NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

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Replacing GB 20891-2007

Limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (CHINA III, IV)

(Released Version)

非道路移动机械用柴油机排气污染物排放限值及测量方法(中国第三、四阶段)

（发布稿）

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Contents

Foreword

This standard is formulated with a view to implementing "Environmental Protection Law of the People's Republic of China" and "Law on Prevention of Air Pollution of the People's Republic of China", preventing and controlling pollutants emission from diesel engines of non-road mobile machinery on environment, and improving the ambient air quality.

This standard specifies Stage III limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery, and also introduces forecast requirements of Stage IV.

This standard is modified in relation to the relevant technical content on diesel engines of non-road mobile machinery of EU directives 97/68/EC (by revision 2004/26/EC) "Law on Coordinating Member Countries in Taking Measures to Prevent the Emission of Gaseous Pollutants and Particulate Matters from Compression Ignition Engines of Non-road Mobile Machinery".

The main changes between this standard and the contents related to diesel engines of non-road mobile machinery in 2004/26/EC directives are as follows:

——G2 test cycle in ISO 8178 is added.

——Technical requirements in EU IV are excluded.

——Control requirements of diesel engine below 19 kW are added.

——Control requirements of diesel engine above 560 kW are added.

——Determination methods of conformity inspection are simplified.

——Test requirements on carrier volume and content of precious metal of catalytic converter.

——Partial technical parameters of test reference diesel.

This standard is a revision to Limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (I & II) (GB 20891-2007). The main contents revised are as follows:

——The pollutants emission limit is stricter.

——Transient cycle (NRTC) is added.

——Control requirements of diesel engine above 560 kW are added.

——Determination methods of conformity inspection are simplified.

——The emission control durability requirements are added.

——Test requirements on carrier volume and content of precious metal of catalytic converter.

——Technical requirements on test reference diesel are revised.

Annexes A, B, C, D, E, F and G of this standard are normative, and Annex H is informative.

The national implementation dates of Stage IV control requirements on exhaust pollutants from diesel engines of non-road mobile machinery will be announced at another time. Capable regions are encouraged implement Stage IV in advance.

This standard is organized and formulated by the Department of Science, Technology and Standards of the Ministry of Environmental Protection.

Drafting organizations of this standard: Jinan Automobile Test Center, Chinese Research

Academy of Environmental Sciences and Yuchai Machinery Co., Ltd.

This standard will be approved by the Ministry of Environmental Protection on □□ □□, 20□□.

This standard will be implemented on 01 October, 2014.

The Ministry of Environmental Protection is in charge of the explanation of this standard.

Limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (China III, IV)

1 Scope

The standard specifies the limits and measurement methods for the exhaust pollutant from diesel engines of non-road mobile machinery (including marine diesel engines with a rated net power not exceeding 37kW) and the secondary diesel engines installed on road vehicles for carrying people (cargo).

This standard is applicable to type approval and production conformity inspection of the diesel engines installed for the following (including but not limited to) non-road mobile machinery and operating at non-constant speed, e.g.:

——Industrial drilling equipment;

——Construction machinery (including loader, bulldozer, roller, asphalt paver, truck for non-highway, excavator, forklift, etc.);

——Agricultural machinery (including large tractor, combine-harvester, etc.);

——Forestry machinery;

——Material handling machinery;

——Snowplough equipment;

——Airport ground servicing equipment.

This standard is applicable to type approval and production conformity inspection of the diesel engines installed for the following (including but not limited to) non-road mobile machinery and operating at constant speed, e.g.:

——Air compressor;

——Generator unit;

——Fishery machinery (automatic aerator, pond excavator, etc.);

——Water pump.

2 Normative References

This standard refers to the provisions of the following documents or therein. For undated references, the effective versions are applicable to this standard.

GB 252 General Diesel Fuels

GB/T 6072 Reciprocating Internal Combustion Engines – Performance

GB/T 6379.2-2004 Accuracy (Trueness and Precision) of Measurement Methods and Results Part 2: Basic Methods for the Determination of Repeatability and Reproducibility of a Standard Measurement Method

GB 17691-2005 Limits and measurement methods for exhaust pollutants from compression ignition and gas fuelled positive ignition engines of vehicles (III, IV, V)

GB/T 17692-1999 Measurement Methods of Net Power for Automotive Engines

HJ509-2009 Determination of Platinum, Palladium and Rhodium Loading in the

Vehicle-used Ceramic Catalytic Converters Inductive Coupled Plasma-Optical Emission Spectrometry and Inductive Coupled Plasma-Mass Spectrometry

3 Terms and Definitions

3.1 Non-road mobile machinery

Various machinery used for non-road and mentioned in "scope", i.e.:

(1) Self-driven or double function: machinery self-driven and operating other functions;

(2) Machinery which fails to be self-driven, but is designed to be capable of moving or being moved from one place to another place.

3.2 Secondary engine

Diesel engine which is mounted for road vehicle, does not provide driving force for vehicle but provides power for vehicle-mounted special facilities.

3.3 Test cycle

Procedures that diesel engines are tested according to, with defined speed and torque under steady state or transient state (NRTC) conditions.

3.4 NRTC test (non-road transient cycle)

Test cycle consisting of 1238 second-by-second transient modes to be applied in accordance with Attachment BE of this standard.

3.5 Reference speed (n_{ref})

Actual value of speed when the relative speed gets to point of 100% in NRTC test, according to description in Attachment BB in GB 17691-2005.

3.6 Diesel engine type-approval

Approve a diesel engine type with respect to emission level of exhaust pollutants from diesel engine.

3.7 Diesel engine type

Diesel engine of the same type without basis characteristic parameter difference from the diesel engine listed in Attachment AA.

3.8 Diesel engine family

A group of diesel engines designed by the manufacturing enterprise according to those specified in Attachment AB, which have similar exhaust emission characteristic; all the diesel engines in the same family must meet the corresponding emission limits.

3.9 Parent engine

Diesel engine which is selected from diesel engine family and capable of representing the emission characteristic of this diesel engine family.

3.10 Emission pollutants

Gaseous pollutants and particulate matter emitted from exhaust pipe of diesel engine.

3.11 Gaseous pollutants

Carbon monoxide (CO), hydrocarbon (HC) and oxynitride (NO_x) in emission pollutants. Hydrocarbon (HC) is expressed with C_1 equivalent (assume carbon hydrogen ratio as 1:1.88) and oxynitride (NO_x) is expressed with nitrogen dioxide (NO_2) equivalent.

3.12 Particulate matter (PM)

All the matters in the exhaust collected by specified filter medium according to the test method described in Annex B and in the diluted exhaust with temperature not exceeding 325K (52°C).

3.13 Net power (P)

Power measured at diesel engine crank shaft end or its equivalent unit according to the measurement method for net power specified in GB/T 17692-1999 on the diesel engine test stand and under the test condition[1)] specified in this standard.

3.14 Rated net power (P_{max})

Net power indicated by the manufacturing enterprise for diesel engine type-approval.

3.15 Rated speed

Full-load maximum speed specified in the manufacturing enterprise's operating instructions and allowed by speed governor; if the diesel engine is not equipped with speed governor, it refers to the speed at the maximum power of diesel engine specified in the manufacturing enterprise's operating instructions.

3.16 Percent load

Percentage of maximum torque obtained at a certain speed of diesel engine.

3.17 Intermediate speed

Speed of diesel engine designed to operate at non-permanent speed and meeting one of the following conditions when operating according to full load torque curve:

——If the nominal maximum torque speed is 60%~75% of the rated speed, the intermediate speed shall take the nominal maximum torque speed;

——If the nominal maximum torque speed is less than 60% of the rated speed, the intermediate speed shall take 60% of the rated speed;

——If the nominal maximum torque speed is greater than 75% of the rated speed, the intermediate speed shall take 75% of the rated speed.

3.18 Useful life

Service time which is specified in Article 5.2.2 of this standard, ensures normal operation of diesel engines of non-road mobile machinery and their emission control systems (if any) and meets the relevant gaseous pollutants and particulate matter emission limits, and has been confirmed in type approval.

3.19 Replacement diesel engine

New diesel engine for non-road mobile machinery, whose sole usage is as replacement.

3.20 Abbreviations, symbols and units

3.20.1 Test parameter symbols

All the volumes and volume flows must be converted to 273K (0°C) and 101.3kPa reference conditions.

Symbol	Unit	Definition
A_P	m^2	Cross-sectional area of equivalent dynamic sampling probe
A_T	m^2	Cross-sectional area of exhaust pipe
Aver		Weighted average
	m^3/h	—Volume flow
	kg/h	—Mass flow

1) In net power test, the devices and accessories installed in diesel engine are detailed in Annex E and the used equivalent fuel technical parameters are detailed in Annex D.

C_1	—	Hydrocarbon, expressed with C_1 equivalent
conc	ppm (or Vol %)	Concentration of some composition (expressed with subscript)
$conc_c$	ppm (or Vol %)	Concentration of some composition after background correction (expressed with subscript)
$conc_d$	ppm (or Vol %)	Concentration of some composition in diluent air (expressed with subscript)
DF	—	Dilution coefficient
f_a	—	Laboratory atmosphere factor
F_{FH}	—	Fuel oil characteristic coefficient, used for transferring dry basis concentration to wet basis concentration according to hydrogen-carbon ratio
G_{AIRW}	kg/h	Wet-basis intake mass flow
G_{AIRD}	kg/h	Dry-basis intake mass flow
G_{DILW}	kg/h	Wet-basis diluent air mass flow
G_{EDFW}	kg/h	Wet-basis equivalent diluted exhaust mass flow
G_{EXHW}	kg/h	Wet-basis exhaust mass flow
G_{FUEL}	kg/h	Fuel oil mass flow
G_{TOTW}	kg/h	Wet-basis diluted exhaust mass flow
H_{REF}	g/kg	Absolute humidity reference value 10.71g/kg, used for calculating humidity correction coefficient of NO_x and particulate matter
H_a	g/kg	Absolute humidity of intake
H_d	g/kg	Absolute humidity of diluent air
i	—	Subscript expressing a certain operating condition
K_H	—	NO_x humidity correction coefficient
K_p	—	Particulate matter humidity correction coefficient
$K_{w,a}$	—	Intake dry-wet-basis correction coefficient
$K_{w,d}$	—	Diluent air dry-wet-basis correction coefficient
$K_{w,e}$	—	Diluted exhaust dry-wet-basis correction coefficient
$K_{w,r}$	—	Original exhaust dry-wet-basis correction coefficient
L	%	Percentage of torque at test speed to maximum torque
Mass	g/h	Subscript of mass flow of emission pollutants
M_{DIL}	kg	Mass of diluent air through particulate matter sampling filter paper
M_{SAM}	kg	Mass of diluted exhaust through particulate matter sampling filter paper
M_d	mg	Mass of particulate matter collected from diluent air
M_f	mg	Mass of collected particulate matter

p_a	kPa	Saturated vapor pressure of intake (ISO 3046: p_{sy}=PSY test environment)
p_B	kPa	Total atmospheric pressure (ISO 3046: p_x=PX total pressure in field environment p_y=PY total pressure in test environment)
p_d	kPa	Saturated vapor pressure of diluent airdiluent air
p_s	kPa	Dry air pressure
$P_{(n)}$	kW	Maximum power measured at test speed (install devices and accessories of Annex E)
$P_{(a)}$	kW	Power absorbed by accessories of diesel engine installed in the test
$P_{(b)}$	kW	Power absorbed by accessories of diesel engine dismantled in the test
$P_{(m)}$	kW	Power measured on test bench
Q	—	Dilution ratio
R	—	Ratio of cross-sectional areas of equivalent dynamic sampling probe and exhaust pipe
R_a	%	Relative humidity of intake
R_d	%	Relative humidity of diluent air
R_f	—	FID response coefficient
S	kW	Set value of dynamometer
T_a	K	Absolute temperature of intake
T_D	K	Absolute dew point temperature
T_{ref}	K	Reference temperature (intake: 298K)
V_{AIRD}	m^3/h	Dry-basis intake volume flow
V_{AIRW}	m^3/h	Wet-basis intake volume flow
V_{DIL}	m^3	Volume of diluent air through particulate matter sampling filter paper
V_{DILW}	m^3/h	Wet-basis diluent air volume flow
V_{EDFW}	m^3/h	Wet-basis equivalent diluted exhaust volume flow
V_{EXHD}	m^3/h	Dry-basis exhaust volume flow
V_{EXHW}	m^3/h	Wet-basis exhaust volume flow
V_{SAM}	m^3	Volume of diluted exhaust through particulate matter sampling filter paper
V_{TOTW}	m^3/h	Wet-basis diluted exhaust volume flow
WF	—	Weighting coefficient
WF_E	—	Effective weighting coefficient
DF	—	Deterioration coefficient or deterioration correction value
EDP	—	Emission duration period
N_{ref}	r/min	Reference speed of diesel engine in NRTC test
W_{act}	kWh	Actual work of NRTC
W_{ref}	kWh	Reference work of NRTC

3.20.2 Symbols of chemical compositions

CO	Carbon monoxide
CO_2	Carbon dioxide
HC	Hydrocarbon
NMHC	Non-methane hydrocarbon
NO_X	Oxynitride
NO	Nitric oxide
NO_2	Nitrogen dioxide
O_2	Oxygen
PM	Particulate matter
DOP	Dioctyl phthalate
CH_4	Methane
C_3H_8	Propane
H_2O	Water
PTFE	Polytetrafluoroethylene

3.20.3 Abbreviations

FID	Hydrogen flame ionization detector
HFID	Heating hydrogen flame ionization detector
NDIR	Nondispersive infrared ray detector
CLD	Chemiluminescence detector
HCLD	Heating chemiluminescence detector
PDP	Positive displacement pump
CFV	Critical flow venturi tube

4 Application and Authorization of Type Approval

4.1 Application of type approval

The application of type approval for diesel engines of non-road mobile machinery is proposed by manufacturing enterprise or its authorized agent to the type approval institution, and the inspection content required by this standard shall be completed.

4.1.1 The technical data related to type approval and the relevant durability test method and test result data shall be submitted according to the requirements of Annex A and Attachment BD of this standard.

4.1.2 The production conformity guarantee plan shall be submitted according to the requirements of Annex G of this standard.

4.1.3 A diesel engine meeting the characteristic of "diesel engine type" (or "parent engine") described in Annex A shall be submitted to the inspection organization responsible for conducting type approval test to complete the inspection content specified in this standard.

4.1.4 If the inspection organization considers the parent engine provided by the applicant fails to completely represent the diesel engine family defined in Attachment AB, another parent engine may be provided by the manufacturing enterprise, and the type approval shall be submitted according to the requirements of Article 4.1.1 and Article 4.1.3.

4.1.5 Two sets of identical aftertreatment system shall be provided when durability test is carried out for the diesel engine of aftertreatment system loaded with precious metal materials.

4.2 Authorization of type approval

4.2.1 The type approval institution authorizes the type approval for diesel engine type (or family) meeting the requirements of Article 5 and Annex G of this standard, and issues type approval certificate specified in Annex F.

4.2.2 When the diesel engine is capable of completing its function only operating in combination with other parts of non-road mobile machinery or provides an operating characteristic, the type approval must verify whether one or more requirements when the diesel engine operates in combination with other parts of non-road mobile machinery (no matter real or simulative) are met. The range of diesel engine type-approval shall be restricted according to these conditions; the type approval certificate of diesel engine type or family shall cover service restriction conditions and installation instructions.

4.3 Exemption of type approval

For diesel engines to be used for special purposes, such as export, exhibition, rescue, emergency, matching test, replacement and so on, the type approval can be exempted by submitting application to type approval institution. The materials to be submitted to the type approval institution shall include the following, such as model, power, manufacturer, purpose, emission level reached, number, manufacturing date and so on.

5 Technical Requirements and Test

5.1 General

The technical measures taken by the manufacturing enterprises must ensure the emission of diesel engine under normal operating conditions and within the useful life period specified in Article 5.2.2 of this standard meets the requirements of this standard.

The durability test shall be completed through mature-technology engineering method in accordance with the technical requirements in Attachment BD of this standard. In the durability test process, the parts such as diesel oil filter element and engine oil filter element or system may be periodically replaced, and such work must be conducted within the allowable technology range. The requirements for system maintenance must be included in the user's manual (including warranty of manufacturing enterprise for durability of exhaust aftertreatment device). When the manufacturing enterprise applies for type approval, the content summary related to aftertreatment device maintenance and replacement in the operating instructions must be included in type approval declaration materials described in Annex A.

5.2 Provisions for exhaust pollutants

5.2.1 Test regulations and sampling system

The measurement and sampling regulations for exhaust pollutants from diesel engine shall be in accordance with those specified in Attachment BA of Annex B. Test cycle shall be conducted following the specified steady-state test cycle in Table B.1.1, Table B.1.2, or Table B.2 of Annex B. Diesel engines of Stage IV with non-constant speed and below 560 kW shall also be tested in accordance with the NRTC transient cycle specified by Attachment BE.

The exhaust pollutants from diesel engine shall be determined by the system described in Annex C.

If other system or analyzer is capable of obtaining the result equivalent to the following reference system, the type approval institution may authorize:

——System used for measuring gaseous pollutants in original exhaust (see Figure C.1 of Annex C);

——System used for measuring gaseous pollutants in full-flow dilution system (see Figure C.2 of Annex C);

——System used for measuring particulate matter in full-flow dilution system and sampling with single filter paper (use a pair of filter paper in the whole test cycle) method or multiple filter paper (use a pair of filter paper for each operating condition) method (see Figure C.12 of Annex C).

The equivalence between other system or analyzer and one or several reference systems of this standard shall be confirmed based on correlation study on at least 7 pairs of samples.

The criterion for equivalence judgment is defined as the consistency of paired sample mean within ±5%. For new system introduced into this standard, its equivalence shall be calculated according to reproducibility and repeatability stated in GB/T 6379.2-2004 as the criterion.

5.2.2 Useful life

It shall be ensured that the emission control device of the diesel engine operates properly within defined useful life time in Table 1, and that the pollutants emitted are in accordance with the limits requirements defined in 5.2.3.

For the diesel engine durability running test, the durability test specified in Table 1 shall be completed in accordance with the requirements of Attachment BD. The minimum running time or equivalent running time of diesel engine emission durability shall not be lower than 25% of the diesel engine useful life specified in Table 2, and the deterioration coefficient or deterioration correction value shall be determined. For engines equipped with catalytic converter loaded with precious mental, the manufacturer shall also provide 2 sets of identical catalytic converters before test. The type approval institution shall choose a random set for durability test; and use the other set to test carrier volume and previous metal content according to HJ 509, and the measured value shall not exceed 1.1 times of values reported by the manufacturer.

Table 1 Durability Time Requirements

<table>
<tr><th>Diesel Engine Power Range (kW)</th><th>Speed (r/min)</th><th>Useful life (h)</th><th>Allowable minimum test duration (h)</th></tr>
<tr><td>$P_{max} \geq 37$</td><td>Any speed</td><td>8000</td><td>2000</td></tr>
<tr><td rowspan="3">$19 \leq P_{max} < 37$</td><td>Non-constant speed</td><td rowspan="2">5000</td><td rowspan="2">1250</td></tr>
<tr><td>Constant speed <3000</td></tr>
<tr><td>Constant speed ≥3000</td><td rowspan="2">3000</td><td rowspan="2">750</td></tr>
<tr><td>$P_{max} < 19$</td><td>Any speed</td></tr>
</table>

5.2.3 Limits

The brake specific emission of carbon monoxide (CO), hydrocarbon (HC), oxynitride (NO_x) and particulate matter (PM) in exhaust pollutants from diesel engines of non-road mobile machinery, multiplied by the deterioration coefficient determined according to Article BD.2.9 in Attachment BD of this standard (for diesel engines installed with exhaust aftertreatment system), or plus the deterioration correction value determined according to Article BD.2.10 in Attachment BD of this standard (for diesel engines not installed with exhaust aftertreatment system) shall not exceed the limit specified in Table 2.

Table 2 Emission Limits of Exhaust Pollutants from Diesel Engines of Non-road Mobile Machinery

Stage	Rated net power (P_{max}) (kW)	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	$HC+NO_x$ (g/kWh)	PM (g/kWh)
Stage III	$P_{max}>560$	3.5	——	——	6.4	0.2
	$130 \le P_{max} \le 560$	3.5	——	——	4.0	0.2
	$75 \le P_{max} < 130$	5.0	——	——	4.0	0.3
	$37 \le P_{max} < 75$	5.0	——	——	4.7	0.4
	$P_{max} < 37$	5.5	——	——	7.5	0.6
Stage IV	$P_{max}>560$	3.5	0.40	3.5, 0.67[1)]	——	0.10
	$130 \le P_{max} \le 560$	3.5	0.19	2.0	——	0.025
	$75 \le P_{max} < 130$	5.0	0.19	3.3	——	0.025
	$56 \le P_{max} < 75$	5.0	0.19	3.3	——	0.025
	$37 \le P_{max} < 56$	5.0	——	——	4.7	0.025
	$P_{max} < 37$	5.5	——	——	7.5	0.6
(1) Applicable for the diesel engine with $P_{max}>900$kW for mobile generation sets use.						

5.2.4 According to the definition of Attachment AB of Annex A, if there are multiple power-section diesel engines in a diesel engine family, the value of exhaust pollutants from the parent engine and the diesel engine in this family must meet the emission requirements stricter than the corresponding high power section. The manufacturing enterprise may limit the diesel engine family within a power section and conduct the type approval application for diesel engine family of this power section.

5.2.5 Replacement diesel engine shall meet emission requirements of the time when the diesel engine to be replaced was manufactured.

5.3 Requirements for installing diesel engine on non-road mobile machinery

The diesel engine installed on non-road mobile machinery shall meet the following characteristics of this diesel engine type-approval:

5.3.1 The intake pressure drop shall not exceed the pressure drop of the engine subjected to type approval specified in Attachment AA.1.18.

5.3.2 The exhaust back pressure shall not exceed the back pressure of the engine subjected to type approval specified in Attachment AA.1.19.

6 Production Conformity Inspection

The manufacturing enterprise shall take measures according to the requirements of Annex G to guarantee production conformity.

6.1 General requirements

6.1.1 For diesel engine type (or family) of non-road mobile machinery subjected to type approval and produced in batch, the manufacturing enterprise must take measures to ensure diesel engine type (or family) is in conformity with emission declaration materials of this diesel engine type (or family).

6.1.2 The type approval institution shall conduct production conformity inspection based on the content of emission declaration materials of this diesel engine type (or family) of non-road mobile machinery.

6.1.3 The type approval institution may take prototypes according to the requirements of Article 6.2 in the manufacturing enterprise based on the need of supervision and management.

6.1.4 If some diesel engine type (or family) fails to meet the requirements of Article 5 of this standard, the manufacturing enterprise shall positively take measures to recover production conformity assurance system. The type approval institution, before the production conformity assurance system of this diesel engine type (or family) is recovered, may temporarily cancel the type approval certificate of this diesel engine type (or family).

6.1.5 The production conformity inspection shall use commercially available diesel oil specified in GB 252; as required by the manufacturing enterprise, the reference diesel oil described in Annex D may be used.

6.2 Production conformity inspection of engine emission test

6.2.1 One prototype shall be randomly taken from the diesel engines produced in batch. The manufacturing enterprise shall not make any adjustment for the diesel engines sampled for inspection, but may conduct grinding-in according to the manufacturing enterprise's technical specification.

6.2.2 The brake specific emission results of gaseous pollutants and particulate matters of the above-mentioned prototype diesel engine are to be adjusted according to the deterioration factor or deterioration corrected value determined by the type approval. If none of them exceeds the limits specified in Article 5 of this standard, then the production conformity of this batch of products is determined to be qualified.

6.2.3 If the one diesel engine randomly taken from the production batch cannot meet the limits required in Article 5 of this standard, the manufacturer can ask that a number of diesel engines be taken from the production batch for production conformity inspection. The manufacturer shall determine n, the number of prototypes to be taken (including the one prototype already taken). Besides the one prototype that is taken and tested, other diesel engines shall be tested. Then the arithmetic average ($\overline{X}$) is calculated according to the brake specific emission of each kind of pollutant obtained from tests of the n prototypes taken. If the requirements below can be met, the production conformity of this batch of products is determined to be qualified. Otherwise, it is determined to be unqualified.

$$\overline{X} + k \cdot S \le L_i$$

$$S^2 = \sum_{i=1}^{n} \frac{(x_i - \overline{x})^2}{n-1}$$

Where,

L_i – The limit of specific pollutant specified in Table 1.

k – The statistics factor determined according to n, the number of prototypes taken. See values in Table 3.

x_i – The test result of the number i prototype among the n prototypes.

$\overline{X}$ – The arithmetic average of the test results of n prototypes.

Table 3 Statistics Factor

n	2	3	4	5	6	7	8	9	10
k	0.973	0.613	0.489	0.421	0.376	0.342	0.317	0.296	0.279
n	11	12	13	14	15	16	17	18	19

k	0.265	0.253	0.242	0.233	0.224	0.216	0.210	0.203	0.198

If n⩾20, then $k = \frac{0.860}{\sqrt{n}}$

6.2.4 Even though there are requirements as specified from 6.2.1 to 6.2.3, during the prototype sampling process for production conformity inspection, the type approval authority can choose the method and determination rules as below:

- Three prototypes are randomly taken from the diesel engines produced in batch. The manufacturing enterprise shall not make any adjustment for the diesel engines sampled for inspection, but may conduct grinding-in according to the manufacturing enterprise's technical specification.
- If none of the brake specific emission results of all pollutants of the above-mentioned three diesel engines taken exceeds 1.1 times of the limits specified in Article 5 of this standard, and their average value does not exceed limits specified in Article 5 of this standard, then the environmental protection conformity inspection is determined to be qualified.
- If the brake specific emission result of any kind of pollutant from any of the three sample engines exceeds 1.1 times of the limits, or the average value exceeds the limits, then the environmental protection conformity inspection is determined to be unqualified.

6.3 Production conformity inspection of catalytic converter

6.3.1 Randomly take three sets of catalytic converters from the assembly line or products in batch for carrying out measurement for their carrier volume and the content of each precious metal according to the requirements of HJ 509.

6.3.2 Determination criteria for the production conformity of catalytic converter:

——If the measurement results of the carrier volume and the content of each precious metal of the three sets of tested catalytic converter are not less than 0.85 times the declared values and the average is not less than 0.9 times the declared value, the production conformity inspection for catalytic converter is determined qualified.

——If the measurement results of the carrier volume and the content of each precious metal of any one of the three sets of tested catalytic converter are less than 0.85 times the declared values, or the average is less than 0.9 times the declared value, the production conformity inspection for catalytic converter is determined unqualified.

7 Diesel Engine Label

7.1 The diesel engine manufacturer shall fix a label on each engine when it is manufactured, and the label shall comply with the following requirements:

a) The label shall not be able to be removed unless the label becomes destroyed or the appearance of the engine got damaged.

b) The label shall remain readable within the whole service life of diesel engine.

c) The label shall be fixed on an engine part that is needed during proper operation of the engine, and the part shall be the kind of part that are usually not to be replaced during the whole engine life.

d) When the engine is installed in the mobile machine, the location of the label shall be obvious and visible.

7. 2 When the diesel engine is installed in the mobile machine, if the engine label cannot be obvious and easy to see because of being blocked by the machine, then the engine manufacturer shall provide an additional label to mobile machine manufacturer. This additional label shall comply with the following requirements:

a) The label shall not be able to be removed unless the label becomes destroyed or the appearance of the engine got damaged.

b) The label shall be fixed on a mechanical part that is necessary for proper operation of the mobile machine, and the part shall be the kind of part that are usually not to be replaced during the whole service life of the mobile machine.

7. 3 The label shall consist of the following information:

a) Corresponding power section with authorized type approval described in Article 5.2.3, limit stage, and type approval number described in Annex F.

b) The type, family name and power parameter of the diesel engine.

c) Manufacturing date of the engine:__Year__Month__Day (the content “Day” is optional, and if the manufacturing date is marked in other area of the engine, then the label doesn’t have to mark it again).

d) Complete name of engine manufacturer.

e) Type of the after-treatment device, if equipped with (such as SCR, DPF, etc.).

f) Other information considered as important information by the manufacturer.

7. 4 The label of the diesel engines that are exempted for type approval in accordance with Article 4.3 shall mark its purpose and reasons for exemption, and it shall also comply with the requirements in 7.1-7.3.

7. 5 When the engine goes through the final check and before the engine leaves the production line, the label shall be installed on it.

7. 6 The location of the engine label shall be reported in Annex A. It shall be verified by the type approval inspection institution, and indicated in the type approval certificate of Annex F.

8 Parameters for Determining Diesel Engine Family

The diesel engine family shall be determined according to the necessary common basic design parameters of the diesel engine in the family. Under certain conditions, some design parameters may have mutual influence which must be taken into account so as to ensure only the diesel engine with similar emission characteristic is included in a diesel engine family.

The diesel engines of the same family must jointly have the following basic parameters and types:

8.1 Operating cycle

——2-stroke

——4-stroke

8.2 Cooling medium

——Air

——Water

——Oil

8.3 Single cylinder displacement

——Differences among diesel engines in the family do not exceed 15%

——Cylinder quantity (for diesel engine with aftertreatment device)

8.4 Intake mode

——Natural aspiration

——Supercharge

——Supercharge intercooling

8.5 Combustion chamber type/structure

——Preignition combustion chamber

——Swirl combustion chamber

——Open combustion chamber

8.6 Air valve and port——structure, dimension and quantity

——Cylinder cap

——Cylinder wall

——Crankcase

8.7 Fuel injection system

——Pump-pipe-nozzle

——In-line pump

——Dispensing pump

——Monoblock pump

——Pump nozzle

8.8 Other characteristics

——Exhaust gas recirculation

——Water spraying/emulsification

——Air jet

——Supercharge intercooling system

8.9 Exhaust aftertreatment

——Oxidation catalyst

——Reduction catalyst

——Thermal reactor

——Particulate matter trap

9 Selection of Parent Engine

9.1 The selection of parent engines in diesel engine family shall take the maximum fuel oil feed capacity per stroke at maximum torque speed as the first choice principle; if two or more diesel engines meet the first choice principle, the maximum fuel oil feed capacity per stroke at rated speed shall be taken as the second choice principle. In Article 5.2.4 or under some conditions, another one (or several) diesel engines may be selected for test to determine the worst emission ratio in the family. Thus, one (or several) diesel engines may be added for test, and the selected diesel engines have the worst emission level in this family.

9.2 If the diesel engines in the family have other variable characteristics influencing the emission, these characteristics, during parent engine selection, shall be determined and taken into account.

10 Standard Implementation

From October 1, 2014, all diesel engines of non-road mobile machinery subjected to emission type approval of exhaust pollutants must meet the Stage III requirements of this standard. Before this specified implementation date, the type approval application and authorization may be conducted according to the corresponding requirements of this standard.

For diesel engines of non-road mobile machinery of which the type approval is authorized according to this standard, the production conformity inspection shall be performed as the date of authorization.

From October 1, 2015, all manufacturing and selling of stage II diesel engines of non-road mobile machinery shall be stopped, and the emission of exhaust pollutants of all manufactured and sold diesel engines of non-road mobile machinery must meet the Stage III requirements of this standard. From April 1, 2016, all manufacturing, importing and selling of non-road mobile machinery with stage II diesel engine shall be stopped, and all non-road mobile machinery manufactured, imported and sold shall be installed with diesel engine in compliance with the Stage III requirements of this standard.

Capable regions are encouraged to implement this standard in advance.

Annex A

(Normative)

Type Approval Declaration Materials

For type approval declaration of diesel engines of non-road mobile machinery, the following data and content contents shall be provided in triplicate.

If any diagram, the details shall be described sufficiently in proper proportion; the format shall be A4 or folded to this dimension. If any picture, the details shall be displayed. If the diesel engine type or diesel engine family adopts microprocess computer control, the relevant data shall be provided.

Parent engine/diesel engine type[1]:

A.1 General

A.1.1 Label:____

A.1.2 Name of parent engine and diesel engine family (if applicable)[1]:_______________

A.1.3 Manufacturing enterprise's name and address:____

Name and address of manufacturing enterprise's authorized agent (if any):________________

A.1.4 Position and fixing method of diesel engine label:_______________________

A.1.5 Address of general assembly plant:____________________________________

A.1.6 Operation mode of diesel engine (constant speed/non-constant speed)[1]:_________

A.2 Auxiliary documents

A.2.1 Basic characteristics and relevant test data of diesel engine (parent engine) (see Attachment AA).

A.2.2 Basic characteristics of diesel engine family (see Attachment AB).

A.2.3 Basic characteristics of each diesel engine type in family (see Attachment AC).

A.2.4 Picture and/(or) drawing of parent engine/type.

A.2.5 List other auxiliary documents (if any).

A.3 Date and file

[1] Scratch out those not applicable.

Attachment AA

(Normative)

Basic Characteristics and Relevant Test Data of Diesel Engine (Parent Engine)[1)]

AA.1 Diesel engine description
AA.1.1 Manufacturing enterprise:______________________________
AA.1.2 Manufacturing enterprise's engine type:______________________
AA.1.3 Cycle: four-stroke/two-stroke[2)]
AA.1.4 Cylinder quantity and arrangement:______________________
AA.1.4.1 Cylinder diameter:____________________________mm
AA.1.4.2 Stroke:______________________________mm
AA.1.4.3 Ignition sequence: ______________________________
AA.1.5 Displacement:_______________________________cm^3
AA.1.6 Volume compression ratio[3)]:__________________________
AA.1.7 Combustion chamber and piston top diagram:________________
AA.1.8 Minimum cross-sectional area of intake and exhaust port: _________cm^2
AA.1.9 Combustion system description:________________________
AA.1.10 Idling speed:_________________________________r/min
AA.1.11 Rated speed: _________________________________r/min
AA.1.12 Rated net power: _______________kW at_____________r/min
AA.1.13 Maximum net torque: __________Nm at______________r/min
AA.1.14 Cooling system
AA.1.14.1 Liquid cooling
AA.1.14.1.1 Liquid property:______________________________
AA.1.14.1.2 Circulating pump: Yes/No[2)]
AA.1.14.1.3 Characteristic or label and type (if applicable): _____________
AA.1.14.1.4 Drive ratio (if applicable):_________________________
AA.1.14.2 Air cooling
AA.1.14.2.1 Fan: Yes/No[2)]
AA.1.14.2.2 Characteristic or label and type (if applicable): _____________
AA.1.14.2.3 Drive ratio (if applicable):_________________________
AA.1.15 Allowable temperature of manufacturing enterprise
AA.1.15.1 Liquid cooling: maximum temperature at coolant outlet:__________K
AA.1.15.2 Air cooling: datum point: ____Maximum temperature at datum point: ____K
AA.1.15.3 Maximum temperature of air at intake intercooler (if applicable) outlet:____K
AA.1.15.4 Maximum exhaust temperature in exhaust pipe near exhaust manifold or supercharger outlet flange:________K
AA.1.15.5 Lubricating oil temperature: minimum______K, maximum________K
AA.1.16 Supercharger: Yes/No[2)]

AA.1.16.1 Manufacturing enterprise:____

AA.1.16.2 Type:____

AA.1.16.3 System description [for example: maximum boost pressure and exhaust bypass valve (if any)]:______________________

AA.1.17 Intercooler: Yes/No[1)]

AA.1.17.1 Manufacturing enterprise:_______________________________

AA.1.17.2 Type:_________________________________

AA.1.18 Intake system

Allowable maximum intake pressure drop according to the net power measurement method specified in GB/T 17692-1999, under the test conditions specified in this standard and at the rated speed and 100% load of diesel engine:______________kPa

[1)] For the condition with several parent engines, this attachment shall be submitted separately.

[2)] Scratch out those not applicable.

[3)] Indicate tolerance.

AA.1.19 Exhaust system

Allowable maximum exhaust back pressure according to the net power measurement method specified in GB/T 17692-1999, under the test conditions specified in this standard and at the rated speed and 100% load of diesel engine:______________kPa

AA.2 Measures for preventing air pollution

AA.2.1 Additional pollution control device (provided, but not included in other items)

AA.2.1.1 Catalytic converter: Yes/No[1)]

AA.2.1.1.1 Manufacturing enterprise:______________________

AA.2.1.1.2 Type:________________________

AA.2.1.1.3 Quantity of catalytic converter and its catalytic unit: _______________

AA.2.1.1.4 Dimension, shape and volume of catalytic converter:_______________

AA.2.1.1.5 Type of catalytic reaction:_________________________

AA.2.1.1.6 Total content of precious metal:_________________________

AA.2.1.1.7 Ratio between each type of precious metal:__________________

AA.2.1.1.8 Carrier (structure and material):______________________

AA.2.1.1.9 Hole density:__________________________

AA.2.1.1.10 Type of catalytic converter shell:______________________

AA.2.1.1.11 Position of catalytic converter (position and reference distance in exhaust pipeline):____________________

AA.2.1.1.12 Manufacturer of metering pump:__________________________

AA.2.1.1.13 Type of metering pump:__________________________

AA.2.1.1.14 Type of reactant:__________________________

AA.2.1.1.15 Density of reactant:__________________________

AA.2.1.1.16 Manufacturer of NO_x sensor:__________________________

AA.2.1.1.17 Type of NO_x sensor:__________________________

AA.2.1.2 Oxygen sensor: Yes/No[1)]

AA.2.1.2.1 Manufacturing enterprise:______________________

AA.2.1.2.2 Type:________________________

AA.2.1.2.3 Position:________________________

AA.2.1.3 Air jet: Yes/No[1)]

AA.2.1.3.1 Type (pulsating air, air pump, etc.):____________________

AA.2.1.4 EGR: Yes/No[1)]

AA.2.1.4.1 Characteristic (flow, etc.): ________________________

AA.2.1.5 Particulate matter trap: Yes/No[1)]

AA.2.1.5.1 Manufacturing enterprise:________________________

AA.2.1.5.2 Type:__________________________

AA.2.1.5.3 Dimension, shape and volume of particulate matter trap:__________________

AA.2.1.5.4 Type and structure of particulate matter trap:____________________

AA.2.1.5.5 Position (reference distance in exhaust pipeline): ________________________

AA.2.1.5.6 Regeneration method or system, description and (or) drawing:_____________

AA.2.1.6 Other system: Yes/No[2)]

AA.2.1.6.1 Category and action:_____________________________________

AA.3 Fuel supply

AA.3.1 Oil transfer pump

Pressure[1)]:______________________________kPa

AA.3.2 Spray system

AA.3.2.1 Injection pump

AA.3.2.1.1 Manufacturing enterprise:__________________________

1) Scratch out those not applicable.

AA.3.2.1.2 Type:____________________________

In full load oil supply position, pump speed:______r/min (rated and maximum torque), oil feed capacity[1)]:______mm^3/stroke (or cycle); or characteristic curve (describe the test method used: on diesel engine/on oil pump test bench[2)])

AA.3.2.1.3 Oil injection advance

AA.3.2.1.3.1 Oil injection advance curve[1)]:________________________________

AA.3.2.1.3.2 Static oil injection timing[1)]:______________________________

AA.3.2.1.4 High-pressure oil pipe

AA.3.2.1.4.1 Length:_________________________________mm

AA.3.2.1.4.2 Inside diameter:_________________________________mm

AA.3.2.1.5 Oil injector

AA.3.2.1.5.1 Manufacturing enterprise:___________________________

AA.3.2.1.5.2 Type:_____________________________

AA.3.2.1.5.3 Open pressure:____________________________ kPa[1)]

or characteristic curve[1), 2)]:_______________________________

AA.3.2.1.6 Speed governor

AA.3.2.1.6.1 Manufacturing enterprise:__________________________

AA.3.2.1.6.2 Type:____________________________

AA.3.2.1.6.3 Speed of oil reduction point at full load:__________________________r/min

AA.3.2.1.6.4 Maximum idling speed:_______________________________________r/min

AA.3.2.1.6.5 Idling speed:____r/min

AA.3.2.2 Cold start device

AA.3.2.2.1 Manufacturing enterprise:____

AA.3.2.2.2 Type:____

AA.3.2.2.3 Description:____

AA.3.2.3 Electronic Control Unit (ECU)

AA.3.2.3.1 Manufacturer/brand:____

AA.3.2.3.2 Type:____

AA.3.2.3.3 Adjustability:____

AA.4 Air valve timing

AA.4.1 Maximum lift of air valve, open and close angle:______________________

AA.4.2 Reference value and (or) setting range[1]:______________________________

AA.5 Diesel engine driven accessories

The diesel engine submitted to test shall be provided with accessories required for diesel engine operation (see Annex E).

AA.5.1 Accessories installed in the test

If it is impossible or unsuitable to install these accessories on the test stand, the power absorbed by these accessories shall be determined and subtracted from the diesel engine power measured within the whole operating range of test cycle.

AA.5.2 Accessories dismantled in the test

Only the accessories (such as air compressor and air conditioning system) required for non-road mobile machinery operation shall be dismantled in the test. If these accessories are incapable of being dismantled, the power absorbed by these accessories shall be determined and added into the diesel engine power measured within the whole operating range of test cycle.

AA.6 Additional description for test conditions

AA.6.1 Lubricating oil used

AA.6.1.1 Manufacturing enterprise:___________________________

[1] Indicate tolerance.

[2] Scratch out those not applicable.

AA.6.1.2 Designation:______________________________

AA.6.2 Diesel engine driven accessories (if applicable)

Only determine the power absorbed by accessories:

——If accessories required for diesel engine operation are not installed on the diesel engine, and (or)

——If the accessories not required by diesel engine operation are installed on the diesel engine.

AA.6.2.1 List and determine the details:____

AA.6.2.2 Power absorbed under the specified diesel engine speed (in accordance with the manufacturing enterprise's requirements) (Table AA.1)

Table AA.1

Accessories	Power absorbed under different diesel engine speeds, kW			
	Idling speed	Intermediate speed (if applicable)	Rated speed	Reference speed
P(a) Accessories required for diesel engine operation (deduct from the measured diesel engine power, see Article AA.5.1)	0	0	0	0
P(b) Accessories not required for diesel engine	0	0	0	0

operation (increase to the measured diesel engine power, see Article AA.5.2)				

AA.7 Diesel engine performance

AA.7.1 Diesel engine speed[1)]

Idling speed:___________________________r/min

Intermediate speed (if applicable):___________________r/min

Rated speed:__________________________r/min

For NTRC

Reference speed: __________________________r/min

AA.7.2 Diesel engine power (Table AA.2)

Table AA.2

Condition	Diesel engine speed			
	Idling speed	Intermediate speed (if applicable)	Rated speed	Reference speed[1]
P(m) Power measured on test stand, kW				
P(a) Power absorbed by accessories installed in the test according to Article AA.5.1, kW ——If installed ——If not installed	0	0	0	0
P(b) Power absorbed by accessories dismantled in the test according to Article AA.5.2, kW ——If installed ——If not installed	0	0	0	0
Net power of diesel engine $P_{(n)}=P_{(m)}-P_{(a)}+P_{(b)}$				
[1] Only for NRTC test				

AA.7.3 Dynamometer setting (kW)

Dynamometer setting for NRTC test reference cycle shall done based on engine net power P(n) of AA.7.2 of this attachment. It is recommended to install engine with its net power state on the test bench. At this point of time, P(m) is equal to P(n). If the engine is not possible or suitable to run with the net power state, then the above formula shall be used to calibrate the dynamometer setting to the net power state.

AA.7.3.1 NRTC test

If the engine is not tested with the net power state, then the manufacturer shall provide the calibration formula to the test institution for approval, which is used for converting the actual measured power or actual measured cycle work into the net power or net cycle work during the whole work range of the cycle, and is determined in accordance with Article BB.2 in Attachment BB of GB 17691-2005.

[1)] Scratch out those not applicable.

Attachment AB

(Normative)

Basic Characteristics of Diesel Engine Family

AB.1 Public parameters

AB.1.1 Combustion cycle:____

AB.1.2 Cooling medium:____

AB.1.3 Air suction mode:____

AB.1.4 Combustion chamber type/structure:__________________________

AB.1.5 Air valve and port——structure, dimension and quantity:__________________

AB.1.6 Fuel system:____

AB.1.7 Diesel engine management system:______________________________________

Certify the following items same according to the provided table or list:

——Supercharge intercooling system[1]:______________________________________

——Exhaust gas recirculation[1]:____

——Water spraying/emulsification[1]:____

——Air jet[1]:____

AB.1.8 Exhaust aftertreatment[1]:____

Provide table or list (of relevant exhaust aftertreatment device):__________________

Certify the ratio of "system capacity/oil feed capacity per stroke" same according to above-mentioned provided table or list, or the ratio for parent engine is the minimum.

AB.2 List of diesel engine family

AB.2.1 Name of diesel engine family:____

AB.2.2 Specification of diesel engine in this family (Table AB.1):

Table AB.1

				Parent engine[2]
Diesel engine type				
Cylinder quantity				
Rated speed (r/min)				
Oil feed capacity per stroke at corresponding rated speed (mm^3)				
Rated net power (kW)				
Maximum torque speed/(r/min)				
Oil feed capacity per stroke at corresponding maximum torque speed (mm^3)				
Maximum torque (Nm)				
Low idling speed (r/mm)				
Percentage of cylinder displacement to parent engine, %				100
Ignition timing				
EGR flow				
Oil transfer pump, Yes/No				
Oil transfer pump flow				

[1] If not applicable, indicate "not applicable".

[2] Details are detailed in Attachment AA.

Attachment AC

(Normative)

Basic Characteristics of Diesel Engine Type in Family[1)]

AC.1 Diesel engine description

AC.1.1 Manufacturing enterprise:____

AC.1.2 Manufacturing enterprise's diesel engine type: ______________________________

AC.1.3 Cycle: four-stroke/two-stroke[2)]

AC.1.4 Cylinder quantity and arrangement:______________________________

AC.1.4.1 Cylinder diameter:______________________________________mm

AC.1.4.2 Stroke:____mm

AC.1.4.3 Ignition sequence: ______________________________________

AC.1.5 Displacement:____cm^3

AC.1.6 Volume compression ratio[3)]:__________________________________

AC.1.7 Combustion chamber and piston top diagram:_____________________

AC.1.8 Minimum cross-sectional area of intake and exhaust port:_____________cm^2

AC.1.9 Combustion system description:________________________________

AC.1.10 Idling speed:____r/min

AC.1.11 Rated speed:____r/min

AC.1.12 Rated net power: _______________kW at_____________________r/min

AC.1.13 Maximum net torque: ___________Nm at_____________________r/min

AC.1.14 Cooling system

AC.1.14.1 Liquid cooling

AC.l.14.1.1 Liquid property:_______________________________________

AC.1.14.1.2 Circulating pump: Yes/No[2)]

AC.1.14.1.3 Characteristic or label and type (if applicable):____________________

AC.1.14.1.4 Drive ratio (if applicable):__________________________________

AC.1.14.2 Air cooling

AC.l.14.2.1 Fan: Yes/No[2)]

AC.1.14.2.2 Characteristic or label and type (if applicable):_____________________

AC.1.14.2.3 Drive ratio (if applicable):

AC.1.15 Allowable temperature of manufacturing enterprise

AC.1.15.1 Liquid cooling: maximum temperature at coolant outlet:_______________K

AC.1.15.2 Air cooling: datum point:______Maximum temperature at datum point:____K

AC.1.15.3 Maximum temperature of air at intake intercooler (if applicable) outlet:_________K

AC.1.15.4 Maximum exhaust temperature in exhaust pipe near exhaust manifold or supercharger outlet flange:___________K

AC.1.15.5 Lubricating oil temperature: minimum________K, maximum_________K

AC.1.16 Supercharger: Yes/No[2)]

AC.1.16.1 Manufacturing enterprise:____

AC.1.16.2 Type:____

AC.1.16.3 System description [for example: maximum boost pressure and exhaust bypass valve (if any)]:_______________________

AC.1.17 Intercooler: Yes/No[1)]

AC.1.17.1 Manufacturing enterprise:_____________________________________

AC.1.17.2 Type:__________________________________

AC.1.18 Intake system

Allowable maximum intake pressure drop according to the net power measurement method specified in GB/T 17692-1999, under the test conditions specified in this standard and at the rated speed and 100% load of diesel engine:________________kPa.

1) Details of each diesel engine type in family provided by manufacturing enterprise

2) Scratch out those not applicable.

3) Indicate tolerance.

AC.1.19 Exhaust system

Allowable maximum exhaust back pressure according to the net power measurement method specified in GB/T 17692-1999, under the test conditions specified in this standard and at the rated speed and 100% load of diesel engine:__________________kPa.

AC.2 Measures for preventing air pollution

AC.2.1 Additional pollution control device (provided, but not included in other items)

AC.2.1.1 Catalytic converter: Yes/No[1)]

AC.2.1.1.1 Manufacturing enterprise:_________________________

AC.2.1.1.2 Type:___________________________

AC.2.1.1.3 Quantity of catalytic converter and its catalytic unit:______________

AC.2.1.1.4 Dimension, shape and volume of catalytic converter:______________

AC.2.1.1.5 Type of catalytic reaction:__________________________

AC.2.1.1.6 Total content of precious metal: ____________________________

AC.2.1.1.7 Relative concentration of precious metal:________________________

AC.2.1.1.8 Carrier (structure and material):_________________________

AG.2.1.1.9 Hole density:________________________

AC.2.1.1.10 Type of catalytic converter shell:________________________

AC.2.1.1.11 Position of catalytic converter (position and reference distance in exhaust pipeline):____________________

AC.2.1.1.12 Manufacturer of metering pump:_________________________

AC.2.1.1.13 Type of metering pump:_________________________

AC.2.1.1.14 Type of reactant:_________________________

AC.2.1.1.15 Density of reactant:_________________________

AC.2.1.1.16 Manufacturer of NO_x sensor:_________________________

AC.2.1.2 Oxygen sensor: Yes/No[1)]

AC.2.1.2.1 Manufacturing enterprise:____________________________

AC.2.1.2.2 Type:______________________________

AC.2.1.2.3 Position:______________________________

AC.2.1.3 Air jet: Yes/No[1)]

AC.2.1.3.1 Type (pulsating air, air pump, etc.): ____________________________

AC.2.1.4 EGR: Yes/No[1)]

AG.2.1.4.1 Characteristic (flow, etc.): ______________________________

AC.2.1.5 Particulate matter trap: Yes/No[1)]

AC.2.1.5.1 Manufacturing enterprise:______________________________

AC.2.1.5.2 Type:________________________________

AC.2.1.5.3 Dimension, shape and volume of particulate matter trap:_______________

AC.2.1.5.4 Type and structure of particulate matter trap: ____________________

AG.2.1.5.5 Position (reference distance in exhaust pipeline):_________________

AC.2.1.5.6 Regeneration method or system, description and (or) drawing:____________

AC.2.1.6 Other system: Yes/No[2)]

AC.2.1.6.1 Category and action:____________________________________

AC.3 Fuel supply

AC.3.1 Oil transfer pump

Pressure[1)]:____________________________________kPa

AC.3.2 Spray system

AC.3.2.1 Injection pump

AC.3.2.1.1 Manufacturing enterprise:_____________________________

1) Scratch out those not applicable.

2) Indicate tolerance.

AC.3.2.1.2 Type:_______________________________

In full load oil supply position, pump speed:______r/min (rated and maximum torque), oil feed capacity[1)]:______mm^3/stroke (or cycle); or characteristic curve (describe the test method used: on diesel engine/on oil pump test bench[2)])

AC.3.2.1.3 Oil injection advance

AC.3.2.1.3.1 Oil injection advance curve[1)]:_________________________

AC.3.2.1.3.2 Static oil injection timing[1)]:_________________________

AC.3.2.1.4 High-pressure oil pipe

AC.3.2.1.4.1 Length:_________________________mm

AC.3.2.1.4.2 Inside diameter:_________________________mm

AC.3.2.1.5 Oil injector

AC.3.2.1.5.1 Manufacturing enterprise:_________________________

AC.3.2.1.5.2 Type:____________________________

AC.3.2.1.5.3 Open pressure:_____________________________kPa[1)]

or characteristic curve[1),2)]:________________________

AC.3.2.1.6 Speed governor

AC.3.2.1.6.1 Manufacturing enterprise:_____________________________

AC.3.2.1.6.2 Type:_____________________________

AC.3.2.1.6.3 Speed of oil reduction point at full load:_______________________r/min

AC.3.2.1.6.4 Maximum idling speed:_________________________________r/min

AC.3.2.1.6.5 Idling speed:______________________________________r/min

AC.3.2.2 Cold start device

AC.3.2.2.1 Manufacturing enterprise:_____________________________________

AC.3.2.2.2 Type:____

AC.3.2.2.3 Description:____

AC.3.2.3 Electronic Control Unit (ECU)

AC.3.2.3.1 Manufacturer/brand:____

AC.3.2.3.2 Type:____

AC.3.2.3.3 Adjustability:____

AC.4 Air valve timing

AC.4.1 Maximum lift of air valve, open and close angle: ___________________

AC.4.2 Reference value and (or) setting range[1]:______________________________

[1] Indicate tolerance.

[2] Scratch out those not applicable.

Annex B

(Normative)

Test Regulations

B.1 General

B.1.1 This Annex describes the measurement methods for exhaust pollutants from diesel engine, including steady state test cycle and transient state test cycle:

- Steady state test cycle, including five cycles, six cycles and 8 cycles, is applicable for measurement of exhaust pollutants for all Stage III and Stage IV diesel engines.

- Transient state test cycle (NRTC), consisting of 1238 second-by-second transient modes, is applicable for measurement of exhaust pollutants from Stage IV diesel engines below 560 kW and with non-constant speed. Enterprises can also choose this cycle for measurement of exhaust pollutants from Stage III diesel engines with non-constant speed.

B.1.2 The test shall be carried out on the engine dynamometer stand.

B.2 Test conditions

B.2.1 All the volumes and volume flows must be converted to 273K (0°C) and 101.3kPa reference conditions.

B.2.2 Test conditions of diesel engine

B.2.2.1 The absolute temperature T_a of diesel engine intake is expressed with K; the dry air pressure P_s is expressed with kPa; and the laboratory atmosphere factor f_a shall be calculated according to the following formulae:

For naturally aspirated and mechanically supercharged diesel engine:

$$f_a = \left(\frac{99}{P_s}\right) \times \left(\frac{T_a}{298}\right)^{0.7}$$

For turbocharged diesel engine with or without intake intercooling:

$$f_a = \left(\frac{99}{P_s}\right)^{0.7} \times \left(\frac{T_a}{298}\right)^{1.5}$$

B.2.2.2 Judgment of test validity

When the laboratory atmosphere factor f_a meets the following conditions, the test is considered as valid:

$$0.96 \le f_a \le 1.06$$

B.2.2.3 For supercharged intercooled diesel engine, the temperature of cooling medium and supercharged air must be recorded. The intercooling temperature at the point of rated net power shall be within ±5 ºC range from the temperature specified by manufacturer, and it shall not be lower than 20 ºC.

B.2.3 Intake system of diesel engine

The test diesel engine shall be equipped with a set of intake system, and the intake pressure drop shall be the upper limit specified by the manufacturing enterprise: intake pressure drop generated by clean air filter under the maximum intake flow operating condition of diesel engine specified by the manufacturing enterprise.

If the laboratory system may represent the actual operating condition of diesel engine, it may be used.

B.2.4 Exhaust system of diesel engine

The test diesel engine shall be equipped with a set of exhaust system, and the exhaust back pressure shall be the upper limit specified by the manufacturing enterprise: exhaust back pressure generated under the maximum rated net power operating condition of diesel engine.

B.2.5 Cooling system

The cooling system of diesel engine shall be provided with adequate capacity to make the diesel engine keep the normal working temperature specified by the manufacturing enterprise.

B.2.6 Lubricating oil

The specification of lubricating oil used in the test shall be recorded.

B.2.7 Test fuel oil

The equivalent fuel specified in Table D.1, Table D.2 of Appendix D shall be used in the test.

Cetane number, sulfur content and density of equivalent fuel for test use shall be separately recorded in Article FA.1.1 of Attachment FA.

The fuel oil temperature at injection pump inlet shall be 306~316K (33~43℃) or meet the manufacturing enterprise's requirements.

B.2.8 Power

In the test, some accessories installed on diesel engine and only used for manipulating non-road mobile machinery shall be dismantled. Such as:

——Air compressor for braking;

——Compression pump for braking steering;

——Air conditioning compressor;

——Hydraulic driven pump.

See the description of Annex E.

If above-mentioned accessories are not dismantled, the power absorbed by these accessories at the test speed shall be determined for the purpose of calculating the set value of the dynamometer according to the requirements of Article B.2.9.

B.2.9 Determination of set value of dynamometer

The set value of intake pressure drop and exhaust back pressure shall be regulated to the upper limit specified by the manufacturing enterprise according to the requirements of Article B.2.3 and Article B.2.4.

In order to calculate the torque value of the specified test operating condition, the maximum torque value at the specified test speed shall be determined according to the test. For the diesel engine not operating within the speed range of full load torque characteristic curve, the maximum torque at the test speed shall be determined by the manufacturing enterprise.

The set value of diesel engine of each test operating condition shall be calculated with the following formula:

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

If $\frac{P_{(\mathrm{b})} - P_{(a)}}{P_{(n)}}$≥0.03, then ($P_{(\mathrm{b})}$-$P_{(\mathrm{a})}$) needs to be subject to the consent of the type approval institution.

B.3 Test

B.3.1 Prepare sampling filter paper

Each piece (pair) of filter paper shall be placed into a covered but untight petri dish at least 1h before the test and put into a weighing room for stabilization. After stabilization completion, weigh and record the net mass of each piece (pair) of filter paper, and then place this piece (pair) of filter paper into a covered petri dish or on a filter paper holder until test need; if this piece (pair) of filter paper is not used within 8h from leaving weighing room, stabilize and weigh again before use.

B.3.2 Install measuring equipment

Instrument and sampling probe shall be installed as required. When the exhaust is diluted with full-flow dilution system, the exhaust pipe shall be connected with the system.

B.3.3 Start dilution system and diesel engine

Start and preheat dilution system and diesel engine until all the temperatures and pressures at full load and rated speed reach the requirements specified by the manufacturing enterprise.

B.3.4 Regulate dilution ratio

The setting of diluent air shall guarantee the surface temperature of filter paper of each test operating condition not exceeding 325K (52°C), and the total dilution ratio shall not be less than 4.

For single filter paper method of full-flow dilution system, the sampling mass flow through filter paper and the diluted exhaust mass flow under all the operating conditions (except the first 10s of each operating condition for the system without bypass capacity) shall keep a constant proportion, and the deviation of this mass flow ratio shall be controlled within ±5%. For single filter paper method of partial flow dilution system, the sampling mass flow through filter paper under all the operating conditions (except the first 10s of each operating condition for the system without bypass capacity) shall keep constant, and its deviation shall be within ±5%.

B.3.5 Measure background particulate matter

For single filter paper method (optional multiple filter paper method), start particulate matter sampling system and operate under bypass conditions. Sample particulate matter for diluent air according to the method specified in Attachment BA, and measure the background particulate matter value of diluent air. If the diluent air is filtered, measure once at any time before, during or after the test. If not, measure three times at least (i.e.: after start, close to test cycle middle and before end), and then average.

B.3.6 Measure background diluent air concentration

For the system which controls the dilution ratio through measuring CO_2 and NO_x concentration, the content of CO_2 and NO_x in diluent air shall be measured at the beginning and end of each test, and the background concentration of CO_2 and NOx in diluent air measured before and after the test shall be within 100ppm and 5ppm respectively.

If diluted exhaust analysis system is used, the relevant background concentration shall be determined according to the diluent air collected into the sampling bag during the whole test process.

The continuous background concentration (without sampling bag) shall be measured for three times at least before the test, close to test cycle middle and after the test, and then averaged. As required by the manufacturing enterprise, the background measurement may be neglected.

B.3.7 Check analyzer

The zero point and span point of emission analyzer shall be calibrated.

B.3.8 Test procedure

B.3.8.1 Steady state test cycle

B.3.8.1.1 The diesel engine operating at non-permanent speed shall be tested according to eight cycles under operating condition in Table B.1.

Table B.1

Operating condition No.	Diesel engine speed	Percent load	Weighting coefficient
1	Rated speed	100	0.15
2	Rated speed	75	0.15
3	Rated speed	50	0.15
4	Rated speed	10	0.1
5	Intermediate speed	100	0.1
6	Intermediate speed	75	0.1
7	Intermediate speed	50	0.1
8	Idling speed	0	0.15

The diesel engine with rated net power less than 19kW and operating at non-permanent speed may also be tested according to six cycles under operating condition in Table B.2.

Table B.2

Operating condition No.	Diesel engine speed	Percent load	Weighting coefficient
1	Rated speed	100	0.09
2	Rated speed	75	0.20
3	Rated speed	50	0.29
4	Rated speed	25	0.30
5	Rated speed	10	0.07
6	Idling speed	0	0.05

B.3.8.1.2 The diesel engine operating at permanent speed shall be tested according to five cycles under operating condition in Table B.3.

Table B.3

Operating condition No.	Diesel engine speed	Percent load	Weighting coefficient
1	Rated speed	100	0.05
2	Rated speed	75	0.25
3	Rated speed	50	0.3
4	Rated speed	25	0.3
5	Rated speed	10	0.1

B.3.8.2 Transient state test cycle (NRTC)

B.3.8.2.1 Stage IV diesel engines shall be tested in accordance to test regulations specified in Attachment BB of GB 17691-2005, with NRTC test cycle defined in Attachment BE of this standard.

B.3.8.2.2 NRTC test cycle consists of cold start cycle and hot start cycle:

When cold start cycle starts, the engine coolant and oil, as well as treatment system and auxiliary device of the engine shall all be between 20-30℃.

When cold state test is over, a 20-minute hot dip period shall be conducted immediately. When the hot dip period is over, the hot start cycle test shall be started immediately.

B.3.8.2.3 Results of pollutants shall be obtained under two kinds of cycles, the cold state cycle and the hot state one. The final result shall be a weighted result of 10% of the cold start cycle result and 90% of the hot start cycle result.

B.3.8.2.4 Verification statistics on effectiveness of test cycle

In Table 4, the points that are allowed to be deleted in determination of effectiveness of test cycle are listed.

Table B.4 Points allowed to be deleted in regression analysis

Work Mode	Points to Delete
The starting 24s() and the last 25s	Speed/torque and power
Throttle valve all open, torque feedback<95% of reference torque	Torque and/or power
Throttle valve all open, speed feedback<95% of reference speed	Speed and/or power
Throttle valve all closed, speed feedback>idling speed+50min-, and torque feedback>105% of reference torque	Torque and/or Power
Throttle valve all closed, speed feedback≤speed+50min-, and torque feedback=manufacturer specified/measured idling torque+2% max torque	Speed and/or power
Throttle valve ??, speed feedback>105% of reference speed	Speed and/or power

B.3.8.3 Regulation of diesel engine

In order to stabilize the diesel engine parameters to the specified value of the manufacturing enterprise, the diesel engine and system shall be preheated at rated speed and 100% percent load.

B.3.8.4 Test procedure

The test shall be carried out in sequence according to the operating condition No. listed in Table B.1 or Table B.2 or Table 3 of Article B.3.8.1.

In the test cycle, the specified speed must remain stable after transition period of each operating condition, and the deviation shall be ±1% of rated speed or ±3r/min, whichever is the greater; and the idling speed point shall be within the deviation specified by the manufacturing enterprise. The average specified torque in test measurement stage shall remain stable and the deviation shall be within ±2% of maximum torque at test speed.

Each operating condition shall need 10min at least; when testing some diesel engine, the test operating condition time may be extended as required when longer sampling time is required to obtain adequate particulate matter mass on measuring filter paper.

The operating condition time shall be recorded and written into the report.

The concentration value of gaseous pollutants shall be measured and recorded at last 3min of each operating condition.

Before the diesel engine reaches stable state, the sampling of particulate matter and the measurement of gaseous pollutants shall not be carried out, and the stable conditions shall be determined by the manufacturing enterprise. The completion time of particulate matter sampling and gaseous pollutants measurement shall be consistent.

The fuel oil temperature shall be measured at the position specified by the manufacturing enterprise or at the inlet of fuel injection pump, and the position of the measuring point shall be recorded.

B.3.8.5 Analyzer response

The exhaust shall pass through the analyzer at last 3min of each operating condition, and the output result of the analyzer shall be recorded with magnetic tape recorder or equivalent data acquisition system. If the diluted CO and CO_2 gases are measured through sampling bag method, the exhaust shall be put into the sampling bag at last 3min of each operating condition, and then the sampling bag shall be analyzed and the result shall be recorded.

B.3.8.6 Particulate matter sampling

For the particulate matter sampling through single filter paper method or multiple filter paper method, the results generated due to different methods may be different slightly, thus the method used must be described together with the result.

For single filter paper method, the weighting coefficient in test cycle shall be considered in the sampling process, and the sampling flow and sampling time shall be regulated hereby.

Sampling must be carried out at the end of each operating condition as much as possible; the sampling time of each operating condition shall be 20s at least for single filter paper method and 60s at least for multiple filter paper method; for the system without bypass function, the sampling time of each operating condition must be 60s at least for single filter paper and multiple filter paper methods.

B.3.8.7 State of diesel engine

After the diesel engine of each operating condition stabilizes, the speed, load, intake temperature, fuel flow, intake or exhaust flow of diesel engine shall be measured.

If it is impossible to measure the exhaust flow or intake flow, but possible to measure the fuel consumption, the calculation may be carried out through carbon balance method or oxygen balance method.

Any additional data required for calculation must be recorded.

B.3.9 Analyzer check

After emission test, the analyzer shall be rechecked through zero gas and identical span gas; if the check result difference before and after the test does not exceed 2%, then the test is considered as valid.

Attachment BA

(Normative)

Measurement and Sampling Specification

BA.1 Measurement and sampling specification

The system specified in Annex C shall be adopted to measure the exhaust pollutants from diesel engine submitted to test. Annex C has described recommended analytical system of gaseous pollutants (see Article C.1.1) and recommended particulate matter dilution and sampling system (see Article C.1.2).

BA.1.1 Technical specification of dynamometer

Dynamometer possessed of proper characteristic shall be adopted to complete the test cycle specified in Article B.3.8.1. Through additional calculation, the measuring instruments of torque and speed shall make the measured shaft end power within the range of allowable power.

The precision of the measuring equipment shall not exceed the maximum limit provided in Table BA.1.

BA.1.2 Exhaust flow

The exhaust flow shall be measured according to one of the methods mentioned in Article BA.1.2.1~Article BA.1.2.4.

BA.1.2.1 Direct measurement method

The exhaust flow shall be directly measured with flow nozzle or equivalent flowmeter system[1)].

BA.1.2.2 Measurement method for intake air flow and fuel consumption

Air flowmeter and fuel flowmeter with precision which is in accordance with those specified in Table BA.1 shall be adopted to measure the intake air flow and fuel consumption.

The exhaust flow shall be calculated according to the following formulae:

$G_{EXHW}=G_{AIRW}+G_{FUEL}$ (Wet-basis exhaust mass flow)

or

$V_{EXHD}=V_{AIRD}-0.766\times GFUEL$ (Dry-basis exhaust volume flow)

or

$V_{EXHW}=V_{AIRW}+0.746\times G_{FUEL}$ (Wet-basis exhaust volume flow)

BA.1.2.3 Carbon balance method

The exhaust mass flow shall be calculated with carbon balance method according to fuel consumption and exhaust concentration (see Attachment BC).

BA.1.2.4 Measurement method of total diluted exhaust flow

Where full-flow dilution system is used, the total diluted exhaust (G_{TOTW} and V_{TOTW}) flow shall be measured with PDP or CFV method (see Article C.1.2.1.2), and the measurement precision shall meet the requirements of Article BB.2.2.

BA.1.3 Precision requirements for measuring equipment

The calibration of all the measuring equipment shall be capable of tracing to national standards and shall meet the condition specified in Table BA.1:

Table BA.1

No.	Measured Item	Accuracy
1	Engine speed	±2% or ±1% of the max speed of engine
2	Torque	±2% or ±1% of the max torque of engine
3	Fuel consumption	±2% of max fuel consumption of engine
4	Air consumption	±2% or ±1% of the max air consumption of engine
5	Exhaust flow	±2% or ±1.5% of the max air consumption of engine
6	Temperature≤600K(327℃)	±2K absolute pressure
7	Temperature>600K(327℃)	±1% of the reading
8	Exhaust pressure	±0.2kPa
9	Intake resistance	±0.05kPa
10	Atmospheric pressure	±0.1kPa
11	Other pressure	±0.1kPa
12	Absolute humidity	±5% of the reading
13	Diluted air flow	±2% of the reading
14	Diluted exhaust flow	±2% of the reading

1) See the descriptions in ISO 5167 for details.

BA.1.4 Determination of gaseous pollutants

BA.1.4.1 General technical specification of analyzer

The analyzer shall have measuring range with precision required for measuring the exhaust composition concentration (see Article BA.1.4.1.1); it is recommended that the analyzer shall carry out measurement between 15% and 100% of full range; and the measured concentration shall be within this range.

If the full range value is 155ppm (or ppm C_1) or below, or the readout system (computer, data recorder) is capable of reaching sufficient precision and resolution when it is 15% below the full range, then the concentration measurement result which is 15% below the full range may be accepted. Under such circumstances, additional calibration points shall be increased to guarantee the accuracy of calibration curve (see Article BB.1.5.5.2).

The electromagnetic compatibility of equipment shall reach the level of minimizing additional error.

BA.1.4.1.1 Measuring error

The total measuring error, including cross response to other gases (see Article BB.1.9), shall not exceed ±2% of the reading or 0.3% of the full range, whichever is the smaller.

BA.1.4.1.2 Repeatability

For 2.5 times the standard deviation of 10 repeated response values measured for certain given calibration or span gas, for gases exceeding 155ppm (or ppm C_1), it shall not exceed ±1% of the full range concentration of the measuring range; for gases below 155ppm (or ppm C_1), it shall not exceed ±2% of the full range concentration of the measuring range.

BA.1.4.1.3 Response value

In all applied measuring ranges, the peak-peak response value of analyzer to zero gas, calibration gas or span gas within 10s shall not exceed 2% of the full range.

BA.1.4.1.4 Zero drift

Average response to zero gas (including response value) within a time interval of 30s.

For minimum measuring range used, the zero drift within 1h shall not exceed 2% of the full range of the measuring range.

BA.1.4.1.5 Span point drift

Average response to span gas (including response value) within a time interval of 30s.

For minimum measuring range used, the span point drift within 1h shall not exceed 2% of the full range of the measuring range.

BA.1.4.2 Gas drying

The selected gas dryer must have minimum effect on the concentration of the measured gas. Chemical dryer shall not be adopted to remove the moisture in the sample gas.

BA.1.4.3 Analyzer

Article BA.1.4.3.1~Article BA.1.4.3.4 describe the measurement principle of analyzer used, and the detailed description of the measuring system is detailed in Annex C.

The measured gas shall be subjected to analysis with the following equipment; for nonlinearized analyzer, linearizer may be used.

BA.1.4.3.1 Carbon monoxide (CO) analyzer

The carbon monoxide analyzer shall be non-dispersive infrared absorbing analyzer (NDIR).

BA.1.4.3.2 Carbon dioxide (CO_2) analyzer

The carbon dioxide analyzer shall be non-dispersive infrared absorbing analyzer (NDIR).

BA.1.4.3.3 Hydrocarbon (HC) analyzer

The hydrocarbon analyzer shall be heating hydrogen flame ionization analyzer to heat components such as detector, valve and pipeline in order to maintain gas temperature at 463K (190°C)±10K.

BA.1.4.3.4 Oxynitride (NO_x) analyzer

When measuring under dry basis condition, oxynitride analyzer shall adopt chemiluminescence detector (CLD) or heating chemiluminescence detector (HCLD) with NO2/NO converter; when measuring under wet basis condition, and the water extinguishing light inspection (see Article BB.1.9.2.2) meets the requirements, the heating chemiluminescence detector (HCLD) with converter with temperature above 333K (60°C) may be used.

BA.1.4.4 Sampling of gaseous pollutants

The sampling probe of gaseous pollutants must be installed at the upstream at least 0.5m or 3 times the exhaust pipe diameter (whichever is the greater) from the exhaust system outlet, and shall keep away from the exhaust pipe outlet and approach the diesel engine as much as possible in order to guarantee the exhaust temperature at the probe is not less than 343K (70°C).

For the diesel engine possessed of branch exhaust manifold, the probe inlet position shall be located in a far enough place downstream in order to guarantee the taken gas sample represents the average emissions of all cylinders. If the multi-cylinder diesel engine is possessed of several groups of exhaust manifolds such as "V"-shaped diesel engine, separate sampling from each group of exhaust manifolds is permitted, and average exhaust emission amount shall be calculated, or other methods which are related to above-mentioned method may be used. Total flow of exhaust mass must be used for the calculation of exhaust emission amount.

If the exhaust composition is affected by exhaust aftertreatment system, exhaust sampling must be at downstream of exhaust aftertreatment system. When full-flow dilution system is used to measure particulate matter emissions, the gaseous pollutants may also be determined according to the measurement for diluted exhaust. In dilution tunnel, the exhaust sampling probe shall be sufficiently close to the particulate matter sampling probe (see DT in Article C.1.2.1.2 and PSP in Article C.1.2.2); the emission measurement for CO and CO_2 may be carried out by putting sample gas into sample gas bag and determining through measuring the gas concentration in the sample gas bag.

BA.1.5 Measurement of particulate matter

The measurement of particulate matter requires using dilution system which is divided into full-flow dilution system and partial flow dilution system. The flow capacity of the dilution system shall be sufficient to completely eliminate water condensation in dilution and sampling system and make the temperature of diluted exhaust which abuts upon upstream of filter paper holder not exceed 325K (52°C). If the air humidity is high, dehumidification may be allowed before the diluent air enters the dilution tunnel. If the ambient temperature is below 293K (20°C), it is recommended to preheat the diluent air to exceed the upper temperature limit 303K (30°C). However, before the exhaust is led into the dilution tunnel, the diluent air temperature shall not exceed 325K (52°C).

For partial flow dilution system, shown as EP and SP in Figure 4~Figure 12 of Article C.1.2.1.1, the particulate matter sampling probe shall abut upon and be located at upper stream of exhaust sampling probe which is defined in Article C.1.1.1.

The design of partial flow dilution system divides the exhaust flow into two parts; therein, a small part is used for the measurement of particulate matter after being diluted by air. It is very important to accurately determine the dilution ratio. Different methods of gas split may be used. The split method used decides, to a great extent, the sampling system and sampling procedure used (see Article C.1.2.1.1).

The measurement of particulate matter amount requires particulate matter sampling system, particulate matter sampling filter paper, microgram balance, and weighing room with controlled temperature and humidity.

For particulate matter sampling, two methods may be adopted:

——Single filter paper method: use a pair of filter paper under all operating conditions of test cycle (see Article BA.1.5.1.3). In test sampling stage, special attention shall be paid to sampling time and flow. However, only a pair of filter paper is required throughout the test cycle.

——Multiple filter paper method: use a pair of filter paper under each operating condition of test cycle (see Article BA.1.5.1.3); such method has more easing requirements for sampling procedure but requires multiple pairs of filter paper.

BA.1.5.1 Particulate matter sampling filter paper

BA.1.5.1.1 Filter paper specification

For type approval test, fluorocarbon coated glass fibre filter or diaphragm filter paper with fluorocarbon as the matrix shall be adopted. For particular application, different filter paper materials may be used. For all types of filter paper, when the gas head-on speed is at 35cm/s~100cm/s, the collection efficiency to 0.3μm DOP (dioctyl phthalate) shall be at least

95%. Where comparison tests are carried out between laboratories and between the manufacturing enterprise and the type approval organization, filter paper with the same quality level must be used.

BA.1.5.1.2 Filter paper dimension

The minimum diameter of particulate matter sampling filter paper is 47mm (the diameter of polluted surface is 37mm), or filter paper with larger diameter may be used (see Table BA.2).

BA.1.5.1.3 Primary filter paper and secondary filter paper

In the test, a pair of primary filter paper and secondary filter paper of tandem arrangement shall be used to sample the diluted exhaust; the secondary filter paper shall be located in a downstream place not exceeding 100mm from the primary filter paper and shall not contact the primary filter paper. Filter paper shall be weighed respectively or weighed together after placing polluted surfaces of filter paper opposite.

BA.1.5.1.4 Filter paper head-on speed

The head-on speed of gas passing through filter paper shall be 35cm/s~1000cm/s. From the test beginning to the end, the increment of pressure drop shall not exceed 25kPa.

BA.1.5.1.5 Filter paper loading

For single filter paper method, the recommended minimum filter paper loading is 0.5mg/1075mm^2 polluted area; for the dimension of most frequently-used filter paper, the recommended loading is detailed in Table BA.2:

Table BA.2

Filter paper diameter (mm)	Recommended polluted surface diameter (mm)	Recommended minimum loading (mm)
47	37	0.11
70	60	0.25
90	80	0.41
110	100	0.62

For multiple filter paper method, the recommended minimum filter paper loading of the sum of all filter paper is the product of the above corresponding recommended minimum loading and operating condition number square root.

BA.1.5.2 Weighing room and analytical balance

BA.1.5.2.1 Weighing room condition

During the pretreatment and weighing of particulate matter sampling filter paper, the temperature in the weighing room shall be maintained at 295K (22℃)±3K; the humidity shall be maintained at dew point temperature of 282.5K (9.5℃)±3K and relative humidity of 45±8%.

BA.1.5.2.2 Weighing of reference filter paper

In the stabilization process of particulate matter sampling filter paper, the weighing room shall be free from any environmental pollutants which possibly fall on the filter paper (for example, dust). The weighing room may deviate from the condition of Article BA.1.5.2.1 provided that the deviation duration does not exceed 30s. When operating personnel enters the weighing room to carry out weighing, the weighing room shall meet the condition of Article BA.1.5.2.1. Within 4h after weighing the sampling filter paper (pair), two pieces of unused reference filter paper or reference filter paper pair shall be weighed simultaneously, and the dimension and material of reference filter paper (pair) shall be the same as sampling filter paper.

During two weighings of sampling filter paper, if the variation of average mass of reference filter paper (pair) exceeds ±5% (±7.5% for filter paper pair) of recommended minimum loading (see Article BA.1.5.1.5) of filter paper, then all sampling filter paper is invalid and exhaust test shall be carried out again.

If the weighing room does not conform to the condition of Article BA.1.5.2.1, but the weighing of reference filter paper (pair) meets above-mentioned requirements, then the diesel engine manufacturing enterprise may choose to admit the mass of sampling filter paper or negate this test and carry out the test again after adjusting the weighing room control system.

BA.1.5.2.3 Analytical balance

The precision and resolution of analytical balance shall be 2μg and 1μg respectively.

BA.1.5.2.4 Elimination of electrostatic effect of filter paper

In order to eliminate electrostatic effect, filter paper shall be neutralized before weighing. Plutonium neutralizer or devices which have the same effect shall be carried out for neutralization.

BA.1.5.3 Additional conditions of particulate matter measurement

From the exhaust pipe to the filter paper holder, all the parts of dilution system and sampling system which contact with original exhaust and diluted exhaust must be designed to have minimum adhesion and change to particulate matter. All the parts shall be made of conducting materials which do not react with exhaust composition and must be earthed in order to prevent from electrostatic effect.

Attachment BB

(Normative)

Calibration Specification

BB.1 Calibration of analytical instruments

BB.1.1 General

Each analyzer shall be frequently calibrated as required to meet the requirements of this standard to the instrument accuracy. For analyzers listed in Article BA.1.4.3, this attachment states the calibration method that is used.

BB.1.2 Calibration gas

The storage date of all calibration gases must be complied with.

The expiry date of calibration gases specified by manufacturing enterprise shall be recorded.

BB.1.2.1 Pure gas

The following working gases shall be provided, and the impurity content in such gases shall not exceed the following limits:

—Pure nitrogen; therein, impurities: $C_1 \leq 1ppm$, $CO \leq 1ppm$, $CO_2 \leq 400ppm$, $NO \leq 0.1ppm$

—Pure oxygen: with purity>99.5%v/v O_2

—Hydrogen-helium gas mixture (hydrogen with volume fraction of 40%±2% and helium serves as equilibrium gas); therein, impurities: $C_1 \leq 1ppm$, $CO_2 \leq 400ppm$

—Synthetic air; therein impurities: $C_1 \leq 1ppm$, $CO \leq 1ppm$, $CO_2 \leq 400ppm$, $NO \leq 0.1ppm$; with oxygen content of 18%~21%v/v

BB.1.2.2 Calibration gas and span gas

Mixed gas of the following chemical compositions shall be possessed of:

—C_3H_8 and synthetic air

—CO and pure nitrogen

—NO and pure nitrogen (herein, the NO_2 content in calibration gas shall not exceed 5% of NO content)

—O_2 and pure nitrogen

—CO_2 and pure nitrogen

Note: Other mixed gases are allowable, provided that these gases do not have interreaction. The actual concentration of calibration gas and span gas must be within ±2% of the nominal value; the concentration of all calibration gases and span gases shall be expressed in volume fraction or volume ppm.

Gases used for calibration and spanning may also be obtained through gas splitter, and diluted with pure nitrogen or synthetic air. The accuracy of mixing device must make the concentration error of diluted calibration gas within ±2%.

BB.1.3 Operation specification of analyzer and sampling system

The operation specification of analyzer shall comply with the start-up and operating instructions of the instrument manufacturing enterprise, and shall cover the minimum requirements provided in Article BB.1.4~Article BB.1.9.

BB.1.4 Leakage test

Leakage test shall be carried out systematically. Dismantle the sampling probe from the exhaust system, block up the end part with stopper; start the sampling pump of analyzer; the readings of all flowmeters shall be zero after the initial stable period. If zero is unavailable, check the sampling pipeline and clear faults. The maximum allowable leakage amount is 0.5% of the in-service flow of the part under inspection in the system. Estimate the in-service flow with the analyzer flow and bypass flow.

The alternative method: introduce the calibration gas with concentration increasing step by step from zero gas to span gas at the front end of sampling pipeline; if the time is sufficiently long, and the concentration reading on analyzer is less than the concentration of introduced span gas, problems on calibration or leakage are then defined.

BB.1.5 Calibration specification

BB.1.5.1 Analyzer assembly

Analyzer assembly shall be calibrated and calibration gas shall be used to check the calibration curve. The flow used by calibration gas shall be the same as that of the exhaust sampling.

BB.1.5.2 Preheating time

Preheating time shall be in accordance with the requirements of the manufacturing enterprise. If no requirements are given, then it is recommended to preheat the analyzer for at least 2h.

BB.1.5.3 NDIR and HFID analyzers

NDIR analyzer shall be adjusted as required and the burning flame of HFID analyzer shall be adjusted to optimum (see the requirements of Article BB.1.8.1).

BB.1.5.4 Calibration

Normal operating range shall be calibrated.

Synthetic air (or nitrogen) shall be adopted to calibrate the zero position of CO, CO_2, NO_X, HC and O_2 analyzers.

Introduce proper calibration gases to the analyzer and record the value, then establish the calibration curve according to Article BB.1.5.5.

If necessary, re-check the zero calibration and repeat the calibration specification.

BB.1.5.5 Establishment of the calibration curve

BB.1.5.5.1 General

The calibration curve of analyzer shall at least be composed of five calibration points (excluding zero point) which are evenly distributed as much as possible. The maximum nominal concentration shall be equal to or greater than 90% of the full range.

The calibration curve shall be calculated with least square method. If the degree of polynomial is greater than 3, then the number of calibration points (including zero point) shall be at least equal to the sum of the degree of polynomial and two.

The difference of nominal values between the calibration curve and each calibration point shall not be greater than ±2% and the difference at zero point shall not be greater than ±1% of the full range.

Whether the calibration is correct can just be inspected according to calibration curves and calibration points; different characteristic parameters of analyzer shall be indicated, especially:

—Measurement range

—Sensitivity

—Calibration date

BB.1.5.5.2 Calibration less than 15% of full range

The calibration curve of analyzer shall at least be composed of ten calibration points with approximately equal spacing (excluding zero point); therein, 50% calibration points are below 10% of the full range.

The calibration curve is calculated with least square method.

The difference of nominal values between the calibration curve and each calibration point shall not be greater than ±4% and the difference at zero point shall not be greater than ±1% of the full range.

BB.1.5.5.3 Alternative methods

If it is indicated that the alternative technologies (such as computer, electronic control range switch etc.) can reach identical accuracy, then these alternative technologies can be applied.

BB.1.6 Verification of calibration

Prior to each operation, each normally-used operating range shall be checked according to the following procedures.

Check the calibration with zero gas and span gas, the nominal value of span gas shall be above 80% of the measurement full range.

If the difference between the measured value and nominal value of these two points is not greater than ±4% of the full range, then the adjustment parameter may be revised. Otherwise, a new calibration curve shall be established according to Article BB.1.5.5.

BB.1.7 Efficiency inspection of NO_X converter

Inspect the efficiency of converter converting NO_2 into NO according to the requirements of Article BB.1.7.1~Article BB.1.7.8.

BB.1.7.1 Inspection device

Inspect the efficiency of converter with an ozone generator by utilizing the inspection device as shown in Figure BB.1 and according to procedures below.

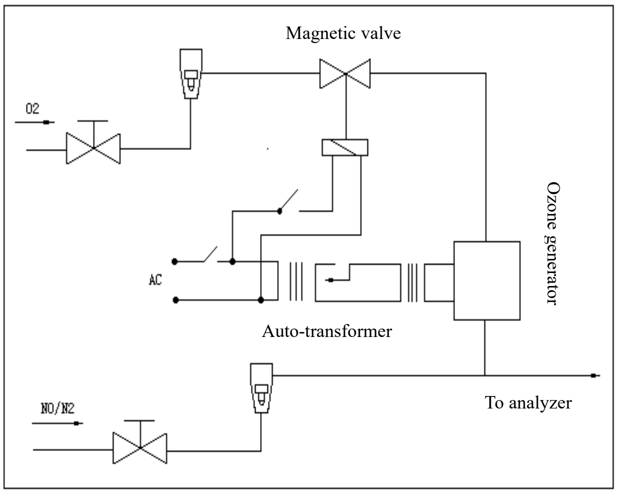


Figure BB.1 Equipment Flow Chart of NO_2 conversion Efficiency

BB.1.7.2 Calibration

Zero gas and span gas shall be used to calibrate CLD and HCLD at most normally-used operating range according to the manufacturing enterprise's specifications (the NO content in span gas shall reach about 80% of the operating range, the NO_2 concentration in gas mixture shall be less than 5% of the NO concentration). The NO_X analyzer shall be placed at NO mode to make span gas not go through the converter. Record the indicated concentration.

BB.1.7.3 Calculation

The efficiency of NO_X converter is calculated according to the following formula:

$$Efficiency \quad (\%) = \left(1 + \frac{a-b}{c-d}\right) \times 100$$

a: the NO_X concentration obtained according to Article BB.1.7.6;

b: the NO_X concentration obtained according to Article BB.1.7.7;

c: the NO concentration obtained according to Article BB.1.7.4;

d: the NO concentration obtained according to Article BB.1.7.5.

BB.1.7.4 Add oxygen

Place the analyzer at NO mode, continuously add the oxygen or synthetic air into gas flow through a "T" Type joint until the indicated concentration ratio is about 20% less than the calibration concentration provided in Article BB.1.7.2; record the indicated concentration (c).During this process, the ozone generator is out of function.

BB.1.7.5 Stimulate the ozone generator

Place the analyzer at NO mode, stimulate the ozone generator to generate sufficient ozone and make the NO concentration drop to about 20% of the calibration concentration provided in Article BB.1.7.2 (the minimum is 10%); record the indicated concentration (d).

BB.1.7.6 NO_X mode

Switch the analyzer to NO_X mode to make the gas mixture (containing NO, NO_2, O_2 and N_2) pass through the converter; record the indicated concentration (a).

BB.1.7.7 Stop stimulating the ozone generator

Place the analyzer at NO_X mode, stop stimulating the ozone generator to make the gas mixture described in Article BB.1.7.6 pass through the converter; record the indicated concentration (b).

BB.1.7.8 NO mode

Under the circumstance that ozone generator stops stimulating, switch to NO mode, cut off the gas flow of oxygen or synthetic air; and the NO_X reading of analyzer shall not deviate above ±5% from the measured value according to Article BB.1.7.2.

BB.1.7.9 Test interval

Conduct the efficiency test of converter each time before calibrating NO_X analyzer.

BB.1.7.10 Efficiency requirements

The converter efficiency shall not be less than 90% but it is recommended that the efficiency exceeds 95%.

Note: Within most normally-used range of the analyzer, if the ozone generator fails to make NO concentration drop from 80% to 20% according to Article BB.1.7.5, then the maximum range capable of reaching this reduction amount shall be adopted in the test.

BB.1.8 Adjustment of FID

BB.1.8.1 Optimization of detector response

FID shall be adjusted according to the requirements of manufacturing enterprise's instructions. The propane span gas that the synthetic air is used as the equilibrium gas to optimize the response of most normal range.

Set the flow of H_2/He gas mixture and synthetic air at the recommended value of the manufacturing enterprise and introduce (350±75)ppm C_1 of span gas into the analyzer. Response under given H_2/He gas mixture flow shall be determined according to the difference between span gas response and zero gas response. The H_2/He gas mixture flow shall be respectively subjected to step-up adjustment at values above and below the manufacturing enterprise's requirements; record the response of span gas and zero gas under these H_2/He gas mixture flows. Then draw the difference between the responses of span gas and zero gas into a curve and adjust the H_2/He gas mixture flow to the high response area of the curve.

BB.1.8.2 Hydrocarbon response factor

Adopt the propane span gas that the synthetic air serves as equilibrium gas and the synthetic air to calibrate the analyzer.

When the analyzer is started and after periodic overhaul for it, the response factor shall be determined. The response factor (R_f) of a certain hydrocarbon refers to the ratio of the C_1 reading of FID to the cylinder gas concentration expressed in ppm C_1.

The concentration of test gas must be able to generate the response that is about 80% of the full range. Based on the weight reference, the known concentration expressed with volume must reach $\underline{+}$2% of the accuracy. In addition, the cylinder shall be subjected to pretreatment for 24h under the temperature of 298K+5K (25°C+5°C).

The adopted test gas and recommended response factor scope are as follows:

Methane and synthetic air	$1.00 \leq Rf \leq 1.15$
Propylene and synthetic air	$0.90 \leq Rf \leq 1.10$
Methylbenzene and synthetic air	$0.90 \leq Rf \leq 1.10$

The above values are the corresponding response factors when R_f of propane and synthetic air is 1.

BB.1.8.3 Oxygen interference check

When the analyzer is started and after periodic overhaul for it, the oxygen interference shall be checked.

The response factor shall be determined according to the requirements of Article BB.1.8.2, and the adopted inspection gas and recommended response factor are as follows:

Propane and pure nitrogen	$0.95 \leq Rf \leq 1.15$

The above value is the corresponding response factor when R_f of propane and synthetic air is 1.

The oxygen concentration of the air in FID burner shall be within ±1mole% of that of the air in burner used in the recent oxygen interference check; if the difference is quite obvious, oxygen interference check shall be carried out, and if necessary, the analyzer shall be adjusted.

BB.1.9 Interference on NDIR and CLD analyzers

Besides the analyzed gas, other gases in the exhaust may interfere with the reading in various ways. The positive interference in NDIR instrument refers to that the interference gas produces the influence the same as that of tested gas, but the influence degree is smaller. The negative interference occurred in NDIR instrument refers to the enlarged absorption band of tested gas due to interference gas; the negative interference occurred in CLD instrument is due to the extinguishing-light action of interference gas. Before the analyzer is started and after periodic overhaul for it, the interference check shall be carried out according to the requirements of Article BB.1.9.1 and Article BB.1.9.2.

BB.1.9.1 Interference check of CO analyzer

Water and CO_2 may interfere with the performance of CO analyzer. Therefore, CO_2 span gas whose concentration is 80%~100% of the maximum operating range used in the test shall be bubbled and flowed out from water, and the response value of analyzer shall be recorded. If the CO range is equal to or greater than 300ppm C_1, then the response value of analyzer shall not be greater than 1% of the full range; if the CO range is less than 300ppm C_1, then the response value of analyzer shall not be greater than 3ppm.

BB.1.9.2 Extinguishing-light check of NO_X analyzer

The two kinds of gases which have extinguishing-light action to CLD (or HCLD) analyzer are CO_2 and vapour. The extinguishing-light response of these gases is proportional to the concentration. As a result, it is required to use a test method to determine the extinguishing-light under the maximum concentration supposed according to test experience.

BB.1.9.2.1 CO_2 extinguishing-light check

Introduce CO_2 span gas with the concentration that the maximum operating range is 80%~100% of full range into NDIR analyzer, record CO_2 value as A; and then dilute with NO span gas to about 50% and introduce into NDIR and (H)CLD, respectively record CO_2 and NO values as B and C; then cut off CO_2, only let NO span gas pass through (H) CLD and record NO value as D.

Extinguishing-light calculated according to the following formula shall not exceed 3%:

$$\%\ CO_2\ Extinguishing\ light = \left[1 - \left(\frac{C \times A}{D \times A - D \times B}\right)\right] \times 100$$

Where,

A: the undiluted CO_2 concentration determined by NDIR, %;

B: the diluted CO_2 concentration determined by NDIR, %;

C: the diluted NO concentration determined by (H)CLD, ppm;

D: the undiluted NO concentration determined by (H)CLD, ppm.

BB.1.9.2.2 Water-extinguishing-light check

Such check is only applicable to the wet-basis NO_X analyzer. The calculation of water extinguishing-light must adopt water vapour to dilute NO span gas and make the water vapour concentration of gas mixture reach the expected concentration in the test.

Introduce NO span gas with concentration that the normally-used range is 80%~100% of full range into (H)CLD, record NO value as D; NO span gas bubbles and flows through NO analyzer at room temperature, record NO value as C. Determine the absolute pressure of analyzer and water temperature of bubbler; respectively record as E and F. Calculate the saturated vapor pressure of gas mixture corresponding to the water temperature (F) of bubbler, record as G, and then calculate the water vapor concentration (H, %) of gas mixture according to the following formula:

$$H = 100 \times \left(\frac{G}{E}\right)$$

Calculate the expected concentration (D_e) of diluted NO span gas (in vapour) according to following formula:

$$D_e = D \times \left(1 - \frac{H}{100}\right)$$

For diesel engine exhaust gas, given that the fuel atom H:C is 1.8:1 and according to the concentration (A, determined according to Article BB.1.9.2.1) of undiluted CO2 span gas, the estimation for the expected maximum concentration (H_m, %) of vapour in exhaust during the test is as follows:

$$H_m = 0.9 \times A$$

Water extinguishing-light calculated according to the following formula shall not exceed 3%:

$$\%\ H_2O\ Extinguishing\ light = 100 \times \left(\frac{D_e - C}{D_e}\right) \times \left(\frac{H_m}{H}\right)$$

Where,

D_e: the expected concentration of diluted NO, ppm;

C: the concentration of diluted NO, ppm;

H_m: the maximum vapour concentration, %;

H: the actual vapour concentration, %.

Note: As absorption of NO_2 in water is not considered in the calculation of extinguishing-light, the concentration of NO_2 contained in NO span gas in this check shall be as low as possible.

BB.1.10 Calibration period

Calibrate the analyzer at least once every three months according to the requirements of Article BB.1.5, or carry out calibration after system overhaul and adjustment which possibly affects the calibration.

BB.2 Calibration of particulate matter measurement system

BB.2.1 General

In order to reach the accuracy requirement of this standard, each part shall be frequently calibrated. This Section describes the calibration method of parts shown in Article BA.1.5 and Annex C.

BB.2.2 Flow measurement

Calibration of gas flowmeter or flow measuring instrument shall be traced to international standard and/or national standard.

The maximum error of measured value shall be within ±2% of the reading.

If the gas flow is determined with pressure difference flow measurement method, then the maximum error of flow difference shall make the accuracy of G_{EDFW} within ±4% (see EGA in Article C.1.2.1.1).This value can be calculated with the root mean square of the error of each instrument.

BB.2.3 Check the dilution ratio

Where the particulate matter sampling system without exhaust analyzer is adopted (see Article C.1.2.1.1), for each set of newly-installed diesel engine, check the dilution ratio by operating the diesel engine and measuring the concentration of CO_2 or NO_X in original exhaust or diluted exhaust.

The measured dilution ratio shall be within ±10% of the dilution ratio calculated according to measured concentration of CO_2 or NO_X.

BB.2.4 Checking the partial flow condition

Check the exhaust speed and pressure fluctuation scope; if applicable, make adjustment according to the requirements of EP in Article C.1.2.1.1.

BB.2.5 Calibration period

The flow measuring device shall be subjected to regular calibration or carry out the calibration when the system has changes which possibly affect the calibration.

Attachment BC

(Normative)

Data Determination and Calculation

BC.1 Data determination and calculation

BC.1.1 Data determination of gaseous pollutants

For determination of gaseous pollutants, the reading of every operating condition recorded in the last 60s shall be averaged. The average concentration (conc) of HC, CO, NO_X and CO_2 (if carbon balance method is adopted) of each operating condition shall be determined according to the average value of recorded readings and corresponding correction data. If obtaining equivalent data is guaranteed, different recording types may be used.

The average background concentration ($conc_d$) may be determined according to readings of dilute air sampling bag or continuous background readings and corresponding correction data.

BC.1.2 Particulate matter

For the determination of particulate matter emission amount, the sampling mass ($M_{SAM, i}$) or volume ($V_{SAM, i}$) passes through the filter paper in every operating condition shall be recorded.

After the test, send the filter paper back to the weighing room for stabilization for 1h at least, but not exceeding 80h, and then carry out weighing. Record the total mass of filter paper and deduct its net mass (see Article B.3.1), the particle matter mass (single filter paper method is for M_f, and multiple filter paper method is for $M_{f, i}$) is the mass sum of the particle matter collected with primary and secondary filter papers.

If background correction is carried out, the mass (M_{DIL}) or volume (V_{DIL}) of dilute air and mass of particulate matter (M_d) passes through the filter paper shall be recorded. If multiple measurements are carried out, M_d/M_{DIL} or M_d/V_{DIL} of each measurement shall be calculated and subjected to averaging.

BC.1.3 Calculation of gaseous pollutants

The final result of test shall be calculated according to the following procedures.

BC.1.3.1 Determination of exhaust flow

The exhaust flow (G_{EXHW}, V_{EXHW} or V_{EXHD}) in every operating condition shall be determined according to Article BA.1.2.1~Article BA.1.2.3.

Where the full-flow dilution system is adopted, the total diluted exhaust flow (G_{TOTW}, V_{TOTW}) in every operating condition shall be calculated according to Article BA.1.2.4.

BC.1.3.2 Dry/wet-basis calibration

Where G_{EXHW}, V_{EXHW}, G_{TOTW} or V_{TOTW} are applied, if the measurement is not carried out in wet-basis condition, the dry-basis concentration shall be converted to wet-basis concentration according to the following formula:

$$conc\ (wet)=K_w \times conc\ (dry)$$

For sampling of original exhaust:

$$K_{w,r,1} = \left(1 - F_{FH} \times \frac{G_{FUEL}}{G_{AIRD}}\right) - K_{w2}$$

Or

$$K_{w,r,2} = \left(\frac{1}{1 + 1.85 \times 0.005 \times (\%CO[dry] + \%CO_2[dry]}\right) - K_{w2}$$

For sampling to diluted exhaust:

$$K_{w,e,1} = \left(1 - \frac{1.85 \times CO_2\%(wet)}{200}\right) - K_{w1}$$

Or

$$K_{w,e,2} = \left(\frac{1 - K_{w1}}{1 + \frac{1.85 \times CO_2\%(dry)}{200}}\right)$$

FH is calculated according to the following formula:

$$F_{FH} = \frac{1.969}{\left(1 + \frac{G_{FUEL}}{G_{AIRW}}\right)}$$

For dilute air:

$$K_{w,\,d} = 1 - K_{w1}$$

$$K_{w1} = \frac{1.608 \times [H_d \times (1 - 1/DF) + H_a \times (1/DF)]}{1000 + 1.608 \times [H_d \times (1 - 1/DF) + H_a \times (1/DF)]}$$

Where,

$$H_d = \frac{6.22 \times R_d \times p_d}{p_B - p_d \times R_d \times 10^{-2}}$$

$$H_a = \frac{6.22 \times R_a \times p_a}{p_B - p_a \times R_a \times 10^{-2}}$$

For intake (if different from the dilute air):

$$K_{w,\,a} = 1 - K_{w2}$$

$$K_{w2} = \frac{1.608 \times H_a}{1000 + 1.608 \times H_a}$$

$$H_a = \frac{6.22 \times R_a \times p_a}{p_B - p_a \times R_a \times 10^{-2}}$$

BC.1.3.3 NO_X humidity calibration

As NO_X emission is related to ambient atmosphere condition, the concentration of NO_X shall be subjected to ambient temperature and humidity calibrations according to coefficient

K_H given in the following formula; the humidity correction coefficient formula of NO_X is as follows:

$$K_H = \frac{1}{1 + A \times (H_a - 10.71) + B \times (T_a - 298)}$$

Where,

A=-0.0182

B=0.0045

$$H_a = \frac{6.22 \times R_a \times p_a}{p_B - p_a \times R_a \times 10^{-2}}$$

BC.1.3.4 Calculation of emission mass flow

The emission mass flow of every operating condition shall be calculated according to the following formula:

(a) For original exhaust [1]:

$$Gas_{mass} = u \times conc \times G_{EXHW}$$

(b) For diluted exhaust:

$$Gas_{mass} = u \times conc_c \times G_{TOTW}$$

Where,

$conc_c$ is the background correction concentration

$$conc_c = con_c - conc_d \times (1 - 1/DF)$$

$$DF = \frac{13.4}{concCO_2 + (concCO + concHC) \times 10^{-4}}$$

The coefficient u-wet basis shall be used according to Table BC.1:

Table BC.1

Gas	u	conc
NO_X	0.001587	ppm
CO	0.000966	ppm
HC	0.000479	ppm
CO_2	15.19	%

[1] The concentration of NO_X (NO_Xconc or NO_Xconc$_c$) must multiply K_H (NO_X humidity correction coefficient, see BC.1.3.3). The formula is as below:

$$K_H \times NO_X conc \text{ (or } NO_X conc_c\text{)}$$

BC.1.3.5 Calculation of brake specific emission

The brake specific emission (g/kWh) of every kind of composition shall be calculated according to the following formula:

$$Each\ gas = \frac{\sum_{i-1}^{n} \left(Gas_{mass,\,i} \times WF_i\right)}{\sum_{i=1}^{n} \left(P_{(n)_i} \times WF_i\right)}$$

The weighting coefficient and operating condition number (n) used in the above-mentioned calculation shall be in accordance with the requirements of Article B.3.8.1.

BC.1.4 Calculation of particulate matter

The particulate matter shall be calculated according to the following formula:

BC.1.4.1 Humidity correction coefficient of particulate matter

As the particulate matter emission of diesel engine is related to ambient atmosphere condition, the mass flow of particulate matter shall adopt coefficient K_p in the following formula to correct the ambient air humidity; the mass flow PM_{mass} of particulate matter used for calculating the final result equals to the measured mass of particulate matter multiplied by the humidity correction coefficient K_p.

$$K_p = \frac{1}{1 + 0.0133 \times (H_a - 10.71)}$$

$$H_a = \frac{6.22 \times R_a \times p_a}{p_B - p_a \times R_a \times 10^{-2}}$$

BC.1.4.2 Partial flow dilution system

The final result of particulate matter shall be determined according to the following procedure. As different dilution flow control methods are adopted, different calculation methods may be used for equivalent exhaust mass flow G_{EDEW} or equivalent exhaust volume flow V_{EDFW}. All calculations shall be based on the average value taken at the sampling stage of each operating condition.

BC.1.4.2.1 Isokinetic system

$$G_{EDFW,\,i} = G_{EXHW,\,i} \times q_i$$

Or:

$$V_{EDFW,\,i} = V_{EXHW,\,i} \times q_i$$

Where,

$$q_i = \frac{G_{DILW,i} + (G_{EXHW,i} \times r)}{(G_{EXHW,i} \times r)}$$

Or:

$$q_i = \frac{V_{DILW,i} + (V_{EXHW,i} \times r)}{(V_{EXHW,i} \times r)}$$

Where,

$$r = \frac{A_p}{A_T}$$

BC.1.4.2.2 System with CO_2 or NO_X concentration measurement

$$G_{EDFW,\,i} = G_{EXHW,\,i} \times q_i$$

Or:

$$V_{EDFW,\,i} = V_{EXHW,\,i} \times q_i$$

$$q_i = \frac{Conc_{E,i} - Conc_{A,i}}{Conc_{D,i} - Conc_{A,i}}$$

Where,

$Conc_E$: the wet-basis concentration of tracing gas in the original exhaust;

$Conc_D$: the wet-basis concentration of tracing gas in the diluted exhaust;

$Conc_A$: The wet-basis concentration of tracing gas in dilute air.

The measured dry-basis concentration shall be converted to wet-basis concentration according to Article BC.1.3.2.

BC.1.4.2.3 System with CO_2 measurement and carbon balance method

$$G_{EDFW,i} = \frac{206.6 \times G_{FUEL,i}}{CO_{2D,i} - CO_{2A,i}}$$

Where,

CO_{2D}: the CO_2 concentration in diluted exhaust, expressed in wet-basis volume fraction (%);

CO_{2A}: the CO_2 concentration in dilute air, expressed in wet-basis volume fraction (%);

Calculations of the following formulae are based on the assumed carbon balance (namely: all carbon atoms supplied to diesel engine are exhausted in the form of CO_2).

$$G_{EDFW,\ i}=G_{EXHW,\ i}\times q_i$$

$$q_i = \frac{206.6 \times G_{FUEL,i}}{G_{EXHW,i} \times (CO_{2D,i} - CO_{2A,i})}$$

BC.1.4.2.4 System with flow measurement

$$G_{EDFW,\ i}=G_{EXHW,\ i}\times q_i$$

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

BC.1.4.3 Full-flow dilution system

The final result of particulate matter shall be determined according to the following procedure.

All calculations shall be based on the average value taken at the sampling stage of each operating condition.

$$G_{EDFW,\ i}=G_{TOTW,\ i}$$

Or:

$$V_{EDFW,\ i}=V_{TOTW,\ i}$$

BC.1.4.4 Calculation of particulate matter mass flow

The mass flow of particulate matter shall be calculated according to the following formulae:

For single filter paper method:

$$PM_{mass} = \frac{M_f}{M_{SAM}} \times \frac{(G_{EDFW})_{aver}}{1000}$$

Or:

$$PM_{mass} = \frac{M_f}{V_{SAM}} \times \frac{(V_{EDFW})_{aver}}{1000}$$

Where,

$(G_{EDFW})_{aver}$, $(V_{EDFW})_{aver}$, $(M_{SAM})_{aver}$ and $(V_{SAM})_{aver}$ in the whole test cycle are the sum of average values of each operating condition during sampling.

$$(G_{EDFW})_{aver} = \sum_{i=1}^{n} G_{EDFW,i} \times WF_i$$

$$(V_{EDFW})_{aver} = \sum_{i=1}^{n} V_{EDFW,i} \times WF_i$$

$$M_{SAM} = \sum_{i=1}^{n} M_{SAM,i}$$

$$V_{SAM} = \sum_{i=1}^{n} V_{SAM,i}$$

Where,

i=1, …n

For multiple filter papers method:

$$PM_{mass,i} = \frac{M_{f,i}}{M_{SAM,i}} \times \frac{G_{EDFW,i}}{1000}$$

Or:

$$PM_{mass,i} = \frac{M_{f,i}}{V_{SAM,i}} \times \frac{V_{EDFW,i}}{1000}$$

Where,

i=1, …n

The mass flow of particulate matter shall be subjected to background correction according to the following formulae:

For single filter paper method:

$$PM_{mass} = \left[\frac{M_f}{M_{SAM}} - \left(\frac{M_d}{M_{DIL}} \times \left(\sum_{i=1}^{n}\left(1 - \frac{1}{DF_i}\right) \times WF_i\right)\right)\right] \times \frac{(G_{EDFW})_{aver}}{1000}$$

Or:

$$PM_{mass} = \left[\frac{M_f}{V_{SAM}} - \left(\frac{M_d}{V_{DIL}} \times \left(\sum_{i=1}^{n}\left(1 - \frac{1}{DF_i}\right) \times WF_i\right)\right)\right] \times \frac{(V_{EDFW})_{aver}}{1000}$$

If multiple measurements are carried out, then (M_d/M_{DIL}) or (M_d/M_{DIL}) shall respectively be replaced by $(M_d/M_{DIL})_{aver}$ and $(M_d/M_{DIL})_{aver}$.

$$DF = \frac{13.4}{concCO_2 + (concCO + concHC) \times 10^{-4}}$$

Or:

$$DF = \frac{13.4}{concCO_2}$$

For multiple filter papers method:

$$PM_{mass,i} = \left[\frac{M_{f,i}}{M_{SAM,i}} - \left(\frac{M_d}{M_{DIL}} \times \left(1 - \frac{1}{DF} \right) \right) \right] \times \frac{G_{EDFW,i}}{1000}$$

Or:

$$PM_{mass,i} = \left[\frac{M_{f,i}}{V_{SAM,i}} - \left(\frac{M_d}{M_{DIL}} \times \left(1 - \frac{1}{DF} \right) \right) \right] \times \frac{V_{EDFW,i}}{1000}$$

If multiple measurements are carried out, then (M_d/M_{DIL}) or (M_d/V_{DIL}) shall respectively be replaced by (M_d/M_{DIL})aver and $(M_d/V_{DIL})_{aver}$.

$$DF = \frac{13.4}{concCO_2 + (concCO + concHC) \times 10^{-4}}$$

Or:

$$DF = \frac{13.4}{concCO_2}$$

BC.1.4.5 Calculation of brake specific emission

The brake specific emission of particle matter (PM (g/kWh)) shall be calculated according to the following formulae:[1)]

For single filter paper method:

$$PM = \frac{PM_{mass}}{\sum_{i=1}^{n} (P_{(n)_i} \times WF_i)}$$

For multiple filter papers method:

$$PM = \frac{\sum_{i=1}^{n} (PM_{mass,i} \times WF_i)}{\sum_{i=1}^{n} (P_{(n)_i} \times WF_i)}$$

BC.1.4.6 Effective weighting coefficient

For single filter paper method, the effective weighting coefficient of every operating condition shall be calculated according to the following formulae:

$$WF_{E,i} = \frac{M_{SAM,i} \times (G_{EDFW,i})_{aver}}{M_{SAM} \times G_{EDFW,i}}$$

Or:

$$WF_{E,i} = \frac{V_{SAM,i} \times (V_{EDFW,i})_{aver}}{V_{SAM} \times V_{EDFW,i}}$$

Where,

i=1, …n

[1)] PM_{mass} must be multiplied by Kp (humidity correction coefficient of particulate matter, see BC.1.4.1).

Effective weighting coefficients shall be in the range of ±0.005 (absolute value) of weighting coefficients listed in Table B.1.1 or Table B.1.2 or Table B.2.

Attachment BD

(Normative)

Technical Requirements for Durability

BD.1 General

This Annex specifies the determination method for deterioration coefficient or deterioration correction value.

BD.2 Determination of deterioration coefficient or deterioration correction value

BD.2.1 The enterprise shall adopt the test cycle that can represent the deterioration of emission performance of the in-service diesel engine to conduct durability test on the engine pedestal based on good engineering methods. The durability time shall not be less than the allowable minimum test duration specified in Table 1. The accelerated deterioration durability test method may be adopted, and relevant accelerated deterioration factors shall be determined by the enterprise according to good engineering methods.

BD.2.2 During durability test, maintenance or replacement for key parts for emission shall be avoided in addition to the routine maintenance recommended by the enterprise.

BD.2.3 One or more diesel engine families with the same emission control technology may adopt the same emission deterioration coefficient or deterioration correction value. The enterprise shall determine the diesel engine for emission durability test according to good engineering methods, and the diesel engine for test shall be able to represent emission deterioration characteristics of one or more diesel engine families.

BD.2.4 The emission test shall be carried out at more than five spacing points selected at the end of run-in period and durability test or during durability test.

BD.2.5 The emission durability test and emission test shall be carried out according to the test cycle determined in BD.2.1, and the deterioration coefficient or deterioration correction value shall also be determined.

BD.2.6 The deterioration coefficient or deterioration correction value for each kind of pollutant shall be respectively determined. The deterioration correction value of NO_x+HC shall be calculated out according to the total amount of NO_x+HC measured during emission durability test; the deterioration coefficients of NO_x+HC shall be respectively determined according to NO_x and HC measured during emission durability test; the emission test results at the end of useful life periods of NO_x and HC shall be respectively calculated, and calculated emission values of NO_x and HC shall be finally added with each other to judge whether the standard requirements are met.

BD.2.7 Where the emission durability test doesn't cover the entire emission durability, the emission value at the end of emission duration period shall be extrapolated to the end point of the emission duration period according to the deterioration tendency established during test.

BD.2.8 The emission test result shall be recorded periodically, and the proper regression equation shall be adopted to determine the emission value at the end point of useful life period.

BD.2.9 For diesel engines installed with the exhaust aftertreatment system, the deterioration coefficient (DFi) of respective pollutant are as follows:

$$DF\mathrm{i}=\frac{Mi1}{Mi0}$$

Where,

$Mi0$——the emission amount of pollutant i at the start point of durability test, g/kW·h;

$Mi1$———the emission amount of pollutant i at the end point of useful life period, g/kW·h.

The deterioration coefficient shall be regarded as 1 if DFi is less than 1.

BD.2.10 For diesel engines not installed with the exhaust aftertreatment system, the deterioration correction value (DCi) of respective pollutant are as follows:

$$DC\mathrm{i}=Mi1-Mi0$$

Where,

$Mi0$—the emission amount of pollutant i at the start point of durability test, g/kW·h;

$Mi1$—the emission amount of pollutant i at the end point of useful life period, g/kW·h.

The deterioration correction value shall be regarded as 0 if DCi is less than 0.

BD.2.11 On the basis of reasonable technical analysis and approved by type approval organization, the manufacturing enterprise may apply deterioration coefficients or deterioration correction values established by approved heavy road or non-road diesel engines to diesel engines of non-road mobile machinery of the same model.

BD.2.12 If allowed by type approval organizations, good engineering methods may be adopted to determine the deterioration coefficient or deterioration correction value.

BD.2.13 For the diesel engine installed with exhaust aftertreatment system, deterioration corrected value determined according to BD 2.10 can be used, if it is requested by the manufactuer and it is approved by the type approval authority.

BD.3 DF value of type approval application

BD.3.1 For the diesel engine family not installed with exhaust aftertreatment system, a deterioration correction value (DCi) shall be determined for each kind of pollutant.

BD.3.2 For the diesel engine family installed with exhaust aftertreatment system, a deterioration coefficient (DFi) shall be determined for each kind of pollutant.

BD.3.3 The enterprise shall provide the information required by type approval organizations to support DF value. The information includes emission test result, durability test schedule, maintenance procedure and the information supporting the judgment for the equivalence of diesel engine technique (if applicable).

Attachment BE

(Normative)

Dynamometer Setting Criteria in NRTC Test Cycle

Table BE.1

Time	Reference Speed	Reference Torque	Time	Reference Speed	Reference Torque	Time	Reference Speed	Reference Torque
(S)	(%)	(%)	(S)	(%)	(%)	(S)	(%)	(%)
1	0	0	51	102	50	101	75	24
2	0	0	52	102	46	102	73	30
3	0	0	53	102	41	103	74	24
4	0	0	54	102	31	104	77	6
5	0	0	55	89	2	105	76	12
6	0	0	56	82	0	106	74	39
7	0	0	57	47	1	107	72	30
8	0	0	58	23	1	108	75	22
9	0	0	59	1	3	109	78	64
10	0	0	60	1	8	110	102	34
11	0	0	61	1	3	111	103	28
12	0	0	62	1	5	112	103	28
13	0	0	63	1	6	113	103	19
14	0	0	64	1	4	114	103	32
15	0	0	65	1	4	115	104	25
16	0	0	66	0	6	116	103	38
17	0	0	67	1	4	117	103	39
18	0	0	68	9	21	118	103	34
19	0	0	69	25	56	119	102	44
20	0	0	70	64	26	120	103	38
21	0	0	71	60	31	121	102	43
22	0	0	72	63	20	122	103	34
23	0	0	73	62	24	123	102	41
24	1	3	74	64	8	124	103	44
25	1	3	75	58	44	125	103	37
26	1	3	76	65	10	126	103	27
27	1	3	77	65	12	127	104	13
28	1	3	78	68	23	128	104	30
29	1	3	79	69	30	129	104	19
30	1	6	80	71	30	130	103	28
31	1	6	81	74	15	131	104	40
32	2	1	82	71	23	132	104	32
33	4	13	83	73	20	133	101	63
34	7	18	84	73	21	134	102	54
35	9	21	85	73	19	135	102	52
36	17	20	86	70	33	136	102	51
37	33	42	87	70	34	137	103	40
38	57	46	88	65	47	138	104	34
39	44	33	89	66	47	139	102	36
40	31	0	90	64	53	140	104	44
41	22	27	91	65	45	141	103	44
42	33	43	92	66	38	142	104	33
43	80	49	93	67	49	143	102	27
44	105	47	94	69	39	144	103	26
45	98	70	95	69	39	145	79	53
46	104	36	96	66	42	146	51	37
47	104	65	97	71	29	147	24	23
48	96	71	98	75	29	148	13	33
49	101	62	99	72	23	149	19	55
50	102	51	100	74	22	150	45	30

Time (S)	Reference Speed (%)	Reference Torque (%)	Time (S)	Reference Speed (%)	Reference Torque (%)	Time (S)	Reference Speed (%)	Reference Torque (%)
151	34	7	206	27	34	261	52	96
152	14	4	207	32	33	262	63	62
153	8	16	208	41	31	263	71	6
154	15	6	209	43	31	264	33	16
155	39	47	210	37	33	265	47	45
156	39	4	211	26	18	266	43	56
157	35	26	212	18	29	267	42	27
158	27	38	213	14	51	268	42	64
159	43	40	214	13	11	269	75	74
160	14	23	215	12	9	270	68	96
161	10	10	216	15	33	271	86	61
162	15	33	217	20	25	272	66	0
163	35	72	218	25	17	273	37	0
164	60	39	219	31	29	274	45	37
165	55	31	220	36	66	275	68	96
166	47	30	221	66	40	276	80	97
167	16	7	222	50	13	277	92	96
168	0	6	223	16	24	278	90	97
169	0	8	224	26	50	279	82	96
170	0	8	225	64	23	280	94	81
171	0	2	226	81	20	281	90	85
172	2	17	227	83	11	282	96	65
173	10	28	228	79	23	283	70	96
174	28	31	229	76	31	284	55	95
175	33	30	230	68	24	285	70	96
176	36	0	231	59	33	286	79	96
177	19	10	232	59	3	287	81	71
178	1	18	233	25	7	288	71	60
179	0	16	234	21	10	289	92	65
180	1	3	235	20	19	290	82	63
181	1	4	236	4	10	291	61	47
182	1	5	237	5	7	292	52	37
183	1	6	238	4	5	293	24	0
184	1	5	239	4	6	294	20	7
185	1	3	240	4	6	295	39	48
186	1	4	241	4	5	296	39	54
187	1	4	242	7	5	297	63	58
188	1	6	243	16	28	298	53	31
189	8	18	244	28	25	299	51	24
190	20	51	245	52	53	300	48	40
191	49	19	246	50	8	301	39	0
192	41	13	247	26	40	302	35	18
193	31	16	248	48	29	303	36	16
194	28	21	249	54	39	304	29	17
195	21	17	250	60	42	305	28	21
196	31	21	251	48	18	306	31	15
197	21	8	252	54	51	307	31	10
198	0	14	253	88	90	308	43	19
199	0	12	254	103	84	309	49	63
200	3	8	255	103	85	310	78	61
201	3	22	256	102	84	311	78	46
202	12	20	257	58	66	312	66	65
203	14	20	258	64	97	313	78	97
204	16	17	259	56	80	314	84	63
205	20	18	260	51	67	315	57	26

Time	Reference Speed	Reference Torque	Time	Reference Speed	Reference Torque	Time	Reference Speed	Reference Torque
(S)	(%)	(%)	(S)	(%)	(%)	(S)	(%)	(%)
316	36	22	371	32	0	426	81	58
317	20	34	372	10	8	427	74	51
318	19	8	373	17	7	428	76	57
319	9	10	374	16	13	429	76	72
320	5	5	375	11	6	430	85	72
321	7	11	376	9	5	431	84	60
322	15	15	377	9	12	432	83	72
323	12	9	378	12	46	433	83	72
324	13	27	379	15	30	434	86	72
325	15	28	380	26	28	435	89	72
326	16	28	381	13	9	436	86	72
327	16	31	382	16	21	437	87	72
328	15	20	383	24	4	438	88	72
329	17	0	384	36	43	439	88	71
330	20	34	385	65	85	440	87	72
331	21	25	386	78	66	441	85	71
332	20	0	387	63	39	442	88	72
333	23	25	388	32	34	443	88	72
334	30	58	389	46	55	444	84	72
335	63	96	390	47	42	445	83	73
336	83	60	391	42	39	446	77	73
337	61	0	392	27	0	447	74	73
338	26	0	393	14	5	448	76	72
339	29	44	394	14	14	449	46	77
340	68	97	395	24	54	450	78	62
341	80	97	396	60	90	451	79	35
342	88	97	397	53	66	452	82	38
343	99	88	398	70	48	453	81	41
344	102	86	399	77	93	454	79	37
345	100	82	400	79	67	455	78	35
346	74	79	401	46	65	456	78	38
347	57	79	402	69	98	457	78	46
348	76	97	403	80	97	458	75	49
349	84	97	404	74	97	459	73	50
350	86	97	405	75	98	460	79	58
351	81	98	406	56	61	461	79	71
352	83	83	407	42	0	462	83	44
353	65	96	408	36	32	463	53	48
354	93	72	409	34	43	464	40	48
355	63	60	410	68	83	465	51	75
356	72	49	411	102	48	466	75	72
357	56	27	412	62	0	467	89	67
358	29	0	413	41	39	468	93	60
359	18	13	414	71	86	469	89	73
360	25	11	415	91	52	470	86	73
361	28	24	416	89	55	471	81	73
362	34	53	417	89	56	472	78	73
363	65	83	418	88	58	473	78	73
364	80	44	419	78	69	474	76	73
365	77	46	420	98	39	475	79	73
366	76	50	421	64	61	476	82	73
367	45	52	422	90	34	477	86	73
368	61	98	423	88	38	478	88	72
369	61	69	424	97	62	479	92	71
370	63	49	425	100	53	480	97	54

Time	Reference Speed	Reference Torque	Time	Reference Speed	Reference Torque	Time	Reference Speed	Reference Torque
(S)	(%)	(%)	(S)	(%)	(%)	(S)	(%)	(%)
481	73	43	536	81	17	591	104	59
482	36	64	537	76	45	592	103	54
483	63	31	538	76	30	593	102	56
484	78	1	539	80	14	594	102	56
485	69	27	540	71	18	595	103	61
486	67	28	541	71	14	596	102	64
487	72	9	542	71	11	597	103	60
488	71	9	543	65	2	598	93	72
489	78	36	544	31	26	599	86	73
490	81	56	545	24	72	600	76	73
491	75	53	546	64	70	601	59	49
492	60	45	547	77	62	602	46	22
493	50	37	548	80	68	603	40	65
494	66	41	549	83	53	604	72	31
495	51	61	550	83	50	605	72	27
496	68	47	551	83	50	606	67	44
497	29	42	552	85	43	607	68	37
498	24	73	553	86	45	608	67	42
499	64	71	554	89	35	609	68	50
500	90	71	555	82	61	610	77	43
501	100	61	556	87	50	611	58	4
502	94	73	557	85	55	612	22	37
503	84	73	558	89	49	613	57	69
504	79	73	559	87	70	614	68	38
505	75	72	560	91	39	615	73	2
506	78	73	561	72	3	616	40	14
507	80	73	562	43	25	617	42	38
508	81	73	563	30	60	618	64	69
509	81	73	564	40	45	619	64	74
510	83	73	565	37	32	620	67	73
511	85	73	566	37	32	621	65	73
512	84	73	567	43	70	622	68	73
513	85	73	568	70	54	623	65	49
514	86	73	569	77	47	624	81	0
515	85	73	570	79	66	625	37	25
516	85	73	571	85	53	626	24	69
517	85	72	572	83	57	627	68	71
518	85	73	573	86	52	628	70	71
519	83	73	574	85	51	629	76	70
520	79	73	575	70	39	630	71	72
521	78	73	576	50	5	631	73	69
522	81	73	577	38	36	632	76	70
523	82	72	578	30	71	633	77	72
524	94	56	579	75	53	634	77	72
525	66	48	580	84	40	635	77	72
526	35	71	581	85	42	636	77	70
527	51	44	582	86	49	637	76	71
528	60	23	583	86	57	638	76	71
529	64	10	584	89	68	639	77	71
530	63	14	585	99	61	640	77	71
531	70	37	586	77	29	641	78	70
532	76	45	587	81	72	642	77	70
533	78	18	588	89	69	643	77	71
534	76	51	589	49	56	644	79	72
535	75	33	590	79	70	645	78	70

Time	Reference Speed	Reference Torque		Time	Reference Speed	Reference Torque		Time	Reference Speed	Reference Torque
(S)	(%)	(%)		(S)	(%)	(%)		(S)	(%)	(%)
646	80	70		701	102	68		756	103	47
647	82	71		702	100	69		757	102	49
648	84	71		703	102	70		758	102	42
649	83	71		704	102	68		759	102	52
650	83	73		705	102	70		760	102	57
651	81	70		706	102	72		761	102	55
652	80	71		707	102	68		762	102	61
653	78	71		708	102	69		763	102	61
654	76	70		709	100	68		764	102	58
655	76	70		710	102	71		765	103	58
656	76	71		711	101	64		766	102	59
657	79	71		712	102	69		767	102	54
658	78	71		713	102	69		768	102	63
659	81	70		714	101	69		769	102	61
660	83	72		715	102	64		770	103	55
661	84	71		716	102	69		771	102	60
662	86	71		717	102	68		772	102	72
663	87	71		718	102	70		773	103	56
664	92	72		719	102	69		774	102	55
665	91	72		720	102	70		775	102	67
666	90	71		721	102	70		776	103	56
667	90	71		722	102	62		777	84	42
668	91	71		723	104	38		778	48	7
669	90	70		724	104	15		779	48	6
670	90	72		725	102	24		780	48	6
671	91	71		726	102	45		781	48	7
672	90	71		727	102	47		782	48	6
673	90	71		728	104	40		783	48	7
674	92	72		729	101	52		784	67	21
675	93	69		730	103	32		785	105	59
676	90	70		731	102	50		786	105	96
677	93	72		732	103	30		787	105	74
678	91	70		733	103	44		788	105	66
679	89	71		734	102	40		789	105	62
680	91	71		735	103	43		790	105	66
681	90	71		736	103	41		791	89	41
682	90	71		737	102	46		792	52	5
683	92	71		738	103	39		793	48	5
684	91	71		739	102	41		794	48	7
685	93	71		740	103	41		795	48	5
686	93	68		741	102	38		796	48	6
687	98	68		742	103	39		797	48	4
688	98	67		743	102	46		798	52	6
689	100	69		744	104	46		799	51	5
690	99	68		745	103	49		800	51	6
691	100	71		746	102	45		801	51	6
692	99	68		747	103	42		802	52	5
693	100	69		748	103	46		803	52	5
694	102	72		749	103	38		804	57	44
695	101	69		750	102	48		805	98	90
696	100	69		751	103	35		806	105	94
697	102	71		752	102	48		807	105	100
698	102	71		753	103	49		808	105	98
699	102	69		754	102	48		809	105	95
700	102	71		755	102	46		810	105	96

Time (S)	Reference Speed (%)	Reference Torque (%)	Time (S)	Reference Speed (%)	Reference Torque (%)	Time (S)	Reference Speed (%)	Reference Torque (%)
811	105	92	866	83	29	921	80	50
812	104	97	867	83	22	922	81	37
813	100	85	868	83	16	923	82	49
814	94	74	869	83	12	924	83	37
815	87	62	870	83	9	925	83	25
816	81	50	871	83	8	926	83	17
817	81	46	872	83	7	927	83	13
818	80	39	873	83	6	928	83	10
819	80	32	874	83	6	929	83	8
820	81	28	875	83	6	930	83	7
821	80	26	876	83	6	931	83	7
822	80	23	877	83	6	932	83	6
823	80	23	878	59	4	933	83	6
824	80	20	879	50	5	934	83	6
825	81	19	880	51	5	935	71	5
826	80	18	881	51	5	936	49	24
827	81	17	882	51	5	937	69	64
828	80	20	883	50	5	938	81	50
829	81	24	884	50	5	939	81	43
830	81	21	885	50	5	940	81	42
831	80	26	886	50	5	941	81	31
832	80	24	887	50	5	942	81	30
833	80	23	888	51	5	943	81	35
834	80	22	889	51	5	944	81	28
835	81	21	890	51	5	945	81	27
836	81	24	891	63	50	946	80	27
837	81	24	892	81	34	947	81	31
838	81	22	893	81	25	948	81	41
839	81	22	894	81	29	949	81	41
840	81	21	895	81	23	950	81	37
841	81	31	896	80	24	951	81	43
842	81	27	897	81	24	952	81	34
843	80	26	898	81	28	953	81	31
844	80	26	899	81	27	954	81	26
845	81	25	900	81	22	955	81	23
846	80	21	901	81	19	956	81	27
847	81	20	902	81	17	957	81	38
848	83	21	903	81	17	958	81	40
849	83	15	904	81	17	959	81	39
850	83	12	905	81	15	960	81	27
851	83	9	906	80	15	961	81	33
852	83	8	907	80	28	962	80	28
853	83	7	908	81	22	963	81	34
854	83	6	909	81	24	964	83	72
855	83	6	910	81	19	965	81	49
856	83	6	911	81	21	966	81	51
857	83	6	912	81	20	967	80	55
858	83	6	913	83	26	968	81	48
859	76	5	914	80	63	969	81	36
860	49	8	915	80	59	970	81	39
861	51	7	916	83	100	971	81	38
862	51	20	917	81	73	972	80	41
863	78	52	918	83	53	973	81	30
864	80	38	919	80	76	974	81	23
865	81	33	920	81	61	975	81	19

Time	Reference Speed	Reference Torque		Time	Reference Speed	Reference Torque		Time	Reference Speed	Reference Torque
(S)	(%)	(%)		(S)	(%)	(%)		(S)	(%)	(%)
976	81	25		1031	84	25		1086	99	38
977	81	29		1032	86	23		1087	102	24
978	83	47		1033	85	22		1088	100	31
979	81	90		1034	83	26		1089	100	28
980	81	75		1035	83	25		1090	98	3
981	80	60		1036	83	37		1091	102	26
982	81	48		1037	84	14		1092	95	64
983	81	41		1038	83	39		1093	102	23
984	81	30		1039	76	70		1094	102	25
985	80	24		1040	78	81		1095	98	42
986	81	20		1041	75	71		1096	93	68
987	81	21		1042	86	47		1097	101	25
988	81	29		1043	83	35		1098	95	64
989	81	29		1044	81	43		1099	101	35
990	81	27		1045	81	41		1100	94	59
991	81	23		1046	79	46		1101	97	37
992	81	25		1047	80	44		1102	97	60
993	81	26		1048	84	20		1103	93	98
994	81	22		1049	79	31		1104	98	53
995	81	20		1050	87	29		1105	103	13
996	81	17		1051	82	49		1106	103	11
997	81	23		1052	84	21		1107	103	11
998	83	65		1053	82	56		1108	103	13
999	81	54		1054	81	30		1109	103	10
1000	81	50		1055	85	21		1110	103	10
1001	81	41		1056	86	16		1111	103	11
1002	81	35		1057	79	52		1112	103	10
1003	81	37		1058	78	60		1113	103	10
1004	81	29		1059	74	55		1114	102	18
1005	81	28		1060	78	84		1115	102	31
1006	81	24		1061	80	54		1116	101	24
1007	81	19		1062	80	35		1117	102	19
1008	81	16		1063	82	24		1118	103	10
1009	80	16		1064	83	43		1119	102	12
1010	83	23		1065	79	49		1120	99	56
1011	83	17		1066	83	50		1121	96	59
1012	83	13		1067	86	12		1122	74	28
1013	83	27		1068	64	14		1123	66	62
1014	81	58		1069	24	14		1124	74	29
1015	81	60		1070	49	21		1125	64	74
1016	81	46		1071	77	48		1126	69	40
1017	80	41		1072	103	11		1127	76	2
1018	80	36		1073	98	48		1128	72	29
1019	81	26		1074	101	34		1129	66	65
1020	86	18		1075	99	39		1130	54	69
1021	82	35		1076	103	11		1131	69	56
1022	79	53		1077	103	19		1132	69	40
1023	82	30		1078	103	7		1133	73	54
1024	83	29		1079	103	13		1134	63	92
1025	83	32		1080	103	10		1135	61	67
1026	83	28		1081	102	13		1136	72	42
1027	76	60		1082	101	29		1137	78	2
1028	79	51		1083	102	25		1138	76	34
1029	86	26		1084	102	20		1139	67	80
1030	82	34		1085	96	60		1140	70	67

Time	Reference Speed	Reference Torque	Time	Reference Speed	Reference Torque	Time	Reference Speed	Reference Torque
(S)	(%)	(%)	(S)	(%)	(%)	(S)	(%)	(%)
1141	53	70	1174	76	8	1207	68	62
1142	72	65	1175	76	7	1208	68	62
1143	60	57	1176	67	45	1209	68	62
1144	74	29	1177	75	13	1210	54	50
1145	69	31	1178	75	12	1211	41	37
1146	76	1	1179	73	21	1212	27	25
1147	74	22	1180	68	46	1213	14	12
1148	72	52	1181	74	8	1214	0	0
1149	62	96	1182	76	11	1215	0	0
1150	54	72	1183	76	14	1216	0	0
1151	72	28	1184	74	11	1217	0	0
1152	72	35	1185	74	18	1218	0	0
1153	64	68	1186	73	22	1219	0	0
1154	74	27	1187	74	20	1220	0	0
1155	76	14	1188	74	19	1221	0	0
1156	69	38	1189	70	22	1222	0	0
1157	66	59	1190	71	23	1223	0	0
1158	64	99	1191	73	19	1223	0	0
1159	51	86	1192	73	19	1224	0	0
1160	70	53	1193	72	20	1225	0	0
1161	72	36	1194	64	60	1226	0	0
1162	71	47	1195	70	39	1227	0	0
1163	70	42	1196	66	56	1228	0	0
1164	67	34	1197	68	64	1229	0	0
1165	74	2	1198	30	68	1230	0	0
1166	75	21	1199	70	38	1231	0	0
1167	74	15	1200	66	47	1232	0	0
1168	75	13	1201	76	14	1233	0	0
1169	76	10	1202	74	18	1234	0	0
1170	75	13	1203	69	46	1235	0	0
1171	75	10	1204	68	62	1236	0	0
1172	75	7	1205	68	62	1237	0	0
1173	75	13	1206	68	62	1238	0	0

See Figure BE.1 for dynamometer setting specifications in NRTC cycle.

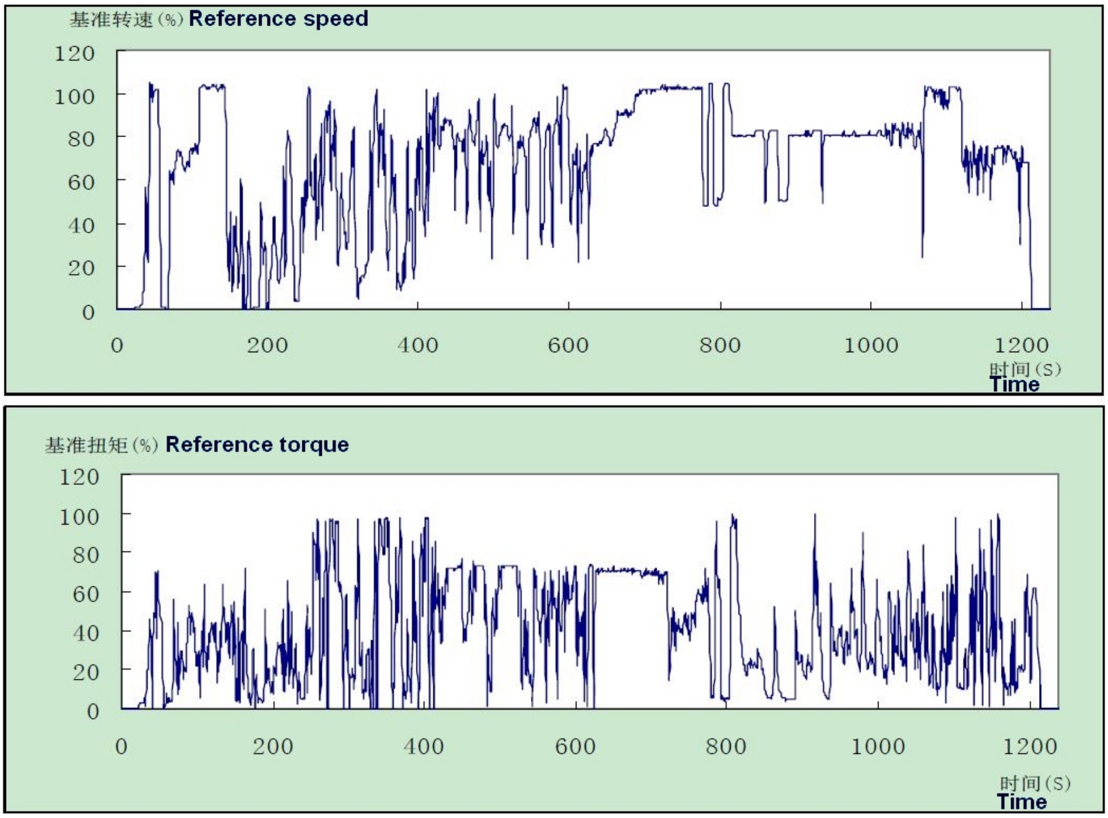


Figure BE.1 Figure of specifications for dynamometer setting in NRTC cycle

Annex C

(Normative)

Sampling System for Gas and Particulate Matter

C.1 Analysis and sampling system

Sampling System for Gas and Particulate Matter (See Table C.1)

Table C.1

Figure number	Description
2	Exhaust analysis system of original exhaust
3	Exhaust analysis system of diluted exhaust
4	Partial flow, isokinetic flow, air pump control, partial sampling
5	Partial flow, isokinetic flow, compressor control, partial sampling
6	Partial flow, CO_2 and NO_X control, partial sampling
7	Partial flow, CO_2 and carbon balance control, gross sampling
8	Partial flow, single venturi and concentration measurement, partial sampling
9	Partial flow, double venturi or orifice plate and concentration measurement, partial sampling
10	Partial flow, pipeline branching and concentration measurement, partial sampling
11	Partial flow, flow control, gross sampling
12	Partial flow, flow control, partial sampling
13	Total flow, volumetric pump or critical flow venturi, partial sampling
14	Particulate matter sampling system
15	Full-flow dilution system

C.1.1 Determination of gaseous pollutants

Figure C.1 and Figure C.2 in Article C.1.1.1 include the recommended sampling and elaboration for the analysis system and it is unnecessary to fully comply with these figures because different arrangements may generate the identical effects. The additional parts like meter, valve, solenoid valve, pump, and switch may be used to provide additional information and functions to coordinate part system. If other parts are not required for keeping accuracy of some systems, they may be removed via the mature engineering judgment.

C.1.1.1 Gaseous pollutants components CO, CO_2, HC, NO_x

Description of analysis system for gaseous pollutants determination in original exhaust and diluted exhaust is on the basis of application of the following analyzers.

——HFID for measurement of hydrocarbon;

——NDIR for measurement of CO and CO_2;

——HCID or equivalent analyzer for measurement of NO_x.

For the original exhaust (Figure C.1), the sampling for all the components may use a sampling probe or two close sampling probes and divide them to different analyzers interiorly. Measures shall be taken to ensure no coagulation of exhaust component (including water and sulfate) at any part of the analysis system.

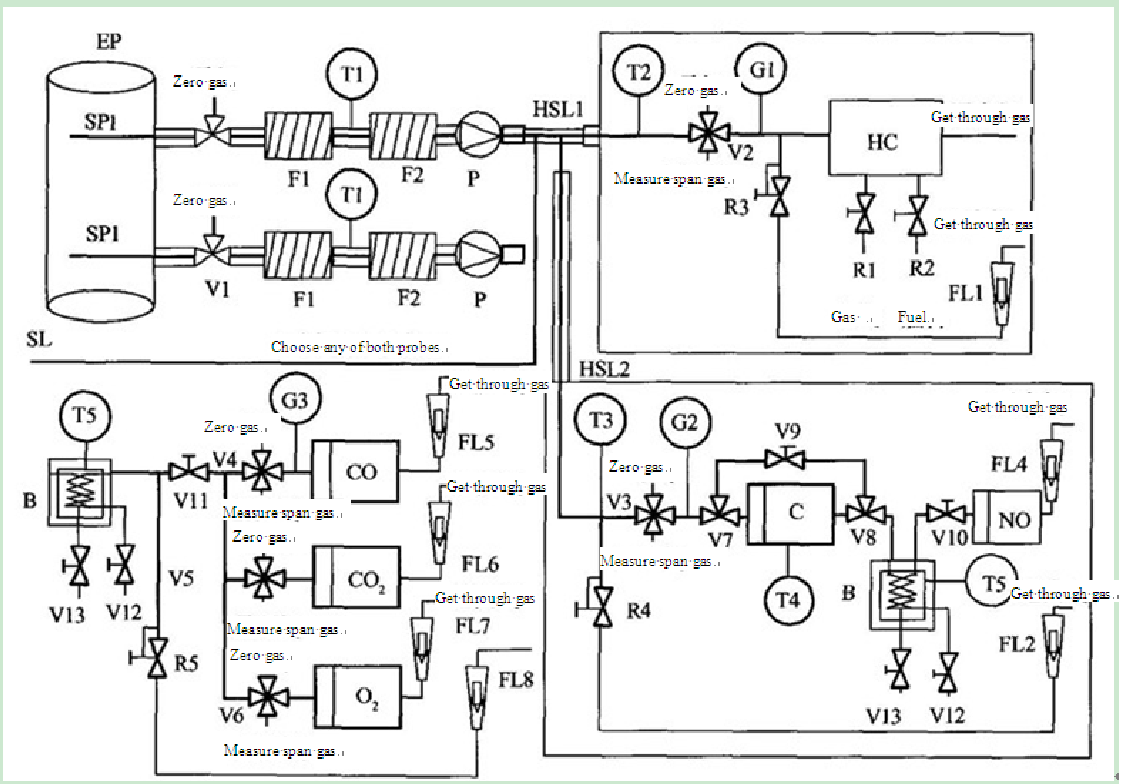


Figure C.1 Flow chart of Analysis System for Measurement of Original Exhaust CO, CO2, O2, NOx and HC

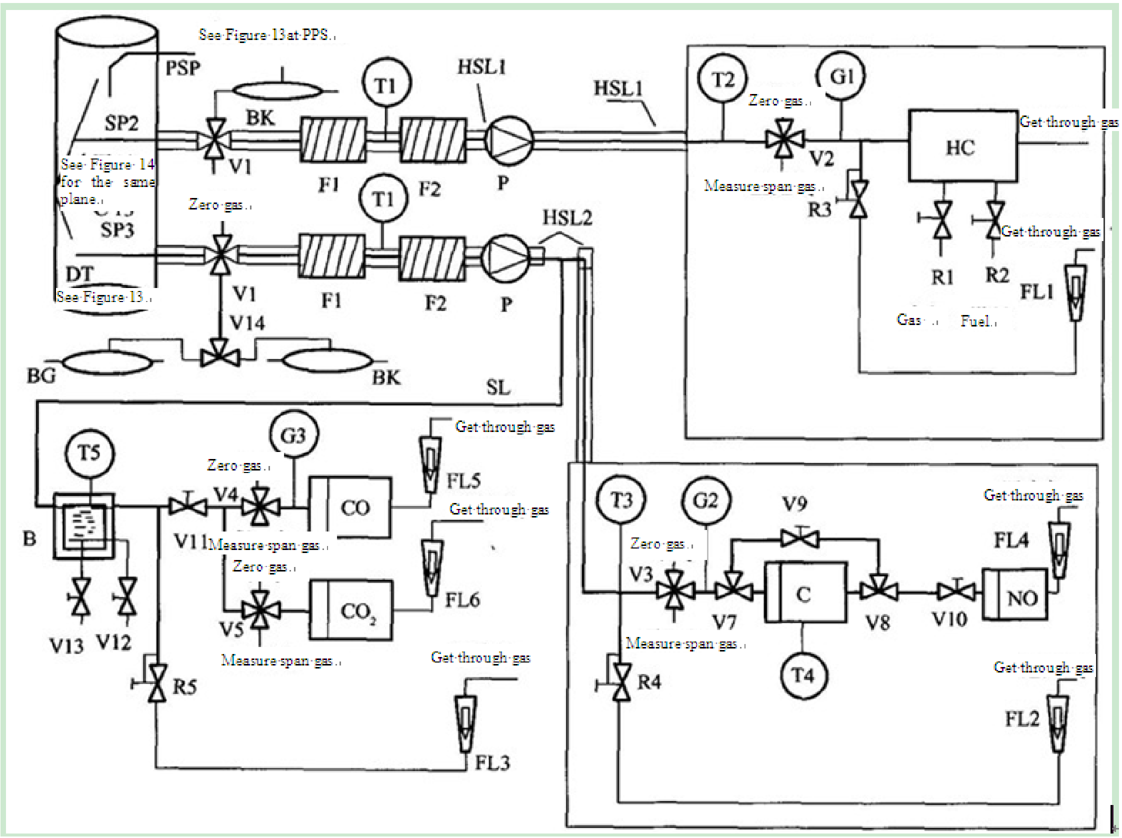


Figure C.2 Flow Chart of Analysis System for Measurement of Diluted Exhaust CO, CO2, NOx and HC

Description-Figure C.1 and Figure C.2

General Provisions:

All the parts of sampling passage must keep corresponding temperature required by each system.

(1) SP1 original exhaust sampling probe (only applicable to Figure C.1)

Multi-pore and stainless steel normal probes with top sealed are recommended. The inside diameter shall not exceed that of the sampling tube. The wall thickness of the sampling probe shall not exceed 1mm and at least three holes with approximately the same sampling flow rate shall be provided on three different radial planes. The sampling probe must extend through to at least 80% of the inside diameter of the exhaust pipe.

(2) SP2 sampling probe for diluted exhaust HC (only applicable to Figure C.2)

Sampling probe shall:

——Defined as a part from 254mm to 762mm in the front end of HC sampling line (HSL1);

——Minimum inside diameter 5mm;

——Installed within dilution tunnel DT (see Article 1.2.1.2) where the diluent air and exhaust are mixed fully (for example: the place about 10 times the pipe diameter away from down stream of the point where the exhaust enters the dilution tunnel);

——Far enough from other sampling probe and pipe wall (in radial direction) in order to avoid influence of eddy flows or wake flow;

—Heated to make the air flow temperature at the outlet of sampling probe at 463K(190℃)±10K.

(3) SP3 sampling probe for diluted exhaust CO, CO_2 and NO_x (only applicable to Figure 3)

Sampling probe shall:

——Located at the identical plane as SP2;

——Far enough from other sampling probe and pipe wall (in radial direction) in order to avoid influence of eddy flows or wake flow;

——Heated throughout the length and insulated from heat to make the temperature at above 328 K (55°C) undermost to prevent from coagulation of water content.

(4) HSL1 heating sampling line

Sampling pipe sends the sample gas from a sampling probe to the split point and HC analyzer.

The sampling line shall:

——Minimum inside diameter is 5mm and maximum inside diameter is 13.5mm;

——Made of stainless steel or polytetrafluoroethylene (PTFE);

——If discharge temperature at sampling probe is equal to or less than 463K (190°C), keep wall temperature of each controlled heating at 463K (190°C)±10K;

——If discharge temperature at sampling probe is above 463K (190°C), keep wall temperature above 453K (180°C);

——Keep the gas temperature before heating filter (F2) and HFID at 463K(190℃)+10K.

(5) HSL2 heated NO_x sampling line

Sampling line must:

——When using a cooler, wall temperature shall be kept from 328K to 473K (55°C~200°C) before arrival of a converter; when a cooler is not used, the wall temperature shall be kept from 328K to 473K (55°C~200°C) before arrival of an analyzer;

——Made of stainless steel or PTFE;

Because heating of sampling line is only used to prevent the coagulation of water and sulfate, the temperature of sampling line depends on sulfur content of the fuel.

(6) SL $CO(CO_2)$ sampling line

Sampling line is made of stainless steel or PTEE and may be heated or not.

(7) BK background sampling bag (optional, only used for Figure C.2)

Used for measurement of sampling concentration.

(8) BK sampling bag (optional, only used for CO and CO_2 in Figure C.2)

Used for measurement of sampling concentration.

(9) F1 heated prefilter (optional)

Temperature shall be identical with HSL1.

(10) F2 heated filter

Before the sample gas enters the analyzer, the filter shall remove any solid particulate matter at the temperature identical with HSL1; the filter shall be replaced as required.

(11) P heated sampling pump

The sampling pump shall be heated to the temperature of HSL1

(12) HC

Hydrogen flame ionization detector (HFID) for measurement of hydrocarbon shall remain at 453~473K (180~200°C) in terms of its temperature.

(13) CO, CO_2

NDIR analyzer for measurement of CO and CO_2.

(14) NO

CLD analyzer for measurement of NOx shall remain at 328~473K (55~200°C) if the HCLDD analyzer is used.

(15) C converter

The converter which is used prior to CLD or HCLD analyzer and is capable of catalytically reducing NO_2 into NO.

(16) B condensate tank

In order to condense water content in the exhaust sample, ice or condenser shall be used to make the temperature of the condensate tank at 273~277K (0~4°C). The condensate tank is an optional part if the analyzer is determined free from the interference of vapor in accordance with Article BB.1.9.1 and Article BB.1.9.2.

Chemical dryer is not allowable to be adopted to remove water content in the sample gas.

(17) T1, T2 and T3 temperature sensor

Used to monitor gas flow temperature.

(18) T4 temperature sensor

Temperature of NO_2-NO converter.

(19) T5 temperature sensor

Used to monitor temperature of condensate tank.

(20) G1, G2, G3 pressure gauge

Used to measure pressure of sampling line.

(21) R1 and R2 pressure regulating valve

Respectively control the air and fuel pressure of HFID.

(22) R3,R4,R5 pressure regulating valve

Control pressure of sampling line and the air flow to the analyzer.

(23) FL1,FL2,FL3 flowmeter

Used to monitor bypass flow of sample gas.

(24) FL4~FL7 flowmeter (optional)

Used to monitor flow passing through analyzer.

(25) V1~V6 selector valve

Used to select the sample gas, span gas or zero gas flowing to analyzer.

(26) V7, V8 solenoid valve

Bypass NO_2-NO converter.

(27) V9 needle valve

Flow passing through NO_2-NO converter and bypass equally.

(28) V10 and V11 needle valve

Regulate flow to analyzer.

(29) V12, V13 toggle valve

Remove water content in condensate tank B.

(30) V14 selector valve

Select sample gas sampling bag or background sampling bag.

C.1.2 Measurement of particulate matter

Figure C.3~Figure C.14 in Article C.1.2.1 and Article C.1.2.2 include the recommended sampling and elaboration for the dilution system and it is unnecessary to fully comply with these figures because different arrangements may generate the identical effects. The additional parts like meter, valve, solenoid valve, pump, and switch may be used to provide additional information and functions to coordinate part system. If other parts are not required for keeping accuracy of some systems, they may be removed via the mature engineering judgment.

C.1.2.1 Dilution system

C.1.2.1.1 Partial flow dilution system (Figure C.3~Figure C.11)

This paragraph describes the dilution system based on dilution of partial exhaust air flow. The branching and subsequent disposal by dilution for exhaust air flow may be realized through different dilution system types. For the subsequent particulate matter collection, complete diluted exhaust or just partial diluted exhaust may be adopted to pass through the sampling system of particulate matter (Figure C.13 in Article C.1.2.2). The first method is total flow sampling type and the second method is partial flow sampling type.

Calculation of dilution ratio depends on type of used dilution systems.

The following types of dilution systems are recommended:

——Equal kinetic system (Figure C.3 and Figure C.4)

These systems make the flow of transport tube similar to exhaust volume flow in terms of gas flow and (or) pressure, therefore exhaust flow free from interference or uniform exhaust flow shall be obtained at the sampling probe, which may be realized usually by adopting rectifier or straight pipe section at the up stream of the sampling point. The split ratio may be calculated through pipe diameter value which may be measured easily. Attention shall be drawn that the isokinetic type is only similar to the flow condition instead of dimension distribution; the latter is generally is unnecessary because the particulate matter is small enough to flow along with flow line of exhaust flow.

——Flow control system with concentration measurement (Figure C.5~Figure C.9)

This system is to collect the sample gas from total exhaust flow through regulating diluent air flow and total diluted exhaust flow. The dilution ratio may be calculated according to concentration of tracing gas like CO_2 and NO_x produced naturally in diesel engine exhaust. The concentration of tracing gas in diluted exhaust and diluent air shall be measured while concentration of tracing gas in original exhaust may be obtained through measurement; if the fuel oil components are known, the concentration may be also obtained according to formula of fuel flow and carbon balance. The system may be control led by calculated dilution ratio (Figure C.5 and Figure C.6) or by the flow into the transport tube (Figure C.7, Figure C.8 and Figure C.9).

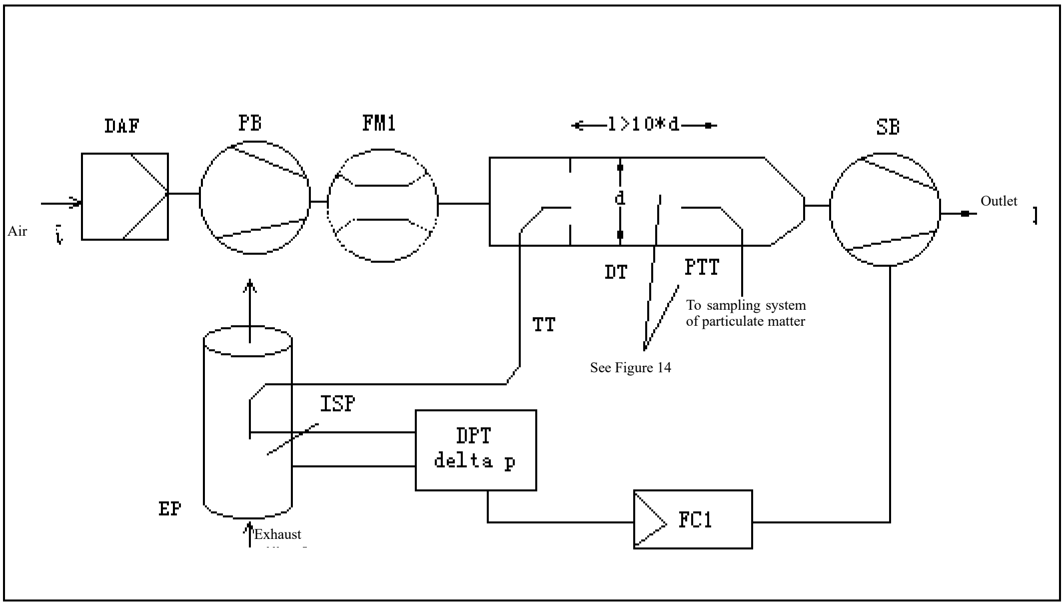
——Flow control system with flow measurement (Figure C.10 and Figure C.11)

This system is to collect sample gas from total exhaust flow through setting diluent air flow and total diluted exhaust flow. The dilution ratio may be calculated according to difference of two flows. Two flowmeters (Figure C.8 and each figure above) shall be intercalibrated accurately because relative difference of two flows will lead to great error in case of high dilution ratio. If necessary, flow may be controlled directly by keeping constant flow of diluted exhaust and changing flow of diluent air.

In order to realize merits of dilution system of partial flow, a matter of loss of particulate matter in transport tube shall be avoided to ensure the adopted sample gas to represent the diesel engine exhaust and split ratio shall be calculated.

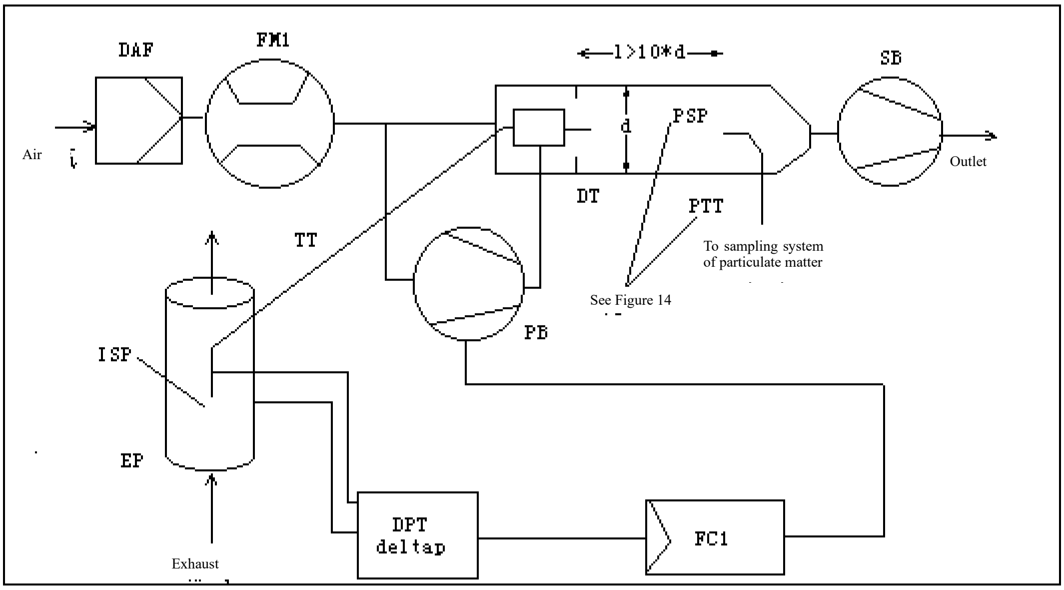
The above systems must pay attention to these key aspects.

Figure C.3 Partial Flow Dilution System with Isokinetic Probe and Partial Flow Sampling (SB Control)



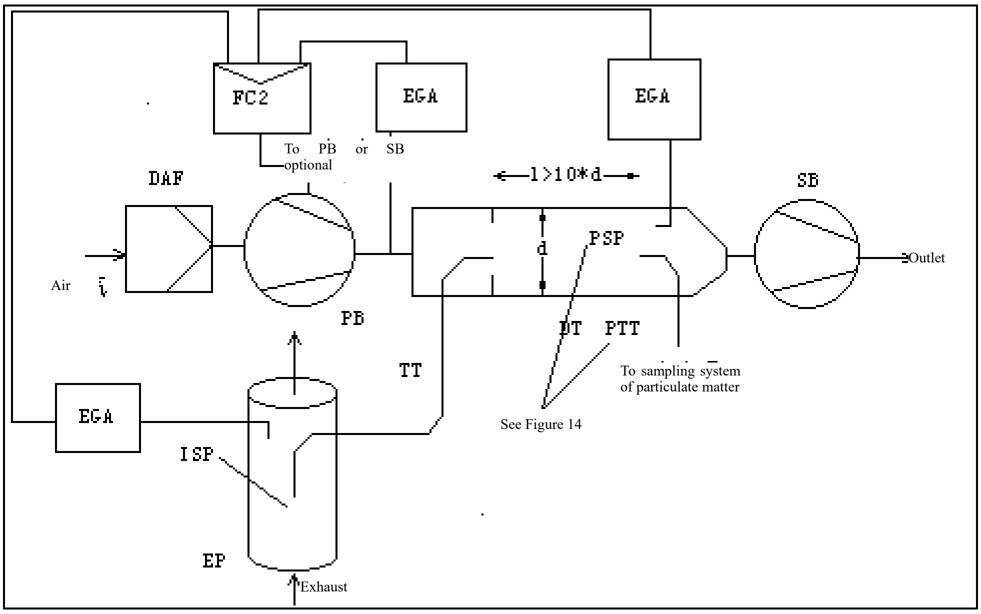
The original exhaust is conveyed to dilution tunnel DT from exhaust pipe EP through transport tube TT by sampling of isokinetic sampling probe ISP. Exhaust pressure difference between exhaust pipe and probe inlet shall be measured with pressure transducer DPT. This signal is transmitted to flow controller FC1 which controls the suction blower SB and makes the probe end at the zero pressure difference. Under these conditions, the exhaust speeds in EP and ISP are the same and the flow passing through ISP and TT is a fixed proportion relative to exhaust flow. The split ratio may be calculated according to cross-sectional area of EP and ISP. The flow of diluent air is measured with flow measurer FM1 and the dilution ratio may be calculated according to diluent air flow and split ratio.

Figure C.4 Partial Flow Dilution System with Isokinetic Probe and Partial Flow Sampling (PB control)



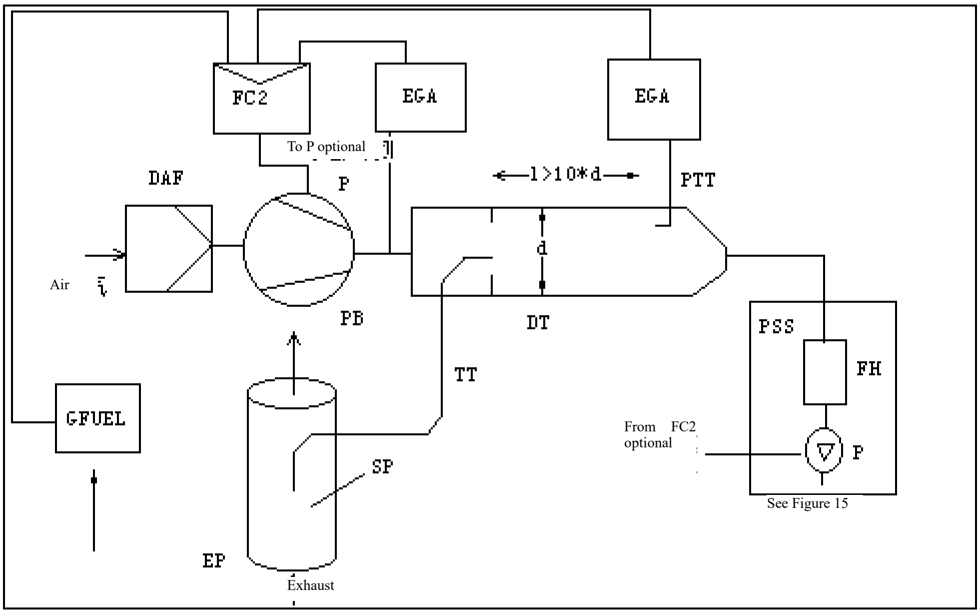
The original exhaust is conveyed to dilution tunnel DT from exhaust pipe EP through transport tube TT by sampling of isokinetic sampling probe ISP. Exhaust pressure difference between exhaust pipe and probe inlet shall be measured with pressure transducer DPT. This signal is transmitted to flow controller FC1 which controls the suction blower SB and makes the probe end at the zero pressure difference. The flow of diluent air is measured with flow measurer FM1; adopt some diluent air from the diluent air and put it back to TT with a pneumatic orifice plate. Under these conditions, the exhaust speeds in EP and ISP are the same and the flow passing through ISP and TT is a fixed proportion relative to exhaust flow. The split ratio may be calculated according to cross-sectional area of EP and ISP. The diluent air is sucked with suction blower SB through DT and the flow shall be measured with flow measurer FM1 at the DT inlet; dilution ratio may be calculated according to diluent air flow and split ratio.

Figure C.5 Partial Flow Dilution System with CO_2 and NOx Concentration Measure and Partial Flow Sampling



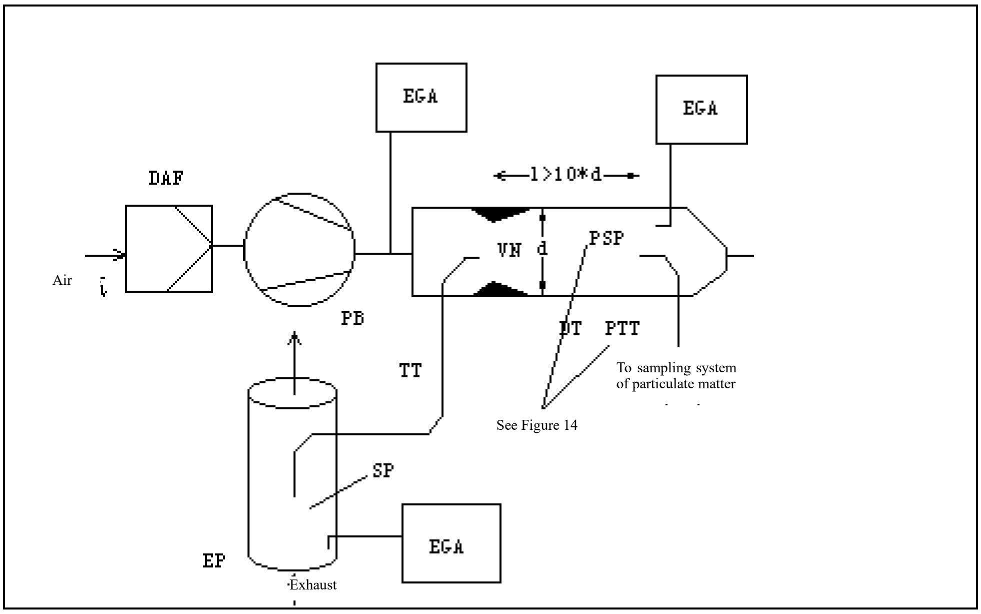
The original exhaust is conveyed to dilution tunnel DT from exhaust pipe EP through transport tube TT by sampling of sampling probe SP. The concentration of tracing gas (CO_2 or NO_x) in original exhaust, diluted exhaust and diluent air shall be measured with exhaust gas analyzer EGA. These signals are transmitted to flow controller FC2 which controls pressure blower PB or suction blower SB to maintain the expectant exhaust split ratio and dilution ratio in DT. Dilution ratio may be calculated according to concentration of tracing gas in original exhaust, diluted exhaust and diluent air.

Figure C.6 Partial Flow Dilution System with CO2 Concentration Measurement, Carbon Balance and Gross Sampling



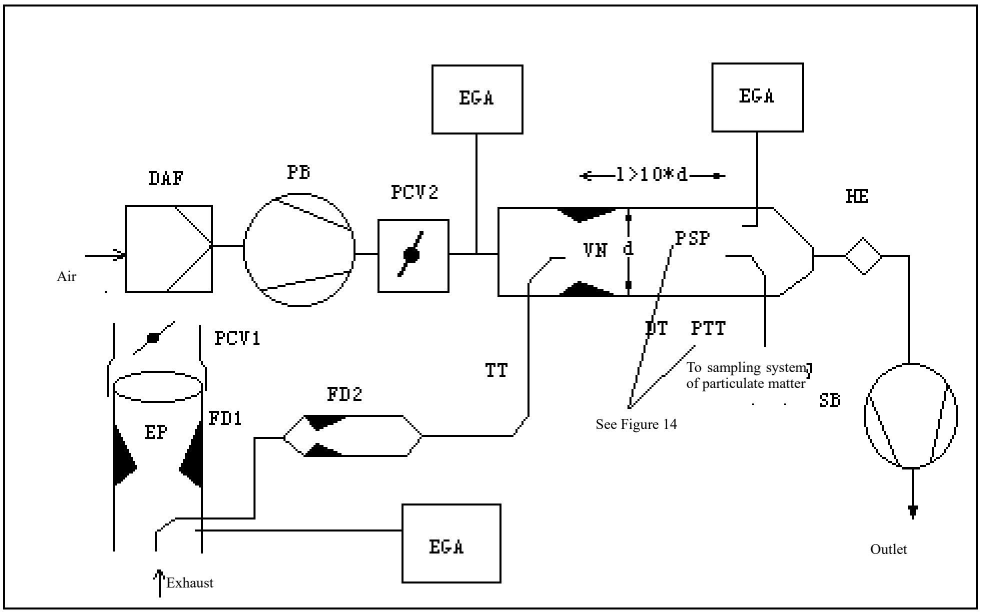
The original exhaust is conveyed to dilution tunnel DT from exhaust pipe EP through transport tube TT by sampling of sampling probe SP. The CO_2 concentration in diluted exhaust and diluent air is measured with exhaust gas analyzer EGA. CO_2 and fuel flow G_{FUEL} signal is transmitted to flow controller FC2 or flow controller FC3 in particulate matter sampling system (see Figure 14). FC2 controls pressure blower PB while FC3 controls the sampling system of particulate matter (see Figure 14), in this way, the flow of the inlet and outlet system may be regulated to maintain the expectant exhaust split ratio and dilution ratio in DT. The dilution ratio may be calculated according to CO_2 concentration and G_{FUEL} in carbon balance method.

Figure C.7 Partial Flow Dilution System with Single Venturi, Concentration Measurement and Partial Flow Sampling



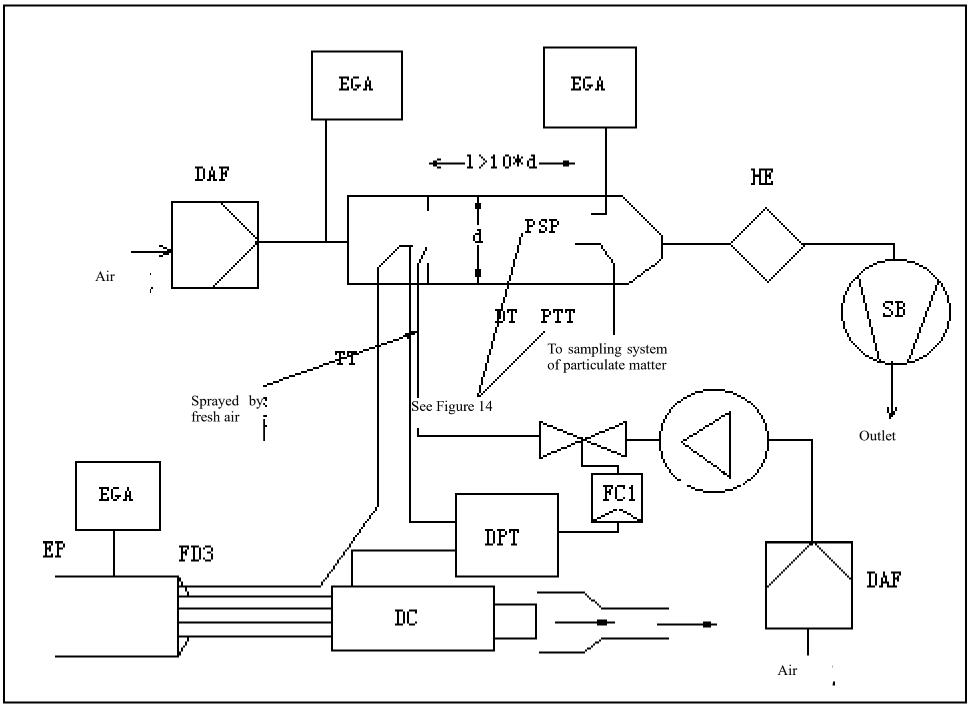
Due to negative pressure produced by venturi VN in DT, original exhaust is conveyed from exhaust pipe EP to dilution tunnel DT through transport tube TT and is sampled by sampling probe SP. The gas flow passing through TT depends on momentum exchange in venturi, so it is influenced by the absolute gas temperature at TT outlet. The exhaust diversion under given dilution tunnel gas flow is not constant and the dilution ratio of low loads is slightly lower than that of the high load. The concentration of tracing gas (CO_2 or NO_x) in the original exhaust, diluted exhaust and diluent air shall be measured with exhaust gas analyzer EGA and the dilution ratio shall be calculated according to the above-mentioned measured value.

Figure C.8 Partial Flow Dilution System with Double Venturi or Double Flow Pore, Concentration Measurement and Partial Flow Sampling



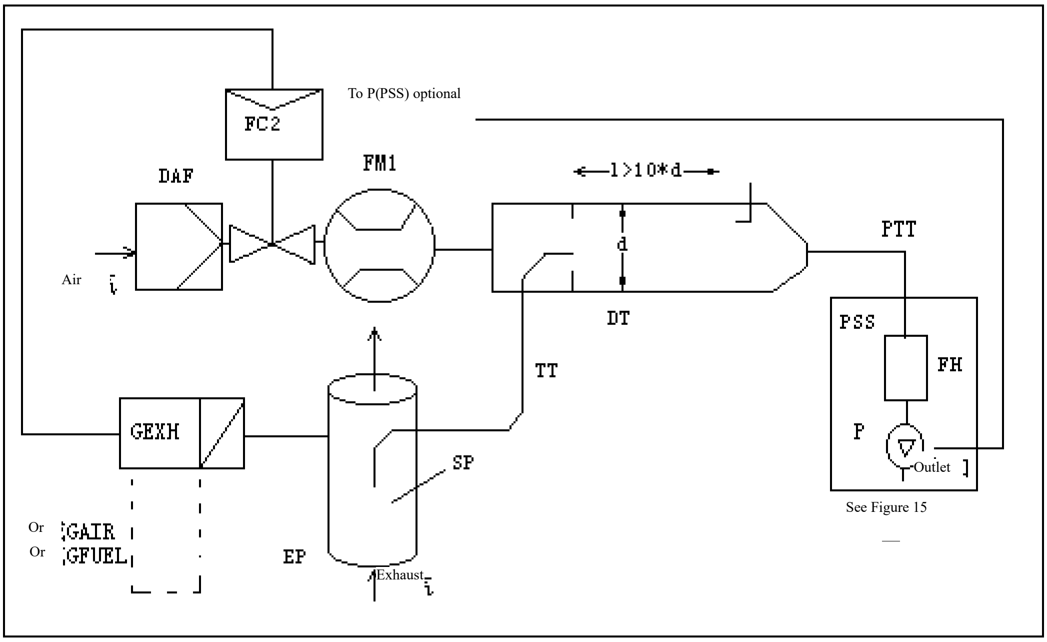
Through the flow diverter containing a pair of orifice plate or venturi, original exhaust is conveyed from exhaust pipe EP to dilution tunnel DT through transport tube TT by sampling of sampling probe SP. The first one (FD1) is in EP and the second one (FD2) is in TT. Moreover, two pressure control valves (PCV1 and PCV2) must be provided for keeping a constant exhaust split ratio by control of back pressure in EP and pressure in DT. PCV1 is at the down stream of EP while PCV2 is between pressure blower PB and DT. The concentration of tracing gas (CO_2 or NO_x) in original exhaust, diluted exhaust and diluent air may be measured with exhaust gas analyzer EGA. The concentration of tracing gas (CO_2 or NO_x) must be measured for regulating PCV1 and PCV2 in order to check the exhaust split ratio and realize accurate shunting operations. The dilution ratio may be calculated according to concentration of tracing gas.

Figure C.9 Partial Flow Dilution System with Multiple Divider, Concentration Measurement and Partial Flow Sampling



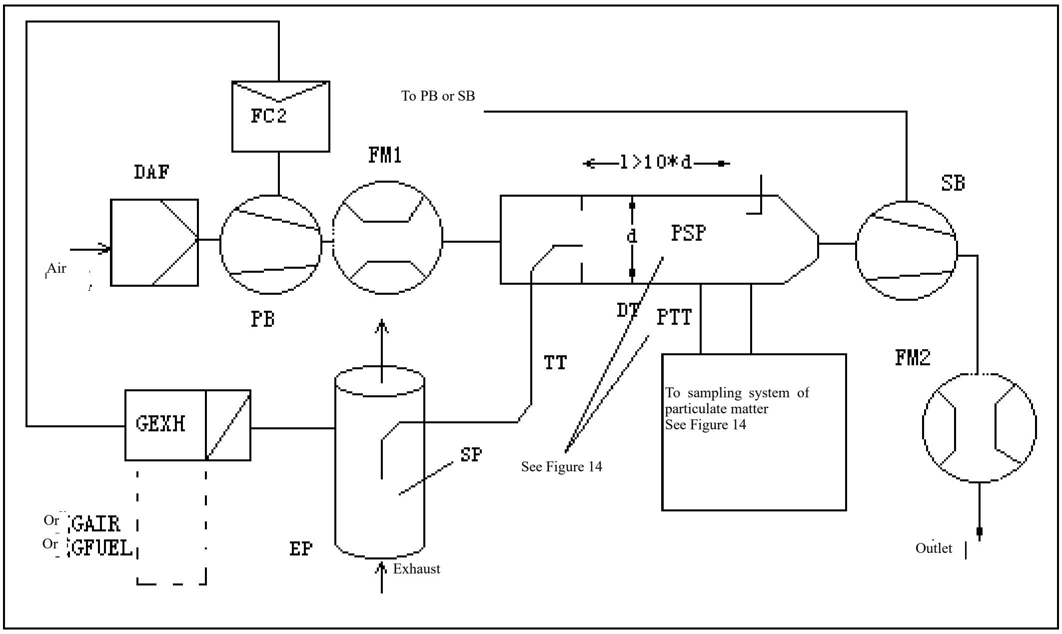
Through flow diverter FD3 composed of several pipes of the same dimension (the same diameter, length and bending radius) installed in EP, original exhaust is conveyed from exhaust pipe EP to dilution tunnel DT through transport tube TT. In these pipelines, the exhaust in one of the pipelines is introduced to DT and the exhaust in the rest pipeline is introduced into damping chamber. Therefore, the exhaust split ratio is determined by the total pipe number and the control of constant split ratio requires pressure difference between DC and TT outlet to be zero which shall be measured with differential pressure transducer DPT. Zero pressure difference may be realized by spraying fresh air into DT at TT outlet. The concentration of tracing gas (CO_2 or NO_x) in original exhaust, diluted exhaust and diluent air may be measured with exhaust gas analyzer EGA. The concentration of tracing gas (CO_2 or NO_x) must be measured for regulating injection air volume in order to check the exhaust split ratio and realize accurate shunting operations. The dilution ratio may be calculated according to concentration of tracing gas.

Figure 10 Partial Flow Dilution System with Flow Control and Total Sampling



The original exhaust is conveyed from exhaust pipe EP to dilution tunnel DT through transport tube TT by sampling of sampling probe SP. The total flow passing through the dilution tunnel is regulated by flow controller FC3 of particulate matter sampling system (see Figure C.15) and sampling pump P. The diluent air flow is controlled by flow controller FC2 and the G_{EXH}, G_{AIR} or G_{FUEL} may be used as command signal to obtain the expectant exhaust branch. The sampling flow entering DT is the difference of total flow and diluent air. Diluent air flow is measured with flow measurer FM1 and the total gas flow is measured with flow measurer FM3 in particulate matter sampling system (Figure C.13). The dilution ratio may be calculated according to these two flows.

Figure C.11 Partial Flow Dilution System with Flow Control and Partial Flow Sampling



The original exhaust is conveyed from exhaust pipe EP to dilution tunnel DT through transport tube TT by sampling of sampling probe SP. The exhaust branch and the flow into DT are controlled by flow controller FC2, as required, FC2 may regulate the flow (or speed) of pressure blower or suction blower SB. Because the sample gas in sampling system of particulate matter returns to DT, this control mode is possible. G_{EXH}, G_{AIR} or G_{FUEL} may be used as command signal of FC2. The diluent air flow is measured with flow measurer FM1 and the total gas flow is measured with flow measurer FM2 and the dilution ratio may be calculated according to these two flows.

Description of Figure C.3~Figure C.11

(1) EP exhaust pipe

The exhaust pipe may be subjected to heat insulation. In order to reduce the thermal inertia, the ratio of wall thickness to diameter of exhaust pipe is recommended to be less than or equal to 0.015. The flexible line shall be controlled so that the ratio of length to diameter is 12 or less. In order to reduce the inertia settlement, the bending shall be as less as possible. If the system includes a test bench muffler, the muffler shall also be subjected to heat insulation.

For an isokinetic system, the exhaust pipe shall be safe from influence of eddy currents, bending and pipe diameter mutation within six times the pipe diameter at the up stream of probe end and three times the pipe diameter at the down stream. Except the idle speed, the gas flow in the sampling area shall exceed 10m/s and the fluctuation of mean pressure within the exhaust pipe shall not exceed ±500Pa. Any measure to reduce the fluctuation of pressure shall not change the performance of diesel engine or cause settlement of particulate matter unless exhaust system of diesel engine (including muffler and after-treatment device) used for road mobile machinery.

For the system without isokinetic sampling probe, the area within six times the pipe diameter at the upstream of probe end and three times the pipe diameter at the downstream shall be straight pipe.

(2) SP sampling probe (Figure C.5~Figure C.11)

The minimum inside diameter shall be 4mm and the minimum diameter ratio of exhaust pipe and probe shall be 4. The probe shall be open tube, facing directly the center line upstream of exhaust pipe or multi-pore probe described in SP1 of 1.1.1.

(3) ISP isokinetic sampling probe (Figure C.3 and Figure C.4)

Isokinetic sampling probe must be installed at center line of exhaust pipe and faced to up stream; EP must meet certain flow condition and ISP is designed to provide original exhaust sampling of a certain proportion. The minimum inside diameter shall be 12mm.

Control system must realize isokinetic exhaust branching by keep zero pressure difference between EP and ISP. Under this condition, the exhaust speed in EP and ISP is identical and the mass flow through ISP is a constant part of exhaust flow. ISP must be connected with a differential pressure transducer. The pressure difference between EP and ISP may be zero by blower speed and flow controller.

(4) FD1, FD2 flow divider (Figure C.8)

A set of venturi or flow orifice plate shall be installed in exhaust pipe EP and transport tube TT respectively to provide sample gas of original exhaust of a certain proportion. The flow control system including two pressure control valves PCVl and PCV2 is necessary to realize exhaust branching of a certain proportion by control of pressure in EP and DT.

(5) FD3 flow divider (Figure C.9)

Install a group of pipes (multitube part) in exhaust pipe EP to provide sample gas of original exhaust of a certain proportion. One of the pipes transmits the exhaust to dilution tunnel DT and other pipes transmit the exhaust to damping chamber DC. These pipes must have the same dimension (the same diameter, length and bending radius) and the exhaust branching depends on the total pipe number. The proportion branching of control system is necessary to maintain the pressure difference between multitube unit outlet and TT outlet at zero. Under this condition, the exhaust speed in EP and ISP is proportionable and the mass flow through TT is a constant proportion of exhaust flow. The two points must be connected to differential pressure transducer DPT. The zero pressure difference is controlled and provided by flow controller FC1.

(6) EGA exhaust analyzer (Figure C.5~Figure C.9)

CO_2 and NO_x analyzers are possible (CO_2 analyzer only in carbon balance method). The analyzer shall be calibrated as the analyzer measures gaseous pollutants. One or more analyzer may be used to measure different concentrations.

Survey system precision shall make precision of G_{EDFW} or V_{EDFW} within ±4%.

(7) TT transport tube (Figure C.3~Figure C.11)

Sampling transport tube of particulate matter shall:

——Length shall be as short as possible but shall not exceed 5m;

——Diameter is equal to or larger than probe diameter but shall not exceed 25mm;

——Discharged at center line of dilution tunnel, facing down stream.

If line length is less than or equal to 1m, it shall be insulated by the material with maximum heat conductivity factor 0.05 W/(m·K) and its radial insulation thickness is equivalent to probe diameter. If the line length is greater than 1m, this tube must be insulated from heating and heated at the minimum wall temperature of 523K (250°C).

Correspondingly, wall temperature of transport tube shall be determined according to standard heat transfer calculation.

(8) DPT differential pressure sensor (Figure C.3, Figure C.4 and Figure C.9)

Measuring range of differential pressure sensor shall be less than or equal to ±500Pa.

(9) FC1 flow controller (Figure C.3, Figure C.4 and Figure C.9)

For isokinetic system (Figure C.3 and Figure C.4), flow controller shall be adopted to keep pressure difference between EP and ISP zero. Make adjustments through the following procedure:

(a) Control speed and flow of suction blower (SB) at every operating condition to keep stable speed of pressure blower (PB).

or

(b) Regulate suction blower (SB) to make mass flow of diluted exhaust stable and control flow of pressure blower, therefore regulate exhaust gas sampling flow within a certain area at the end of transport tube (TT) (Figure C.4).

In pressure control system, error within control circuit shall not exceed ±3Pa and pressure fluctuation within dilution tunnel shall not exceed ±250Pa of mean value.

For multi-pipe system (Figure C.9), in order to reach proportion branching, flow controller must be adopted to keep the pressure difference between multi-pipe unit outlet and TT outlet zero. Make adjustments through control of air flow at TT outlet into DT.

(10) PCV1, PCV2 pressure control valve (Figure C.8)

For double venturi or double flow orifice plate system, in order to reach proportion branching, two pressure control valves must be adopted to control back pressure of EP and pressure of DT. Two valves shall be installed at the down stream of SP in EP and between PB and DT.

(11) DC damping chamber (Figure C.9)

Damping chamber shall be installed at outlet of multi-pipe unit to reduce pressure fluctuation of exhaust pipe EP.

(12) VN venturi (Figure C.7)

The venturi shall be installed in dilution tunnel DT to generate negative pressure at the outlet area of transport tube TT. The gas flow through TT is determined by momentum exchange in venturi tube area and in a certain proportion with flow of pressure blower PB, leading to constant dilution ratio. Because momentum exchange is influenced by the TT outlet temperature and pressure difference between EP and DT, the actual dilution ratio is lower at the lower load than at the high load.

(13) FC2 flow controller (Figure C.5, Figure C.6, Figure C.10 and Figure C.11, optional)

Flow controller may be used to control the flow of pressure blower PB and suction blower SB and it may amplify signal connection in an equal differential motion with exhaust flow or fuel flow signal and/or CO_2 or NO_x.

When the compressed air feeding device (Figure C.10) is applied, FC2 may directly control the air flow.

(14) FM1 flow measurer (C.5, Figure C.6, Figure C.10 and Figure C.11)

Adopt gas flowmeter or other flow measurers to measure diluent air flow. If calibrated PB is used to measure the flow, FM1 is an optional part.

(15) FM2 flow measurer (Figure C.11)

Adopt gas flowmeter or other flow measurers to measure diluent air flow. If calibrated suction blower SB is used to measure the flow, FM2 is an optional part.

(16) PB pressure blower (Figure C.3, C.4, C.5, C.6, C.7, C.8 and C.11)

In order to control diluent air flow, PB may be connected to flow controller FC1 or FC2. When disc valve is adopted, PB is unneeded. After calibration, PB may be used to measure diluent air flow.

(17) SB suction blower (Figure C.3, C.4, C.5, C.8, C.9 and C.11)

Used to only partial flow sampling system. After calibration, SB may be used to measure diluted exhaust flow.

(18) DAF diluent air filter (Figure C.3~Figure C.11)

It is best to filter diluent air and eliminate background hydrocarbon with activated carbon. The diluent air shall be kept at 298K(25°C)±5K.

As required by the manufacturing enterprise, the diluent air shall be sampled in accordance with good engineering experience to determine the background particulate matter level which shall be deducted from the measured value of particulate matter in diluted exhaust.

(19) PSP particulate matter sampling probe (Figure C.3, C.4, C.5, C.7, C.8, C.9 and C.11)

This probe is a leader of PTT, and:

——Shall face up stream, installed at the place where the diluent air is mixed with exhaust fully, namely the center line of dilution tunnel DT of dilution system and at the place about the ten times the pipe diameter at the down stream of the dilution tunnel entered by the exhaust;

——Minimum inside diameter is 12mm;

——The wall temperature may be heated not above 325K (52°C) in the direct heating method or diluent air may be used for preheat provided than the air temperature shall not exceed 325K (52°C) before the exhaust enters the dilution tunnel;

——Thermal isolation shall be carried out.

(20) DT dilution tunnel (Figure C.3~Figure C.11)

This dilution tunnel:

——Shall have adequate length to mix fully the exhaust and diluent air at turbulence condition;

——Made of stainless steel and:

——For dilution tunnel with inside diameter over 75mm, the ratio of thickness to diameter thereof shall be less than or equal to 0.025;

——For dilution tunnel with inside diameter less than or equal to 75mm, nominal wall thickness of dilution tunnel shall not be less than 1.5 mm;

——For partial sampling type, inside diameter thereof shall be 75mm at least;

——For total flow sampling type, at least 25mm inside diameter is recommended;

——The wall temperature may be heated not above 325K (52°C) in the direct heating method or diluent air may be used for preheat provided than the air temperature shall not exceed 325K (52°C) before the exhaust enters the dilution tunnel;

——Thermal isolation shall be carried out.

Diesel engine exhaust shall be mixed with diluent air fully. For partial sampling system, after the system is put into service, under the operating state of diesel engine, the CO2 concentration profile (at least four measuring points with approximately equal spacing) in the tunnel shall be used to inspect the mixed quality. If necessary, mixed airflow measuring orifice plate may be used.

Note: If the ambient temperature nearby dilution tunnel is below 293K (20°C), measures shall be taken to prevent loss of particulate matter on cold wall of dilution tunnel. Therefore heat or insulate dilution tunnel within recommended temperature range above.

In case of high load of the diesel engine, the tunnel may be cooled by such not so violent method as circulation fan, provided that cooling medium temperature is not less than 293K (20°C).

(21) HE heat exchanger (Figure C.8 and Figure C.9)

Heat exchanger shall be provided with adequate ability to keep the temperature at the inlet of suction blower SB within ±11K of measured average operating temperature throughout test process.

C.1.2.1.2 Full-flow dilution system (Figure C.12)

The mentioned dilution system is a system for dilution of all the exhaust based on concept of constant volume sampling (CVS). The total volume of exhaust mixed with diluent air must be measured. The PDP or CFV system may be used.

For subsequent particulate matter collection, introduce sample gas of diluted exhaust to sampling system of particulate matter (Figure C.13 and Figure C.14 of Article C.1.2.2). If doing this directly, it is called as single-stage dilution. If the diluted sample gas is diluted within the secondary-stage dilution tunnel, it is called as two-stage dilution. In case of single-stage dilution, if the surface temperature of filter paper fails to meet the requirements, double-stage dilution shall be used. Although the double-stage dilution is part of dilution system, it may be used as a variant of sampling system of particulate matter in Figure C.14 of Article C.1.2 because it has a majority of parts of sampling system of typical particulate matter.

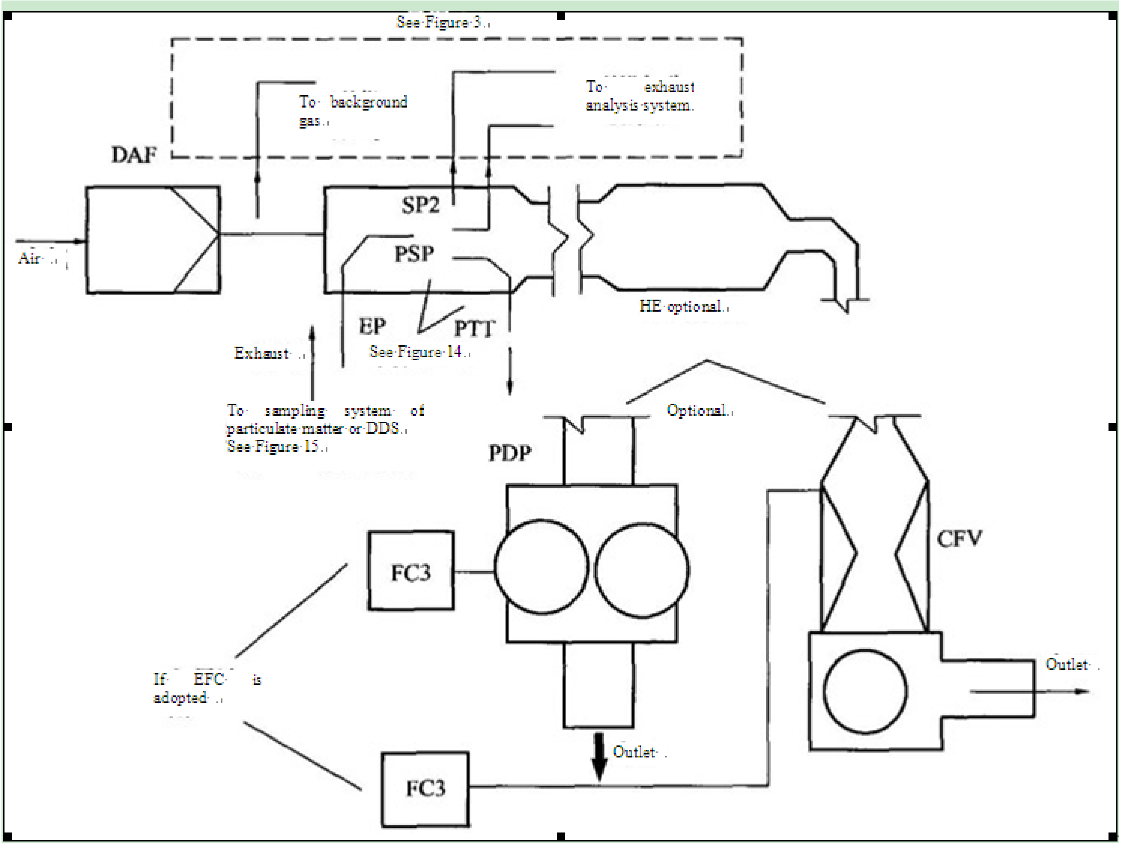
Gaseous pollutants may also be determined in dilution tunnel of full-flow dilution system. Therefore, sampling probe of gaseous component is indicated in Figure C.12 but it is not in description list. The corresponding requirements are described in Article C.1.1.1.

Description-Figure C.12

(1) EP exhaust pipe

The length of exhaust pipe from exhaust manifold outlet of diesel engine, turbocharger outlet or after-treatment device to dilution tunnel shall not exceed 10m. If the system length exceeds 4m, the parts over 4m shall be insulated. In case of cascading smokemeter, smokemeter point may be excluded. The radial thickness of insulating materials shall not be less than 25mm. The heat transfer rate of insulating materials at 673K (400℃) shall not exceed 0.1 W/(m·K). In order to reduce the thermal inertia of exhaust pipe, the ratio of wall thickness to diameter shall be less than or equal to 0.015. For the used flexible part, the ratio of length to diameter shall be 12 or less.

Figure C.12 Full-flow Dilution System



Complete original exhaust shall be mixed with diluent air within dilution tunnel DT.

Diluted exhaust flow may be measured with positive displacement pump PDP or critical flow venturi. The heat exchanger (HE) or electronic flow compensator (EFC) may be used for sampling of proportion particulate matter and flow measurement. Because the particulate matter volume measurement is based on total diluted exhaust flow, the dilution ratio may not be calculated.

(2) PDP positive displacement pump

PDP measures the total diluted exhaust flow according to revolution number and discharge capacity of the pump. The back pressure of exhaust system shall not be reduced artificially by PDP or dilution intake system. Under the same diesel engine rotation speed and load, the difference between the static exhaust back pressure measured with connection with CVS system and that measured without connection of CVS system shall kept at ±1.5kPa.

When the flow compensation is not adopted, the temperature of gas mixture before PDP shall be within ±6K of average operating temperature in the test process.

Only when inlet temperature of PDP does not exceed 50°C (323K), flow compensation can be used.

(3) CFV critical flow venturi

CFV measures total diluted exhaust flow by blocking the flow (critical flow). Under the same rotation speed and load of diesel engine, the difference between the static exhaust back pressure measured with connection with CVS system and that measured without connection of CVS system shall kept at ±1.5kPa. When the flow compensation is not adopted, the temperature of gas mixture before CFV shall be within ±11K of average operating temperature in the test process.

(4) HE heat exchanger (if EFC is used, optional)

Heat exchanger shall be provided with adequate ability to keep the temperature within the above requirements.

(5) EFC electronic flow compensation (if HE is used, optional)

If inlet temperatures of PDP or CFV do not within the above range, in order to measure the flow continuously and conduct proportional sampling control in sampling system of particulate matter, flow compensation system shall be used.

For the purposes above, the flow signal of continuous measurement is used to revise sample gas flow of sampling filter paper of particulate matter through sampling system of particulate matter (see Figure C.13 and Figure C.14).

(6) DT dilution tunnel

This dilution tunnel:

——Diameter thereof shall be small enough to form turbulence (Reynolds number greater than 4000); length thereof shall be long enough to mix exhaust fully with diluent air and flow mix orifice plate may be used;

——Diameter is 75mm at least;

——Heat insulation treatment may be carried out.

Diesel engine exhaust shall face down stream and be mixed fully at the place where diesel engine exhaust is introduced to dilution tunnel.

When single-stage dilution system is adopted, the sample gas from dilution tunnel is conveyed to sampling system of particulate matter (see Figure C.13 of Article C.1.2.2). In order to maintain the diluted exhaust temperature before primary filter paper in dilution tunnel not above 325K (52°C), PDP or CFV shall be provided with adequate flow ability.

When double-stage dilution system is used, the sample gas from dilution tunnel is conveyed to secondary dilution tunnel and diluted further here and then passes the sampling filter paper (see Figure C.14 of Article C.1.2.2).

PDP or CFV shall be provided with adequate ability to make the diluted exhaust temperature within DT sampling section not exceed 464K (191℃). The secondary dilution system shall provide adequate secondary diluent air to make the temperature of dilution flow of double-stage diluted exhaust before sampling filter paper of primary particulate matter not exceed 325K (52℃).

(7) DAF diluent air filter

The diluent air is suggested to be filtered and the active carbon shall be used to remove the background hydrocarbon. The diluent air shall remain at 298K (25℃)±5K. As the required by the manufacturing enterprise, diluent air shall be sampled according to the good engineering experience to determine the background particulate matter level which shall be deducted from the measured value of particulate matter in diluted exhaust.

(8) PSP particulate matter sampling probe

This probe is a leader of PTT, and:

——Facing up stream, install at the place where the diluent air is mixed with exhaust fully, namely the center line of dilution tunnel DT of dilution system and at the place about the ten times pipe diameter at the down stream of the dilution tunnel entered by the exhaust;

——Minimum inside diameter is 12mm;

——The wall temperature may be heated not above 325K (52℃) in the direct heating method or diluent air may be used for preheat provided than the air temperature shall not exceed 325K (52℃) before the exhaust enters the dilution tunnel;

——Heat insulation treatment may be carried out.

C.1.2.2 Sampling system of particulate matter (Figure C.13 and Figure C.14)

The sampling system of particulate matter shall be used for collecting particulate matter on the sampling filter paper of particulate matter. For the conditions of partial flow dilution and gross sampling, all the sample gas of diluted exhaust passes the filter paper and the dilution system (see Figure C.6 and Figure C.10 of Article C.1.2.1.1) and sampling system form an integral generally. For the condition of partial flow dilution or full-flow dilution system and partial sampling, only partial diluted exhaust passes the filter paper (see Figure C.3, C.4, C.5, C.7, C.8, C.9 and C.11 in Article C.1.2.1.2) and the sampling system generally is other units.

In this standard, double-stage dilution system DDS (Figure C.14) of full-flow dilution system may be used as a specific variant of typical of particulate matter shown as Figure C.13. Double-stage dilution system includes all the important parts of sampling system of the particulate matter, such as filter paper retainer, sampling pump and several other dilution system characteristics like diluent air source and secondary dilution tunnel.

To avoid any influence of the control cycle, the sampling pump is recommended to be operated through the test. The bypass system shall be used to make the sample gas pass sampling filter paper within the specified time for the single filter paper method. The influence of switching on the control cycle must be at the minimum.

Description-Figure C.13 and Figure C.14

(1) PSP particulate matter sampling probe (Figure C.13 and Figure C.14)

Sampling probe of particulate matter shown in the figure is a leader of conveyer pipe

PTT of particulate matter and:

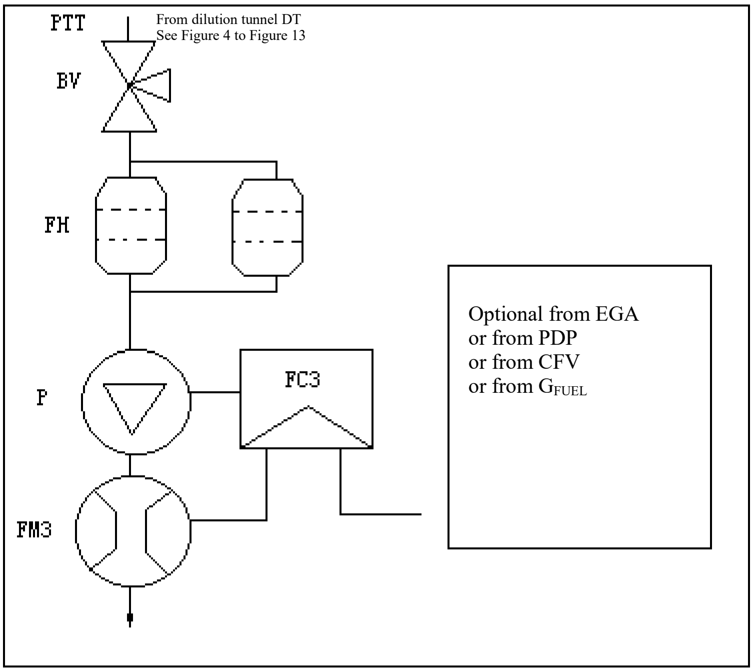
——Shall face up stream, install at the place where the dilution air is mixed with exhaust fully, namely the center line of dilution tunnel DT of dilution system and at the place about the ten times pipe diameter at the down stream of the dilution tunnel entered by the exhaust;

——Minimum inside diameter is 12mm;

——The wall temperature may be heated not above 325K (52℃) in the direct heating method or diluent air may be used for preheat provided than the air temperature shall not exceed 325K (52℃) before the exhaust enters the dilution tunnel;

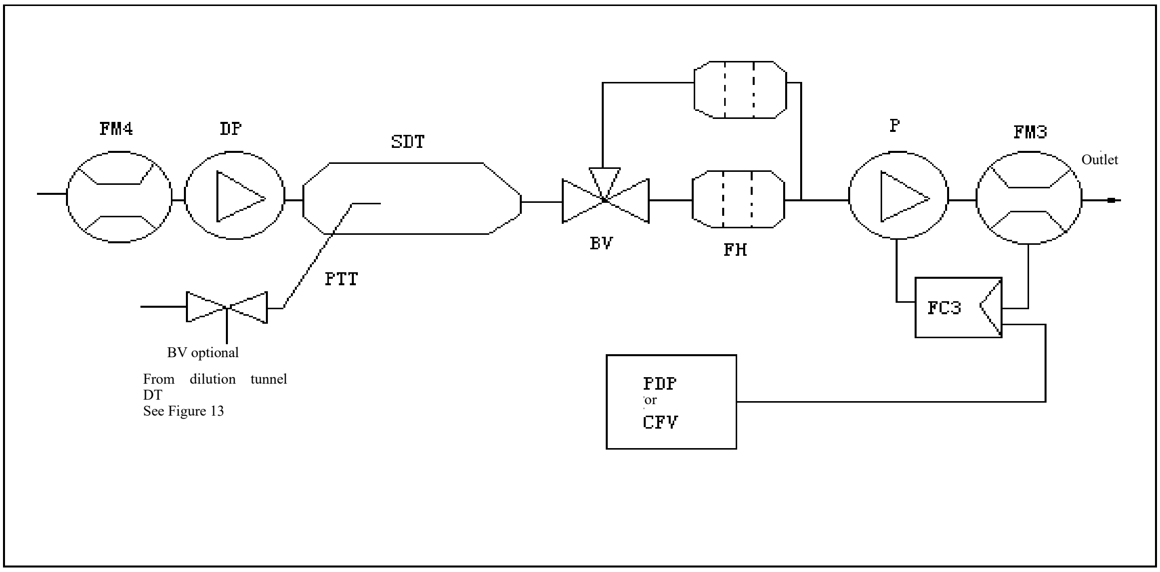
——Heat insulation treatment may be carried out.

Figure C.13 Sampling System of Particulate Matter



The sample gas of diluted exhaust is discharged from fractional flow full-flow dilution system through particulate matter sampling probe PSP and particulate matter transport tube PTT and dilution tunnel DT with sampling pump P. The sample gas passes through filter paper retainer containing sampling filter paper of particulate matter. The sample gas flow is controlled by flow controller FC3. If the electronic flow compensator EFC is used (see Figure C.12), the diluted exhaust flow may be the control signal of FC3.

Figure C.14 Dilution System (only Used for Total-flow System)



The sample gas of diluted exhaust is conveyed to secondary dilution tunnel SDT and diluted further there from dilution tunnel DT of full-flow dilution system through particulate matter sampling probe PSP and particulate matter transport tube PTT. The sample gas passes through filter paper holder FH containing sampling filter paper of particulate matter. When the sample gas flow is controlled by flow controller FC3, the dilution air flow is stable generally. If the electronic flow compensator EFC is used (see Figure C.12), the total diluted exhaust flow may be the control signal of FC3.

(2) PTT particulate matter transport tube (Figure C.13 and Figure C.14)

Transport tube length of particulate matter shall not exceed 1020mm and shall be as short as possible.

This length is:

——For partial flow dilution partial sampling system and total flow single dilution system, from probe top to filter paper holder;

——For partial flow dilution full sampling system, from dilution tunnel top to filter paper holder;

——For total flow double-stage dilution system, from probe top to secondary dilution tunnel.

Transport tube:

——The wall temperature may be heated not above 325K (52°C) in the direct heating method or diluent air may be used for preheat provided than the air temperature shall not exceed 325K (52°C) before the exhaust enters the dilution tunnel;

——Heat insulation treatment may be carried out.

(3) SDT secondary dilution tunnel (Figure C.14)

The minimum diameter of secondary dilution tunnel shall be 75mm and secondary dilution tunnel shall be long enough to provide 0.25s minimum retention period for the sample gas diluted in two stages. The primary filter paper holder FH must be within 300mm of SDT outlet.

Secondary dilution tunnel:

——The wall temperature may be heated not above 325K (52℃) in the direct heating method or diluent air may be used for preheat provided than the air temperature shall not exceed 325K (52℃) before the exhaust enters the dilution tunnel;

——Heat insulation treatment may be carried out.

(4) FH filter paper holder (Figure C.13 and Figure C.14)

For primary filter paper and secondary filter paper, one filter paper filter chamber or separate filter chamber may be used. The requirements in Article BA.1.5.1.3 shall be met.

Filter paper holder:

——The wall temperature may be heated not above 325K (52℃) in the direct heating method or diluent air may be used for preheat provided than the air temperature shall not exceed 325K (52℃);

——Heat insulation treatment may be carried out.

(5) P sampling pump (Figure C.13 and Figure C.14)

If FC 3 is not used to correct the flow, the sampling pump of particulate matter shall be located at a far enough place from the tunnel for keeping constant inlet temperature (±3K).

(6) DP diluent air pump (Figure C.14) (only used for total flow double-stage dilution system)

Diluent air pump shall be able to provide secondary diluent air at a temperature of 298K(25℃)±5K.

(7) FC3 flow controller (Figure Figure C.13 and Figure C.14)

If no other appropriate measures are available, the flow controller shall be used to compensate the sampling flow fluctuation of particulate matter caused by temperature and back pressure fluctuate within sampling path. If the electronic flow compensator is used, flow controller FC3 (see Figure C.12) shall be used.

(8) FM3 flow measurer (Figure C.13 and Figure C.14) (sampling flow of particulate matter)

If FC3 is not used to correct the flow, the gas flowmeter or flow measurer shall be located at a far enough place from the sampling pump for keeping constant inlet temperature (±3K).

(9) FM4 flow measurer (Figure C.14) (diluent air, only used for total flow double-stage dilution)

Gas flowmeter or flow measurer shall be located at the place where the inlet temperature remains at 298K(25℃)±5K.

(10) BV ball valve (optional)

Ball valve diameter shall not be less than the inside diameter of sampling pipe and the switch time shall be less than 0.5s.

Note: If the ambient temperature nearby PSP, PTT, SDT and FH is below 293K (20℃), measures shall be taken to prevent the loss of particulate matter on the cold wall of dilution tunnel. Therefore these parts are recommended to be heated or dealt with heat insulation to make the temperature within their own described ones. It is best to make the temperature on the surface of the filter paper shall be not less than 293K (20℃) during the sampling.

In case of high load of the diesel engine, the above parts may be cooled by such not violent method as circulation fan, provided that cooling medium temperature is not less than 293K (20℃).

Annex D

(Normative)

Technical Requirements of Reference Diesel[1)]

Table D.1 Technical requirements on reference diesel for Stage III

Parameter	Unit	Limit[2)]		Test method
		Min.	Max.	
Cetane number[3)]		46	50	GB/T 386
Density below 20°C	kg/m^3	825	840	GB/T 1884 GB/T 1885
Distillation range -50% point -95% point Distillation end point	 ℃ ℃ ℃	 245 345 —	 300 355 365	GB/T 6536
Flashing point	℃	55	—	GB/T 261
Cold filter plugging point	℃	—	-5	SH/T 0248
Viscosity below 20°C	mm^2/s	3.0	8.0	GB/T 265
Polynucyclic aromatic hydrocarbon	%m/m	3	6	SH/T 0606
Sulfur content	mg/kg	250	350	GB/T 380
Copper corrosion		—	Level 1	GB/T 5096
10% of carbon residue on residuum	% m/m	—	0.3	GB/T 268
Ash content	% m/m	—	0.01	GB/T 508
Moisture	% m/m	—	0.05	GB/T 260
Neutralization number (strong acid)	mg KOH/g	—	0.02	GB/T 258
Oxidation stability[4)]	mg/ml	—	0.025	SH/T0175

Notes:

[1] If it is necessary to calculate the thermal efficiency of diesel engine or non-road mobile machinery, fuel calorie value may be calculated according to the following formula:

Specific energy (heat value) (net) MJ/kg=(46.423-8.792×d2+3.17·d)×(1- (x+y+s))+9.42×s-2.499×X

Where,

d-the concentration of 288K (15°C);

x-the mass percentage of water (%/100);

y-the mass percentage of ash (%/100);

s-the mass percentage of sulphur (%/100).

[2] The quoted value in technical specifications is "real value", where determining these limits, the clauses are adopted from ISO 4259 "Petroleum Products-The Determination and Utilization of Precise Data Concerned with Test Methods"; where determining the minimum value, the minimum difference value of 2R above zero is taken into account; where determining the maximum value and minimum value, the minimum difference value is 4R (R=reproducibility).

Though such necessary measures are taken due to statistics, the fuel manufacturing enterprise shall aim at zero value, where the specified maximum value is 2R; and on the occasion expressed by the maximum and minimum value, the manufacturing enterprise shall aim at the mean value; once whether the fuel meets the requirements of technical specification is required to be clarified, the clauses from ISO 4259 shall be used.

[3] The cetane number range fails to meet the requirements where the minimum range is 4R. But, if dispute occur between the fuel supplier and fuel user, such dispute may be solved by adopting clauses in ISO 4259, and a sufficient number of repeated measurements is required to reach necessary accuracy.

[4] Even though the oxidation stability is under control, the storage life of fuel may still be limited. Suggestions on storage conditions and storage life from the supplier shall be asked for.

Table D.2 Technical requirements on reference diesel for Stage IV

Parameter	Unit	Limit[2]		Test method
		Min.	Max.	
Cetane number[3]			54	GB/T 386
Density below 15℃	kg/m^3	833	865	GB/T 1884 GB/T 1885
Distillation range -50% point -95% point Distillation end point	 ℃ ℃ ℃	 245 345 —	 350 370	GB/T 6536
Flashing point	℃	55	—	GB/T 261
Cold filter plugging point	℃	—	-5	SH/T 0248
Viscosity below 40℃	mm^2/s	32.3	3.3	GB/T 265
Polynucyclic aromatic hydrocarbon	%m/m	3.0	6.0	SH/T 0606
Sulfur content	mg/kg	—	10	GB/T 380
Copper corrosion		—	Level 1	GB/T 5096
10% of carbon residue on residuum	% m/m	—	0.2	GB/T 268
Ash content	% m/m	—	0.01	GB/T 508
Moisture	% m/m	—	0.02	GB/T 260
Neutralization number (strong acid)	mg KOH/g	—	0.02	GB/T 258
Oxidation stability[4]	mg/ml	—	0.025	SH/T0175

Notes:

[1] If it is necessary to calculate the thermal efficiency of diesel engine or non-road mobile machinery, fuel calorie value may be calculated according to the following formula:

Specific energy (heat value) (net) MJ/kg=(46.423-8.792×d2+3.17·d)×(1- (x+y+s))+9.42×s-2.499×X

Where,

d-the concentration of 288K (15℃);

x-the mass percentage of water (%/100);

y-the mass percentage of ash (%/100);

s-the mass percentage of sulphur (%/100).

[2] The quoted value in technical specifications is "real value", where determining these limits, the clauses are adopted from ISO 4259 "Petroleum Products-The Determination and Utilization of Precise Data Concerned with Test Methods"; where determining the minimum value, the minimum difference value of 2R above zero is taken into account; where determining the maximum value and minimum value, the minimum difference value is 4R (R=reproducibility).

Though such necessary measures are taken due to statistics, the fuel manufacturing enterprise shall aim at zero value, where the specified maximum value is 2R; and on the occasion expressed by the maximum and minimum value, the manufacturing enterprise shall aim at the mean value; once whether the fuel meets the requirements of technical specification is required to be clarified, the clauses from ISO 4259 shall be used.

[3] The cetane number range fails to meet the requirements where the minimum range is 4R. But, if dispute occur between the fuel supplier and fuel user, such dispute may be solved by adopting clauses in ISO 4259, and a sufficient number of repeated measurements is required to reach necessary accuracy.

[4] Even though the oxidation stability is under control, the storage life of fuel may still be limited. Suggestions on storage conditions and storage life from the supplier shall be asked for.

Annex E

(Normative)

Devices and Accessories Installed for Diesel Engine Power Test

Table E.1

SN	Device and accessories	Installation condition for emission test
1	**Intake system**	
	Intake manifold	Yes, install standard production parts
	Emission control system of crankcase	Yes, install standard production parts
	Control device for double air suction and intake manifold system	Yes, install standard production parts
	Air flowmeter	Yes, install standard production parts
	Inkake pipeline system	Yes[1]
	Air filter	Yes[1]
	Intake silencer	Yes[1]
	Speed-limiting device	Yes[1]
2	**Intake manifold inflow heating devices**	Yes, install standard production parts. Adjust to the optimum state as much as possible.
3	**Exhaust system**	
	Exhaust purifier	Yes, install standard production parts
	Exhaust manifold	Yes, install standard production parts
	Connecting pipe	Yes[2]
	Silencer	Yes[2]
	Tail pipe	Yes[2]
	Exhaust brake	No [3]
	Supercharging device	Yes, install standard production parts
4	Oil transfer pump	Yes, install standard production parts[4]
5	**Fuel injection device**	
	Coarse strainer	Yes, install standard production parts or test bench installation
	Filtrator	Yes, install standard production parts or test bench installation
	Injection pump	Yes, install standard production parts
	High-pressure oil pipe	Yes, install oil engine of standard production parts
	Oil atomizer	Yes, install standard production parts
	Air intake valve	Yes, install standard production parts [5]
	Electronic control device and air flowmeter, etc.	Yes, install standard production parts
	Speed regulation/control system	Yes, install standard production parts
	Full-load automatic limiting device with rack controlled along with atmospheric conditions	Yes, install standard production parts

6	**Liquid cooling device**	
	Radiator	No
	Fan	No
	Fan housing	No
	Water pump	Yes, install standard production parts[6)]
	Thermostat	Yes, install standard production parts[7)]
7	**Air cooling apparatus**	
	Wind scooper	No[8)]
	Fan or blower	No[8)]
	Temperature regulating device	No
8	**Electrical equipment**	
	Generator	Yes, install standard production parts[9)]
9	**Supercharging device**	
	Air compressor, driven directly by diesel engine or driven by exhaust	Yes, install standard production parts
	Intercooler	Yes, install standard production parts[10)11)]
	Cooling pump or fan (diesel driven)	No[8)]
	Coolant flow control equipment	Yes, install standard production parts
10	**Test bench auxiliary fan**	Yes, install if necessary.
11	**Antipollution device**	Yes, install standard production parts[12)]
12	**Starting device**	Use test bench equipment
13	**Lubricating oil pump**	Yes, install standard production parts

Notes:

1) If belonging to the following situations, all the intake systems shall be installed:

——When it may have great influence on diesel engine power,

——When the manufacturing enterprise proposes this requirement.

On other occasions, an equivalent intake system may be used, but it shall be checked to ensure that the difference between the intake pressure and the upper limit of the intake pressure specified by the manufacturing enterprise and when installed with clean air filter not greater than 100Pa.

2) If belonging to the following situations, all the exhaust systems shall be installed:

——When it may have great influence on diesel engine power

——When manufacturing enterprise proposes this requirement.

On other occasions, an equivalent exhaust system may be used, but the difference between the measured pressure and the upper limit of the pressure specified by the manufacturing enterprise shall not be greater than 1000Pa.

3) If the diesel engine is equipped with exhaust brake device, then the throttling valve shall be fixed to a fully open position.

4) If necessary, the fuel supply pressure may be regulated so as to reach the required pressure again when the diesel engine exerts certain function (especially when using "fuel return-flow").

5) The inlet valve is the control valve of injection pump pneumatic speed governor; speed governor or fuel injection device may be equipped with other devices having influence on injection quantity.

6) Only the pump of diesel engine may be used to carry out the coolant cycle. The external cycle may be used to cool the coolant, so that the pressure loss of this cycle and the pump inlet pressure shall maintain approximately the same as the previous diesel engine cooling system.

7) Thermostat shall be fixed to a fully open position.

8) Where cooling fan or blower is equipped in the test, its absorbed power shall be added to the test result. The power of fan or

blower shall be in accordance with the test speed, and calculated according to the calibrating characteristics or determined by actual test.

9) Minimum power of generator: the electric power of the generator shall be restricted to the absorbed power when the accessories required for diesel engine running are operating. If the storage battery needs to be connected, then it shall be fully charged and in good condition.

10) Intake intercooled diesel engine shall be equipped with an intercooler (liquid cooled or air cooled) for test, but if the manufacturing enterprise has requirements, the stand test system may be used to replace the intercooler. In any case, the power at each speed shall be measured according to the diesel engine air specified by the manufacturing enterprise passing through the maximum pressure drop and the minimum temperature drop of the intercooler on the test bench.

11) These devices include the exhaust gas recirculation system (EGR), catalytic converter, thermal reactor, secondary air supply system, fuel evaporation protection system, etc.

12) The starting power of electrical or other systems shall be provided by the test bench.

Annex F

(Normative)

Type Approval Certificate

According to the requirements of…… (name and serial number of this standard), type approval/type approval expansion is given for the following diesel engine type or diesel engine family1).

Type approval number: ___________________Type approval expansion number: _________________________

Reason for type approval expansion (if applicable): ____

F.1 General

F.1.1 Label: _____________________

F.1.2 Name of diesel engine type or diesel engine family:______________________

F.1.3 Name and address of the manufacturing enterprise:_____________________

Name and address of the manufacturing enterprise's authorized agent (if any):________________________

F.1.4 Diesel engine label

Position: _________________________

Fixing method:_________________________

F.1.5 Address of general assembly plant: _________________________

F.1.6 Description for diesel engine driven mobile machinery2): ____ ____ ___________________

F.2 Limit conditions in use (if any): _________________________

F.2.1 Special conditions to be followed when diesel engine is installed to non-road mobile machinery:

F.2.1.1 Maximum allowable intake resistance: _________________________ kPa

F.2.1.2 Maximum allowable exhaust back pressure: ________________________ kPa

F.3 Inspection organization responsible for test:________________________

F.4 Test report date:________________________

F.5 Test report number:________________________

F.6 Criteria of type approval expansion: ________________________

F.7 Authorization of type approval

Seal: ____

Issuing date:____

Auxiliary data:

Type approval related technical data meeting the requirements of Annex A submitted by the manufacturing enterprise.

Test result (see Attachment FA).

1) Delete those not applicable.

2) Refer to "Scope" in the text.

Attachment FA

(Normative)

Test Results

FA.1 Information related to test[1)]

FA.1.1 Equivalent fuel used for test

FA.1.1.1 Cetane number:_______________________

FA.1.1.2 Sulfur content (m/m):_______________________

FA.1.1.3 Concentration (20°C):_______________________

FA.1.2 Lubricating oil

FA.1.2.1 Label: _______________________

FA.1.2.2 Type: _______________________

FA.1.3 Diesel engine driven accessories (if applicable)

FA.1.3.1 List and amplify the details: _______________________

FA.1.3.2 Power absorbed under the specified diesel engine speed (determined by the manufacturing enterprise) (see Table FA.1)

Table FA.1

Accessories	Power absorbed by accessories at different rotate speeds/kW			
	Idling speed	Intermediate speed (if applicable)	Rated speed	Reference speed
$P_{(a)}$ Accessories required for diesel engine operation (deduct from the measured diesel engine power, see Article AA.5.1)				
$P_{(b)}$ Accessories not required for diesel engine operation (add to the measured diesel engine power, see Article AA.5.2)				

FA.1.4 Diesel engine performance

FA.1.4.1 Diesel engine speed:

Idling speed: ___________________________r/min

Intermediate speed (if applicable): ________________r/min

Rated speed: _______________________r/min

For NRTC cycle

Reference speed: _______________________r/min Reference speed [1]

FA.1.4.2 Diesel engine power[2)] (see Table FA.2)

Table FA.2

Condition	Diesel engine power at different rotate speeds/kW			
	Idling speed	Intermediate speed (if applicable)	Rated speed	Reference speed
$P_{(m)}$				

Power measured on test stand,/kW				
$P_{(a)}$ Power absorbed by accessories possibly installed in the test according to Article AA.5.1, kW ——If installed ——If not installed	0	0	0	0
$P_{(b)}$ Power absorbed by accessories possibly dismantled in the test according to Article AA.5.2, kw ——If installed ——If not installed	0	0	0	0
Net power of diesel engine $P_{(n)}=P_{(m)}-P_{(a)}+P_{(b)}$				
[1] For NRTC test only				

1) If the tests for several parent engines have been carried out, each parent engine shall be provided with corresponding relevant test information.

2) The measured non-corrected power according to the condition of Section 2.4 of this standard.

FA.1.5 Emission level

FA.1.5.1 Test cycle emission results

Applied cycles (eight cycles under operating condition/six cycles under operating condition/five cycles under operating condition/NRTC) [2)]________________________

	CO	HC	NOx	PM
DF value				
	CO (g/kW·h)	HC (g/kW·h)	NOx (g/kW·h)	PM (g/kW·h)
0h test result				
Final result within useful life				

FA.1.5.3 Sampling system used for test

FA.1.5.3.1 Gas emission[1)]:

FA.1.5.3.2 Particulate matter[1)]:

FA.1.5.3.2.1 Method[2)]: single/multiple filter paper

1) Fill in the diagram number defined in Article C.1 of Annex C.

2) Scratch out those not applicable.

Annex G

(Normative)

Production Conformity

G.1 General

To ensure the conformity of emission characteristics of diesel engine produced in batch with type approval, the type approval institution proposes the requirements for production conformity guarantee to the manufacturing enterprise.

G.2 Production conformity guarantee plan

G.2.1 The type approval institution, when authorizing the type approval, must verify whether the manufacturing enterprise has been provided with production conformity guarantee plan made for corresponding type approval content.

G.2.2 The manufacturing enterprise must produce according to the production conformity guarantee plan, so as to guarantee each diesel engine type (or family) type approved according to this standard in conformity with the diesel engine type (or family) subjected to type approval. Production conformity guarantee shall include at least the following:

G.2.2.1 Be provided with and comply with the regulations which is capable of effectively controlling the conformity of products (system, spare parts or assembly) and diesel engine types (or family) subjected to type approval;

G.2.2.2 In order to check the conformity of type approved diesel engine types (or family), the essential test equipment or other corresponding equipment shall be used;

G.2.2.3 Record the result of test or check and form a document, which shall be reserved all the time within the period specified by the type approval institution;

G.2.2.4 Analyze the result of test or check, so as to verify and guarantee the stability of production emission characteristics, and prepare the control allowable tolerance during manufacturing process;

G.2.2.5 If any group of sample or test piece is confirmed not conformed to the conformity in the required test or check, sampling again and test or check shall be carried out. Necessary corrective measures shall be taken to recover the production conformity.

G.3 Supervision and inspection

G.3.1 The type approval institution may supervise and inspect the persistent validity of the production conformity guarantee plan of the manufacturing enterprise at any time and/or at regular intervals.

G.3.1.1 Supervision and inspection shall be carried out by the type approval institution and (or) its entrusted unit.

G.3.1.2 The period of supervision and inspection shall be determined by the type approval institution, so that the sustaining validity of production conformity guarantee plan of the manufacturing enterprise is supervised and inspected.

G.3.2 If unsatisfied result is found in supervision and inspection, the manufacturing enterprise must take all the necessary measures to recover the production conformity as soon as possible.

Annex H

(Informative)

Bibliography

GB/T 258 "Determination of Acidity of Gasoline-Kerosene and Diesel Fuels"

GB/T 260 "Determination of Water Content in Petroleum Products"

GB/T 261 "Petroleum products-Determination of Flash Point (Closed Cup Method)"

GB/T 265 "Petroleum Products-Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity"

GB/T 268 "Petroleum Products-Determination of Carbon Residue (Conradson Method)"

GB/T 380 "Determination of Sulfur Content in Petroleum Products (Lamp Method)"

GB/T 386 "Diesel Fuels Determination of Ignition Quality by the Cetane Method"

GB/T 508 "Petroleum Products-Determination of Ash"

GB/T 1884 "Crude Petroleum and Liquid Petroleum Products-Laboratory Determination of Density-Hydrometer Method"

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GB/T 6072 "Reciprocating Internal Combustion Engines-Performance"

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GB/T 6536 "Petroleum Products-Determination of Distillation"

SH/T 0175 "Standard Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method)"

SH/T 0248 Determination of Cold Filter Plugging Point of Distillate Fuels

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ISO 4259 "Petroleum Products-Determination and Application of Precision Data in Relation to Methods of Test"

ISO5167-3:2003 "Measurement of Fluid Flow by Means of Pressure Differential Devices Inserted in Circular Cross-section Conduits Running Full-Part 3: Nozzles and Venturi Nozzles"

ISO8528-1:1993 "Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets-Part 1: Application, Ratings and Performance"