Transmitted by the expert from
the JRC of the European Commission

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http://www.unece.org/trans/main/wp29/wp29wgs/wp29grpe/grpeinf57.html

to the

Working document ECE/TRANS/WP.29/GRPE/2009/16

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as deposited at GRPE secretariat on the 20 March 2009 and released 1 April 2009 with changes by the GRPE secretariat.

Explanation: This informal document contains text segments which have been copied from the 'Working document ECE/TRANS/WP.29/GRPE/2009/16'. The changes have then been inserted into these segments via the 'track change' function and some additional comments added; please make sure that the track changes are visible when reading this document.

Formatting changes and other minor corrections are not reported here, simply for their sheer quantity. Alone the numbers of changes necessary to place the paragraph numbers to the left of the text are many thousands.

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Comment [A1]: formatting of first page by GRPE secretariat

INLAND TRANSPORT COMMITTEE

Comment [A2]: no list of content according to GRPE secretariat

World Forum for Harmonization of Vehicle Regulations

Working Party on Pollution and Energy

Fifty-eighth session
Geneva, 9-12 June 2009
Item 5 of the provisional agenda

EXHAUST EMISSIONS TEST PROTOCOL OF NON-ROAD MOBILE MACHINERY (NRMM)

Proposal for draft global technical regulation concerning the test procedure for compression-ignition (C.I.) engines to be installed in agricultural and forestry tractors and in non-road mobile machinery with regard to the emissions of pollutants by the engine

Submitted by the expert from the European Commission

A. STATEMENT OF TECHNICAL RATIONALE AND JUSTIFICATION

Comment [A3]: changes to lay-out according to GRPE secretariat; for example numbering of paragraphs

1. TECHNICAL AND ECONOMIC FEASIBILITY

1. The objective of this proposal is to establish a global technical regulation (gtr) for non-road mobile machinery (NRMM) compression-ignition (C.I.) engine emissions under the 1998 Global Agreement. The basis is the harmonized non-road test protocol, including test cycles, as developed by the NRMM informal group of the GRPE and also using the non-road transient test cycle (NRTC) developed between 2000 – 2002 by an international task force.

2. Some countries have already introduced regulations governing exhaust-emissions from non-road mobile machinery engines but the test procedures vary. To ensure the maximum benefit to the environment as well as the efficient use of energy, it is desirable that as many countries as possible use the same test protocol for emission control. Society will benefit from this harmonization of requirements through a general global reduction of the emission levels. Manufacturers of non-road mobile machinery are already operating in a world market and it is economically more efficient for them to develop engine models to meet internationally consistent emissions regulations. The harmonization achieved through this gtr enables manufacturers to develop new models most effectively. Finally, the consumer would benefit by having a choice of low emitting engines built to a globally recognized standard at a lower price.

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3. New research into the world-wide pattern of real NRMM use was fed into the transient cycle development work which had been initiated by the United States Environmental Protection Agency (US-EPA) and developed in cooperation with the Joint Research Centre (JRC) of the European Commission and an international task force. From the collected data a transient test cycle with both cold and hot start requirements was developed. For hot start steady state test cycle the basis was offered by an expert committee of the International Organization for Standardization (ISO). The test cycles have been published in standard series ISO 8178. The procedure reflects exhaust emissions measurement technology with the potential to accurately measure the pollutant emissions from future low emission engines. The NRTC test cycle has been adopted in the European Union (EU), Canada and US emission legislation and it is the basis for the special vehicle legislation under development in Japan. This gtr intends to achieve a high level of harmonization of the complementary testing conditions among these existing or progressing legislations.

4. The test procedure reflects world-wide NRMM engine operation, as closely as possible, and provides a marked improvement in the realism of the test procedure for measuring the emission performance of existing and future NRMM engines. In summary, the test procedure was developed so that it would be:

(a) representative of world-wide non-road mobile machinery engine operations,
(b) able to provide the highest possible level of efficiency in controlling non-road mobile machinery engine emissions,
(c) corresponding to state-of-the-art testing, sampling and measurement technology,
(d) applicable in practice to existing and foreseeable future exhaust emissions abatement technologies, and
(e) capable of providing a reliable ranking of exhaust emission levels from different engine types.

5. At this stage, the gtr is being presented without limit values and the NRMM engines' applicable power range. In this way, the test procedure can be given a legal status, based on which the Contracting Parties are required to start the process of implementing it into their national law. The gtr contains one option, the adoption of which is left to the discretion of the Contracting Parties. This option is related to the allowed dilution air temperature range.

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Deleted: Those options are

Deleted: hot soak procedure between the cold and hot NRTC and the weighting factor of cold and hot NRTC. However, these aspects have to be fully harmonized when common limit values are established.¶

6. When implementing the test procedure contained in this gtr as part of their national legislation or regulation, Contracting Parties are invited to use limit values which represent at least the same level of severity as their existing regulations, pending the development of harmonized limit values by the Executive Committee (AC.3) of the 1998 Agreement administered by the World Forum for Harmonization of Vehicle Regulations (WP.29). The performance levels (emissions test results) to be achieved in the gtr will, therefore, be discussed on the basis of the most recently agreed legislation in the Contracting Parties, as required by the 1998 Agreement.

7. In order to facilitate the regulatory activities of certain countries, in particular those that have not yet enforced legislation in this field or whose legislation is not yet as rigorous as the ones mentioned above, a guidance document is also available. The format is based on the one used in the EU for New and Global Approach Directives. It is important to note that only the text of the gtr is legally binding. The guidance document has no legal status as it does not introduce any additional requirements but aims at facilitating the use of the gtr and to help in applying the gtr. The guidance document is placed side by side with the gtr at the UNECE WP.29 website as already agreed by AC.3.

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B. TEXT OF REGULATION

Comment [A4]: lay-out changed according to GRPE secretariat and in line with other gtrs; for example numbering of paragraphs in separate space to the left of text

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6.10. Crankcase emissions

No crankcase emissions shall be discharged directly into the ambient atmosphere, with the following exception: engines equipped with turbochargers, pumps, blowers, or superchargers for air induction may discharge crankcase emissions to the ambient atmosphere if the emissions are added to the exhaust emissions (either physically or mathematically) during all emission testing. Manufacturers taking advantage of this exception shall install the engines so that all crankcase emission can be routed into the emissions sampling system. For the purpose of this paragraph, crankcase emissions that are routed into the exhaust upstream of exhaust aftertreatment during all operation are not considered to be discharged directly into the ambient atmosphere.

Open crankcase emissions shall be routed into the exhaust system for emission measurement, as follows:

(a) The tubing materials shall be smooth-walled, electrically conductive, and not reactive with crankcase emissions. Tube lengths shall be minimized as far as possible.

(b) The number of bends in the laboratory crankcase tubing shall be minimized, and the radius of any unavoidable bend shall be maximized.

(c) The laboratory crankcase exhaust tubing shall meet the engine manufacturer's specifications for crankcase back pressure.

(d) The crankcase exhaust tubing shall connect into the raw exhaust downstream of any aftertreatment system, downstream of any installed exhaust restriction, and sufficiently upstream of any sample probes to ensure complete mixing with the engine's exhaust before sampling. The crankcase exhaust tube shall extend into the free stream of exhaust to avoid boundary-layer effects and to promote mixing. The crankcase exhaust tube's outlet may orient in any direction relative to the raw exhaust flow.

7. TEST PROCEDURES

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7.2.1.3. Combined sampling

Any combination of continuous and batch sampling is permitted (e.g. PM with batch sampling and gaseous emissions with continuous sampling).

The following figure 7.1 illustrates the two aspects of the test procedures for measuring emissions: the equipments with the sampling lines in raw and diluted exhaust gas and the operations requested to calculate the pollutant emissions in steady-state and transient test cycles (figure 7.1).

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7.3.1.4. Calibration of gas analyzers

Appropriate gas analyzer ranges shall be selected. Emission analyzers with automatic or manual range switching are allowed. During a ramped modal or a NRTC test and during a sampling period of a gaseous emission at the end of each mode for discrete mode testing, the range of the emission analyzers may not be switched. Also the gains of an analyzer's analogue operational amplifier(s) may not be switched during a test cycle.

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All continuous analyzers shall be zeroed and spanned using internationally-traceable gases that meet the specifications of paragraph 9.5.1. FID analyzers shall be spanned on a carbon number basis of one (C_1).

7.3.1.5. PM filter preconditioning and tare weighing

The procedures for PM filter preconditioning and tare weighing shall be followed according to paragraph 8.2.3.

Deleted: If the engine shall comply with a PM standard, the

7.3.2. Post-test procedures

The following steps shall be taken after emission sampling is complete:

7.3.2.1. Verification of proportional sampling

For any proportional batch sample, such as a bag sample or PM sample, it shall be verified that proportional sampling was maintained according to paragraph 8.2.1. For the single filter method and the discrete steady-state test cycle, effective PM weighting factor shall be calculated. Any sample that does not fulfil the requirements of paragraph 8.2.1. shall be voided.

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7.4. Test cycles

The following duty cycles apply:

(a) for variable-speed engines, the 8-mode test cycle or the corresponding ramped modal cycle, and the transient cycle NRTC as specified in Annex A.1.;

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(b) for constant-speed engines, the 5-mode test cycle or the corresponding ramped modal cycle as specified in Annex A.1.

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7.4.1. Steady-state test cycles

Steady-state test cycles are specified in Annex A.1. as a list of discrete modes (operating points), where each operating point has one value of speed and one value of torque. A steady-state test cycle shall be measured with a warmed up and running engine according to manufacturer's specification. A steady-state test cycle may be run as a discrete-mode cycle or a ramped-modal cycle, as explained in the following paragraphs.

7.4.1.1. Steady-state discrete mode test cycles

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The steady-state discrete 8-mode test cycle consists of eight speed and load modes (with the respective weighing factor for each mode) which cover the typical operating range of variable speed engines. The cycle is shown in Annex A.1.

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The steady-state discrete 5-mode constant-speed test cycle consists of five load modes (with the respective weighing factor for each mode) all at rated speed which cover the typical operating range of constant speed engines. The cycle is shown in Annex A.1.

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7.4.1.2. Steady-state ramped test cycles

Deleted: (RMC-C1 and -D2)

The ramped modal test cycles (RMC) are hot running cycles where emissions shall be started to be measured after the engine is started, warmed up and running as specified in paragraph 7.8.2.1. The engine shall be continuously controlled by the test bed control unit during the RMC test cycle. The gaseous and particulate emissions shall be measured and sampled continuously during the RMC test cycle in the same way as in a transient cycle.

In case of the 5-mode test cycle the RMC consists of the same modes in the same order as the corresponding discrete steady-state test cycle. For the 8-mode test cycle the RMC has one mode more (split idle mode) and the mode sequence is not the same as the corresponding steady-state discrete mode cycle, in order to avoid extreme changes in the after-treatment temperature. The length of the modes shall be selected to be equivalent to the weighting factors of the corresponding discrete steady-state test cycle. The change in engine speed and load from one mode to the next one has to be linearly controlled in a time of 20±1 seconds. The mode change time is part of the new mode (including the first mode).

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Deleted: C1

7.4.2. Transient test cycle (NRTC) ……

The transient test cycle shall be run twice (see paragraph 7.8.3.):

(a) As cold start after the engine and aftertreatment systems have cooled down to room temperature after natural engine cool down, or as cold start after forced cool down and the engine, coolant and oil temperatures, aftertreatment systems and all engine control devices are stabilized between 20 and 30 °C. The measurement of the cold start emissions shall be started with the start of the cold engine.

(b) Hot soak period – Immediately upon completion of the cold start phase, the engine shall be conditioned for the hot start by a 20 minutes ± 1 minute hot soak period.

(c) The hot-start shall be started immediately after the soak period with the cranking of the engine. The gaseous analyzers shall be switched on at least 10 seconds before the end of the soak period to avoid switching signal peaks. The measurement of emissions shall be started in parallel with the start of the hot start phase including the cranking of the engine.

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Deleted: using one of the following options:¶
(i) 5 minutes ±1 minute hot soak period;¶
(ii)

Deleted: The option shall be selected by the Contracting Parties.¶

Brake specific emissions expressed in (g/kWh) shall be determined by using the procedures of this section for both the cold and hot start test cycles. Composite weighted emissions shall be computed by weighting the cold start results by 10 per cent and the hot start results by 90 per cent as detailed in Annexes A.7.-A.8.

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Deleted: Y

Deleted: (X% + Y% = 100 %)

Deleted: . where X and Y can be 10% + 90% or 5% + 95% and are quantities defined by the Contracting Parties

…….

7.5.1.2. Engine stalling

(a) If the engine stalls anywhere during the cold start test of the NRTC, the test shall be voided.

(b) If the engine stalls anywhere during the hot start test of the NRTC, the test shall be voided. The engine shall be soaked according to paragraph 7.8.3., and the hot start test repeated. In this case, the cold start test does not need to be repeated.

(c) If the engine stalls anywhere during the steady-state cycle (discrete or ramped), the test shall be voided and be repeated beginning with the engine warm-up procedure. In the case of PM measurement utilizing the multi-filter method (one sampling filter for each operating mode), the test shall be continued by stabilizing the engine at the previous mode for engine temperature conditioning and then initiating measurement with the mode where the engine stalled.

…….

7.6.1. Engine mapping for steady-state 8-mode cycle

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In the case of engine mapping for the steady-state 8-mode cycle (only for engines which have not to run the NRTC cycle), good engineering judgment shall be used to select a sufficient number (20 to 30) of evenly spaced set-points. At each setpoint, speed shall be stabilized and torque allowed to stabilize at least for 15 seconds. The mean speed and torque shall be recorded at each set-point. Linear interpolation shall be used to determine the 8-mode test speeds and torques if needed. If the derived test speeds and loads do not deviate for more than ±2.5 per cent from the speeds and torques indicated by the manufacturer, the manufacturer defined speeds and loads shall be applied. When engines shall be run on the NRTC too, then the NRTC engine mapping curve shall be used to determine steady-state test speeds and torques.

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7.7. Test cycle generation

7.7.1. Generation of steady-state test cycles

Deleted: cycle (C1 and D2)¶

……

7.7.1.2. Generation of steady-state 8-mode test cycle (discrete and ramp modal)

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……

7.7.1.3. Generation of steady-state 5-mode test cycle (discrete and ramp modal)

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During the test cycle, the engine shall be operated at the engine speeds and torques that are defined in Annex A.1.

The maximum mapping torque value at the specified rated speed (see paragraph 7.7.1.1.) shall be used to generate the 5-mode test cycle. A warm minimum torque that is representative of in-use operation may be declared. For example, if the engine is typically connected to a machine that does not operate below a certain minimum torque, this torque may be declared and used for cycle generation. When both measured and declared values are available for the maximum test torque for cycle generation, the declared value may be used instead of the measured value if it is within 95 to 100 per cent of the measured value.

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7.8. Specific test cycle running procedure

7.8.1. Emission test sequence for discrete steady-state test cycles

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7.8.1.1. Engine warming-up for steady state discrete-mode test cycles

For preconditioning the engine shall be warmed up according to the recommendation of the manufacturer and good engineering judgment. Before emission sampling can start, the engine shall be running until engine temperatures (cooling water and lube oil) have been stabilized (normally at least 10 minutes) on mode 1 (100 per cent torque and rated speed for the 8-mode test cycle and at rated or nominal constant engine speed and 100 per cent torque for the 5-mode test cycle). Immediately from this engine conditioning point, the test cycle measurement starts.

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Deleted: D2

Pre-test procedure according to paragraph 7.3.1. shall be performed, including analyzer calibration.

7.8.1.2. Performing discrete-mode test cycles

(a) The test shall be performed in ascending order of mode numbers as set out for the test cycle (see Annex A.1.).

(b) Each mode has a mode length of at least 10 minutes. In each mode the engine shall be stabilized for at least 5 minutes and emissions shall be sampled for 1-3 minutes for gaseous emissions at the end of each mode. Extended time of sampling is permitted to improve the accuracy of PM sampling.
The mode length shall be recorded and reported.

(c) The particulate sampling may be done either with the single filter method or with the multiple filter method. Since the results of the methods may differ slightly, the method used shall be declared with the results.
For the single filter method the modal weighting factors specified in the test cycle procedure and the actual exhaust flow shall be taken into account during sampling by adjusting sample flow rate and/or sampling time, accordingly. It is required that the effective weighing factor of the PM sampling is within ±0.003 of the weighing factor of the given mode.
Sampling shall be conducted as late as possible within each mode. For the single filter method, the completion of particulate sampling shall be coincident within ± 5 s with the completion of the gaseous emission measurement. The sampling time per mode shall be at least 20 s for the single filter method and at least 60 s for the multi-filter method. For systems without bypass capability, the sampling time per mode shall be at least 60 s for single and multiple filter methods.

(d) The engine speed and load, intake air temperature, fuel flow and air or exhaust gas flow shall be measured for each mode at the same time interval which is used for the measurement of the gaseous concentrations.
Any additional data required for calculation shall be recorded.

(e) If the engine stalls or the emission sampling is interrupted at any time after emission sampling begins for a discrete mode and the single filter method, the test shall be voided and be repeated beginning with the engine warm-up procedure. In the case of PM measurement utilizing the multi-filter method (one sampling filter for each operating mode), the test shall be continued by stabilizing the engine at the previous mode for engine temperature conditioning and then initiating measurement with the mode where the engine stalled.

(f) Post-test procedures according to paragraph 7.3.2. shall be performed.

7.8.1.3. Validation criteria

During each mode of the given steady-state test cycle after the initial transition period, the measured speed shall not deviate from the reference speed for more than ±1 per cent of rated speed or ±3 min^{-1}, whichever is greater except for idle which shall be within the tolerances declared by the manufacturer. The measured torque shall not deviate from the reference torque for more than ±2 per cent of the maximum torque at the test speed.

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7.8.2. Ramped modal test cycles

Deleted: cycle (RMC-C1, RMC-D2)¶

7.8.2.1. Engine warming-up

Before starting the steady-state ramped modal test cycles (RMC), the engine shall be warmed-up and running until engine temperatures (cooling water and lube oil) have been stabilized on 50 per cent speed and 50 per cent torque for the RMC test cycle (derived from the 8-mode test cycle) and at rated or nominal engine speed and 50 per cent torque for the RMC test cycle (derived from 5-mode test cycle). Immediately after this engine conditioning procedure, engine speed and torque shall be changed in a linear ramp of 20 ± 1 s to the first mode of the test. In between 5 to 10 s after the end of the ramp, the test cycle measurement shall start.

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Deleted: -D2

7.8.2.2. Performing a ramped modal test cycle

The ramped modal cycles derived from 8-mode and 5-mode test cycle are shown in Annex A.1.

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Deleted: D2

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7.8.3.4. Calculation of cycle work

Before calculating the cycle work, any speed and torque values recorded during engine starting shall be omitted. The actual cycle work W_{act} (kWh) shall be calculated based on engine feedback speed and torque values. The reference cycle work W_{ref} (kWh) shall be calculated based on engine reference speed and torque values. The actual cycle work W_{act} is used for comparison to the reference cycle work W_{ref} and for calculating the brake specific emissions (see paragraph 7.2.)
W_{act} shall be between 85 per cent and 105 per cent of W_{ref}.

Deleted: Points with negative torque values have to be accounted for as zero work.

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For regression purposes only, point deletions are permitted where noted in table 7.3 of this paragraph before doing the regression calculation. However, those points shall not be deleted for the calculation of cycle work and emissions. An idle point is defined as a point having a normalized reference torque of 0 per cent and a normalized reference speed of 0 per cent. Point deletion may be applied to the whole or to any part of the cycle; points to which the point deletion is applied have to be specified.

Event	Conditions (n = engine speed, T = torque)	Permitted point deletions
Minimum operator demand (idle point)	n_{ref} = 0 per cent and T_{ref} = 0 per cent and $T_{act} > (T_{ref} - 0.02\ T_{maxmappedtorque})$ and $T_{act} < (T_{ref} + 0.02\ T_{maxmappedtorque})$	speed and power
Minimum operator demand	$n_{act} \leq 1.02\ n_{ref}$ and $T_{act} > T_{ref}$ and $n_{act} > n_{ref}$ and $T_{act} \leq T_{ref}$ and $n_{act} > 1.02\ n_{ref}$ and $T_{ref} < T_{act} \leq (T_{ref} + 0.02\ T_{maxmappedtorque})$	power and either torque or speed
Maximum operator demand	$n_{act} < n_{ref}$ and $T_{act} \geq T_{ref}$ and $n_{act} \geq 0.98\ n_{ref}$ and $T_{act} < T_{ref}$ and $n_{act} < 0.98\ n_{ref}$ and $T_{ref} > T_{act} \geq (T_{ref} - 0.02\ T_{maxmappedtorque})$	power and either torque or speed

Table 7.3: Permitted point deletions from regression analysis

8. MEASUREMENT PROCEDURES

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8.1.2. Summary of calibration and verification

The table 8.1 summarizes the calibrations and verifications described in paragraph 8. and indicates when these have to be performed.

Type of calibration or verification	Minimum frequency [(a)]
8.1.3: accuracy, repeatability and noise	Accuracy: Not required, but recommended for initial installation. Repeatability: Not required, but recommended for initial installation. Noise: Not required, but recommended for initial installation.
8.1.4: linearity	Speed: Upon initial installation, within 370 days before testing and after major maintenance. Torque: Upon initial installation, within 370 days before testing and after major maintenance. Clean gas and diluted exhaust flows: Upon initial installation, within 370 days before testing and after major maintenance, unless flow is verified by propane check or by carbon or oxygen balance. Raw exhaust flow: Upon initial installation, within 185 days before testing and after major maintenance, unless flow is verified by propane check or by carbon or oxygen balance. Gas analyzers: Upon initial installation, within 35 days before testing and after major maintenance. PM balance: Upon initial installation, within 370 days before testing and after major maintenance. Stand-alone pressure and temperature: Upon initial installation, within 370 days before testing and after major maintenance.
…..	…..

Table 8.1 – Summary of Calibration and Verifications

…….

8.1.4.1. Scope and frequency

A linearity verification shall be performed on each measurement system listed in table 8.2 at least as frequently as indicated in the table, consistent with measurement system manufacturer recommendations and good engineering judgment. The intent of a linearity verification is to determine that a measurement system responds proportionally over the measurement range of interest. A linearity verification shall consist of introducing a series of at least 10 reference values to a measurement system, unless otherwise specified. The measurement system quantifies each reference value. The measured values shall be collectively compared to the reference values by using a least squares linear regression and the linearity criteria specified in table 8.2 of this paragraph.

……

8.1.9. CO and CO_2 measurements

8.1.9.1. H_2O interference verification for CO_2 NDIR analyzers ……..

8.1.9.1.4. Procedure

The interference verification shall be performed as follows:

(a) The CO_2 NDIR analyzer shall be started, operated, zeroed, and spanned as it would be before an emission test.

(b) A humidified test gas shall be created by bubbling zero air that meets the specifications in paragraph 9.5.1 through distilled water in a sealed vessel. If the sample is not passed through a dryer, control the vessel temperature to generate an H_2O level at least as high as the maximum expected during testing. If the sample is passed through a dryer during testing, control the vessel temperature to generate an H_2O level at least as high as the level determined in paragraph 9.3.2.3.1.

(c) The humidified test gas temperature shall be maintained at least 5 °C above its dew point downstream of the vessel.

(d) The humidified test gas shall be introduced downstream of any sample dryer, if one is used during testing.

(e) The water mole fraction, x_{H2O}, of the humidified test gas shall be measured, as close as possible to the inlet of the analyzer. For example, dew point, T_{dew}, and absolute pressure p_{total}, shall be measured to calculate x_{H2O}.

(f) Good engineering judgment shall be used to prevent condensation in the transfer lines, fittings, or valves from the point where x_{H2O} is measured to the analyzer.

(g) Time shall be allowed for the analyzer response to stabilize. Stabilization time shall include time to purge the transfer line and to account for analyzer response.

(h) While the analyzer measures the sample's concentration, 30 s of sampled data shall be recorded. The arithmetic mean of this data shall be calculated. The analyzer meets the interference verification if this value is within (0.0 ± 0.4) mmol/mol

……..

8.1.10.3. Non-methane cutter penetration fractions ……..

8.1.10.3.4. Procedure

Any one of the procedures specified in paragraphs 8.1.10.3.4.1., 8.1.10.3.4.2. and 8.1.10.3.4.3. is recommended. An alternative method recommended by the instrument manufacturer may be used.

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This method is recommended over

8.1.10.3.4.1. Procedure for a FID calibrated with the NMC

If a FID is always calibrated to measure CH_4 with the NMC, then the FID shall be spanned with the NMC using a CH_4 span gas, the product of that FID's CH_4 response factor and CH_4 penetration fraction, $RFPF_{CH4[NMC\text{-}FID]}$, shall be set equal to 1.0 (i.e. efficiency E_{CH4} [-] is set to 0) for all emission calculations, and the combined ethane (C_2H_6) response factor and penetration fraction, $RFPF_{C2H6[NMC\text{-}FID]}$ (and efficiency E_{C2H6} [-]) shall be determined as follows:

Deleted: cutter

(a) Both a CH_4 gas mixture and a C_2H_6 analytical gas mixture shall be selected meeting the specifications of paragraph 9.5.1. Both a CH_4 concentration for spanning the FID during emission testing and a C_2H_6 concentration that is typical of the peak NMHC concentration expected at the hydrocarbon standard or equal to THC analyzer's span value shall be selected.

(b) …….

8.1.10.3.4.2. Procedure for a FID calibrated with propane bypassing the NMC

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If a FID is used with an NMC that is calibrated with propane, C_3H_8, by bypassing the NMC, penetrations fractions $PF_{C2H6[NMC\text{-}FID]}$ and $PF_{CH4[NMC\text{-}FID]}$ shall be determined as follows:

(a) ……

8.1.10.3.4.3. Procedure for a FID calibrated with methane, bypassing the NMC

If a FID is used with an NMC that is calibrated with methane, CH_4, by bypassing the NMC, determine its combined ethane (C_2H_6) response factor and penetration fraction, $RFPF_{C2H6[NMC\text{-}FID]}$, as well as its CH_4 penetration fraction, $PF_{CH4[NMC\text{-}FID]}$, as follows:

(a) …….

……

8.2.2. Gas analyzer range validation, drift validation and drift correction ……

8.2.2.2. Drift validation and drift correction

If the drift is within ±1 per cent, the data can be either accepted without any correction or accepted after correction. If the drift is greater than ±1 per cent, two sets of brake specific emission results shall be calculated for each pollutant, or the test shall be voided. One set shall be calculated using data before drift correction and another set of data calculated after correcting all the data for drift according to Appendix 2 of Annexes A.7. or A.8. The comparison shall be made as a percentage of the uncorrected results. The difference between the uncorrected and the corrected brake-specific emission values shall be within ±4 per cent of the uncorrected brake-specific emission values. If not, the entire test is void.

Deleted: or applicable emissions limits, whichever is greater

Deleted: or ±4 per cent of the emission limit, whichever is greater.

Deleted: Only the drift-corrected emission results shall be used when reporting emissions.

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9. MEASUREMENT EQUIPMENT …….

9.2. Dilution procedure (if applicable) ……

9.2.2. Full flow system

Full-flow dilution; constant-volume sampling (CVS). The full flow of raw exhaust is diluted in a dilution tunnel. Constant flow may be maintained by maintaining the temperature and pressure at the flow meter within the limits. For non constant flow the flow shall be measured directly to allow for proportional sampling. The system shall be designed as follows (see figure 9.1):

(a) A tunnel with inside surfaces of stainless steel shall be used. The entire dilution tunnel shall be electrically grounded.

(b) The exhaust system backpressure shall not be artificially lowered by the dilution air inlet system. The static pressure at the location where raw exhaust is introduced into the tunnel shall be maintained within ±1.2 kPa of atmospheric pressure.

(c) To support mixing the raw exhaust shall be introduced into the tunnel by directing it downstream along the centreline of the tunnel. A fraction of dilution air maybe introduced radially from the tunnel's inner surface to minimize exhaust interaction with the tunnel walls.

(d) Diluent. For PM sampling the temperature of the diluents (ambient air, synthetic air, or nitrogen as quoted in paragraph 9.2.1.) shall be maintained within one of the following ranges (option):
(i) between 293 and 303 K (20 and 30 °C) or
(ii) between 293 and 325 K (20 to 52°C)
The range shall be selected by the Contracting Party.

(e) The Reynolds number, *Re*, shall be at least 4000 for the diluted exhaust stream, where *Re* is based on the inside diameter of the dilution tunnel. *Re* is defined in Annexes A.7-A.8. Verification of adequate mixing shall be performed while traversing a sampling probe across the tunnel's diameter, vertically and horizontally. If the analyzer response indicates any deviation exceeding ±2 per cent of the mean measured concentration, the CVS shall be operated at a higher flow rate or a mixing plate or orifice shall be installed to improve mixing.

(f) Flow measurement preconditioning. The diluted exhaust may be conditioned before measuring its flow rate, as long as this conditioning takes place downstream of heated HC or PM sample probes, as follows:
   (i) Flow straighteners, pulsation dampeners, or both of these maybe used.
   (ii) A filter maybe used.
   (iii) A heat exchanger maybe used to control the temperature upstream of any flow meter but steps shall be taken to prevent aqueous condensation.

(g) Aqueous condensation. To ensure that a flow is measured that corresponds to a measured concentration, either aqueous condensation shall be prevented between the sample probe location and the flow meter inlet in the dilution tunnel or aqueous condensation shall be allowed to occur and humidity at the flow meter inlet measured. The dilution tunnel walls or bulk stream tubing downstream of the tunnel may be heated or insulated to prevent aqueous condensation. Aqueous condensation shall be prevented throughout the dilution tunnel. Certain exhaust components can be diluted or eliminated by the presence of moisture.

For PM sampling, the already proportional flow coming from CVS goes through secondary dilution (one or more) to achieve the requested overall dilution ratio as shown in figure 9.2 and mentioned in paragraph 9.2.3.2.

(h) The minimum overall dilution ratio shall be within the range of 5:1 to 7:1 and at least 2:1 for the primary dilution stage based on the maximum engine exhaust flow rate during the test cycle or test interval.

(i) The overall residence time in the system shall be between 0.5 and 5 seconds, as measured from the point of diluent introduction to the filter holder(s).

(j) The residence time in the secondary dilution system, if present, shall be at least 0.5 seconds, as measured from the point of secondary diluent introduction to the filter holder(s).

To determine the mass of the particulates, a particulate sampling system, a particulate sampling filter, a gravimetric balance, and a temperature and humidity controlled weighing chamber, are required.

……

9.2.3. Partial flow dilution (PFD) system

9.2.3.1. Description of partial flow system …….

9.2.3.2. Dilution

The temperature of the diluents (ambient air, synthetic air, or nitrogen as quoted in paragraph 9.2.1.) shall be maintained within one of the following ranges (option):
(a) between 293 and 303 K (20 and 30 °C) or
(b) between 293 and 325 K (20 to 52°C)
in close proximity to the entrance into the dilution tunnel. The range shall be selected by the Contracting Party.

De-humidifying the dilution air before entering the dilution system is permitted. The partial flow dilution system has to be designed to extract a proportional raw exhaust sample from the engine exhaust stream, thus responding to excursions in the exhaust stream flow rate, and introduce dilution air to this sample to achieve a temperature at the test filter as prescribed by paragraph 9.3.3.4.3. For this it is essential that the dilution ratio be determined such that the accuracy requirements of paragraph 8.1.8.6.1. are fulfilled.

To ensure that a flow is measured that corresponds to a measured concentration, either aqueous condensation shall be prevented between the sample probe location and the flow meter inlet in the dilution tunnel or aqueous condensation shall be allowed to occur and humidity at the flow meter inlet measured. The PFD system may be heated or insulated to prevent aqueous condensation. Aqueous condensation shall be prevented throughout the dilution tunnel.

The minimum dilution ratio shall be within the range of 5:1 to 7:1 based on the maximum engine exhaust flow rate during the test cycle or test interval.

The residence time in the system shall be between 0.5 and 5 s, as measured from the point of diluent introduction to the filter holder(s).

To determine the mass of the particulates, a particulate sampling system, a particulate sampling filter, a gravimetric balance, and a temperature and humidity controlled weighing chamber, are required.

…..

9.4.5.3. Raw exhaust flow meter ……..

9.4.5.3.3. Exhaust cooling

Exhaust cooling upstream of the flow meter is permitted with the following restrictions:
(a) PM shall not be sampled downstream of the cooling.

(b) If cooling causes exhaust temperatures above 202 °C to decrease to below 180 °C, NMHC shall not be sampled downstream of the cooling.

(c) If cooling causes aqueous condensation, NO_x shall not be sampled downstream of the cooling unless the cooler meets the performance verification in paragraph 8.1.11.4.

(d) If cooling causes aqueous condensation before the flow reaches a flow meter, T_{dew} and pressure p_{total} shall be measured at the flow meter inlet. These values shall be used in emission calculations according to Annexes A.7-A.8.

Deleted: the water content ($g_{H2O}/kg_{dry\ air}$)

Deleted: Flow calculations

Deleted: adjusted

……..

9.5. Analytical gases and mass standards ….

9.5.1.1. Gas specifications ….

The following gas specifications shall be considered:

…….

(c) The following gas mixtures shall be used, with gases traceable within ±1.0 per cent of the international and/or national recognized standards true value or of other gas standards that are approved:

…….

(vii) NO2, balance purified synthetic air ~~N2~~.

……

(d) Gases for species other than those listed in paragraph (c) of this section may be used (such as methanol in air, which may be used to determine response factors), as long as they are traceable to within ±~~1~~3.0 per cent of the international and/or national recognized standards true value, and meet the stability requirements of paragraph 9.5.1.2.

Annex A.7 MOLAR BASED EMISSION CALCULATIONS has been corrected according to the latest updating of US 40 CFR 1065

…….

Annex A.8 MASS BASED EMISSION CALCULATIONS has been corrected according to the latest updating of WHDC and the corrections indicated by the secretary of WHDC as agreed during the 57th GRPE meeting

…….

A.7.1.4. Total HC and non-methane HC concentration …..

A.7.1.4.3. Approximation of NMHC from THC

NMHC (non-methane hydrocarbon) emissions can be approximated as 98 percent of THC (total hydrocarbon).

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¶
For engines subject to NMHC standards, the manufacturer may base compliance on

Deleted: (THC) emissions. If the manufacturer uses this option, THC emissions are measured and NMHC emissions are calculated as 98 percent of THC emissions, as shown in the following equation:¶

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$$NMHC = 0.98 \cdot THC \qquad (A.7\text{-}10)$$

…..

A.8.1. Basic Parameters

A.8.1.1. Determination of methane and non-methane HC concentration

NMHC (non-methane hydrocarbon) emissions can be approximated as 98 percent of THC (total hydrocarbon).