Transmitted by the expert from
the European Commission

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agenda item 2(a))

Proposal for amendments to Regulation No. 49
with regard to the Off-Cycle Emission provisions (OCE)

This proposal has been prepared by the experts from the European Commission in order to transpose Off-Cycle Emission (OCE) requirements of the draft global technical regulation into UNECE Regulation No. 49.

A. PROPOSAL FOR A NEW ANNEX 10 TO ECE REGULATION No. 49

Content – Annexes, amend to read:

"CONTENTS

REGULATION Page

……

ANNEXES

……

Annex 10 - Technical requirements on Off-cycle Emissions (OCE)……."

Insert a new Annex 10, to read:

"Annex 10

TECHNICAL REQUIREMENTS ON OFF CYCLE EMISSIONS (OCE)

1. APPLICABILITY

This annex establishes performance-based off-cycle emission requirements and a prohibition on defeat strategies for heavy-duty engines and vehicles so as to achieve effective control of emissions under a broad range of engine and ambient operating conditions encountered during normal in-use vehicle operation.

2. Reserved 1/.

3. DEFINITIONS

3.1. "Auxiliary Emission Strategy" ("AES") means an emission strategy that becomes active and replaces or modifies a base emission strategy for a specific purpose or purposes and in response to a specific set of ambient and/or operating conditions and only remains operational as long as those conditions exist.

3.2. "Base Emission Strategy" ("BES") means an emission strategy that is active throughout the speed and load operating range of the engine unless an AES is activated.

3.3. "Defeat strategy" means an emission strategy that does not meet the performance requirements for a base and/or auxiliary emission strategy as specified in this annex.

3.4. "Element of design" means:
(a) the engine system,
(b) any control system, including: computer software; electronic control systems; and computer logic,
(c) any control system calibration, or
(d) the results of any interaction of systems.

3.5. "Emission strategy" means an element or set of elements of design that is incorporated into the overall design of an engine system or vehicle and used in controlling emissions.

3.6. "Emission control system" means the elements of design and emission strategies developed or calibrated for the purpose of controlling emissions.

3.7. "Engine family" means a manufacturer's grouping of engines as defined in gtr No. 4 1/.

3.8. "Engine starting" means the process from the initiation of engine cranking until the engine reaches a speed 150 min^{-1} below the normal, warmed up idle speed (as determined in the drive position for vehicles equipped with an automatic transmission).

3.9. "Engine system" means the engine, the emission control system and the communication interface (hardware and messages) between the engine electronic control unit(s) and any other powertrain or vehicle control unit.

3.10. "Engine warm-up" means sufficient vehicle operation such that the coolant temperature reaches a minimum temperature of at least 70 °C.

3.11. "Periodic regeneration" means the regeneration process of an exhaust aftertreatment system that occurs periodically in typically less than 100 hours of normal engine operation.

3.12. "Rated speed" means the maximum full load speed allowed by the governor as specified by the manufacturer in his sales and service literature, or, if such a governor is not present, the speed at which the maximum power is obtained from the engine, as specified by the manufacturer in his sales and service literature

3.13. "Regulated emissions" means "gaseous pollutants" defined as carbon monoxide, hydrocarbons and/or non-methane hydrocarbons (assuming a ratio of $CH_{1.85}$ for diesel, $CH_{2.525}$ for LPG and $CH_{2.93}$ for NG, and an assumed molecule $CH_3O_{0.5}$ for ethanol fuelled diesel engines), methane (assuming a ration of CH_4 for NG) and oxides of nitrogen (expressed in nitrogen dioxide (NO_2) equivalent) and "particulate matter" (PM) defined as any material collected on a specified filter medium after diluting exhaust with clean filtered air to a temperature between 315 K (42 °C) and 325 K (52 °C), as measured at a point immediately upstream of the filter, this is primarily carbon, condensed hydrocarbons, and sulphates with associated water.

1/ Test Procedures for Compression-Ignition (C.I.) Engines and Positive-Ignition (P.I.) Engines Fuelled with Natural Gas (NG) or Liquefied Petroleum Gas (LPG) with regard to the Emission of Pollutants (established in the Global Registry on 15 November 2006). References to gtr No. 4 relate to the document established on 15 November 2006. Later changes to the WHDC gtr will have to be revaluated as to their applicability to this annex.

4. GENERAL REQUIREMENTS

Any engine system and any element of design liable to affect the emission of regulated pollutants shall be designed, constructed, assembled and installed so as to enable the engine and vehicle to comply with the provisions of this annex.

4.1. Prohibition of defeat strategies

Engine systems and vehicles shall not be equipped with a defeat strategy.

4.2. World-harmonized Not-To-Exceed emission requirement

This annex requires that engine systems and vehicles comply with the WNTE emission limit values described in paragraph 5.2. For laboratory based testing according to paragraph 7.4., no test result shall exceed the emissions limits specified in paragraph 5.2.

5. PERFORMANCE REQUIREMENTS

5.1. Emission strategies

Emission strategies shall be designed so as to enable the engine system, in normal use, to comply with the provisions of this annex. Normal use is not restricted to the conditions of use as specified in paragraph 6.

5.1.1. Requirements for Base Emission Strategies (BES)

A BES shall not discriminate between operation on an applicable type approval or certification test and other operation and provide a lesser level of emission control under conditions not substantially included in the applicable type approval or certification tests.

5.1.2. Requirements for Auxiliary Emission Strategies (AES)

An AES shall not reduce the effectiveness of the emission control relative to a BES under conditions that may reasonably be expected to be encountered in normal vehicle operation and use, unless the AES satisfies one the following specific exceptions:

(a) its operation is substantially included in the applicable type approval or certification tests, including the WNTE provisions of paragraph 7.,

(b) it is activated for the purposes of protecting the engine and/or vehicle from damage or accident,

(c) it is only activated during engine starting or warm up as defined in this annex,

(d) its operation is used to trade-off the control of one type of regulated emissions in order to maintain control of another type of regulated emissions under specific ambient or operating conditions not substantially included in the type approval or certification tests. The overall affect of such an AES shall be to compensate for the effects of extreme ambient conditions in a manner that provides acceptable control of all regulated emissions.

5.2. World-harmonized Not-To-Exceed limits for gaseous and particulate exhaust emissions

5.2.1. Exhaust emissions shall not exceed the applicable WNTE emission limits specified in paragraph 5.2.2. when the engine is operated in accordance with the conditions and procedures set out in paragraphs 6. and 7.

5.2.2. The applicable WNTE emission limits are determined, as follows:

WNTE Emission Limit = WHTC Emission Limit + WNTE Component

where:

"WHTC Emission Limit" is the emission limit (EL) to which the engine is certified pursuant to the WHDC gtr; and

"WNTE Component" is determined by equations 1 to 4 in paragraph 5.2.3.

5.2.3. The applicable WNTE components shall be determined using the following equations, when the ELs are expressed in g/kWh:

for NOx:	WNTE Component = 0.25 x EL + 0.1	(1)
for HC:	WNTE Component = 0.15 x EL + 0.07	(2)
for CO:	WNTE Component = 0.20 x EL + 0.2	(3)
for PM:	WNTE Component = 0.25 x EL + 0.003	(4)

Where the applicable ELs are expressed in units other than units of g/kWh, the additive constants in the equations shall be converted from g/kWh to the appropriate units.

The WNTE component shall be rounded to the number of places to the right of the decimal point indicated by the applicable EL in accordance with the rounding method of ASTM E 29-06.

6. APPLICABLE AMBIENT AND OPERATING CONDITIONS

The WNTE emission limits shall apply at:

(a) all atmospheric pressures greater than or equal to 82.5 kPa,

(b) all temperatures less than or equal to the temperature determined by equation 5 at the specified atmospheric pressure:

$$T = -0.4514 \times (101.3 - p_b) + 311 \quad (5)$$

where:

T is the ambient air temperature, K

p_b is the atmospheric pressure, kPa

(c) all engine coolant temperatures within the range of 343 K to 373 K (70 °C to 100 °C)

The applicable ambient atmospheric pressure and temperature conditions are shown in figure 1.

WNTE Atmospheric Pressure and Temperature Range

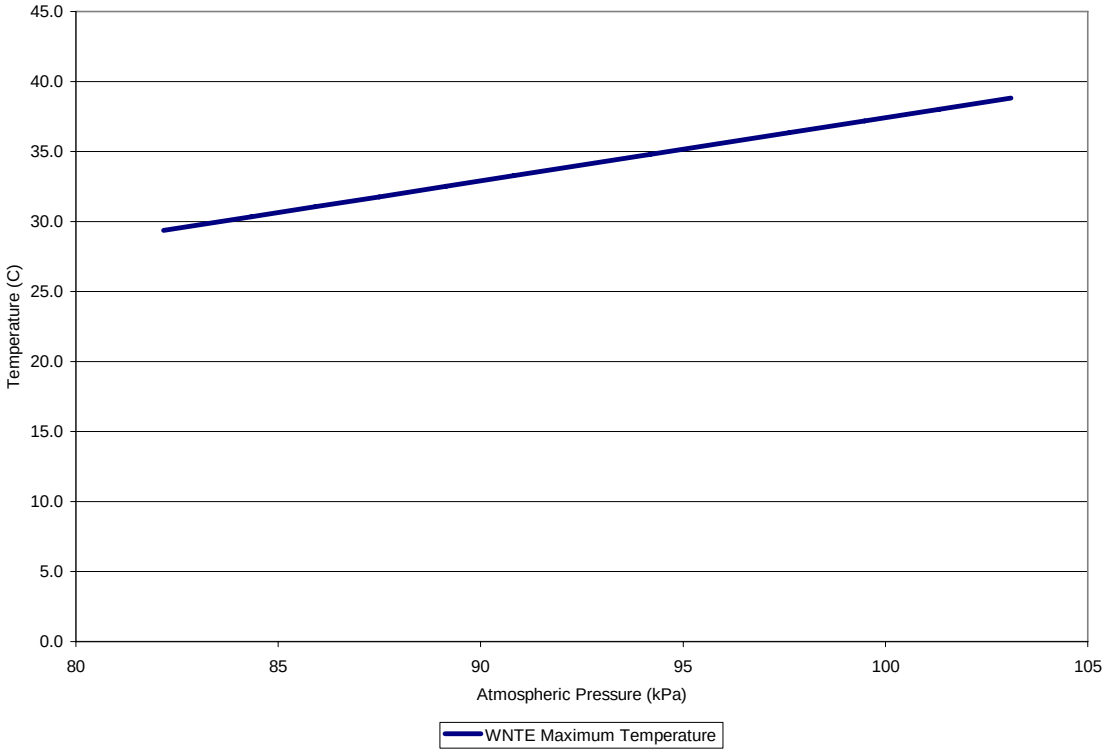


Figure 1: Illustration of atmospheric pressure and temperature conditions

7. WORLD-HARMONIZED NOT-TO-EXCEED METHODOLOGY

7.1. World-harmonized Not-To-Exceed control area

The WNTE control area consists of the engine speed and load points defined in paragraphs 7.1.1. through 7.1.6. Figure 2 is an example illustration of the WNTE control area.

7.1.1. Engine speed range

The WNTE control area shall include all operating speeds between the 30^{th} percentile cumulative speed distribution over the WHTC test cycle, including idle, (n_{30}) and the highest speed where 70 per cent of the maximum power occurs (n_{hi}). Figure 3 is an example of the WNTE cumulative speed frequency distribution for a specific engine.

7.1.2. Engine torque range

The WNTE control area shall include all engine load points with a torque value greater than or equal to 30 per cent of the maximum torque value produced by the engine.

7.1.3. Engine power range

Notwithstanding the provisions of paragraphs 7.1.1. and 7.1.2., speed and load points below 30 per cent of the maximum power value produced by the engine shall be excluded from the WNTE Control Area for all emissions.

7.1.4. Application of engine family concept

In principal, any engine within a family with a unique torque/power curve will have its individual WNTE control area. For in-use testing, the individual WNTE control area of the respective engine shall apply. For type approval (certification) testing under the engine family concept of the WHDC gtr the manufacturer may optionally apply a single WNTE control area for the engine family under the following provisions:

(a) A single engine speed range of the WNTE control area may be used; if the measured engine speeds n_{30} and n_{hi} are within ± 3 per cent of the engine speeds as declared by the manufacturer. If the tolerance is exceeded for any of the engine speeds, the measured engine speeds shall be used for determining the WNTE control area.

(b) A single engine torque/power range of the WNTE control area may be used, if it covers the full range from the highest to the lowest rating of the family. Alternatively, grouping of engine ratings into different WNTE control areas is permitted.

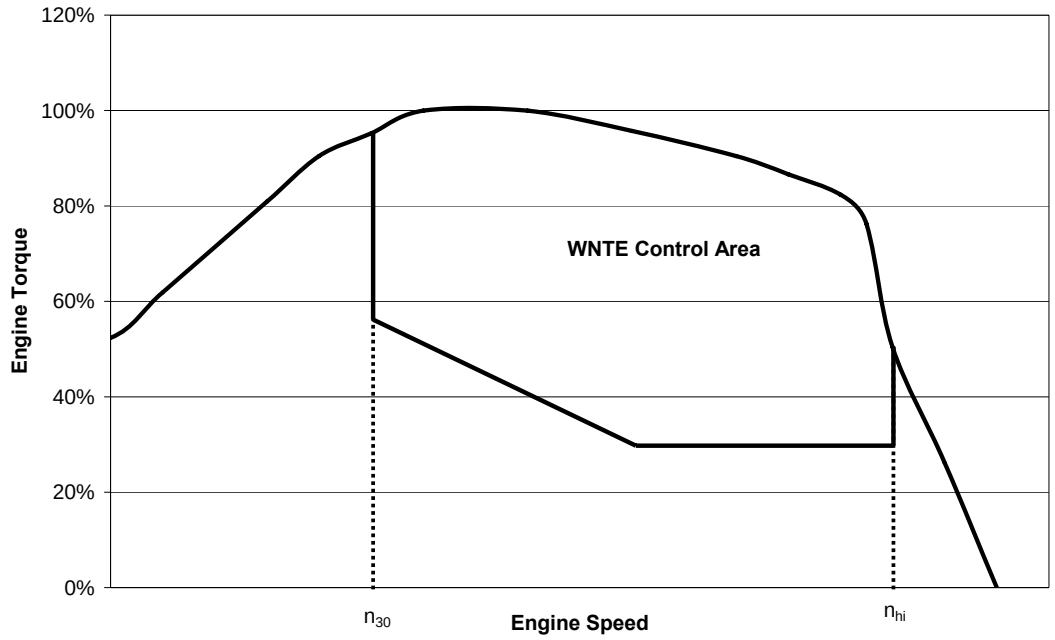


Figure 2: Example WNTE control area

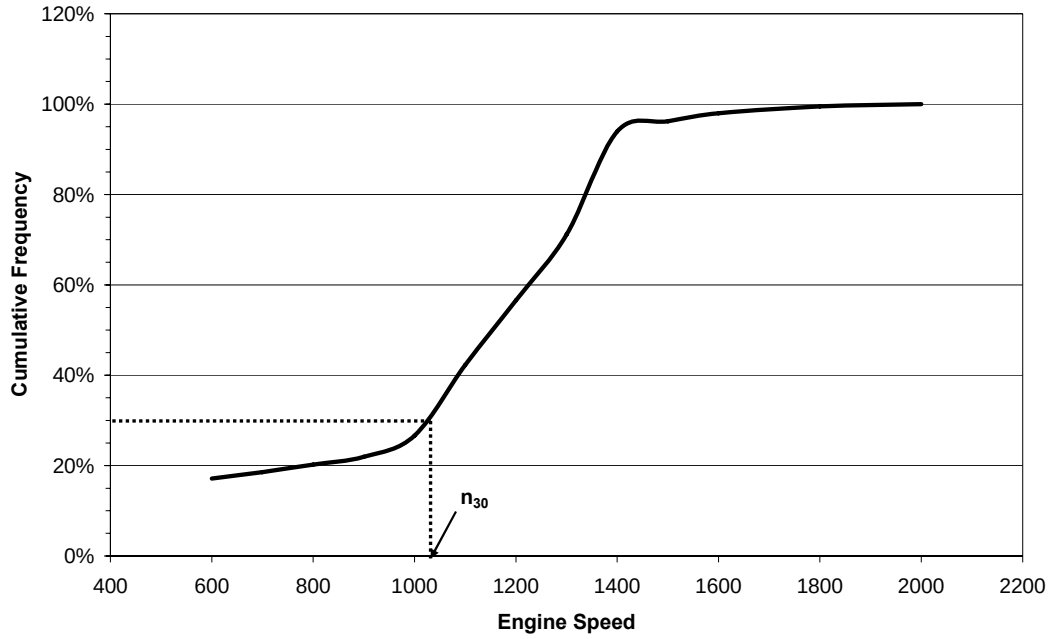


Figure 3: Example of WNTE cumulative speed frequency distribution

7.1.5. Compliance exclusion from certain WNTE operating points

The manufacturer may request that the approval authority excludes operating points from the WNTE control area defined in paragraph 7.1.1 through 7.1.4 during the certification/type approval. The approval authority may grant this exclusion if the manufacturer can demonstrate that the engine is never capable of operating at such points when used in any vehicle combination.

7.2. Minimum World-harmonized Not-To-Exceed event duration and data sampling frequency

7.2.1. To determine compliance with the WNTE emissions limits specified paragraph 5.2., the engine shall be operated within the WNTE control area defined in paragraph 7.1. and its emissions shall be measured and integrated over a minimum period of 30 seconds. A WNTE event is defined as a single set of integrated emissions over the period of time. For example, if the engine operates for 65 consecutive seconds within the WNTE control area and ambient conditions this would constitute a single WNTE event and the emissions would be averaged over the full 65 second period. In the case of laboratory testing, the integrating period of time of 7.5 shall apply.

7.2.2. For engines equipped with emission controls that include periodic regeneration events, if a regeneration event occurs during the WNTE test, then the averaging period shall be at least as long as the time between the events multiplied by the number of full regeneration events within the sampling period. This requirement only applies for engines that send an electronic signal indicating the start of the regeneration event.

7.2.3. A WNTE event is a sequence of data collected at the frequency of at least 1 Hz during engine operation in the WNTE control area for the minimum event duration or longer. The measured emission data shall be averaged over the duration of each WNTE event.

7.3. World-harmonized Not-To-Exceed in-use testing

Where the provisions of this annex are used as basis for in-use testing, the engine shall be operated under actual in-use conditions. The test results out of the total data set that comply with the provisions of paragraphs 6., 7.1. and 7.2. shall be used for determining compliance with the WNTE emission limits specified in paragraph 5.2. It is understood that emission during some WNTE events may not be expected to comply with the WNTE emission limits. Therefore, statistical methods should be defined and implemented for determining compliance that are consistent with paragraphs 7.2. and 7.3.

7.4. World-harmonized Not-To-Exceed laboratory testing

Where the provisions of this annex are used as the basis for laboratory testing the following provision shall apply:

7.4.1. The specific mass emissions of regulated pollutants shall be determined on the basis of randomly defined test points distributed across the WNTE control area. All the test points shall be contained within 3 randomly selected grid cells imposed over the control area. The grid shall comprise of 9 cells for engines with a rated speed less than 3000 min^{-1} and 12 cells for engines with a rated speed greater than or equal to 3000 min^{-1}. The grids are defined as follows:

(a) The outer boundaries of the grid are aligned to the WNTE control area;

(b) 2 vertical lines spaced at equal distance between engine speeds n30 and ,n_{hi} for 9 cell grids, or 3 vertical lines spaced at equal distance between engine speeds n30 and n_{hi} for 12 cell grids; and

(c) 2 lines spaced at equal distance of engine torque (⅓) at each vertical line within the WNTE control area.

Examples of the grids applied to specific engines are shown in Figures 5 and 6.

7.4.2. The 3 selected grid cells shall each include 5 random test points, so a total of 15 random points shall be tested within the WNTE control area. Each cell shall be tested sequentially; therefore all 5 points in one grid cell are tested before transiting to the next grid cell. The test points are combined into a single ramped steady state cycle.

7.4.3. The order in which each of the grid cells are tested, and the order of testing the points within the grid cell, shall be randomly determined. The 3 grid cells to be tested, the 15 test points, the order of testing the grid cells, and the order of the points within a grid cell shall be selected by the Type Approval or Certification Authority using acknowledged statistical methods of randomization.

7.4.4. The average specific mass emissions of regulated gaseous pollutants shall not exceed the WNTE limit values specified in paragraph 5.2. when measured over any of the cycles in a grid cell with 5 test points.

7.4.5. The average specific mass emissions of regulated particulate pollutants shall not exceed the WNTE limit values specified in paragraph 5.2. when measured over the whole 15 test point cycle.

7.5. Laboratory test procedure

7.5.1. After completion of the WHSC cycle, the engine shall be preconditioned at mode 9 of the WHSC for a period of three minutes. The test sequence shall start immediately after completion of the preconditioning phase.

7.5.2. The engine shall be operated for 2 minutes at each random test point. This time includes the preceding ramp from the previous steady state point. The transitions between the test points shall be linear for engine speed and load and shall last 20 ± 1 seconds.

7.5.3. The total test time from start until finish shall be 30 minutes. The test of each set of 5 selected random points in a grid cell shall be 10 minutes, measured from the start of the entry ramp to the 1st point until the end of the steady state measurement at the 5th point. Figure 5 illustrates the sequence of the test procedure.

7.5.4. The WNTE laboratory test shall meet the validation statistics of paragraph 7.7.2. of the WHDC gtr.

7.5.5. The measurement of the emissions shall be carried out in accordance with paragraph 7.8. of WHDC gtr.

7.5.6. The calculation of the test results shall be carried out in accordance with paragraph 8. of WHDC gtr.

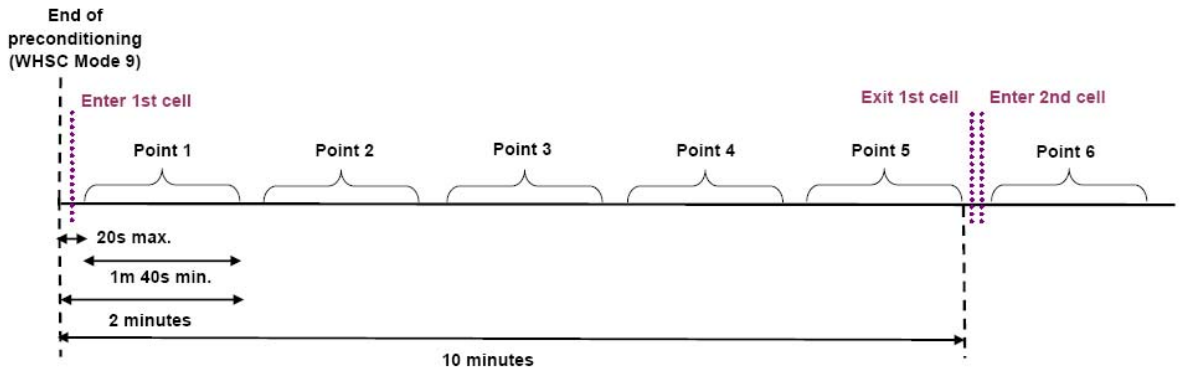
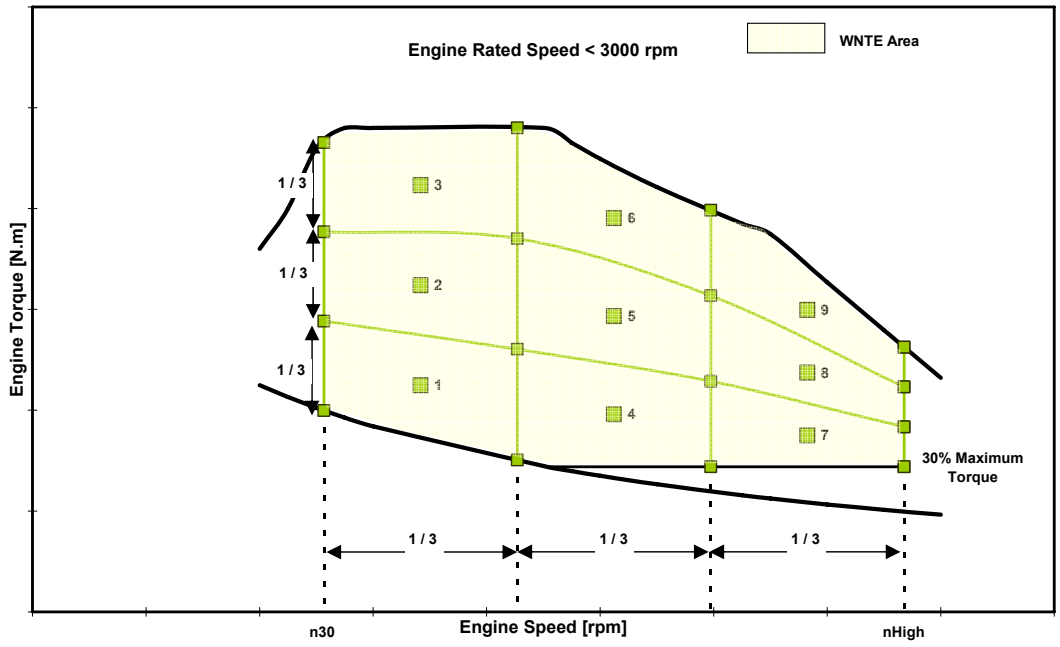
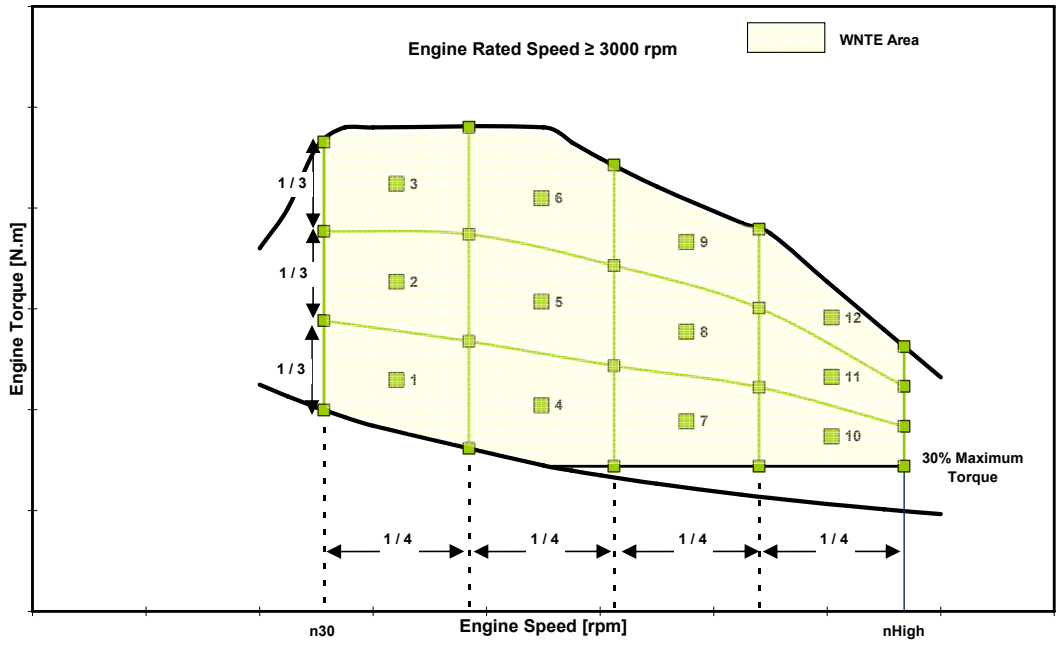


Figure 4: Schematic example of the start of the WNTE test cycle





Figures 5 and 6: WNTE test cycle grids

7.6. Rounding

Each final test result shall be rounded in one step to the number of places to the right of the decimal point indicated by the applicable WHDC emission standard plus one additional significant figure, in accordance with ASTM E 29-06. No rounding of intermediate values leading to the final brake specific emission result is permitted.

8. WORLD-HARMONIZED NOT-TO-EXCEED DEFICIENCIES

The concept of a deficiency is to allow an engine or vehicle to be certified as compliant with a regulation even though specific requirements, limited in scope, are not fully met. A WNTE deficiency provision would allow a manufacturer to apply for relief from the WNTE emission requirements under limited conditions, such as extreme ambient temperatures and/or severe operation where vehicles do not accumulate significant mileage.

9. WORLD-HARMONIZED NOT-TO-EXCEED EXEMPTIONS

The concept of a WNTE exemption is a set of technical conditions under which the WNTE emission limits set out in this annex would not apply. A WNTE exemption shall apply to all engine and vehicle manufacturers.

It may be decided to provide a WNTE exemption, in particular with the introduction of more stringent emission limits. For example a WNTE exemption may be necessary if the Approval Authority determines that certain engine or vehicle operation within the WNTE control area cannot achieve the WNTE emission limits. In such a case, the Approval Authority may determine that it is not necessary for engine manufacturers to request a WNTE deficiency for such operation, and that the granting of a WNTE exemption is appropriate. The Approval Authority can determine both the scope of the exemption with respect to the WNTE requirements, as well as the period of time for which the exemption is applicable.

10. STATEMENT OF OFF-CYCLE EMISSION COMPLIANCE

In the application for certification or type approval the manufacturer shall provide a statement that the engine family or vehicle complies with the requirements of this OCE gtr. In addition to this statement, compliance with the WNTE limits shall be verified through additional tests and certification procedures defined by the Contracting Parties.

10.1. Example statement of Off-Cycle Emission compliance

The following is an example compliance statement:

> "(Name of manufacturer) attests that the engines within this engine family comply with all requirements of this annex. (Name of manufacturer) makes this statement in good faith, after having performed an appropriate engineering evaluation of the emissions performance of the engines within the engine family over the applicable range of operating and ambient conditions."

10.2. Basis for Off-Cycle Emission compliance statement

The manufacturer shall maintain records at the manufacturer's facility which contain all test data, engineering analyses, and other information which provides the basis for the OCE compliance statement. The manufacturer shall provide such information to the Certification or Type Approval Authority upon request.

11. DOCUMENTATION

The Approval Authority may decide to require that the manufacturer provides a documentation package. This should describe any element of design and emission control strategy of the engine system and the means by which it controls its output variables, whether that control is direct or indirect.

The information may include a full description of the emission control strategy. In addition, this could include information on the operation of all AES and BES, including a description of the parameters that are modified by any AES and the boundary conditions under which the AES operate, and indication of which AES and BES are likely to be active under the conditions of the test procedures in this annex."

(Editorial note: Figures 2, 3, 4, 5 and 6 will be updated and provided by OICA)

B. JUSTIFICATION

The European Commission, following the recommendations of the High Level Group on the CARS21 (Competitive Automotive Regulatory System for the 21 century) program, is introducing new harmonized legislative measures by making reference to the technical provisions in the equivalent Regulations in the UNECE framework.

In that context, ECE Regulation No. 49. needs to be updated with the provisions and technical requirements of the draft OCE gtr in order to facilitate reference for new legislation regarding pollutant emissions from heavy duty vehicles (Euro VI stage).

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