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الآلات والمعدات غير المخصصة للاستخدام على الطرق - الحدود المسموح بها لانبعاثات الملوثات
الغازية والجسيمية إلى البيئة الصادرة من محركات الاحتراق الداخلي

**Non-Road Mobile Machinery – Allowable Limits of Gaseous and
Particulate Pollutants Emitted into the Environment from Internal
Combustion Engines**

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Pollutants Emitted into the Environment from Internal Combustion Engines**

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Foreword

Saudi Standards, Metrology and Quality Organization (SASO) has updated the Saudi Standard No. SASO XXXX:2026 " Non-Road Mobile Machinery – Allowable Limits of Gaseous and Particulate Pollutants Emitted into the Environment from Internal Combustion Engines " based on relevant ADMO, International and National foreign Standards and references.

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Abbreviations

AECS	Additional Emission Control Strategy
BECS	Basic Emission Control Strategy
CO	Carbon Monoxide
deNOx	deNOx System
EDP	Emission Durability Period
EGR	Exhaust Gas Recirculation
HEPA	HEPA Filter
kW	Kilowatt
NOx	Oxides of Nitrogen
PM	Particulate Matter
PN	Particle Number
NRTC	Non-road Transient Test Cycle
LSI-NRTC	Light-duty Spark Ignition Non-road Transient Test Cycle
NRSC	Non-road Steady-State Cycle
NRMM	Non-Road Mobile Machinery
NRE	NRE Engine Category
NRG	NRG Engine Category
NRS	NRS Engine Category
NRSh	NRSh Engine Category
SMB	SMB Engine Category
ATS	ATS Engine Category
ATVs	All-Terrain Vehicle

SbS	Side-by-Side
SV	Swept Volume
ECU	Electronic Control Unit
UNECE	United Nations Economic Commission For Europe
AECS	Additional Emission Control Strategy

1. Scope

This standard specifies the technical requirements, measurement and test methods for exhaust emissions, and the maximum permissible limits for gaseous and particulate pollutants emitted into the environment from internal combustion engines used in machinery and equipment not intended for road use, with compression ignition fuelled with diesel fuel, or spark ignition fuelled with gasoline fuel.

This standard applies to engine categories with test cycles and power ranges as described in **UNECE Regulation No. 96 – 05 series of amendments**, concerning emissions of pollutants from internal combustion engines used in agricultural tractors and machinery and equipment not intended for road use. This standard specifies exhaust emission limits, emission durability periods, and the associated technical requirements and testing procedures for engines covered by its scope of application, in accordance with the requirements of **Stage V**.

2. Complementary References

- 2.1 **UNECE Regulation No. 96 – 05 series of amendments:** " Uniform provisions concerning the approval of engines to be installed in agricultural and forestry tractors and in nonroad mobile machinery with regard to the emissions of pollutants by the engine" Proposal for the 05 series of amendments to UN Regulation No. 96 (Diesel emission (agricultural tractors))".
- 2.2 **SASO 844** "Clean Diesel Fuel".
- 2.3 **SASO 1951** "Clean Gasoline Fuel".

3. Definitions

- 3.1 **Non-Road Mobile Machinery:** means any mobile machine, transportable equipment or vehicle with or without bodywork or wheels, not intended for the transport of passengers or goods on roads, and includes machinery installed on the chassis of vehicles intended for the transport of passengers or goods on roads, with internal combustion engines operate either by compression-ignition (C.I.) or spark ignition

(Positive-Ignition, P.I.), according to the classification in complementary reference 2.1 as follows:

- 3.1.1 **NRE**: engines for category T vehicles and non-road mobile machinery intended and suited to move, or to be moved, by road or otherwise, and are not included in any other category set out in this standard;
- 3.1.2 **NRG**: engines having a reference power that is greater than 560 kW, exclusively for use in generating sets; engines for generating sets other than those having those characteristics are included in the categories NRE or NRS, according to their characteristics;
- 3.1.3 **NRSh**: hand-held Spark Ignition (SI) engines having a reference power that is less than 19 kW, exclusively for use in hand-held machinery;
- 3.1.4 **NRS**: SI engines for category T vehicles and non-road mobile machinery having a reference power that is less than 56 kW and not included in category NRSh;
- 3.1.5 **SMB**: SI engines exclusively for use in snowmobiles; engines for snowmobiles other than SI engines are included in category NRE;
- 3.1.6 **ATS**: SI engines exclusively for use in All-terrain vehicles (ATVs) and Side-by-Side (SbS) that are either category T vehicles or non-road mobile machinery; engines for ATVs and SbS other than SI engines are included in category NRE.
- 3.1.7 **All-Terrain Vehicle (ATV)**: means a non-road mobile machine or category T vehicle, propelled by an engine, intended primarily to travel on unpaved surfaces on four or more wheels with low-pressure tyres, having a seat designed to be straddled by the driver only, or a seat designed to be straddled by the driver and a seat for no more than one passenger, and handlebars for steering;
- 3.1.8 **Side-by-side vehicle (SbS)**: means a self-propelled, operator-controlled, non-articulated non-road mobile machinery or category T vehicle intended primarily to travel on unpaved surfaces on four or more wheels, having a minimum unladen mass, in running order, of 300 kg (including standard equipment, coolant, lubricants, fuel and tools but excluding optional accessories and the driver) and a maximum design speed of 25 km/h or more; such a vehicle is also designed to transport persons and/or goods, and/or to pull and push equipment, is steered by a control other than a handlebar, is designed for

recreational or utility purposes and carries no more than six people including the driver, sitting side by side on one or more non-straddle seats.

- 3.2 **Stationary Machinery:** means machinery that is intended to be permanently installed in one location for its first use and is not intended to be moved, by road or otherwise, except during shipment from the place of manufacture to the place of first installation.
- 3.3 **Generating Set:** means an independent non-road mobile machine that is not part of a power train, primarily intended to produce electric power.
- 3.4 **Snowmobile:** means a self-propelled machine that is intended for off-road travel primarily on snow, is driven by tracks in contact with snow and steered by a ski or skis in contact with the snow, and has a maximum unladen mass, in running order, of 454 kg (including standard equipment, coolant, lubricants, fuel and tools but excluding optional accessories and the driver).
- 3.5 **Hand-held SI engine:** means an SI engine having a reference power of less than 19 kW, and used in a piece of equipment that meets at least one of the following conditions:
- 3.5.1 It is carried by the operator throughout the performance of its intended function(s);
- 3.5.2 It operates multi-positionally, such as upside down or sideways, to perform its intended function(s);
- 3.5.3 Its dry mass, including engine, is less than 20 kg, and it meets at least one of the following conditions:
- 3.5.3.1 Its operator provides physical support for or, alternatively, carries the equipment throughout the performance of its intended function(s);
- 3.5.3.2 Its operator provides physical support or attitudinal control for the equipment throughout the performance of its intended function(s);
- 3.5.3.3 It is used in a generator or a pump.
- 3.6 **Manufacturer:** means any natural or legal person who is responsible to the Type Approval Authority for all aspects of the engine approval and for ensuring conformity of engine production, whether or not they are directly involved in all stages of the design and construction of the engine which is the subject of the approval process.

- 3.7 **End-user:** means any natural or legal person, other than the manufacturer or OEM, that is responsible for operating the engine installed in non-road mobile machinery or category T vehicle.
- 3.8 **Internal Combustion Engine** or '**Engine**': means an energy converter, other than a gas turbine, designed to transform chemical energy (input) into mechanical energy (output) with an internal combustion process; it includes, where they have been installed, the emission control system and the communication interface (hardware and messages) between the engine's electronic control unit(s) and any other powertrain or category T vehicle or non-road mobile machinery control unit necessary to comply with this standard.
- 3.9 **Constant-Speed Engine:** means an engine the type-approval of which is limited to constant-speed operation, excluding engines the constant-speed governor function of which is removed or disabled; it may be provided with an idle speed that can be used during start-up or shut-down and it may be equipped with a governor that can be set to an alternative speed when the engine is stopped.
- 3.10 **Variable-Speed Engine:** means an engine that is not a constant-speed engine.
- 3.11 **Crankcase:** means the enclosed spaces in, or external to, an engine which are connected to the oil sump by internal or external ducts through which gases and vapours can be emitted.
- 3.12 **Parent Engine:** means an engine type selected from an engine family in such a way that its emissions characteristics are representative of that engine family.
- 3.13 **Engine Type:** means a group of engines which do not differ in such essential engine characteristics as defined in Annex 10 of complementary reference 2.1.
- 3.14 **Engine Family:** means a manufacturer's grouping of engine types which, through their design, have similar exhaust emission characteristics, and respect the applicable emission limit values.
- 3.15 **Net power:** means the power in " kW" obtained on the test bench at the end of the crankshaft, or its equivalent, measured in accordance with the method described in UN Regulation No. 120 on the measurement of the net power, net torque and specific fuel

consumption of internal combustion engines for agricultural and forestry tractors and non-road mobile machinery.

- 3.16 **Maximum Net Power:** means the highest value of the net power on the nominal full-load power curve for the engine type.
- 3.17 **Rated Net Power:** means the net power in kW as declared by the manufacturer of an engine at rated speed.
- 3.18 **Maximum Torque Speed:** means the engine speed at which the maximum torque is obtained from the engine, as specified by the manufacturer.
- 3.19 **Reference Power:** means the net power that is used to determine the applicable emission limit values for the engine.
- 3.20 **High Speed** or ' n_{hi} ': means the highest engine speed where 70 per cent of the maximum power occurs.
- 3.21 **Rated Speed:** means the maximum full load speed allowed by an engine's governor, as designed by the manufacturer, or, if a governor is not present, the speed at which the maximum net power is attained by the engine, as specified by the manufacturer.
- 3.22 **Low Speed** or ' n_{lo} ': means the lowest engine speed where 50 per cent of the maximum power occurs.
- 3.23 **Idle Speed:** means the lowest engine speed with minimum load (greater than or equal to zero load), where an engine governor function controls engine speed. For engines without a governor function that controls idle speed, idle speed means the manufacturer-declared value for lowest engine speed possible with minimum load. Note that warm idle speed is the idle speed of a warmed-up engine.
- 3.24 **Engine Governed Speed:** means the engine operating speed when it is controlled by the installed governor.
- 3.25 **Engine Production Date:** means the date, expressed as the month and year, on which the engine passes the final check, after it has left the production line, and is ready to be delivered or to be put into stock.
- 3.26 **Governor:** means a device or control strategy that automatically controls engine speed or load, other than an over- speed limiter as installed in an engine of category NRSh

limiting the maximum engine speed for the sole purpose of preventing the engine operating at speeds in excess of a certain limit.

- 3.27 **Emission Control System:** means any device, system, or element of design that controls or reduces the emissions of regulated pollutants from an engine.
- 3.28 **Emission Control Strategy:** means an element or a set of design elements incorporated into the overall design of an engine, or into non-road mobile machinery in which an engine is installed and used in controlling emissions.
- 3.29 **Base emission control strategy** or "**BECS**": means an emission control strategy that is active throughout the range of torque and speed over which the engine operates, unless an Auxiliary Emission Control Strategy (AECS) is activated.
- 3.30 **Auxiliary emission control strategy** or "**AECS**": means an emission control strategy that is activated and temporarily modifies a Base Emission Control Strategy (BECS) for a specific purpose and in response to a specific set of ambient and/or operating conditions and only remains in operation as long as those conditions exist.
- 3.31 **Defeat Strategy:** means an emission control strategy that reduces the effectiveness of the emission control system under ambient or engine operating conditions encountered either during normal machine operation or outside the approval test procedures.
- 3.32 **Electronic Control Unit:** means an engine's electronic device that is part of the emission control system and uses data from engine sensors to control engine parameters.
- 3.33 **Exhaust After-Treatment System:** means a catalyst, particulate filter, deNO_x system, or any other emission-reducing device, including any combination of systems that share the same physical components, that is installed downstream of the engine. This definition excludes exhaust gas recirculation (EGR) and turbochargers, which are considered an integral part of the engine.
- 3.34 **DeNO_x System:** means an exhaust after-treatment system designed to reduce emissions of oxides of nitrogen (NO_x) (e.g. passive and active lean NO_x catalysts, NO_x adsorbers and selective catalytic reduction (SCR) systems).

- 3.35 **Exhaust-Gas Recirculation** or "**EGR**": means a technical device that is part of the emission control system and reduces emissions by routing exhaust gases that have been expelled from the combustion chamber(s) back into the engine to be mixed with incoming air before or during combustion, except for the use of valve timing to increase the amount of residual exhaust gas in the combustion chamber(s) that is mixed with incoming air before or during combustion.
- 3.36 **Particulate After-treatment System**: means an exhaust after-treatment system designed to reduce emissions of particulate pollutants through a mechanical, aerodynamic, diffusional or inertial separation.
- 3.37 **Open Crankcase Emissions**: means any flow from an engine's crankcase that is emitted directly into the environment.
- 3.38 **Gaseous Pollutants**: means the following pollutants in their gaseous state emitted by an engine: carbon monoxide (CO), total hydrocarbons (HC) and oxides of nitrogen (NO_x); NO_x being nitric oxide (NO) and nitrogen dioxide (NO₂), expressed as NO₂ equivalent.
- 3.39 **Regeneration**: means an event during which emissions levels change while the exhaust after-treatment system's performance is being restored by design and which can be classified as continuous regeneration or infrequent (periodic) regeneration.
- 3.40 **Particulate Matter (PM)**: means any material collected on a specified filter medium after diluting an engine exhaust gas with clean filtered air so that the temperature does not exceed 325 K (52 °C).
- 3.41 **Particle Number (PN)**: means the number of solid particles emitted by an engine with a diameter greater than 23 nm.
- 3.42 **Particulate Pollutants**: means any matter emitted by an engine that is measured as PM or PN.
- 3.43 **Specific Emissions**: means the mass emissions expressed in g/kWh.
- 3.44 **Test Cycle**: means a sequence of test points, each with a defined speed and torque, to be followed by the engine when being tested under steady state or transient operating conditions.

- 3.45 **Steady-State Test Cycle:** means a test cycle in which engine speed and torque are held at a finite set of nominally constant values; steady-state tests are either discrete mode tests or ramped-modal tests.
- 3.46 **Constant-Speed Operation:** means an engine operation with a governor that automatically controls the operator demand to maintain engine speed, even under changing load.
- 3.47 **Constant-speed non-road steady-state test cycle:** (hereinafter 'constant-speed NRSC') means any of the following non-road steady-state test cycles defined in Appendix A.6 to Annex 4 of complementary reference 2.1: D2, G1, G2 or G3.
- 3.48 **Transient Test Cycle:** means a test cycle with a sequence of normalised speed and torque values that vary on a second-by-second basis with time.
- 3.49 **Test Interval:** means a duration of time over which brake-specific emissions are determined.
- 3.50 **Variable-speed non-road steady-state test cycle:** (hereinafter "variable-speed NRSC") means a non-road steady-state test cycle that is not a constant-speed NRSC.
- 3.51 **Emission Durability Period** or 'EDP': means the number of hours or, where applicable, the distance used to determine the deterioration factors.
- 3.52 **Deterioration Factors:** means the set of factors that indicate the relationship between emissions at the start and end of the emission durability period.
- 3.53 **HEPA Filter:** means high-efficiency particulate air filters that are rated to achieve a minimum initial particle-removal efficiency of 99.97 per cent using ASTM F 1471–93.
- 3.54 **Clean Diesel Fuel:** Diesel fuel with a sulfur content not exceeding 10 parts per million, in accordance with the Saudi clean fuel standard specifications referred to in complementary reference 2.2.
- 3.55 **Clean Gasoline Fuel:** Gasoline fuel with a sulfur content not exceeding 10 parts per million, in accordance with the Saudi clean fuel standard specifications referred to in complementary reference 2.3.

- 3.56 **Reference Fuel:** The test fuel used in all emission tests specified in this standard, in accordance with the characteristics specified in Annex 10 of complementary reference 2.1.
- 3.57 **Reagent:** means any consumable or non-recoverable medium required and used for the effective operation of the exhaust after-treatment system.
- 3.58 Any other definitions not specified herein shall be directly referred to section (2) of complementary reference 2.1.

4. Classification and Categories of Engines

- 4.1 The engines covered by this standard are classified according to the categories defined in complementary reference 2.1, and in accordance with the definitions set out in Section 3 of this standard. These categories include:

- 4.1.1 Category NRE;
- 4.1.2 Category NRG;
- 4.1.3 Category NRSh;
- 4.1.4 Category NRS;
- 4.1.5 Category SMB;
- 4.1.6 Category ATS.

- 4.2 The classification of an engine into the appropriate category is determined based on the type of ignition (compression-ignition or spark-ignition), the reference net power range (kW), and the intended application of the engine, in accordance with the definitions and criteria specified in complementary reference 2.1 and Section 3 of this standard.
- 4.3 The subcategory of each engine within the categories referred to in paragraph 4.1 is determined according to the type of ignition, reference net power range, and operating characteristics, as specified in the subcategory tables in paragraph 7.1 of this standard.

5. General Requirements and Provisions

Internal combustion engines used in machinery and equipment not intended for road use, as defined in this standard, are subject to the technical requirements set forth in

Section 5 of complementary reference 2.1. The engine design and the emissions control and after-treatment systems must be designed to ensure continuous compliance throughout the approved emission durability period. The main requirements and general provisions are reiterated below, without prejudice to the aforementioned reference.

- 5.1 Engines shall be designed, constructed and assembled so as to enable them to comply with the provisions of this standard.
- 5.2 The technical measures taken by the manufacturer shall be such as to ensure that the gaseous and particulate pollutant emissions are effectively limited, as specified in paragraph 7.2 of this standard, throughout the emission durability period specified in paragraph 7.3 of this standard, and under normal conditions of use.
- 5.3 For this purpose, the engine final emission test result calculated according to the requirements of paragraph 5.4. shall not exceed the exhaust emission limits set out in paragraph 7.2 of this standard, when:
 - 5.3.1 Tested in accordance with the test conditions and detailed technical procedures set out in Annex 4 of complementary reference 2.1,
 - 5.3.2 Using the fuel(s) specified in paragraph 5.5 of this standard.
 - 5.3.3 Using the test cycles specified in paragraph 7.4 of this standard, in accordance with Appendix A.6 to Annex 4 of complementary reference 2.1.
- 5.4 The final exhaust emission test results for engines subject to this standard shall be calculated by applying all of the following to the laboratory test results:
 - 5.4.1 The emissions of crankcase gases as required by paragraph 6.6 of this standard;
 - 5.4.2 Any necessary adjustment factor, where the engine includes an infrequently regenerating exhaust after-treatment system;
 - 5.4.3 In respect of all engines, as a final step in the calculation, deterioration factors appropriate to the emission durability periods specified in paragraph 7.3 of this standard and calculated in accordance with the methodology set out in Annex 8 of complementary reference 2.1.
- 5.5 In accordance with Appendix 4 of complementary reference 2.1, the testing of an engine type or engine family to determine whether it meets the emission limits set out in this

standard shall be carried out by using the appropriate reference fuels or fuel combinations, as specified in Appendix 4 of complementary reference 2.1.

- 5.6 The engine type or engine family shall, in addition, meet the exhaust emission limits set out in this standard in respect of any other specified fuels, fuel mixtures or fuel emulsions included by a manufacturer in an application for type approval and described in Appendix 4 of complementary reference 2.1.
- 5.7 As regards the conduct of measurements and tests, the technical requirements shall be met in respect of:
- 5.7.1 Apparatus and procedures for the conduct of tests;
 - 5.7.2 Apparatus and procedures for emission measurement and sampling;
 - 5.7.3 Methods for data evaluation and calculations;
 - 5.7.4 Methods for establishing deterioration factors;
 - 5.7.5 Methods for taking account of emissions of crankcase gases;
 - 5.7.6 Methods for determining and taking account of continuous or infrequent regeneration of exhaust after-treatment systems;
 - 5.7.7 In relation to electronically controlled engines in categories NRE and NRG complying with the emission limits set out in paragraph 7.2 of this standard and using electronic control to determine both the quantity and timing of injecting fuel or using electronic control to activate, de-activate or modulate the emission control system used to reduce NO_x:
 - 5.7.7.1 Emission control strategies, and shall include the documentation required to demonstrate those strategies;
 - 5.7.7.2 NO_x control measures, and shall include the method used to demonstrate those control measures;
 - 5.7.7.3 The area associated with the relevant non-road steady-state test cycle, within which the amount by which the emissions are permitted to exceed the emission limits set out in paragraph 7.2 of this standard is controlled;

- 5.7.7.4 The selection by the technical service of additional measurement points from within the control area during the emission bench test.
- 5.8 Any adjustment, repair, disassembly, cleaning or replacement of engine components or systems which are scheduled to be performed on a periodic basis to prevent malfunction of the engine, shall only be done to the extent that is technologically necessary to ensure proper functioning of the emission control system as set out in paragraph 3.4 of Annex 8 of complementary reference 2.1.
- 5.9 Where, in accordance with the parameters defining the engine family laid down in Annex 10 of complementary reference 2.1, one engine family covers more than one power range, the parent engine (for the purposes of type-approval) and all engine types within the same family (for the purposes of conformity of production) shall, with respect to the applicable power ranges:
- 5.9.1 Meet the most stringent emission limit values;
- 5.9.2 Be tested using the test cycles that correspond to the most stringent emission limit values;
- 5.9.3 Be subject to the earliest applicable dates for type-approval and placing on the market set out in paragraph 12 of complementary reference 2.1.
- 5.10 The technical requirements relating to emission control strategies as set out in Annex 9 of complementary reference 2.1 shall apply.
- 5.11 The use of defeat strategies shall be prohibited.
- 5.12 Engine types and engine families shall be designed and fitted with emission control strategies in such a way as to prevent tampering to the extent possible. For this purpose, paragraphs 3 and 4 of Annex 9 and Appendix A.3 of Annex 9 of complementary reference 2.1 shall apply.

6. Measurements and tests with regard to the area associated with the non-road steady-state test cycle (NRSC)

6.1 General requirements

- 6.1.1 This paragraph shall apply to electronically controlled engines of categories NRE and NRG, complying with emission limits set out in paragraph 7.2 of this standard and using electronic control to determine both the quantity and timing of injecting fuel or using electronic control to activate, de-activate or modulate the emission control system used to reduce NO_x.
- 6.1.2 This paragraph sets out the technical requirements relating to the area associated with the relevant NRSC, within which the amount by which the emissions shall be permitted to exceed the emission limits set out in paragraph 7.2 of this standard is controlled.
- 6.1.3 When an engine is tested as set out in the test requirements of paragraph 6.4., the emission of gaseous and particulate pollutants sampled at any randomly selected point within the applicable control area set out in paragraph 6.2. shall not exceed the applicable emission limit values in paragraph 7.2 of this standard multiplied by a factor of 2.0.
- 6.1.4 Paragraph 6.3. sets out the selection by the technical service of additional measurement points from within the control area during the emission bench test, in order to demonstrate that the requirements of this paragraph have been met.
- 6.1.5 The manufacturer may request that the Technical Service excludes operating points from any of the control areas set out in paragraph 6.2. during the demonstration set out in paragraph 6.3. The Technical Service may grant this exclusion if the manufacturer can demonstrate that the engine is never capable of operating at such points when used in any non-road mobile machinery or category T vehicle combination.
- 6.1.6 The installation instructions provided by the manufacturer to the OEM in accordance with Appendix 5 of complementary reference 2.1 shall identify the upper and lower boundaries of the applicable control area and shall include a statement to clarify that the OEM shall not install the engine in such a way that it constrains the engine to operate permanently at only combinations of speed and torque outside of the control area for the torque curve corresponding to the approved engine type or engine family.

6.2 Engine control area

The applicable control area for conducting the engine test shall be the area identified in this paragraph that corresponds to the applicable Non-Road Steady-State Cycle (NRSC) for the engine being tested.

6.2.1 Control area for engines tested on NRSC cycle C1

These engines operate with variable-speed and load. Different control area exclusions apply depending upon the (sub-)category and operating speed of the engine.

6.2.1.1 Variable-speed engines of category NRE with maximum net power ≥ 19 kW and variable-speed engines of category NRG.

The control area (see Figure 1.) is defined as follows:

upper torque limit: full load torque curve;

engine speed range: speed A to n_{hi} ;

where:

$$\text{speed A} = n_{lo} + 0.15 \cdot (n_{hi} - n_{lo});$$

n_{hi} = high speed (see paragraph 3.20.),

n_{lo} = low speed (see paragraph 3.22.).

The following engine operating conditions shall be excluded from testing:

- i. Points below 30 per cent of maximum torque;
- ii. Points below 30 per cent of maximum net power.

If the measured engine speed A is within ± 3 per cent of the engine speed declared by the manufacturer, the declared engine speeds shall be used. If the tolerance is exceeded for any of the test speeds, the measured engine speeds shall be used.

Intermediate test points within the control area shall be determined as follows:

$\% \text{ torque} = \text{per cent of maximum torque}$

$$\% \text{ speed} = \frac{(n - n_{idle})}{(n_{100\%} - n_{idle})} * 100$$

where: $n_{100\%}$ is the 100 per cent speed for the corresponding test cycle,

n_{idle} is the idle speed.

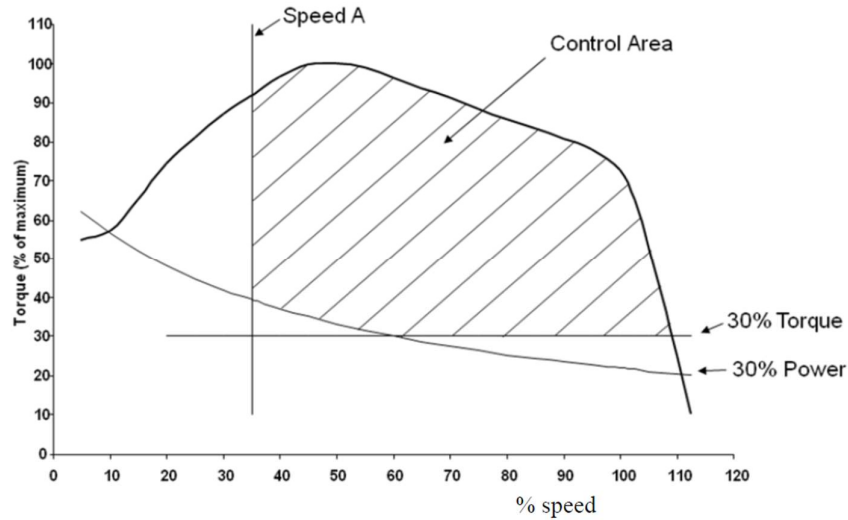


Figure 1 : Control area for variable-speed engines of category NRE with maximum net power ≥ 19 kW and variable-speed engines of category NRG.

6.2.1.2 Variable-speed engines of category NRE with maximum net power < 19 kW.

The control area specified in paragraph 6.2.1.1. shall apply but with the additional exclusion of the engine operating conditions given in this paragraph and illustrated in Figures 2. and 3.

- i. For particulate matter only, if the C engine speed is below 2400 r/min, points to the right of or below the line formed by connecting the points of 30 % of maximum torque or 30 per cent of maximum net power, whichever is greater, at the B engine speed and 70 per cent of maximum net power at the high speed;
- ii. For particulate matter only, if the C engine speed is at or above 2400 r/min, points to the right of the line formed by connecting the points of 30 per cent of maximum torque or 30 per cent of maximum net power, whichever is greater, at the B engine speed, 50 per cent of maximum net power at 2400 r/min, and 70 per cent of maximum net power at the high speed.

where:

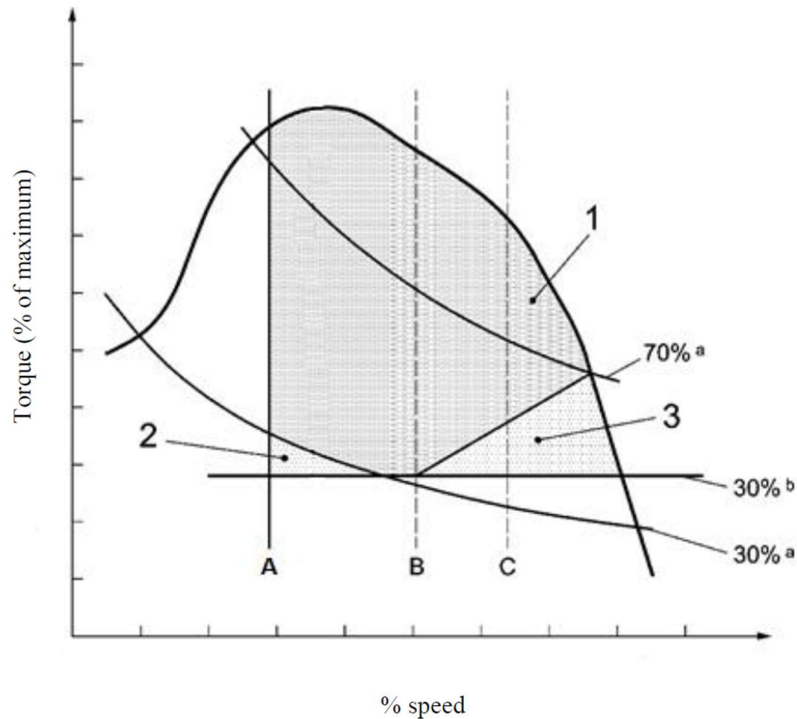
$$\text{engine speed B} = n_{lo} + 0.5 \cdot (n_{hi} - n_{lo});$$

$$\text{engine speed C} = n_{lo} + 0.75 \cdot (n_{hi} - n_{lo}).$$

n_{hi} = high speed (see paragraph 3.20.),

n_{10} = low speed (see paragraph 3.22.).

If the measured engine speeds A, B and C are within $\pm 3 \%$ of the engine speed declared by the manufacturer, the declared engine speeds shall be used. If the tolerance is exceeded for any of the test speeds, the measured engine speeds shall be used.



Key

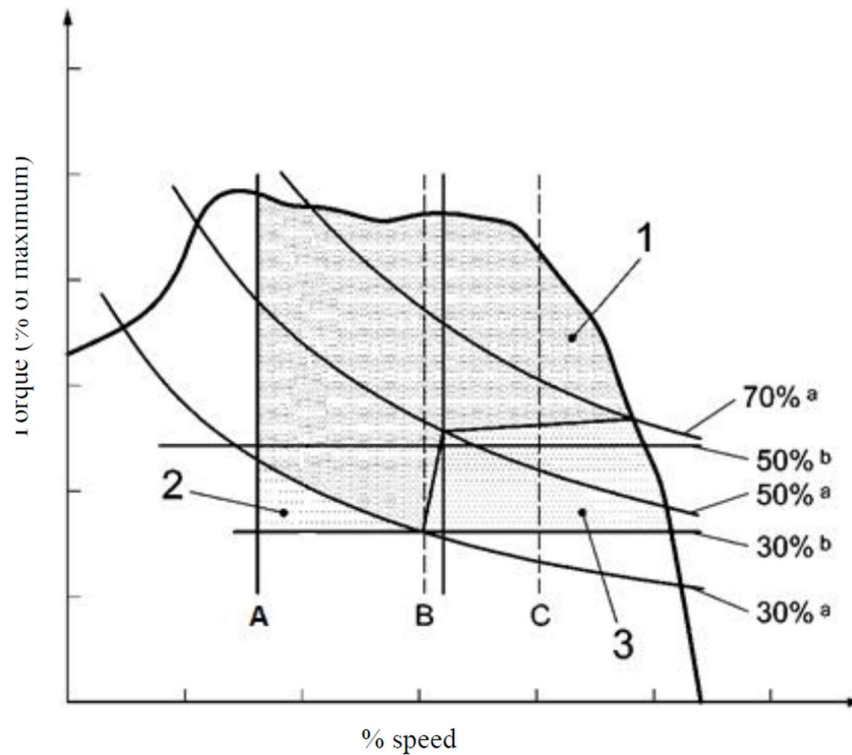
1 Engine Control Area

2 All Emissions Carve-Out

3 PM Carve-Out

^a per cent of maximum net power^b per cent of maximum torque

Figure 2 : Control area for variable-speed engines of category NRE with maximum net power < 19 kW and speed C < 2400 rpm.



Key

- | | |
|-----------------------|--|
| 1 Engine Control Area | 2 All Emissions Carve-Out |
| 3 PM Carve-Out | ^a Per cent of maximum net power |
| | ^b Per cent of maximum torque |

Figure 3 : Control area for variable-speed engines of category NRE with maximum net power < 19 kW and speed C $\geq$ 2400 rpm.

6.2.2 Control area for engines tested on NRSC cycles D2 and G2

These engines are mainly operated very close to their designed operating speed; hence the control area is defined as:

- i. engine speed: 100 per cent.
- ii. torque range: 50 per cent to the torque corresponding to maximum power.

6.3 Demonstration requirements

The technical service shall select random load and engine speed points within the control area for testing. For engines subject to paragraph 6.2.1. up to three points shall be selected. For engines subject to paragraph 6.2.2. one point shall be selected. The technical service shall also determine a random running order of the test points. The

test shall be run in accordance with the principal requirements of the NRSC, but each test point shall be evaluated separately.

6.3.1 For the purpose of the random selections required in paragraph 6.3., recognised statistical methods of randomization shall be used.

6.4 Test requirements

The test shall be carried out immediately after the applicable NRSC as follows:

6.4.1 The test of the randomly selected torque and engine speed points shall either be carried out immediately after the discrete-mode NRSC test sequence described in sub-paragraphs (a) to (e) of paragraph 7.8.1.2. of Annex 4 but before the post test procedures (f) or after the Ramped Modal non-road steady-state test Cycle ("RMC") test sequence described in sub-paragraphs (a) to (d) of paragraph 7.8.2.3. of Annex 4 but before the post test procedures (e) as relevant;

6.4.2 The tests shall be carried out as required in sub-paragraphs (b) to (e) of paragraph 7.8.1.2. of Annex 4 using the multiple filter method (one filter for each test point) for each of the test points chosen in accordance with paragraph 6.2.;

6.4.3 A specific emission value shall be calculated (in g/kWh or #/kWh as applicable) for each test point;

6.4.4 Emissions values may be calculated on a mass basis using Appendix A.1. of Annex 5 of complementary reference 2.1 or on a molar basis using Appendix A.2. of Annex 5 of complementary reference 2.1, but shall be consistent with the method used for the discrete-mode NRSC or RMC test;

6.4.5 For gaseous and PN, if applicable, summation calculations, N_{mode} in equation (A.5-64) or (A.5-136) and (A.5-180) shall be set to 1 and a weighting factor of 1 shall be used;

6.4.6 For particulate calculations the multiple filter method shall be used; for summation calculations, N in equation (A.5-67) shall be set to 1 and a weighting factor of 1 shall be used.

6.5 Regeneration

In the case that a regeneration event occurs during or immediately preceding the procedure in paragraph 6.4., upon completion of that procedure the test may be voided at the request of the manufacturer irrespective of the cause of the regeneration. In this case the test shall be repeated. The same torque and engine speed points shall be used although the running order may be changed. It shall not be deemed necessary to repeat any torque and engine speed points for which a pass result has already been obtained. The following procedure shall be used for the repeat test:

- 6.5.1 The engine shall be operated in a manner to ensure that the regeneration event has completed and, where applicable, the soot load in the particulate after-treatment has been re-established;
- 6.5.2 The engine warm-up procedure shall be performed according to paragraph 7.8.1.1. of Annex 4 of complementary reference 2.1;
- 6.5.3 The test procedure specified in paragraph 6.4. shall be repeated commencing at paragraph 6.4.2.

6.6 Verifying emissions of crankcase gases

- 6.6.1 Engines may discharge crankcase emissions into the exhaust upstream of any after-treatment device during all operation.
- 6.6.2 Crankcase emissions that are discharged directly into the ambient atmosphere shall be added to the exhaust emissions during all emission testing. For this purpose, the manufacturer shall install the engines so that all crankcase emissions can be routed into the emissions sampling system, according to the requirements set out in paragraph 6.10. of Annex 4 of complementary reference 2.1.

7. Maximum allowable limits for pollutants according to the classification, power, and type of ignition of the engine

7.1 Definition of engine subcategories

Table 1: Sub-categories of engine category NRE.					
Category	Ignition Type	Speed Operation	Power Range (kW)	Sub-category	Reference Power
NRE	CI	Variable	$0 < P < 8$	NRE-v-1	Maximum net power
	CI		$8 \leq P < 19$	NRE-v-2	
	CI		$19 \leq P < 37$	NRE-v-3	
	CI		$37 \leq P < 56$	NRE-v-4	
	All		$56 \leq P < 130$	NRE-v-5	
			$130 \leq P \leq 560$	NRE-v-6	
			$P > 560$	NRE-v-7	
	CI	Constant	$0 < P < 8$	NRE-c-1	Rated net power
	CI		$8 \leq P < 19$	NRE-c-2	
	CI		$19 \leq P < 37$	NRE-c-3	
	CI		$37 \leq P < 56$	NRE-c-4	
	All		$56 \leq P < 130$	NRE-c-5	
			$130 \leq P \leq 560$	NRE-c-6	
			$P > 560$	NRE-c-7	

Table 2: Sub-categories of engine category NRG.

Category	Ignition Type	Speed Operation	Power Range (kW)	Sub-category	Reference Power
NRG	All	Variable	P>560	NRG-v-1	Maximum net power
		Constant	P>560	NRG-c-1	Rated net power

Table 3: Sub-categories of engine category NRSh.

Category	Ignition Type	Speed Operation	Power Range (kW)	Total swept volume (cm ³)	Sub-category	Reference Power
NRSh	SI	Variable or Constant	0<P<19	SV<50	NRSh-v-1a	Maximum net power
				SV≥50	NRSh-v-1b	

Table 4: Sub-categories of engine category NRS.

Table 4: Sub-categories of engine category NRS.						
Category	Ignition Type	Speed Operation	Power Range (kW)	Total swept volume (cm ³)	Sub-category	Reference Power
NRS	SI	Variable ≥ 3600 rpm, or Constant	0<P<19	80≤SV<225	NRS-vr-1a	Maximum net power
				SV≥225	NRS-vr-1b	
		Variable< 3600 rpm		80≤SV<225	NRS-vi-1a	
				SV≥225	NRS-vi-1b	
		Variable or Constant	19≤P<30	SV≤1000	NRS-v-2a	Maximum net power
				SV>1000	NRS-v-2b	
			30≤P<56	any	NRS-v-3	Maximum net power
For engines <19 kW with SV<80 cm ³ in machinery other than hand-held machinery, engines of the category NRSh shall be used.						

Table 5: Sub-categories of engine category SMB.

Category	Ignition Type	Speed Operation	Power Range (kW)	Sub-category	Reference Power
SMB	SI	Variable or Constant	$P > 0$	SMB-v-1	Maximum net power

Table 6: Sub-categories of engine category ATS.

Category	Ignition Type	Speed Operation	Power Range (kW)	Sub-category	Reference Power
ATS	SI	Variable or Constant	$P > 0$	ATS-v-1	Maximum net power

7.2 Exhaust Emission Limits

Table 7: Emission limits for engine category NRE.

Table 7: Emission limits for engine category NRE.								
Engine sub- category	Power Range (kW)	Ignition Type	CO	HC	NOx	PM mass	PN	A
			g/kWh	g/kWh	g/kWh	g/kWh	#/kWh	
NRE-v-1	0<P<8	CI	8.00	(HC+NOx≤7.50)		0.40*	–	1.10
NRE-c-1								
NRE-v-2	8≤P<19	CI	6.60	(HC+NOx≤7.50)		0.40	–	1.10
NRE-c-2								
NRE-v-3	19≤P<37	CI	5.00	(HC+NOx≤4.70)		0.015	1E+12	1.10
NRE-c-3								
NRE-v-4	37≤P<56	CI	5.00	(HC+NOx≤4.70)		0.015	1E+12	1.10
NRE-c-4								
NRE-v-5	56≤P<130	All	5.00	0.19	0.40	0.015	1E+12	1.10
NRE-c-5								
NRE-v-6	130≤P≤560	All	3.50	0.19	0.40	0.015	1E+12	1.10
NRE-c-6								
NRE-v-7	P>560	All	3.50	0.19	3.50	0.045	–	6.00
NRE-c-7								
*0.60 for hand-startable, air-cooled direct injection engines.								

Table 8: Emission limits for engine category NRG.

Engine sub-category	Power Range (kW)	Ignition Type	CO	HC	NOx	PM mass	PN	A
			g/kWh	g/kWh	g/kWh	g/kWh	#/kWh	
NRG-v-1	P>560	All	3.50	0.19	0.67	0.035	-	6.00
NRG-c-1								

Table 9: Emission limits for engine category NRSh.

Engine sub-category	Power Range (kW)	Ignition Type	CO	HC + NOx
			g/kWh	g/kWh
NRSh-v-1a	0<P<19	SI	805	50
NRSh-v-1b			603	72

Table 10: Emission limits for engine category NRS.

Table 10: Emission limits for engine category NRS.				
Engine sub-category	Power Range (kW)	Ignition Type	CO	HC + NOx
			g/kWh	g/kWh
NRS-vr-1a	0<P<19	SI	610	10
NRS-vi-1a				
NRS-vr-1b			610	8
NRS-vi-1b				
NRS-v-2a	19≤P≤30		610	8
NRS-v-2b	19≤P<56		4.40*	2.70*
NRS-v-3				
*Optionally, as an alternative, any combination of values satisfying the equation $(HC+NOx) \times CO^{0.784} \leq 8,57$ as well as the following conditions: CO ≤ 20,6 g/kWh and (HC+NOx) ≤ 2,7 g/kWh.				

Table 11: Emission limits for engine category SMB.

Engine sub-category	Power Range (kW)	Ignition Type	CO	NOx	HC
			g/kWh	g/kWh	g/kWh
SMB-v-1	P>0	SI	275	–	75

Table 12: Emission limits for engine category ATS.				
Engine sub-category	Power Range (kW)	Ignition Type	CO	HC + NOx
			g/kWh	g/kWh
ATS-v-1	P>0	SI	400	8

7.3 Emission Durability Periods (EDP)

Table 13: Emission durability periods (EDP) for engine category NRE.

Table 13: Emission durability periods (EDP) for engine category NRE.					
Category	Ignition Type	Speed Operation	Power Range (kW)	Sub-category	EDP (hours)
NRE	CI	Variable	$0 < P < 8$	NRE-v-1	3000
	CI		$8 \leq P < 19$	NRE-v-2	
	CI		$19 \leq P < 37$	NRE-v-3	5000
	CI		$37 \leq P < 56$	NRE-v-4	8000
	All		$56 \leq P < 130$	NRE-v-5	
			$130 \leq P \leq 560$	NRE-v-6	
			$P > 560$	NRE-v-7	
	CI	Constant	$0 < P < 8$	NRE-c-1	3000
	CI		$8 \leq P < 19$	NRE-c-2	
	CI		$19 \leq P < 37$	NRE-c-3	
	CI		$37 \leq P < 56$	NRE-c-4	8000
	All		$56 \leq P < 130$	NRE-c-5	
			$130 \leq P \leq 560$	NRE-c-6	
			$P > 560$	NRE-c-7	

Table 14: Emission durability periods (EDP) for engine category NRG.

Category	Ignition Type	Speed Operation	Power Range (kW)	Sub-category	EDP (hours)
NRG	All	Variable	P>560	NRG-v-1	8000
		Constant		NRG-c-1	

Table 15: Emission durability periods (EDP) for engine category NRSh.

Category	Ignition Type	Speed Operation	Power Range (kW)	Total swept volume (cm ³)	Sub-category	EDP (hours)
NRSh	SI	Variable or Constant	0<P<19	SV<50	NRSh-v-1a	50/125/300*
				SV≥50	NRSh-v-1b	

*EDP hours correspond to the EDP categories Cat 1/Cat 2/Cat 3 as set out in Table A.8-2 of Annex 8 of complementary reference 2.1.

Table 16: Emission durability periods (EDP) for engine category NRS.

Category	Ignition Type	Speed Operation	Power Range (kW)	Total swept volume (cm ³)	Sub-category	EDP (hours)
NRS	SI	Variable rated, or Constant	0<P<19	80≤SV<225	NRS-vr-1a	50/125/300*
		Variable intermediate			NRS-vi-1a	
		Variable rated, or Constant		SV≥225	NRS-vr-1b	250/500/1000*
		Variable intermediate			NRS-vi-1b	
		Variable or Constant	19≤P<30	SV≤1000	NRS-v-2a	1000
				SV>1000	NRS-v-2b	5000
			30≤P<56	any	NRS-v-3	5000
*EDP hours correspond to the EDP categories Cat 1/Cat 2/Cat 3 as defined as set out in Table A.8-2 of Annex 8 of complementary reference 2.1.						

Table 17: Emission durability periods (EDP) for engine category SMB.

Category	Ignition Type	Speed Operation	Power Range (kW)	Sub-category	EDP (hours)
SMB	SI	Variable or Constant	P>0	SMB-v-1	400*
*بدلاً من ذلك، يُسمح بفترة متانة انبعاثات مقدارها 8,000 كم.					

Table 18: Emission durability periods (EDP) for engine category ATS.

Category	Ignition Type	Speed Operation	Power Range (kW)	Sub-category	EDP (hours)
ATS	SI	Variable or Constant	P>0	ATS-v-1	500/1000*
*EDP hours correspond to the following total engine swept volumes: < 100 cm ³ /≥ 100 cm ³ .					

7.4 Test cycles based on engine categories and subcategories

Table 19: NRSC test cycles for engine category NRE.				
Category	Speed Operation	Purpose	Sub-category	Test cycle NRSC
NRE	Variable	Variable speed engine having a reference power less than 19 kW	NRE-v-1	G2 or C1
			NRE-v-2	
		Variable speed engine having a reference power greater than or equal to 19 kW but not more than 560 kW	NRE-v-3	C1
			NRE-v-4	
			NRE-v-5	
			NRE-v-6	
		Variable speed engine having a reference power greater than 560 kW	NRE-v-7	C1
	Constant	Constant speed engine	NRE-c-1	D2
			NRE-c-2	
			NRE-c-3	
			NRE-c-4	
			NRE-c-5	
			NRE-c-6	
			NRE-c-7	

Table 20: NRSC test cycles for engine category NRG.

Category	Speed Operation	Purpose	Sub-category	Test cycle NRSC
NRG	Variable	Variable speed engine for generating set	NRG-v-1	C1
	Constant	Constant speed engine for generating set	NRG-c-1	D2

Table 21: NRSC test cycles for engine category NRSh.

Category	Speed Operation	Purpose	Sub-category	Test cycle NRSC
NRSh	Variable or Constant	Engine having a reference power of not more than 19 kW, for use in handheld machinery	NRSh-v-1a	G3
			NRSh-v-1b	

Table 22: NRSC test cycles for engine category NRS.

Category	Speed Operation	Purpose	Sub-category	Test cycle NRSC
NRS	variable, <3600 rpm	Variable speed engine having a reference power of not more than 19 kW, intended for operation <3,600 rpm	NRS-vi-1a	G1
			NRS-vi-1b	
	variable, ≥ 3600 rpm; or constant	Variable speed engine having a reference power of not more than 19 kW, intended for operation $\geq 3,600$ rpm; constant speed engine having a reference power of not more than 19 kW	NRS-vr-1a	G2
			NRS-vr-1b	
	variable or constant	Engine having both a reference power between 19 kW and 30 kW and a total swept volume of less than 1,000 cm ³	NRS-v-2a	G2
		Engine having a reference power of greater than 19 kW, other than engine having both a reference power between 19 kW and 30 kW and a total swept volume of less than 1,000 cm ³	NRS-v-2b NRS-v-3	C2

Table 23: NRSC test cycles for engine category SMB.

Category	Speed Operation	Purpose	Sub-category	Test cycle NRSC
SMB	Variable or Constant	Engines for propulsion of snowmobiles	SMB-v-1	H

Table 24: NRSC test cycles for engine category ATS.

Category	Speed Operation	Purpose	Sub-category	Test cycle NRSC
ATS	Variable or Constant	Engines for propulsion of ATV or SbS	ATS-v-1	G1

Table 25: NRTC test cycles for engine category NRE.

Category	Speed Operation	Purpose	Sub-category	Test cycle
NRE	Variable	Variable speed engine having reference power greater than or equal to 19 kW but not more than 560 kW	NRE-v-3	NRTC
			NRE-v-4	
			NRE-v-5	
			NRE-v-6	

Table 26: LSI–NRTC test cycles for engine category NRS.				
Category	Speed Operation	Purpose	Sub–category	Test cycle
NRS	Variable or Constant	Engine having a reference power of greater than 19 kW, other than engine having both a reference power between 19 kW and 30 kW and a total swept volume of less than 1,000 cm3	NRS–v–2b	LSI–NRTC
			NRS–v–3	
*Only applicable for engines with maximum test speed ≤ 3400rpm.				

8. References

- (UNECE Regulation No. 96 – 05 series of amendments): Uniform provisions concerning the approval of engines to be installed in agricultural and forestry tractors and in nonroad mobile machinery with regard to the emissions of pollutants by the engine ‘’ Proposal for the 05 series of amendments to UN Regulation No. 96 (Diesel emission (agricultural tractors))’’.