.4.1 cannot be met, the test work cycle shall represent the actual operation of the machine as closely as possible.

E. 2.4.3 Regardless of whether the test is carried out during actual operation of the machine or in a representative test work cycle, the test shall:

- a) Assess the overall actual operation of the selected machine category in use;
- b) Exclude sporadic workload at idle speed;
- c) Include sufficient load conditions to achieve the requirements set forth in E.3.4.1;
- d) Ensure uninterrupted operation of the machine during the test.

E.2.5 Equipment installation and connection

E. 2. 5.1 Main unit

The PEMS shall be installed on the tested machine according to applicable operating requirements in a position that is minimally affected by the following external conditions:

- ambient temperature change
- ambient atmospheric pressure change
- electromagnetic radiation
- mechanical vibration

E. 2. 5. 2 Exhaust flowmeter

The exhaust flowmeter shall be connected to the exhaust pipe of the machine being tested. A short flexible connector can be used if necessary, provided the connector is sealed with a stainless steel hose clamp or clip and the area of contact between the exhaust gas and the flexible connector is minimized to avoid deviations in measurements due to complex terrain. The length of the straight pipes upstream and downstream of the exhaust flowmeter sensor shall be at least twice the diameter of the exhaust flowmeter.

The exhaust flowmeter shall not be installed in such a way that the exhaust back pressure is greater than the value recommended by the engine manufacturer.

E.2.5. 3 ECU data reading device

The ECU data reading device shall be able to record the engine parameters listed in Table E.1 in

real time. The device may obtain the ECU data of the tested machine according to standard protocols such as SAE J1939, ISO 15765-4, or ISO 15031.

E.2.5. 4 Sampling system

The sampling probe shall be installed after the flow measuring device has been installed as specified by the instrument manufacturer. The heating and sampling pipeline for gaseous pollutants (with a heating temperature of $190^{\circ}\text{C}\pm 10^{\circ}\text{C}$, if applicable) shall be insulated at the junction of the sampling probe and the main unit to prevent condensation of hydrocarbons in the sampling system.

If the length of the sampling line changes, the system response time will need to be recalibrated.

E.3 Emission test

E.3.1 Test preparation

E.3.1.1 Start-up and securing of PEMS

The PEMS shall be preheated and secured in accordance with applicable operating requirements so that the pressure, temperature, and flow of the PEMS meet applicable equipment requirements.

E.3.1.2 Cleaning of sampling system

In order to prevent system contamination, the PEMS sampling system shall be purged and cleaned according to applicable operating requirements.

E. 3.1.3 Analysis of leak detection for sampling system

Gas leak detection shall be conducted on the sampling system in accordance with equipment operating requirements.

E.3.1.4 Gas calibration

E. 3. 1.4. 1 Gas calibration shall be conducted in accordance with equipment operating requirements (the calibration gas shall comply with E.6):

—The CO, CO₂, and NO_x (NO and NO₂) analyzers are zeroed using the zero gas (pure synthetic air or nitrogen).

—The normal working measuring range is calibrated using a span gas, and the calibration value shall be more than 80% of full scale.

E. 3. 1.4. 2 Before each test, each normal working measuring range shall be checked with a zero gas and span gas in accordance with the steps outlined above.

E. 3.1.5 Cleaning of exhaust flowmeter

The exhaust flowmeter shall be purged to remove condensate and diesel particulates from the pipeline and relevant measurement ports in accordance with equipment operating requirements.

E. 3. 1.6 Equipment for measuring engine-related information shall be commissioned to ensure that the correct engine-related data is obtained.

E. 3. 1.7 Before the test begins, a segment of data shall be collected in advance to determine whether the equipment has been installed properly and to perform a preliminary check of the readable information of the engine.

E. 3. 1.8 The ambient temperature shall be measured at the beginning and end of the test and at a reasonable distance from the machine. The CAN signal may be used for the intake air temperature (the ambient temperature of the engine). If an intake air temperature sensor is used to estimate the ambient temperature, the recorded ambient temperature shall be the intake air temperature corrected by the applicable nominal compensation between the ambient and intake air temperatures specified by the manufacturer.

E. 3. 2 Start of test

Before the machine is started, PEMS sampling shall be started, exhaust parameters shall be measured, and the engine and environmental parameters shall be recorded. The determination of the emissions compliance using the test data shall start when the coolant temperature of the engine is above 70°C or the coolant temperature change is less than 2°C within 5 minutes (whichever comes first, but no later than 20 minutes after the engine is started).

E. 3. 3 Test operation

The test shall be carried out in accordance with the test conditions specified in E.2.4. During the test, sample gas of all compositions may be sampled using the same sampling probe. Care should be taken to prevent the exhaust gas components (including water vapor, etc.) from condensing in the sample gas channel of the analysis system. After all instrument inspections and calibrations are completed, the machine shall continue its normal operation and data shall be collected.

E.3.4 End of test

E. 3. 4.1 The duration of the test, including all operational procedures and only valid data, shall be sufficiently long. The test shall end when the cumulative work of the machine being tested is 5-7 times the work of the engine's NRTC cycle, or when the test has been run for 2 hours.

E. 3. 4. 2 The valid work-based window shall account for more than 50% of all the work-based windows. Otherwise, the test is invalid and shall be restarted according to a modified test plan.

E. 3. 4. 3 The zero and span points of the gas analyzer shall be checked using the calibration gas specified in E.3.1.4 to assess the response drift of the analyzer and compare it with the calibration result from before the test. If it can be confirmed that the zero drift is within the allowable range, zero point calibration may be performed on the analyzer before the span drift is verified. After the test, the instrument drift check shall be completed before the PEMS or individual analyzer or sensor is turned off or before the analyzer is changed to non-operating mode. Difference between the results of the analyzer check before and after the test shall comply with Table E.2.

Table E.2—Allowable analyzer drift during PEMS test

Pollutant	Zero drift	Span drift ¹
CO ₂	≤2,000 ppm/test	≤2% of the reading or ≤2,000 ppm/test, whichever is greater
CO	≤75 ppm/test	≤2% of the reading or ≤75 ppm/test, whichever is greater
NO _x	≤5 ppm/test	≤2% of the reading or ≤5 ppm/test, whichever is greater

¹ If the zero drift is within the allowable range, zero point calibration may be performed on the analyzer before the span drift is verified.

E.4 Data processing and machine emission evaluation

E. 4.1 Data processing

E. 4. 1. 1 The final test result shall be rounded to one decimal place as indicated by the applicable emission standards plus one significant figure. Rounding the intermediate values leading to the final calculation result shall not be required. Continuous sampling shall be conducted during the test, and data recording shall not be interrupted. Processing data combined from multiple working processes is not permitted, except in the following cases:

—A complete working process of the machine being tested does not meet the requirements of E.3.4.1;

—More than 3 minutes of data is lost due to uncontrollable factors;

—The category of the machine being tested has multiple operating areas with different work cycles.

When combined data is processed, the following requirements shall be met:

- a) The same machine and engine shall be used for different working processes;
- b) The combined data includes no more than 3 working processes;
- c) The cumulative work associated with each working process in the combined data shall be at least 1 times the work of the NRTC cycle;
- d) The combined data shall be sorted and integrated according to acquisition time;
- e) Multiple data shall be combined and analyzed as a whole.

E.4.1.2 Time alignment

In order to reduce the time offset between signals when calculating mass emissions, the data related to emission calculations shall be aligned as required by E.4.1.2.1.

E.4.1.2.1 The test parameters of the PEMS are divided into three categories; see Table E.1 for details.

The specific classification requirements are as follows:

- a) Gas analyzer (concentration of CO, CO₂, and NO_x);
- b) Exhaust flowmeter (exhaust mass flow and exhaust temperature);
- c) Engine (torque, speed, temperature, and fuel consumption, from the ECU).

E. 4. 1.2. 2 The time alignment between one category and the other categories shall be confirmed by seeking the parameter with the highest correlation coefficient in the two categories of parameters. All the parameters in a given category shall be adjusted so as to maximize the correlation coefficient. The following parameters shall be used to calculate the correlation coefficient. The requirements for time alignment are as follows:

- a) Time alignment of Category I and II (analyzer and EFM data) and Category III (engine data): from the ECU;
- b) Time alignment of Category I and Category II: CO₂ concentration and exhaust mass;
- c) Time alignment of Category I and Category III: CO₂ concentration and engine oil consumption.

E. 4. 1.3 Data consistency check

E. 4.1.3.1 Analyzer and EFM data

Consistency of data (exhaust mass and gas concentration measured by EFM) shall be confirmed using the correlation between fuel consumption as measured by the ECU and fuel consumption as calculated according to Formula 2 of GB/T 27840-2011 (HC may be ignored). Linear regression is performed using the calculated and measured fuel consumption values. The best fit can be achieved using the method of least squares to calculate the slope m and the correlation coefficient r^2 ; it is recommended to perform this linear regression from 15% of the maximum fuel consumption to the maximum fuel consumption, with a test frequency greater than or equal to 1 Hz. When the two parameters specified in Table E.3 are met, the test can be considered acceptable.

$$y=mx+b$$

Where:

- y —calculated fuel consumption, g/s;
- m —slope of the regression line;
- x —measured fuel consumption, g/s;
- b — y -intercept of the regression line.

Table E.3—Deviation

Slope of the regression line, m	0.9 - 1.1 (recommended)
Correlation coefficient, r^2	Minimum of 0.90 (required)

E. 4. 1.3. 2 Confirmation of consistency of ECU torque data: The maximum output torque at different speeds (except for idle speed) during the test is compared with the full load torque at different speeds during the type approval test. The difference between the two shall be less than 7% of the full load torque during the type approval test. If there is no full load condition at any speed during the PEMS test, the maximum output load shall be compared with the universal characteristic curve provided by the manufacturer, and the deviation shall be less than 7%. If the above requirement is not satisfied, the test shall be invalid.

E. 4. 1.4 Algorithm for determining valid events during in-use inspection

E. 4. 1.4. 1 General requirements

E.4.1.4. 1.1 Invalid work event

The following events shall be regarded as invalid work events:

- Events where the engine power is lower than 10% of maximum power;
- Events corresponding to the cold state (cold start) of the engine listed in E.3.2;
- Events recorded when the ambient conditions fail to meet the requirements of E.2.1;
- Events recorded during regular inspections of measurement equipment.

Invalid work events shall be classified into short-term work events ($\leq D2$) and long-term work events ($> D2$) (see Table E.4).

Table E.4—Values of D0, D1, D2, and D3

Parameter	Value
D0	2 minutes
D1	2 minutes
D2	10 minutes
D3	4 minutes

E. 4. 1.4. 1. 2 Determination of invalid work events

—Invalid work events shorter than D0 shall be considered valid work events and shall be combined with surrounding valid work events (see Table E.4).

—The start-up period after a long-term invalid work event ($> D2$) shall be regarded as an invalid work event, until the exhaust temperature reaches 523 K (250°C). If the exhaust temperature does not reach 523 K (250°C) within D3 minutes, all events occurring after D3 shall be considered valid work events (see Table E.4).

—For all invalid work events, the first D1 event shall be considered a valid work event (see Table E.4).

E.4. 1.4. 2 Method for determining valid work events

E. 4.1.4.2.1 Step 1

Determine the invalid work events and calculate the duration of each event.

- Determine the invalid work events according to E.4.1.4.1.2;
- Calculate the durations of each invalid work event;
- Mark invalid work events shorter than D0 as valid work events (see Table E.4);
- Calculate the duration of the remaining invalid work events.

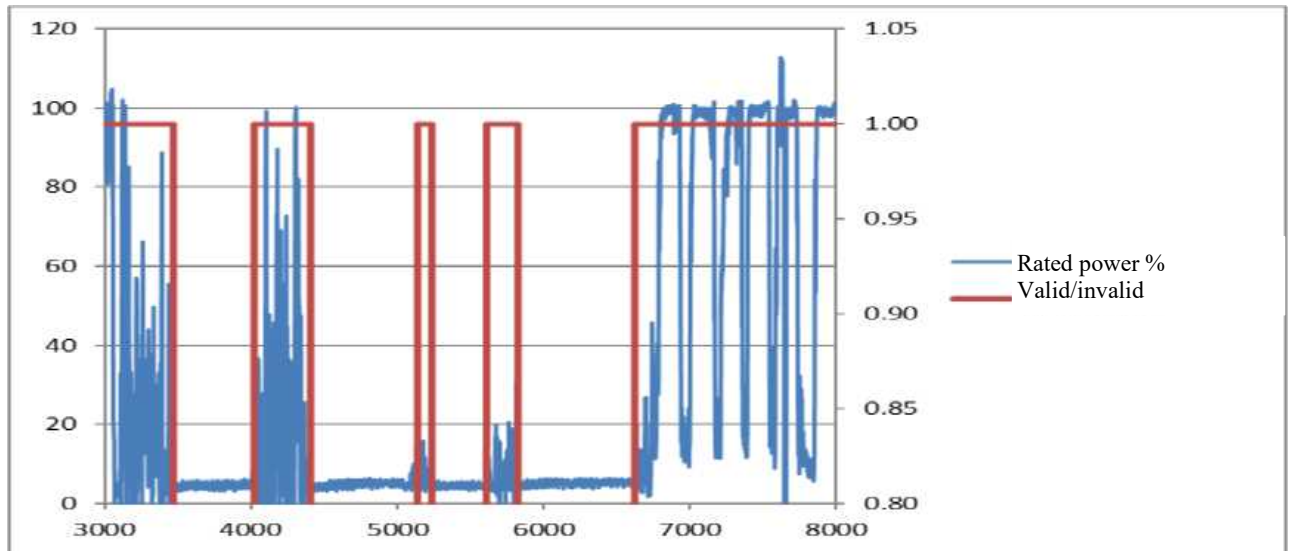


Figure E.1—Illustration of Step 1

E.4.1.4.2.2 Step 2

Combine short-term valid work events with invalid work events.

—Combine valid work events shorter than D0 with surrounding invalid work events longer than D1.

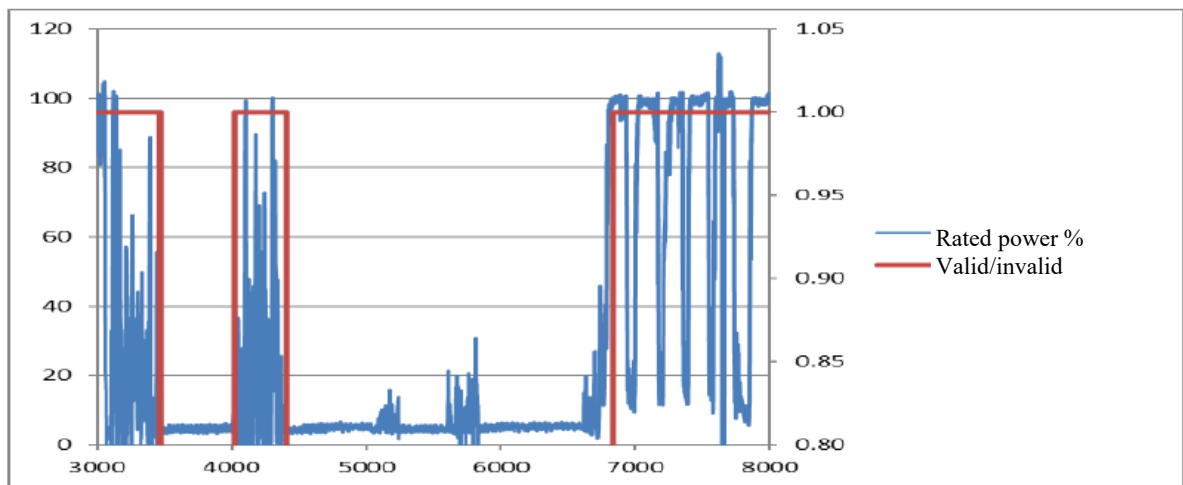


Figure E.2—Illustration of Step 2

E.4.1.4.2.3 Step 3

Exclude valid work events that occur after long-term invalid work events (initial stage of abrupt change in conditions).

—The initial stage of abrupt change in conditions refers to the stage of change in conditions from the first second of a valid work event to T1 or T2 (whichever comes first).

T1—time required for the exhaust temperature to reach 523 K (250°C) for the first time;

T2—first 4 minutes after the start of abrupt change.

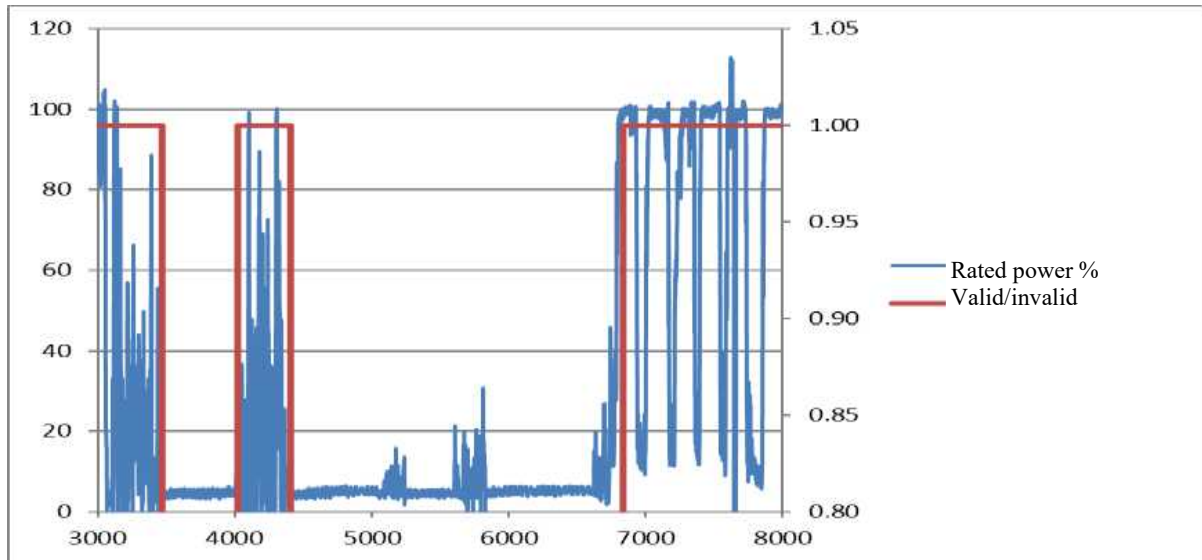


Figure E.3—Illustration of Step 3

E.4.1.4.2.4 Step 4

Incorporate invalid work events into valid work events.

—The first 2 minutes of an invalid work event that closely follows a valid work event shall be considered a valid work event and shall be combined with the previous valid work event.

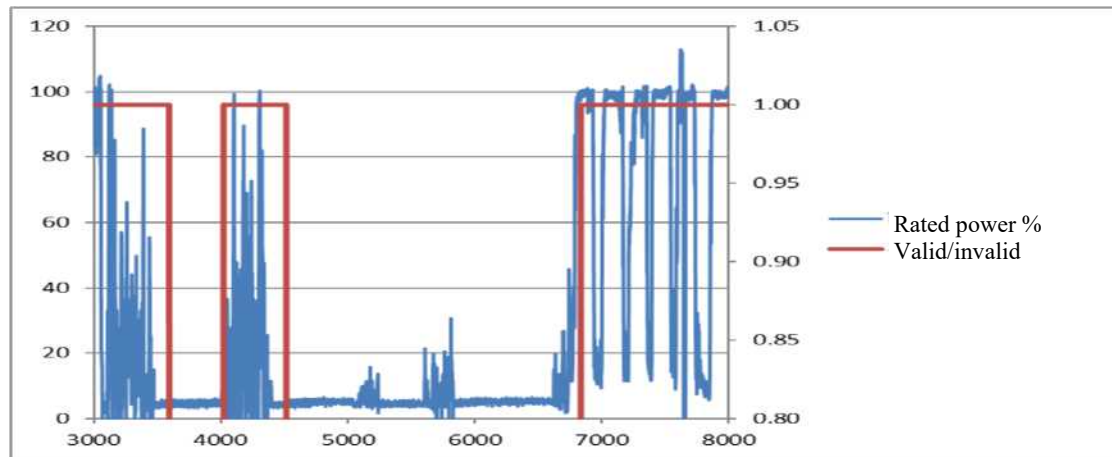


Figure E.4—Illustration of Step 4

E.4.1.4.2 The data contained in the invalid work events determined in accordance with E.4.1.4 shall not be involved in the calculations of E.4.2 and E.4.3. Only valid work events may be used for the calculations.

E.4.2 Calculation of exhaust mass

E. E.4. 2. 1 The instantaneous exhaust mass g_{xt} (g/s) of the gaseous pollutants shall be calculated in accordance with the following formulas (assuming the exhaust density is 1.293 kg/m^3 at 273 K (0°C) and 101.3 kPC):

$$NO_{xt} = \frac{0.001587 \times NO_{xconc} \times G_{exh}}{3600}$$

$$CO_t = \frac{0.000966 \times CO_{conc} \times G_{exh}}{3600}$$

$$THC_t = \frac{0.000479 \times THC_{conc} \times G_{exh}}{3600}$$

Where:

NO_{xt} , CO_{t} , and THC_{t} —instantaneous exhaust masses of the gaseous pollutants, g/s;

NO_{xconc} , CO_{conc} , and THC_{conc} (expressed as the equivalent amount C1)—wet instantaneous concentrations of the gaseous pollutants in the raw exhaust, ppm;

G_{exh} —instantaneous exhaust mass flow, kg/h.

E. 4. 2. 2 Calculate the instantaneous work of the engine. The output power of the engine is obtained according to its actual speed and torque value, and is multiplied by the time interval to obtain the instantaneous work of the engine, expressed in kW·h.

$$W_t = \frac{\pi \times T_t \times n_t}{1.08 \times 10^8}$$

Where:

W_t —instantaneous work, kW·h;

T_t —instantaneous net torque, Nm;

n_t —instantaneous speed, r/min;

π —use 3.14.

E. 4. 3 Calculation and determination of results with work-based window method

E. 4. 3. 1 Principles for calculation of emission test results:

—Test data obtained when the engine coolant temperature is less than 70°C and when the ambient conditions, analyzer calibration, and so forth fail to meet the requirements specified in E.2.1 shall not be used for the calculation of specific emissions;

—The emission test results are calculated according to the specific emissions of all valid work-based windows, not the real-time specific emissions of the entire test;

—The size of a work-based window is a reference value determined by the characteristics and performance of the engine during the same transient cycle used for the engine's type approval test (NRTC), and the size of the reference value determines the characteristics of the averaging process (i.e. the length of the window duration);

—The work-based window brake-specific emissions are calculated by moving forward in time; the amount by which the initial data point of each window is moved is equal to the reciprocal of the exhaust pollutant sampling frequency; the moving average is continuously calculated over time until the end point of the window reaches the end of the test data.

E.4. 3.2 Calculation of work-based window brake-specific emissions and average window power percentage

Determination of the i^{th} work-based window:

$$\sum_{t_{1,j}}^{t_{2,j}} W_t \geq W_{\text{ref}}$$

Where $t_{2,t}$ shall meet the following conditions:

$$\sum_{t_{1,j}}^{t_{2,j}-\Delta t} W_t < W_{\text{ref}} \leq \sum_{t_{1,j}}^{t_{2,j}} W_t$$

Where:

$t_{1,i}$ and $t_{2,i}$ —the start time and end time of the i^{th} work-based window, respectively, s;

W_{ref} —work of the engine during transient cycle (NRTC), kW·h;

Δt —data sampling cycle, no longer than 1 second.

Work-based window brake-specific emissions:

$$EF_{\text{gas}} = \frac{\sum_{t_{1,i}}^{t_{2,i}} \text{gas}_t}{\sum_{t_{1,i}}^{t_{2,i}} W_t}$$

Average window power percentage:

$$AWP\% = \frac{\sum_{t_{1,i}}^{t_{2,i}} W_t}{(t_{2,i} - t_{1,i}) \cdot P_{\text{max}}} \times 3600 \times 100\%$$

Where:

P_{max} —maximum net power of the engine, kW.

E. 4. 3. 3 Count the number of valid work-based windows where the window brake-specific emissions meet the pollutant emission limits specified in 5.7.6, and calculate the ratio of such work-based windows to the total number of valid work-based windows.

E. 4. 4 Method for calculating total specific emissions

For PEMS tests using cumulative specific emissions, the total specific emissions shall be used for calculations.

$$EF_{gas,1} = \frac{\sum_{t_i}^{t_j} gas_t}{\sum_{t_i} W_t}$$

Where:

$EF_{gas,1}$ —cumulative specific emissions, g/kW·h;

t_1 —valid data start time;

t_j —valid data end time.

E.5 Test report

The test report shall meet the requirements of Annex AB and shall include records of the original data from all emission tests.

E.6 Instruments and devices for emission test

E.6.1 General technical specifications of analyzers

The exhaust gas analyzers shall comply with the requirements of Annex BD3.1 in GB 17691-2005.

The following are some of the minimum requirements for required and recommended test devices. The response time refers to the rise time T_{10-90} and the fall time T_{90-10} . The requirements for accuracy, repeatability, and noise are shown in Table E.5.

Table E.5—Requirements for Instruments Used in PEMS Emission Tests

Instrument	Response time (s)	Sampling frequency (Hz)	Accuracy	Precision	Noise
Gas analyzer	5	1	$\pm 2.0\%$ of the reading or $\pm 0.5\%$ of full scale	$\pm 1.0\%$ of full scale ($\pm 2\%$ of full scale concentration if the measuring range is below 155ppm or 155ppmC)	$\pm 2.0\%$ of full scale
Exhaust flowmeter	1	1	$\pm 2.0\%$ of the reading or $\pm 1.0\%$ of full scale	$\pm 1.0\%$ of full scale	$\pm 2.0\%$ of full scale
Equal proportion dilution system	1	1	$\pm 1.5\%$ of the reading	$\pm 0.75\%$ of the reading	$\pm 1.0\%$ of the reading
Temperature sensor	5	1	± 5 K at temperatures ≤ 600 K (327°C), and $\pm 1.0\%$ of the reading at temperatures > 600 K	± 2 K at temperatures ≤ 600 K (327°C), and $\pm 0.4\%$ of the reading at temperatures > 600 K	$\pm 0.5\%$ of full scale
Atmospheric pressure gauge	10	0.1	± 250 PC	± 200 PC	± 100 PC
Relative humidity meter	10	0.1	—	$\pm 5\%$	—
Navigation satellite precision positioning system	1	1	Difference between total driving distance, calculated using the corrected data of the navigation satellite precision positioning system, and the reference value shall be $\leq 4\%$.	—	—

E. 6.2 Working principle of gaseous pollutant analyzers

E. 6. 2.1 Carbon monoxide (CO) analysis

The analyzer shall be of the non-dispersive infrared (NDIR) absorption type.

E. 6. 2. 2 Carbon dioxide (CO₂) analysis

The analyzer shall be of the non-dispersive infrared (NDIR) absorption type.

E. 6. 2. 3 Nitrogen oxides (NO_x) analysis

A chemiluminescence detector (CLD) or a non-dispersive ultraviolet (NDUV) analyzer shall be used.

E. 6. 2. 4 If an alternative method that meets the requirements of E.6.2.1 to E.6.2.3 is adopted, it shall be

described on the information disclosure platform.

E.7 Gases

The storage life of all calibration gases must be followed.

The calibration gas expiration date specified by the manufacturer shall be recorded.

E.7.1 Pure gases

The purity required for each pure gas shall meet the impurity limits given below. The following gases shall be available during operation:

—Pure nitrogen: $\text{HC} \leq 1 \text{ ppmC}$, $\text{CO} \leq 1 \text{ ppm}$, $\text{CO}_2 \leq 400 \text{ ppm}$, $\text{NO} \leq 0.1 \text{ ppm}$;

—Pure synthetic air: $\text{HC} \leq 1 \text{ ppmC}$, $\text{CO} \leq 1 \text{ ppm}$, $\text{CO}_2 \leq 400 \text{ ppm}$, $\text{NO} \leq 0.1 \text{ ppm}$; the volume fraction of oxygen is between 18% and 21%;

—Pure oxygen: purity $\geq 99.5\%$ volume fraction;

Preparation shall be made in accordance with the specific requirements of the test instruments.

E.7.2 Span gases

Gas mixtures of the following chemical components shall be available:

— CO_2 , CO , NO , C_3H_8 , and pure nitrogen;

— NO_2 and pure nitrogen;

— CO_2 , CO , NO , C_3H_8 , CH_4 , and pure nitrogen;

— CO_2 , CO , C_3H_8 , and pure nitrogen.

The actual concentration of the calibration gas shall be within $\pm 2\%$ of its nominal value, and all calibration gas concentrations shall be expressed in volume fractions (% or ppm).

Preparation shall be made in accordance with the specific requirements of the test instruments. The concentration of each component shall be prepared according to the applicable range of emission measurements.

E.8 Auxiliary devices of test systems

E. 8.1 Various auxiliary devices shall be used during tests to connect and supply power to the portable emissions measurement system.

E.8.2 The flow resistance of flowmeters, connectors, and connecting pipes shall not be greater than the maximum value specified by the engine manufacturer.

E.8.3 Protection devices shall be used for flexible connectors, environmental sensors, and other devices as needed.

Reliable installation points should be used. It is recommended to use specially designed clips, suction cups, and magnets.

E.8.4 Auxiliary power supply

Provided that the normal operation of the machine's engine is not affected, power supply may be obtained from the machine being tested or by installing an additional portable power source (e.g. battery, fuel cell, portable generator, etc.).

E. 8. 4.1 Provided that the normal operation of the machine's engine is not affected, power supply may be obtained from the machine being tested, in which case the test devices shall meet the following conditions at maximum power demand:

- The machine's power supply system must be able to ensure the safety of the power supply, e.g. the power required by the test devices must not exceed the capacity of the machine's power supply system;

- The exhaust pollutant emissions of the engine must not undergo significant change on account of the power supply of the test devices;

- The power required by the test devices must not increase the engine's output power by more than 1% of its maximum power.

E.8.4.2 An additional portable power source (e.g. battery, fuel cell, portable generator, etc.) can be installed to supply power as an alternative to the machine being tested. An external power source may be connected to the power system of the machine being tested, provided that the power required by the test devices and provided by the machine does not increase the engine's output power by more than 1% of its maximum power during the test.

Annex F
(Normative)

Production Conformity Assurance Requirements and Inspections

F.1 Overview

The manufacturer shall maintain a production conformity assurance system, including a quality management system and a production conformity assurance plan.

F.2 Quality management system

F. 2.1 The manufacturer shall establish a quality assurance system which effectively controls the plans and procedures of the production process and ensures production conformity control so as to guarantee the effective control of exhaust emissions from machines over their lifecycles.

F. 2.2 The quality management system designed by the manufacturer shall comply with GB/T 19001 or at least meet the requirements of ISO 9001 and shall have valid quality assurance system certification (relevant design and development requirements are exempted).

F. 2.3 The diesel engine manufacturer or a third party aftertreatment device manufacturer designated by the engine manufacturer shall provide the machine manufacturer with complete installation guides for the engine and aftertreatment assembly. The machine manufacturer shall carry out assembly according to the engine and aftertreatment assembly installation guides to ensure the engine and aftertreatment system are properly installed on the machine.

F. 2.4 The manufacturer shall submit the relevant materials and document serial numbers of the quality management system described in F.2.1 to F.2.3 in accordance with the standard requirements, including:

- quality assurance system certification;
- plans and procedures for effective control of production process;
- installation guides for engine and aftertreatment assembly.

F. 2.5 An explanation shall be provided for any revision to the validity and scope of the materials described in F.2.4.

F.3 Production conformity assurance plan

F. 3.1 The manufacturer must provide an information disclosure of the production conformity assurance plan before completing the type approval test and starting batch production.

F. 3.2 For machines applicable to this standard, production shall comply with the requirements of this standard to ensure compliance with the disclosed information, and the manufacturer shall meet the following requirements:

F. 3.2.1 Maintain and implement procedures that can effectively control products (machines, systems, components, or individual technical assemblies) to ensure compliance with the machines disclosed;

F. 3.2.2 In order to test the compliance of each machine that has been disclosed, the necessary test devices or other relevant devices shall be used;

F. 3.2.3 The sampling form and quantity must be statistically representative of the emission control level of the products during the production cycle;

F. 3.2.4 The results of the test or inspection shall be recorded and compiled into a document, which shall be retained and made available for a period of at least 10 years;

F. 3.2.5 The test results of each machine shall be analyzed in order to verify and ensure the stability of the product's emission characteristics and to establish tolerances for production process control.

F. 3. 2. 6 If any group of samples is confirmed in the required test to be non-compliant, resampling shall be performed and another test or inspection shall be conducted; in addition, the manufacturer shall take necessary corrective action to restore production conformity. If a defect involves a product that has already been shipped, remedial action shall be taken immediately and the competent environmental authority shall be notified.

F. F.4 Inspection of production conformity assurance plan

F. 4.1 The competent environmental authority may inspect the production conformity assurance plan implemented by the manufacturer as needed. The inspection may include the quality management system specified in F.2 and the production conformity assurance plan specified in F.3 and its implementation.

F. 4.2 The manufacturer shall furnish test or inspection records and production records in accordance with the requirements of the competent environmental authority.

F. 4.3 The competent environmental authority may randomly take samples and inspect laboratories that meet the requirements of this standard. The test or inspection may include some or all of the test items specified in this standard and GB 20891-2014. Machine inspections shall be carried out in accordance with the requirements specified in 7.3, and engine inspections shall be carried out in accordance with the requirements specified in Chapter 6 of GB 20891-2014.

Annex G
(Normative)

Technical Requirements for In-Use Compliance

G.1 Overview

This annex specifies the in-use compliance test procedures described in Section 8 of this standard. In-use compliance tests include self-inspections carried out by the manufacturer, and self-inspection report inspections and spot checks carried out by the competent environmental authority.

G. 2 In-use compliance self-inspections

G. 2.1 The pollutant emission measurement methods specified in Annex E and GB 36886-2018 shall be adopted for in-use compliance self-inspections carried out by the manufacturer.

G. 2.2 Selection of engine or machine

G. 2.2.1 Every effort shall be made to ensure the engine or machine that is selected has at least 500 h of use.

G. 2.2.2 A maintenance record shall be provided for each machine to demonstrate that the machine being tested has been properly maintained and repaired in accordance with the manufacturer's recommendations.

G. 2.2.3 All NCD and PCD failures associated with a diesel engine shall be corrected before any in-use test is performed on the engine.

G. 2.2.4 The engine or machine shall not have any record of inappropriate use (e.g. overloaded, filled with the wrong fuel, or mishandled) or any other factors that may affect emission performance (e.g. tampering of the emission control system). The system trouble codes and engine runtime information stored in the electronic control unit shall be analyzed.

G. 2.2.5 All emission control system components on the machine shall comply with the information disclosed for the machine.

G. 2.2.6 The information collected by the manufacturer shall be sufficient to determine whether the machine in use complies with the specified conditions of normal use. In selecting the source of the sample machine, differences in ambient conditions, operating conditions, and so forth shall be considered.

G. 2.2.7 When selecting the region of the sample machine, the manufacturer may make a selection from the areas that are considered to be the most representative. In this case, the manufacturer shall demonstrate to the competent environmental authority that the selection is representative (e.g. the annual sales volume of the machine in the region is the highest in the market, the machine has the highest workload, etc.).

G. 2.3 The number of samples collected for compliance self-inspection shall meet the requirements specified in GA.2.

G. 2.4 After completing the type approval test, the manufacturer shall start to conduct self-inspections for the in-use compliance of machinery installed with engines from a given family within 18 months after the first sale of a machine installed with this engine.

F. 2.5 The manufacturer shall submit and disclose in-use compliance self-inspection reports at least every two years, starting from the first sale of the machine. For engine manufacturers, the self-inspections shall be conducted on the same engine type (family). For machine manufacturers, the self-inspections shall be conducted on the machine family.

G. 2.6 The manufacturer may stop submitting in-use compliance self-inspection reports 5 years after production of the engine has been discontinued. If the annual production of an engine type (family) is less

than 300 units, the manufacturer may reduce the number of machines used for in-use compliance self-inspection.

G. 2.7 The in-use compliance self-inspection reports shall meet the requirements of Annex AB.

G. 2.8 If necessary, the manufacturer shall provide the selection criteria used for special machinery.

G. 3 Inspection of in-use compliance self-inspection reports

Based on the inspection of in-use compliance self-inspection reports, the competent environmental authority may make the following determinations:

- a) The in-use compliance test of the manufacturer meets applicable requirements, and no further action is required;
- b) The data furnished by the manufacturer is insufficient to make a determination regarding compliance, and supplemental testing and self-inspections are required;
- c) The in-use compliance test of the manufacturer does not meet applicable requirements, and it is necessary to start the corrective action specified in G.5 of this annex.

G. 4 Spot checks by the competent environmental authority

G.4.1 According to the provisions of 8.2.2, the competent environmental authority may conduct spot checks of in-use compliance.

G.4.2 Pollutant emission tests shall be performed by the competent environmental authority on machines in accordance with Annex E and GB 36886-2018 during in-use compliance spot checks.

G.4.3 The machines selected for spot checks shall be representative machines that meet the requirements of G.2.2 and shall be provided in normal working order.

G.4.4 The machine manufacturer shall confirm the model, type, technical status, test conditions, and other relevant information associated with the sampled products and provide a signature indicating the same.

G.4.5 During in-use compliance tests, the manufacturer shall provide the competent environmental authority with relevant information such as warning failures recorded during any claims or repairs.

This information shall detail the frequency and cause(s) of failure of any emissions-related components and systems.

G.5 Corrective action

G.5.1 If the competent environmental authority determines on the basis of a self-inspection report furnished by the manufacturer that the in-use compliance of the machine does not meet the requirements of this standard, or if the competent environmental authority determines after a spot check that the in-use compliance of the machine does not meet the requirements of this standard, the competent environmental authority shall notify and instruct the machine manufacturer to take corrective action and submit an action plan for correcting the item(s) of non-compliance.

G.5.2 The corrective action shall be applicable to a given machine or machine family and an engine made by the same engine manufacturer which is used in said machine or machine family, and may be extended to engine types (families) and other machines made by the same machine or engine manufacturer which may be affected by the same defect(s). The corrective action plan proposed by the manufacturer must be approved by the competent environmental authority before it can take effect. The corrective action plan shall be implemented by the manufacturer.

G.5.3 The manufacturer shall furnish all the materials related to the corrective action, retain the recall, repair,

and modification records of each engine or machine, and submit progress reports on the corrective action to the competent environmental authority on a regular basis as required.

G.5.4 The corrective action plan shall include the items specified in this section. The manufacturer shall assign a unique identification name or number to the corrective action plan.

G. 5. 4. 1 The corrective action plan shall include a description of each relevant machine (engine type).

G. 5. 4. 2 A description of special improvements, replacements, repairs, corrections, adjustments, or other changes made to ensure the compliance of the machine, including descriptions of supporting data and technical studies used by the manufacturer when determining special corrective action to be taken for the non-compliant engine (machine).

G. 5. 4. 3 The method used by the manufacturer to notify machine owners of the corrective action and the content of the notification.

G. 5. 4. 4 If the manufacturer makes proper maintenance or proper use a condition for repair in the corrective action plan, the details of what constitutes proper maintenance or proper use shall be specified and the reasons for setting these conditions shall be laid out. Imposing any conditions of maintenance or use that are not related to the corrective action is not permitted.

G. 5. 4. 5 The procedures to be followed by machine owners in order for non-compliant machinery to be corrected shall include: the start date of the corrective action, the location of the repair facility, and the time required to complete the repair(s).

G. 5. 4. 6 The manufacturer's method for guaranteeing the supply of parts or systems to ensure the corrective action is carried out to completion, and the start time of the supply of parts or systems.

G. 5. 4.7 Guidance documents provided to repair personnel.

G. 5. 4. 8 Analysis of the impact of corrective action on the emissions of each machine, including data and technical studies supporting these conclusions.

G. 5. 4. 9 Any other materials, reports, or data required by the competent environmental authority for the purpose of evaluating the corrective action plan.

G. 5. 4.10 If the corrective action plan includes a recall, the method of marking or recording the repaired machines shall be submitted to the competent environmental authority. If labels are used, a sample of the labels shall be submitted.

G. 5.5 The machine manufacturer may be required to prepare reasonable designs and perform necessary tests on the parts and machines to be replaced, repaired, improved, or added so as to demonstrate the effects of the replacement, repair, improvement, or addition of the parts.

G.5.6 The machine manufacturer shall provide machine owners with a written description of the new devices replaced, repaired, improved, or added.

Annex GA **(Normative)**

Sampling and Determination Procedures for In-Use Compliance Self-Inspections

GA. 1 Overview

This annex specifies the sampling and compliance determination procedures for in-use compliance self-inspections.

GA.2 Sampling

The minimum sample size is 3 machines, and the maximum sample size is 10 machines. The sampling procedure shall be set in such a way that the pass rate of a batch of machines or engines with a 20% defect rate is 0.90 (i.e. the manufacturer's risk is 10%), and the pass rate of a batch of machines or engines with a 60% defect rate is 0.10 (i.e. the consumer's risk is 10%). The total number of non-compliant tests in n tests shall be determined by the sample.

GA.3 The compliance of in-use compliance self-inspections shall be determined in accordance with the following requirements:

- a) Calculate the number of sample machines with excessive emissions;
- b) If the number of machines with excessive emissions is less than or equal to the compliance determination number listed in Table GA.1, they are deemed compliant;
- c) If the number of machines with excessive emissions is greater than or equal to the non-compliance determination number listed in Table GA.1, they are deemed non-compliant;
- d) If compliance or non-compliance cannot be determined on the basis of the number of machines with excessive emissions, the determination shall continue by adding test samples one by one.

Table GA.1—Compliance and non-compliance determination numbers for sampling plan

Number of samples, n	Number of machines with excessive emissions	
	Compliance determination number ($\leq$)	Non-compliance determination number ($\geq$)
3	-	3
4	0	4
5	0	4
6	1	4
7	1	4
8	2	4
9	2	4
10	3	4

Annex H (Normative)

Technical Requirements for On-Board Terminals

H.1 Overview

This annex specifies the communication protocols and data formats used between the on-board terminals and management platforms of machinery, including functional requirements, performance requirements, test methods, inspection rules, identification labels, and requirements for transportation, storage, and installation. The communication data formats are also specified, including protocol basis, communication connection, message processing, protocol classification, protocol description, and data format.

This annex applies to communication between the on-board terminals and management platforms of machinery.

H.2 Normative references

This standard refers to the following documents or their terms. For undated references, the latest version applies to this standard.

GB 17691-2018 Limits and Measurement Methods for Emissions from Diesel Fueled Heavy-Duty Vehicles (China VI)

GB/T 32960.3 Technical Specifications of Remote Service and Management System for Electric Vehicles - Part 3: Communication Protocol and Data Format

H.3 Terms and definitions

The following terms and definitions, specified in GB 17691-2018 and GB/T 32960.3, apply to this standard.

H.3.1

Register

When the on-board terminal is connected to the management platform, a data packet is sent to the platform for identification; registration shall be completed before the machines are shipped.

H.3.2

Connection

The routine data connections between the on-board terminal and the management platform shall be TCP connections.

H.3.3

Disconnection

Both the management platform and the on-board terminal can actively disconnect according to the TCP protocol, and both sides shall actively determine whether the TCP connection is disconnected.

The management platform may use the following method to determine that the TCP connection has been disconnected:

—According to the TCP protocol, it is determined that the on-board terminal has been actively disconnected;

—A new connection is established by the on-board terminal with the same identity, indicating that the original connection has been disconnected;

—No message is received from the on-board terminal within a certain period of time.

The on-board terminal may use the following method to determine that the TCP connection has been disconnected:

- According to the TCP protocol, it is determined that the management platform has been actively disconnected;
- The data communication link is disconnected;
- The data communication link is normal, and no response is received after the specified number of retransmissions has been reached.

H. 3.4

Packet supplementation

When the data communication link is abnormal, the on-board terminal shall store the report data locally. After the data communication link returns to normal, the stored report data shall be supplemented while the report data is transmitted. The supplemented report data shall be the data stored during periods in which the communication link is abnormal. The data format shall be the same as that of the report data, and it shall be identified as the supplemented information report (0x03).

H.4 Security policy

The on-board terminal shall provide a technically feasible security policy to ensure the properties and functions of the product fall within a secure range. This shall be achieved in the following ways:

- Data stored and transmitted by the on-board terminal shall be encrypted using asymmetric encryption algorithms. The national secret SM2 algorithm or the RSA algorithm may be used, and the private keys shall be strictly protected by means of hardware;
- Data stored and transmitted by the on-board terminal shall be complete;
- During the data transmission process, the data shall be scanned to ensure the timely detection of malicious data and attacks, such as the writing of commands to CAN bus devices such as ECUs, or other instructions beyond normal data reading. The security test shall be able to detect more than 95% of attacks, with a false positive rate of less than 1%, and shall be able to detect an attack and activate protective measures within 10 seconds after the attack starts;
- Without the manufacturer's consent, the on-board terminal shall only be able to read the vehicle data; it shall not be able to send any instructions other than diagnostic requests to the ECU;
- The on-board terminal shall only send data out; it shall not accept operating instructions other than those sent from the manufacturer.

H.5 Functional requirements

H. 5.1 Self-check

The on-board terminal shall indicate the current main status through signal lights, display screens, or sounds when starting to operate on power-up. The main status includes: whether communication is normal and whether the on-board terminal is normal. When the on-board terminal is unable to connect to a network or is operating improperly, the machinery shall be required to prompt the driver by means of the relevant display screen.

G. 5.2 Time and date

The on-board terminal shall be able to provide the time and date. The on-board terminal shall be able to record the time in hours, minutes, and seconds, or in the form hh:mm:ss. It shall be able to record the date in year, month, and day, or in the form yyyy/mm/dd/. The time error compared to standard time shall be ± 5 seconds per 24-hour period.

H. 5.3 Collection function for machine diagnostic information

After the monitored machine is started but before the machine is operated, the on-board terminal shall read the diagnostic information specified in Table H.6 from the machine, and upload the control diagnostic information to the management platform at least once within 24 hours.

H. 5.4 Collection function for engine data

The on-board terminal shall be able to collect relevant data in accordance with Tables H.7 and H.8, and the acquisition frequency shall meet the requirements of H.6.3. Data must be transmitted within 60 s of diesel engine start-up; data does not need to be transmitted after the engine is shut down.

H. 5.5 Storage function for on-board terminal information data

H. 5.5.1 The internal storage medium of the on-board terminal shall be able to store internal data for at least 7 days. The on-board terminal shall have an automatic overwrite function for internally stored data in case the internal storage medium is full.

H. 5.5.2 Data stored internally in the on-board terminal shall be accessible.

H. 5.5.3 In the event the on-board terminal stops working due to a power supply interruption, it shall be able to retain all of the data that was saved in the internal medium before the power supply interruption.

H. 6 Communication requirements

H. 6.1 Protocol structure

The TCP/IP network control protocol shall be used as the underlying communication bearer protocol, as shown in Figure H.1.

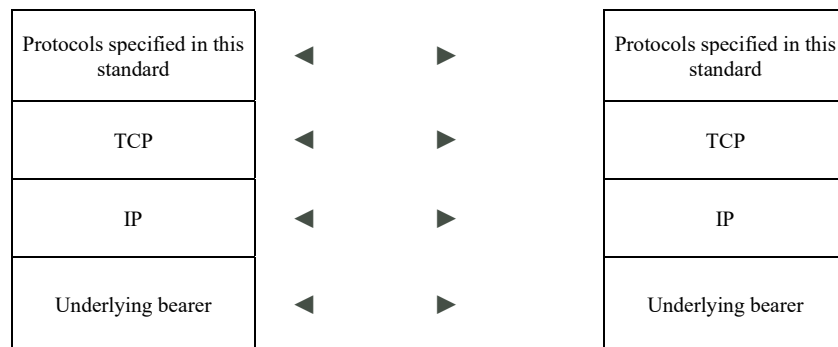


Figure H. 1—Stack of communication protocols between the on-board terminal and the management platform

H. 6.2 Establishing a connection

The on-board terminal initiates a communication connection request to the management platform, after a communication link connection is established. The on-board terminal shall automatically send login information for identification to the management platform, and the remote service and management platform shall verify the received data. If the verification result is correct, the management platform shall accept the data; if the verification result is incorrect, the management platform shall ignore the received data. The login process is shown in Figure H.2.

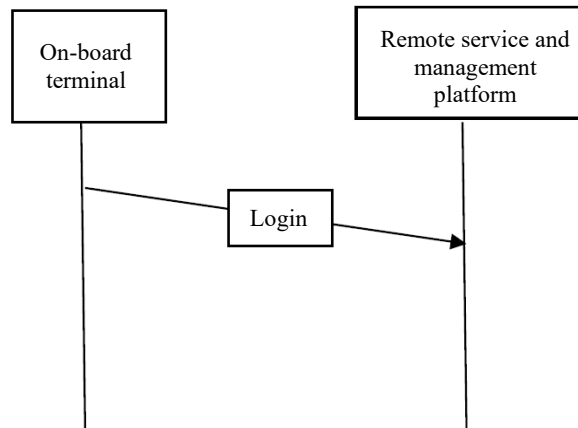


Figure H.2—Schematic diagram of the on-board terminal login process

H. 6.3 Information transmission

During operation, the current time data stream information specified in Table H.4 shall be reported to the management platform at least every 10 minutes. The information reporting process is shown in Figure H.3.

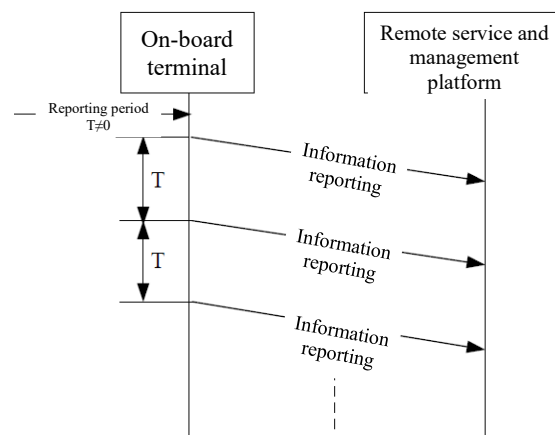


Figure H.3—Schematic diagram of the real-time information reporting process

When the on-board terminal reports information to the management platform, the management platform shall verify the received data. If the verification result is correct, the management platform shall accept the data as normal; if the verification result is incorrect, the management platform shall ignore the received data.

When the on-board terminal reports information to the management platform, the diagnostic information and the data stream shall be assembled and reported according to the actual situation.

H. 6.4 Data packet results and definitions

H. 6.4.1 Data types and transmission rules

The data types and transmission rules shall comply with the requirements specified in B.3.1 of GB/T 32960.3. The protocol shall use the big-endian network byte order to transmit words and double words.

H. 6.4.2 Data packet structure

A complete data packet shall consist of a start character, command unit, machine environmental

identification number, terminal software version number, data encryption mode, data unit length, data unit, and verification code. The data packet structure and definitions are shown in Table H.1.

Table H.1—Data packet structure and definitions

Start character	Definition	Data type	Description and requirements
0	Start character	STRING	Fixed to the ASCII character “##”, represented by “0x23, 0x23”
2	Command unit	BYTE	The command unit definitions are shown in Table H.2
3	Machine environmental identification number	STRING	The machine environmental identification number is a unique identifier consisting of a 17-digit code.
20	Terminal software version number	BYTE	The valid value range of the on-board terminal software version number is 0-255
21	Data encryption mode	BYTE	0x01: data is not encrypted; 0x02: data is encrypted by the RSA algorithm; 0x03: data is encrypted by the national secret SM2 algorithm; “0xFE” means an exception, “0xFF” means invalid, and others are reserved
22	Data unit length	WORD	Data unit length is the total number of bytes of a data unit, with a valid value range of: 0-65531
24	Data unit		Data unit formats and definitions are shown in H.6.4.5.
Last byte	Verification code	BYTE	The BCC (XOR) method is used. The verification range starts from the first byte of the command unit, which is XORed with the next byte and so on until the first byte before the verification code. The verification code occupies one byte.

H. 6.4. 3 Command unit

The command unit shall be the unique identifier of the initiator. The command unit definitions are shown in Table H.2.

Table H.2—Command unit definitions

Code	Definition	Direction
0x01	Machine login	Upstream
0x02	Real-time information report	Upstream
0x03	Supplemented information report	Upstream

Code	Definition	Direction
0x04	Machine logout	Upstream
0x05	Removal warning	Upstream
0x06 to 0x7F	Reserved by system for upstream data	Upstream

H. 6. 4. 4 Time

All time shall be in GMT+8, and the time definition shall meet the requirements specified in 6.4 of GB/T 32960.3.

H. 6.4.5 Data unit format and definitions

H. 6. 4. 5. 1 Machine login

The data format and definitions of machine login are shown in Table H.3.

Table H.3—Data format and definitions of machine login

Start byte	Content represented by	Data type	Description and requirements
0	Data acquisition time	BYTE[6]	See H.6.4.4 for time definition.
6	Login serial number	WORD	Each time the on-board terminal logs in, the login serial number is automatically incremented by 1 (starting from 1), with a maximum value of 65531. The cycle is given in days.
10	SIM card ICCID	STRING	The ICCID number of the SIM card (the ICCID shall be the value obtained by the on-board terminal from the SIM card and shall not be manually filled in or modified).

H.6.4. 5. 2 Real-time information report

H. 6. 4. 5. 2.1 Real-time information report format

The format and definitions of real-time information reports are shown in Table H.4.

Table H.4—Data format and definitions of real-time information reports

Content represented by data	Length (bytes)	Data type	Description and requirements
Data acquisition time	6	BYTE	See H.6.4.4 for time definition.
Information serial number	2	BYTE	Expressed in days. The real-time information serial number of each packet is unique and is incremented starting from 1.
Positioning information	9	BYTE	The report data format and definitions are shown in Table H.8.
Information type flag (n)	1	WORD	The information type flag definitions are shown in Table H.5.
Information body (n)			The length and data type vary depending on the information type.
.....			
Information type flag (m)	1	BYTE	The information type flag definitions are shown in Table H.5.
Information body (m)			The length and data type vary depending on the information type.

H. 6. 4. 5. 2. 2 Information type flag

The information type flag definitions are shown in Table H.5.

Table H.5—Information types

Type code	Description
0x01	Emissions control diagnostic information
0x02	Data stream information
0x03—0x7F	Reserved
0x80—0xFE	User-defined

H.6.4. 5. 2. 3 Real-time information body

a) The data format and definitions of emissions control diagnostic information (if applicable) are shown in Table H.6.

Table H.6—Data format and definitions of emissions control diagnostic information reports

Data item	Length (bytes)	Data type	Description and requirements
Emissions control diagnostic protocol	1	BYTE	The valid range is 0-3, where “0” stands for ISO 15765, “1” stands for ISO 27145, “2” stands for SAE J1939, “3” stands for ISO 15031, and “0xFE” means invalid.
Emissions control warning light status	1	BYTE	The valid range is 0-2, where “0” stands for OFF, “1” stands for ON, and “2” stands for FLASHING.
Total number of emissions control trouble codes	1	BYTE	Valid range: 0-253; “0xFE” means invalid.
Emissions control trouble code information list	Σ information length of each trouble code	N*BYTE (4)	Each failure consists of four bytes. The trouble codes can be sorted in the order in which the failures occur.

b) The data format and definitions of data stream information (if applicable) are given in Table H.7.

Table H.7—Data format and definitions of data stream information reports

Start byte	Data item	Data type	Description and requirements
0	Vehicle speed	WORD	Data length: 2 bytes Accuracy: 1/256 km/h per bit Offset: 0 Data range: 0 to 250.996 km/h “0xFF, 0xFF” means invalid

2	Atmospheric pressure (direct measurement or estimate)	BYTE	Data length: 1 byte Accuracy: 0.5 kPa/bit Offset: 0 Data range: 0 to 125 kPa “0xFF” means invalid
---	---	------	---

3	Diesel engine net output torque (as a percentage of the diesel engine's maximum reference torque), or diesel engine's actual/indicated torque (as a percentage of diesel engine's maximum reference torque, e.g. calculated based on the injected fuel amount)	BYTE	Data length: 1 byte Accuracy: 1%/bit Offset: -125 Data range: -125 to 125% "0xFF" means invalid
4	Friction torque (as a percentage of the engine's maximum reference torque)	BYTE	Data length: 1 byte Accuracy: 1%/bit Offset: -125 Data range: -125 to 125% "0xFF" means invalid
5	Diesel engine speed	WORD	Data length: 2 bytes Accuracy: 0.125/bit Offset: 0 Data range: 0 to 8031.875 rpm "0xFF, 0xFF" means invalid
7	Diesel engine fuel flow	WORD	Data length: 2 bytes Accuracy: 0.05 L/h Offset: 0 Data range: 0 to 3212.75 L/h "0xFF, 0xFF" means invalid
9	Output value of NO _x sensor upstream of SCR	WORD	Data length: 2 bytes Accuracy: 0.05 ppm Offset: -200 Data range: -200 to 3012.75 ppm "0xFF, 0xFF" means invalid
11	Output value of NO _x sensor downstream of SCR	WORD	Data length: 2 bytes Accuracy: 0.05 ppm Offset: -200 Data range: -200 to 3012.75 ppm "0xFF, 0xFF" means invalid
13	Reagent level	BYTE	Data length: 1 byte Accuracy: 0.4%/bit Offset: 0 Data range: 0 to 100% "0xFF" means invalid

14	Air intake	WORD	Data length: 2 bytes Accuracy: 0.05 kg/h per bit Offset: 0 Data range: 0 to 3212.75 kg/h “0xFF, 0xFF” means invalid
16	SCR inlet temperature	WORD	Data length: 2 bytes Accuracy: 0.03125°C/bit Offset: -273 Data range: -273 to 1734.96875°C “0xFF, 0xFF” means invalid
18	SCR inlet temperature	WORD	Data length: 2 bytes Accuracy: 0.03125°C/bit Offset: -273 Data range: -273 to 1734.96875°C “0xFF, 0xFF” means invalid
20	DPF differential pressure	WORD	Data length: 2 bytes Accuracy: 0.1 kPa/bit Offset: 0 Data range: 0 to 6425.5 kPa “0xFF, 0xFF” means invalid
22	Diesel engine coolant temperature	BYTE	Data length: 1 byte Accuracy: 1°C/bit Offset: -40 Data range: -40 to 210°C “0xFF” means invalid
23	Fuel tank level	BYTE	Data length: 1 byte Accuracy: 0.4%/bit Offset: 0 Data range: 0 to 100% “0xFF” means invalid
24	Actual EGR valve opening	BYTE	Data length: 2 bytes Accuracy: 0.0025%/bit Offset: 0 Data range: 0 to 160.6375% “0xFF, 0xFF” means invalid
26	Actual EGR valve opening	BYTE	Data length: 2 bytes Accuracy: 0.0025%/bit Offset: 0 Data range: 0 to 160.6375% “0xFF, 0xFF” means invalid

d) The data format and definitions of positioning information are shown in Table H.8.

Table H.8—Data format and definitions of positioning information reports

Start byte	Data item	Data type	Description and requirements
0	Status bit	BYTE	Data length: 1 byte See Table H.9 for status bit definitions.
1	Longitude	DWORD	Data length: 4 bytes Accuracy: 0.000001°/bit Offset: 0 Data range: 0 to 180.000000° “0xFF, 0xFF, 0xFF, 0xFF” means invalid
5	Longitude	DWORD	Data length: 4 bytes Accuracy: 0.000001°/bit Offset: 0 Data range: 0 to 90.000000° “0xFF, 0xFF, 0xFF, 0xFF” means invalid

Table H.9—Status bit definitions

Bit	Status
0	0: Valid positioning; 1: Invalid positioning (when the positioning information cannot be obtained under normal data communication, the last valid positioning information shall be sent, and the positioning status shall be set as invalid).
1	0: North latitude; 1: South latitude.
2	0: East longitude; 1: West longitude.
3	0: Connected; 1: Disconnected (connection status between on-board terminal and machine).
4-7	Reserved.

H. 6. 4. 5. 3 Supplementation

The data units of supplemented data are consistent with H.6.4.5.2.

H. 6. 4. 5. 4 Removal warnings

The report data format and definitions of removal warnings are shown in Table H.10.

Table H.10—Data format and definitions of removal warnings

Content represented by data	Length (bytes)	Data type	Description and requirements
Data acquisition time	6	BYTE	See H.6.4.4 for time definition.
Information serial number	2	BYTE	Expressed in days. The real-time information serial number of each packet is unique and is incremented starting from 1.
Positioning information	9	BYTE	The report data format and definitions are shown in Table H.8.

Removal status	1	BYTE	0: Control diagnostic information available; 1: Control diagnostic information unavailable
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H. 6. 4. 5. 5 Machine logout information

The data format and definitions of logout are shown in Table H.11.

Table H.11—Data format and definitions of logout

Content represented by data	Length (bytes)	Data type	Description and requirements
Logout time	6	BYTE	See H.6.4.4 for time definition.
Logout serial number	2	WORD	The logout serial number is the same as the current login serial number.

H.7—Positioning function

The on-board terminal shall be able to provide the positioning information specified in GB/T 32960.3. The accuracy requirements are as follows:

- a) The horizontal positioning accuracy shall be less than 10 m;
- b) Positioning time:
 - 1) Cold start: The time from system power-up to capture shall not exceed 120 s;
 - 2) Hot start: The capture time shall be less than 10 s.

H.8 Management function

The on-board terminal shall have a function to support remote registration and activation on a specified server.

H.9 On-board terminal performance requirements and test methods

The performance of the on-board terminal shall meet the requirements specified in Q.7.3, Q.7.5, and Q.7.6 of GB 17691-2018.

Annex I

(Normative)

Machine Environmental Information Label

I.1 Overview

This annex specifies the content and format of environmental information labels for machinery as well as the rules for information disclosure numbers.

I.2 Label content

- l. 2.1 The label shall display the words “environmental information label”.
- l. 2.2 The emission standard(s) followed and the corresponding stage, information disclosure number, and manufacture date.

- ### l. 2.3 Basic information:

Machine manufacturer name, machine name, trademark, machine type, machine model, engine manufacturer name, engine model, fuel injection system type, etc.

1. 2.4 Pollution control technical information (if applicable):

ECU, NCD, PCD, EGR, turbocharger, intercooler, fuel injection pump, fuel injector, DOC, DPF, SCR, air filter, intake muffler, exhaust muffler, etc.

I.3 Label format

The standard size of environmental information labels for machinery is recommended to be 130 mm × 60 mm. The size can be adjusted as needed. The content of the label shall be legible. Examples of labels are shown in Tables I.1 and I.2:

Figure I.1—Machine environmental information label format (title on the top)

Environmental Information Label	
Compliant with GB 20891-2014 Stage X Emission Standard	Manufacture Date: mm/yyyy
Environmental Information Disclosure Number:	
Basic information	Manufacturer name, machine name, trademark, machine type, machine model, importer name (if applicable), engine model and manufacturer name, fuel injection system type
Environmentally critical parts	ECU, NCD, PCD, EGR, turbocharger, intercooler, fuel injection pump, fuel injector, DOC, DPF, SCR, air filter, intake muffler, exhaust muffler

Figure I.2—Machine environmental information label format (title on the left)

Machine Environmental Information Label	Compliant with GB 20891-2014 Stage X Emission Standard Manufacture Date: mm/yyyy	
	Environmental Information Disclosure Number:	
	Basic information	Machine model, name, trademark, machine type, manufacturer name, importer name (if applicable), engine model and manufacturer name, fuel injection system type
	Environmentally critical parts	ECU, EGR, turbocharger, intercooler, fuel injection pump, fuel injector, DOC, DPF, SCR, air filter, intake muffler, exhaust muffler

I.4 Rules for environmental information disclosure numbers

An environmental information disclosure number (EIDN) is a combination of letters and numbers and has a total of 24 digits. The numbering rules are as follows: CN + machine type + pollutant emission stage + noise emission stage + manufacturer code + information disclosure serial number. The details are as follows:

- a) CN: 2 digits, standing for China;
- b) Machine type: 2 digits, with FJ standing for a machine with a diesel engine installed;
- c) Pollutant emission stage: 2 digits, where “G” in the first digit stands for national standard, and “X” in the second digit is a number standing for the pollutant emission stage of the machine;
- d) Noise emission stage: 2 digits, where “Z” in the first digit stands for national noise standard, and “X” in the second digit is a number standing for the noise emission stage of the machine. “00” shall be substituted at present.
- e) Manufacturer code: 4 digits; a unique code assigned to each machine manufacturer, automatically generated by the information disclosure system;
- f) Information disclosure serial number: 12 digits; the first 6 digits represent different machine models, and the last 6 digits represent different configurations of the same machine model, expressed in Arabic numerals.

I. 5 Label-related requirements

I. 5.1 Material

The label material shall ensure that the label is not easily destroyed and the content is clearly legible over the lifecycle of the machine. Metal material is recommended.

I. 5.2 Position

The label shall be affixed on a part of the machine necessary for its normal operation and not normally requiring replacement during the lifecycle of the machine;

The attachment of the label shall not impair the normal operation of the machine;

After all the accessories required for machine operation have been installed, the label shall be located in a place where it will be readily visible and protected against wear;

Whenever possible, the label shall be affixed in a place that is not easily damaged during machine operation or that is minimally affected by the weather;

The manufacturer may affix two identical labels in different places on the same machine;

The manufacturer shall, as a minimum, disclose the position of the label via the information disclosure platform.

I. 5.3 Characters

The characters shall be displayed on the label in a way that ensures their permanence and legibility throughout the lifecycle of the machine; in general, the height of words and numbers shall be at least 4 mm.

I. 5.4 Attachment

The label must be secured throughout the lifecycle of the machine; it should be impossible to replace or remove the label without causing damage to the label or the machine’s appearance.

I. 5.5 Other requirements

The label shall be marked in at least Chinese.

Machinery from domestic manufacturers shall be labeled before delivery, and machinery from importers shall be labeled before entering the country.

The manufacturer may combine a machine's environmental information label and nameplate into a single label, provided the combined label meets the requirements of this standard. If the machine is of a limited size and does not provide ample space for affixing the environmental information label, the characters on the label may be reduced in size or the content related to the environmentally critical parts may be deleted as appropriate.

Annex J
(Normative)

Technical Requirements for Confirmation Inspections

J.1 Overview

This annex specifies the sampling process and test procedures to be followed during confirmation inspections.

J.2 Sampling process

J. 2.1 Verification of critical parts. Sampling personnel shall, in accordance with the parameters set forth in the sampling checklist and plan appendices, check the spare parts (not less than 30 units) of the critical components of the diesel engine to be sampled and verify the model and manufacturer name.

J. 2.2 After the engine starts to be assembled on the line, supervise the work stations of the assembly process.

J. 2.3 At the engine block numbering station, record each of the 30 engine block numbers and mark them.

J. 2.4 After all 30 engines have left the line and passed the inspection, check the engine configurations according to the sampling list and the recorded engine numbers.

J. 2.5 Select 3 (or 4) of the 30 engines at random and seal them as samples. (For on-site visual tests, the engines being tested do not need to be sealed, but the sample list must be filled out; the only engines that need to be sealed are those to be transported.) After the entire engines have been wrapped with plastic bags, they shall be sealed in such a way that the sealing tape is arranged in a cross or “#” pattern. The tape shall be free of breakpoints and shall be connected end to end. Attach a label displaying the text “Sealed” to the tape joint. This label shall cover the end of the tape and the plastic bag. After the sample is sealed, the plastic bag shall be covered by another plastic bag to protect the seal label. Photographs shall be taken of the sample sealing process and shall include, as a minimum, photographs of the engine label, critical components, and nameplate (or engraving) as well as a photograph of the entire sample after it has been sealed and an enlarged photograph that shows the seal label in detail.

J. 2.6 Fill out and sign the Diesel Engine Confirmation Inspection Sample Registration Form. See Table J.1.

J. 2. 7 For diesel engines with aftertreatment devices, aftertreatment samples shall be sealed separately. Mark the surface of the aftertreatment housing with an electric engraving pen (sealer's signature and sealing date). Wrap the aftertreatment sample in a plastic bag and seal the entire sample with tape and a seal label. Take photographs of the sealing process, including, as a minimum, photographs of the aftertreatment nameplate (or engraving) and markings, a photograph of the whole sample after sealing, and an enlarged photograph that shows the seal label in detail.

J. 2. 8 Fill out and sign the Aftertreatment Device Sampling Registration Form. See Table J.2.

J. 2. 9 Have the manufacturer review, stamp, and return the Informed Consent Form for Confirmation Inspection Sampling Rules. See Table J.3.

J. 3 Test flow

J. 3. 1 The test agency shall, in accordance with the requirements of applicable standards, carefully complete the inspections and tests, ensure fairness of the process and the authenticity of data, and keep the testing confidential. The entire test process shall be carried out under video surveillance.

J. 3. 2 Sample unpacking. Diesel engines for the emission test shall be selected from among the samples by

the competent environmental authority. The samples shall be unpacked by personnel from the test agency. First, verify the seal is intact. Take a photo of the seal label; remove the sealing tape according to the order in which it was wound, and take note of whether the tape is broken in the middle. Confirm that the seal label and sealing tape are intact.

J. 3. 3 Verification of critical diesel engine components. Check the information on the diesel engine label and critical component nameplates (or engravings).

J. 3. 4 Bench installation of diesel engine.

J. 3. 5 Diesel engine break-in. The break-in conditions shall be provided by the manufacturer, and the break-in time shall not exceed 50 hours. The oil products used for break-in shall be the same as those used for the emission test.

J. 3. 6 Confirmation of boundary conditions for diesel engine test. Fill out and sign the Test Conditions Confirmation Form. See Table J.4.

J. 3. 7 Reference gas inspection and calibration of analyzer. Fill out the Reference Gas Inspection Record Form. See Table J.5.

J. 3. 8 Conduct emission tests as well as NCD and PCD function verification as specified in applicable standards.

J. 3. 9 The weighing and handling of filters shall be carried out under video surveillance. Record the particulate weighing data and fill out the Particulate Weighing Record Form. See Table J.6.

J. 3. 10 After completion of the three emission tests, one of the engines tested shall be selected by a test supervisor and subjected to a 300-hour durability test and post-durability emission test. The durability test conditions shall be the conditions declared by the manufacturer in the durability plan.

J. 3. 11 Confirmation and inspection of oil products. Reference fuels that meet the requirements of applicable standards shall be used for emission tests. Commercially available fuels that comply with applicable emission standards may be used for durability tests. Lubricating oils shall comply with the information declared by the manufacturer or shall be provided by the manufacturer.

J. 3.12 During the engine break-in, test, and durability processes, manufacturer personnel shall not make any adjustments to the engine; they may conduct regular maintenance and repair in accordance with type test and durability test maintenance specifications.

J. 3.13 Manufacturer personnel may assist with the bench installation of the diesel engine. They shall not enter the test room without permission once the diesel engine test has begun. One person is allowed to stay in the operation room and observe the test process.

J. 3.14 Determination of results. If the emission test results of the 3 sample vehicles (machines) selected for the confirmation inspection and the emission test result of the 1 sample vehicle (machine) following completion of the 300-hour durability test meet the required limits, the confirmation inspection is determined to be acceptable.

J. 3.15 After the test is completed, all the original paper records and printed records must be signed. The test agency shall issue an official inspection report.

Table J.1—Diesel Engine Confirmation Inspection Sample Registration Form

Manufacturer of sample			
Sample number			
Trademark		Sample model	
No. of samples		Sampling method	
Sampling base		Sampling date	
Sampling location		Sealing method	
Delivery method		Sample destination and ETD	
Pre-test break-in requirements		Test fuel	
Test item(s)			
No.	Manufacture date	Diesel engine no.	Certificate no.
1			
2			
3			
4			
Sampler's signature:		Sealer's signature:	
Date:		Date:	
Signature of the legal representative from the sampled organization (authorized agent ¹):		Comments:	
Date:			
¹ The authorized agent shall have power of attorney.			

Table J. 2 Aftertreatment Device Sampling Registration Form¹

Category	Catalytic converter
Vehicle (machine) model	
Vehicle (machine) manufacturer	
Engine no.	
Emission stage	
Catalyst model	
Catalyst manufacturer	
No. of catalysts	
No. of units	
Carrier material	
Carrier manufacturer	
Coating manufacturer	
New or post-durability catalyst	
Metal housing retained (yes/no)	
Sampler's signature: Date:	Signature of the legal representative from the sampled organization (authorized agent): Date:
¹ The aftertreatment sampling records shall be executed in duplicate, with one copy kept by the sealing work group and one copy sent with the sample to the testing unit.	

Table J.3—Informed Consent Form for Confirmation Inspection Sampling Rules

In the process of confirmation inspection sampling, the manufacturer must strictly follow applicable requirements to ensure the sampling is carried out smoothly. If any of the following conditions are met, the confirmation inspection may be determined to be unacceptable:

1. The manufacturer does not cooperate with the inspection and sample sealing;
2. Personnel from the manufacturer deliberately damage the sample seal without permission;
3. The sample is not delivered to the designated location within the specified time;
4. The delivered sample is inconsistent with the sample as collected;
5. The sample has not been broken-in as required.

Signature (stamp) of manufacturer representative

Date:

Table J.4—Test Conditions Confirmation Form

Manufacturer name: Engine model:

Item	Manufacturer's declared value	Measured value	Comments
Rated net power/speed (kW/r/min)			Confirmation inspection tolerance $\pm 5\%$ ¹ Consistency inspection tolerance $\pm 5\%$
Maximum torque/speed (Nm/r/min)			Confirmation inspection $\pm 5\%$ ² Consistency $\pm 5\%$
Intake resistance (kPa)			As close as possible to the manufacturer's declared value without going over
Exhaust back pressure (kPa)			As close as possible to the manufacturer's declared value without going over
Temperature after intercooling (K)			Within 5 K of the manufacturer's declared value without going over; not lower than 318 K
Fuel temperature (K)			As close as possible to the declared value
Coolant temperature (K)			As close as possible to the declared value
Intermediate speed (r/min)			The declared value shall be used if the measured value is within $\pm 3\%$ of the declared value. The measured value shall be used if the speed is out of tolerance.
Non-standard cycle emission			Three test points shall be automatically generated by the system.
The test conditions meet applicable requirements. The test is allowed to start.			
¹ Confirmation inspection and consistency inspection tolerance 10% for engines below 37 kW.			
² Confirmation inspection and consistency inspection tolerance 10% for engines below 37 kW.			

Signature of test agency:

Signature of manufacturer:

Date:

Table J.5—Reference Gas Inspection Record Form

Manufacturer name: Engine model:

Diesel engine no.:				
Reference gas	C ₃ H ₈ (ppm)	CO (ppm)	NO _x (ppm)	CO ₂ (%)
Gas cylinder no.				
Concentration				
Validity period				
Zero gas (before)				
Zero gas (after)				
Measuring range				
Span gas (before)				
Span gas (after)				
Determination criteria	Not greater than $\pm 2\%$			
Deviation (%)				
Determination result				

Signature of test agency:

Date:

Table J.6—Engine Exhaust Particulate Weighing Record Form

Manufacturer name:					Engine model:				
Item	Mass of filter before test (mg)				Mass of filter after test (mg)				Mass of particulate matter (mg)
	1st test	2nd test	3rd test	Mean	1st test	2nd test	3rd test	Mean	
Emission									
Background									
Reference filter									Total mass of particulate matter
Weighing time									
Atmospheric pressure (kPa)									
Atmospheric temperature (°C)									
Relative humidity (%)									
Time needed for filter to reach constant weight after test (h)					Mass of filter after placement (mg)				Mass of particulate matter (mg)
					1st test	2nd test	3rd test	Mean	
Weighing time			Emission						
Atmospheric pressure (kPa)			Background						
Atmospheric temperature (°C)			Reference filter						Mass of particulate matter (mg)
Relative humidity (%)									
Particulate matter weighing process					Particulate matter weighing process				
Pre-test filter weighing process					Filter holder removal process				
Filter holder removal process					Post-test initial filter weighing process				
					Weighing process after filter reaches constant weight				

Signature of test agency:

Date:

Table J. 7—Test Data Record Form

Manufacturer name: Engine model:

Condition no.	HC (ppm)	CO (ppm)	NO _x (ppm)	CO ₂ (ppm)	Fuel (kg/h)	Air-flow (kg/h)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

Signature of test agency:

Date:

Table J.8—NCD or PCD Verification Test Record Form

Manufacturer name:

Engine model:

No.	Test item	Trouble code	Description of result
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Signature of test agency:

Date:

Annex K
(Normative)
Machine Environmental Identification Number

K.1 Overview

This annex specifies the numbering rules and related requirements for the environmental identification numbers of machinery. Each machine must have a unique machine environmental identification number.

K.2 Machine environmental identification number format

An example of the environmental identification number of a machine is shown in Figure K.1:

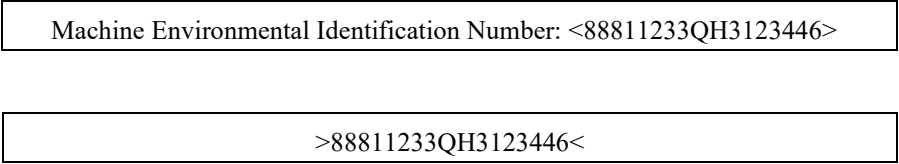


Figure K.1—Machine Environmental Identification Number Format

K.3 Numbering rules for machine environmental identification numbers

A machine environmental identification number has 17 digits and consists of a set of alphanumeric characters. For machines that have implemented Earth-Moving Machinery - Product Identification Numbering System (GB/T 25606-2010 / ISO 10261:2002), the machine environmental identification number may be replaced by the machine’s product identification number (PIN). The numbering rules for the environmental identification numbers of other machinery are as follows: Manufacturer identification part + machine description part + check digit + machine indication part. The details are shown in Figure K.2:

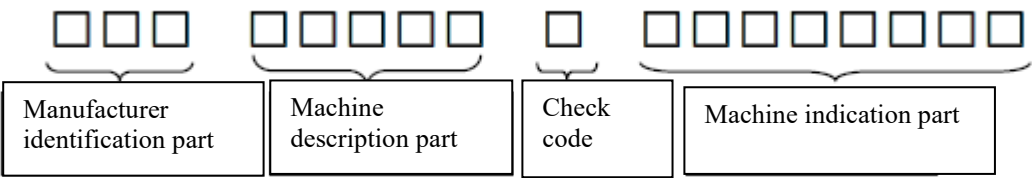


Figure K.2—Schematic diagram of numbering rules for machine environmental identification numbers

- K.3.1 The 1st to 3rd digits comprise the manufacturer identification part and consist of 3 alphanumeric characters. The digits are used to indicate the machine manufacturer or importer, and are generated automatically by the information disclosure system using the last three digits of the manufacturer code.
- K.3.2 The 4th to 8th digits comprise the machine description part and consist of 5 alphanumeric characters representing different machine models. The 4th digit shall indicate the machine category. See Table K.1 for details.

Table K.1—Designated machine category codes

Machine category	Code	Machine category	Code
Construction machinery	1	Mining machinery	5
Agricultural machinery	2	Generator	6
Forestry machinery	3	Other	7
Fishery machinery	4		

The 5th digit represents fuel type. See Table K.2 for details.

Table K.2—Designated fuel type codes

Fuel type	Code	Fuel type	Code
Diesel	1	Fuel gas	3
Gasoline	2	Other	4

For the 6th to 8th digits, the manufacturer has two options:

Automatically generated by the information disclosure system using the 16th to 18th digits of the machine's environmental information disclosure number; Customized by the manufacturer (this part shall provide information on the machine's product category, main parameters, basic characteristics, and so forth).

K.3.3 The 9th digit comprises the check code and consists of 1 alphanumeric character. The check code is calculated after the manufacturer has determined the other 16 digits. It may be any number between 0-9, or the letter "X". See K.5 for details on calculating the check code.

K.3. 4 The 10th to 17th digits comprise the machine indication part and consist of 8 alphanumeric characters. They are used to indicate differences between one machine and another machine of the same model. Further details are provided below:

K.3. 4. 1 The 1st digit of the machine indication part, i.e. the 10th digit of the machine environmental identification number, shall indicate the year of manufacture. See Table K.3 for details.

Table K.3—Designated year codes

Year	Code	Year	Code	Year	Code	Year	Code
2015	F	2023	P	2031	1	2039	9
2016	G	2024	R	2032	2	2040	A
2017	H	2025	S	2033	3	2041	B
2018	J	2026	T	2034	4	2042	C
2019	K	2027	V	2035	5	2043	D
2020	L	2028	W	2036	6	2044	E
2021	M	2029	X	2037	7	2045	F
2022	N	2030	Y	2038	8	2046	G

K. 3. 4. 2 The 2nd digit of the machine indication part, i.e. the 11th digit of the machine environmental identification number, shall indicate the pollutant emission stage of the machine. See Table K.4 for details.

Table K.4—Designated pollutant

Pollutant emission stage	Code	Pollutant emission stage	Code
China II	2	China III	3
China IV	4	China V	5
China VI	6		

K.3. 4. 3 The 3rd to 8th digits of the machine indication part, i.e. the 12th to 17th digits of the machine environmental identification number, are customized by the manufacturer. They shall indicate the machine assembly plant (if applicable), production or import sequence number, and other information that the manufacturer believes to require explanation.

K.4 Related requirements of machine environmental identification numbers

K.4.1 Characters

Only the following Arabic numerals and uppercase letters from the Roman alphabet shall be used in machine environmental identification numbers:

1234567890

ABCDEFGHIJKLMNOPQRSTUVWXYZ

(the letters I and O cannot be used)

K. 4.2 Separators

For machine environmental identification numbers marked on the machine's body or structural members, a suitable symbol shall be placed before the first digit or character and after the last digit. This symbol shall be:

- an asterisk (*);
- a greater than symbol or less than symbol (> or <); or
- the company logo.

The greater than symbol or less than symbol may be replaced with an angle bracket or a symbol similar to a “V” but horizontally pointing forward; in this case, the character shall be placed on either

side of the machine environmental identification number.

A machine environmental identification number marked on a machine's body or structural member shall consist of 17 characters arrayed on a separate horizontal line, and the characters shall not be broken or separated. No extra marks, letters, or characters shall appear before or after the separators.

K.4.3 Uniqueness

The manufacturer shall ensure that a given 17-digit machine environmental identification number will not be reissued for a period of 30 years. For all machines that have left the factory and entered the country, the manufacturer/importer is obligated to keep complete records of the machine environmental identification numbers.

K.4.4 Marking position

The machine environmental identification number shall be marked on the machine's frame, or another sturdy structural member that does not need to be replaced throughout the lifecycle of the machine.

The machine environmental identification number shall be marked on the machine in a position that is easily accessible and that is visible from outside the machine. In the case of large machinery, the preferred position is close to the right side of the front part of the machine, and the number shall be visible without having to move any part of the machine.

The manufacturer may mark the machine environmental identification number in different locations of a single machine.

The manufacturer shall mark the machine environmental identification number in at least one of the documents accompanying the machine.

The manufacturer shall, as a minimum, disclose the position of the machine environmental identification number via the information disclosure platform.

K.4.5 Marking methods

The machine environmental identification number shall be marked on the machine's frame or other sturdy structural member by embossing, stamping, or imprinting.

K.4.6 Marking requirements

The characters comprising the machine environmental identification number shall in all cases be legible, durable, difficult to replace, and readable in daylight.

In general, with respect to the character height of the machine environmental identification number: the character height shall be at least 6 mm, and the character depth shall be at least 0.2 mm.

When marked on the machine, the machine environmental identification number shall be marked on the same line whenever possible. In this case, separators shall be used. In special cases where the number must be marked on two lines for technical reasons, there shall be no blank line between the two lines, and a separator shall be used at the beginning and end of each line.

When marked on documents, the machine environmental identification number shall be marked on the same line without any spaces or separators.

K.4.7 Other requirements

Machinery manufacturers/importers shall, in accordance with this standard, formulate the coding rules for their own machine environmental identification numbers. The coding rules shall lay out in detail the coding rules for each digit of the machine environmental identification number as well as the marking positions and methods of machine environmental identification numbers.

The coding rules of machinery manufacturers/importers shall be uploaded to the environmental information disclosure platform.

Each machine manufacturer/importer shall be responsible for marking the machine environmental identification number on each machine according to the marking position and marking method required by this standard, and each machine manufacturer and importer shall indicate the marking position and marking method in a document accompanying the machine.

K.5 Method for calculation of check code

The 9th digit of the machine environmental identification number comprises the check digit, which may be any number from 0-9, or the letter "X". After determining the other 16 digits of the machine environmental identification number, the manufacturer or importer shall calculate the check digit using the method shown below.

- a) The corresponding values of numerals and letters in the machine environmental identification number are shown in Tables K.5 and K.6:
- b) A weighting coefficient shall be assigned to each digit of the machine environmental identification number in accordance with Table K.7:

Table K.5—Corresponding values of numerals in the machine environmental identification number

Numeral in machine environmental identification number	0	1	2	3	4	5	6	7	8	9
Corresponding value	0	1	2	3	4	5	6	7	8	9

Table K.6—Corresponding values of letters in the machine environmental identification number

Letter in machine environmental	A	B	C	D	E	F	G	H		JK	LM	N	PR	S	TU	V	W	X	Y	Z
Corresponding value	1	2	3	4	5	6	7	8		12	34	5	79	2	34	5	6	7	8	9

Table K. 7—Position weighting coefficients in the machine environmental identification number

Position in machine environmental identification number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Weighting coefficient	8	7	6	5	4	3	2	10	*	9	8	7	6	5	4	3	2

c) The weighting coefficient of each of the 16 digits (excluding the check digit) is multiplied by the corresponding value of each numeral or letter. Then the products are added, and the resulting sum is divided by 11.

d) The remainder is the check digit; if the remainder is 10, the check digit shall be the letter X.

Example:

The process of determining the check digit is illustrated by the example shown in Table K.8.

Table K. 8—Determination of check digit

Position in machine environmental identification number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MEIN code	2	3	4	1	1	A	C	3		H	3	1	2	3	4	4	6
Corresponding value	2	3	4	1	1	1	3	3		8	3	1	2	3	4	4	6
Weighting coefficient	8	7	6	5	4	3	2	10	*	9	8	7	6	5	4	3	2
Sum of products	16+21+24+5+4+3+6+30+72+24+7+12+15+16+12+12=279																
Remainder	279/11=25 remainder 4																

According to the above calculation, the check digit in the machine environmental identification number is determined to be 4. Therefore, the complete machine environmental identification number of the product is: 23411AC34H3123446.