United Nations ECE/TRANS/WP.29/GRPE/2025/12

Economic and Social Council

Distr.: General
10 January 2025

Original: English

Informal document GRPE-92-25-Rev.2
92nd GRPE, 25-28 March 2025
Agenda item 4 (a)

Updates to Working Document
GRPE/2025/12 are shown using tracked

Economic Commission for Europe

Inland Transport Committee

World Forum for Harmonization of Vehicle Regulations

Working Party on Pollution and Energy

Ninety-second session
Geneva, 25–28 March 2025
Item 4 (a) of the provisional agenda
Heavy duty vehicles:
UN Regulations Nos. 49 (Emissions of compression ignition and positive ignition (LPG and CNG) engines) and 132 (Retrofit Emissions Control devices (REC))

Proposal for a new Supplement to the 07 series of amendments to UN Regulation No. 49 (Emissions of compression ignition and positive ignition (LPG and CNG) engines)

Submitted by the experts from the European Commission*

The text reproduced below was prepared by the experts from the European Commission and proposes to introduce new provisions to accommodate type-approval of hydrogen Type 1A dual fuel engines and vehicles, modifications to include Fourier Transform Infrared (FTIR) and Quantum Cascade Laser mid-Infrared detection (QCL-IR) instruments and new provisions to accommodate monitoring on-board fuel and/or energy consumption during PEMS testing. The modifications to the current text of the Regulation are marked in bold for new or strikethrough for deleted characters.

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[*] In accordance with the programme of work of the Inland Transport Committee for 2025 as outlined in proposed programme budget for 2025 (A/79/6 (Sect. 20), table 20.6), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

I. Proposal

Paragraph 3.5.1., amend to read*:*

"3.5.1. In case of an application for type approval of engines fueled with hydrogen, hydrogen shall be the fuel the engine is designed to run on primarily. **This shall include dual-fuel engines of Type 1A with hydrogen as gaseous fuel.** Requirements for **all other types of** dual-fuel hydrogen engines have not yet been established under this regulation."

Paragraph 4.12.3.3.7., amend to read:

"4.12.3.3.7. For dual-fuel engines the approval mark shall contain a series of digits after the national symbol, the purpose of which is to distinguish for which dual-fuel engine type and with which range of gases the approval has been granted.

This series of digits will be constituted of two digits identifying the dual-fuel engine type as defined in Annex 15 followed by the letter(s) specified in paragraphs 4.12.3.3.1. to 4.12.3.3.6. corresponding to the natural gas/biomethane composition used by the engine **or paragraph 4.12.3.3.8. in case of hydrogen**.

The two digits identifying the dual-fuel engines types according to the definitions of Annex 15 are the following:

(a) 1A for dual-fuel engines of Type 1A;

(b) 1B for dual-fuel engines of Type 1B;

(c) 2A for dual-fuel engines of Type 2A;

(d) 2B for dual-fuel engines of Type 2B;

(e) 3B for dual-fuel engines of Type 3B. "

Annex 4

Paragraph 3.1., add new definitions as follows:

"~~[~~**3.1.22.**~~]~~ **"*Instrument manufacturer*" is the manufacturer of a measurement device (e.g. analyzers), test systems (e.g. dynamometers) and calibration and diagnostic check devices (e.g. gas dividers).**

"~~[~~**3.1.23.**~~]~~ ***"Type of analyzer",* also referred to as "*analyzer type*", means a group of analyzers produced by the same "Instrument manufacturer" based on the identical analytical principle to determine the concentration of one or more specified gaseous exhaust gas components."**

Paragraph 3.4., add new row to the table as follows:

"3.4. Symbols and abbreviations for the chemical components

…	
H_2O	Water
NH_3	**Ammonia**
NMHC	Non-methane hydrocarbons
…	

"

Paragraph 3.5., add new row to the table as follows:

"3.5. Abbreviations

…

PTT	Particle transfer tube
QCL-IR	**Quantum cascade laser mid-infrared detection**
SSV	Subsonic venturi

…

"

Paragraph 7.6.6., amend to read:

"7.6.6. …

(e) Start recording the feedback data of speed and torque of the dynamometer.

If raw exhaust measurement is used, the emission concentrations ((NM)HC, CO, ~~and~~ NO_x, **CO_2, CH_4 and H_2O (if applicable)**) and the exhaust gas mass flow rate shall be measured continuously and stored with at least 2 Hz on a computer system. All other data may be recorded with a sample rate of at least 1 Hz. For analogue analyzers the response shall be recorded, and the calibration data may be applied online or offline during the data evaluation.

…"

Paragraph 7.7.4., amend to read:

"7.7.4. …

(e) Start recording the feedback data of speed and torque of the dynamometer.

If raw exhaust measurement is used, the emission concentrations ((NM)HC, CO, ~~and~~ NO_x, **CO_2, CH_4 and H_2O (if applicable)**) and the exhaust gas mass flow rate shall be measured continuously and stored with at least 2 Hz on a computer system. All other data may be recorded with a sample rate of at least 1 Hz. For analogue analyzers the response shall be recorded, and the calibration data may be applied online or offline during the data evaluation.

…"

Paragraph 8.1.1., amend to read:

"8.1.1. …

$$k_{w,r} = \left(\frac{1}{1 + \alpha \times 0{,}005 \times (c_{CO2} + c_{CO})} - k_{w1}\right) \times 1{,}008 \qquad (15)$$

or in the case of hydrogen fuelled engine

$$\mathbf{k_{w,r} = \left(1 - \frac{c_{H2O}}{100}\right) \times 1.008} \qquad \mathbf{(15a)}$$

Where:

…

cCO is the dry CO concentration, per cent

c_{H2O} is the H_2O concentration, per cent

Equations 13 and 14 are principally identical with the factor 1.008 in equations 13 and 15 being an approximation for the more accurate denominator in equation 14. Equation 15 is not applicable, if one of the fuels used has a molar carbon to hydrogen ratio of 0 as defined in paragraph 8. of this annex. Equations 13 to 17 are not applicable in the case that water injection is used."

Paragraph 8.4.2.1., amend to read:

"8.4.2.1. Introduction

The gaseous components in the raw exhaust gas emitted by the engine submitted for testing shall be measured with the measurement and sampling systems described in paragraph 9.3., Appendix 2 **and Appendix 7** to this annex. The data evaluation is described in paragraph 8.4.2.2. "

Paragraph 8.6.2., amend to read:

"8.6.2. Calculation of NMHC and CH_4

The calculation of NMHC and CH_4 depends on the calibration method used **and analyzer used**. The FID for the measurement without NMC (lower path of Appendix 2 to this annex, Figure 11), shall be calibrated with propane. For the calibration of the FID in series with NMC (upper path of Appendix 2 to this annex, Figure 11), the following methods are permitted.

…

In the case that CH_4 was measured using FTIR or QCL-IR, the calculation of CH_4 undertaken according to this paragraph shall be excluded."

Paragraph 9.3.1.8., amend to read:

"9.3.1.8. Gas drying

Exhaust gases may be measured wet or dry**, except for HC, NH_3 and H_2O which shall be measured wet**. **Gas dryers are not permitted for H_2O and NH_3 measurement.** A gas-drying device, if used, shall have a minimal effect on the composition of the measured gases. Chemical dryers are not an acceptable method of removing water from the sample."

Paragraph 9.3.2., amend to read:

"9.3.2. Gas analyzers

9.3.2.1. Introduction

Paragraphs 9.3.2.2. to 9.2.3.7. describe the measurement principles to be used. A detailed description of the measurement systems is given in Appendix **2 and Appendix 7** to this annex. The gases to be measured shall be analyzed with the following instruments. For non-linear analyzers, the use of linearising circuits is permitted.

9.3.2.2. Carbon monoxide (CO) analysis

The carbon monoxide analyzer shall be of the non-dispersive infrared (NDIR) absorption type. **When CO is measured from raw exhaust, FTIR or QCL-IR analyzers can be used as an alternative to NDIR. As another alternative, either a FTIR or a QCL-IR may be used, provided it meets the criteria specified in paragraphs 9.3.2.8. or 9.3.2.9., respectively.**

9.3.2.3. Carbon dioxide (CO_2) analysis

The carbon dioxide analyzer shall be of the non-dispersive infrared (NDIR) absorption type. **When CO_2 is measured from raw exhaust, FTIR or QCL-IR analyzers can be used as alternative to NDIR. As another alternative,**

either a FTIR or a QCL-IR may be used, provided it meets the criteria specified in paragraph 9.3.2.8. or 9.3.2.9., respectively.

9.3.2.4. Hydrocarbon (HC) analysis

The hydrocarbon analyzer shall be of the heated flame ionization detector (HFID) type with detector, valves, pipework, etc. heated so as to maintain a gas temperature of 463 K ± 10 K (190 ± 10 °C). Optionally, for natural gas fuelled and PI engines, the hydrocarbon analyzer may be of the non-heated flame ionization detector (FID) type depending upon the method used (see Appendix 2 to this annex, paragraph A.2.1.3.).

9.3.2.5. Methane (CH_4) and non-methane hydrocarbon (NMHC) analysis

The determination of the methane and non-methane hydrocarbon fraction shall be performed with a heated non-methane cutter (NMC) and two FIDs as per Appendix 2 to this annex, paragraph A.2.1.4. and paragraph A.2.1.5. The concentration of the components shall be determined as per paragraph 8.6.2. **When CH_4 is measured from raw exhaust, FTIR or QCL-IR analyzers may be used as an alternative to the requirements in paragraph A.2.1.4. and paragraph A.2.1.5. of Appendix 2 to this annex, and concentration shall not be determined as per paragraph 8.6.2. of this annex. As another alternative, either a FTIR or a QCL-IR may be used provided it meets the criteria specified in paragraph 9.3.2.8. or 9.3.2.9., respectively.**

9.3.2.6. Oxides of nitrogen (NO_x) analysis

Two measurement instruments are specified for NO_x measurement and either instrument may be used provided it meets the criteria specified in paragraphs 9.3.2.6.1. or 9.3.2.6.2., respectively. For the determination of system equivalency of an alternate measurement procedure in accordance with paragraph 5.1.1., only the CLD is permitted. **When NOx (i.e., NO + NO_2) are measured from raw exhaust, FTIR or QCL-IR analyzers may be used as alternative to CLD. As another alternative, either a FTIR or a QCL-IR may be used provided it meets the criteria specified in paragraphs 9.3.2.8. or 9.3.2.9., respectively.**

9.3.2.6.1. Chemiluminescent detector (CLD)

If measured on a dry basis, the oxides of nitrogen analyzer shall be of the chemiluminescent detector (CLD) or heated chemiluminescent detector (HCLD) type with a NO_2/NO converter. If measured on a wet basis, a HCLD with converter maintained above 328 K (55 °C) shall be used, provided the water quench check (see paragraph 9.3.9.2.2.) is satisfied. For both CLD and HCLD, the sampling path shall be maintained at a wall temperature of 328 K to 473 K (55 °C to 200 °C) up to the converter for dry measurement and up to the analyzer for wet measurement.

9.3.2.6.2. Non-dispersive ultraviolet detector (NDUV)

A non-dispersive ultraviolet (NDUV) analyzer shall be used to measure NO_x concentration. If the NDUV analyzer measures only NO, a NO_2/NO converter shall be placed upstream of the NDUV analyzer. The NDUV temperature shall be maintained to prevent aqueous condensation, unless a sample dryer is installed upstream of the NO_2/NO converter, if used, or upstream of the analyzer.

9.3.2.7. Air to fuel measurement

The air to fuel measurement equipment used to determine the exhaust gas flow as specified in paragraph 8.4.1.6. shall be a wide range air to fuel ratio sensor or lambda sensor of Zirconia type. The sensor shall be mounted directly on the exhaust pipe where the exhaust gas temperature is high enough to eliminate water condensation.

9.3.2.8. Fourier Transform Infrared (hereinafter FTIR) analyzer

The FTIR employs the broad waveband infrared spectroscopy principle. It allows simultaneous measurement of exhaust components whose spectra are available in the instrument. The absorption spectrum (intensity/wavelength) is calculated from the measured interferogram (intensity/time) by means of the Fourier transform method.

The FTIR shall be installed in accordance with the instrument manufacturer's instructions. For the exhaust measurement the evaluation method has to be selected, which is specified by the instrument manufacture for the fuel type used. The sample path (sampling line, pre-filter(s) and valves) shall be made of stainless steel or PTFE and shall be heated to set point between 110 – 191 °C in order to minimise NH_3 losses and sampling artefacts. In addition, the sampling line shall be as short as practicably possible.

The spectral resolution of the laser shall ~~be within~~ have a nominal value $\leq$ 0.5 cm^{-1} in order to minimise cross interference from other gases present in the exhaust gas.

The portable analyzers shall be assessed according to CEN EN 17507:2021 (Road vehicles – Portable Emission Measuring Systems (PEMS) – Performance assessment).

9.3.2.8.1. The instrument manufacturer shall declare, in an “Analyzer compliance declaration”, which gases interfere with measured components and how strong the expected interference is depending on the fuel type and based on concentrations which can be generally expected at emission tests.

The instrument manufacturer shall specify for which range of fuel types the interferences specification applies. Especially spectrometer evaluations, like FTIR, may be tuned for individual fuel types (e.g.: Gasoline, Diesel, H_2, ethanol, or others).

The analyzer compliance declaration shall at least include:

- Analyzer type.
- Analyzer accuracy, noise, drift, linearity and repeatability specifications
- Required intervals between calibration and zero/span drift checks.
- Range of ambient conditions covered.
- Matrix including cross interference gases for each type of fuel for which the specifications apply. Cross interference specifications. The gases for which cross sensitivities exist and how large the maximum interferences are.
- The concentration/s of the gas/es used to check potential interferences.
- Types of fuels and fuel mixtures for which the specifications apply.
- In cases, where different analytical evaluation methods are applied, the definition which evaluation method shall be used, depending on the fuel used and test application.

On request of the authority, engineering data shall be made available, which are the base for such a compliance declaration.

The analyzer type shall be type-examined by an international or national metrological institute, which shall certify the requirements present in the compliance declaration and in the specifications included in paragraph 9.3.1. of this annex for the different types of fuels for which the analyzer type applies.

9.3.2.9. Laser Infrared Analyzer

A Quantum Cascade Laser mid-Infrared detection (QCL-IR) can emit coherent light in the near-infrared region or in the mid-infrared region respectively, where nitrogen compounds including NH_3 have strong absorption. These laser optics give a pulsed-mode high resolution narrow band near-infrared or mid-infrared spectrum. Therefore, laser infrared analyzers can reduce interference caused by the spectral overlap of co-existing components in engine exhaust gas.

The analyzer shall be installed either directly in the exhaust pipe (in-situ) or within an analyzer cabinet using extractive sampling in accordance with the instrument manufacturer's instructions. If installed in an analyzer cabinet, the sample path (sampling line, pre-filter(s) and valves) shall be made of stainless steel or PTFE and shall be heated to set point between 110 – 191 °C in order to ~~minimize~~ minimise NH_3 losses and sampling artefacts. In addition, the sampling line shall be as short as practicably possible.

The portable analyzers shall be assessed according to CEN EN 17507:2021 (Road vehicles – Portable Emission Measuring Systems (PEMS) – Performance assessment).

9.3.2.9.1. The instrument manufacturer shall declare, in an "Analyzer compliance declaration", which gases interfere with measured components and how strong the expected interference is depending on the fuel type and based on concentrations which can be generally expected at emission tests.

The instrument manufacturer shall specify for which range of fuel types the interferences specification apply.

The analyzer compliance declaration shall at least include:

- Analyzer type.
- Analyzer accuracy, noise, drift, linearity and repeatability specifications
- Required intervals between calibration and zero/span drift checks.
- Range of ambient conditions covered.
- Matrix including cross interference gases for each type of fuel for which the specifications apply. Cross interference specifications. For which gases cross sensitivities exist and how large the maximum interferences are.
- The concentration/s of the gas/es used to check potential interferences.
- Types of fuels and fuel mixtures for which the specifications apply.
- In cases, where different analytical evaluation methods are applied, the definition which evaluation method shall be used, depending on the fuel used and test application.

On request of the authority, engineering data shall be made available, which are the base for such a compliance declaration.

The analyzer type shall be type-examined by an international or national metrological institute, which shall certify the requirements present in the compliance declaration and in the specifications included in paragraph 9.3.1. of this annex for the different types of fuels for which the analyzer type applies."

Paragraph 9.3.9., amend the first paragraph to read:

"9.3.9. Interference effects

Other gases than the one being analyzed can interfere with the reading. **A check for interference effects and the correct functionality of analyzers shall be performed by the analyzer manufacturer prior to market introduction, at least once for each type of analyzer or device addressed in paragraph 9.3.2. except for paragraph 9.3.2.7. on 'Air to fuel measurement'**~~in several ways~~. Positive interference occurs in NDIR instruments where the interfering gas gives the same effect as the gas being measured, but to a lesser degree. Negative interference occurs in NDIR instruments by the interfering gas broadening the absorption band of the measured gas, and in CLD instruments by the interfering gas quenching the reaction. The interference checks in paragraphs 9.3.9.1. and 9.3.9.3. shall be performed prior to an analyzer's initial use and after major service intervals.

…"

Add a new paragraphs 9.3.9.5. and 9.3.9.6., to read:

"9.3.9.5. FTIR interference check

Due to the physical properties of a FTIR ~~analyser~~analyzer, interferences between some gases are possible. Compensation algorithms may be used to reduce interference effects. Compensation algorithms that are used during an emission test shall be active when performing interference checks.

Linearisation shall be done, as specified by the instrument manufacturer, at least annually or after major service intervals.

The spectral resolution of the laser or target wavelength shall ~~be within~~ have a nominal value ≤ 0.5 cm^{-1}~~0.5 per cm~~ in order to minimise cross interference from other gases present in the exhaust gas.

9.3.9.5.1. Procedure

9.3.9.5.1.1. Start the FTIR analyzer and wait long enough until all temperatures and pressures have reached their operation value. Create a new background as would be the case before an emission test.

9.3.9.5.1.2. Use a span gas to get a reference value for the measured component. Allow the analyzer to stabilise its reading. After that record its output for 30 seconds and calculate the arithmetic mean of this data. If the span gas is created by vaporising a liquid, avoid condensation at all parts of the system.

9.3.9.5.1.3. For different analyzer technologies different interference components shall be considered. The instrument manufacturer shall use good ~~technical~~ engineering judgement for checking and reporting gases interfering on target components as this depends on the wavelengths used to measure the target component.

Multi-component span gas or span mixtures that incorporates the target interference species and the specifications included in paragraph 9.3.3. of this annex shall be used~~It is allowable to run interference gases separately for each individual component or as a mixed gas~~.

9.3.9.5.1.4. The levels of the interference gases should be at least as high as expected during the emission tests. If the interference gas levels are higher than the maximum levels expected during testing, it is allowable to scale down each observed interference value.

9.3.9.5.1.5. Allow ~~all~~ gas~~es~~ to stabilise, then record 30 seconds of data and calculate the arithmetic mean. The combined interference shall be less than ~~[~~2 per cent of ~~full scale]~~the measured value or 2 ppm, whichever is larger.

~~9.3.9.5.1.6. The instrument manufacturer shall declare, in an "Analyzer compliance declaration", which gases interfere with measured components and how strong the expected interference is depending on the fuel type and based on concentrations which can be generally expected at emission tests.~~

~~The instrument manufacturer shall specify for which range of fuel types the interferences specification applies. Especially spectrometer evaluations, like FTIR, may be tuned for individual fuel types (e.g.: Gasoline, Diesel, H_2, ethanol, or others).includedof this annex~~

~~The analyzer compliance declaration shall at least include:~~

- ~~Analyzer type.~~
- ~~Analyzer accuracy, noise, drift and repeatability specifications~~
- ~~Required intervals between calibration and zero/span drift checks.~~
- ~~Range of ambient conditions covered.~~
- ~~Cross sensitivity specifications. Which gases exist cross sensitivities and how the maximum interferences are.~~
- ~~The concentration/s of the gas/es used to check potential interferences.~~
- ~~Types of fuels and fuel mixtures for which the specifications apply.~~
- ~~In cases, where different analytical evaluation methods are applied, the definition which evaluation method shall be used, depending on the fuel used and test application.~~

~~On request of the authority, engineering data shall be made available, which are the base for such a compliance declaration.~~

9.3.9.6. QCL-IR interference check

Due to the physical properties of a QCL-IR analyzer interferences between some gases are possible. The interference test shall be performed for the gas analyzers upon initial installation.

Linearisation shall be done, as specified by the instrument manufacturer, at least annually or after major service intervals.

The spectral resolution of the laser or target wavelength shall ~~be within 0.5 per cm~~ have a nominal value ≤ 0.5 cm^{-1} in order to minimise cross interference from other gases present in the exhaust gas.

9.3.9.6.1. Procedure

9.3.9.6.1.1. Start the QCL-IR analyzer and wait long enough until all temperatures and pressures have reached their operation value.

9.3.9.6.1.2. Use a span gas to get a reference value for the measured component. Allow the analyzer to stabilise its reading. After that, record its output for 30 seconds and calculate the arithmetic mean of this data. If the span gas is created by vaporising a liquid, avoid condensation at all parts of the system.

9.3.9.6.1.3. For different analyzer technologies different interference components shall be considered. The instrument manufacturer must use good ~~technical~~ engineering judgement for checking and reporting gases interfering on target components as this depends on the wavelengths used to measure the target component

Multi-component span gas or span mixtures that incorporates the target interference species and the specifications included in paragraph 9.3.3. of this annex shall be used.~~Interference checks may be performed using gas mixtures or separate gases for each component~~.

9.3.9.6.1.4. The levels of the interference gases should be at least as high as expected during the emission tests. If the interference gas levels are higher than the maximum levels expected during testing, it is allowable to scale down each observed interference value.

9.3.9.6.1.5. Allow ~~all~~ gas~~es~~ to stabilise, then record 30 seconds of data and calculate the arithmetic mean. The combined interference shall be less than ~~[~~2 per cent of the measured value~~full scale]~~ or 2 ppm, whichever is larger.

~~9.3.9.6.1.6. The instrument manufacturer shall declare, in an "Analyzer compliance declaration", which gases interfere with measured components and how strong the expected interference is depending on the fuel type and based on concentrations which can be generally expected at emission tests.~~

~~The instrument manufacturer shall specify for which range of fuel types the interferences specification apply.includedof this annex~~

~~The analyzer compliance declaration shall at least include:~~

~~- Analyzer type.~~

~~- Analyzer accuracy, noise, drift and repeatability specifications~~

~~- Required intervals between calibration and zero/span drift checks.~~

~~- Range of ambient conditions covered.~~

~~- Cross sensitivity specifications. Which gases exist cross sensitivities and how the maximum interferences are.~~

~~- The concentration/s of the gas/es used to check potential interferences.~~

~~- Types of fuels and fuel mixtures for which the specifications apply.~~

~~- In cases, where different analytical evaluation methods are applied, the definition which evaluation method shall be used, depending on the fuel used and test application.~~

~~On request of the authority, engineering data shall be made available, which are the base for such a compliance declaration.~~

"

Annex 4, Appendix 2

Paragraph A.2.1.2., amend to read:

"A.2.1.2. Description of the analytical system

Analytical system for the determination of the gaseous emissions in the raw exhaust gas (Figure 9) or in the diluted exhaust gas (Figure 10) are described based on the use of:

(a) HFID or FID analyzer for the measurement of hydrocarbons;

(b) NDIR analyzers for the measurement of carbon monoxide and carbon dioxide;

(c) HCLD or CLD analyzer for the measurement of the oxides of nitrogen;

(d) FTIR analyzer for the measurement of methane, carbon monoxide, carbon dioxide, oxides of nitrogen and water from the raw exhaust gas;

(e) **QCL-IR analyzer for the measurement of methane, carbon monoxide, carbon dioxide, oxides of nitrogen from the raw exhaust gas. "**

Paragraph A.5.2., add new row to read:

"A.5.2. Basic data for stoichiometric calculations

…

Molar mass of dry air	28.96559 g/mol
Molar mass of methane	**16.0425 g/mol"**

Annex 4

Add a new Appendix 9, to read:

"Annex 4 - Appendix 9

Procedure for the measurement of water (H_2O)

A.9.1. This appendix describes the procedure for measurement of water (H_2O). For non-linear analyzers, the use of linearising circuits shall be permitted.

A.9.2. The analyzer used for H_2O measurement shall meet the criteria specified in paragraph A.9.2.2.

When measuring H_2O, the H_2O ~~analyser~~ analyzer shall be calibrated with an accurately humidified gas using one of the options in paragraph A.9.5.

A.9.2.1. ~~[placeholder]~~ Quantum cascade laser mid-infrared detector (hereinafter QCL-IR) analyzer

A.9.2.1.1. Measurement principle

A quantum cascade laser mid-infrared detector (QCL-IR) can emit coherent light in the near-infrared region or in the mid-infrared region respectively, where H_2O have strong absorption. These laser optics give a pulsed-mode high resolution narrow band near-infrared or mid-infrared spectrum. Therefore, laser infrared analyzers can reduce interference caused by the spectral overlap of co-existing components in engine exhaust gas.

A.9.2.1.2. Installation and sampling

The analyzer shall be installed within an analyzer cabinet using extractive sampling in accordance with the instrument manufacturer's instructions.The H_2O wavelength shall be selected for evaluation.

The analyzer shall be heated and all surfaces that are exposed to emissions maintained at a temperature of ~~(~~110 to 191~~)~~ °C. In addition, the sampling line shall be as short as practically possible and the sampling point as close as practicably possible to that of the criteria gaseous pollutants analyzers.

A.9.2.1.3. Cross interference

The spectral resolution of the laser shall have a nominal value ≤ 0.5 cm^{-1} in order to minimise cross interference from other gases present in the exhaust gas.

Interference shall be verified for laser infrared analyzers using the procedures described in paragraph A.9.2.1.3.1.

Good engineering judgment shall be used to determine interference species for analyzer that are appropriate for each H_2O infrared

absorption band, or the interference species may be identified based on the instrument manufacturer's recommendations.

Note that interference species are dependent on the H_2O infrared absorption band chosen by the instrument manufacturer.

A.9.2.1.3.1. Interference verification for H_2O Laser Infrared Analyzer.

The amount of interference shall be determined after initial analyzer installation and after major maintenance.

If the analyzer uses compensation algorithms that utilise measurements of other gases to meet this interference verification, these other measurements shall be conducted simultaneously to test the compensation algorithms during the analyzer interference verification.

An H_2O laser infrared analyzer shall have a combined interference that is within (0.0 ± 0.4) mmol/mol

Procedure:

(1) Start, operate, zero, and span the H_2O laser infrared analyzer as would be the case before an emission test.

(2) Flow a multi-component span gas that incorporates the target interference species and the specifications included in paragraph 9.3.3. of this annex through the analyzer inlet. Use interference span gas concentrations that are at least as high as the maximum expected during testing.

(3) Allow time for the analyzer response to stabilise. Stabilisation time may include time to purge the transfer line and account for analyzer response.

(4) Record the analyzer output for 30 seconds while it measures the sample's concentration. Calculate the arithmetic mean of this data. When performed with all the gases simultaneously, this is the combined interference. The analyzer meets the interference verification if this value is within (0.0 ± 0.4) mmol/mol.

Interference verification procedures can be performed for individual interference species. If the concentration of any interference species used is higher than the maximum levels expected during testing, each observed interference value may be scaled down by multiplying the observed interference value by the ratio of the maximum expected concentration value to the concentration in the span gas. The sum of the scaled interference values must meet the tolerance for combined interference.

A.9.2.2. **Fourier Transform Infrared (hereinafter FTIR) analyzer**

A.9.2.2.1. **Measurement principle**

The FTIR employs the broad waveband infrared spectroscopy principle. It allows simultaneous measurement of exhaust components whose spectra are available in the instrument. The absorption spectrum (intensity/wavelength) is calculated from the measured interferogram (intensity/time) by means of the Fourier transform method.

A.9.2.2.2. Installation and sampling

The FTIR shall be installed in accordance with the instrument manufacturer's instructions. For the exhaust measurement the evaluation method has to be selected, which is specified by the instrument manufacture for the fuel type used. The FTIR analyzer shall be heated and all surfaces that are exposed to emissions maintained at a temperature of 110 to 191 °C. In addition, the sampling line shall be as short as practicably possible and the sampling point as close as practicably possible to that of the criteria gaseous pollutants analyzers.

A.9.2.2.3. Cross interference

The spectral resolution of the H_2O wavelength shall be ~~within~~ have a nominal value ≤ 0.5 cm^{-1}~~0.5 per cm~~ in order to minimise cross interference from other gases present in the exhaust gas.

CO_2 interference shall be verified for FTIR analyzers using the procedures described in paragraph A.9.2.2.3.1.

Good engineering judgment shall be used to determine other interference species for FTIR analyzers. Possible interference species include, but are not limited to: CO, NO, C_2H_4, and C_7H_8. Interference verification shall be performed using the procedures described in paragraph A.9.2.2.3.1., replacing occurrences of CO_2 with the targeted interferent species.

This verification for CO_2 may be omitted for engines operating only on hydrogen.For each analyzer the H_2O infrared absorption band shall be determined. For each H_2O infrared absorption band, good engineering judgment shall be used to determine interference species to use in the verification.

A.9.2.2.3.1. CO_2 interference verification for H_2O FTIR analyzers

The amount of CO_2 interference shall be determined after initial analyzer installation and after major maintenance.

If the FTIR analyzer uses compensation algorithms that utilise measurements of other gases to meet this interference verification, these other measurements shall be conducted simultaneously to test the compensation algorithms during the analyzer interference verification.

An H_2O FTIR analyzer shall have a CO_2 interference that is within (0.0±0.4) mmol/mol.

Procedure:

(1) Start, operate, zero, and span the H_2O FTIR analyzer as would be the case before an emission test.

(2) Flow a multi-component span gas that incorporates the target interference species and the specifications included in paragraph 9.3.3. to this annex through the analyzer inlet. Use interference span gas concentrations that are at least as high as the maximum expected during testing~~Use a CO_2 span gas that meets the specifications of paragraph 9.3.3. to this annex and a concentration that is approximately the maximum CO_2 concentration expected during emission testing~~.

~~(3) Introduce the CO_2 test gas into the sample system.~~

(43) Allow time for the analyzer response to stabilize. Stabilisation time may include time to purge the transfer line and to account for ~~analyser~~ analyzer response.

(~~5~~4) While the analyzer measures the sample’s concentration, record 30 seconds of sampled data. Calculate the arithmetic mean of this data. When performed with all the gases simultaneously, this is the combined interference. The analyzer meets the interference verification if this value is within (0.0 ± 0.4) mmol/mol.

Interference verification procedures can be performed for individual interference species. If the concentration of any interference species used is higher than the maximum levels expected during testing, each observed interference value may be scaled down by multiplying the observed interference value by the ratio of the maximum expected concentration value to the concentration in the span gas. The sum of the scaled interference values must meet the tolerance for combined interference.

A.9.3. Emissions test procedure and evaluation

A.9.3.1. Checking the analyzers

Prior to the emissions test, the analyzer range shall be selected. Emission analyzers with automatic or manual range switching shall be permitted. During the test cycle, switching of analog amplifiers in the ~~analyser~~ analyzer shall not be allowed.

Zero and span response shall be determined, if the provisions of paragraph A.9.3.4.2. do not apply for the instrument. For the span response, a H_2O gas that meets the specifications of paragraph A.9.5. shall be used.

A.9.3.2. Collection of emission relevant data

The H_2O data collection shall be commenced before the start of the test sequence. The H_2O concentration shall be measured continuously and stored with at least 1 Hz on a computer system.

A.9.3.3. Operations after test

At the completion of the test, sampling shall continue until system response times have elapsed. Determination of analyzer's drift according to paragraph A.9.3.4.1. shall only be required if the information in paragraph A.9.3.4.2. is not available.

A.9.3.4. Analyzer drift

A.9.3.4.1. As soon as practical but no later than 30 minutes after the test cycle is complete or during the soak period, the zero and span responses of the analyzer shall be determined. The difference between the pre-test and post-test results shall be less than 2 per cent of full scale.

A.9.3.4.2. Determination of analyzer drift is not required in the following situations:

(a) If the zero drift and span drift specified by the instrument manufacturer in paragraphs A.9.4.2.3. and A.9.4.2.4. meet the requirements of paragraph A.9.3.4.1.,

(b) The time interval for zero drift and span drift specified by the instrument manufacturer in paragraphs A.9.4.2.3. and A.9.4.2.4. exceed the duration of the test.

A.9.4. Analyzer specification and verification

A.9.4.1. Linearity requirements

The analyzer shall comply with the linearity requirements specified in Table 7 of this annex. The linearity verification in accordance with paragraph 9.2.1. of this annex, shall be performed at least every 12 months or whenever a system repair or change is made that could influence linearity.

For the linearity verification, purified nitrogen or purfied synthetic air meeting the requirements in Annex 4 paragraph 9.3.3.1. and H_2O contamination ≤5 µmol/mol shall be used.

Instruments, whose signals are used for compensation algorithms, shall meet the linearity requirements specified in Table 7 of this annex. Linearity verification shall be done as required by internal audit procedures, by the instrument manufacturer or in accordance with ISO 9000 requirements.

Note that the system shall meet the linearity verification in using a water generation system that meets the requirements of paragraph A.9.5.

A.9.4.2. Analyzer specifications

~~[~~A.9.4.2.1. ~~Minimum detection limit~~

~~The analyzer shall have a minimum detection limit of [xx] under all conditions of testing.~~Reserved~~]~~

A.9.4.2.2. Accuracy

The accuracy, defined as the deviation of the analyzer reading from the reference value, shall not exceed ±2 per cent of the reading or ±0.3 per cent of full scale, whichever is greater.

A.9.4.2.3. Zero drift

The drift of the zero response and the related time interval shall be specified by the instrument manufacturer.

A.9.4.2.4. Span drift

The drift of the span response and the related time interval shall be specified by the instrument manufacturer.

A.9.4.2.5. System response time

The system response time shall be ≤ 10 seconds.

A.9.4.2.6. Rise time

The rise time of the analyzer shall be ≤ 2.5 seconds.

A.9.4.2.7. Noise

The analyzer peak-to-peak response to zero and calibration or span gases over any 10 seconds period shall not exceed ± 1 per cent of the maximum value.

~~[~~A.9.5. H_2O calibration gas

A gas mixture with the following chemical composition shall be available. The H_2O calibration gas may be created with a calibration gas generator that meets the uncertainty requirement for the H_2O calibration gas.

H_2O in purified air or purified nitrogen.

H_2O calibration gases shall be generated with a humidity generator.

The H_2O concentration uncertainty shall be within ±3% of reading (Note it is not ±3% of absolute H_2O humidity).~~]~~

A.9.6. Alternative systems

Other systems or ~~analysers~~ analyzers may be approved by the Type Approval Authority, if it is found that they yield equivalent results in accordance with paragraph 5.1.1. of this annex."

Annex 8

Paragraph 10.1.7.1., the following paragraph is added*:*

"10.1.7.1a Odometer reading at test end ~~[~~(km)~~]~~ "

Paragraph 10.1.8., the following new paragraphs are added:

"…

10.1.8a. OBFCM instantaneous measured data (if applicable)

10.1.8a.1~~8~~. Total fuel consumed (lifetime) (~~kilograms~~kg)

10.1.8a.2~~19~~. Total fuel consumed (lifetime) (litres)

10.1.8a.~~20~~3. Total distance travelled (lifetime) (~~kilometres~~km)

10.1.8a.4~~21~~. Engine fuel rate (g/s)

10.1.8a.~~22~~5. Engine fuel rate (l/h)

10.1.8a.~~23~~6. Vehicle fuel rate (g/s)

10.1.8a.~~24~~7. Vehicle total mass (kg)"

Paragraph 10.1.10., the following new paragraphs are added*:*

"…

10.1.10a.~~13.~~ OBFCM values (if applicable)

10.1.10a.1~~13a~~. Total fuel consumed (lifetime) (litres) at test start

10.1.10a.2~~13b~~. Total fuel consumed (lifetime) (litres) at test end

10.1.10a.3~~13c~~. Total fuel consumed (lifetime) (~~kilograms~~kg) at test start

10.1.10a.4~~13d~~. Total fuel consumed (lifetime) (~~kilograms~~kg) at test end

10.1.10a.5~~13e~~. Total distance travelled (lifetime) (~~kilometres~~km) at test start

10.1.10a.~~13f~~6. Total distance travelled (lifetime) (~~kilometres~~km) at test end

10.1.10a.7~~13g~~. Accumulated Engine fuel rate (l)

10.1.10a.8~~13h~~. Accumulated Engine fuel rate (g)

10.1.10a.9~~13i~~. Accumulated Vehicle fuel rate (g)

10.1.10a.10~~13j~~. Average of vehicle total mass"

Paragraph 10.1.7., the following new paragraph is added:

"10.1.7.8. Actual mass of the vehicle for the PEMS test with payload (kg) "

Annex 8

Appendix 1

Paragraph A.1.1., add a new paragraph at the end to read:

"A.1.1. …

For dual-fuel engines of Type 1A with hydrogen as main fuel, separate measurement of CH_4 and NMHC shall not be mandatory and total hydrocarbon (THC) emissions shall be measured instead. The emission limit for the THC emissions as defined in paragraph 5.3. of this Regulation shall apply. For the purposes of the calculation of the conformity factors pursuant to paragraph A.1.4.2.3., the applicable limit shall in that case be the THC emission limit only. Furthermore, for dual-fuel engines of Type 1A with hydrogen as main fuel, lambda and optionally air mass flow shall be measured as well to enable the data consistency check as described in paragraph A.1.3.2."

Paragraph A.1.2.1., add a new paragraph to read:

"…

A.1.2.1.6. A connection with the vehicle OBFCM device, if applicable."

Paragraph A.1.2.2., Table 1, add the following new rows:

"A.1.2.2. …

…	…	…
Vehicle longitude	degree	GPS
H_2O concentration [8]	**per cent**	**Gas ~~analyser~~analyzer**
Total fuel consumed (lifetime)	**kg**	**OBFCM device or ECU (if applicable)**
Total fuel consumed (lifetime)	**l**	**OBFCM device or ECU (if applicable)**
Total distance travelled (lifetime)	**km**	**OBFCM device or ECU (if applicable)**
Engine fuel rate	**g/s**	**OBFCM device or ECU (if applicable)**
Engine fuel rate	**l/h**	**OBFCM device or ECU (if applicable)**
Vehicle fuel rate	**g/s**	**OBFCM device or ECU (if applicable)**
Vehicle total mass	**kg**	**OBFCM device or ECU (if applicable)**

"

Paragraph A.1.2.2. Table 1, the footnotes are amended and added to, to read:

"*Notes:*

…

[6] Only for engines where ~~**all**~~ **one of** the fuels used ~~**have**~~ **has** a molar carbon to hydrogen ratio of 0 as defined in paragraph 8. of Annex 4.

[7] Optional for engines where ~~**all**~~ **one of** the fuels used ~~**have**~~ **has** a molar carbon to hydrogen ratio of 0 as defined in paragraph 8. of Annex 4

[8] For dual-fuel engines where one of the fuels used has a molar carbon to hydrogen ratio of 0 as defined in paragraph 8. of Annex 4

"

~~*Paragraph A.1.2.4.*, the following new paragraph is added:~~

~~"…~~

~~**A.1.2.4.8. OBFCM device**~~

~~**If an engine of the engine family is installed in a vehicle equipped with an on-board device for the monitoring and recording of fuel and/or energy consumption and mileage of motor vehicles [in accordance with requirements referred to in relevant regional legislation], then the test engine shall be equipped with this on-board device."**~~

Paragraph A.1.2.6.1., add a new paragraph at the end to read:

"A.1.2.6.1. …

Where applicable, the recording of the parameters set out in Table 1 as determined by the OBFCM device shall start at the test start."

Paragraph A.1.2.6.2., add a new paragraph at the end to read:

"A.1.2.6.2. …

Where applicable, the recording of the parameters set out in Table 1 as determined by the OBFCM device shall continue throughout the normal in-use operation of the engine."

Paragraph A.1.2.6.3., add a new paragraph at the end to read:

"A.1.2.6.3. …

Where applicable, the recording of the parameters set out in Table 1 as determined by the OBFCM device shall end at the test end. The odometer reading shall be recorded at the test end."

Paragraph A.1.3.2.1., amend the first paragraph to read:

"A.1.3.2.1. The consistency of the data (exhaust mass flow measured by the EFM and gas concentrations) shall be verified using a correlation between the measured fuel flow from the ECU and the fuel flow calculated using the formula in paragraph 8.4.1.7. of Annex 4 to this Regulation. If the molar carbon to hydrogen ratio of ~~all~~ **one of** the fuels used is 0 as defined in paragraph 8. of Annex 4, then the formula in paragraph 8.4.1.6. of Annex 4 shall be used instead with **lambda and air mass flow measured in accordance with paragraph A.1.1**. **In this case equations 30 and 31 shall be applied for Type 1A dual-fuel hydrogen engines with α, γ, δ and ε being determined according to paragraph A.6.2. of Appendix 6 to Annex 15 and β being set to zero (β=0).**

$y = mx + b$

…"

Paragraph A.1.4.1., add a new second sentence to the first paragraph to read:

"A.1.4.1. The emissions shall be integrated using a moving averaging window method, based on the reference CO_2 mass or the reference work. **For Type 1A dual-fuel hydrogen engines the moving averaging window method shall be based on the reference work.** The principle of the calculation is as follows: …"

Paragraph A.1.4.3., amend to read:

"A.1.4.3. CO_2 mass based method

For Type 1A dual-fuel hydrogen engines this CO_2 mass based method shall not be used in accordance with paragraph A.1.4.1. of this appendix.

Figure 3

…"

Annex 10

Appendix 1

Paragraph A.1.5.1., the following point is inserted after point (j):

"A.1.5.1. …

(k) Information about instantaneous measured OBFCM values as described in paragraphs 10.1.8a.1~~.18.~~ to 10.1.8a.7~~.24.~~ of Annex 8, and averaged and integrated OBFCM values as described in paragraphs 10.1.10a.1~~13.~~ to 10.1.10a.10~~13j.~~ of Annex 8."

Annex 15

Paragraph 4.2.2.3., amend to read:

"4.2.2.3. Repair and maintenance of LNG **or hydrogen** Type A dual-fuel engines and vehicles.

In the case of LNG **or hydrogen** Type A dual-fuel engines and vehicles, the manufacturer may, instead of limiting the vehicle speed at 20 km/h, opt for limiting the power of the engine to 20 per cent of the declared maximum power in dual-fuel mode, and this at any engine speed, when the service mode is activated during a repair or maintenance operation."

Paragraph 6.1., amend text before Table 1 to read:

"6.1. Dual-fuel engines shall be subject to the laboratory tests specified in Table 1.

For dual-fuel engines of Type 1A with hydrogen as main fuel, separate measurement of CH_4 and NMHC shall not be mandatory and the total hydrocarbon (THC) emissions shall be measured instead. The emission limit for the THC emissions as defined in paragraph 5.3. of this Regulation shall apply."

Paragraph 10.3., amend to read:

"10.3. Additional dual-fuel specific CO_2 determination provisions

Section 3.1. of Annex 12 regarding the determination of CO_2 emissions in case of raw measurement is not applicable to dual-fuel engines. Instead the following provisions shall apply:

The measured test-averaged fuel consumption according to section 4.3. of Annex 12 shall be used as the base for calculating the test averaged CO_2 emissions.

The mass of each fuel consumed shall be used to determine, according to section A.6.4. of this annex, the molar hydrogen ratio and the mass fractions of the fuel mix in the test.

The total fuel mass shall be determined according to equations 23 and 24.

For Type 1A dual-fuel hydrogen engines the cycle averaged fuel consumption determined in accordance with paragraph 4. of Annex 12 for the diesel fuel only shall be used to determine the CO_2 emissions resulting from fuel, $m_{CO2,fuel}$, according to equation 24. For the molar hydrogen ratio in equation 24 the value defined in paragraph 8. of Annex 4 for diesel fuel shall be used.

$$m_{fuel,corr} = m_{fuel} - (m_{THC} + \frac{A_C + \alpha \times A_H}{M_{CO}} \times m_{CO} + \frac{w_{GAM} + w_{DEL} + w_{EPS}}{100} \times m_{fuel}) \qquad (23)$$

$$\xcancel{m_{CO_2,fuel} = \frac{M_{CO_2}}{A_C + \alpha \times A_H} \times m_{fuel,corr}}$$ ~~(24)~~

$$\mathbf{m_{CO_2,fuel}} = \frac{\boldsymbol{\beta} \times \mathbf{M_{CO_2}}}{\boldsymbol{\beta} \times \mathbf{A_C} + \boldsymbol{\alpha} \times \mathbf{A_H}} \times \mathbf{m_{fuel,corr}} \qquad \mathbf{(24)}$$

where:

$m_{fuel,corr}$	is the corrected fuel mass of both fuels, g/test
m_{fuel}	total fuel mass of both fuels, g/test
m_{THC}	mass of total hydrocarbon emissions in the exhaust gas, g/test
m_{CO}	mass of carbon monoxide emissions in the exhaust gas, g/test
$m_{CO2,fuel}$	CO_2 mass emission coming from the fuel, g/test
w_{GAM}	sulphur content of the fuels, per cent mass
w_{DEL}	nitrogen content of the fuels, per cent mass
w_{EPS}	oxygen content of the fuels, per cent mass
α	molar hydrogen ratio of the fuels (H/C)

A_C	is the Atomic mass of Carbon: 12,011 g/mol
A_H	is the Atomic mass of Hydrogen: 1,0079 g/mol
M_{CO}	is the Molecular mass of Carbon monoxide: 28,011 g/mol
M_{CO2}	is the Molecular mass of Carbon dioxide : 44,01 g/mol
β	**is the molar carbon ratio of the fuel, with β=1 for fuels containing carbon and β=0 for fuels with a molar carbon to hydrogen ratio of 0 as defined in paragraph 8. of Annex 4**

The CO_2 emission resulting from urea shall be calculated with equation 25:

$$m_{CO_2,urea} = \frac{c_{urea}}{100} \times \frac{M_{CO_2}}{M_{CO(NH_2)_2}} \times m_{urea} \tag{25}$$

where:

$m_{CO2,urea}$	CO_2 mass emission resulting from urea, g/test
c_{urea}	urea concentration, per cent
m_{urea}	total urea mass consumption, g/test
$M_{CO(NH2)2}$	is the Molecular mass of urea: 60,056 g/mol

Then the total CO_2 emission shall be calculated with equation 26:

$$m_{CO_2} = m_{CO_2,fuel} + m_{CO_2,urea} \tag{26}$$

The brake specific CO_2 emissions, e_{CO2} shall then be calculated according to section 3.3. of Annex 12."

Annex 15

Appendix 4

Paragraph A.4.3.1., amend first paragraph and insert a new paragraph at the end, to read:

"A.4.3.1. The recommended measurement procedure for dual-fuel engines is procedure (b) listed in paragraph 7.1.3. of Annex 4 (CVS system). **This recommendation shall not apply for dual-fuel hydrogen engines.**

…

For Type 1A dual-fuel hydrogen engines method (a) listed in paragraph 7.1.3. of Annex 4 (raw gaseous/partial flow measurement) shall be used. Fixed values for fuel parameters and u_{gas}-values shall be applied as described in Appendix 6 of this annex. The methods defined in paragraphs A.4.4.1.2. and A.4.4.4. shall not be used."

Paragraph A.4.4.1.1., add an additional paragraph at the end to read:

"A.4.4.1.1. …

For Type 1A dual-fuel hydrogen engines Equation 15a in Annex 4, paragraph 8.1.1. shall be used to calculate the dry/wet correction instead of Equations 15 and 17."

Paragraph A.4.4.3.1., add an additional paragraph at the end to read:

" A.4.4.3.1. …

In case the airflow and air to fuel ratio measurement method according to paragraph 8.4.1.6. of this Regulation is used for Type 1A dual-fuel hydrogen engines, equations 30 and 31 shall be applied with α, γ, δ and ε

being determined according to paragraph A.6.2. of Appendix 6 to this annex and β being set to zero (β=0)."

Paragraph A.4.4.3.3., add an additional paragraph at the end to read:

"A.4.4.3.3. …

In case the airflow and air to fuel ratio measurement method according to paragraph 8.4.1.6. of this Regulation is used for Type 1A dual-fuel hydrogen engines, Equations 30 and 31 shall be applied with α, γ, δ and ε being determined according to paragraph A.6.2. of Appendix 6 to this annex and β being set to zero (β=0)."

II. Justification

Dual-fuel hydrogen engine and vehicle related proposals

1. Hydrogen fuelled engines could be a complementary option to reduce CO_2 emissions of future heavy-duty vehicles.

2. Hydrogen mono-fuel engines and vehicles are already covered in UN Regulation No. 49, however hydrogen dual-fuel engines and vehicles are not yet possible to be type-approved. This proposal introduces the requirements in UN Regulation No. 49 to accommodate type-approval of Type 1A hydrogen dual-fuel, as done for hydrogen mono-fuel.

3. Validation of the procedures presented in this proposal has been performed on Type 1A hydrogen dual-fuel engines.

4. The equivalency of the instruments measuring gaseous criteria pollutants and CO_2, as well as the measurement of water using FTIR, can be found in the following JRC study:

   "*Alternative Analyzers for the Measurement of Gaseous Compounds During Type-Approval of Heavy-Duty Vehicles*", available at: doi.org/10.3390/en17225676

HDV OBFCM related proposals

5. The European Union has set CO_2 emission targets for heavy-duty vehicles towards 2040.

6. The effectiveness of these targets is strongly dependent on the real-world representativeness of the methodology used for determining the CO_2 emissions. Therefore, the EU is putting in place a mechanism to assess the real-world representativeness of the CO_2 emission and energy consumption values determined with VECTO through on-board fuel and/or energy consumption monitoring (OBFCM) devices.

7. These OBFCM devices are being introduced in the EU, and to ensure that the data provided by these devices remain representative during the use of the vehicles, while minimising the additional testing burden, the accuracy of these devices should be verified during the regulatory procedures, such as the PEMS test.

8. Therefore, a targeted supplement to the UNR49 Regulation should enable the relevant OBFCM data to be collected during the PEMS.