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Draft Off-Cycle Emissions GTR April 8, 2005
Note:
Edits from 1st Editorial Committee meeting are in Red
Edits from 2nd Editorial Committee meeting are in Blue
Suggested GTR language is in Green

A. Statement of Technical Rationale and Justification

1. Introduction

The objective of this Global Technical Regulation (GTR) is to establish a harmonized regulation which ensures off-cycle emissions from heavy-duty engines and vehicles are appropriately controlled over a broad range of engine and ambient operating conditions encountered during normal in-use vehicle operation. The GTR is intended to complement emission limits established under the test procedures of the World-Harmonized Heavy-duty Certification (WHDC) GTR.

To that purpose, this Off-cycle Emissions (OCE) GTR includes provisions that prohibit the use of defeat strategies. This OCE GTR also adopts new harmonized emissions limits and test requirements which cover a broad range of engine and ambient operating conditions, the World-Harmonized Not-to-Exceed requirements ("WNTE"). The WNTE requires the control of emissions during engine and ambient operating conditions that are not covered in emissions testing during the two components of the WHDC, the World-Harmonized Transient Cycle and the World-Harmonized Steady-state Cycle.

2. Background on Off-cycle Emissions

The basic regulatory approach historically utilized by a number of countries to reduce exhaust emissions from heavy-duty engines was to use a combination of an emissions certification test cycle with an emissions limit (or standard) and a prohibition against the use of defeat strategies.

The test cycle for heavy-duty engines, while different among various countries, had a number of common characteristics. The test cycle was based on an engine test, performed in a laboratory, under a limited range of ambient conditions, and the test cycle contained a pre-defined set of speed and load point always run in the same order. The prohibition against the use of defeat strategies generally required that the engine could not be designed to operate in-use in a manner which reduced the effectiveness of the engine's emission control system relative to its emission performance over the certification test cycle. Emissions which occur under conditions not well represented by the laboratory-based test cycle are typically called off-cycle emissions.

Heavy-duty vehicles are driven over a wide variety of operating conditions, including starts, stops, accelerations, decelerations, steady cruises, and

under varying ambient conditions (e.g., temperature, humidity and barometric pressure). While the establishment of the WHDC GTR will result in a laboratory-based test cycle which reflects world-wide on-road heavy-duty engine operation, a substantial portion of the wide variety of real world driving conditions are not incorporated in the procedures.

Heavy-duty engines have progressed over the past decade to become a very sophisticated electronic and mechanical system. The system is capable of controlling the performance of heavy-duty engines over a wide variety of driving conditions. A central aspect of this sophisticated engineering is the capability to continuously monitor a wide range of operating parameters, including engine rotational speed, vehicle ground speed, and intake manifold pressure and temperature, and to modify the performance of the engine and its emission control systems in real-time in response to the monitored data.

The defeat strategy provisions do not provide a quantified numerical emissions limit and associated test procedure for conditions not encountered on the regulatory test cycles. This has generally resulted in the need for case-by-case decision making during the certification and type-approval process regarding whether a particular element of design constitutes a defeat strategy. These design-based reviews have become increasingly difficult as the engines and the emission control technologies have grown more complex.

The approach contained in this GTR reduces the reliance on case-by-case design reviews by requiring compliance with the WNTE provisions in addition to meeting emission limits based on a laboratory-based test cycle. The WNTE is intended to allow for a more efficient and objective performance-based means of evaluating off-cycle emissions behavior in addition to the prohibition against defeat strategies. The WNTE provisions accomplish this by substantially increasing the range of engine and ambient operating conditions which are subject to an emission limit.

The GTR does not specify obligations or requirements for in-use testing by manufacturers or certification agencies. Rather, by specifying emission limits under a wide range of engine and ambient operating conditions, the GTR provides a framework to enable in-use testing as a means of verifying that engines are designed and manufactured to comply with emission limits when operated under such conditions.

When considered as a whole, the WHDC GTR and this OCE GTR provide the opportunity for a globally harmonized set of regulations to effectively reduce air pollution from heavy-duty vehicles and engines.

3. Procedural Background and Development of GTR

This GTR was developed by the GRPE informal working group on Off-cycle Emissions (the OCE Informal group). A full report of the work of the OCE Informal group, its deliberations and conclusions is provided in the group's Technical Report, TRANS/WP.29/GRPE/xxxxx.

The work to develop this GTR began in XXX 2001 with the establishment of the OCE Informal group. The OCE Informal group had its first meeting in December 2001.

As required by the 1998 Global Agreement, a formal proposal for the establishment of a GTR was proposed to the Executive Committee for the 1998 Agreement (AC3) by the United States. At its session on 13th March 2005, the proposal from the United States was approved as a GTR project by AC.3 ((TRANS/WP.29/AC.3/13).

> [Include a discussion of any key issues discussed and resolved by the OCE Informal group or by GRPE in the development of the GTR]

One of the key issues discussed during the development of the OCE GTR was the scope of the GTR with respect to in-use, on-vehicle emissions testing. After considerable debate by the OCE working group, it was decided the OCE GTR would not include requirements for in-use testing or specifications for on-vehicle emission measurement equipment. It was decided that at this time, regulations concerning such testing and equipment could be developed by individual countries and regional authorities. However, it was clearly recognized that the OCE GTR was developed with the specific intent to allow for testing of compliance with the WNTE during in-use, on the road operation of the engine. As such, individual countries and regional authorities may specify their own provisions in this regard in order to enforce this GTR, and such enforcement provisions could include requirements for in-use, on-vehicle emissions testing of heavy-duty engines.

4. Technical and Economic Feasibility

> [Draft and insert text at a later date]

5. Anticipated Benefits

This GTR can result in a number of benefits, including: improved emissions control; more efficient certification or type approval methods, and reduced costs for engine and vehicle manufacturers.

The addition of harmonized defeat strategy provisions and WNTE requirements to the certification testing regime (e.g., the WHDC test

cycles) will better ensure that an appropriate control of emissions is achieved in-use, under a wide range of operating conditions. As a result, it can be expected that the application of this GTR by Contracting Parties will result in an improved level of emissions control.

The GTR can reduce the need for time consuming case-by-case design reviews and provide a more efficient and objective performance-based means for evaluating off-cycle emissions.

Finally, heavy-duty engines and vehicles are often produced for the world market. It is economically more efficient for manufacturers to design and produce models which meet emissions objectives specified in a common Global Technical Regulation rather than developing products to meet a wide array of different and potentially conflicting regulatory requirements in individual countries and regions. This in turn is expected to allow manufacturers to develop new models more effectively at a lower cost.

6. Potential Cost Effectiveness

[Develop and insert text at a later date, taking into consideration the language developed for the WMTC GTR]

B. Text of Regulations

1. Scope and Purpose

This regulation establishes performance-based emission requirements and a prohibition on the use of defeat strategies for heavy-duty engines to require effective control of emissions under a broad range of engine and ambient operating conditions.

Editorial Comment: may need to include reference to emission control strategy discussion from OICA based on the future discussion of OICA suggestion by the Plenary Group.

2. Application

This regulation applies to the emission of gaseous and particulate pollutants from compression-ignition engines, natural gas engines and positive-ignition engines fuelled with LPG, generally used for propelling motor vehicles having a design speed exceeding 25 km/h and having a total mass exceeding 3.5 tonnes.

Editorial Comment: Chairperson to contact other GTR Chairs to determine what Application section states in their respective GTRs and to what extent do we want to have commonality amongst GTRs

Editorial Comment: Language reserved for further discussions among chairperson of the other working groups. Recommend

reviewing appropriateness of vehicle classification language from "Special Resolution 1" adopted June 2004 at WP.29.

3. Definitions

Editorial Comment: Will add text at a later date as we discussed in previous OCE meetings. Below are listed the potential definitions we have discussed thus far.

Element of Design
Emission Control Strategy
Basic Emission Control Strategy
Auxiliary Emission Control Strategy
Defeat Strategy

Editorial Comment: US EPA and EMA to have further discussion on the latest versions of their respective definitions to see if consensus can be reached

Beer-Lambert relationship
Engine starting
Engine Family

Editorial Comment: do we need to define this term? WHDC has a definition for Engine Family

Engine rating/configuration
Heavy-duty engine

Editorial Comment: do we need to define this term?

Passive regeneration
Active regeneration
Diesel derived engines

Editorial Comment: do we need to define this term?

Steady-State Engine Operation [referring to smoke requirements]
Transient Engine Operation [referring to smoke requirements]

4. General Requirements

Engines shall be designed, constructed and assembled as to enable the engine and/or vehicle in normal use to comply with the provisions of this Regulation.

Editorial Comment: inconsistency here, does this regulation apply to vehicles or to engines?

4.1 Prohibition of Defeat Strategies

No engine and/or vehicle shall be equipped with a defeat strategy

Editorial Comment: as currently drafted this GTR will not prohibit the use of multiple setting engines provided they meet all of the requirements

4.2 WNTE Requirement.
Emissions must not exceed specified emission limit values when measured over a broad range of engine speed and load points (the WNTE control area) and a broad range of ambient conditions which can reasonably be expected to be encountered in normal vehicle operation and use.

5. Performance Requirements

Editorial Note: The following text from OICA is included so that the Plenary Group can review it for consideration.

5.1 Emission Control Strategy
5.1.1 Any element of design and emission control strategy (ECS) liable to affect the emission of gaseous and particulate pollutants from diesel engines and the emission of gaseous pollutants from gas engines shall be so designed, constructed, assembled and installed as to enable the engine, in normal use, to comply with the provisions of this GTR. ECS consists of the base emission control strategy (BECS) and usually one or more auxiliary emission control strategies (AECS).

5.1.2. Requirements for base emission control strategy

5.1.2.1. The base emission control strategy (BECS) shall be so designed as to enable the engine, in normal use, to comply with the provisions of this GTR. Normal use is not restricted to the conditions of use as specified in section 5.1.3.4.

5.1.3. Requirements for auxiliary emission control strategy

5.1.3.1. An auxiliary emission control strategy (AECS) may be installed to an engine or on a vehicle provided that the AECS:

– operates only outside the conditions of use specified in section 5.1.3.4 for the purposes defined in paragraph 5.1.3.5 or,

– is activated only temporarily within the conditions of use specified in section 5.1.3.4 for the purposes defined in section 5.1.3.5 and not longer than is needed for these purposes.

5.1.3.2. An auxiliary emission control strategy (AECS) that operates within the conditions of use specified in section 5.1.3.4 and which results in the use of a different or modified emission control strategy (ECS) to that normally employed during the applicable emission test cycles will be permitted if, in complying with the requirements of section 5.1.4, it is fully demonstrated that the measure does not permanently reduce the effectiveness of the emission control system. In all other cases, such strategy shall be considered to be a defeat strategy.

5.1.3.3. An auxiliary emission control strategy (AECS) that operates outside the conditions of use specified in section 5.1.3.4 will be permitted if the manufacturer fully demonstrates that the measure is the minimum strategy necessary for the purposes of section 5.1.3.5 with respect to environmental protection and other technical aspects. In all other cases, such a strategy shall be considered to be a defeat strategy.

5.1.3.4. As provided for in section 5.1.3.1, the following conditions of use apply under steady state and transient engine operations:

– an altitude not exceeding 1 600 meters (or equivalent atmospheric pressure of 83.5 kPa), and,

– an ambient temperature within the range 275 K to 308 K (2°C to 35°C) and,

– engine coolant temperature within the range 343 K to 373 K (70°C to 100°C).

5.1.3.5. An auxiliary emission control strategy (AECS) may be installed to an engine, or on a vehicle, provided that:

- the operation of the AECS is substantially included in the applicable test cycle, or,
- the AECS is activated only by on-board signals for the purpose of protecting the engine system (including air-handling device protection) and/or vehicle from damage, or
- the AECS is activated for purposes such as operational safety, permanent emission default modes and limp-home strategies, or
- the AECS is activated for such purposes as excessive emissions prevention, cold start or warming-up, or
- the AECS is used to trade-off the control of one regulated pollutant under specific ambient or operating conditions in order to maintain control of all other regulated pollutants within the emission limit values that are appropriate for the engine in question. The overall effects of such an AECS is to compensate for naturally occurring phenomena and do so in a manner that provides acceptable control of all emission constituents.

5.1.4. Documentation requirements

Editorial Comment: If we include this type of requirement, the Editorial Committee suggests that it be drafted in a manner to indicate they are suggested documentary requirements and not

mandatory documentary documents. If we accept this approach suggest moving this section to section 11 of the GTR.

The manufacturer shall provide a documentation package that gives access to any element of design and emission control strategy (ECS) of the engine system and the means by which it controls its output variables, whether that control is direct or indirect. The documentation shall be made available in two parts:

(a) the formal documentation package, which shall be supplied to the technical service at the time of submission of the type-approval application, shall include a full description of the ECS. This documentation may be brief, provided that it exhibits evidence that all outputs permitted by a matrix obtained from the range of control of the individual unit inputs have been identified. This information shall be attached to the documentation required in [CERTIFICATION SECTION];

(b) additional material that shows the parameters that are modified by any auxiliary emission control strategy (AECS) and the boundary conditions under which the AECS operates. The additional material shall include a description of the fuel system control logic, timing strategies and switch points during all modes of operation. The additional material shall also contain a justification for the use of any AECS and include additional material and test data to demonstrate the effect on exhaust emissions of any AECS installed to the engine or on the vehicle. The justification for the use of an AECS may be based on test data and/or sound engineering analysis.

This additional material shall remain strictly confidential, and be made available to the type-approval authority on request. The type-approval authority will keep this material confidential.

5.2 WNTE Limits for Gaseous and Particulate Exhaust Emissions

5.2.1 Exhaust emissions of NOx, (NM)HC, CO and PM from an engine shall not exceed the applicable WNTE emission limits when the engine is operated under the conditions specified in section 6.0 and emissions are determined in accordance with the procedures specified in section 7.0.

5.2.2 For the purposes of section 5.2.1, the applicable WNTE emission limits for an engine shall be determined using the following formula

WNTE Emission Limit = WHDC Emission Limit x WNTE Factor

where

"WHDC Emission Limit" is the emission limit to which the engine is certified pursuant to the WHDC test procedures; and

"WNTE Factor" is determined by reference to Table 1 and is based on the engine's WHDC Emission Limit

Table 1: WNTE Factors for Gaseous and Particulate Emissions

Pollutant	WHDC Emission Limit*	WNTE Factor*
NOx	= 2.0 g/kWh	1.5
	> 2.0 g/kWh	1.25
(NM)HC	= 0.6 g/kWh	1.5
	> 0.6 g/kWh	1.25
CO	= 1.0 g/kWh	1.5
	> 1.0 g/kWh	1.25
PM	= 0.05 g/kWh	1.5
	> 0.05 g/kWh	1.25

***Editorial Comment: these emission limit and WNTE Factor numbers are suggestions by OICA, Plenary Group must decide what the actual numbers will be in the final GTR as well as the pollutants to be covered i.e. HC, NMHC, CH4**

5.3 WNTE Smoke emissions requirements

Editorial Comment: need to discuss at the plenary level whether smoke emission requirements apply to all engines covered by GTR or only to those with a PM emission limit greater than "X"

Operation within the WNTE control area (defined in Section 7.1) must comply with either of the alterative limits in section 5.3.1 or 5.3.2. The manufacturer selects which option and must declare at the time of certification or type approval which option has been selected.

Editorial Comment:
Caution raised over possibility of increased NO2 levels from oxidizing after treatment devices being detected by smoke opacity meters. NO2 should not be considered smoke as smoke is only carbon based.

5.3.1 A filter smoke number of 1.0 under steady-state operation, or the following alternate opacity limits:

5.3.2 A 30 second transient test average opacity limit of 4% for a 5 inch path; and a 10 second steady state test average opacity limit of 4% for a 5 inch path.

Editorial Note: Plenary group to consider language below from OICA; group to consider if this is appropriate means of smoke measurement

5.3.1 A filter smoke number (FSN) of 1.0 under steady-state operation, or the following alternate light absorption coefficient limits:

5.3.2 A 30 second transient test average light absorption coefficient limit of 0.35 m^{-1}; and a 10 second steady state test average light absorption coefficient limit of 0.35 m^{-1}.

5.3.3 The standards set forth in Section 5.3.1 and 5.3.2 of this section refer to exhaust smoke emissions generated under the conditions specified in Section 7.1 and 7.3 and calculated in accordance with the procedures set forth in Section 7.4.

6. Applicable Ambient Conditions

Editorial Comment: pending discussion of OICA proposed section 5.1 Emission Control Strategy, we should consider whether we should have a single ambient operating region section that applies to the WNTE and the Emission Control Strategy

The WNTE emission limits apply over one of the two alternative ambient operating regions specified in Section 6.1 or Section 6.2. The manufacturer shall select which ambient operating region and shall declare the selected option at the time of certification or type-approval of an engine.

6.1 Option (A) The WNTE emission limits apply at all altitudes less than or equal to 5,500 feet above sea-level and at all ambient temperature and humidity conditions. Temperature and humidity ranges for which correction factors are allowed are specified in Section 7.3; or

Editorial Comment: Editorial Committee has identified the altitude cut point as an issue to be further discussed by the Plenary group.

6.2 Option (B) The WNTE emission limits apply at all altitudes less than or equal to 5,500 feet above sea-level, for temperatures less than or equal to the temperature determined by the following equation at the specified altitude:

$$T = -0.00254 \times A + 100$$

Where:

T = ambient air temperature in degrees Fahrenheit.
A = altitude in feet above sea-level (A is negative for altitudes below sea-level).

Editorial Comment:
Issues/Concerns/Follow-up:
1)Desire not to design for altitudes above 1000 meters for countries where less than 2% VMT (Vehicle Miles Traveled) is spent at such altitude (argument is that high altitude requirements drive engine design, both hardware and software, which ultimately applies to low altitude operation as well). Not clear that is the case.
2) Altitude requirements drive design requirements in terms of cooling capacity, cab dimensions.
3)Special consideration has to be given to countries at altitudes greater than 1680 meters.
4) Plenary group to provide suggestion whether to split out altitude ranges and how to address cost benefit discussion.
5) Need to understand specific design issues and the potential for an altitude engine control strategy to resolve the stated concerns.
6) Need to consider the lost benefit of harmonization.
7) Need to consider aftermarket sales/cross border migration
8) Altitude tiers that could be considered: 1000 meters and below, 1000 to <1680 meters and greater than 1680 meters.

7. WNTE Test Procedures

7.1 WNTE control area for diesel heavy-duty engines.

The WNTE Control Area for heavy-duty engines consists of the engine speed and load points defined in Sections 7.1.1 through 7.1.6. Figure 1 is an example illustration of the WNTE control area.

7.1.1 Engine speed range. The WNTE control area shall include all operating speeds greater than the speed calculated using the following formula:

$$n_{lo} + 0.15 \times (n_{hi} - n_{lo})$$

where n_{hi} and n_{lo} are determined according to the provisions in *[EPA Sec. 86.1360(c)/reference to participating country's Euro Steady-State test regulation cite Preference is to refer to WHDC GTR]*.

7.1.2 Engine load range. The WNTE control area shall include all engine load points greater than or equal to 30% or more of the maximum torque value produced by the engine.

7.1.3 Engine power range. Notwithstanding the provisions of Sections 7.1.1 and 7.1.2, speed and load points below 30% of the maximum power value produced by the engine shall be excluded from the WNTE control area for all emissions.

7.1.4 Additional WNTE Area Requirements for Vehicles Using CVT. All operating speed and load points with brake specific fuel consumption (BSFC) values within 5% of the minimum BSFC value of the engine are included in the WNTE control area when the engine is used in a vehicle with a continuously variable transmission. BFSC must be calculated under the general test cell conditions specified in **[Editorial comment: include language to describe applicable test. May have excluded vehicles we should not have excluded i.e. hybrids]**

Editorial Comment: Will insert WNTE control area speed and load diagram for engines with PM below "x g/kW-hr" in this location

7.1.5 Particulate matter engine speed and load carve-out. For engines certified to a PM standard greater than 0.07 g/kW-hr **[Editorial Comment: OICA has suggested 0.05g/kW-hr]**, speed and load points determined by using the applicable method described below shall be excluded from the WNTE Control Area for the purposes of compliance with the WNTE PM emission limits.

7.1.5.1 C speed below 2400 rpm (see Figure 1). Exclude engine speed and load points to the right of or below the line formed by connecting the two points defined by 7.1.5.1.1 and 7.1.5.1.2:

7.1.5.1.1 30% of maximum torque or 30% of maximum power, whichever is greater, at the B speed; and
7.1.5.1.2 70% of maximum power at 100% speed (n_{hi})

7.1.5.2 C speed is above 2400 rpm (see Figure 2). Exclude engine speed and load points to the right of the line formed by connecting following the two points in Section 7.1.5.2.1 and 7.1.5.2.2 and below the line formed by connecting the two points in Section **7.1.5.2.2** and **7.1.5.2.3**:

7.1.5.2.1 30% of maximum torque or 30% of maximum power, whichever is greater, at the B speed;
7.1.5.2.2 50% of maximum power at 2400 rpm;
7.1.5.2.3 70% of maximum power at 100% speed (n_{hi}).

7.1.5.3 Determining B and C engine speeds. B and C engine speeds shall be determined according to the provisions in *[EPA Sec. 86.1360(c)/reference to participating country's Euro Steady-State test regulation cite Preference is to refer to WHDC GTR]*:

Editorial Comment: The method for determining the B and C speeds should be described herein.

Figure 1. Example Not-To-Exceed Control Area When C Speed < 2,400 rpm

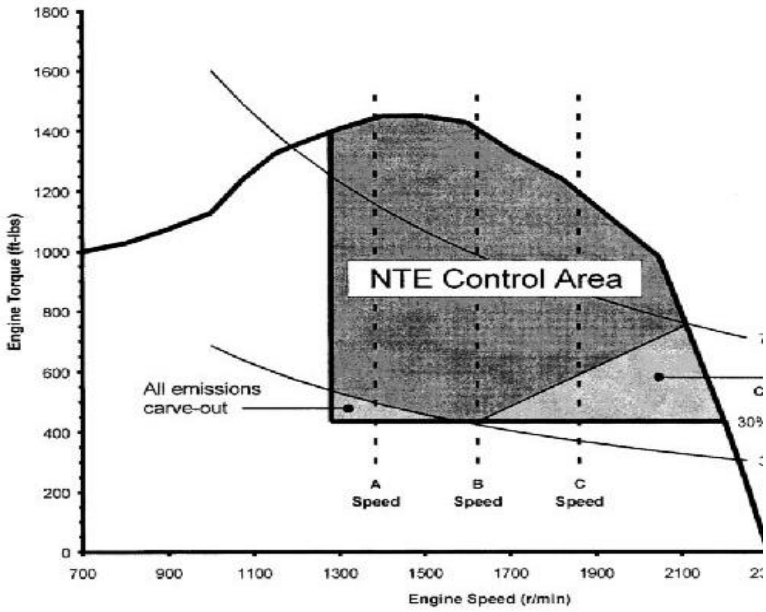
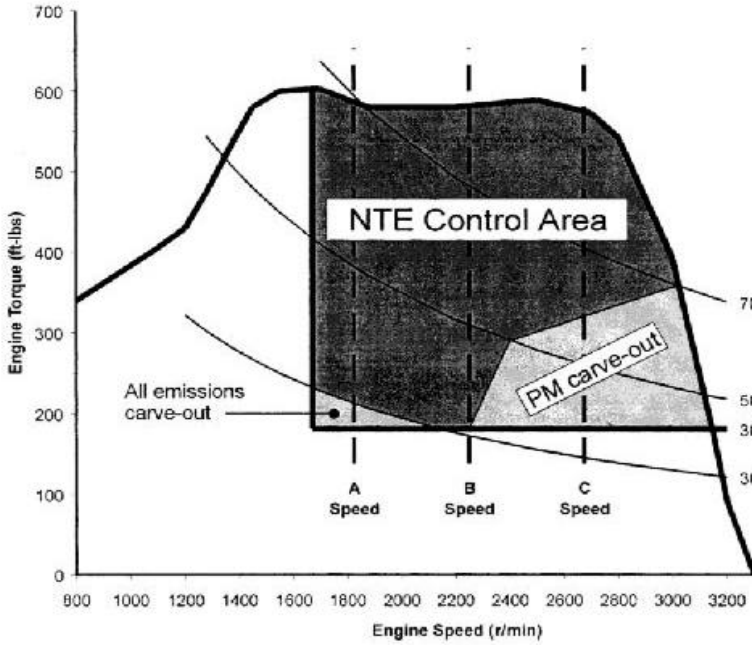


Figure 2. Example Not-To-Exceed Control Area When C Speed > 2,400 rpm



Editorial Comment: Will update diagrams to correspond with final control area established in GTR and will add example figures without PM carve out.

7.1.6 Compliance exclusion from certain WNTE operating points.
At the time of certification or type approval, the manufacturer may request approval of the Certification or Type Approval Authority to exclude operating points from the WNTE control area defined in Section 7.1.1 through 7.1.5 if the manufacturer can demonstrate that the engine is not capable of operating at such points when used in the specific engine-vehicle combination(s) identified by the manufacturer.

Editorial Comment: this provision provides the opportunity to limit the size of the WNTE control area during engine only based testing

7.2 WNTE minimum sampling period.

7.2.1 When determining compliance with the emissions standards specified Section 5.0, an engine shall operate within the WNTE Control Area defined in Section 7.1 and its emissions shall be measured and averaged over any period of time greater than or equal to continuous 30 seconds, except where a longer averaging period is required by Section 7.2.2.

Editorial Comment: Include example. If the engine operates for 35 consecutive seconds within the WNTE conditions this could be construed to be a single WNTE event with one set of average emissions or this could be divided into 5 separate 30 second events each with its own set of average emission values.

7.2.2 Engines equipped with emission controls that include discrete 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. The requirement in this Section only applies for engines that send an electronic signal indicating the start of the regeneration event.

Editorial Comment: EMA to draft additional language to clarify the regeneration requirements.

7.2.3 WNTE Limited Testing Region Provision.

At the time of certification or type approval, manufacturers may request that the Certification or Type Approval Authority approve a limited testing region in a single defined region of speeds and loads within the WNTE control area. If approved, compliance testing would not be allowed with sampling periods in which operation within that region constitutes more than 5.0 percent of the time-weighted operation within the sampling period. The 5.0 percent is calculated on a time-weighted basis, e.g. no more than 2 seconds out of a 40 second-WNTE averaging period could be within the approved limited testing region. Such a defined region must generally be of elliptical or rectangular shape, and must share some portion of its torque/speed boundary with the torque/speed boundary of the WNTE control area. Approval of this limited testing region by the Certification or Type Approval Authority is contingent on the manufacturer satisfactorily demonstrating that operation at the speeds and loads within that region accounts for less than 5.0 percent of all in-use operation (weighted by vehicle-miles-traveled or other weightings approved by the Certification or Type Approval Authority) for the in-use engines of that configuration (or sufficiently similar engines). At a minimum, this demonstration must include operational data from representative in-use vehicles.

Editorial Comment: US EPA AC-24 and Guidance Documents have been circulated to the plenary/editorial groups and if there is language that should be included in the GTR, the suggestion should be made by editorial or plenary group members to include this additional information in the GTR

Editorial Note: the following sections have been drafted by OICA and the plenary group must determine if, how and where they are to be incorporated in text of GTR:

7.X.X For the WNTE mapping, the engine shall be warmed up and then operated at a minimum of 20 steady-state test modes throughout the WNTE control area. A representative set of test modes shall be established by the manufacturer and approved by the type approval authority prior to the start of the test. The engine shall be operated with standard settings of inlet and exhaust restriction and at standard test cell temperature and humidity.

7.X.Y Upon completion of the WNTE map at the above test conditions, the 5 modes having the highest emissions shall be determined individually for each emission component, and those modes shall repeated under a worst case sets of test conditions (e.g. high inlet temperature, high charge air cooler outlet temperature etc.).

7.3 Ambient emissions corrections.
For engine operation within the conditions specified in Sections 6.1 ~~and~~ or 6.2, the measured data shall be corrected based on the ambient conditions under which it was taken, as specified in this section.

7.3.1 For engines operating within the ambient conditions specified in Section 6.1.1:

7.3.1.1 NOx emissions shall be corrected for ambient air humidity to a standard humidity level of 7.14 g/kg if the humidity of the intake air was below 7.14 g/kg, or to 10.71 g/kg if above 10.71 g/kg .
7.3.1.2 NOx and PM emissions shall be corrected for ambient air temperature to a temperature of 12 degrees C for ambient air temperatures below 12 degrees C or to 35 degrees C if the ambient air temperature is above 35 degrees C.
7.3.1.3 No ambient air temperature or humidity correction factors shall be used within the ranges of 12 degrees C – 35 degrees C or 7.14 g/kg – 10.71 g/kg.

7.3.2 For engines operating within the ambient conditions specified in Section 6.1.2:

7.3.2.1 NOx emissions shall be corrected for ambient air humidity to a standard humidity level of 7.14 g/kg if the humidity of the intake air was below 7.14 g/kg, or to 10.71 g/kg if above 10.71g/kg.
7.3.2.2 NOx and PM emissions shall be corrected for ambient air temperature to a temperature of 12 degrees C for ambient air temperatures below 12 degrees C.
7.3.2.3 No ambient air temperature or humidity correction factors shall be used for temperatures greater than or equal to 12 degrees C or within the range of 7.14 g/kg – 10.71 g/kg.

7.3.3 Where test conditions require such correction factors, the manufacturer shall use good engineering judgment to determine the appropriate correction factors, subject to prior approval by the certification authority.

Editorial comment: The following is some suggested language from OICA on correction factors for the plenary group to consider.

7.3.4 If applicable, the following correction factors shall be used:

- NOx: $k_{h,D} = \frac{1}{1 - 0{,}0182 \times (H_a - 10{,}71) + 0{,}0045 \times (T_a - 298)}$
- PM: $K_p = \frac{1}{[1 + 0{,}0133 \times (H_a - 10{,}71)]}$

Other correction factors may be used if they can be justified or validated based on good engineering judgment and generally accepted engineering practice and with the prior approval of the type approval authority.

Editorial Comment: Editorial Committee has decided not to continue work on 7.4 until decisions have been made by the plenary group on the form of the smoke requirement in 5.3 considering recent comments from OICA.

7.4 Measuring smoke emissions within the WNTE control area.
This section contains the measurement techniques to be used for determining compliance with the filter smoke limit or opacity limits in Section 5.3.

7.4.1 For steady-state or transient smoke testing using full-flow opacimeters. 10.7.1.1 Equipment meeting the requirements of *subpart I of this part or ISO/DIS-11614 ``Reciprocating internal combustion compression-ignition engines--Apparatus for measurement of the opacity and for determination of the light absorption coefficient of exhaust gas*" is required. This document is incorporated by reference *(see Sec. 86.1 /reference to participating country's applicable test regulation cite)*.

7.4.1.1 All full-flow opacimeter measurements shall be reported as the equivalent percent opacity for a five inch effective optical path length using the Beer-Lambert relationship.

Editorial Comment: Concern raised that correcting to 5 inch optical path will penalize smaller engines that are typically used with vehicles having smaller tail pipes.

7.4.1.2 Zero and full-scale (100 percent opacity) span shall be adjusted prior to testing.

7.4.1.3 Post test zero and full scale span checks shall be performed. For valid tests, zero and span drift between the pre-test and post-test checks shall be less than two percent of full-scale.

Editorial Comment: Concern raised that 2% of full scale drift is 50% of allowable limit for smoke. Drift limits need to be substantially reduced.

7.4.1.4 Opacimeter calibration and linearity checks shall be performed using manufacturer's recommendations or good engineering practice.

7.4.2 For steady-state testing using a filter-type smoke meter. Equipment meeting the requirements of *ISO/FDIS-10054 ``Internal combustion compression-ignition engines--Measurement apparatus for smoke from engines operating under steady-state conditions--Filter-type smokemeter''* is recommended. Other equipment may be used provided it is approved in advance by the Certification or Type Approval Authority.

7.4.2.1 All filter-type smoke meter results shall be reported as a filter smoke number (FSN) that is similar to the Bosch smoke number (BSN) scale.

7.4.2.2 Filter-type smoke meters shall be calibrated every 90 days using manufacturer's recommended practices or good engineering practice.

7.4.3 For steady-state testing using a partial-flow opacimeter. Equipment meeting the requirements of *ISO-8178-3 and ISO/DIS-11614* is recommended. Other equipment may be used provided it is approved in advance by the Certification or Type Approval Authority.

Editorial Comment: See previous adsorption coefficient comment in section 7.4.1.

7.4.3.1 All partial-flow opacimeter measurements shall be reported as the equivalent percent opacity for a five inch effective optical path length using the Beer-Lambert relationship.

7.4.3.2 Zero and full scale (100 percent opacity) span shall be adjusted prior to testing.

7.4.3.3 Post-test zero and full scale span checks shall be performed. For valid tests, zero and span drift between the pre-test and post-test checks shall be less than two percent of full scale.

7.4.3.4 Opacimeter calibration and linearity checks shall be performed using manufacturer's recommendations or good engineering practice.

7.4.4 Replicate smoke tests. Replicate tests may be run to improve confidence in a single test or stabilization. If replicate tests are run, three additional tests which confirm to this section shall be run, and the final reported test results must be the average of all the valid tests.

7.4.5 A minimum of thirty seconds sampling time shall be used for average transient smoke measurements. The opacity values used for this averaging must be collected at a minimum rate of 1 data point per second, and all data points used in the averaging must be equally spaced in time.

7.5 Calculating WNTE emissions.

Editorial Note: Initial suggestion from OICA to calculate WNTE emissions, taken from WHDC.

WNTE emissions shall be calculated in accordance with the following formula:

Gas_{mass} = (u_{gas} x c_{gas} x q_{mew}) divided by P

$$PT_{mass} = \frac{m_f}{m_{sep}} \times \frac{\overline{q_{medf}}}{1000} \times P$$

Editorial Comment: Refer to an Annex, another GTR, or insert language directly into this GTR. Consider using calculations in EPA 40 CFR 1065.

7.6 Rounding.

WNTE emissions determined under Section 7.0 shall be rounded to the same number of significant figures as the applicable cycle-based standards using the conventions described in Annex "XX".

Editorial Comment: Annex "XX" would incorporate ASTM E29-93a and ISO XXX by reference.

Editorial Comment: Suggested language for consideration from the Motorcycle GTR: ***The reported test results shall be computed for each test and each cycle part by use of the following formulas. The results of all emission tests shall be rounded, using the "Rounding-Off Method" specified in ASTM E 29-67, to the number of places to the right of the decimal point indicated by expressing the applicable standard to three significant figures***.

Editorial Note: Following comments were presented by EMA for further discussion: ***Consistent with the comment in 7.5, there is a need to clarify if rounding is to be done only once the brake specific emissions (or Beer-Lambert corrected smoke opacity or filter smoke number) have been assessed or if rounding is also to be performed at intermediate calculation steps used to arrive at these values.***

9. WNTE deficiencies

9.1 General.

For the first three years after an emission limit is implemented which results in a more stringent WNTE emission limit, such as a more stringent WHDC emission limit, a manufacturer may request from the Certification or Type Approval Authority at the time of certification a WNTE deficiency as described below. A WNTE deficiency allows an engine or vehicle to be certified as compliant with this GTR even though specific requirements, limited in scope, are not fully met. The Certification or Type Approval Authority has the discretion to decide the duration that the WNTE deficiency will be granted during the three year period. The WNTE deficiency provisions 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.

9.2 Evaluation criteria.

Deficiencies will be granted only if compliance is determined to be infeasible or unreasonable considering such factors as, but not limited to: technical feasibility of the given hardware and lead time and production cycles including phase-in or phase-out of engines or vehicle designs and programmed upgrades of computers. A WNTE deficiency may be granted where unreasonable hardware or software modifications would be necessary to correct the deficiency, and the manufacturer has demonstrated an acceptable level of effort toward compliance as determined by the Certification or Type Approval Authority.

Editorial Comment: Will look at WWH-OBD language, as well as the EU 70/220/EEC – ANNEX XI, to see if additional evaluation criteria is available.

Editorial Comment: Explicitly state general criteria such as why the deficiency is needed, why the problem can not be solved without a deficiency, how much above the NTE does the deficiency cause emissions to increase, how frequently the deficiency will activate in terms of vehicle miles traveled and/or % of operation etc.

9.3 Number of deficiencies.
The number of deficiencies allowed cannot be greater than three per engine family.

10. WNTE Carve-Outs and Technology-based WNTE exclusions.

Editorial Comment: At this point in time the Editorial Committee has deferred further revisions to section 10 until plenary group has discussed issue of including these exclusions in the GTR versus a technology neutral approach

10.1 WNTE cold temperature operating exclusion.
Engines equipped with exhaust gas recirculation (EGR) are not subject to any applicable WNTE emission limits when the engine is operated during cold temperature conditions as specified using either of the following two criteria even when the engine is operated within the WNTE control area specified in Section 7.1.

10.1.1 Intake manifold temperature (IMT) less than or equal to the temperature defined by the following relationship between IMT and absolute intake manifold pressure (IMP) for the corresponding IMP:

P=0.0875 x IMT – 7.75
Where:
P = absolute intake manifold pressure in bars.
IMT = intake manifold temperature in degrees Fahrenheit.

10.1.2 Engine coolant temperature (ECT) less than or equal to the temperature defined by the following relationship between ECT and absolute intake manifold pressure (IMP) for the corresponding IMP:

P = 0.0778 x ECT – 9.8889
Where: P = absolute intake manifold pressure in bars.
ECT = engine coolant temperature in degrees Fahrenheit.

10.2 NOx and NMHC Aftertreatment warm-up.
For engines equipped with one or more aftertreatment devices that reduce NOx or NMHC emissions, the applicable WNTE NOx and NMHC emission limits do not apply when the exhaust gas temperature measured within 12 inches of the outlet of the aftertreatment device is less the 250 deg.C. For multi-bed systems, the temperature at the outlet of the device having the maximum flow rate shall be used to determine whether the WNTE limits apply.

Editorial Comment: See comments in Section 10.1.

11. Documentation for Application for Compliance *(or Annex)*

11.1 Statement of WNTE compliance.
The manufacturer shall provide a statement in the application for certification that the diesel heavy-duty engine for which certification is being requested complies with the applicable WNTE emission limits specified in Section 5.0 when operated under all conditions which may reasonably be expected to be encountered in normal vehicle operation and use.

11.1.1 Example statement of compliance.
"These engines comply with the WNTE emission limits specified in Section 5.1 when operated under all conditions which may reasonably be encountered in normal vehicle operation and use."

11.2 Basis for WNTE 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 compliance statement, where such information exists. The manufacturer shall provide such information to the Certification or Type Approval Authority upon request.

Editorial Comment:
Issue raised that type approval authorities will not accept a compliance statement without actual emission data;
Request made to describe the minimum level of laboratory data and engineering judgement required for certification/type approval
For example, test at 30 steady-state data points in a lab. Extrapolated lab results to NTE conditions not included during lab testing with correction factors developed from real-world evaluations.
Refer to relevant sections of Advisory Circular 24-3. Questions 1,2,3,4 focus on what information a manufacturer has to have in possession to support an NTE statement. Perhaps create an annex that include this information to provide guidance to manufacturers.

11.3 Technology exclusion descriptions.
For engines equipped with exhaust gas recirculation, the manufacturer shall provide a detailed description of the control system the engine will use to comply with the requirements of Sections 6.2 and 10.1 for the WNTE cold temperature operating exclusion. The description shall include but is not limited to the method the manufacturer will use to access this exclusion during normal vehicle operation. Specifically, the manufacturer must describe how control system will identify the conditions described in Section 10.6 and limit access to the cold temperature exclusion during normal vehicle operation.

Editorial Comment: Would eliminate this text if eliminate tech exclusions in Section 10.

11.4 NOx and NMHC Aftertreatment warm-up.
For engines equipped with one or more aftertreatment devices that reduce NOx or NMHC emissions, the manufacturer must provide a detailed description of the control system the engine will use to comply with the requirements of Section 10.2 for the WNTE exhaust aftertreatment warm-up exclusion, including but not limited to the method the manufacturer will use to access this exclusion during normal vehicle operation. Specifically, the manufacturer must describe how control system will identify the conditions described in Section 10.2.

Editorial Comment: Would eliminate this text if eliminate tech exclusions in Section 10.

11.5 Deficiency Descriptions.
For each engine model and/or horsepower rating within an engine family for which a manufacturer is requesting a WNTE deficiency(ies) under the provisions of Section 8.0, the manufacturer's application for an WNTE deficiency(ies) must include a complete description of the deficiency. The description shall include but is not limited to: the specific description of the deficiency; the reason the deficiency is needed; the pollutant that is the subject of the deficiency; all engineering efforts made by the manufacturer to overcome the deficiency; the specific engine and ambient operating conditions for which the deficiency is being requested (i.e., temperature ranges, humidity ranges, altitude ranges, etc.); the frequency the deficiency will be used (i.e., %VMT, % operation),; if applicable, the specific emissions control system parameters modulated in response to the deficiency and the purpose of that modulation; if applicable, a full description of the auxiliary emission control device(s) which will be used to maintain emissions to the lowest practical level; and identification of the lowest practical emission level .

11.6 WNTE Limited Testing Region ~~5% Carve-Out~~ Descriptions and Demonstrations

For each engine model and/or horsepower rating within an engine family for which a manufacturer is requesting a 5% limited testing region ~~carve-out~~ under the provisions of Section 7.2.3 ~~10.3~~, the manufacturer's application shall include a complete description of the carve-out including but not limited to the range of engine load and speed which define the carve-out region and the methods or analyses used to arrive at the carve-out region. Manufacturers shall provide analyses of typical engine operation that reflects known or reasonably anticipated engine use patterns that may be based on in-use data from testing of representative vehicle/engine configurations, valid engineering calculations corresponding to operational data from in use vehicles, or a combination of the two.

Editorial Comment: Advisory Circular 24-3 Questions 6,7,8,9,10,11 all address guidance on the 5% carve-out region.
Request future comment on how the information in the guidance should be explicitly included in the GTR or in an annex to the GTR

11.7 WNTE Exclusion Descriptions and Demonstrations

For any engine family which contains an engine-vehicle combination for which a manufacturer is applying for a WNTE exclusion for certain operating points under the provisions of Section 7.1.6 ~~8.1 and 8.2~~, the manufacturer must describe those operating points and the basis for concluding that the engine is not capable of being operated at ~~(Section 8.1 criteria) or expected to be operated at (Section 8.2 criteria)~~ such points when used in the specified engine-vehicle combination(s).

Editorial Comment: Reserve comment until decide whether Sections 8.1 and 8.2 are modified or eliminated.