# GB

NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA

# GB 17691-2018

Replacing GB 17691-2005

# Limits and measurement methods for emissions from diesel fueled heavy-duty vehicles (CHINA VI)

重型柴油车污染物排放限值及测量方法

（中国第六阶段）

**Issued on: June 22, 2018** **Implemented on: July 01, 2019**

**Issued by: Ministry of Ecology and Environment;**

State Market Regulatory Administration.

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# Limits and measurement methods for emissions from diesel fueled heavy-duty vehicles (CHINA VI)

## 1 Scope

This standard specifies the emission limits and test methods for gaseous and particulate pollutants as emitted by the vehicles equipped with compression ignition engine and its engines, as well as the emission limits and test methods for gaseous pollutants emitted from the ignition engine vehicles and its engine which use natural gas (NG) or liquefied petroleum gas (LPG) as fuel.

This standard is applicable to the type test, production consistency inspection, supervisory inspection of emission from new produced vehicle, compliance inspection of in-use vehicle of the category $M_2$, $M_3$, $N_1$, $N_2$, $N_3$ which is equipped with compression ignition and gas-fueled ignition engines as well as the category $M_1$ vehicles which have a total mass of more than 3500 kg.

The type test of whole vehicle according to this standard may be extended to variants and modified vehicles which have a reference mass exceeding 2380 kg.

If the category $M_1$, $M_2$, $N_1$, $N_2$ vehicles which are equipped with compression ignition and gas-fueled ignition engines have been type-tested according to GB 18352.6-2016, they may be exempted from the type test of this standard.

## 2 Normative references

This standard refers to the following documents or their terms. For undated references, the latest edition applies to this standard.

GB/T 2624 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full (IDT ISO 5176)

GB/T 3730.2 Road vehicle - Masses - Vocabulary and codes

GB/T 8190.1 Reciprocating internal combustion engines - Exhaust emission measurement - Part 1: Test-bed measurement of gaseous and particulate exhaust emissions

GB/T 15089 Classification of power-driven vehicles and trailers

GB/T 17692 Measurement methods of net power for automotive engines

GB 18047 Compressed natural gas as vehicle fuel

GB 18352.6-2016 Limits and measurement methods for emissions from light-duty vehicles (CHINA 6)

GB/T 19001 Quality management systems - Requirements

GB/T 27840 Fuel consumption test methods for heavy-duty commercial vehicles

GB 30510 Fuel consumption limits for heavy-duty commercial vehicles

ISO 5725 Measurement method and result accuracy

ISO 7000 Equipment graphic symbol - Index and list

ISO 13400 Road vehicles - Internet protocol (DoIP)-based diagnostic communication

ISO 15031 Road vehicles - Vehicles and emission diagnostics related equipment communication

ISO 15031-3 Road vehicles - Communication between vehicle and external equipment for emissions-related diagnostics - Part 3: Diagnostic connector and related electrical circuits: Specification and use

ISO 15031-7 Road vehicles - Communication between vehicle and external equipment for emissions-related diagnostics - Part 7: Data link security

ISO 15765-4 Road vehicles - Diagnostic communication over Controller Area Network (DoCAN) - Part 4: Requirements for emissions-related systems

ISO 27145 Road vehicles - Implementation of World-Wide Harmonized On-Board Diagnostics (WWH-OBD) communication requirements

SAE J1708 Serial data communications between microcomputer systems in heavy-duty vehicle applications

SAE J1939 Communication protocol of local area network (CAN bus) for commercial vehicle's control system

SAE J1939-13 External diagnostic connector

SAE J1939-73 Application layer - diagnosing

SAE J2186 Electrical/electronic (E/E) data link security

ASTM E 29-06B Standard practice for using significant digits in test data to

additional type test of engine. Except for engine test, all vehicles undergoing type test are required to be subject to the test by the portable emission measurement system (PEMS) as specified in 6.2.2.

**4.1.1.4** Requirements for fuels of type test

**4.1.1.4.1** When the parent engine is subjected to type test, it shall use the reference fuel complying with the provisions of Appendix D of this standard.

**4.1.1.4.2** For natural gas and liquefied petroleum gas engines (vehicles), it shall use the fuel types as specified in Appendix M to carry out type test.

**4.1.1.4.3** Type test of natural gas engines and LPG engines shall meet the requirements of Tables M.1 and M.2 of Appendix M.

**4.1.1.4.4** The type test of the dual-fuel engine shall meet the requirements of Table N.2 of clause N.6.1.2.

**4.1.1.4.5** If the fuel to be used in the design of the engine family is not included in the reference fuel range specified in Appendix D, the manufacturer shall:

a) A clear description of the types of commercially available fuel that the engine family can use.

b) Prove that the parent engine can meet the requirements of this standard when burning commercially available fuel.

c) Prove that the engine can meet the in-use compliance requirements when using the specified fuel in combination with any of the commercially available fuels of any component.

**4.1.2 Type test of engine family (parent engine)**

**4.1.2.1** When the engine is subject to type test, select a parent engine that can represent the engine model or family. If the selected engine does not fully represent the model or family as described in Appendix A, it shall select another representative engine for testing.

**4.1.2.2** When the whole vehicle is subject to type test, select a vehicle that can represent the vehicle model (family) for type test. If the selected vehicle does not fully represent the vehicle model (family) as described in clause 8.4, it shall select another representative vehicle for testing.

**4.1.2.3** The parent engine (or the base model) represents the emission level of all engine models (vehicle models) in the family, the type test of the parent engine (or the parent vehicle) may be extended to all members of the family. Other members in the family do not need to be tested.

be disclosed after technical processing.

# 5 Signage of engine (vehicle)

## 5.1 General requirements

The engine's signage may be in the form of text and numbers, or in the form of a two-dimensional code.

The signage must be concise and clear, its text, numbers or graphics shall be clear, obvious, readable, not erased. The fixing method of the signage must be firm throughout the life of the engine and must not be removed.

## 5.2 Location of engine signage

The installation position of the signage on the engine shall not hinder the normal operation of the engine. In the service life of engine, it generally requires no position change. In addition, when all the accessories required for engine operation are installed, the signage shall be located where it is easy for normal people to see.

The signage shall be close to or incorporated on the nameplate of the manufacturer.

## 5.3 Contents of engine signage

The engine's signage shall contain at least the following:

a) Engine model;

b) Date of manufacture: Year, month, day ("day" is optional. If the date of manufacture has been marked in other parts, it may not be indicated in the signage repeatedly);

c) The words “CHINA VI”;

d) The trademark or full name of the manufacturer;

e) Emission control key components (e.g., EGR, DOC, SCR, DPF, etc.).

## 5.4 Special requirements for natural gas and LPG engine (vehicle)'s signages with a defined fuel range

**5.4.1** For natural gas and liquefied petroleum gas engines with a defined fuel range during type test, in addition to meeting the requirements of 5.3, it shall also include the following information:

a) Limited to the use of natural gas of high (low) calorific value;

**6.9.1** The manufacturer shall demonstrate that under all normal conditions, especially at low temperatures, the NOx system can maintain its emission control function.

**6.9.2** The manufacturer shall report the information on the control strategy of the exhaust gas recirculation system (EGR) and the selective catalytic reduction system (SCR) in a low temperature environment to the competent department of ecological environment under the State Council. The information shall also include a description of the impact of this system running at low temperature system onto the emission.

**6.9.3** Ensure the normal operation of the NOx control measures, meet the requirements of Appendix G. Follow the requirements of Appendix G to conduct test and verification.

**6.10 Requirements for duel fuel engine**

Dual-fuel engines or vehicles that meet the requirements of this standard and are tested according to Appendix N.

**6.11 Requirements for replacement pollution control devices**

The design, manufacture and installation of the replacement pollution control device shall achieve the performance of the original emission control device, so that the pollutant emissions of the engine and the vehicle comply with the provisions of this standard, thereby effectively control the pollutant emission under normal conditions of use and throughout the full life of the vehicle.

The replacement pollution control device shall be type-tested according to the provisions of Appendix O.

**6.12 Technical requirements for whole vehicle**

**6.12.1** The vehicle manufacturer shall install the engine on the whole vehicle and shall strictly follow the installation requirements specified in Chapter 7, to ensure that the vehicle meets the non-standard cycle emission requirements as specified in Table 4.

**6.12.2** The vehicle manufacturer shall ensure that after assembling the engine into the whole vehicle, the OBD system and the NOx control system are not changed; meanwhile when verified according to Annex KE along actual road, it can still meet the technical requirements as specified in clause 6.8 and clause 6.9.

**6.12.2.1** The vehicle shall have an OBD diagnostic interface that meets the requirements of ISO 15031. The diagnostic interface shall be in the vicinity of the driver in the vehicle, in a location that is easy to find and access, marked

shall not exceed the power absorbed by the accessories as specified in Appendix A for engines that have been type-tested.

**7.1.4** The characteristics of the exhaust aftertreatment system shall be consistent with the declarations in the engine type test in Appendix A.

### 7.2 Installation of type-tested engine on vehicle

An engine that is type-tested as an independent technical assembly shall meet the following requirements when installed on a vehicle:

a) The OBD systems shall, when installed according to the requirements of Annex FA, meet the installation requirements of the engine manufacturer as specified in Appendix A.

b) The NOx control system shall, when installed according to the provisions of Annex GD, meet the installation requirements of the engine manufacturer as specified in Appendix A.

c) The dual-fuel engines that are type-tested as independent technical assemblies shall, when installed on vehicle, also meet the requirements of N.6.3 and N.8.2, as well as the installation requirements of engine manufacturer as specified in Annex AA.

## 8 Family and parent engine

### 8.1 Engine family

#### 8.1.1 Determine the parameters of engine family

The same engine family must have the basic parameters as specified in C.4.2.

For dual-fuel engines, the engine family shall also comply with the additional requirements of N.3.1 of Appendix N.

#### 8.1.2 Selection of parent engine

The parent engine of the family shall be selected according to the requirements specified in C.4.3.

For dual-fuel engines, the selection of parent engine shall also meet the additional requirements of N.3.2.

#### 8.1.3 Expansion of engine family

**8.1.3.1** If the requirements of 8.1.1 are met, it may incorporate the new engine model into the engine family that has been type-tested.

that meets the requirements of paragraphs b) ~ d) of 8.4.1.

# 9 Up-to-standard requirements and inspection of new produced vehicles

## 9.1 General requirements

**9.1.1** Vehicle and engine manufacturers shall take measures according to Appendix I to ensure production consistency.

**9.1.2** Engine manufacturers must take measures to ensure that the engine, system, component or independent technology assembly is consistent with the engine type that has been type-tested.

**9.1.3** The production consistency inspection shall be based on the information disclosure materials in Appendix A and Appendix B.

**9.1.4** The vehicle and engine used for the test shall be randomly selected. The manufacturer must not make any adjustments to the taken vehicle or engine (including updates to the ECU software).

**9.1.5** The vehicle shall not run-in in principle. If the manufacturer requests it, it can be run-in according to the running-in specifications, but it must not exceed 500 km. Meanwhile it shall not make any adjustment of the vehicle.

## 9.2 Up-to-standard self-inspection of new produced vehicle

**9.2.1** In order to ensure that the mass-produced vehicles meet the technical requirements as specified in clause 6.12, the vehicle manufacturer shall formulate an off-line inspection plan for each vehicle type (family), including inspection items, inspection methods, sampling methods, sampling ratios, etc.

**9.2.2** The self-inspection of the pollutant emission of vehicle shall be tested according to the PEMS test method of whole vehicle as specified in Appendix K of this standard. If the vehicle is subject to the production consistency inspection of the fuel consumption of whole vehicle according to GB 30510, it shall carry out pollutant emission inspection according to Appendix L at the same time.

**9.2.3** The sampling method shall be statistically representative, which can represent the emission control level of the same batch of vehicles within a certain production cycle.

**9.2.4** The vehicle manufacturer shall record and archive the vehicle inspection test in detail. The record document shall be kept for at least 5 years. The competent department of ecological environment may check the test records

competent department of ecological environment shall conduct sampling inspection according to the requirements of 10.2.2.

**10.2.1 Self-inspection of manufacturer**

**10.2.1.1** When the engine family is type-tested, the engine manufacturer shall also formulate a self-inspection plan for in-use compliance. The self-inspection of the engine manufacturer's in-use compliance shall be based on the engine family.

**10.2.1.2** When the vehicle model (family) is type-tested, the vehicle manufacturer shall also establish a self-inspection plan for in-use compliance. The vehicle manufacturer's self-inspection for in-use compliance shall be based on the vehicle model or vehicle family, which may cover the extended vehicle models produced by refitted vehicle manufacturer.

**10.2.1.3** The self-inspection plan for in-use compliance includes the test schedule and sampling plan, which shall be reported to the competent department of ecological environment under the State Council.

**10.2.1.4** The engine manufacturer shall carry out the self-inspection of in-use compliance according to the self-inspection plan, try to select the vehicles from different vehicle manufacturers to conduct tests. The self-inspection report of the in-use compliance of the engine family shall disclose the information, meanwhile be used as a part of the self-inspection report of the in-use compliance of the vehicle family of the vehicle manufacturer.

**10.2.1.5** The vehicle manufacturer shall carry out the self-inspection of in-use compliance according to the self-inspection plan, try to select different vehicle models from the vehicle family to conduct test. The self-inspection report of in-use compliance of the vehicle model (family) shall disclose the information.

**10.2.2 Sampling inspection by competent department of ecological environment**

**10.2.2.1** The competent department of ecological environment may follow the test procedures of the in-use compliance as specified in Appendix J, to conduct sampling inspection of the in-use compliance of the vehicle model (family).

**10.2.2.2** If the competent department of ecological environment under the State Council confirms that a certain vehicle model (family) does not meet the requirements of this standard, the manufacturer shall take corrective measures according to clauses 10.3 and J.5 of this standard.

**10.3 Corrective measures**

**10.3.1** The manufacturer shall submit a plan for rectification measures to the

a) Official documents: It shall be disclosed to the competent department of ecological environment under the State Council and may be provided to relevant parties as needed.

b) Extended documents: It shall be kept confidential. The extension documents shall be disclosed to the competent department of ecological environment under the State Council or may be kept by the manufacturer. However, it shall be ensured that these documents can be checked at any time when the validity of the type test is being confirmed.

**A.3.5.2** If all output signals are clearly represented by the matrix obtained from the control range of the individual unit's input signals, the file shall describe the functional operation of the drivability limit system as required by Appendix G, including the parameters required to retrieve system-related information. The material shall be disclosed to the competent department of ecological environment under the State Council.

**A.3.5.3** The extension document package shall include the operation information of all auxiliary emission control strategy (AES) and basic emission control strategy (BES), including description of AES revision parameters, AES working boundary conditions, descriptions on possible startup of AES and BES under the test conditions as specified in Appendix E. The extension document shall also contain the descriptions on the control logic of the fuel system, timing strategy, switching points during all operating conditions. It shall also include a complete description of the drivability limitation system as required in Appendix G, including related monitoring strategies.

**A.3.6** For engine models or families that are type-tested as independent technical assemblies, it shall also submit the following materials:

a) For ignition engines, as described in Appendix C, if misfire occurs from the beginning of the emission and causes the engine's emissions to exceed the limits as specified in Appendix F, or causes the exhaust catalyst to overheat and eventually causes irreparable damage, the manufacturer shall declare the minimum misfire rate in all above misfire events;

b) Instructions for preventing tampering and modification of the emission control electronics unit, including preventing the renewal of equipment approved or calibrated by the manufacturer;

c) The OBD document which complies with the requirements of F.8;

d) The OBD-related information provided for access of OBD shall comply with the requirements of Appendix P of this standard;

e) Declare compliance with non-standard cyclic emissions according to the requirements of 6.4.3 and the template of Appendix E;

requirements of CB.2. The technical indicators of the measurement system shall comply with the requirements of clause CB.3 (measurement of gaseous pollutants), clause CB.4 (measurement of particulate pollutants), Annex CE.

If other systems or analyzers are able to obtain the equivalent results as described in C.3.2, the testing agency may approve them.

**C.3.2 Equivalent system**

To determine the equivalence between an equivalent system and a system of this Appendix, it shall be confirmed on the basis of a correlation study of at least seven pairs of samples.

The result is the specific emission value of the cycle. The comparison test shall be carried out in the same laboratory, on the same test bench, on the same engine, preferably at the same time. Under the test bench and engine conditions of the laboratory as described above, the equivalency of the sample's mean values is obtained from the F-test and t-test statistics as described in clause CF.3. Outlier data is determined according to ISO 5725 and removed from the database. The system used for the comparison test shall be reported to the competent department of ecological environment under the State Council.

**C.4 Engine family**

**C.4.1 Overview**

The design parameters are characteristics of a certain engine family. All engines of the family members have these parameters. Engine manufacturers may determine which engines belong to a family according to the criteria of the family members in clause C.4.2.

The manufacturer shall submit to the State Council's competent department of ecological environment the reasonable information on the emission level of the engine family members.

**C.4.2 Parameters of engine family**

When determining the engine family, certain design parameters may interact with each other under certain conditions. It shall ensure that only engines with similar emissions characteristics can be included in the same engine family. The manufacturer shall confirm this situation and report to the competent department of ecological environment under the State Council. This can be used as a standard for building a new engine family.

If the devices and characteristics as not listed in this clause seriously affect emissions, the manufacturer shall identify the device based on good

it is a parent engine or a family member engine, if the same aftertreatment system as the parent engine is installed, the engine must not be assigned to the same engine family without the aftertreatment system.

### C.4.3 Selection of parent engine

#### C.4.3.1 Compression ignition engine

The parent engine of the engine family shall be selected based on the preferred principle of maximum fuel supply per stroke at the maximum torque speed. If there are two or more engines complying with the preferred standard, it shall use the maximum fuel supply per stroke at the rated speed as the secondary principle for selecting parent engine.

#### C.4.3.2 Spark ignition engine

The parent engine in the family shall be selected according to the preferred principle of maximum displacement. If two or more engines are according to the preferred principle, the parent engine shall be selected according to the following order of secondary selection:

a) Maximum fuel supply per stroke at rated power speed

b) Maximum ignition timing

c) Minimum EGR rate

#### C.4.3.3 Supplementary provisions for parent engine selection

In some cases, the inspection agency may add a second engine to conduct emission test according to the technical data as provided by the engine manufacturer, to facilitate determining the worst emission level of the engine in the family.

If the engine in the family has other variable characteristics that can affect the exhaust pollutants, these characteristics shall also be taken into account when selecting the parent engine.

### C.5 Test conditions

#### C.5.1 Laboratory test conditions

It shall measure the absolute temperature of the air at the engine inlet (Ta, expressed in Kelvin) and dry air pressure (Ps, expressed in kPa). For multi-cylinder engines with multiple sets of intake manifolds, such as “V-type” engines, it shall measure the average temperature of each group of intake manifolds. It shall follow the requirements below to determine the laboratory atmospheric factors $f_\alpha$, which shall be recorded together with the test result. When $f_\alpha$ meets

The engine shall be tested by installing accessories and equipment required by the Annex CG.

If the engine accessories cannot be installed as required, the power of the accessories shall be calculated according to the provisions of C.5.3.2 to C.5.3.5.

**C.5.3.2 Accessories/equipment to be installed for testing**

If the accessories to be installed according to the requirements of Annex CG are not installed during the test, the power (reference and actual power) as absorbed by these accessories shall be subtracted from the test.

**C.5.3.3 Accessories/equipment that do not need to be installed for testing**

If the accessories that shall not be installed according to the requirements of Annex CG cannot be removed during the test, the power (reference and actual power) as absorbed by these accessories shall be added during the test. If the total power as absorbed by these accessories is more than 3% of the maximum net power, the manufacturer shall provide a written description.

**C.5.3.4 Determination of accessory power**

In case:

a) As required by the Annex CG, the accessories/equipment that shall be installed on the engine are not installed, and/or

b) As required by the Annex CG, the accessories/equipment that shall not be installed on the engine cannot be removed.

It needs to determine the power absorbed by the accessory/equipment. Meanwhile the testing agency shall confirm the test/calculation method for the accessory power throughout the test cycle as submitted by the engine manufacturer.

**C.5.3.5 Engine cycle power**

According to clause C.5.3.1, it shall be based on the engine power to calculate the reference and actual cycle power (see clause C.6.4.8 and clause C.6.8.6). In this case, the $P_f$ and $P_r$ Where are equal to 0, whilst P is equal to $P_m$.

If the corresponding accessories/equipment are installed according to C.5.3.2 and/or C.5.3.3, the transient cycle power $P_{m,i}$ shall be corrected as follows:

$$P_i = P_{m,i} - P_{f,i} + P_{r,i}$$

Where:

type of reagent required for testing and the amount of reagent consumed.

Engines equipped with a continuous regenerative aftertreatment system do not require special tests, but requires verification of the regeneration process specified in C.5.6.2.

Engines equipped with a cyclic regenerative aftertreatment system shall be tested according to the requirements of C.5.6.3 and the results of the emission shall be corrected in consideration of the regeneration. In this case, in the test portion where regeneration occurs, the average emissions depend on the frequency at which regeneration occurs.

**C.5.6.2 Continuous regeneration**

For continuously regenerated exhaust aftertreatment systems, it shall, after the aftertreatment system stabilizes, measure the pollutant emissions. At least one regenerative test shall be carried out in the WHTC hot state test cycle. The manufacturer shall state the conditions at which regeneration occurs (particle load, temperature, exhaust back pressure, etc.).

To verify the continuous regeneration process, it shall carry out at least 3 WHTC hot state cycles. When the engine is subject to the WHTC hot state test cycle, it shall be warmed up according to the requirements of C.6.4.1 and hot-dipped according to the requirements of C.6.6.3, then perform the first WHTC hot state test, the other two WHTC tests shall also be carried out after hot dip according to C.6.6.3. During the test, it shall record the exhaust temperature and pressure (temperature before and after aftertreatment, exhaust back pressure, etc.).

If the test proves the regenerative conditions as specified by the manufacturer and that the deviation of the specific emission results of the particulate matter masses of the three WHTC hot state tests is less than ±25% or 0.005 g/kwh (whichever is larger), the exhaust aftertreatment system is considered to be continuously regenerative. It is tested according to the testing rules of clause C.6.6 (WHTC) and clause C.6.7 (WHSC).

If the exhaust aftertreatment system has a safe mode that can be converted to a cyclic regeneration mode, it shall be inspected according to C.5.6.3. In this particular case, emissions may exceed emission limits and emissions are not weighted.

**C.5.6.3 Cyclic regeneration**

For cyclic regenerative exhaust aftertreatment systems, emissions shall be measured in at least 3 WHTC hot state cycles, wherein one is during the regeneration process, two outside the regeneration process, meanwhile it shall be the WHTC cycle after the exhaust aftertreatment system is stabilized. Finally make the measurement results weighted according to the formula of C.5.6.3.

commercially available fuel according to national standards.

The fuel temperature and measuring point shall be as specified by the manufacturer.

**C.5.10 Crankcase emissions**

It is not allowed to emit any gas in the crankcase to the atmosphere.

For engines equipped with an air intake booster such as a turbocharger, pump, fan, or mechanical supercharger, which may discharge the emission from the crankcase into the environment, it shall, when the engine is subject to emission test, add the emission from crankcase to the exhaust emission.

If, under all operating conditions, crankcase emissions are introduced into the upstream exhaust of the exhaust aftertreatment, the crankcase emissions are deemed to meet the requirements.

Pollutants in open crankcases shall be introduced into the exhaust gas for measurement as follows:

a) The inner wall of the connecting pipe shall be smooth, conductive, not reacting with the crankcase pollutants, have a length as short as possible;

b) The number of elbows in the crankcase's piping shall be as small as possible, the radius of the elbows that must be installed shall be as large as possible;

c) The crankcase's exhaust pipe shall be heated, thin-walled or insulated. The back pressure of the crankcase shall meet the requirements of the engine manufacturer;

d) The crankcase's exhaust shall be routed downstream of the aftertreatment or emission control device, but shall be upstream of the sampling probe and fully mixed with the engine exhaust before sampling. In order to accelerate mixing to avoid boundary layer effects, the exhaust pipe of the crankcase shall extend into the exhaust flow, the direction of the crankcase's exhaust pipe outlet is fixed relative to the direction of the exhaust.

If the emission test results meet the limit requirements, it is determined that the crankcase emissions meet the standard requirements.

**C.5.11 Requirements for emission measurement of crankcases for ignition engines**

**C.5.11.1** The crankcase pressure shall be measured at the appropriate position throughout the test cycle. The pressure measurement accuracy of the

crankcase pressure shall be within ±1 kPa.

**C.5.11.2** If the crankcase pressure is not more than atmospheric pressure under any of the measurement conditions of C.5.11.1, the crankcase emissions are considered to comply with the provisions of C.5.10.

### C.6 Test procedure

#### C.6.1 Principles of emission measurement

Run the test cycle according to the requirements of C.6.2.1. and C.6.2.2. Perform the measurement of pollutant according to the sampling methods described in C.6.1.1 and C.6.1.2. Use the mass of various pollutants exhausted and the corresponding engine cycle work to calculate the specific emission.

#### C.6.1.1 Continuous sampling

Pollutant concentration, exhaust mass flow (raw or diluted) are continuously tested in raw or diluted emissions, to calculate pollutant mass flow and cycle emissions.

#### C.6.1.2 Air bag sampling

The diluted sample gas is continuously extracted and stored in proportion. Use air bag to collect the gaseous pollutants. Use filter paper to collect the particulate matter. Calculate the specific emission of gaseous pollutants and the specific emission of particulate matter.

#### C.6.1.3 Measurement procedures

In this standard, it describes two measurement systems with the same function:

a) The gas component is measured directly from the original exhaust gas, the particulate matter is measured by a partial-flow dilution system;

b) Gas components and particulate matter are measured by a full-flow dilution system (CVS system).

Both measurement systems can be used in the emission measurement cycle and allow any combination of the two systems (e.g., direct gas measurement and full-flow particle measurement, etc.).

#### C.6.2 Test cycle

#### C.6.2.1 World harmonized transient cycle (WHTC)

The world harmonized transient cycle (WHTC) in Annex CJ includes a set of nominal percentages of speed and torque that vary from second to second. The WHTC test cycle is as shown in Figure C.3. In order to perform tests on an

experience. At the end of the warm-up of engine, it shall ensure that the temperature of engine coolant and lubricant remain within ±2% of the average for at least 2 min, or the engine coolant's temperature is regulated by the thermostat.

**C.6.4.2 Determination of transient performance speed**

Use the formula below to determine the minimum and maximum transient performance speeds.

Minimum transient performance speed = Idle speed;

Maximum transient performance speed = $n_{hi}$ × 1.02 or the speed at which the torque drops to 0 (whichever is smaller).

**C.6.4.3 Transient performance curve of engine**

According to the requirements of C.6.4.1, when the engine has been running stably, it shall follow the steps below to test the engine's transient performance.

a) The engine shall be unloaded and operated at idle speed;

b) The engine shall be operated with the full load setting of the fuel injection pump and the minimum transient performance speed;

c) The average increase rate of the engine from the minimum transient performance speed to the maximum transient performance speed is 8 ± 1 (r/min) / s. Or use a constant rate to increase the minimum transient performance speed to the maximum transient performance speed in 4 ~ 6 minutes. It shall use the sampling rate at least one point per second to record the speed and torque of the engine. When selecting the item b) in C.6.4.7, to determine the negative torque, it can be set directly to the minimum throttle after the transient performance test, reducing from the maximum transient performance speed to the minimum transient performance speed.

**C.6.4.4 Determination of alternative performance**

If the manufacturer believes that the measurement technique of the engine's transient performance curve as described above is unsafe or does not represent the engine, it may use a measurement technique for alternative engine transient performance curve. The alternative measurement technique for engine transient performance curve must achieve the purpose of the specified determination procedure for engine transient performance curve, that is, to determine the maximum effective torque that can be produced over the entire allowable speed range of the engine. For safety or representative reasons, if the measurement technique for engine transient performance curve

The choice of analyzer's range. An emission analyzer capable of automatically or manually switching the range can be used, but during the test cycle, the range of the emission analysis shall not be switched. At the same time, the gain of the analyzer's analog amplifier shall not be switched during the test cycle.

It shall use the traceable standard gas which meets the technical requirements as described in CB.3.3 to determine the zero gas and span gas response of the analyzer. The FID analysis unit shall be based on a single carbon element (C1) for analysis.

#### C.6.5.4 Preparation of particle sampling filter paper

At least one hour before the test, it shall place the filter paper in a dust-proof and vented petri dish and place it in a weighing chamber for stabilization. After the stabilization is completed, it shall weigh the filter paper and record the dead-weight. Then store the filter paper in a petri dish or in a sealed filter holder, until it is required for the test. If the filter paper is removed from the weighing chamber, it must be used within 8 hours.

#### C.6.5.5 Adjustment of dilution system

The total diluted exhaust flow rate of the dilution system or the diluted exhaust flow that passes through the particle flow system shall be set to prevent condensation of water in the system, meanwhile, to ensure that the diluted exhaust's temperature immediately before the particulate matter's primary filter paper is between 315 K (42 °C) and 325 K (52 °C).

#### C.6.5.6 Startup of particle sampling system

The particle sampling system shall initially work in bypass mode. The test can be performed against the background of the particles. Background measurements may be made prior to or after the test. If the measurements are taken before and after the test, it shall take the average value. If there is another sampling system is available for background measurements, it may perform sampling test for the background whilst sampling the exhaust particles.

### C.6.6 WHTC cycle

#### C.6.6.1 Engine cooling

It may use natural cooling or forced cooling. For forced cooling, use a mature engineering experience to set the system to pass cold air through the engine. The cold oil passes through the engine lubrication system. Use the engine cooling system to take away the heat from the coolant, to reduce the temperature of the exhaust aftertreatment system. When the aftertreatment device is forced to cool down, unless otherwise the aftertreatment system has been cooled to a temperature lower than its catalytic activation temperature, it

a) At the beginning of the test cycle, the test equipment shall start synchronously:

b) If it is a full-flow dilution system, start collecting and analyzing the dilution air;

c) According to the method used, start collecting and analyzing the original exhaust or diluted exhaust;

d) Start measuring the amount of diluted exhaust gas and the necessary temperature and pressure;

e) If analyzing the original exhaust gas, start recording the exhaust mass flow;

f) Start recording the feedback value of the dynamometer's speed and torque.

If the original exhaust measurement method is used, the concentration of gaseous pollutants ((NM) HC, CO, NOx) and the mass flow of exhaust gas shall be continuously measured and recorded in the computer system. The data recording frequency is at least 2 Hz, the other data recording frequencies are at least 1 Hz. For the analog recorder, it shall record its responsiveness. The calibration shall be performed online or offline during data evaluation.

If a full-flow dilution system is used, HC and NOx shall be continuously measured in the dilution tunnel, which has a minimum measurement frequency of 2 Hz. The average concentration is calculated by integrating the measured values of the analyzer in the entire test cycle. The system's response time does not exceed 20 s. If necessary, it shall be aligned with CVS flow fluctuations, sampling time, test cycle. The CO, $CO_2$, NMHC are integration of continuously measured values or the analyzed bag-sampling results of the entire cycle. Prior to continuous sampling and analysis of the bag-sampling concentration, determine the concentration of pollutants in the background air. All other data that needs to be measured is recorded at a frequency of at least 1 Hz.

**C.6.6.7 Sampling of particulate matter**

At the beginning of the test cycle, the particle sampling system shall be switched back from the bypass state.

If a partial-flow sampling system is used, it shall control the sampling pump, so that the flow through the particle sampling probe or delivery tube is proportional to the mass flow of the exhaust gas as determined according to CA.5.1.

If a full-flow sampling system is used, it shall control the sampling pump, so that the flow through the particle sampling probe or delivery tube is within ±2.5% of the set flow. If flow compensation is used (i.e., proportional flow control of

#### C.6.7.4 Record of emission-related data

a) At the beginning of the test cycle, the test equipment shall start synchronously:

b) If it is a full-flow dilution system, start collecting and analyzing the dilution air;

c) According to the method used, start collecting and analyzing the original exhaust or diluted exhaust;

d) Start measuring the amount of diluted exhaust gas and the necessary temperature and pressure;

e) If analyzing the original exhaust gas, start recording the exhaust mass flow;

f) Start recording the feedback value of the dynamometer's speed and torque.

If the original exhaust measurement method is used, the concentration of gaseous pollutants ((NM) HC, CO, NOx) and the mass flow of exhaust gas shall be continuously measured and recorded in the computer system. The data recording frequency is at least 2 Hz, the other data recording frequencies are at least 1 Hz. For the analog recorder, it shall record its responsiveness. The calibration shall be performed online or offline during data evaluation.

If a full-flow dilution system is used, HC and NOx shall be continuously measured in the dilution tunnel, which has a minimum measurement frequency of 2 Hz. The average concentration is calculated by integrating the measured values of the analyzer in the entire test cycle. The system's response time does not exceed 20 s. If necessary, it shall be aligned with CVS flow fluctuations, sampling time, test cycle. The CO, $CO_2$, NMHC are integration of continuously measured values or the analyzed bag-sampling results of the entire cycle. Before the exhaust enters the dilution tunnel, carry out continuous sampling or use the background air-bag sampling method to determine the concentration of pollutants in the background air. All other data that needs to be measured is recorded at a frequency of at least 1 Hz.

#### C.6.7.5 Sampling of particulate matter

At the beginning of the test cycle, the particle sampling system shall be switched back from the bypass state. If a partial-flow sampling system is used, it shall control the sampling pump, so that the flow through the particle sampling probe or delivery tube is proportional to the mass flow of the exhaust gas as determined according to CB.4.6.1.

If a full-flow sampling system is used, it shall control the sampling pump, so that

purposes of this clause, the test cycle is defined as follows;

a) WHTC: Cold start - hot-dip - hot start;

b) Hot WHTC: Hot-dip - hot start;

c) Hot start WHTC for multiple regenerations - All hot start tests;

d) WHSC - Test cycle.

The deviation of the analyzer shall meet:

a) Before determining the drift, substitute the measured values of the zero point and the span gas before and after the test into the formula in CA.7.1 for calculation;

b) If the deviation before and after the test is within ±1% F.S, the measured concentration does not need to be corrected or corrected according to the requirements of CA.7.1;

c) If the deviation before and after the test exceeds ±1% F.S, the test is invalid, or it is corrected as required by CA.7.1.

**C.6.8.5 Sampling analysis by gas bag**

Specific requirements are as follows:

a) Gas bag analysis shall be carried out within 30 minutes after the completion of the hot start test, or cold start sampling bag analysis during hot-dip period;

b) Background sampling bag analysis shall be performed within 60 minutes after the hot start test.

**C.6.8.6 Calculation of cycle work**

Before calculating the cycle work, it shall delete any records during engine start. The actual cycle power $W_{act}$ (kWh) of the entire test cycle shall be determined based on the speed and torque values as feedback by the engine, to calculate the transient power. The transient power of the entire test cycle is integrated to obtain the actual cycle work $W_{act}$ (kWh). If the engine is not equipped with accessories/equipment as described in C.5.3.1, use the formula of C.5.3.5 to correct the power.

Calculate the actual cycle work in the same way through integration as in C.6.4.8.

Compare the actual cycle work $W_{act}$ with the reference cycle work $W_{ref}$, wherein $W_{act}$ shall be between 85% $W_{ref}$ and 105% $W_{ref}$.

Where:

$c_{ref,z}$ - The reference concentration of zero gas (usually 0), ppm;

$c_{ref,s}$ - The reference concentration of the span gas, ppm;

$c_{pre,z}$ - The concentration of zero gas in the analyzer before the test, ppm;

$c_{pre,s}$ - The concentration of the span gas in the analyzer before the test, ppm;

$c_{post,z}$ - The concentration of zero gas in the analyzer after the test, ppm;

$c_{post,s}$ - The concentration of the span gas in the analyzer after the test, ppm;

$c_{gas}$ - The concentration of the sample gas, ppm.

After all corrections have been completed, follow the requirements of clause CA.7.3 to calculate the specific emissions of each pollutant component of the two groups. One set of calculations use the uncorrected concentration. The other set uses the concentration after drift correction according to the formula in clause CA.7.1.

Depending on the measurement system and calculation method used, calculate the uncorrected emissions using the formulas in CA.5.2.3, CA.5.2.4, CA.6.2.3.1 or the formula in CA.6.2.3.3. Correspondingly, when calculating the corrected emissions, use the formulas in clause CA.5.2.3, CA.5.2.4, CA.6.2.3.1 or the formula in clause CA.6.2.3.3, wherein the $C_{gas}$ is replaced by $C_{cor}$ in the formula of CA.7.1, respectively. If the transient concentration value $c_{gas,i}$ is used in the corresponding formula, the corrected value is also the transient concentration value $c_{cor,i}$. In the formulas in CA.6.2.3.1, both the measured value and the background concentration need to be corrected.

The final specific emission results of the corrected concentration calculation are compared with the uncorrected specific emissions. The difference between the two shall be within ±4% of the uncorrected result or ±4% of the limit, whichever is larger. If it exceeds ±4%, the test is invalid.

If drift correction is performed, the results as shown in the report shall be the corrected results.

### CA.7.2 Calculation of NMHC and $CH_4$

The calculation method of NMHC and $CH_4$ is determined by the calibration method. FID test equipment without non-methane cut-off NMC (the lower part of Figure CE.3 in Annex CE) shall be calibrated by propane. For FID test equipment with non-methane cut-off NMC (upper part of Figure CE.3 in Annex) may be calibrated as follows:

d) The linearization inspection shall confirm at least 10 points (including the zero point) from the zero point to the maximum value of the emission test. For gas analyzers, the gas of known concentration which complies with CB.3.3.2 shall be directly led into the analyzer interface;

e) Measure the reference value at a frequency of not less than 1 Hz. Continuously record it for 30 seconds;

f) Calculate the arithmetic mean of the 30 second period. Follow the formula of C.6.8.7 and use the least squares method to calculate the linear regression parameter;

g) Linear regression parameters shall meet the requirements of CB.1 in Table CB.1;

h) If necessary, check the zero setting again and repeat the confirmation procedure.

## CB.3 Measurement and sampling system of gaseous pollutants

### CB.3.1 Technical requirements for analyzer

#### CB.3.1.1 General requirements

The analyzer's range and response time shall be compatible with the accuracy required to measure the exhaust component's concentration under transient and steady-state conditions.

The electromagnetic compatibility level of the equipment shall minimize additional errors.

#### CB.3.1.2 Accuracy

Accuracy is the deviation of the analyzer reading from the reference value, which shall not exceed ±2% of the reading or ±0.3% of full range, whichever is larger.

#### CB.3.1.3 Precision

Precision is 2.5 times the standard deviation of 10 repeated response values for a given calibration gas or span gas. For calibration gas or span gas of more than 155 ppm (or ppm C), the repeatability does not exceed 1% of the full range concentration of the range; for the calibration gas or span gas which is less than 155 ppm (or ppm C), it shall not exceed 2% of the full range concentration of the range.

#### CB.3.1.4 Noise

(190 ± 10 °C). For NG-fueled engines or ignition engines, hydrocarbon analyzers may be of non-heated hydrogen flame ion analyzers (FID, see Annex CE.2.1.1) depending on the method of measurement.

**CB.3.2.5 Analysis of methane and non-methane hydrocarbons (NMHC)**

The determination of components of methane and non-methane hydrocarbon shall be carried out according to Annex CE.2.2 by the use of a heated non-methane cut-off (NMC) and two FIDs. The concentration of the components shall be determined according to CA.7.2.

**CB.3.2.6 Nitrogen oxide (NOx) analyzer**

There are two types of measuring instruments for NOx measurement. Any instrument may be used as long as it meets the corresponding criteria of CB.3.2.6.1 or CB.3.2.6.2. However, when following the requirements of C.3.2 to determine the equivalence of different test systems, only CLD is allowed as the benchmark.

**CB.3.2.6.1 CLD**

For dry-base measurements, the NOx analyzer shall use a CLD or a heated CLD equipped with a $NO_2$/NO converter. For wet-base measurements, it shall use the HCLD whose water-extinction inspection complies with requirements (see CB.3.9.2.2) which has a converter that maintains a temperature above 328 K (55 °C). Regardless of CLD and HCLD, the inner wall temperature of the sampling path shall be maintained at 328K ~ 473K (55 °C ~ 200 °C). For dry-base measurement, the thermal insulated sampling line connects to the converter. For wet-base measurement, the thermal insulated sampling line connects to the analyzer.

**CB.3.2.6.2 Non-dispersive UV detector (NDUV)**

The measurement of NOx concentration may be performed by the use of a non-dispersive ultraviolet detector (NDUV). If the NDUV only measures NO, it shall install a $NO_2$/NO converter upstream of the NDUV analyzer. The NDUV shall be maintained at a temperature to prevent condensation of water vapor, unless a sample dryer is installed upstream of the $NO_2$/NO converter (if used) or upstream of the analyzer.

**CB.3.2.7 Measurement of air-fuel ratio**

The air-fuel ratio measuring device of the exhaust flow according to CA.5.1.6 shall be a wide air-fuel ratio sensor or a zirconia type λ sensor. Sensor shall be installed directly on the tailpipe. The exhaust temperature is high enough that the water vapor cannot condense.

**CB.3.6.7 Turn off the ozone generator**

Turn off the ozone generator, to allow the mixed gas as described in CB.6.3.6 to flow through the converter into the detector. Record the indicated concentration (b) (the analyzer is placed in NOx mode).

**CB.3.6.8 NO mode**

Switch the ozone generator, in the off state, to NO mode. Cut off the flow of oxygen or synthetic air. At this time, the analyzer's NOx reading shall not deviate by more than ±5% of the value as recorded in CB.3.6.2. (The analyzer is placed in NO mode).

**CB.3.6.9 Test interval**

The efficiency of the converter is measured at least once a month.

**CB.3.6.10 Efficiency requirements**

The efficiency of the converter $E_{NOx}$ must not be less than 95%.

If in the most common range of the analyzer, the ozone generator cannot reduce the NO concentration from 80% to 20% as required by CB.3.6.5, it shall use the highest range of operation of the NOx converter.

**CB.3.7 FID adjustment**

**CB.3.7.1 Optimization of detector response**

The FID shall be adjusted according to the requirements of the instrument manufacturer. It shall, in the most common working range, use propane span gas which uses air as the equilibrium gas to optimize the response.

Set the gas and air flow to the value as recommended by the manufacturer. Lead the span gas of 350 ± 75 ppm into the analyzer. The response of a given gas flow is determined by the difference between the span gas response and the zero gas response. Gas flow is adjusted incrementally above and below the requirements of the manufacturer. Record the response of the span gas and zero gas at these gas flows. Use the difference between the responses of the span gas and the zero gas to draw a curve. Adjust the gas flow to the high response region of the curve. The setting of initial flow rate may need to be further optimized according to the hydrocarbon response and oxygen interference inspection results as specified in CB.3.7.2 and CB.3.7.3. If the hydrocarbon response and oxygen interference inspection results do not meet the following requirements, the flow rate shall be gradually adjusted above and below the conditions as specified by the manufacturer to repeat CB.3.7.2, CB.3.7.3.

recommended to combine the various sets of manifolds upstream of the sampling probe. If this is not possible, it is allowed to take the sample gas from the set of manifolds with the highest $CO_2$ emissions. The calculation of exhaust emissions must use the total exhaust mass flow.

If the engine is equipped with an exhaust aftertreatment system, it shall take the exhaust sample gas downstream of the exhaust aftertreatment system.

**CB.3.11 Sampling from diluted exhaust**

The tailpipe between the engine and the full-flow dilution system shall comply with the requirements of Annex CE. The exhaust sampling probe shall be installed in the dilution tunnel at a position near the particulate sampling probe, where the dilution air and exhaust can be thoroughly mixed.

Sampling may be done in two ways:

a) Collect the pollutants from entire cycle into a sampling bag for measurement after the test is completed. For HC, if the bag sampling result is used, the sampling bag shall be heated to 464 ± 11K (191 ± 11 °C). for NOx, the temperature of sampling bag shall be above the dew point temperature;

b) Continuously sample and integrate the pollutants of entire cycle.

The concentration of background gas shall be determined upstream of the dilution tunnel according to a) or b) and subtracted from the pollutant concentration value as measured in CA.6.2.3.2.

**CB.4 Particulate measurement and sampling system**

**CB.4.1 General provisions**

Particulate mass measurement requires a particulate dilution sampling system, particulate sampling filter paper, microgram balance, weighing chamber of controlled temperature and humidity. The particulate sampling system shall be designed to ensure that the particulate sampling exhaust is proportional to the total diluted exhaust flow. General requirements for dilution systems: particulate measurement requires using dilution gas (filtered ambient air, synthetic air, or nitrogen) to dilute the sample gas. The requirements for dilution system are as follows:

a) Completely eliminate condensation of water in the dilution and sampling system;

b) Maintain the diluted exhaust temperature within 20 cm upstream or downstream of the filter holder at 315 K (42 °C) ~ 325 K (52 °C);

### CB.4.3 Sampling filter paper of particulate matter

During the test, the diluted exhaust gas shall pass through a filter paper that meets the requirements of CB.4.4.1 ~ CB.4.4.3.

#### CB.4.3.1 Requirements for sampling filter paper

All filter paper types have a collection efficiency of at least 99% for 0.3 μm DOP (dioctyl dicarboxylate) or PAO (poly alpha olefin). Whether the filter paper meets the requirements can be judged by the product grade as ranked by the sampling filter paper manufacturer according to the test conditions. Filter paper material shall be:

a) Glass fiber filter paper coated with fluorocarbon (PTFE);

b) Membrane filter paper based on fluorocarbon (PTFE).

#### CB.4.3.2 Size of filter paper

The nominal diameter of the filter paper shall be 47 mm (with a tolerance of 46.50 ± 0.6 mm). The filter paper's contamination diameter shall be at least 38 mm.

#### CB.4.3.3 Oncoming speed of filter paper

The oncoming speed of the gas passing through the filter paper shall be 0.90 ~ 1.00 m/s, the recorded airflow value of up to 5% can exceed this range. If the total mass of the particulate matter on the filter paper exceeds 400 μg, the oncoming speed of the filter paper may be reduced to 0.50 m/s. The oncoming speed shall be calculated by dividing the volumetric flow of the filter paper at the upstream pressure of the filter paper and the surface temperature of the filter paper by the contaminated area of the filter paper.

### CB.4.4 Technical requirements for weighing chambers and analytical balances

The weighing chamber (compartment) environment shall be free of any environmental pollutants (such as dust, aerosols or semi-volatiles) that may contaminate the particulate filter paper. The weighing chamber shall meet the specified technical conditions for at least 60 minutes before the filter paper is weighed.

#### CB.4.4.1 Conditions of weighing chamber

During the pretreatment and weighing of the filter paper, the temperature of the weighing chamber for pretreatment and weighing of the particulate filter paper shall be maintained at 295K ± 1K (22 ± 1 °C). The humidity shall be maintained at a dew point of 282.5 ± 1K (9.5 ± 1 °C).

tweezers;

c) The tweezers shall be grounded through the grounding wire or grounded by the operator through the grounding wire, so that the grounding wire and the balance are grounded together. The grounding wire shall have an appropriate resistance to prevent accidental electric shock.

**CB.4.4.5 Additional technical requirements**

All components of the dilution system and sampling system from the tailpipe to the filter holder are designed to minimize the adhesion or variation of particulate matter due to contact with the original and diluted exhaust. All components must be made of a conductive material that does not react with the exhaust components and must be grounded, to prevent electrostatic effects.

**CB.4.4.6 Calibration of flow measuring instrument**

Each flow meter used in the particulate matter sampling and partial-flow dilution system shall be linearly confirmed according to CB.2.3, to confirm that the frequency meets the accuracy requirements of this standard. For airflow reference values, it shall be measured by accurate flowmeters that meet international and/or national standards. The reference requirements for the measurement of different airflows are as shown in CB.4.5.2.

**CB.4.5 Special requirements for partial-flow dilution system**

The partial-flow dilution system shall ensure that a certain proportion of the original exhaust sample is extracted from the engine's exhaust flow. The dilution ratio or sampling rate $r_d$ or $r_s$ is determined to ensure reaching the accuracy as specified in CB.4.5.2.

**CB.4.5.1 System response time**

Partial-flow dilution systems require fast system response. The system's switching time shall be determined according to the procedures as specified in CB.4.5.6. If the exhaust flow measurement (see CA.5.1.2) and the partial-flow system have a combined switching time ≤ 0.3 seconds, it shall use online control. If the switching time exceeds 0.3 seconds, it shall carry out the pre-judgment control based on the previously recorded test cycle. In this case, the comprehensive rise time shall be ≤ 1 second and the comprehensive delay time shall be ≤ 10 seconds.

The overall system response design shall ensure that the particulate sampling gas ($q_{mp,i}$) is proportional to the exhaust flow. In order to determine the proportional relationship, it shall use the data collection frequency of at least 5 Hz to perform regression analysis for $q_{mp,i}$ and $q_{mew,i,}$ and meet the following criteria:

d) The absolute accuracy of $q_{mdew}$ and $q_{mdw}$ shall be within ±0.2% of full range. The maximum deviation of difference between $q_{mdew}$ and $q_{mdw}$ shall be within 0.2%. In the test, the linearity deviation shall be within ±0.2% of the maximum value of $q_{mdew}$.

**CB.4.5.3 Calibration of differential flow measurement**

It shall use one of the following methods to calibrate the flowmeter or the flow measuring instrument, to ensure that the flow $q_{mp}$ of the probe which extends into the tunnel reaches the accuracy requirements of CB.4.5.2.

a) The $q_{mdw}$ flowmeter shall be connected in series with the $q_{mdew}$ flowmeter. The deviation of two flowmeters shall be calibrated for at least 5 calibration points. The gas flow at these 5 calibration points shall be evenly distributed between the minimum value $q_{mdw}$ used in the test and the $q_{mdew}$ used in the test. The dilution tunnel may be bypassed;

b) The calibrated flow device shall be connected in series with the $q_{mdew}$ flowmeter and shall be checked for the numerical accuracy of the test. The calibrated flow device is connected in series with the $q_{mdw}$ flowmeter. Within the dilution ratio of 3 ~ 50, select at least 5 reference points, to check the accuracy of the corresponding $q_{mdew}$ as used in the test;

c) Disconnect the transmission tube (TT) from the exhaust and connect the calibrated flow measuring device to the transmission tube. The measured range shall be suitable for measuring $q_{mp}$. $q_{mdew}$ shall be set to the value used in the test. The $q_{mdw}$ within the range of corresponding dilution ratio 3 ~ 50 shall be set sequentially to at least 5 values. Alternatively, it may also provide a dedicated calibration airflow path to bypass the tunnel. However, the total airflow passing through the corresponding flowmeter and the dilution airflow shall be same as those in actual test;

d) Tracer gas shall be led into the exhaust transmission tube (TT). The tracer gas can be an exhaust component, such as $CO_2$ or NOx. After being diluted in the tunnel, the tracer gas's component is measured. It shall be performed at 5 dilution ratios between 3 and 50. The accuracy of the sample gas flow shall be determined according to the dilution ratio formula $r_d$.

$$q_{mp} = q_{mdew} / r_d$$

To ensure the accuracy of $q_{mp}$, it shall consider the accuracy of the gas analyzer.

**CB.4.5.4 Inspection of carbon flow**

In order to detect, identify and control problems and confirm that the partial-flow

determined, that is, from the start of the step response to the time when the flow meter's response reaches 50%. The conversion time of the $q_{mp}$ signal in the partial-flow system and the $q_{mew,i}$ signal in the exhaust flow meter shall be confirmed in a similar manner. These signals will be used for regression testing after each test (see CB.4.5.1).

The above calculation shall be repeated for at least 5 ascending and descending responses and the average of the results is calculated. The internal switching time (< 100 ms) shall be subtracted from this value, which is the pre-judgement control value for the partial-flow dilution system, which will be used for CB.4.5.1.

## CB.5 Calibration of CVS system

### CB.5.1 General requirements

The CVS system shall be calibrated by the use of precision flow meters and throttling devices. The flow through the system needs to be measured in different throttling states. It shall measure the control parameters of the system which are related to the flow.

Various types of flow meters can be used, such as calibrated venturis, calibrated laminar flow meters, calibrated rotameters.

### CB.5.2 Calibration of positive displacement pump (PDP)

All pump-related parameters, as well as the relevant parameters of the flowmeter in series with the pump, shall be measured simultaneously, to plot the calculated flow ratio (in $m^3/s$ at the pump inlet, under absolute pressure and temperature) corresponding to the correlation function. The correlation function is a specific combination of the parameters of the pump. A linear equation of pump flow and correlation function can be determined from the curve. If the CVS system has multiple drives, each range used shall be calibrated.

The temperature shall be kept stable during the calibration process.

Leakage of all joints and piping between the venturi and the CVS pump shall be kept below 0.3% of the lowest flow point (maximum throttling and minimum PDP speed point).

#### CB.5.2.1 Data analysis

Each throttling set value (minimum of 6 set values) is measured according to the method as specified by the manufacturer. It is converted to the standard CVS volume flow ($V_0$), expressed in $m_3/s$. Then the standard air flow as well as the absolute temperature and absolute pressure at the pump inlet are substituted into the following equation, to convert it to the pump flow ($V_0$),

c) Be installed at the position where the dilution air and exhaust are thoroughly mixed in the dilution tunnel DT (see Figure CE.7) (i.e., about 10 times the diameter of the tunnel downstream from the point where exhaust enters the dilution tunnel);

d) Maintain a sufficient distance (radial) from the other probes and the inner wall of the tunnel, to protect it from any wake flow or eddy flow;

e) Heat to increase the exhaust temperature at the outlet of the probe to 463K ± 10K (190 ± 10 °C), or 385K ± 10K (112 ± 10 °C) for ignition engine;

f) If using the FID analyzer (cold), it does not require heating.

4) CO, $CO_2$, NOx sampling probe for SP3 diluted exhaust (only Figure CE.2)

The probe shall:

a) Be in the same plane as SP2;

b) Maintain a sufficient distance (radial) from the other probes and the inner wall of the tunnel, to protect it from any wake flow or eddy flow;

c) Heat and insulate the entire length, so that the temperature is not lower than 328K (55 °C), to prevent water condensation.

5) HF1 heated pre-filter (optional)

The temperature shall be the same as HSL1

6) HF2 heated filter

The filter shall filter the solid particles from the sample gas before entering the gas analyzer. The filter's temperature shall be the same as HSL1. The filter may be replaced as needed.

7) HSL1 heated sampling tube

The sampling tube delivers sample gas from a single probe to the split point and HC analyzer.

The sampling tube shall:

a) Have an inner diameter which ranges 4 ~ 13.5 mm;

b) Be made of stainless steel or Teflon;

c) Maintain the temperature of the tube wall of each section independently controlled and heated at 463K ± 10K (190 °C ± 10 °C) (if the exhaust

temperature at the sampling probe is ≤ 463K (190 °C));

d) Maintain the tube wall's temperature > 453K (180 °C) (if the exhaust temperature at the sampling probe is > 463K (190 °C));

e) Maintain the gas temperature close to the heated filter HF2 and HFID at 463K ± 10K (190 °C ± 10 °C).

8) HSL2 NOx heated sampling tube

The sampling tube shall:

a) Maintain the tube wall's temperature before the converter (in case of dry base measurement) or before the analyzer (in case of wet base measurement) at 328K ~ 473K (55 °C ~ 200 °C);

b) Be made of stainless steel or Teflon.

9) HP heated sampling pump

The pump shall be heated to the same temperature as the HSL.

10) SL CO and $CO_2$ sampling tube

The sampling tubes shall be made of stainless steel or Teflon. It can either be heated or not heated.

11) HC HFID analyzer

For the heated hydrogen flame ionization detector (HFID) or hydrogen flame ionization detector (FID) for measuring the hydrocarbons, the temperature shall be maintained at 453K ~ 473K (180 °C ~ 200 °C).

12) CO, $CO_2$ NDIR analyzer

NDIR analyzer for measuring carbon monoxide and carbon dioxide (can be used to measure dilution ratio in particulate matter measurement).

13) NOx CLD analyzer or NDUV analyzer

For the measurement of nitrogen oxides, it may use CLD, HCLD or NDUV analyzer. If HCLD is used, its temperature shall be kept at 328K ~ 473K (55 °C ~ 200 °C).

14) B ice trough (selected for NO test)

Condense the water from the exhaust sample gas. As described in Annex CB.3.9.2.2, the analyzer is not affected by water vapor interference. This device may be selected. If condensation is used to

Annex CA.5.1. The flow controller shall be installed upstream or downstream of the corresponding fan. When using compressed air, FC1 can directly control the flow of compressed air.

5) FM1 flow measuring device

Use a gas flow meter or other flow meter to measure the diluted exhaust flow. If the calibrated pressure air blower PB is used to measure the flow, it may select to use FM1.

6) DAF dilution air filter

It shall use a high efficiency particulate air filter (HEPA) to filter the dilution air (ambient air, synthetic air or nitrogen). According to EN 1822-1 (filter grade of H14 or better), ASTM F 1471-93 or equivalent standards, the filter has an initial minimum collection efficiency of 99.97%.

7) FM2 flow measuring device (only for partial sampling type, Figure CE.5)

Use a gas flow meter or other flow meter to measure the diluted exhaust flow. If the calibrated suction blower SB is used to measure the flow, it may select to use FM2.

8) PB pressure blower (only for partial sampling type, Figure CE.5)

Used to control the dilution air flow. The PB can be connected to the flow controller FC1 or FC2. When using a butterfly valve, there is no need to use PB. If calibrated, PB can be used to measure the dilution air flow.

9) SB suction blower (only for partial sampling type, Figure CE.5)

If calibrated, the SB can be used to measure the dilution air flow.

10) DT dilution tunnel (partial-flow)

Dilution tunnel

a) For partial sampling systems, there shall be sufficient length to allow the exhaust and dilution air to be thoroughly mixed under turbulent conditions (Reynolds number Re is more than 4000; Reynolds number is calculated based on the inner diameter of the tunnel), e.g., full sampling type, which does not require thorough mixing;

b) It shall be made of stainless steel;

c) The wall can be heated but the temperature does not exceed 325K (52 °C);

d) It can be insulated.

11) PSP particulate sampling probe (only for partial sampling type, Figure CE.5)

The particulate sampling probe is the guiding part of the PTT of the particulate transmission tube PTT (see CE.3.3.1) and has the following requirements:

a) It faces upstream and is installed at the position where the dilution air and exhaust are thoroughly mixed, that is, on the centerline of the dilution tunnel (DT), about 10 times the diameter of air duct downstream of the point where the exhaust enters the dilution tunnel;

b) The minimum inner diameter is 8 mm;

c) The wall temperature can be directly heated to not more than 325K (52 °C) or it may preheat the dilution air. The temperature of the dilution air before entering the dilution tunnel shall not exceed 325K (52 °C);

d) It can be insulated.

**CE.3.2 Full-flow dilution system**

The dilution system as described in Figure CE.7 is based on the dilution of total exhaust by constant-volume sampling (CVS) principle.

For the measurement of the diluted exhaust flow, it may use the positive displacement pump PDP, critical flow venturi CFV, or subsonic venturi SSV. The heat exchanger (HE) or electronic flow compensator (EFC) may be used for proportional sampling of particulate matter and flow measurement. Because the measurement of the mass of the particulate matter is based on the total diluted exhaust flow, so there is no need to calculate the dilution ratio.

To continuously collect particulate matter, lead the diluted exhaust sample gas into a two-stage diluted particulate sampling system (see Figure CE.9). Although the secondary dilution system is part of the dilution system, it has most of the components of a typical particulate sampling system and is therefore a variant of the particulate sampling system.

PDP or the dilution air intake system. The static back pressure measured when the PDP system is operating shall be kept within ±1.5 kPa of the exhaust back pressure as measured by the PDP under the same engine speed and load. When flow compensation (ECC) is not used, the temperature of the mixed dilution exhaust immediately before the PDP shall be within ±6K of the average working temperature as measured during the test. Flow compensation can only be used when the temperature at the PDP inlet does not exceed 325K (52 °C).

3) CFV Critical flow venturi

The CFV maintains the airflow at the throttling state (critical flow) to measure the total diluted exhaust. The static back pressure measured when the CFV system is operating shall be kept within ±1.5 kPa of the static exhaust back pressure as measured when the engine is at the same speed and load without connecting CFV. When not using the electronic flow compensator (EFC), the temperature of the mixed diluted exhaust immediately before the CFV shall be within ±11K of the average operating temperature as measured during the test.

4) SSV subsonic venturi

The SSV uses the inlet pressure, temperature, pressure drop between the venturi inlet and the throat to calculate the total diluted exhaust flow. It shall be kept within ±1.5 kPa of the static exhaust back pressure as measured when the engine is at the same speed and load without connecting SSV. When not using the electronic flow compensator (EFC), the temperature of the mixed diluted exhaust immediately before the SSV shall be within ±11K of the average operating temperature as measured during the test.

5) HE Heat exchanger (optional)

The heat exchanger shall have sufficient capacity to maintain the temperature within the range as specified above. If electronic flow compensator (EFC) is used, it may not require the heat exchanger.

6) EFC Electronic flow compensator (optional)

If the temperature at the inlets of PDP, CFV, SSV cannot be maintained within the above specified range, it requires a flow compensation system, to continuously measure the flow and control the proportional sampling within the particulate sampling system. Therefore, a continuously measured flow signal is required to ensure that the sample gas flow through the particulate filter paper in the two-stage diluted particulate sampling system is within ±2.5% of the deviation. (See Figure CE.7).

# Annex CH
# (Normative)
# Test procedure for ammonia

## CH.1 Overview

This Annex specifies the measurement procedures for ammonia ($NH_3$). For nonlinear analyzers, it is allowed to use the linearization circuits.

## CH.2 Measurement principle

The measurement principle of ammonia shall comply with the requirements of clause CH.2.1 or CH.2.2. It shall not use the gas dryers during the $NH_3$ measurement.

### CH.2.1 Laser diode spectrometer (LDS)

#### CH.2.1.1 Measurement principle

The LDS uses a single-tunnel spectroscopy principle to scan the near-infrared spectral range via a single diode laser, to determine the absorption line of $NH_3$.

#### CH.2.1.2 Installation

The analyzer is installed directly in the exhaust pipe (in situ) or in the analyzer's sampling cabinet, to take sample according to the recommendations of the manufacturer. If installed in the analyzer's sampling cabinet, the sampling lines (sampling tubes, coarse filters, valves) shall be made of stainless steel or Teflon and heated to at least 463 ± 10K (190 ± 10 °C), to reduce ammonia loss and the effects of sampling. In addition, the sampling tube shall be as short as possible according to the actual situation.

It shall minimize the effects of the exhaust temperature and pressure, the installation environment, the vibration on the test, or otherwise use the compensation techniques.

If applicable, the shielding gas used to connect the in-situ measurement and to protect the instrument shall not affect the measurement of any concentration of exhaust components downstream of the equipment. If affected, it may place the sampling points of other exhaust components upstream of the equipment.

#### CH.2.1.3 Inspection of interference

In order to minimize interference from other components in the exhaust, the laser spectral resolution shall be within 0.5 $cm^{-1}$.

### CH.2.2 Fourier transform infrared spectroscopy (FTIR) analyzer

or changes may affect the calibration, follow the requirements of CB.2.3 of this Appendix to carry out linearization inspection. If it can be verified that the same accuracy is achieved and the prior approval is obtained from the inspection agency, the number of benchmarks allowed for calibration is less than 10.

The $NH_3$ used for linearization inspection shall comply with the requirements of clause CH.4.2.7. It is allowed to use the reference test chamber which contains $NH_3$ span gas. The test instrument whose signal is used for the compensation algorithm shall meet the linearization requirements as specified in CB.2 of this Appendix. Linearization inspections shall be carried out according to internal inspection procedures, equipment supplier's recommendations, or GB/T 19001.

**CH.4.2 Technical parameters of analyzers**

The analyzer's range and response time shall meet the accuracy requirements for $NH_3$ concentration measurement under steady-state cycle and transient cycle.

**CH.4.2.1 Minimum detection limit**

The analyzer's detection limit shall be < 2 ppm under all test conditions.

**CH.4.2.2 Accuracy**

That is, the deviation between the analyzer's reading and the reference value.

It shall not exceed ± 3% of the reading or ± 2 ppm, whichever is larger.

**CH.4.2.3 Zero drift**

The drift of the zero gas's response and the associated time interval shall meet the specifications of the instrument manufacturer.

**CH.4.2.4 Drift of span gas**

The drift of the span gas's response and the associated time interval shall meet the specifications of the instrument manufacturer.

**CH.4.2.5 System response time**

System response time shall be ≤ 20 s.

**CH.4.2.6 Rise time**

Analyzer's rise time shall be ≤ 5 s.

**CH.4.2.7 $NH_3$ standard gas**

It shall have a mixed gas of chemical components as follows.

# Annex CI
# (Normative)
# Measuring equipment of particle number emissions

## CI.1 Technical requirements

### CI.1.1 System overview

**CI.1.1.1** The particulate sampling system shall be composed of the sampling tube or sampling probe which takes sample from the uniform mixed gas in the dilution system as described in CE.3.1 or CE.3.2, the volatile particle remover installed upstream of the particle number counter (PNC), an appropriate transmission tube.

**CI.1.1.2** It is recommended to install a particle size pre-classifier (e.g., cyclone or force type) in front of the volatile particle remover (VPR). It may also use the sampling probe with appropriate particle size grading function as shown in Figure CE.6 to replace the particle size pre-classifier. For partial-flow systems, the mass of particulate matter and the particle number can be sampled by the same pre-classifier, wherein the particle number sampling is performed in the dilution system downstream of the pre-classifier. Alternatively, it may also use an independent pre-classifier, wherein the particle number sampling is performed in the dilution system upstream of the particulate mass pre-classifier.

### CI.1.2 General requirements

**CI.1.2.1** The particle sampling point shall be located in the dilution tunnel.

The particle transmission system (PTS) consists of a particle sampling probe or probe (PSP) and a particle transmission tube (PTT). A particle transmission system (PTS) directs the sample gas from the dilution tunnel into the inlet of the volatile particle remover (VPR). The particle transmission system (PTS) shall meet the following conditions:

For the full-flow dilution system and the partial-flow dilution system of partial sampling type (as described in CE.3), the sampling tube shall be installed near the center line of the dilution tunnel, at a distance 10 to 20 times the tunnel's diameter downstream the gas inlet, at a position facing the gas flow direction. The center axis of the sampling probe is parallel to the central axis of the dilution tunnel. The sampling probe shall be installed in the dilution tunnel area, to ensure that the sample is a homogeneous mixture of dilution air and exhaust.

For the partial-flow systems of full sampling type (as described in CE.3.1), the particulate sampling point or sampling probe shall be installed in the particulate transmission tube, upstream of the filter holder, flow measuring device, any sampling/bypass separation points. The location of the sampling point or sampling tube shall ensure that the dilution air and exhaust are evenly mixed.

**CI.1.3.1** The particulate sample gas shall not pass through the sampling pump before flowing through the particle number counter.

**CI.1.3.2** It is recommended to use a sampling pre-classifier (PCF).

**CI.1.3.3** The sampling pretreatment unit shall:

**CI.1.3.3.1** Be able to dilute the sample gas one or more times, so that the particle number concentration is lower than the upper limit of the single particle counting module in the particle counter, and make the temperature at the inlet of the particle number counter is below 35 °C.

**CI.1.3.3.2** It includes an initial heating dilution process, wherein the temperature of the output sample gas is from 150 °C to 400 °C and a dilution factor is at least 10.

**CI.1.3.3.3** Control the heating phase to a constant operating temperature, which is within the range as specified in CI.1.3.3.2 with a tolerance of ±10 °C.

**CI.1.3.3.4** Use the indicated information to display whether the heating phase is at correct operating temperature.

The particle concentration attenuation factor ($f_r(d_i)$, the definition of which is as shown in CI.2.2.2) of the electromigration diameters of 30 nm and 50 nm is not more than 30% and 20%, respectively. For the volatile particle remover (VPR) as a whole, the particulate attenuation factor corresponding the particle which has an electromigration diameter of less than 100 nm does not exceed 5%.

**CI.1.3.3.5** By heating and lowering the partial pressure of tetradecane ($CH_3(CH_2)_{38}CH_3$), the vaporization rate of 30 nm n-tetradecane ($CH_3(CH_2)_{38}CH_3$) particles which have an inlet concentration ≥ 10000 $cm^{-3}$ can be > 99.0 %.

**CI.1.3.4 Particle number counter (PNC)**

**CI.1.3.4.1** It works under full-flow conditions.

**CI.1.3.4.2** Based on the traceability principle, within the range from 1 $cm^{-3}$ to the upper limit of a single particle counting module, the counting accuracy is ±10%. If the measured average particle concentration during the extended sampling period is less than 100 $cm^{-3}$, it may require a higher statistical confidence to verify the accuracy of the particle number counter (PNC).

**CI.1.3.4.3** The resolution of at a particle concentration below 100 $cm^{-3}$ is at least 0.1 $cm^{-3}$.

**CI.1.3.4.4** The single particle counting module has a linear response to particle concentration over the entire measurement range.

(evaporation tube ET). The sampling probe or probe for the gas to be tested shall be installed in the dilution tunnel, to extract a representative sample gas from the homogeneous mixture of air and exhaust. The sum of the residence time of the particulate matter in the sampling system and the $T_{90}$ response time of the particle number counter cannot be more than 20 s.

**CI.1.4.2 Particle transmission system**

The sampling probe or probe and the particle transmission tube (PTT) together form a particulate transmission system (PTS).

For full-flow dilution systems and partial-flow dilution systems (as described in CE.3), the sampling tube shall be installed near the centerline of the dilution tunnel, approximately 10 to 20 times the diameter of the tunnel downstream of the gas inlet, facing the direction of the airflow. The center axis of the sampling probe is parallel to the central axis of the dilution tunnel. The sampling probe shall be installed in the dilution tunnel area, to ensure that the sample is a homogeneous mixture of dilution air and exhaust.

For full-sampling type partial-flow dilution systems (as described in CE.3), the particle sampling point or sampling probe shall be installed in the particle transmission tube, upstream of filter holder, flow measuring device, any sampling/bypassing point. The sampling point or sampling tube shall be positioned to ensure uniform mixing of the dilution air and exhaust. The size of the particle sampling tube shall not affect the normal operation of the partial-flow dilution system.

In the particle transmission system, the sample gas shall meet the following conditions:

For the full-flow dilution system, the airflow's Reynolds number Re is < 1700;

The residence time in the particle transmission system shall be ≤ 3 s.

Other particle transmission sampling system structures are also acceptable if it can be demonstrated that particles which have a particle size of 30 nm have equivalent permeability.

The outlet tube (OT) that directs the diluted sample gas from the volatile particle remover (VPR) into the particle counter's inlet shall have the following characteristics:

The inner diameter shall be ≥ 4 mm;

The residence time of the sample gas which flows through the outlet tube (POT) is ≤ 0.8 s.

Other outlet tube sampling structures are also acceptable if it can be

gas shall pass through a high efficiency particle air filter (HEPA) and the dilution factor can be adjusted from 10 to 200 times.

**CI.1.4.4.2 Evaporation tube (ET)**

The evaporation tube's wall temperature shall be controlled to be more than or equal to the primary particle number dilution device. The wall temperature shall be maintained at a fixed value between 300 and 400 °C with a deviation of ± 10 °C.

**CI.1.4.4.3 Secondary particle number dilution device ($PND_2$)**

The secondary particle number dilution device shall be designed to dilute the particle number concentration. The dilution device shall be connected to a high efficiency particle air filter (HEPA) and the dilution factor can be adjusted from 10 to 30 times. The dilution factor of the secondary particle number dilution device shall be selected between 10 and 15 times, so that the downstream particle number concentration is lower than the upper limit of the single particle number counting module in the particle counter, meanwhile make the gas temperature before entering the particle number counter be lower than 35 °C.

**CI.1.4.5 Particle number counter (PNC)**

The particle number counter shall meet the requirements of CI.1.3.4.

**CI.2 Calibration and confirmation of the particle number sampling system**

**CI.2.1 Calibration of particle number counter**

**CI.2.1.1** The testing agency shall ensure that the particle number counter has a traceable verification certificate and that the certificate is valid for 12 months during the test.

**CI.2.1.2** The particle number counter shall, if subjected to any significant maintenance, be calibrated again and obtain a new calibration certificate.

**CI.2.1.3** It shall use standard traceable calibration methods:

a) When sampling the standard particles which had been electrostatically graded, the calibration is performed by comparing the response of the calibrated and to-be-calibrated particle number counter of air electrometer; or

b) Use the second particle number counter (this counter has been directly calibrated by the above method), carry out calibration by comparing the response of the particle number counter

For electrometer's calibration, it shall use at least 6 standard concentration

$N_{in}$ ($d_i$) and $N_{out}$ ($d_i$) shall be corrected under the same conditions.

It shall use the formulas below to calculate the average particle concentration attenuation factor ($\overline{f_r}$) for a given dilution setting as follows

$$\overline{f_r} = \frac{f_r(30nm) + f_r(50nm) + f_r(100nm)}{3}$$

It is recommended to calibrate and confirm the volatile particle remover as a whole.

**Cl.2.2.3** For volatile particle removers, the testing agency shall ensure that the test is within the 6 months of valid period of the calibration certificate of the volatile particle removal efficiency. If the volatile particle remover has a temperature monitoring alert function, it allows a valid period of calibration of 12 months. At the minimum dilution setting and the operating temperature as recommended by the manufacturer, when the inlet concentration is ≥ 10000 $cm^{-3}$, it shall be verified that the volatile particle remover can remove more than 99% of n-tetradecane ($CH_3(CH_2)_{38}CH_3$) particles which has an electromigration diameter of 30 nm.

**Cl.2.3 Inspection program of particle number counting system**

**Cl.2.3.1** Prior to the test, when a high efficiency particle air filter (at least H13 grade or equivalent performance as specified in EN 1822) is installed at the inlet of the entire particle sampling system (volatile particle remover and particle number counter), the particle number counter displays a measured concentration value of less than 0.5 $cm^{-3}$.

**Cl.2.3.2** Each month, it shall use the calibrated flowmeter to check the particle number counter. The difference between the measured value of the particle number counter's flow and the nominal value shall not exceed 5%.

**Cl.2.3.3** Before the test, when the high efficiency particle air filter (at least the H13 or the corresponding grade or equivalent performance as specified in EN 1822) is installed at the inlet of the particle number counter, the particle number counter shall display the measured concentration value of ≤ 0.2 $cm^{-3}$. After removing this filter and changing to ambient air, the particle number counter shall display the measured concentration value of at least 100 $cm^{-3}$. When installing the high efficiency particle air filter again, the measured concentration value shall be returned to ≤ 0.2 $cm^{-3}$.

**Cl.2.3.4** Before the test, it shall confirm that the evaporation tube of the key component of the measuring system has reached its normal operating indication temperature.

# Appendix E

## (Normative)

### Test requirements of non-standard cycle of engine

### E.1 Scope of application

This Appendix specifies the performance requirements and the disable requirements for defeat strategy for engine and vehicle during type test, as well as the requirements for effective control of the emission levels of normally used vehicles under the environmental conditions and engine operating areas as specified in this Appendix.

This Appendix also specifies test procedures for non-cyclic emissions of type test vehicles.

### E.2 Definition

#### E.2.1 Engine starting

The engine's crankshaft is from a standstill until it is 150 rpm lower than the normal warm-up idle speed of the engine (defined as the forward gear for vehicles with automatic transmissions).

#### E.2.2 Engine warm-up

The vehicle is fully operated so that the coolant's temperature is not lower than 70 °C.

#### E.2.3 Rated speed

The maximum full-load speed allowed by the speed limiter as specified by the manufacturer in the sales and service manual or the maximum power speed (without speed limiter) that the engine can achieve in the sales and service manual as specified by the manufacturer.

### E.3 General requirements

The design, manufacture, assembly, installation of any engine system and elements of design that affect the emission of conventional pollutants shall be such that the engine and vehicle meet the technical requirements of this Appendix.

#### E.3.1 Prohibition of defeat strategy

Engine systems and vehicles shall be prohibited from using a defeat strategy.

selected 3 grids shall contain 5 random test points, respectively, totally 15 points. Each grid shall be tested in turn. That is, after testing all five test points in one grid, the test can be performed by switching to the next grid. These test points form a gradually changed steady-state cycle.

**E.6.2.3** The test sequence of each grid as well as the test sequence of each test point in the grid are randomly determined. The 3 grids used for the test, the 15 operating condition points, the test order of the grid, the test order of each point in the grid shall be randomly determined by the testing agency by a conventional statistical method.

**E.6.2.4** The average specific emission of conventional gaseous pollutants as measured in the 5 operating condition points of any grid shall not exceed the WNTE limits as specified in clause E.4.2.

**E.6.2.5** The mass specific emission of particulate matter at 15 operating condition points throughout the test cycle shall not exceed the WNTE limit.

**E.6.3 Laboratory test procedures**

**E.6.3.1** After the WHSC test is passed, perform the WNTE test. Before the start of the WNTE test, it shall follow the 9$^{th}$ operating condition point of the WHSC cycle to carry out pretreatment for 3 min. Start the test immediately after it is finished.

**E.6.3.2** The engine shall be operated for 2 minutes at each random test point, including the transition time from the previous steady state test point. The engine speed and load transition between test points shall be linear, which has a duration of 20 ± 1 s.

**E.6.3.3** The total time from start to finish is 30 min, the cycle time of 5 points as randomly selected in each grid is 10 min, that is, from the transition after entering the 1$^{st}$ point to the end of the steady state measurement at the 5$^{th}$ point. Figure E.4 shows the sequence of test procedures.

**E.6.3.4** The WNTE laboratory test shall meet the validity statistics of clause C.6.8.7 in Appendix C.

**E.6.3.5** Emission tests shall be carried out according to C.6.5, C.6.7, CA.6.8 of Appendix C.

**E.6.3.6** The calculation of the test results is carried out according to Annex CA.

Figure E.4 Schematic diagram of the start of the WNTE test cycle (top left in the Figure: preset end (the 9$^{th}$ operating condition point of WHSC); enter the 1$^{st}$ grid; exit the 1$^{st}$ grid, enter the 2$^{nd}$ grid).

# Appendix F

## (Normative)

### On-board diagnostic system (OBD)

### F.1 Overview

This Appendix specifies the functional requirements for an onboard diagnostic (OBD) system for engine (vehicle)'s emissions control.

### F.2 Terms and definitions

#### F.2.1 Alert system

It refers to an on-board system that alerts the driver of the vehicle or other related personnel when the OBD system detects a fault.

#### F.2.2 Non-volatile random access memory

Non-volatile random access memory (NVRAM) refers to the random access memory which can still store the information when the power supply is interrupted (for example, the vehicle battery is disconnected, the control unit's fuse is removed). Usually, the non-volatile nature of NVRAM is achieved by using a spare battery equipped on an on-board computer, or by using an electronically erased and programmable read-only memory chip.

#### F.2.3 MI status

The command status of the malfunction indicator (MI), i.e., continuous-MI continuous indication, short-MI indication, on-demand-MI indication or off.

#### F.2.4 Continuous-MI

Continuous-MI means the malfunction indicator MI starts the continuous indication after the key is switched on and the engine is started (Key on - engine on), or starts continuous indication from the start of the vehicle, whichever occurs first. The malfunction indicator MI extinguishes when the key is switched off.

#### F.2.5 Short-MI

Short-MI refers to the steady display state in the time period from the point when the malfunction indicator MI starts to light up after the key is switched on and the engine is started (Key on - engine on), or starts to light up after the vehicle is started, to the point when the MI distinguishes after 15 s or the key is switched off (whichever occurs first).

a) Direct measurement of emissions by exhaust emission sensors, which are directly linked to test cycle emissions by models.

b) The amount of increase in emissions as indicated from the relationship between the input and output information of the computer and specific emission of test cycle.

**F.2.15 Performance monitoring**

Refers to failure monitoring which consists of functional inspections and parameter monitoring that is not related to emission thresholds. This monitoring is usually verified by whether the component or system is operating within the appropriate range.

**F.2.16 Total functional failure monitoring**

Monitoring of failures that cause the system to completely lose its intended function.

**F.2.17 Component monitoring**

Monitoring of circuit failures and rationality failures of the input components, as well as monitoring of circuit failures and functional failures of the output components. It is applicable to the circuit components as connected to the engine control system.

**F.2.18 Electrical circuit failure**

A fault (such as an open-circuit or short-circuit) that causes the measured signal (i.e., voltage, current, frequency, etc.) to exceed the sensor's design operating range.

**F.2.19 Rationality failure**

When evaluating the signal of a sensor or component in a control system, the failure of difference between the signal of one sensor or component and the expected signal. Test signals for rationality failure (e.g., voltage, current, frequency, etc.) shall be within the working range of the sensor design.

**F.2.20 Functionality failure**

A failure that the output component does not respond as expected by the computer's instructions.

**F.2.21 Malfunction emission control strategy (MECS)**

A strategy that is activated within the engine system when an emission-related failure occurs.

#### F.3.1 Primary type test

Engine manufacturers can propose OBD type test in one of three ways:

a) The engine manufacturer can propose a type test as an independent OBD system by proving that the OBD system meets all the requirements of Appendix F.

b) The engine manufacturer can carry out type test for OBD family by demonstrating that the OBD parent engine system in the family meets all the requirements specified in Appendix F.

c) The engine manufacturer may propose a type test for the OBD system by demonstrating that the OBD system belongs to an OBD family that has passed the type test.

#### F.3.2 Extension/modification of existing product catalogs

##### F.3.2.1 Extension of new engine system to an OBD family

At the request of the manufacturer, the new engine system can be classified into the OBD family that has passed the type test. The extended engine system has common emission failure monitoring/diagnostic method, but it shall be reported to the competent department of ecological environment under the State Council.

If all OBD technical elements of the OBD parent system can represent the new engine system, the OBD parent system remains unchanged and the manufacturer shall modify the documentation according to F.8.

If the new OBD system contains technical features that cannot be represented by the OBD parent system, meanwhile the new OBD system can represent the entire family, the new engine system shall be used as the OBD parent system. In this case, it shall be verified that the new technical features of the OBD comply with the requirements of this Appendix and that the documentation shall be modified according to F.8.

##### F.3.2.2 Extension of design changes to OBD system

As requested by the manufacturer, after reporting to the competent department of ecological environment under the State Council, if the manufacturer proves the modification of the OBD system complies with the requirements of Appendix F, the existing product catalog of the OBD system can be extended.

The OBD document shall be modified according to F.8.

If the current certificate is applicable to an OBD family, the manufacturer shall demonstrate that the emission-related failure monitoring / diagnosis of each

Annex FC lists the systems or components that the OBD system needs to monitor, describes the type of monitoring of each component or system (i.e. emission threshold monitoring, performance monitoring, total functional failure monitoring, component monitoring).

Manufacturers may decide to monitor additional systems and components.

#### F.4.2.1 Selection of monitoring technology

Manufacturer may use monitoring technologies other than those listed in Annex FC. Meanwhile it shall demonstrate that the selected monitoring technology is reliable, timely and effective (i.e., through technical considerations, test results, prior agreements, etc.), disclose the information of relevant certification materials.

If the system or component is not included in the Annex FC, the manufacturer shall submit the materials to the competent department of ecological environment under the State Council, describing the selected monitoring types and monitoring technologies (that is, emission threshold monitoring, performance monitoring, total functional failure monitoring, component monitoring). Meanwhile follow the requirements of Annex FC to prove that the selected monitoring types and monitoring technologies are stable, timely, efficient.

##### F.4.2.1.1 Correlation of actual emissions

For emission threshold monitoring, it is usually verified on a test engine in the test chamber, to obtain a correlation with the cyclic specific emissions.

For other monitoring (i.e., performance monitoring, total functional failure monitoring or component monitoring), it does not requires obtaining the emission of actual emission. However, it shall provide the test data to verify whether it complies with the failure classification as required in F.6.2.

Example:

A circuit failure does not require an emission test, which is a Yes/No fault.

According to the requirements of this Appendix, if the manufacturer can demonstrate that the total functional failure, the removal of component, or system failure will not result in emissions exceeding the OBD limit, it is allowed to carry out functionality monitoring of the component or system.

When an exhaust sensor is used to monitor the emission of a particular pollutant, all other monitoring for that pollutant does not require further testing for the correlation with actual emissions. However, this exemption does not preclude the need for such monitoring, such as monitoring techniques for fault isolation

d) Failure will not delay or affect the performance of the original design of the emission control system (e.g., damage to the reagent heating system under cold conditions is not a special case).

The emission test shall be carried out on an engine test bench which is equipped with a dynamometer according to the verification procedures specified in this Appendix.

The verification test involved in item d) is not decisive. The manufacturer shall submit appropriate design information, such as good engineering practice, technical considerations, simulation and test results, to the competent department of ecological environment under the State Council.

**F.4.2.3 Monitoring of purification performance of post-exhaust processor**

**F.4.2.3.1** The OBD system is, based on the engine exhaust aftertreatment system configuration, according to the monitoring requirements of FC.2.c (DPF), FC.3.d (SCR), FC.4.a (LNT) or FC.15.a (TWC), real-time monitoring the performance of emission aftertreatment purifier. If the emission aftertreatment processor fails within the full life of the vehicle which causes the emissions to exceed the OBD limit, it shall activate the driver alert system as specified in G4 of Appendix G, prompt the driver to repair it as soon as possible. When the alert system includes an information display system, display the cause of the alert (for example, "aftertreatment device's purification efficiency is low", "post-processor's performance deteriorates", etc.).

**F.4.2.3.2** Use the monitoring system specified in GB.4/emission post-processor's type A failure counter to record the number of hours of engine operation after the emission post-processor's type A failure is confirmed and activated. The criteria for the activation and deactivation of this counter as well as the operating mechanism are as shown in Annex GB of Appendix G.

**F.4.2.3.3** If the post-processor's type A fault as described in F.4.2.3.1 causes the driver's alert system to be activated, meanwhile the failure is still not repaired within 36 hours of continuous engine operation, the primary drivability limit system as described in G.5.3 shall be enabled and activated.

**F.4.2.3.4** If the post-processor's type A failure as described in F.4.2.3.1 causes the driver's alert system to be activated, meanwhile the failure is still not repaired within 100 hours of continuous engine operation, the severe drivability limit system as described in G.5.4 shall be enabled and activated.

**F.4.2.3.5** If the failure occurs repeatedly, it shall follow the requirements of Annex GB to reduce the number of hours before activating the drivability limit system.

**F.4.2.3.6** The principles for the activation and deactivation of driver alert and

status without going through the “potential DTC” phase. If this failure is defined as a "potential DTC" state, it will remain in the previously active state until it is confirmed and activated.

**F.4.3.4** The monitoring system shall, after the first detection of the failure and before the end of the next operation process, determine whether the failure exists. If the failure exists, the system records a “confirmed and active DTC” and the alert system is activated.

**F.4.3.5** For the recoverable malfunction emission control strategy MECS (i.e., automatic recovery to normal and MECS deactivation before the next engine start), there is no need to save the "confirmed and active DTC", unless the MECS is activated again before the end of the next operation process. For unrecoverable MECS, once the MECS is activated, it shall store the “confirmed and active DTC”.

**F.4.3.6** In some specific cases, the monitoring function requires more than two operating procedures to detect and confirm the diagnostic trouble code (such as the use of statistical models on the vehicle or monitoring of liquid consumption), if the manufacturer proves to take a long time (for example, through technical principles, test results, internal experience, etc.) and after reporting to the competent department of ecological environment under the State Council, it is allowed for more than two operational procedures.

**F.4.3.7** For failures that have been confirmed and activated, if they are no longer detected by the system during a complete operation process, the failure shall be set to the previously active state before the start of the next operation and remain in this state until the OBD information associated with the failure as specified in F.4.4 is cleared by the scan-tool or cleared by the electronic control unit from the memory.

Note: The above requirements are described in the Annex FB.

**F.4.3.8 Permanent fault code**

**F.4.3.8.1** The failure as confirmed and activated by continuous-MI via continuous light-up is recorded as a permanent fault code. This permanent fault code shall be stored in the non-volatile random access memory at the latest before the end of the ignition cycle.

**F.4.3.8.1.1** The type A failures as confirmed and activated are recorded as permanent fault codes.

**F.4.3.8.1.2** The failures which have an accumulated time of more than 200 hours, are confirmed and activated by the type B1 which is activated but unrepaired by continuous-MI are recorded as permanent fault code. According to the number of B1 counters in the OBD system, it is divided into the following

codes and related information (including the associated freeze frame) cannot be deleted directly from the electronic control unit by the OBD system. Only when the confirmed diagnostic trouble code is kept for at least 40 warmup cycle at the previously active state or this failure cannot be detected within 200 hours of operation of engine, whichever comes first, this previously active diagnostic trouble code and related information (including related freeze frames) can be deleted by the OBD system from the electronic control unit.

**F.4.4.3 Clearing of permanent fault code**

**F.4.4.3.1** If the OBD system records a permanent fault code, only after the OBD system itself confirms that the failure that caused the permanent fault code no longer exists, the OBD system can immediately clear the permanent fault code.

**F.4.4.3.2** If all failure information except the permanent fault code in the onboard computer is cleared (for example: using scan-tools, etc.), the OBD system does not activate and light up the malfunction indicator, if the OBD system performs one or more diagnostics in one driving cycle to confirm that the failure as indicated by the stored fault code does not exist and that the failure does not occur throughout the driving cycle, the OBD system can erase the permanent fault code at the end of the cycle.

**F.4.4.3.3** If more than one permanent fault codes are stored in the OBD system, when the monitoring item of a permanent fault code satisfies the requirements of F.4.4.3.1 or F.4.4.3.2, the OBD system can clear this permanent fault code. Before clearing a permanent fault code, the OBD system does not require all stored permanent fault codes to meet the requirements of F.4.4.3.1 or F.4.4.3.2.

**F.4.5 Failure classification**

Failure classification refers to the assignment of the corresponding failure category when the failure is detected according to the requirements of F.4.2 of this Appendix.

A failure is classified into a certain category throughout the full life of the vehicle, unless it is confirmed by the competent ecological authority or the manufacturer that it is necessary to classify this failure again.

If a failure has different effects on different pollutant emissions, or causes different classifications due to affecting other monitoring capabilities, according to the differential display principle, the failure shall be set to the priority display category (e.g., type A failures take precedence over type B failures).

If MECS is activated after a failure is detected, it shall be classified based on the impact of the activated MECS on emissions and other monitoring capabilities. According to the differential display principle, the failure is set as the priority display category.

In order to activate the malfunction indicator MI, the continuous-MI shall be displayed with precedence over the short-MI and on-demand-MI, the short-MI shall be displayed with precedence over the on-demand-MI.

#### F.4.6.3.1.1 Type A failures

When storing a confirmed and active type A diagnostic trouble code, the OBD system shall give a continuous-MI activation command.

#### F.4.6.3.1.2 Type B failures

When storing a confirmed and active type B diagnostic trouble code, before the next key-on, the OBD system shall give a short-MI activation command.

When the type B1 failure counter reaches 200 hours and the OBD system detects that a type B1 failure still exists, it shall issue a continuous-MI activation command.

#### F.4.6.3.1.3 Type C failures

Prior to engine start-up, the manufacturer may prompt for type C failure information by means of an on-demand-MI display.

#### F.4.6.3.1.4 MI deactivation scheme

If a single monitoring event occurs, and the failure that originally activates the continuous-MI is not detected during the current operation, meanwhile there is no new continuous-MI activation command due to other failures, then this "continuous-MI" shall be converted to the "short-MI" display mode.

The short-MI deactivation condition is that the failure is no longer detected during the three consecutive operation periods from the operation process in which the monitoring system has confirmed that the failure does not exist, meanwhile the MI is not activated due to other type A or type B failures, then this "short-MI" shall be deactivated.

Figure FB.1, FB.4A, FB.4B in the Annex FB respectively describe the conditions for deactivation of the short-MI and continuous-MI under different conditions of use.

### F.4.6.4 MI activation in case of key-on engine-off

MI activation in case of key-on engine-off consists of two steps, which are separated by a 5s MI off state:

a) Step 1 is used to display the readiness of the MI function and monitoring component.

#### F.4.6.4.2.4 Active mode 4 - "Continuous-MI"

According to the priority display strategy as described in F.4.6.3.1, if the OBD system gives a “continuous-MI” command, the malfunction indicator shall remain light-up (“continuous-MI”).

### F.4.6.5 Failure-related counter

#### F.4.6.5.1 MI counter

##### F.4.6.5.1.1 Continuous-MI counter

The OBD system shall contain a continuous-MI counter that records the number of engine operating hours after the continuous-MI is activated.

Continuous-MI counters shall be accumulated every hour until the maximum value that the 2-byte counter can display, unless otherwise the conditions at which the counter can be reset to zero occur. Otherwise, the value shall be frozen all the time.

1) Operation requirements of continuous-MI counter

The continuous-MI counter operates as follows:

a) If, starting from 0, there is a continuous-MI being activated, the continuous-MI counter shall start counting;

b) After the continuous-MI is deactivated, the continuous-MI counter shall stop and freeze the current value;

c) When the failures as activated by the continuous-MI are detected in 3 operation processes, the continuous-MI counter shall continue counting from the previously frozen count value;

d) From the last time the continuous-MI counter is frozen, if a failure that causes the continuous-MI to be activated is detected after 3 operation processes, the continuous-MI counter shall recount from 0.

e) In the following cases, the continuous-MI counter shall be reset to zero:

i) From the last time the counter was frozen, the engine is running 40 warm-up cycles or running for 200 hours (whichever comes first), no failure which activates the continuous-MI is detected;

ii) Use the OBD scan-tool to clear the OBD information.

k) The maximum engine running time as recorded by the B1 counter;

l) Confirmation of type B1 failure and activation of diagnostic trouble code, as well as the running time of engine as read from the B1 counter;

m) Confirmation of type C failure and activation of diagnostic trouble code;

n) Pending diagnostic trouble code and their classification;

o) Previously active diagnostic trouble code and their classification;

p) Real-time information on sensor signals, internal and output signals selected and supported by the OEM (see F.4.7.2 and Annex FE).

q) The freeze frame data required by this Appendix (see F.4.7.1.4 and Annex FE);

r) Software calibration identification code;

s) Calibration verification code.

According to the provisions of Annex FH, external fault test equipment can be used to clear diagnostic trouble codes and related information (running time information, freeze frames, etc.) other than permanent fault codes as recorded by the engine's OBD system.

**F.4.7.1.4 Freeze frame information**

According to the manufacturer's requirements, when storing a potential diagnostic trouble code or a confirmed and active diagnostic trouble code, at least the freeze frame information is saved. The manufacturer can update the freeze frame information whenever the potential diagnostic trouble code is detected again.

The freeze frame shall provide the vehicle operating conditions when the failure is detected and when the data associated with the diagnostic trouble code is stored. The freeze frame shall include the information listed in Table FE.1. The freeze frame shall also include the information as described in Table FE.2 and Table FE.3, which shall be used for monitoring or control purposes in the specific control unit of the stored diagnostic trouble code (DTC).

Freeze frames of type A failure shall be stored preferentially compared to other types of failures. Freeze frames of type B1 failures shall be stored preferentially compared to type B2 and C failures. Freeze frames of type B2 failure shall be stored preferentially compared to type C failures. A previously detected failure shall be stored preferentially compared to the most recent failure store, unless the most recent failure has a higher priority.

Appendix.

#### F.4.7.1.5.2 Readiness of monitoring function

Refer to the requirements of this Appendix, except for FC.11 and FC.12 in the Annex FC, the readiness is applicable to each or each set of the monitoring functions as specified in this Appendix.

#### F.4.7.1.5.3 Readiness of continuous monitoring

For the continuous operation monitoring function as specified in this Appendix, in case of readiness of one or a set of monitoring functions as specified in FC.1, FC.7, FC.10 of the Annex FC, it shall always indicate the "finished" status.

### F.4.7.2 Data stream information

The OBD system shall provide the information displayed in the Table FE.1 ~ Table FE.4 to the scan tool in real time according to the request signal (the actual signal value shall be used in preference to the replacement value).

To calculate the load and torque parameters, the OBD system shall report the most accurate value as calculated by the electronic control unit (such as the ECU).

Table FE.1 gives mandatory OBD information on engine load and speed.

Table FE.3 gives other OBD information that must be included, such as for emission systems or OBD systems to enable or disable OBD monitoring.

Table FE.4 gives the perceptual or calculated information of the engine configuration that needs to be covered. At the request of the manufacturer, other freeze frames or data stream information may also be included.

If the OBD monitors a device which is not covered in the Annex FE (e.g., SCR), it shall follow the similar method as described in Annex FE, save the information of the sensor and actuator of the device to the data stream information. This information shall be submitted to the competent department of ecological environment under the State Council during the type test.

### F.4.7.3 Acquisition of OBD information

The acquisition of OBD information shall be carried out according to the standard methods as mentioned in Annex FH and the provisions of this part. It shall not encrypt the standard OBD communication protocol.

The acquisition of OBD information shall not depend on any access code, reading device or method that can only be obtained from the manufacturer or supplier. The interpretation of OBD information cannot rely on any special

Disconnection of the vehicle's battery does not result in the deletion of OBD information.

### F.4.8 Safety of electronic control system

Unless authorized by the manufacturer, the emission control unit on any vehicle shall have tamper-proof functionality. If these modifications are necessary for diagnosis, maintenance, inspection, vehicle modification or repair, the manufacturer shall authorize the modification.

Any reprogrammable computer code or operating parameters shall be protected from tampering. The exchange of security information via the protocols and diagnostic interfaces in this Appendix shall provide the same protection level as specified in ISO 15031-7 (SAE J2186) or J1939-73. Any removable calibration memory chip shall be placed in a sealed container or protected by an electronic algorithm, so that it can only be modified by specialized tools and procedures.

Modifications to computer-programmed engine operating parameters must also use specialized tools and follow prescribed procedures (such as soldered or packaged computer components or sealed computer control boxes).

The manufacturer shall take sufficient measures to ensure that the maximum fuel supply setting of the vehicle is not tampered with during the maintenance process.

For vehicles that do not require protection, the manufacturer may request an exemption from the competent department of ecological environment under the State Council. The evaluation criteria that the competent department of ecological environment under the State Council may consider granting exemptions include, but are not limited to, the availability of high-performance chips, the efficient functioning of vehicles, the estimated sales volume of vehicles.

When a manufacturer uses a programable computer programming device such as an electrically erasable programmable read-only memory (EEPROM), it shall prevent the unauthorized recompilation. For off-site computer devices as maintained by the manufacturer, the manufacturer shall strengthen the tamper-proof protection measures and write protection functions. After reporting to the competent department of ecological environment under the State Council, it may use the same level of alternative tamper-proof methods.

### F.4.9 Durability of OBD system

The OBD system shall be designed and manufactured to ensure that the type of failure is identified throughout the useful life of the vehicle and engine system.

may be temporarily interrupted. The manufacturer may set a higher limit than the above value, to make the system monitoring temporarily interrupted, but the above situation shall be reported to the competent authority.

The manufacturer shall demonstrate that the monitoring below the above voltage limits will be unreliable and that the vehicle cannot run a longer time under the voltage at which the OBD function is temporarily interrupted, or otherwise when the OBD system is monitoring the battery or the system voltage, the monitoring function will be interrupted due to the detection of a low voltage.

**F.5.4.2 High voltage**

After the manufacturer reports to the competent department of ecological environment under the State Council, for the emission-related monitoring system affected by the battery or system voltage, when the battery or system voltage exceeds the value as specified by the manufacturer, the monitoring function may be temporarily interrupted.

The manufacturer shall demonstrate that monitoring above its specified voltage limits is unreliable and that the charging system/alternator alert lights are to be illuminated (or the meter is in the “red zone”). The OBD system detects voltage failures in other temporarily interrupted monitoring functions by monitoring the battery or system voltage.

**F.5.5 Power take off (PTO)**

After the manufacturer reports to the competent department of ecological environment under the State Council, on the vehicle equipped with the power take off (PTO), when the PTO unit is temporarily activated, the affected monitoring function may be temporarily interrupted.

**F.5.6 Forced regeneration**

After the manufacturer reports to the competent department of ecological environment under the State Council, the OBD monitoring function affected during the forced regeneration of the engine's downstream emission control system (such as particulate filter) may be temporarily interrupted.

**F.5.7 Auxiliary emissions strategy (AES)**

After the manufacturer reports to the competent department of ecological environment under the State Council, except for the conditions of F.5.2, if the monitoring capability of a monitoring system is affected by the AES work, the OBD monitoring function may be temporarily interrupted during AES work.

**F.5.8 Refueling**

After refueling, when the system ECU needs to identify and adapt to changes

c) Principles of functional monitoring and component monitoring;

d) Monitoring parameters (e.g., frequency).

The commonality of the above basic parameters shall be proved by the manufacturer through relevant engineering verification or other reasonable methods, meanwhile it shall be reported to the competent department of ecological environment under the State Council.

The manufacturer may prove to the competent department of ecological environment under the State Council that the changes in the engine system structure have little impact on the monitoring/diagnostic methods of the engine emission control system, and the manufacturers may determine that these methods are similar:

a) Their differences are limited to the specific parameter comparison of the corresponding components (such as size, exhaust flow, etc.), or

b) Their commonality is based on good engineering judgment.

**F.6.2.2 OBD parent engine system**

For the compliance requirements of the OBD family, it shall verify that the OBD parent engine in the family meets the requirements of this Annex.

The OBD parent engine is selected by the manufacturer and reported to the competent department of ecological environment under the State Council.

Prior to testing, the competent authority has the right to require the manufacturer to select additional engines for testing.

Manufacturer may also propose to the competent department of ecological environment under the State Council to test additional engines, to cover the entire emission OBD family.

**F.6.3 Verification method of failure classification**

The manufacturer shall provide reasonable documents to the competent department of ecological environment under the State Council to prove the rationality of each failure classification. This document includes failure analysis (e.g., “failure mode and impact analysis”) and shall also include:

a) Simulation results;

b) Test results;

c) Reference to the previous classification.

In the following clauses, it lists the verification methods and test requirements

of ecological environment reclassifies the failure as type B2 or type C. In this case, according to the requirements of the competent department of ecological environment, the document shall record that the failure has been reclassified.

#### F.6.3.4 Type B2 verification (distinguishing between B2 and B1)

If the failure is type B2, the manufacturer shall indicate that the resulting emissions are lower than OTLs.

If the competent department of ecological environment determines that its emissions are higher than OTLs and does not agree to classify it as type B2, manufacturers can test to prove that the emissions caused by the failure are lower than OTLs. If the test fails, the competent department of ecological environment shall reclassify the failure to type A or type B1; the manufacturer shall then prove the rationality of the classification and update the documentation.

#### F.6.3.5 Type B2 verification (distinguishing between B2 and C)

If the competent department of ecological environment does not agree the manufacturer to classify the failure into type B2, because the emission caused by the failure does not exceed the emission limit, the competent department of ecological environment requires classifying the failure into type C. According to the requirements of the competent department of ecological environment, the type test documents shall be recorded.

#### F.6.3.6 Type C verification

To prove that a failure is a type C failure, the manufacturer shall demonstrate that its emissions are below the emission limits.

If the competent department of ecological environment does not agree to classify it as type C, a verification test is required to prove that the emission due to failure is lower than the specified emission limits.

If the test fails, the competent department of ecological environment shall request a reclassification of the failure, the manufacturer shall then demonstrate the rationality of the classification and update the documentation.

#### F.6.3.7 Verification of permanent fault code

According to the provisions of F.4.3.8, verify the OBD system's storage operation of the permanent fault code. According to the provisions of F.4.4.3, verify that when the failure as indicated by the permanent fault code does not exist, the OBD system may clear the stored permanent fault code by itself.

### F.6.4 Verification program of OBD performance

**distinguish type A and B1 failures**

**F.6.4.2.1.1 Emission threshold monitoring**

If the emission caused by the failure as selected by the competent department of ecological environment exceeds the requirements of OBD limit, the manufacturer shall carry out the emission test verification according to F.7. The qualified deteriorated components or devices shall not cause the relevant emission to exceed the OTL limit by 20%.

**F.6.4.2.1.2 Performance monitoring**

When performing performance monitoring, emissions may exceed the OTL limit by 20%. This requirement is permissible for individual cases, but shall be reported to the competent department of ecological environment under the State Council.

**F.6.4.2.1.3 Component monitoring**

When component monitoring is performed, the inspection of the qualified deteriorated component does not require an OTL reference.

**F.6.4.2.2 Monitoring of qualified deteriorated component for verification of type B2 failures**

In the case of a type B2 failure, the manufacturer shall, according to the emission test specified in F.7, demonstrate that the qualified deteriorated component or device does not cause the associated emissions to exceed its corresponding OTL.

**F.6.4.2.3 Detection of qualified deteriorated component for verification of type C failures**

In the case of a type C failure, the manufacturer shall, according to the emission test specified in F.7, demonstrate that the qualified deteriorated component or device does not cause the associated emissions to exceed the emission limits of conventional pollutants.

**F.6.4.2.4 Drivability limit system of degraded emission aftertreatment device for verification of type A failure**

According to F.4.2.3, carry out test verification of the alert and vehicle drivability limit strategy as adopted by the type A failure where the emission exceeds OBD limit due to failure of emission aftertreatment device.

**F.6.4.3 Test report**

The test report shall contain at least the information as required by the Annex

### F.7 Test procedure

#### F.7.1 Test flow

During the test, the correct verification of the failure classification and the performance verification of the OBD system may be performed separately. For example, when the type A failure is subject to OBD performance test, it does not require carrying out the verification test for the failure classification.

If applicable, it may use the same test to verify the failure classification, verification of the qualified deteriorated components as provided by the manufacturer, the normal monitoring function of OBD system.

Engines used for OBD system testing shall comply with the emission requirements of this standard.

##### F.7.1.1 Verification of failure classification

According to F.6.3, the competent department of ecological environment requires the manufacturer to verify a failure classification. The compliance verification shall include a series of emission tests.

According to F.6.3.2, when the competent department of ecological environment verifies the type B1 failure but not type A failure, the manufacturer shall prove that under the selected test conditions, the emissions caused by the corresponding failure shall be less than the OTLs:

a) The test conditions selected by the manufacturer shall be subject to the approval of the competent authority;

b) Manufacturers are not required to demonstrate that emissions in other failures are higher than OTLs.

According to the requirements of the manufacturer, the emission test can be carried out up to 3 times.

If the emission value measured by any of the emission tests is lower than the OTL, then it agrees to classify the failure as type B1.

If the competent department of the ecological environment requires testing to prove the rationality of classifying a failure into type B2 but not type B1, or the rationality of classifying it into type C but not type B2, the emission test shall not be repeated. In this case, if the measured emission exceeds the OTL value or the emission limit, the failure shall be reclassified.

Note: According to the provisions of F.6.3.1, the requirements for failure classification verification of this paragraph are not applicable to type A failures.

#### F.7.1.2.3 Failure detection

The failure monitoring as selected by the competent department of ecological environment shall be tested on the engine bench. After being replaced with qualified deteriorated components, the failure monitoring shall make response within two consecutive OBD test cycles as specified in F.7.2.2 of this Appendix, in a method complying with the requirements of this Appendix.

If it has been specially noted in the description of the function monitoring and reported to the competent department of ecological environment under the State Council, some special function monitoring verification requires completion by more than two operation processes. The number of OBD test cycles can be increased accordingly according to the requirements of the manufacturer.

Each individual OBD test cycle is differentiated by engine OFF during the verification process. The timing of the engine OFF until the next start-up shall take into account any functionality inspection that may occur after the engine OFF, as well as the necessary conditions for a functionality inspection that occurs at the next start-up.

The test is considered complete as long as the response of the OBD system meets the requirements of this Appendix.

### F.7.2 Type test

The test cycle for type test of the OBD system includes an emission test cycle and an OBD test cycle. The emission test cycle is a conventional emission test cycle used for inspection of qualified deteriorated components or systems. The OBD test cycle is a test cycle that verifies the OBD system's ability to monitor failures.

#### F.7.2.1 Emission test cycle

The emission test cycle is the WHTC cycle in Annex CJ.

#### F.7.2.2 OBD test cycle

The OBD test cycle is the hot WHTC cycle in Annex CJ.

For a particular monitoring function, it may select an alternative OBD cycle for verification (e.g., cold state WHTC cycle). The documents (technical factors, simulations, test results, etc.) that enterprises shall provide to the competent department of ecological environment under the State Council are as follows:

a) Test cycle conditions for verification of this monitoring function will occur under actual driving conditions.

b) Hot state WHTC cycle is not suitable for monitoring of this failure (e.g.,

perform separate torque measurement when verifying the primary drivability limit system.

At the end of each verification test, the manufacturer verifies that the engine ECU has activated the torque limiter to the competent department of ecological environment, the verification of the primary drivability limit system is finished.

#### F.7.4.3 Activation verification of severe drivability limit system

Verification of the severe drivability limit system shall begin after the activation of the primary drivability limit system is activated; it can be used as a continuation of the verification of primary drivability limit system. The engine continues to operate. When the type A failure counter of the monitoring system/emission aftertreatment device as specified in GB.4.1 reaches 100 hours, if the failure is not eliminated, it shall activate the severe drivability limit system, to apply speed limit control of the vehicles according to the effective conditions of the severe drivability limit system as set in G.5.4.

At the end of each verification test, if the manufacturer verifies that the engine ECU has activated the vehicle speed limiter to the competent department of ecological environment, the verification of the severe drivability limit system is completed.

The manufacturer shall provide technical documents based on algorithms, functional analysis and previous test results to the competent department of ecological environment under the State Council, to prove the speed limit after the activation of the severe drivability limit system. As an alternative method, after reporting to the competent department of ecological environment under the State Council, the manufacturer may choose to fix the whole vehicle on a suitable test bench according to the requirements of GA.5.4 or verify the speed limit on the test track according to the required control conditions.

Considering that the verification process of drivability limit system activation requires the vehicle/engine to run for a long time, in order to reduce the burden on the manufacturer, if possible, when performing functionality inspection on these systems, it may select a counter simulation with a longer operating hours.

### F.7.5 Test report

The test report shall contain at least the contents as required in Annex FD.

## F.8 Document requirements

### F.8.1 Type test materials

The manufacturer shall provide an OBD document that includes a description of all OBD systems. The document shall be divided into two parts:

This information shall include the technical basis for the classification of type A, B1, B2 failures as required by F.4.5.

**F.8.1.3 Documents related to OBD family**

The second part of the document shall contain, but is not limited to, the following information for the OBD family:

It shall provide a description of the OBD family, which shall include a list of engine types within the OBD family, a description of the OBD parent engine system, all technical features that can represent the OBD family according to the requirements of F.6.2.1 of this Appendix.

If the engine included in the OBD family belongs to a different engine family, it shall provide a brief description of the engine family.

In addition, manufacturers shall list all electronic input/output lists and communication protocols used by each OBD family.

**F.8.2 Document description of engine equipped with an OBD system installed in a vehicle**

Engine manufacturers shall provide documentation to propose the corresponding requirements for the installation of their engine systems, to ensure that the vehicle meets the requirements of this Annex when used on the road or elsewhere (if applicable). This document shall include but is not limited to:

a) Detailed technical description, including the requirements for compatibility of the OBD system of engine systems;

b) Verification process.

The degree of compliance with this installation requirement can be verified during the type test process of engine system.

Note: This document is not required if the vehicle manufacturer directly performs a type test on the engine's OBD system installed on the vehicle.

**F.9 In-use monitoring performance**

This paragraph describes the requirements for in-use monitoring performance of the OBD system.

**F.9.1 Technical requirements**

**F.9.1.1** Annex FG specifies the technical requirements for monitoring performance of OBD systems, including relevant communication protocols,

## Annex FC
## (Normative)
## Monitoring requirements

This Annex specifies the systems or components (if any) as monitored by the OBD system as required by F.4.2. Unless otherwise specified, this requirement apply to all types of engines.

### FC.1 Monitoring of electrical / electronic component

The electrical/electronic components used to control or monitor the emission control system shall be monitored according to F.4.2. It shall be composed of at least a pressure sensor, a temperature sensor, an emission sensor and an oxygen sensor (if any), a knock sensor, a fuel or reagent injector in the emission, an exhaust burner or heater, a glow plug, an intake heater.

As long as there is feedback closed-loop control, the OBD system must monitor its designed feedback control capability (for example, possible failures: no feedback control is performed within the time interval as specified by the manufacturer, or the system cannot perform feedback control, or feedback control adjustment parameters exceed the setting range of the manufacturer) - component monitoring.

In particular, if the reagent injection is closed-loop control, it shall also meet the monitoring requirements of this clause, but the detected failure shall not be classified as a type C failure.

Note: These requirements apply to all electrical-electronic components, even if they belong to other different monitoring systems in this Appendix.

### FC.2 DPF system

The OBD system shall monitor the components and performance parameters of the DPF system:

a) DPF carrier: The OBD system shall detect failure when the DPF is unable to capture particles (meaning that the DPF carrier is completely damaged, removed, lost or the particle trap is replaced by a silencer or straight tube) - Total functional failure monitoring;

b) DPF performance: DPF blockage - Total functional failure monitoring;

c) DPF performance: Monitor the DPF filtration and regeneration process. When the DPF performance is degraded and the particulate emissions exceed the OBD limit, the OBD system shall detect the failure - Emission threshold monitoring;

Note: It is also necessary to monitor whether the DPF cyclic regeneration device

item may be exempted.

**FC.11.3.2** If the CV valve is designed to be fastened directly to the crankcase, the removal of the CV valve from the crankcase needs cut off the connection between the CV valve and the intake pipeline, meanwhile the connection between the CV valve and the intake pipeline has been monitored, then the competent department of ecological environment may allow the manufacturer not to monitor the disconnection failure between the crankcase and CV valve.

**FC.11.3.3** If it can be confirmed that the connection between the crankcase and the CV valve is as follows, and it is reported to the competent department of ecological environment under the State Council, it may not implement monitoring. The manufacturer shall submit technical data and/or engineering evaluation documents.

a) It can prevent aging or accidental disconnection;

b) It is obviously more difficult to disconnect between the CV valve and the crankcase than disconnect between the CV valve and the intake pipeline;

c) The maintenance and service of the manufacturer for the other part than the CV system do not relate to the CV system.

**FC.11.3.4** After reporting to the competent authority, under the following conditions, it may not monitor the “disconnection” of the pipeline between the CV valve and the intake pipeline. The manufacturer shall submit technical data and/or engineering evaluation documents.

a) “Disconnection” of the pipeline between the CV valve and the intake pipeline will cause the engine to stop immediately during idle operation;

b) Integrated design of CV valve and intake pipeline (for example, the connecting pipe between CV valve and intake pipeline is the internal passage of the engine, not the external pipeline) does not cause "disconnection" of the pipeline between the CV valve and the intake pipeline.

**FC.11.4** If the manufacturer can prove that the failure monitoring of the CV system requires additional monitoring hardware to clearly identify the failure of CV system, then the stored diagnostic trouble code for the CV system need not be specifically designated as a CV system (e.g., can be stored as a diagnostic trouble code related to idle speed control or fuel system monitoring), but the manufacturer must include inspection of the CV system in the repair program of the failure detected.

**FC.12 Monitoring of engine cooling system**

# Annex FF
# (Normative)
# Verification of performance monitoring

## FF.1 General requirements

This Annex specifies the verification test procedures associated with performance monitoring.

## FF.2 Verification of performance monitoring

### FF.2.1 Type test of failure classification

**FF.2.1.1** According to the provisions of F.4.2.1.1, performance monitoring does not need to test the corresponding actual emission value. However, the competent department of ecological environment may require testing of emission data in order to confirm the failure classification as described in F.6.3.

### FF.2.2 Type test of the performance monitoring items as selected by the manufacturer

**FF.2.2.1** When conducting type test on the performance monitoring items selected by the manufacturer, the competent department of ecological environment shall consider the technical information as provided by the manufacturer.

**FF.2.2.2** The functionality thresholds of the monitoring items as selected by the manufacturer shall be obtained by the verification test of the parent engine in the OBD engine family:

**FF.2.2.2.1** The verification test shall be carried out by the same method as specified in F.6.4.2.

**FF.2.2.2.2** It shall test the performance degradation of all the component being evaluated and use it as the performance threshold of the parent engine of the OBD engine family.

**FF.2.2.3** The performance monitoring criteria for the type-tested parent engine applies to all other engines in the OBD engine family without requiring re-verification.

**FF.2.2.4** It shall allow manufacturer to reach an agreement with the competent department of the ecological environment, to adjust the above functionality threshold of the members in the OBD engine family, to cover different design parameters as much as possible (e.g., EGR cooler size). The agreement shall be based on technical elements that indicate its relevance.

**FF.2.2.4.1** At the request of the competent department of ecological

# Annex FG
# (Normative)
# Technical requirements and verification of in-use monitoring performance of on-board diagnostic system (OBD)

## FG.1 Scope of application

This Annex specifies the technical requirements and verification methods for the in-use monitoring performance of the on-board diagnostic system (OBD) of engines and vehicles.

## FG.2 Terms and definitions

### FG.2.1 Numerator

The numerator of a monitoring function refers to the number of vehicle operations when the monitoring conditions required for the monitoring function are fully met.

### FG.2.2 Denominator

The denominator of a monitoring function refers to the number of vehicle driving cycles associated with the monitoring function, or the number of occurrences of vehicle driving events related to the monitoring function.

### FG.2.3 In-use monitoring frequency (IUPR)

**FG.2.3.1** In-use monitoring frequency of a certain monitoring function m of OBD system ($IUPR_m$)

$$IUPR_m = Numerator_m/Denominator_m$$

Where, $Numerator_m$ is the numerator for monitoring function m, $Denominator_m$ is the denominator for monitoring function m.

**FG.2.3.2** In-use monitoring frequency of a group of monitors ($IUPR_g$)

$$IUPR_g = Numerator_g / Denominator_g$$

$Numerator_g$ is a numerator in a group of monitors g, which is the value of numerator of the specific monitoring function m as corresponding to the minimum IUPR value in a group of monitors g as installed on a specific vehicle;

$Denominator_g$ is the denominator in a group of monitors g, which is the value of denominator of the specific monitoring function m as corresponding to the minimum IUPR value in a group of monitors g as installed on a specific vehicle.

### FG.2.4 General denominator

use performance evaluation of individual vehicles.

**FG.4 Calculation requirements for in-use monitoring frequency**

**FG.4.1 Calculation of in-use monitoring frequency**

For each monitoring function m considered in this Annex, it shall use the formula FG.2.3.1 to calculate the in-use monitoring frequency, wherein the numerator m and the denominator m are gradually increased as specified in this paragraph.

**FG.4.1.1 Ratio requirements for system calculation and storage**

The value range of each $IUPR_m$ is minimum 0, and maximum 7.99527. The value interval is 0.000122 (this value corresponds to the resolution 0x1 of the maximum hexadecimal number 0xFFFF).

When a particular component has a corresponding numerator count of zero but the denominator count is not zero, the ratio shall be zero.

When the denominator count corresponding to a specific component is zero or the actual value as obtained by dividing the numerator by the denominator exceeds the maximum value 7.99527, the ratio shall be taken as the maximum value 7.99527.

**FG.4.2 Numerator increase requirements**

The increment of the numerator for each driving cycle cannot exceed 1.

The numerator for specific monitoring shall be increased within 10 s if and only if the following conditions are met within one driving cycle:

a) All monitoring conditions required for failure monitoring and potential DTC storage for specific component monitoring items, including start conditions, presence of relevant DTCs, sufficiently long monitoring time, assignment of diagnostic execution's priority (e.g., diagnostic "A" shall be prioritized over the diagnostic "B"), etc. are satisfied;

   Note: In order to increase the numerator of a specific monitor, only all the monitoring conditions required for the monitor to confirm the elimination of the failure may not be sufficient.

b) For monitors that require multiple phases or events for failure monitoring within a driving cycle, all monitoring conditions required for all monitoring events shall be met.

c) For monitors used for failure identification and is operated only after one potential DTC storage, the numerator and denominator may be the same as the count value of the monitoring item wherein the initial failure is

"on", "Open", "closed", "locked"), or the cumulative action time is more than or equal to 10 seconds (whichever occurs first), its denominator shall be increased.

**FG.4.3.2.5 DPF dedicated denominator**

Except for the requirements of FG.4.3.1 a) and b), after the corresponding denominator is increased last time, if the cumulative mileage of the vehicle is at least 800 km or the engine accumulates running at least 750 minutes, the corresponding denominator increases in at least one driving cycle. After reporting to the competent department of ecological environment under the State Council, the conditions for increasing the denominator of DPF may be based on the accumulated mileage of the vehicle or the cumulative running time of the engine set by the manufacturer. The manufacturer must provide technical data such as test data, such as the average time of DPF regeneration cycle or the cumulative mileage of the vehicle.

**FG.4.3.2.6 Dedicated denominator for oxidation catalyst**

Except for the requirements of FG.4.3.1 a) and b), if the command time of a DPF regeneration event is more than or equal to 10 s, the denominator of the oxidation catalyst for DPF active regeneration is increased in at least one driving cycle.

**FG.4.3.2.7 Hybrid dedicated denominator (reserved)**

**FG.4.4 Increase requirements for general denominator**

The general denominator shall be incremented within 10s if and only if the following conditions are met within a single driving cycle:

a) The cumulative time since the cycle started is more than or equal to 600 s, while satisfying:

   1) The altitude is lower than 2500 m;

   2) Ambient temperature is more than or equal to 266K (-7 °C)

   3) Ambient temperature is less than or equal to 311K (38 °C)

b) The engine has a cumulative running time at a speed of 1150 r/min or above is more than or equal to 300 s under the conditions of FG.4.4 a); or as an alternative to the 1150 r/min speed, the manufacturer may choose to operate the engine at 15% of the calculated load or above or operate the vehicle at a speed of 40 km/h or above.

c) Under the condition of FG.4.4 a), the vehicle continuously idles (the driver releases the accelerator pedal, the speed of the vehicle is less than or equal to 1.6 km/h, the engine speed is lower than or equal to the speed of

In any other case, the general denominator's counting operation cannot be interrupted.

### FG.5 Tracking and recording requirements for in-use monitoring performance data

For the monitoring function group as listed in FG.7, the OBD system shall separately track the numerator and denominators for each monitoring function of this group as listed in the Annex FC of Appendix F.

Simply report the corresponding numerator counter and denominator values for the particular monitor which has the minimum IUPR ratio.

If two or more specific monitoring functions have the same ratio, it shall report the corresponding numerator and denominator of the monitoring function with the maximum denominator in the group.

In order to determine the minimum ratio of the monitoring function group indiscriminately, only the monitoring specifically mentioned in this group of monitoring functions is considered (for example, when determining the monitoring function as listed in "SCR" in Annex FC.3, the NOx sensor shall be considered in the "exhaust sensor group" of the monitoring function, not in the "SCR" group of the monitoring function).

The OBD system shall also track and report the general denominator and the ignition cycle counter.

Note: According to FG.3.1.1, the manufacturer is not required to separately track and report the numerator and denominators of the continuously running monitoring function through the software algorithm of the OBD system.

### FG.6 Storage and communication requirements of in-use monitoring performance data

Communication of in-use monitoring performance data is a new application case, which is not included in three application cases for determining the possibility of failure.

#### FG.6.1 Information of in-use monitoring performance data

The information related to the in-use monitoring performance data as recorded by the OBD can be obtained offline according to FG.6.2.

This information shall provide the in-use monitoring performance data to the competent department of ecological environment under the State Council.

The OBD system shall provide all information to the external IUPR test equipment (according to the standards specified in Annex FH of Appendix F)

# Appendix G

## (Normative)

### Requirements for proper operation of the NOx control system

### G.1 Overview

This Appendix specifies the technical requirements for the proper implementation of NOx control measures, including the requirements for vehicle which needs to use reagent to reduce emissions.

### G.2 General requirements

All engine systems within the scope of this Appendix shall be designed, manufactured, installed to ensure that the requirements of this Appendix are met during the service life and under normal conditions of use. For this reason, deterioration of performance and monitoring system's monitoring performance of engines that exceed the applicable useful life cycle as described in 6.6 of this standard is acceptable.

#### G.2.1 Type test materials

**G.2.1.1** The manufacturer shall submit a complete description of the functionality of the engine system which covers the requirements of this standard, in the form of Appendix GA.

**G.2.1.2** In type test, the manufacturer shall specify the consumption characteristics of all reagents in any emission control system. The documentation shall also include the type, concentration (if applicable), pressure of use (if applicable), temperature conditions of use, internationally relevant standards on the reagent.

**G.2.1.3** At the same time when the manufacturer proposes a type test, submit a functionality description text of the driver alert system as described in G.4 and the drivability limit system as described in G.5 in details.

**G.2.1.4** When a manufacturer proposes a type test for an engine or engine family as an independent technical unit, it shall include documents complying with the requirements of A.3.5 of this standard, to ensure that both road or non-road vehicles can meet the requirements of this standard. The documents shall contain the following information:

a) Includes detailed technical requirements for all engine system monitoring, activation of alert and drivability limit system that meet the requirements of this standard.

for 72 hours to reduce the reagents to the required temperature or until the reagent freezes (if using liquid reagent).

**G.2.3.2.2.2** After the cold dipping is completed according to G.2.3.2.2.1, the engine shall be idling for 10 ~ 20 minutes under the environmental conditions of 256K (-17 °C) ~ 266K (-7 °C), after which it is running at a load of not more than 40% for not more than 50 minutes.

**G.2.3.2.2.3** After the completion of the test procedures of G.2.3.2.2.1 and G.2.3.2.2.2, the reagent dosing system shall be capable of normal operation.

**G.2.3.2.2.4** After reporting to the competent department of ecological environment under the State Council, the test requirements of G.2.3.2.2 may be completed in a low temperature warehouse equipped with an engine dynamometer or a chassis dynamometer or at an automobile test site.

**G.2.3.3 Non-heating reagent tanks and dosing systems**

**G.2.3.3.1** If there is no reagent supply under the ambient conditions ≤ 256K (-17 °C), the driver alert system shall be activated as required by G.4.

**G.2.3.3.2** If the vehicle is running without reagent supply within 70 minutes after the vehicle is started under ambient conditions ≤ 256K (-17 °C), the severe drivability limit system shall be activated according to G.5.4.

**G.2.4** When a liquid reagent is used, each individual reagent tank on the vehicle shall be equipped with a reagent sampling device for sampling. The sampling operation shall not require any information that is not on the vehicle. The sampling device shall be easy to sample without the need for specialized tools or equipment. It is not a special tool or equipment to lock the corresponding sampling device by the use of the key or system equipped with the vehicle.

**G.3 Maintenance requirements**

**G.3.1** The manufacturer shall provide the new vehicle or engine owner with instructions on the emission control system and proper operation as prepared according to this standard.

**G.3.2** The instruction manual shall indicate that when the vehicle's emission control system is not working properly, the driver alert system will prompt the driver to have a failure. If the alert is continuously ignored, the drivability limit system will be activated and the vehicle will not work properly.

**G.3.3** The instruction manual shall specify the requirements for proper use and maintenance of the vehicle, to ensure its emission performance, including proper use of reagents under appropriate conditions.

**G.3.4** Instruction manual shall indicate whether the vehicle user is required to

an audible alert component to alert the driver. It allows the driver to eliminate audible alerts.

**G.4.5** The driver alert system shall be activated as required by G.6.2, G.7.2, G.8.4, G.9.3.

**G.4.6** When the conditions under which the driver alert system is activated no longer exist, it shall be deactivated. If the activation conditions are not corrected, the driver alert system cannot be automatically deactivated.

**G.4.7** When an alert signal providing important safety information occurs, it may temporarily interrupt this alert system.

**G.4.8** On rescue vehicles, military vehicles, civil defense vehicles, fire engines and armed vehicles that maintain public order, it allows the presence of equipment that can impair visual alerts as generated by the alert system.

**G.4.9** Annex GB specifies the activation and deactivation methods of the driver alert system.

**G.4.10** As part of the type test of this standard, the manufacturer shall verify the operation of the driver alert system according to the provisions of Annex GA.

**G.5 Drivability limit system**

**G.5.1** Vehicles shall include a two-stage drivability limit system, namely a primary drivability limit system (performance limit) and a severe drivability limit system (effectively limiting vehicle operation).

**G.5.2** The drivability limit system is not applicable to first-aid, military, civil defense, firefighting, and armed vehicle engines or vehicles that maintain public order. The permanent deactivation setting of the drivability limit system can only be done by the engine or vehicle manufacturer.

**G.5.3 Primary drivability limit system**

**G.5.3.1** The primary drivability limit system reduces the maximum output torque between the engine's maximum torque speed and the governor cut-off starting speed to 75% of the external characteristic torque as required by the Annex GC. After the primary drivability limit system is activated, the torque in the speed section below the engine's peak torque speed cannot exceed the peak torque after the torque limit.

**G.5.3.2** When the activation conditions for primary drivability limit system described in G.6.3, G.7.3, G.8.5, G.9.4 are met, the primary drivability limit system shall be activated immediately after the first stop of the vehicle.

Note: When the vehicle decelerates to zero km/h, the vehicle can be regarded

### G.6.1 Reagent indicator

The vehicle shall have a special indicator installed on the dashboard to inform the driver of the reagent inventory of the reagent storage tank. The indicator shall indicate at least the reagent inventory continuously and shall indicate the amount of reagent available when the driver alert system as described in G.4 is activated. The indicator can be displayed in analog or digital form, telling the amount of reagent inventory as a percentage of the tank capacity, or the amount of reagent remaining, or estimating the mileage that the vehicle can continue to travel normally.

The reagent inventory indicator shall be located near the fuel level indicator.

### G.6.2 Activation of driver alert system

**G.6.2.1** According to G.4, the driver alert system shall be activated when the reagent inventory is less than 10% of the storage tank capacity, or less than the higher storage tank capacity ratio as specified by the manufacturer.

**G.6.2.2** The alert as given by the alert system shall clearly prompt the driver that the reagent inventory is relatively low. If an alert message display system is designed, it shall display an alert of lower reagent inventory (e.g., “low urea level”, “low AdBlue level” or “low reagent inventory”).

**G.6.2.3** The driver alert system does not need to be continuously activated at the beginning. However, when the reagent inventory approaches the lower tank inventory setting and when the activation condition for drivability limit system is approached, the activation prompt shall tend to be strong and finally it is continuously activated. The manufacturer shall, at another lower inventory of the reagents (defined by manufacturer), inform the driver by the alert system in the strongest warning mode, at this time, it shall be easier to attract the driver's attention as compared with the activation of the drivability limit system as described in G.6.3.

**G.6.2.4** The continuous alert function shall not be easily prohibited or ignored. However, it may be temporarily interrupted due to other important safety-related information. The alert system includes an information display system that shall display clear information (e.g., “Add urea”, “Add AdBlue”, or “Add reagent”).

**G.6.2.5** Unless the reagents are re-added to the reagent inventory that deactivates the driver's alert system, the driver alert system cannot be turned off.

### G.6.3 Activation of drivability limit system

**G.6.3.1** If the reagent inventory is less than 2.5% of the nominal full capacity or a higher value set by the manufacturer, the primary drivability limit system as

**G.7.3.1** If, after the driver alert system is activated, the quality of the reagent has not been corrected within 10 hours of continuous running of engine, the primary drivability limit system as described in G.5.3 shall be enabled and subsequently activated as required.

**G.7.3.2** If, after the driver alert system is activated, the quality of the reagent has not been corrected within 20 hours of continuous running of engine, the severe drivability limit system as described in G.5.4 shall be enabled and subsequently activated as required.

**G.7.3.3** If the failure occurs repeatedly, it shall, according to the provisions of Annex GB, reduce the operating hours before the drivability limit system is activated.

**G.8 Monitoring of reagent consumption and nozzle motion**

**G.8.1** Vehicles shall include methods for determining reagent consumption, nozzle injection interruption, and providing off-line consumption information.

**G.8.2** Reagent consumption and nozzle action counter

**G.8.2.1** It shall have dedicated counters for reagent consumption (reagent consumption counter) and calculation of nozzle action (nozzle action counter), which can record the engine's running time at abnormal reagent consumption and/or interruption of reagent nozzle.

**G.8.2.2** Annex GB describes the requirements and principles for the activation and deactivation of the reagent consumption counter and nozzle counter.

**G.8.2.3** It shall, according to the standard method as specified in Annex GE, obtain the information of the reagent consumption counter and the nozzle counter.

**G.8.3 Monitoring conditions when using liquid reagents such as urea**

**G.8.3.1** The system shall monitor single or cumulative reagent consumption and nozzle motion. When urea is used as the reagent, the maximum monitoring cycle time for insufficient reagent consumption is 5 hours or equivalent to a duration of at least 2 L of reagent consumption, whichever is longer.

**G.8.3.2** When the reagent consumption is monitored by at least one of the following parameters:

a) The inventory of reagents in the vehicle's reagent tank, or

b) As permitted by the technology, it shall monitor the reagent flow or injection amount as close as possible to the reagent injection position of the emission aftertreatment system,.

proof system:

a) EGR valve stuck;

b) The tamper-proof monitoring system as described in G.9.2.1 fails.

**G.9.2 Monitoring requirements**

**G.9.2.1** Tamper-proof monitoring systems shall monitor circuit faults, as well as the failure to diagnose the other failures as mentioned from G.6 to G.8 due to the removal of any sensor or any tampering that would cause sensor failure (component monitoring).

A simple list of sensors that affect diagnostic capabilities includes sensors that directly measure NOx concentrations, reagent quality sensors, environmental sensors, sensors that monitor reagent feed actions, reagent inventory, or reagent consumption.

**G.9.2.2 EGR valve counter**

**G.9.2.2.1** Use a special counter to monitor the EGR valve stuck failure. The EGR valve counter shall record any engine operation hours after the failure related to EGR valve stuck is confirmed and active.

**G.9.2.2.2** Annex GB describes the criteria and mechanisms for activation and deactivation of EGR valve counters.

**G.9.2.2.3** It shall use the standard method as specified in Annex GB to obtain the information on the EGR valve counter.

**G.9.2.3 Monitoring system counter**

**G.9.2.3.1** Each failure to be monitored as mentioned in G.9.1(b) shall have a special counter. The monitoring system counter shall record the running hours of engine after the failure related to monitoring system is confirmed and active. It is allowed to treat multiple failures in groups and use a single counter to monitor this group of failures.

**G.9.2.3.2** Annex GB describes the criteria and related principles for activation and deactivation of monitoring system counter.

**G.9.2.3.3** It shall use the standard method as specified in Annex GE to obtain the information on the monitoring system counter.

**G.9.3 Activation of driver alert system**

When the failure as specified in G.9.1 occurs, it shall activate the driver alert system and prompt the driver for urgent repairs. When the alert system contains

**GA.3.2.2.1** If the activation of the alert system is verified by the quantitative dosing interruption, the manufacturer shall also provide additional algorithms, functional analysis and previous test results to the competent department of ecological environment under the State Council, to prove the abnormal consumption of the reagents due to other reasons may also activate the alert system.

**GA.3.2.3** According to the provisions of G.9, in order to verify the failure of the alert system verification due to tampering, it shall follow the requirements below to select the test failure:

**GA.3.2.3.1** The manufacturer shall provide a list of these potential failures to the competent department of ecological environment under the State Council.

**GA.3.2.3.2** The competent department of ecological environment selects the test failure from the list of GA.3.2.3.1.

**GA.3.3 Verification**

**GA.3.3.1** To verify the activation of the alert system, each fault as mentioned in GA.3.1 shall be tested separately.

**GA.3.3.2** During the test, there shall be no other failure than those being verified during the test.

**GA.3.3.3** Before the start of the test, all diagnostic trouble codes (DTC) shall be cleared except for the permanent fault code.

**GA.3.3.4** According to the requirements of the manufacturer, after reporting to the competent department of ecological environment under the State Council, the test failure can be simulated.

**GA.3.3.5** Except for the failure of lack of reagents, once the failure has been triggered or simulated, the failure shall be tested according to F.7.1.2.2.

**GA.3.3.5.1** When the selected diagnostic trouble code is displayed as "confirmed and active" state, the testing procedure shall stop.

**GA.3.3.6** To verify the activation of the alert system in case of lack of the reagent, it shall also follow the pre-judgement of the manufacturer, run the engine for one or more operation processes.

**GA.3.3.6.1** When conducting the verification test, the inventory of reagents shall be the level agreed by both the manufacturer and the competent department of ecological environment, but it shall be not less than 10% of the normal capacity of the container.

**GA.3.3.6.2** If the following conditions are met at the same time, the alert system

c) The activation of the primary drivability limit system requires a limit torque. This verification can be done in conjunction with the engine performance test required by this standard. No separate torque measurement is required when performing the verification of drivability limit system. It shall follow the requirements of G.5 to verify the speed limit when the severe drivability limit system is activated.

**GA.4.4** In addition, for failures in G.7, G.8 or G.9 that are not subject to test verification according to GA.4.1 and GA.4.2, the manufacturer shall also verify the activation of the drivability limit system at the time of the failure. This additional verification can be carried out by submitting technical documents based on calculations, functional analysis and previous test results to the competent department of ecological environment under the State Council.

**GA.4.4.1** These additional verifications are proof to the competent department of ecological environment under the State Council that the correct torque limiting mechanism is already included in the engine ECU.

**GA.4.5 Verification of primary drivability limit system**

**GA.4.5.1** When the failure as selected by the competent department of ecological environment is detected, the alert system or the “continuous” alert system is activated, then the verification of the primary drivability limit system is started.

**GA.4.5.2** During the activation of the primary drivability limit system caused by the failure of the missing reagents, the engine shall continue to operate, until the reagent inventory reaches 2.5% of the nominal capacity of the container or the nominal value as determined by the manufacturer according to G.6.3.1. The primary drivability limit system below the reagent inventory setting shall be activated.

**GA.4.5.2.1** After reporting to the competent department of ecological environment under the State Council, regardless of whether the engine is running or shut down, the manufacturer can extract the reagents from the container to simulate the continuous operation of the engine.

**GA.4.5.3** In the activation of the primary drivability limit system activated by the failure of the missing reagents, the engine shall be according to the operating time in Table GB.2 or the operating time as specified by the manufacturer, until the relevant counter reaches the value at which the primary drivability limit system is activated.

**GA.4.5.4** After each verification test required by GA.4.5.2 and GA.4.5.3, the manufacturer shall prove to the competent department of ecological environment under the State Council that the engine ECU has activated the torque limiter, then the verification primary drivability limit system is complete.

the requirements in this Appendix for the test of severe drivability limit system when complying with G.2.1.4 on ensuring the operation of the vehicle along road or other appropriate locations.

**GA.5.3** If the competent department of ecological environment is dissatisfied with the correct verification conclusions of the severe drivability limit system as provided by the manufacturer, the competent department of ecological environment may request verification on a representative vehicle model, to confirm the correct operation of the severe drivability limit system. This verification shall be performed according to the requirements of GA.5.4.

**GA.5.4 Additional verification for whole vehicle on the impact of activation of severe drivability limit system**

**GA.5.4.1** When the competent department of ecological environment is dissatisfied with the correct verification conclusion of the severe drivability limit system as provided by the manufacturer, it shall perform this additional verification at the request of the competent department of ecological environment. After reporting to the competent department of ecological environment under the State Council, it shall perform this verification as soon as possible.

**GA.5.4.2** After reporting to the competent department of ecological environment under the State Council, the manufacturer shall select from the failures of G.6, G.7, G.8 or G.9, introduce or simulate the failure on the engine system.

**GA.5.4.3** The manufacturer shall have the drivability limit system in a state where the primary drivability limit system has been activated but the severe drivability limit system has not been activated.

**GA.5.4.4** The vehicle shall continue to operate, until the counter value associated with the selected failure reaches the operating hours as specified in Table GB.2, or the reagents are used up or reach the inventory of 2.5% of the nominal volume of the container as specified by the manufacturer, the shall activate the severe drivability limit systems.

**GA.5.4.5** If the manufacturer adopts the “limit after restart” strategy as mentioned in G.5.4.1, the vehicle will run until the end of the current operation, during which the vehicle speed may exceed 20 km/h. After the vehicle is restarted, the speed shall be limited to 20 km/h.

**GA.5.4.6** If the manufacturer adopts the “limit after refueling” strategy as mentioned in G.5.4.2, when the vehicle's fuel tank has sufficient remaining capacity to meet the refueling amount to the value as specified in G.5.4.2, the vehicle shall cover only a small distance as specified by the manufacturer. The running speed of the vehicle before refueling can exceed 20 km/h, but after the added amount reaches the value as specified in G.5.4.2, the speed shall be

is OFF.

**GB.2.2.1.3** When clears failure information including DTCs, any failure-related counters and the non-deletable items as specified in Appendix G shall not be deleted.

**GB.3 Principles of activation and deactivation of driver's drivability limit system**

**GB.3.1** After the alert system is activated, the counter associated with this type of failure also reaches the value as specified in Table GB.2, the drivability limit system shall be activated.

**GB.3.2** When no failure has been detected that causes the drivability limit system to activate, or if the DTCs information associated with the failure activation and failure has been cleared by the scan-tool or maintenance tool, the driver's drivability limit system shall be deactivated.

**GB.3.3** After the evaluation of the reagent inventory in the reagent tank, it shall follow the provisions of G.6 (reagent inventory) to immediately activate or deactivate the driver alert system or drivability limit system. However, the principle of activation and deactivation shall not depend on any related DTC state.

**GB.4 Counter mechanism**

**GB.4.1 Overview**

**GB.4.1.1** According to the requirements of Appendix G, the system shall include at least 5 counters for recording the number of hours the engine is running when the system detects the following failures:

a) The quality of the reagents is incorrect;

b) Abnormal consumption of reagents;

c) Interruption of the dosing of reagents;

d) EGR valve stuck;

e) Monitoring system failure as defined in G.9.1(b) and emission aftertreatment device's type A failure as defined in F.4.2.3.

**GB.4.1.2** Each counter shall be accumulated every hour, until the maximum value that can be displayed by the 2-byte counter. Unless there is a condition that allows the counter to reset to zero, the value shall be kept frozen.

**GB.4.1.3** Manufacturers may use single or multiple monitoring system counters,

# Annex GE
# (Normative)
# Access to “NOx control information”

## GE.1 Overview

This Annex specifies the technical requirements for information access to check the correct operating state of the vehicle's NOx control system (NOx control information).

## GE.2 Access method

**GE.2.1** It only allows the provision of “NOx control information” according to the standards used to extract engine system information from the OBD system.

**GE.2.2** Access to “NOx control information” cannot rely on decoded information, other devices or methods that can only be obtained from the manufacturer or the supplier of the manufacturer. Interpretation of this information shall not require any dedicated or special decoding information, unless such decoded information is publicly available.

**GE.2.3** It shall adopt the method of obtaining the OBD information as specified in F.4.7.3 and shall be able to obtain all “NOx control information” from the system.

**GE.2.4** It shall use the test equipment for obtaining OBD information as specified in F.4.7.3 and it shall be able to obtain all “NOx control information” from the system.

**GE.2.5** “NOx control information” shall be accessible for “read-only” access (i.e., no data is cleared, reset, deleted, modified).

## GE.3 Information content

**GE.3.1** “NOx control information” shall contain at least the following information:

a) Vehicle VIN (vehicle identification number);

b) State of alert system (activated; nonactivated);

c) State of primary drivability limit system (activated; enabled; nonactivated);

d) State of severe drivability limit system (activated; enabled; nonactivated);

e) The number of engine warm-up cycles and operating hours after the “NOx control information” is cleared by self-maintenance or repair;

f) Type of counters associated with this Appendix (reagent mass, reagent consumption, reagent metering-dosing system, EGR valve, type A failure

# Appendix H

## (Normative)

### Durability of engine system

**H.1 Overview**

This Appendix specifies the test procedures for specifying the deterioration factor and selecting the engine for the shortest mileage test to determine the deterioration factor. According to the requirements of H.3.7, the deterioration factor is applied to the emission value as measured in Appendix C.

**H.1.1** This Appendix specifies the maintenance schedules which have or have not relation to the emissions of the engine during the shortest mileage. These maintenances shall comply with the maintenance requirements of the in-use engine and inform the owner of the new engine/vehicle.

**H.2 Selection of test engine for determining the deterioration factor within the useful life cycle**

**H.2.1** It shall, from the engine family which complies with the requirements of this standard, select engine for emission test, to obtain the deterioration factor over the useful life cycle.

**H.2.2** Based on the type of emission aftertreatment system used, engines of different engine families may be combined into the same engine-aftertreatment system family. In order to combine the engines of different cylinder numbers and different cylinder configurations, but same technical specifications and installation methods of emission aftertreatment system into one engine-aftertreatment system family, the manufacturer shall provide information to prove the emission reduction of these engine systems is similar.

**H.2.3** According to the provisions of clause H.2.2, the manufacturer shall select a representative engine in the engine-aftertreatment system family to carry out the durability operation test as defined in Appendix H.3.2, inform the competent department of ecological environment under the State Council before the start of the test.

**H.2.3.1** If the competent department of ecological environment under the State Council considers that another engine can better represent the worst emission level of the engine-aftertreatment system family, the competent department of ecological environment under the State Council may select another engine for durability test.

**H.3 Determination of the deterioration factor within the useful life**

regeneration process is resumed.

**H.3.3.2.2** During the durability test, the engine shall be maintained according to the requirements of H.4.

**H.3.3.2.3** During the durability test, it may perform unplanned maintenance of the engine or vehicle, for example: OBD system detects a failure that causes the malfunction indicator (MI) to be activated.

**H.3.4 Report**

**H.3.4.1** All emission tests (hot WHTC and WHSC) results during the durability test shall be disclosed. If there is any invalid emission test, the manufacturer shall explain the reason for the invalidity. In this case, it shall carry out a set of hot WHTC and WHSC tests within the next 100 hours.

**H.3.4.2** Records of all emissions testing and maintenance related information involved during the durability test shall be retained. The information and the results of the emission test shall be submitted to the competent department of ecological environment under the State Council.

**H.3.5 Determination of deterioration factor**

**H.3.5.1** During the durability test, the results of each of the emissions as measured from the hot WHTC and WHSC tests at each test point are subject to the “least squares method” to establish a linear regression equation. The measurement result shall be one more than the decimal place of each emission limit as shown in 6.3 of this standard. According to the requirements of H.3.2.1.4, if only one test cycle (hot WHTC or WHSC) is used in the intermediate test point, whilst two test cycles are used at the beginning and end of the durability test, the regression analysis shall be carried out based on the results of the test cycle which are carried out at all points.

**H.3.5.2** Under the requirements of the manufacturer, and after reporting to the competent department of ecological environment under the State Council, it may use the nonlinear regression analysis.

**H.3.5.3** It shall be based on the regression equation to calculate the emission value of each pollutant at the starting point of the durability test and the end of the useful life. If the durability test mileage is shorter than the useful life, it shall, based on the regression equation as determined according to clause H.3.5.1, use the interpolation method to determine the emission value at the end of the useful life.

**H.3.5.4** The deterioration factor of each pollutant is the ratio of the emission at the end point of useful life to the emission at the starting point of the durability test (multiplied deterioration factor). At the requirements of the manufacturer

In order to ensure the normal operation of the durability test, it shall follow the maintenance manual of the manufacturer to conduct maintenance.

**H.4.1 Planned maintenance items related to emissions**

**H.4.1.1** The mileage or equivalent time interval for emission-related planned maintenance during the durability test shall be as described in the maintenance manual provided by the manufacturer to the vehicle or engine user. If necessary, it may update the maintenance schedule during the durability test. If a certain maintenance has been performed on the engine during the durability test, the maintenance item is not allowed to be removed from the updated maintenance plan.

**H.4.1.2** The manufacturer shall detail the schedule for adjustment, cleaning and maintenance (if required) of the following components within the durability test:

a) Exhaust gas recirculation system, including associated filters, coolers;

b) Crankcase ventilation, if applicable;

c) Oil nozzle (only cleaning);

d) Oil injector;

e) Turbocharger;

f) Related sensors and actuators;

g) Particulate matter aftertreatment system (including related components);

h) deNOx system;

i) exhaust gas recirculation systems, including associated control valves and piping;

j) Any other emission aftertreatment system.

**H.4.1.3** The planned critical maintenance items related to emissions shall be the same as those required by the manufacturer's vehicle maintenance instructions.

**H.4.2 Change of planned maintenance items**

**H.4.2.1** During the durability test, if the manufacturer needs to carry out a new maintenance item, it shall promptly report to the competent department of ecological environment under the State Council, submit the materials to explain the new maintenance plan and the mileage (time) of the maintenance interval. The new maintenance items shall also be changed in the vehicle's maintenance instructions.

# Appendix I

## (Normative)

### Requirements and inspection of production consistency assurance

### I.1 Overview

To ensure that the emissions characteristics of a mass-produced vehicle or engine are consistent with the model or engine model that has been type-tested, the manufacturer shall have a production consistency assurance system, including a quality management system and a production consistency assurance plan.

### I.2 Quality management system

**I.2.1** The manufacturer shall establish a quality assurance system, to effectively control the planning and procedures of the production process, to ensure the production consistency control capability, thereby ensuring that the emission control capability of the mass-produced vehicle models or engine models is consistent with the type-tested vehicle models or engine models.

**I.2.2** The quality management system of the manufacturer shall meet the requirements of GB/T 19001 and have an effective quality assurance system certificate, wherein the requirements for relevant design and development are exempted.

**I.2.3** The engine manufacturer shall provide the whole vehicle manufacturer with the installation instructions for the complete engine and its aftertreatment assembly. The whole vehicle manufacturer shall assemble according to the installation instructions of the engine and its aftertreatment assembly, to ensure the correct installation of the engine and its aftertreatment system on the whole vehicle.

**I.2.4** The manufacturer shall submit relevant materials and documents related to the quality management system as described in I.2.1 to I.2.3 to the competent department of ecological environment under the State Council, including:

- Quality assurance system certificate;

- Plans and procedures for effective control of the production process;

- Installation instructions for the engine and its aftertreatment assembly.

**I.2.5** Any revisions to the validity and scope of the quality assurance system certificate shall be reported to the competent department of ecological environment under the State Council. Meanwhile it shall submit the descriptions

**I.4.1** The competent department of ecological environment may, as needed, inspect the production conformity assurance plan as implemented by the manufacturer.

The inspection contents may include the quality management system as specified in I.2 and the production consistency assurance plan as specified in I.3 as well as their implementation.

**I.4.2** At the request of the competent department of ecological environment, the manufacturer shall provide test or inspection records and production records.

**I.4.3** The competent department of ecological environment may randomly take samples and conduct inspections in laboratories meeting the requirements of this standard. The tests or inspections may include some or all of the test items as specified in this standard. The inspection of the engine shall be carried out according to I.4.4 ~ I.4.6. The inspection of the whole vehicle shall be in accordance with the provisions of clause 9.3.

**I.4.4 Inspection of engine's pollutant emissions**

**I.4.4.1 Sampling and qualification determination**

**I.4.4.1.1** It shall randomly take three engines from the batch products. The manufacturer shall not make any adjustments to the extracted engines.

**I.4.4.1.2** The competent department of ecological environment may conduct all or part of the item tests as specified in 6.3.1 or 6.4.1 for the engine. The measured gaseous pollutants and particulate matter emissions of the engine shall be corrected (except for WNTE tests) by the corresponding deterioration factor (DF), to meet the limit requirements as specified in Table 2 or Table 3.

**I.4.4.1.3** The criteria for determining the production consistency by the competent department of ecological environment are as follows:

- If the emission results of various pollutants of the three engines are less than 1.1 times the limit, meanwhile the average value is less than the limit, then the production consistency inspection is judged to be qualified.

- If the emission results of a certain pollutant in any of the three engines is not less than 1.1 times the limit, or the average value is not less than the limit, the production consistency inspection is judged to be unqualified.

**I.4.4.2 Selection and preparation of engine**

**I.4.4.2.1** The test engine shall try to select the engine that was recently produced.

**I.4.4.2.2** At the request of the manufacturer, it may activate and run the

requirements of K.7.3.

**I.4.5.2** If the OBD scan-tool is working properly according to Appendix F but cannot read OBD information in an appropriate manner, the engine is considered to be unqualified.

**I.4.5.3** It shall follow the requirements of Annex BA to carry out the WHSC test, to verify whether the ECU torque signal complies with the requirements of K.7.3 and K.7.4.3.

**I.4.5.4** If the test equipment does not comply with the relevant requirements of the Appendix of GB/T 17692, the measured torque shall be corrected according to the correction method as specified in Appendix C.

**I.4.5.5** If the calculated torque is within the tolerance as specified in K.7.4.3, the ECU torque signal is considered to be sufficiently consistent.

**I.4.5.6** The manufacturer shall perform the ECU information acquisition and consistency inspection required for the in-use vehicle inspection of each engine model in each engine family in a conventional manner.

**I.4.5.7** When required by the competent department of ecological environment, the manufacturer shall provide the survey results to the competent department of ecological environment.

**I.4.5.8** The manufacturer shall randomly select 1 ~ 3 prototypes from the same model of engines to perform the tests as described in I.4.5.1 ~ I.4.5.4, to verify the acquisition or consistency of engine ECU information for batch products.

**I.4.5.9** If one of the three engines does not meet the requirements, it is determined that the production consistency inspection is unqualified.

**I.4.6 Inspection of on-board diagnostic system (OBD)**

**I.4.6.1** Randomly take 1 ~ 3 engines from mass-produced engines to carry out test according to Appendix F. Prior to the test, the aftertreatment system of the taken prototype may be activated for running for up to 30 hours.

**I.4.6.2** If one of the three engines randomly selected does not meet the requirements of 6.8, the production consistency inspection is judged to be unqualified.

**I.4.7** If during the inspection process, the production consistency is found to be inconsistent, the manufacturer shall take all necessary measures to restore the production consistency as soon as possible. It shall submit a report of the corrective measures to the competent department of ecological environment under the State Council and disclose the information.

**J.2.2.7** All components of emission control system on the vehicle shall be consistent with the information disclosed for the vehicle model.

**J.2.2.8** The information collected by the manufacturer shall be sufficient, to assess whether the in-use vehicle meets the normal conditions of use. When selecting the source of prototype, it shall consider the differences in environmental conditions, average road speed, driving along urban/highway.

**J.2.2.9** When selecting the region of a prototype, the manufacturer can select the vehicle from the region that is considered to be the most representative. In this case, the manufacturer shall prove to the competent department of ecological environment under the State Council that the selection is representative (e.g., the annual sales volume of a certain vehicle family in the region is the largest in the market).

**J.2.3** The number of samples used for self-inspection of in-use compliance shall comply with the provisions of JA.2 in Annex JA.

**J.2.4** After the completion of the type test, the manufacturer shall, within 18 months after the first registration of the vehicle which is equipped with this family of engine, begin self-inspection of the in-use compliance of the vehicle in which the family of engine is installed.

**J.2.5** The manufacturer shall submit the self-inspection report for in-use compliance at least every two years and disclose the information. The self-inspection target of the engine manufacturer shall be the same engine model (family). The self-inspection target of the whole vehicle manufacturer is the same vehicle model (vehicle family).

**J.2.6** After 5 years of out-of-production of engines, the manufacturer may stop submitting the self-inspection report for in-use compliance. If the annual output of an engine which belongs to a certain engine model (family) is less than 300 sets, after reporting to the competent department of ecological environment under the State Council, the manufacturer may reduce the number of vehicles for the self-inspection of in-use compliance.

**J.2.7** The self-inspection report for in-use compliance shall meet the requirements of Annex JB.

**J.2.8** When required by the competent department of ecological environment, the manufacturer shall provide relevant information to the competent department of ecological environment with the relevant information on the OBD failure as recorded during the claim in the warranty period, the repair and maintenance in the warranty period. The data shall detail the frequency and cause of component and system failures associated with emissions.

**J.2.9** The manufacturer shall provide the selection criteria for special vehicles

**J.5.2** Corrective measures shall be applied to all in-use engines or vehicles to the same vehicle model (vehicle family) and extended to the engine models (families) and vehicle models (families) that may be affected by the same defects. The plan for corrective measures as proposed by the manufacturer shall be implemented after filing with the competent department of ecological environment under the State Council and the relevant competent department of ecological environment at provincial level.

**J.5.3** The manufacturer shall provide all the materials related to the corrective measures, keep records of environmental protection recalls, repairs or alterations of each engine or vehicle, regularly submit progress report of corrective measures to the competent department of ecological environment under the State Council and the relevant competent department of ecological environment at provincial level.

**J.5.4** The plan of corrective measures shall include the contents of this clause. The manufacturer shall assign a unique identification name or number to the plan of corrective measures.

**J.5.4.1** The plan of corrective measures shall include a description of each relevant vehicle model (engine model).

**J.5.4.2** Description of special improvements, replacements, repairs, corrections, adjustments or other changes taken to achieve compliance with the vehicle, includes the support data and introduction of techniques used by the manufacturer to determine special corrective measures for substandard engines (vehicles).

**J.5.4.3** The method and content of the corrective measures as notified by the manufacturer to the owner.

**J.5.4.4** If the manufacturer uses the correct maintenance or correct use as the conditions of repair in the plan of corrective measures, it shall detail the contents of the correct maintenance or correct use, explain the causes to use these conditions. It is not allowed to impose any maintenance or use conditions that are not related to corrective actions.

**J.5.4.5** In order to correct the non-compliance vehicle, the procedures to be followed by the owner shall include: the start date of the corrective action to be taken, the location of the repair shop and the time required to complete the repair.

**J.5.4.6** The method to ensure the supply of parts or systems as used by the manufacturer to ensure the completion of corrective measures, as well as the time to start supplying parts or systems.

**J.5.4.7** Guidance document provided to the repairman.

requirements:

**K.3.6.1.1** Dual-fuel engines or vehicles are required to subject to the PEMS test for the dual-fuel mode according to this Appendix.

**K.3.6.1.2** For Type 1B, 2B and 3B dual-fuel engines, an additional PEMS test shall be carried out on the diesel mode immediately before or after the PEMS test at dual-fuel mode. The basis for determining whether the vehicle is up to standard or not is:

a) If the PEMS test results of both the dual-fuel mode and the diesel mode are up to standard, the vehicle emission is determined to reach standard;

b) If any PEMS test result of either the dual-fuel mode or the diesel mode exceeds the standard, the vehicle emission is determined to exceed standard.

### K.3.7 Hybrid electric vehicle

**K.3.7.1** Hybrid electric vehicles shall be subjected to the PEMS test in the state of maximum fuel consumption mode according to the requirements of this Appendix. The vehicle shall have a visible fuel-only mode switch that is easy to switch to pure fuel mode and can operate normally in pure fuel mode (including idle speed), to facilitate the emission test. Meanwhile the position of switch shall be stated in the vehicle's operating instructions.

**K.3.7.2** Hybrid electric vehicles shall fully discharge the rechargeable energy storage system (power battery, supercapacitor, electromechanical flywheel, etc.) before the start of the test. The discharge may be carried out under the urban conditions under the maximum power consumption mode, until the energy storage device reaches the lowest state of charge.

**K.3.7.3** Hybrid electric vehicles shall meet the general requirements of this Appendix when conducting PEMS tests, such as environmental conditions, test routes, load ratios, fuel and reagents, etc. The cumulative work of the engine shall reach 4 ~ 7 times the WHTC cycle work of engine.

## K.4 Test conditions

### K.4.1 Environmental conditions

The test shall be carried out under environmental conditions that meet the following requirements:

The altitude at stage 6a is not higher than 1700 m. The altitude at stage 6b is not higher than 2400 m;

The ambient temperature shall not be lower than 266K (-7 °C), not more than

**K.5.1.2** The composition of the test route shall be close to the distribution of road running conditions during normal use of the vehicle.

**K.5.1.3** Vehicle's test route shall include the urban road, suburban road, highway. According to the type of vehicle, the specific distribution shall be according to K.5.2 to K.5.5, which allows the actual composition ratio to have a deviation of ± 5%. For some practical reasons, the manufacturers may also adjust the test conditions according to the actual situation, but the relevant situation shall be reported to the competent department of ecological environment under the State Council. The above three types of roads shall be distinguished according to the speed of the vehicle;

a) The test shall be carried out continuously based on the sequence of urban - suburban - highway. The first short mileage with a vehicle speed exceeding 55 km/h (refers to the driving process from the end of an idle speed to the starting point of the next idle speed) is recorded as the beginning of the suburb road (70 km/h for category $M_1$, $N_1$ vehicles). The first short mileage with a vehicle speed exceeding 75 km/h is recorded as the beginning of the highway (90 km/h for category $M_1$, $N_1$ vehicles);

b) Urban road: The average speed of vehicles is 15 ~ 30 km/h;

c) Suburban road: The average speed of vehicles is 45 ~ 70 km/h. The average vehicle speed is 60 ~ 90 km/h for category $M_1$, $N_1$ vehicles;

d) Highway: The average vehicle speed is > 70 km/h. The average vehicle speed is > 90 km/h for category $M_1$, $N_1$ vehicles.

**K.5.2** For category $M_1$, $N_1$ vehicles (except for vehicles subject to GB 18352.6), the test roads are composed of 34% urban roads, 33% suburban roads, 33% highways.

**K.5.3** For category $M_2$, $M_3$, $N_2$ vehicles (excluding urban vehicles), the test roads are composed of 45% urban road, 25% suburban road, 30% highway.

**K.5.4** For urban vehicles, the operational roads in the test are composed of 70% urban roads and 30% suburban roads.

**K.5.5** For category $N_3$ vehicles (excluding urban vehicles), the operational road during the test is composed of 20% urban road, 25% suburban road, 55% highway.

**K.5.6** The difference of the altitude between the starting point and the end point of the test shall not exceed 100 m, meanwhile the cumulative positive altitude increase of the test vehicle shall not exceed 1200 m/100 km. The calculation method of the cumulative altitude shall refer to Annex DH of GB 18352.6.

equipment cannot exceed the capacity of the vehicle's power supply system;

b) The power required by the test equipment does not increase the engine output by more than 1% of its maximum power.

**K.6.6.2** It may install additional portable energy sources (such as batteries, fuel cells, portable generators, etc.) instead of test vehicle's power supply. The external power source can be connected to the test vehicle's power system, but during the test, the vehicle power required by the test equipment shall not increase the engine's output power by more than 1% of its maximum power.

**K.6.7** The installation of PEMS equipment shall not affect the emissions and performance of the vehicle.

**K.6.8** It is recommended to carry out vehicle test under normal daytime traffic conditions.

**K.6.9** It shall, according to the provisions of KA.2.2, conduct data consistency inspection. If the competent department of ecological environment is not satisfied with the test result, it has the right to determine that the test is invalid.

**K.7 ECU data stream**

**K.7.1** If the vehicle ECU's preliminary inspection finds one of the following conditions, it determines that the vehicle is unqualified:

a) Vehicle has no communication interface of ECU data;

b) ECU data is lost;

c) It requires access via a non-standard data communication protocol;

d) Collection of ECU data may affect vehicle emissions or vehicle performance.

**K.7.2** For in-use vehicle testing, the calculated load (the percentage of engine torque to maximum reference torque and the maximum torque at engine speed), engine speed, engine's coolant temperature, transient fuel consumption, engine's maximum reference torque shall be mandatory data stream information, which is transmitted in real time through the OBD system at a frequency of not less than 1 Hz.

**K.7.3** The output torque can be estimated by the ECU built-in program by calculating the internally generated torque and friction torque.

**K.7.4** It requires verification of the validity and consistency of the ECU data stream in the test of in-use vehicle.

**K.8.3.1 Vehicle load**

Vehicle load should be selected for reproducible loads, it may use simulated loads. During the test, in stage 6a, the load of the vehicle shall be selected as 50% ~ 100% of the maximum load of the vehicle; in stage 6b, the load of the vehicle shall be selected as 10% ~ 100% of the maximum load. The maximum load refers to the maximum design loading mass as specified in GB/T 3730.2.

**K.8.3.2** OBD system inspection. Once any diagnosed fault has been resolved, it shall be recorded and submitted to the competent department of ecological environment.

**K.8.3.3** Replace fuel, lubricant and reagents, and any other items that need to be replaced.

**K.8.4 Installation of test equipment**

**K.8.4.1 Host unit**

Follow the operating requirements of the PEMS manufacturer to install the PEMS on the test vehicle, at a location which is minimally affected by the following external conditions:

a) Changes in ambient temperature

b) Changes in ambient atmospheric pressure

c) Electromagnetic radiation

d) Mechanical vibration

e) Background THC - If using an FID analyzer which uses air as oxidant gas (if applicable)

**K.8.4.2** Exhaust flow meter (EFM)

The exhaust flow meter shall be connected to the tailpipe of the test vehicle and its measurement range shall be matched to the range of possible exhaust flow during the test. EFM and all devices that adjust and connect the tailpipe shall not adversely affect the operation of the engine or emission aftertreatment system. If necessary, it may use a short flexible connector for connection, but the area of contact between the exhaust and the flexible connector shall be minimized, to avoid affecting test results at high vehicle speeds and high engine loads.

The length of straight tubes upstream and downstream the location where the exhaust flow meter's sensor is located are at least twice the diameter of the exhaust flow meter. It is recommended to install the exhaust flow meter behind

#### K.8.5.2 Cleaning of sampling system

To avoid system contamination, the PEMS sampling system shall be purged and cleaned up to the start of sampling according to the PEMS equipment's operating requirements.

#### K.8.5.3 Inspection and calibration of analyzer

It shall follow the operational requirements of the PEMS manufacturer to check the leakage of the sampling system.

It shall use the calibration gas which meets the requirements of CB.3.3 to calibrate and inspect the zero point and range of the analyzer according to the requirements of CB.3.3.

#### K.8.5.4 Cleaning of exhaust flow meter (EFM)

Prior to testing, it shall follow the operating requirements of PEMS manufacturer to purge the exhaust flow meter, to remove condensate and deposits from the pressure line and pressure measurement port.

### K.8.6 Emission test process

#### K.8.6.1 Test begins

PEMS shall start sampling before the vehicle starts, measure exhaust parameters and record engine and environmental parameters. At the beginning of the test, the engine's coolant temperature must not exceed 30 °C. If the ambient temperature is above 30 °C, the engine's coolant temperature at the start of the test must not exceed 2 °C above ambient temperature. When the engine's coolant temperature is above 70 °C, or when the coolant temperature changes less than 2 °C within 5 minutes, whichever comes first, but not later than 20 minutes after engine start, the test begins formally.

#### K.8.6.2 Test runs

During the test, it shall continue performing the exhaust sampling, measuring the emission parameters, recording the engine and environmental data. The engine can be shut down or restarted, but exhaust sampling shall continue throughout the test.

During the test, the analyzer's operating status is checked at least every 2 hours, to confirm that the analyzer is working properly. However, the data as recorded during the inspection shall be marked and not used for emission calculation.

#### K.8.6.3 Test ends

At the end of the test, it shall reserve sufficient time to ensure the response time

# Annex KA
# (Normative)
# Emission calculation for PEMS test

## KA.1 Overview

This Annex specifies the analytical calculation method for PEMS emission test results.

## KA.2 Emission calculation

The final test results shall be rounded off to one decimal place as indicated by the applicable emission standard, plus a significant number. The intermediate value of the final calculation result shall be allowed not to be rounded off.

### KA.2.1 Alignment of data

When calculating the mass emission, to reduce the time offset between signals, it shall follow the requirements of KA.2.1.1 ~ KA.2.1.4 to align the data as related to emission calculation.

#### KA.2.1.1 Analyzer data

It shall follow the procedures of KA.2.1.4 to reasonably align the data of the analyzer.

#### KA.2.1.2 Analyzer and EFM

It shall, according to the procedures of KA.2.1.4, properly align the analyzer data and EFM data.

#### KA.2.1.3 PEMS and engine data

It shall, according to the procedures of KA.2.1.4, properly align the PEMS data (analyzer and EFM) and the data in engine ECU.

#### KA.2.1.4 Improvement program of time alignment of PEMS data

The measurement data in Table KA.1 is divided into three categories:

a) Analyzer (concentration of NOx, CO, $CO_2$, PN (optional for gas-fueled vehicles), HC (optional), THC (optional for diesel vehicles), PM (optional));

b) Exhaust flow meter (exhaust mass flow and exhaust temperature);

c) Engine (torque, speed, temperature, fuel consumption rate, speed from the ECU).

Time alignment of each category with other categories shall be confirmed by

#### KA.2.2.2 ECU torque data

According to the requirements of this Annex KD, the consistency of the ECU torque data shall be confirmed by comparing the maximum value of the ECU torque data at different engine speeds with the corresponding value on the engine full load torque curve at the type test.

#### KA.2.2.3 Brake specific fuel consumption

The brake specific fuel consumption (BSFC) shall be checked using the following data:

a) The fuel consumption calculated from the emission data (gas analyzer concentration and exhaust mass flow);

b) Work calculated from ECU data (engine torque and engine speed).

#### KA.2.2.4 Driving speed

According to the driving speed as determined by the satellite navigation precision positioning system, calculate the total driving distance, compare it with the reference measurement as obtained by the sensor, effective ECU or digital map, to perform the consistency inspection. It shall correct the data of the satellite navigation precision positioning system with obvious error, retain the original error data file, mark all corrected data. The corrected data shall not exceed 120 s in a row, or the total time shall not exceed 300 s. The total driving distance as calculated by the corrected data of the satellite navigation precision positioning system shall deviate from any reference value for not more than ±4%. If the satellite navigation precision positioning system's data does not meet the above requirements, it may use the other reliable speed sources that have been subject to consistency inspection. Otherwise, the test results are invalid.

#### KA.2.2.5 Altitude

If the altitude of the driving route may be higher than the provisions of K.4.1, or when only one satellite navigation precise positioning system is used to measure the altitude, it shall carry out the consistency inspection of the altitude as measured by the satellite navigation precision positioning system. If necessary, it shall make corrections. Compare the latitude, longitude, altitude data as obtained by the satellite navigation precision positioning system with the altitude as indicated by the digital map, to check and compare the data consistency. It shall make manual correction for the measured value which deviates from the altitude as described in the map for more than 40 m, meanwhile mark it.

### KA.2.3 Dry and wet base correction

# Annex KB
# (Normative)
# Portable test equipment

## KB.1 Overview

This Annex specifies the technical requirements for portable test equipment suitable for actual road testing, including:

a) A gas analyzer, to measure the concentration of conventional gaseous pollutants in the tail gas;

b) Exhaust mass flowmeter, whose working principle is based on the average pitot tube or similar principle;

c) Satellite navigation precision positioning system;

d) Ambient temperature and atmospheric pressure sensors;

e) OBD reader connected to the vehicle's ECU.

## KB.2 Measuring equipment

### KB.2.1 Basic requirements for exhaust analyzer

The technical description of the gas analyzer of the PEMS system shall comply with the requirements of CB.3.1 of this standard.

The technical description of the partial dilution system of particulate matter of the PEMS system shall comply with the requirements of CB.4.1 a) ~ e), CB.4.2.1 and CB.4.5 of this standard. Meanwhile the dilution air is allowed to dehumidify before entering the dilution system (especially for dilution air with higher humidity);

The technical description of the measuring equipment of particle number emission shall meet the requirements of clause DB.6 of GB 18352.6-2016;

The sampling filter paper for the measurement of particle number emission shall comply with the requirements of CB.4.3. The technical description of the weighing chamber and analytical balance shall comply with the requirements of CB.4.4.

### KB.2.2 Measurement principles of analyzer

Gaseous pollutants shall be analyzed and measured by the technology as specified in CB.3.2.

The principle of particle number measurement shall meet the requirements as specified in DB.6 of GB 18352.6-2016.

## Annex KD
## (Normative)

## Inspection method of signal consistency of ECU torque

### KD.1 General requirements

This Annex specifies the method of checking the consistency of the ECU's torque signal during in-use compliance PEMS test.

### KD.2 “Maximum torque” method

**KD.2.1** During the vehicle test, it is proved that the engine has reached 100% ± 5% of the maximum reference torque on the engine speed function curve.

**KD.2.2** If during the PEMS test of in-use compliance, the maximum torque at a certain point cannot reach 100% ± 5% of the maximum reference torque on the engine speed function curve. After the in-use compliance PEMS emission test, the manufacturer has the right to modify the vehicle load and / or test route to describe this situation if necessary.

**KD.3** According to the requirements of K.7.3, it shall use the external OBD scan-tool as described in Appendix F to verify the obtaining of the data stream information as required in K.7.2.

**KD.3.1** If the scan-tool is working properly and still cannot read the information in an appropriate manner, the engine is considered not to meet the requirements.

**KD.3.2** If following the measurement method of engine power as specified in GB/T 17692 and the WHS test requirements as specified in Appendix C and the provisions outside the laboratory cycle during the type test of Appendix E, the ECU torque signal's consistency shall be verified by the engine family's parent engine.

**KD.3.2.1** If the engine power measurement method according to GB/T 17692 is used to inspect the consistency of the ECU's torque signal, it requires verifying each model of the engine family. To this end, it shall verify several other partial load and engine speed operating points (e.g., in WHSC mode and other random points).

**KD.3.3** If the engine does not meet the requirements of the relevant Appendix of GB/T 17692 when testing, it shall be subject to the power correction according to C.5.3.5.

**KD.3.4** If the torque signal is within the deviation as specified by K.7.4.3, the ECU's torque signal is proved to meet the requirements.

lighting strategy meets the requirements of F.4.6.2.

**KE.2.3.2 Inspection of diagnostic interface**

**KE.2.3.2.1** Observe whether the shape of the diagnostic interface meets the requirements of F.4.7.3.1.

**KE.2.3.2.2** Observe whether the position of the diagnostic interface meets the requirements of F.4.7.3.2.

**KE.2.3.2.3** If the diagnostic interface is in a specific equipment box, it shall check whether the door to the box can be manually opened without requiring the use of tools, and whether the box has the "OBD" marking.

**KE.2.3.3 Inspection of OBD information read function**

**KE.2.3.3.1** The use of the general diagnostic equipment shall be able to read all OBD information as specified in F.4.7.

**KE.2.4 Use the failure simulation to check the OBD monitoring function**

**KE.2.4.1** Select the failure according to the failure list as provided by the manufacturer, to produce a failure for the vehicle.

**KE.2.4.2** Depending on the type of failure selected, the failure simulation can be done by disconnecting the connector of the sensor or actuator, plugging the corresponding pipeline, replacing the qualified deteriorated component or electronically simulated method.

**KE.2.4.3** For the need to replace the qualified deteriorated components for failure simulation, the corresponding qualified deteriorated components or systems required shall be provided by the manufacturer.

**KE.2.4.4** After the producing the failure, the OBD system shall be able to correctly alert and record the corresponding diagnostic trouble code. It can observe the malfunction indicator to verify whether it can correctly alert as required by Appendix F; connect the universal scan-tool to verify whether the OBD system correctly stores the corresponding diagnostic trouble code.

**KE.2.5 Failure classification and inspection of alert light response**

**KE.2.5.1** According to the failure list as provided by the manufacturer, select two items of type A failure, one item of type B failure, one item of type C failure to produce failure, verify whether the corresponding malfunction indicator complies with the light up requirements of F.4.6.2.

**KE.2.6 Verification of IUPR basic function**

# Appendix M

## (Normative)

### Special requirements for type test of liquefied petroleum gas and natural gas engines and vehicles

**M.1 Type test of general fuel engine (vehicle)**

**M.1.1 For natural gas engines (vehicles), the parent engine shall have the ability to adapt to any component of fuel on the market.**

Natural gas fuels are divided into two categories, high calorific fuel (H-gas) and low-calorific fuel (L-gas), both of which has a wide range of calorific values. However, the Wobbe Index which represents the heat capacity and its λ-conversion factor ($S_\lambda$) are very different. The calculation formulas for the Wobbe Index and $S_\lambda$ are given in 3.27 and 3.28. Natural gas which has a $S_\lambda$ value of 0.89 ~ 1.08 ($0.89 \leq S_\lambda < 1.08$) is considered to be in the high-calorific range; Natural gas which has a $S_\lambda$ value between 1.08 and 1.19 ($1.08 \leq S_\lambda \leq 1.19$) is considered to be in the low-calorific range. The components of the baseline fuel reflect the extreme changes in $S_\lambda$.

**M.1.1.1** The parent engine shall meet the requirements of this standard when using the reference fuel $G_R$ (reference fuel 1) and $G_{25}$ (reference fuel 2) in Appendix D. It is not allowed to readjust the fuel supply system between the test of the two fuels. However, after replacing the fuel, it is allowed to carry out an adaptive operation of WHTC hot start cycle (not tested). Before the test, the parent engine shall adopt the program as provided in clause C.6.6.1 for cooling down.

**M.1.1.2** At the request of the manufacturer, the engine may be tested by a third fuel (fuel 3) which has an $S_\lambda$ value between 0.89 and 1.19. For example, fuel 3 is a commercially available fuel of natural gas as specified in GB 18047. The results of this test can be used as a basis for evaluating production consistency.

**M.1.2 Type test for parent engines that adapt to high and low calorific gas by switching**

For self-adapting natural gas-fueled engines, it may use both the gas of high-calorific range and the gas of low-calorific range. It uses switch to achieve switchover between the high-calorific range and low-calorific range. The parent engine shall be in the switch position, using the two corresponding reference fuels of each calorific range as specified in Appendix D to carry out test. The gas of high-calorific value range is $G_R$ (reference fuel 1) and $G_{23}$ (reference fuel 3). The gas of high-calorific value range is $G_{25}$ (reference fuel 2) and $G_{23}$ (reference fuel 3).

# Appendix N

## (Normative)

### Technical requirements for diesel-gas dual-fuel engines and vehicles

### N.1 Scope

This Appendix applies to diesel-gas dual-fuel engines and dual-fuel vehicles.

### N.2 Terms and definitions

#### N.2.1 Gas energy ratio, GER

Refers to the percentage of energy of the gaseous fuel [1] to the energy of the two fuels (diesel and gas fuel) of the dual-fuel engine.

#### N.2.2 Average gas ratio

Refers to the average gas energy ratio calculated by a specific operation process.

#### N.2.3 Heavy-duty dual-fuel (HDDF) type 1A engine

Refers to a dual-fuel engine with an average gas ratio of not less than 90% ($GER_{WHTC} \geq 90\%$) in the WHTC test hot cycle, and the idle speed cannot use diesel alone, without diesel mode.

#### N.2.4 Heavy-duty dual-fuel (HDDF) type 1B engine

Refers to a dual-fuel engine with an average gas ratio of not less than 90% ($GER_{WHTC} \geq 90\%$) in the WHTC test hot cycle, and in the duel-fuel mode the idle speed cannot use diesel alone, without diesel mode.

#### N.2.5 Heavy-duty dual-fuel (HDDF) type 2A engine

Refers to a dual-fuel engine with an average gas ratio between 10% and 90% ($10\% < GER_{WHTC} < 90\%$) in the WHTC test hot cycle, without diesel mode; or otherwise with an average gas ratio of not less than 90% ($GER_{WHTC} \geq 90\%$) in the WHTC test hot cycle, meanwhile the idle speed may use diesel alone, without diesel mode.

#### N.2.6 Heavy-duty dual-fuel (HDDF) type 2B engine

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[1] Energy calorific value is based on low-calorific value.

If a dual-fuel engine is developed from a diesel engine that has been type-tested, the diesel mode of the dual-fuel engine needs to be re-type-tested.

**N.4.1.2 Conditions for heavy-duty dual-fuel engine (HDDF engine) to use diesel alone at idle speed**

**N.4.1.2.1** For HDDF 1A engine, except for the warm-up and starting conditions as specified in N.4.1.3, it shall not use diesel alone at idle speed.

**N.4.1.2.2** For HDDF 1B engine, in the duel-fuel mode, it shall not use diesel alone at idle speed.

**N.4.1.2.3** For HDDF types 2A, 2B, 3B engines, it may use diesel alone at idle speed.

**N.4.1.3 Conditions for heavy-duty dual-fuel engine (HDDF engine) to use diesel alone at warm-up and startup**

**N.4.1.3.1** During warmup and startup, the duel-fuel engines of types 1B, 2B, 3B may use diesel alone. At this point, the engine shall be running in diesel mode.

**N.4.1.3.2** During warmup and startup, the duel-fuel engines of types 1A, 2A may use diesel alone. In this case, the strategy shall be declared as the AES strategy and the following additional requirements shall be met:

**N.4.1.3.2.1** When the coolant temperature reaches 70 °C or the strategy has been running for 15 minutes (whichever comes first), the strategy shall be stopped.

**N.4.1.3.2.2** When this strategy is in effect, the service mode shall be activated.

**N.4.2 Service mode**

**N.4.2.1 Conditions for dual-fuel engines and vehicles operating in service mode**

When a vehicle equipped with a dual-fuel engine is operating in a service mode, the vehicle is subject to operating capability limits and is temporarily exempt from the requirements of this standard for exhaust pollutants, OBD, NOX control systems.

**N.4.2.2 Operating capability limits in service mode**

The operating capability limit for a dual-fuel engine in service mode is activated by the “severe drivability limit system” as described in Appendix G.

The activation and failure of the alert and drivability limit system as described in Appendix G does not invalidate the operating capability limit.

When the diagnostic system confirms that the failure is no longer present or that the relevant DTC information is cleared by the scan-tool, the service mode shall automatically fail or reactivate the dual-fuel mode.

**N.4.2.3.2.1** If the failure counter (clause N.4.4) of the gas fuel supply system is not zero, it indicates that the diagnostic system has detected that a failure may reappear. At this time, the DTC is a potential diagnostic trouble code and it shall activate the service mode or diesel mode.

**N.4.2.3.3 Gas fuel failure - Abnormal gas fuel consumption**

In dual-fuel mode, if the gas fuel consumption is abnormal (clause N.7.3), at this time, the DTC associated with the failure is a potential diagnostic trouble code, it shall activate the service mode or diesel mode.

**N.4.3 Dual-fuel indicator**

**N.4.3.1 Dual-fuel working mode indicator**

Dual-fuel engines and vehicles shall provide an indicator that is visible to the driver and indicates the engine's operating mode (dual-fuel mode, diesel mode or service mode).

The characteristics and mounting position of the indicator are determined by the engine manufacturer or may be part of an existing visual indicator system.

The indicator can display information in the form of text messages. The information display system may be same as the information system of the OBD system, or NOx control system, or others for the purposes of maintenance.

The display equipment of the dual-fuel operating mode indicator shall not be same as that of the OBD system, or NOx control system, or others for the purposes of maintenance.

The display level of the safety alert always takes precedence over the work mode indicator.

**N.4.3.1.1** When the service mode is activated, the dual-fuel operating mode indicator shall be set to the service mode at the same time. When the service mode is activated, this indicator shall remain displayed in the service mode.

**N.4.3.1.2** When the engine is operating in dual-fuel mode or diesel mode, the dual-fuel indicator shall be set to dual-fuel mode or diesel mode immediately and last for at least one minute. This indicator can also be displayed according to the driver's request.

**N.4.3.2 Gas fuel depletion alert system (dual-fuel alert system)**

Only when the PEMS demonstration test in dual-fuel mode and the PEMS demonstration test in diesel mode pass at the same time, can the type test pass.

**N.4.7.3 Adaptation strategy**

**N.4.7.3.1** When meeting the following conditions, the dual-fuel engine can adopt an adaptation strategy:

a) The HDDF types of engine (such as: type 1A or type 2B, etc.) are consistent with those during type test.

b) For type 2 dual-fuel engines, the difference, in percentage, between the highest $GER_{WHTC}$ value and the lowest $GER_{WHTC}$ value for the engine in the family shall not exceed the value as specified in clause N.3.1.

c) These strategies have been stated and can ensure that vehicle emissions meet the requirements of Appendix E.

**N.5 Technical requirements**

**N.5.1 Emission limit of HDDF type 1A and type 1B engines**

**N.5.1.1** The emission limits for HDDF type 1A and type 1B engines in dual-fuel mode are consistent with the limits for ignition engines in clause 6.3 of this standard.

**N.5.1.2** The emission limit of the HDDF type 1B engine in diesel mode is the same as the limit of the compression ignition engine in clause 6.3 of this standard.

**N.5.2 Emission limits of HDDF type 2A and 2B engines**

**N.5.2.1 Emission limits of WHSC test cycles**

**N.5.2.1.1** For HDDF type 2A and 2B engines, in dual-fuel mode, the emission limits for the WHSC test cycle are consistent with the limits for the WHSC test cycle for compression ignition engines in clause 6.3 of this standard.

**N.5.2.1.2** The emission limit of the HDDF type 2B engine in diesel mode is consistent with the limit of the compression ignition engine in clause 6.3 of this standard.

**N.5.2.2 Emission limit of the WHTC test cycle**

**N.5.2.2.1 Emission limits of CO, NOx, $NH_3$ and PM**

For the CODF type 2A and HDDF type 2B engines in the dual-fuel mode, the mass emission limits of CO, NOx, $NH_3$ and PM in the WHTC test cycle are consistent with the limits in the WHTC test cycle of the compression ignition

**installed on whole vehicle**

In addition to meeting the requirements for the installation of the engine on the vehicle as specified in this standard, during the type test, it shall, based on appropriate component design, test demonstration and so on, also carry out the demonstration test according to the requirements of Annex NC, to prove that the following contents meet the requirements of this Appendix:

a) Dual-fuel indicator and alert system (images specified in this Appendix, activation scheme, etc.);

b) Fuel storage system;

c) Performance of the vehicle in service mode.

Both the indicator's display and the alert system's activation require an inspection, but any inspection does not require disassembly of the engine system (for example, power cutoff, etc.).

**N.6.3 Demonstration requirements for type 2 dual-fuel engines**

The engine manufacturer shall certify to the competent department of ecological environment under the State Council that the $GER_{WHTC}$ of all engine models in the dual-fuel engine family is within the percentage range as specified in clause N.3.1 of this Appendix (e.g., by algorithm, functional analysis, calculation, simulation, previous test results, etc.).

**N.6.4 Additional demonstration requirements for type test of engine of common fuel range**

At the request of the manufacturer, it is possible to perform up to two adaptative operations of the last 10 minutes of WHTC between tests.

**N.6.5 Durability requirements for dual-fuel engine**

Meet the requirements of Appendix H of this standard.

**N.7 OBD requirements**

**N.7.1 OBD general requirements**

For dual-fuel engines and vehicles, whether operating in dual-fuel mode or diesel mode, it shall meet the requirements for diesel engines in Appendix F of this standard.

If a dual-fuel engine is equipped with an oxygen sensor, the engine shall meet the requirements for a gas fuel engine according to clause FC.13 of Appendix F of this standard.

**N.7.2 Monitoring of gas fuel supply system**

For HDDF engines and vehicles, according to the requirements as specified in FC.1, it shall monitor the gaseous fuel supply system inside the engine system (including the signal from outside the engine system) - Component monitoring.

**N.7.3 Monitoring of gaseous fuel consumption**

Dual-fuel engines shall have a method for determining the consumption of gaseous fuel and a passage for providing gaseous fuel consumption information to the outside of the engine. Abnormal gas fuel consumption (e.g., the deviation of gaseous fuel consumption reaches 50% of normal conditions) shall be monitored - Performance monitoring.

In dual-fuel mode, it shall continuously monitor the insufficiency of gaseous fuel consumption. The maximum monitoring period is 48 hours.

This monitoring is not subject to the limit by IUPR requirements.

**N.7.4 OBD defect**

The requirements of Appendix F are applicable to the defects of diesel engine, as well as the dual-fuel engine.

Defects that occur in both diesel mode and dual-fuel mode shall not be counted separately in each mode.

**N.7.5 Clearing failure information through scan-tools**

**N.7.5.1** Clearing information through scan-tools, including DTCs related to failures, shall be performed according to Appendix F.

**N.7.5.2** Clearing failure information can only be performed when the engine is stopped.

**N.7.5.3** When the failure information is related to the gas fuel supply system as described in clause N.7.2 of this Appendix, when the diagnostic trouble code (DTC) is cleared, the counter associated with the failure cannot be zeroed.

**N.8 Requirements of NOx control system**

**N.8.1** The heavy-duty dual-fuel (HDDF) engines and vehicles, whether operated in dual-fuel mode or diesel mod, shall meet the requirements of the NOx control system as specified in Annex G.

**N.8.2** Additional OBD requirements of type 1B, 2B or 3B dual-fuel engines and vehicles

**N.8.2.1** For the type 1B, 2B or 3B dual-fuel engines, the torque induction follows

**N.10.1 Additional emission test requirements for dual-fuel engines**

**N.10.1.1** The dual-fuel engine shall, when subjected to the emission test, in addition to the requirements of this standard (including Appendix C), also meet the requirements of Annex ND.

**N.10.2** Requirements for additional PEMS emission test procedures for dual-fuel engines

**N.10.2.1** The dual-fuel engine shall, in the PEMS test, in addition to the PEMS requirements as specified in this standard, also meet the requirements in Annex NE.

**N.10.2.2 Torque correction**

If necessary, for example, when the component of the gaseous fuel mixture changes, the manufacturer shall correct the ECU torque signal. At this time, it shall meet the following requirements.

**N.10.2.2.1 Correction of PEMS torque signal**

The manufacturer shall submit to the competent department a description of the torque relationship, i.e., the description of the relationship between the torque obtained from the emission test of 2 applicable reference fuels and the actual torque as induced from the ECU.

**N.10.2.2.1.1** When the torque obtained by the two reference fuel tests is of the same order (within the 7% range as described in K.7.4.3 of this standard), it is not necessary to correct the ECU torque value.

**N.10.2.2.2 Torque value of PEMS test**

For the PEMS test (work-based window), the corrected torque value shall be calculated from the interpolated value.

**N.10.2.2.3 Confirmation of ECU's torque signal**

The “maximum torque” method as specified in the Annex KD shall be understood that the vehicle in the test uses two kinds of reference fuels, to prove that at the same engine speed, they both can reach to the torque value as corresponding to the maximum reference torque curve. The evaluation of this torque value shall be based on the actual fuel consumption, the sampling shall be as close to the engine power curve as obtained from the type test of each reference fuel as possible. During the type test, it shall estimate the value of this point based on the actual fuel component. It shall be as close to the engine power curve as obtained by using the two reference fuels as possible.

**N.10.3 Additional $CO_2$ measurement requirements for dual-fuel engines**

# Annex NB
(Normative)
# Activation and failure mechanism of counters, alert systems, operating capability limits, service modes of dual-fuel engines and vehicles - Descriptions and illustrations

## NB.1 Description of counter mechanism

### NB.1.1 Overview

**NB.1.1.1** To meet the requirements of this Appendix, the system shall include a counter, to record the time the engine continues to operate when the system detects a gaseous supply system failure.

**NB.1.1.1.1** This counter shall be able to record 30 minutes of running time. The interval of counters shall not exceed 3 minutes. When the counter reaches the maximum allowed by the system, it shall record its counted value, until the condition that resets the counter to zero is met.

### NB.1.2 Principle of the counter mechanism

**NB.1.2.1** The counter shall operate as follows:

**NB.1.2.1.1** When a gaseous fuel supply failure is detected, the counter shall immediately start counting from zero and the corresponding diagnostic fault code (DTC) shall be confirmed and active.

**NB.1.2.1.2** If the failure that originally activates the counter is not detected after the diagnosis, or the failure has been deleted by a scan-tool or maintenance software, the counter shall terminate and record the current value.

**NB.1.2.1.2.1** When the service mode is activated, the counter shall also terminate and record the current value.

**NB.1.2.1.3** When the counter is frozen, if a counter-related failure is detected and the service mode is activated, the counter shall be reset to zero and start recounting.

**NB.1.2.1.3.1** When the counter is frozen, from the last recording of the counter, when the monitoring related to the counter has run a monitoring cycle without detecting any failure, and no counter-related failure is detected after 36 hours of engine running, the counter shall be reset to zero.

### NB.1.3 Diagram of counter mechanism

The Figure NB.1 gives three examples to illustrate the counter mechanism.

# Annex NC
(Normative)
# HDDF dual-fuel engine's indicator, alert system, operating capability limits - Demonstration test requirements

## NC.1 Dual-fuel indicator

### NC.1.1 Dual-fuel mode indicator

For the dual-fuel engine, during the type test, it shall verify the activation of the dual-fuel mode indicator when it is operated in the dual-fuel mode.

For the dual-fuel vehicle, during the type test, it shall verify the activation of the dual-fuel mode indicator when it is operated in the dual-fuel mode.

For dual-fuel engines that have been type-tested, the installation requirements for the dual-fuel indicator shall be according to the requirements of N.6.2.

### NC.1.2 Diesel mode indicators

For the type 1B, 2B, 3B dual-fuel engines, during type test, it shall verify the activation of the diesel mode indicator when it is operated in diesel mode.

For the type 1B, 2B, 3B dual-fuel vehicles, during type test, it shall verify the activation of the diesel mode indicator when it is operated in diesel mode.

For type 1B, 2B and 3B dual-fuel engines that have been type-tested, the installation requirements for the diesel mode indicator shall comply with the requirements of N.6.2.

### NC.1.3 Service mode indicator

For the dual-fuel engines, during type test, it shall verify the activation of the service mode indicator when it is operated in service mode.

For the dual-fuel vehicles, during type test, it shall verify the activation of the service mode indicator when it is operated in service mode.

For dual-fuel engines that have been type-tested, the installation requirements for service mode indicators shall be according to the requirements of N.6.2.

**NC.1.3.1** When the engine has sufficient conditions to demonstrate activation of the service mode by the use of the service mode activation switch or to provide evidence to the competent department of ecological environment under the State Council to prove that the activation occurs, the service mode shall be performed under the control of the engine's own system (e.g., by algorithm, simulation, bench test results, etc.).

# Annex ND
(Normative)
# Requirements for additional emission test procedure of dual-fuel engine

## ND.1 Overview

This Annex specifies additional requirements and exceptions to Appendix C, to ensure that the dual-fuel engine emissions test can proceed smoothly, whether the emissions are separate tail gas emissions or contain tail gas emissions from the crankcase emissions as required by clause C.5.10.

## ND.2 Test conditions

The test conditions shall meet the requirements of C.5.

### ND.2.1 Laboratory test conditions

It shall meet the requirements of C.5.1.

The parameter $f_a$ of the dual-fuel engine is determined by the second formula of item a) of clause C.5.1 of this standard.

## ND.3 Test procedure

It shall meet the requirements of C.6.

### ND.3.1 Measurement procedure

It shall meet the requirements of C.6.1.3.

The recommended measurement procedures for dual-fuel engines are as listed in clause C.6.1.3 (CVS system).

This measurement procedure ensures that changes in fuel composition during the test only affect hydrocarbon measurements. It shall be compensated by one of the methods as described in clause ND.4.

Other methods of measurement such as those listed in clause C.6.3.1 (a) (original exhaust measurement / partial-flow measurement) can be used together with some pre-treatment measures for the determination and calculation of exhaust mass flow. The fixed fuel parameters and $u_{gas}$ values shall be used as described in Annex NF.

## ND.4 Emission calculation

Emissions calculations shall be carried out according to the provisions of Annex CA.

### ND.4.1 Dry/wet base conversion

measurement method in clause CA.5.1.3.

In addition, according to the provisions of clauses NF.2 and NF.3 of Annex NF, the method as designated in clause CA.5.1.6 can only be used to measure the air flow and air-fuel ratio when the values of α, γ, δ, ε are determined. It is not allowed to use a zirconia type sensor to measure the air-fuel ratio.

**ND.4.3.2 Determination of gas component**

It shall be carried out according to the provisions of CA.5.2.

Calculations shall be made according to the relevant provisions of Annex CA, but it shall use the $u_{gas}$ value and molar ratio as described in clause NF.2 and clause NF.3 of Annex NF.

**ND.4.3.3 Determination of particulate matter**

Calculations shall be made according to the provisions of CA.5.3.

For the measurement of particulate matter emissions by the use of the partial-flow dilution measurement method, the calculation shall be carried out according to the method as specified in clause CA.5.3.2.

In order to control the dilution ratio, it may use one of two methods:

Direct mass flow measurement as described in clause CA.5.1.3.

The measurement method of air flow and air-fuel ratios as specified in clause CA.5.1.6 can only be used when the values of α, γ, δ, ε as specified in clause NF.2 and NF.3 of Annex NF have been determined, in conjunction with the method as previously mentioned in clause CA.5.1.2.

According to the provisions of CB.4.5.1, it shall carry out quality inspection for each measurement.

**ND.4.3.4 Additional requirements for measurement of exhaust mass flow**

The flow measurements as mentioned in ND.4.3.2 and ND.4.3.3 are not sensitive to changes in exhaust gas component and density. Small errors, for example, Pitot's tube measurement or orifice measurement (equivalent to the square root of the exhaust density), are negligible.

**ND.4.4 Full-flow dilution system (CVS)**

It shall meet the requirements of clause CA.6.

Possible changes in the fuel composition will only affect the calculation of hydrocarbon measurements. For the determination of all other gaseous pollutants, it shall use the formula in clause CA.6.2 to carry out calculation. It

# Appendix O

## (Normative)

### Type test of alternative emission aftertreatment device as an independent assembly

#### O.1 Overview

This Appendix specifies additional requirements for type test of replacement pollution control devices as an independent technical assembly.

#### O.2 Terms and definitions

The following terms and definitions apply to this Appendix.

#### O.2.1 Type of pollution control device

Refers to catalytic converters and particulate traps that do not differ in the following basic parameters:

a) The number, structure and materials of the coated carrier;

b) The type of carrier activity;

c) The volume of carrier, front end area, length ratio of carrier;

d) Catalyst's material content;

e) Catalyst's material ratio;

f) Pore density;

g) Size and shape;

h) Thermal protection.

#### O.2.2 Original equipment pollution control device

Refers to the pollution control device or pollution control device assembly on the type-tested engine (vehicle), the content of which is filled in the corresponding clauses in Appendix B.

#### O.2.3 Replacement pollution control device

Refers to the pollution control device or pollution control device assembly which is intended to be sold in the market, used to replace the original pollution control device of the type-tested engine (vehicle), type-tested according to this Appendix as an independent technical assembly.

marked with the trademark (or logo) and the commercial name;

c) When it is intended to install a replacement pollution control device in a vehicle equipped with an OBD system, it shall also provide an additional sample of the replacement pollution control device. The sample shall be clearly marked with the trademark (or logo) and the commercial name and shall be qualified deteriorated component.

**O.3.1.8** Test conditions shall meet the requirements of C.5. The test engine shall meet the following requirements:

a) There is no defect in the emission control system of the engine;

b) Repair or replace the original parts associated with emissions and having failures or transitional wear;

c) Before the emission test, make correct adjustments and settings according to the requirements of the manufacturer.

**O.3.2 Information disclosure of replacement pollution control devices**

**O.3.2.1** As an independent technical assembly, the replacement emission control device shall be subject to information disclosure according to the requirements of Annex OA and Annex OB by the manufacturer or authorized representative of the supporting vehicle. Relevant content related to corporate secrets may be disclosed only to the competent department of ecological environment under the State Council.

**O.3.2.2** The manufacturer of the replacement pollution control device shall issue a statement proving that the device meets the requirements for OBD information access.

**O.4 General requirements**

**O.4.1 Marking**

The marking shall be permanently fixed or engraved on the pollution control device and will not fall off or be damaged under the high-temperature and vibration conditions of the vehicle.

**O.4.1.1** Replacement pollution control devices shall be marked with at least the following identification contents:

a) The name of the manufacturer or registered trademark;

b) Label and component's identification number of the replacement pollution control device which complies with the records of the documents as specified in Annex OA.

manufacturer shall disclose the following information, which shall be linked with the relevant part number and type test and information disclosure documents:

a) The label and model of the vehicle or engine;

b) The label and model of the original replacement pollution control device;

c) The part number of the original replacement pollution control device;

d) Information disclosure number of the relevant model.

**O.5 Technical requirements**

**O.5.1 General requirements**

**O.5.1.1** The replacement pollution control device shall meet the performance of the original emission control device in design, manufacture and installation, so that the pollutant emissions of the engine and the vehicle comply with the provisions of this standard, thereby effectively controlling the pollutant emissions of the vehicle under the normal use conditions in the full life.

**O.5.1.2** The replacement pollution control device shall be installed at the same position of the original pollution control device. At the position on the tailpipe, the temperature and pressure sensor shall not be changed.

**O.5.1.3** If the original pollution control device contains thermal protection measures, the replacement pollution control device shall contain equivalent protective measures.

**O.5.1.4** The testing agency shall carry out test based on the number of non-regeneration cycles and the number of regeneration cycles in the type test of the original pollution control device of the engine (vehicle), to ensure that the replacement pollution control device has the same test conditions as the original pollution control device.

**O.5.2 General durability requirements**

The replacement pollution control device shall be durable, that is, it shall be reasonably resistant to corrosion and oxidation encountered in various operating conditions of the vehicle in its design, manufacture and installation.

Replacement pollution control devices shall be designed to ensure that the active elements used for emission control are adequately protected against mechanical shocks, thereby ensuring that the emitted pollutants are effectively controlled during normal use and throughout the full life of the vehicle.

The manufacturer shall conduct a simulated mechanical impact test and disclose the test contents and test results according to the requirements of

## Annex OA
## (Normative)
## Type test material for replacement pollution control devices

### OA.1 Overview

**OA.1.1** During type test, it shall provide the following information. The manufacturer or the import enterprise shall carry out information disclosure.

**OA.1.2** If there is a schematic diagram, it shall use appropriate proportion to fully explain the details. The sheet size is A4 or otherwise it shall be folded to this size. If there is photo, it shall show the details. If the system, component or independent technical assembly is controlled by a microprocessor, it shall provide its performance data.

### OA.2 General data

**OA.2.1** Label (name of manufacturer)

**OA.2.2** Model

**OA.2.3** Brand name (if any)

**OA.2.4** Model identification method

**OA.2.5** Manufacturer's name and address

**OA.2.6** For parts and independent technical assembly, the location and method for fixing the markings:

**OA.2.7** Assembly name and address

**OA.2.8** Name and address of authorized representative of manufacturer (if any)

### OA.3 Description of device

**OA.3.1** Type: (oxidation catalysis, three-way catalysis , SCR, DPF, etc.)

**OA.3.2** Drawings, in particular the characteristics as indicated by clause N.1.2.1 of this Appendix

**OA.3.3** Descriptions of applicable engine or vehicle model

**OA.3.4** Number and/or symbol which represents the features of engine and vehicle model

**OA.3.5** Number and/or symbol which represents the features of the original pollution control device to be replaced

# Appendix P

## (Normative)

### Acquisition of vehicle OBD and vehicle maintenance information

**P.1 Access to OBD information**

**P.1.1** In case of type test or product's type change, it shall submit the relevant data of engine or vehicle OBD system at the same time. These relevant materials can be used to make the products of the manufacturer of the vehicle accessories or retrofit parts be compatible with the vehicle OBD system, to ensure that the vehicle users do not experience functional failure without error. Similarly, such relevant data shall also enable the tools and equipment as produced by the manufacturer of scan-tools and test equipment to provide an effective and accurate diagnosis of the engine or vehicle's emission control system.

**P.1.2** On an impartial basis, the engine or vehicle manufacturer shall provide the data related to the OBD system as specified in P.2.1 to the manufacturer concerned with the component, scan-tool or test equipment.

**P.1.3** If the manufacturer involved in the component, scan-tool or test equipment requires acquiring the data of the OBD system of the type-tested engine system or vehicle as required by this standard, then:

- The competent department of ecological environment under the State Council may request relevant vehicle manufacturers to provide relevant data in clause P.2.1;

- The manufacturer shall provide this data within two months of receiving the request of the competent department of ecological environment under the State Council.

**P.1.4** This requirement does not invalidate any previous type tests required by this standard, nor does it impede the type test extensions performed according to this standard.

**P.1.5** The data required can only be the data of the parts or repair parts involved in the type test conducted according to this standard, or the parts of the system involved.

**P.1.6** When the manufacturer concerned with a component, scan-tool or test equipment requires access to data, it shall state that the required data relates to the exact technical specifications of the engine system or vehicle type. It shall

# Appendix Q

## (Normative)

### Technical requirements and communication data format for remote emission management on-board terminal

### Q.1 Overview

This Appendix specifies the technical requirements for the on-board terminal for remote emission management of heavy-duty vehicles, including functional requirements, performance requirements, test methods, testing rules, markings, transportation, storage, installation requirements. It also specifies the communication data format, including protocol basis, communication connection, message processing, protocol classification and description, data format.

This Appendix is applicable to the equipment and device which are installed on the heavy-duty vehicles to collect, store, transmit the vehicle OBD information and engine emission data. Other similar equipment may make reference to it.

From the stage 6a, the vehicle shall be equipped with a remote emission management on-board terminal that complies with the provisions of this Appendix. It is encouraged for the vehicle to perform data transmission according to the requirements of this Appendix. From the stage 6b, the manufacturer shall ensure that in the full life period, the vehicle performs data transmission according to the requirements of this Appendix, which is received by the competent department of ecological environment and manufacturer.

### Q.2 Normative references

This standard refers to the following documents or their terms. For undated references, the latest version applies to this standard.

GB 16735 Road vehicle - Vehicle identification number (VIN)

GB/T 19596 Terminology of electric vehicles

GB/T 32960.2 Technical specifications of remote service and management system for electric vehicles - Part 2: On-board terminal

GB/T 32960.3 Technical specifications of remote service and management system for electric vehicles - Part 3: Communication protocol and data format

### Q.3 Terms and definitions

The terms and definitions as defined in GB/T 19596, GB/T 32960.2, GB/T

- The data communication link is disconnected;

- The data communication link is normal, but no response has been received after the number of retransmissions has been reached.

**Q.3.6 Packet supplementation**

When the data communication link is abnormal, the on-board terminal shall store the reported data locally. After the data communication link returns to normal, the stored report data is supplemented while transmitting the reported data. The supplemented report data shall be the data stored during the abnormal communication link of the current day. The data format is the same as the reported data, meanwhile it is identified as the supplemented information report (0x03).

**Q.4 Security policy**

The on-board terminal shall provide a technically feasible security strategy, to ensure that the various performance and functions of the product are within a secure range. It is implemented from the following aspects:

- The data stored and transmitted by the on-board terminal shall be encrypted. The asymmetric encryption algorithm shall be used. It may use national secret SM2 algorithm or RSA algorithm, use hardware to strictly protect the private key;

- The data stored and transmitted by the on-board terminal shall be complete;

- The data transmission process shall scan the data, to detect malicious data and attack behavior in time, such as writing commands to CAN bus devices such as ECU, or other instructions beyond normal data reading. Security detection shall detect more than 95% attack; the false alarm rate is less than 1%; the attach is detected within 10 s after occurrence and the protective measures activated;

- The on-board terminal can only read the vehicle data and cannot send any instructions other than the diagnostic request to the ECU;

- The on-board terminal shall only send data out and shall not accept operation instructions other than the manufacturer.

**Q.5 Functional requirements**

**Q.5.1 Self-testing**

The on-board terminal shall indicate the current main state via the signal light, display or sound when the power is turned on. The main status includes whether the communication is normal, whether the on-board terminal is normal.

realization of the capture shall not exceed 120s;

2) Hot start: The time required to achieve capture shall be less than 10s.

**Q.6.6 Management function**

The on-board terminal shall have a function of supporting the register and activation on the specified server by remote mode.

**Q.7 Performance requirements and test methods of on-board terminal**

The on-board terminal shall comply with the requirements of clauses 4.3 and 5 of GB/T 32960.2. For function inspection, please carry out testing according to the requirements of Q.7.1 ~ Q.7.6.

**Q.7.1 Preparation before function inspection**

Before the function inspection, it shall connect the tested on-board terminal to a heavy-duty vehicle which complies with the requirements of this standard according to the requirements of the manufacturer, meanwhile carry out register management of this on-board terminal on the corresponding testing demonstration platform.

**Q.7.2 Inspection of connection**

After the vehicle is powered on, follow the product manual of the manufacturer to check whether the on-board terminal is working properly, whether it complies with the requirements of self-inspection function of clause Q.5.1. Then check whether the on-board terminal can connect to the testing platform normally and upload data to the platform.

**Q.7.3 Inspection of time and date**

Test whether the time and date provided by the on-board terminal meet the requirements of Q.5.2.

**Q.7.4 Inspection of data acquisition**

By testing the demonstration platform, it checks whether the frequency of the data reporting, the frequency of the data acquisition, the data content meet the requirements of Q.5.3, Q.5.4, Q.6.3.

**Q.7.5 Inspection of data storage function**

Follow the instruction manual of the manufacturer to inquire whether the data stored in the on-board terminal meets the requirements of Q.5.5. At the same time, according to the data volume continuously transmitted for 10 minutes, calculate whether the storage capacity of the on-board terminal satisfies the

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