Title

The title changed to “Particle Number (PN) Measurement for the Periodical Technical Inspection (PTI) of vehicles equipped with compression ignition engines” after a comment from NL

1. Scope

CITA: M, N vehicles starting from euro 5, V (please use international vehicle classification and euro norm of date). To open the possibility for L vehicles, mainly quadricycles, when appropriate.

DE: a) Bus – A bus is also a commercial vehicle, why it should be separately mentioned? If you want that buses or other categories are not included it’s better to exclusive it or name categories (N;M).

b) Please include the approval status for clarification

NL: Buses with EURO VI engines can be added

AT: The current definition means that Euro 5b (first registration from 1 January 2013) and Euro VI (first registration from 1 January 2014) fall into the scope. It is understood that the legal aspect that vehicles, which were not subject to a PN limit during type approval, could not be subject to a PN limit during roadworthiness testing. As different studies show, vehicles equipped with diesel particulate filters (DPF) can easily meet the suggested PN limit. Thus, it seems justified to include vehicles type approved with a DPF, even if they did not have a PN limit for type approval (i. e. earlier than Euro 5b and Euro VI). A main purpose for PN measurements is to detect defect or tampered DPF during roadworthiness tests and road side inspections, which could be supported by a broader scope.

EGEA: (ASA) a) Bus – A bus is also a commercial vehicle, why it should be separately mentioned? If you want that buses or other categories are not included it’s better to exclusive it or name categories (N;M).

b) What does this mean? Euro 5b onwards?

ES: “~~all passenger cars, commercial vehicles and buses~~ vehicles included in the scope of Regulation (EU) 715/2007 and Regulation (EU) 595/2009 equipped with compression ignition engines. ~~and a solid PN limit applicable during their type approval~~ -> Where does this provision come from?

BE: M, N vehicles starting from euro 5, V (please use international vehicle classification and euro norm of date). There is also fraud by euro 5 and euro 5a cars with compression ignition engines. These cars have only a solid PM limit applicable during their type approval. This PM limit can not be realised without a particulate filter or with a fully defective particulate filter. We support the idea to include also euro 5, V vehicles with compression ignition engines with “a solid PM limit”.

PL: It seems that PTI inspector not always has access to approval database and knowledge if the solid PN limit was applicable during approval for tested car. Perhaps more efficient solution would be to indicate the date of the first registration (i.e. 1st January 2013) taking into account final production batches.

Reply

After suggestions of different MS and organizations the following changes were done:

i) Vehicle categories that will be included in PN-PTI tests are M and N (CITA, DE, EGEA, BE)

ii) The date of registration was specified (light-duty vehicles registered after 1st January 2013 and heavy duty after 1st January 2014) instead of the Euro approval as the latter is not always available.

ES proposed to replace the vehicle's type and Euro standard with the following: "vehicles included in the scope of Regulation (EU) 715/2007 and Regulation (EU) 595/2009 equipped with compression ignition engines." This change was not done because also Euro 5a vehicles would have been included. Instead, we wanted to include only vehicles from Euro 5b (2013+) and to avoid confusion with heavy-duty Euro V.

AT proposed the inclusion of all vehicles with DPF. This change was not done because broadening the scope of PN testing to Euro 4 vehicles with DPF may privilege vehicle owners without DPF as they don't undergo any test.

2. Terms and Definitions

CITA: Add the "Volatile Particle Remover" definition

DE: a) Cross check with the International Vocabulary of Metrology (VIM), JCGM is recommended

b) Add: DC technology, CPC technology, counting efficiency, volatile particles

c) Potentially add: HEPA filter, Measuring range, Resolution of indication, monodisperse/polydisperse aerosol particles, volatile particle remover

NL: Volatile Particle Remover, Gas (pre)conditioning, Cyclone separator, Data system, Counting efficiency

AT: As already clarified by the Commission at the meeting of the RWEG, definitions should be in line with the definitions in the type-approval legislation.

EGEA: a) (CAPELEC) Cross check with the VIM is recommended, b) (ASA) Definitions e.g. regarding the different technologies such as DC technology, CPC technology; counting efficiency; volatile particles, c) Add Volatile particle remover, zero-setting facility, verification, maintenance, adjustment, reference (quantity) value, measurement error, relative error, fault, significant fault.

BE: a) PN-PTI can also be used during road inspections and not only during PTI's. A suitable name could be PN-TI instrument. b) Additional definitions: i) Counting efficiency: The counting efficiency is defined as the ratio of the PN-PTI instrument and the reference instrument readings, ii) Operational hours in measurement mode: …, iii) Volatile Particle Remover

Reply

In this section, the received comments suggested the harmonization of terminology with the International Vocabulary of Metrology (VIM) (DE, EGEA) and the type-approval legislation (AT). Moreover, several terms were proposed to be added in the list of definitions. After suggestions of different MS and organizations the following changes were done:

i) Some definitions were changed; HEPA filter (the new definition is in agreement with PTB requirements), particles (combination of initial definition and 2017/1151 Regulation definition), response time (according to VIM 4.23), particle size (according to De Carlo et al., 2004)

ii) The following definitions were added; PN-PTI instrument type, particle detector (similar definition to VIM), CPC (PTB), counting efficiency, measuring range (from VIM), Resolution of the displaying device (from VIM), Monodisperse and polydisperse particles (PTB), measurement error (VIM), maximum measurement error (VIM), Rated operating conditions (VIM), Disturbance (OIML D 11:2004, 3.13.1.), reference operating conditions (VIM), zero-setting or zero level facility or procedure (similar to VIM), verification (VIM), maintenance (EGEA), adjustment (VIM), significant fault (similar to OIML R99 1 & 2), Metrological traceability (VIM), Expanded uncertainty (VIM), Measurement result (VIM),

Test result, legally relevant software (OIML R99), sample-preconditioning device, vehicle OBD information, correction (VIM 2.53), National metrological institute

iii) We removed motor vehicle (the term “vehicle” is used in the revised version) and aerosol (substituted with “particles” in the revised version)

Some of the terms that were proposed to be added are not included in the document (e.g. the “Volatile Particle Remover” which is already included in the “Sample-Preconditioning device” definition). Moreover, the instrument used at this application remains as initially reported (PN-PTI instrument).

3. Description of the instrument and inscription

Description

CITA: “Particle sample shall not pass through a filter before passing through the detection device(s)” Not possible for cyclone separator with filter [current in use in some equipment]. This penalizes the countries pioneering PN counting in PTI without a clear impact on the air quality.

DE: i) “Sampling probe” The length of 0.3 m is not possible on all vehicles, because tailpipe constructions aren’t fixed in the type approval legislation e.g. EURO VI trucks is extremely difficult. The construction of the probe should allow to input the probe 30 cm into the pipe. ii) “Dilution unit” is needed to avoid agglomeration of the soot particles in sampling line and to guarantee optimal operation mode of particle counter, iii)“it is permissible that the particle detector also pre-conditions the gas (aerosol)” Not only the particle detector itself can precondition, the complete device could do the pre-conditions, iv)“Pump” Replace pumps with device, because you can use other devices than pumps to convey the gas through the system & “the particles shall not pass through a pump…” Same replace, v)“However, the particles sample shall not pass through a filter before passing through the detection device(s)” This sentence is difficult and excludes devices or filters for removing big particles, but exactly this should be done to prevent destroying sensitive devices such as detection device e.g. by big particles or water droplets. It’s better to write neutral that such devices should not have influence to the particle range we want to measure. It should be allowed to remove certain particles by cyclons/diffusion grids or impactors which you can understand also under the definition filter, vi)“Ports –for infield calibration- …… reference particles sample-s-

NL: i)A sampling probe that can be introduced at least 0,3 m in the tail pipe of an operating motor vehicle to collect the exhaust gas sample; ii) Filter(s) to remove particles that could cause contamination of various sensitive parts of the PN-PTI instrument and for example to provide clean air for zero-setting; However, the particles sample shall not pass through a filter before passing through the detection device(s). -> Not possible for cyclone separator with filter, iii)Much of these features are decisions of the manufacturer

EGEA: Check DE and CITA comments

BE: The same comment on the cyclone separator + full stops at the end of the sentences

+ An interface with an existing system to exchange data with the PN-TI instrument;
- A logging device to capture and store data.

PL: The immersion depth of the exhaust gas sampling probe was determined to be at least 0.3 m, the same as for the measurement of vehicles equipped with SI engines. In our opinion, it is more important that the inlet of the exhaust gas sampling probe does not touch the wall of the exhaust pipe, on which various types of contaminants accumulate during the engine work. The mechanical contact of the exhaust gas sampling probe tip had a much greater impact on the measurement result than the immersion depth. Regardless of whether it was 10cm, 20cm or 30cm, the recorded result of the PN concentration, during our measurements and the final result were at a similar level.

Reply

After comments received by DE, EGEA, and PL on tailpipe shapes that do not let sampling in a depth of 0,3 m, it was decided to change the original text and add that the sampling probe design shall permit the user to take samples from at least 0,05 m. Moreover, after proposal of PL it was specified in the instrument description (and measurement procedure) that the inlet of the sampling probe shall not touch the wall of the exhaust tail pipe.

The provision that particles cannot pass through filters upstream the particle detector was removed due to concerns about the use of cyclone separators which are considered filters by some (CITA, DE, EGEA, NL). Filters can be used also during the zero-setting procedure (NL). Furthermore, the term "pump" was replaced with device (DE, EGEA) and the specification that ports are used for in-field verifications was added. Moreover, we added that a logging device shall capture and store data (BE).

The proposal that the entire device could do the aerosol preconditioning was not added as it is not excluded and in any case gas preconditioning is optional. The option to have a dilution unit was added.

Inscription & Operating instructions

DE: "The particle counter shall bear an inscription of the minimum and nominal flow rates" -> TO ADD: Temperature range, measuring range, ambient pressure range, humidity range, warm up time. As described in regulation 2014/32 (MID) Annex 1 chapter 9 or in most national regulations, this information should be on the instrument label or separate label, only if the instrument is too small it´s allowed in the manual, To add in the operating instructions a regularly calibration interval

DK: Add in the inscription the calibration date/interval/acceptance criteria, Add in the operating instructions the calibration interval and service interval

NL: For inscriptions there may be national requirements for special signs, characters etc., Operating instructions: Define the maximum length of sample lines

EGEA: Inscriptions: DE comment (1), extra information according national requirements, Operating instructions: Control lines is not clear, "A list of error messages with explanations" -> data exchange with PTI/test lane software management,

ES: model designation instead of number, Create point vi in inscriptions

BE: Inscription: A CE- mark (CE-label) should be necessary, Operating instructions: The maximum and minimum storage temperatures, humidity and pressures; The maximum and minimum operation temperatures, humidity and pressures;

Reply

According to DE comments, the inscription and operating instructions were aligned with Regulation 2014/32 (MID) Annex 1 chapter 9 and OIML R99. More information was asked for the inscription. Additional national requirements were not included (NL). The request regarding data exchange with PTI/test lane software management was not clear and not added. Model number was removed (ES). The maximum length of the sampling lines was not added as we consider that the manufacturer shall decide this. In any case, the PN-PTI instrument shall pass the counting efficiency tests. Following the DK proposal, the last verification date was added as a requirement but in a different label as it should be renewed every year. Finally, the CE-marking was not added (BE) but instead it was better clarified which information for the type examination should be present.

4. Metrological requirements

Indication of the measurement result

DE & EGEA: Also cm-3 should be allowed. #/cm3 is not allowed in PTB-Spec.

EGEA: Check also VIM (EGEA) and report which units are allowed

Reply

The unit "cm^{-3}" was added as an option. The unit #/cm^3 remained as the symbol # is used in the European regulation (2017/1151)

Measuring range

NL: Why not define "less than 5000 1/cm^3 to twice the PTI-PN-limit value". Measuring range depends on the PTI-PN-limit value.

EGEA: Measuring range: 500 000 (with accuracy) Display range (other colour/ blinking: over 500 000 up to 5 M)

BE: The minimum range shall be from "zero level" tot 5.000.000 #/cm^3 (BE), In Belgium the specifications for the PN test are

- PN-test PASS if measured PN-value ≤ 250.000 #/cm^3
- PN test PASS but a warning will be given : if 250.000#/cm^3 < measured PN-value ≤ 1.000.000 #/cm^3
- PN-test FAIL if 1.000.000 #/cm^3 < measured PN-value

In the proposal, the maximum value was set at 500,000 particles / cm3. The measuring range of the devices at our disposal ended at 10,000,000 particles / cm3. Maybe it would be more correct to set the maximum value to 1,000,000 particles / cm3? (PL)

Reply

This paragraph changed significantly. The measuring range is defined with respect to the limit: from the PN-PTI limit value divided by 20 (maximum value for lower range) to twice the PN-PTI limit value (minimum value for the upper range). Moreover, a recommendation was added for a "displaying range" up to five times the limit. BE proposes to define also a warning area in addition to PASS/FAIL. This proposal is based on a limit of 10^6 1/cm^3. This change was not done because we decided that the test should be only pass/fail.

Resolution of indication

CITA, BE: Calibration or adjustment?

DE: Regarding the 5 mm high: "Particle number concentrations as measurement results must be legible, clear and unambiguously shown with the unit and be unequivocally identifiable as such to the user."

NL: Examination instead of calibration

EGEA: Verification and adjustment instead of calibration

Reply

The title was changed to "Resolution of the displaying device". "Calibration" was replaced with "type examination/initial verification/subsequent verification". Moreover, the proposal of DE for the displaying device was added. The minimum resolution of 100 1/cm^3 at concentrations lower than 50 000 1/cm^3 is no longer obligatory but can be asked by the NMi.

Response time

After a request of DE (at the "Metrological controls" section), the option to perform the response time check at two concentrations was added. Moreover, between the PN measurements in addition to ambient air also HEPA filtered air flow may be provided to the PN-PTI instrument.

Maximum permissible measurement error

CITA, NL, BE: 25.000 cm^{-3} or 25% whichever is greater. 5000 cm^{-3} below is not relevant because of the rejection limit and will cause a much expensive equipment to fulfil this requirement.

DE: Note: PTB-A defines these values for "measurement accuracy": "Under laboratory conditions, with the exception of resistance to interference, measurement accuracy and stability: ±25 % of the measured value, but no less than 5000 cm^{-3}". This is NOT the maximum permissible error.

EGEA: limit should be rounded at 23000 (EGEA)

Reply

MPE was defined as a function of the applicable PN limit. At reference conditions MPE is 25% or the limit divided by 40 (absolute value). At rated operating conditions and disturbances MPE was defined to be 50% or the limit divided with 20 (absolute value).

Efficiency requirements

CITA, NL: The sampling probe cannot be omitted during the calibration

DE: i) The sampling probe is an integral part of the measurement system and should be considered. We understand that omitting the probe can simplify the connection to the outlet of a reference setup, but we would like to make you aware of the fact that an improper sampling probe can cause severe PN losses. Given the current wording a fully compliant PN PTI device can be fitted with a sampling probe that generates high PN losses and always biases the PN PTI test result low. Suggestion: If the losses in the sampling probe are proven to be lower than X %, it can be omitted during calibration. (also EGEA), ii) An additional point at 30 nm? Better fit function, iii) We suggest to provide more details on the electrometer. Suggest to add also FCAE, iv) Alternatively, A clear pathway for traceability (ISO 17025 for reference devices)

NL: i) The PTI-PN measurement is meant to detect DPF failures or removal. It is not meant to check the filtration performance of a DPF over the total particle size distribution. In case of a DPF failure (crack) or removal, particles with a mobility diameter of appr. 10 to 300 nm will be present in the tailpipe. The most dominant particles have a diameter of 70 to 80 nm. So the measurement can be simplified by measuring the most representative particles of 23 to 80 nm. This is still very representative and low-cost particle counters can be realised to serve small PTI-stations. Furthermore cheaper particle counters measure the smaller and bigger particles as well but their counting efficiency might deviate. The Dutch approach with characterisation of particles with a mobility diameter of 23 and 80 nm serves the purpose of a low-cost device. This is still in line with the specification of the particle counter in the type approval (chassis and engine dyno) which is characterised with particles of 23 and 41 nm, ii) Standard deviation of what? Maybe simply > 5000 $1/cm^3$, iii) This specification includes the measurement of particles with a mobility diameter between 10 and 23 nm. These particles were not specified in any type approval test procedure. A d50 ≤ 23 nm is compliant with current legislation.

BE: i) For the purpose of the PTI test these specifications will only increase the cost of the equipment, the NPTI or Dutch specifications are chosen with the intention to have a PTI equipment (and not a laboratorial equipment) who serves the purpose of PTI. In case of a DPF failure (crack) or removal, the most dominant particles have a diameter of 70 to 80 nm. Of course, also particles with a mobility diameter of appr. 10 to 300 nm will be present in the tailpipe, but the equipment can be simplified by measuring the most representative particles of 23 to 80 nm (and CITA), ii) If the procedure with polydisperse particles does not affect the measuring result then it can be used optional.

EGEA: Salt particles can be used but with a correction factor

Reply

Following comments from NL, CITA, DE, and EGEA the sampling probe cannot be omitted during type examination testing of the PN-PTI instrument. Regarding the particle sizes used for the counting efficiency testing of PN-PTI instruments MS have different proposals. DE proposes the addition of 30 nm particle size while NL and BE (and CITA) consider that the particle sizes proposed are too many and they increase the cost of PN-PTI instruments. In the revised document we followed a "minimum requirements" approach and counting efficiency should be checked at 23 nm,50 nm, and 70 or 80 nm (similar to NL, BE) and optionally also at 30-100-200 nm (similar to DE). Typical particle size distributions at idling have mean size below 100 nm and thus, the risk of high errors is low with the minimum requirements approach. We highly welcome experimental data of MS or organizations that show different than the aforementioned mean size of particle size distributions emitted by vehicles equipped with compression ignition engines at idling.

In the corrected document, the electrometer type was specified, the term "calibrated" for reference devices was replaced by "traceable", the possibility to determine the counting efficiency with polydisperse particles was added together with the GMD/GSD requirements, "double charged particles correction" was replaced with "multiple charged particles correction". The possibility to use different than soot-like material during the type examination was removed. Finally, the cut-off size of the reference CPC remained ≤10 nm as for smaller particle sizes (i.e. 23 nm) it is important that the reference instrumentation has a counting efficiency of unity.

Linearity requirements

CITA, BE, NL: MPE: 25.000 cm-3 or 25% whichever is greater

DE: i) Reference CPC: To date in Germany and for type approval 23 nm (DE), ii) Is this with k=2? This is very ambitious for high concentrations. Up to now, there is no European CMC for high PN concentrations and international comparisons are still running. Better 20 % (k=2), because of the high concentration range you want to achieve. Other non-measuring effects dominate the uncertainty like coagulation, agglomeration and residence time the high the concentration the more they dominate (DE)

DK: Should the reference instrument be calibrated according to ISO 17025

NL: i) GMD has a large tolerance, ii) Correction factor for salt particles (and EGEA), iii) Reference device: Why limit to CPC only. A calibrated counter with uncertainty < one third of MPE, iv) Reference device: This specification includes the measurement of particles with a mobility diameter between 10 and 23 nm. These particles were not specified in any type approval test procedure. A d50 ≤ 23 nm is compliant with current legislation, v) Reference system uncertainty: This uncertainty is only a factor 2 lower than MPE. Legal metrology requires a minimum factor of 3

Reply

The term type approval was replaced by type examination.

Maximum permissible error changes were discussed above.

The cut-off size of the reference particle and the type of the particle detector did not change at type examination level. The possibility to use other than soot-like materials during the type examination was removed.

The term "calibrated" was replaced by "traceable" (DK), the GMD of the polydisperse particles was changed to 70 +/- 10 nm (DE, NL) in order to exclude high sub-23 nm fractions and additionally the

GSD was defined to be maximum 1.6. Furthermore, all concentrations were related to the limit instead of setting absolute values.

The linearity test is performed with 9 concentrations (defined with respect to the limit) and the MPE at reference conditions should be respected. The zero test was removed from the linearity test and was described in a separate paragraph.

Finally, different comments were received for the uncertainty of the reference device/system. NL proposes that it should be 1/3 of the MPE (8.3%) while DE claims that the proposed 12,5% is too low because at these high concentrations the uncertainty introduced by agglomeration shall be taken into consideration. JRC believes that the uncertainty of a reference that is composed of a diluter and a particle detector can be <10%. To our knowledge currently available particle detectors may have in single particle measurement mode uncertainties equal to 5% (or even lower). The uncertainty of the diluter can be ~2%. The agglomeration of particles at concentrations up to 1 x 10^6 1/cm^3 for residence time of 4 s is negligible. We consider that the residence time in the diluter or in the tube that after splitting will bring particles to the PN-PTI instrument will be substantially lower than 4 s. However, the main obstacle for requiring uncertainty <10% is the inter-laboratory comparison at high concentrations where uncertainty can be up to 20%. Thus, in the revised document the uncertainty level remains 12.5%, pending experimental evidence for lower inter-laboratory uncertainty.

Zero-level

Zero-level was defined in a separate paragraph and the maximum permissible level was set to 5 000 1/cm3.

Volatile removal efficiency

DE: PTB-A only defines a removal efficiency of 90%.

DE, EGEA: What does greater than 30 nm mean? METAS defines GMD 30nm polydisperse at 100.000 1/cm3 (DE, EGEA)

NL: For polydisperse define max 100000 (NL)

Reply

The required removal efficiency remained 95% while the range of monodisperse and polydisperse tetracontane particles size and concentration was specified. Moreover, the reference instrumentation was defined. Finally, larger tetracontane sizes and concentrations are accepted only if the PN-PTI instrument passes the test.

Stability with time or drift

DE, EGEA: Because drift or stability is often caused by particle contamination we propose to do this test also with high particle concentration and not only without any PN sample. See example NL or METAS

Reply

The concentration used at this test was set at 100 000 1/cm^3. The option of performing an accelerated test with >10 000 000 1/cm^3 concentration was added (similar to METAS). Finally, the required reference system was described.

Repeatability

DE: PTB defines: “Under identical measurement conditions, the measurement values for the particle

number concentration must comply with the maximum permissible error stated in 1.1.1 for laboratory testing in at least three measurement series with each measurement lasting at least five minutes."

Reply

A similar definition to OIML 99 regulation was included in the guidance.

Influence parameters

CITA: Nominal voltage ± 2 % - In practice, Isn't this too strict? Which would be the benefit for air quality?

DE: i) +/- 2°C should be enough, ii) This mandates the implementation of an ambient temperature sensor, which is unusual and difficult for a PTI device. A lot of components are heated inside, so if you want to measure it in the right way you have to place the sensor outside. What will happen during an official calibration according to ISO 17025? You have to calibrate also this sensor. Suggestion: It is sufficient to rely on the critical internal temperatures to be within the limits specified by the instrument manufacturer for compliance with metrological performance requirements (e.g. on a CPC based device Condensor and Saturator temperatures, but also VPR temperature for instruments with VPR installed). Ambient temperature is specified on the type plate, the user is responsible for operate the instrument only inside this range.

NL, BE: Quite strict, mains voltage can vary 5% or more

BE: 0 °C to 40°C because in winter can drop around zero in some regions because the test is done at the beginning of the inspection with open doors of the building.

Reply

Nominal voltage variation was increased to +/- 5% (CITA, NL, BE) while the ambient temperature variability was reduced to +/- 2°C (DE). The indication of warning when operation is done outside the rated operating conditions temperature range was removed (CITA). The temperature range did not change (5-40°C) as it is the minimum requirement and manufacturers can extend it. References to IEC and OIML D11 were added as well as the test level index according to OIML D11.

Disturbances

DE, EGEA: 1 fall of 50 mm means level 2 in the OIML D11 document, normally it´s level 1 (25 mm) e.g. in OIML R99

NL, EGEA: No standards mentioned for the values reported. See OIML.

DE: Alternative: Reference to OIML D 11 with the respective requirements classes e.g. H1, H2, H3; testing based on the area of application specified by the manufacturer (DE)

Reply

Mechanical shock requirements were modified according to DE and EGEA request. All IEC standard references found in the OIML D11 were added. The minimum requirement of 10 V/m for electro-magnetic fields remained in the document. MS can set higher than the proposed test level indexes.

5. Technical requirements

Construction

CITA, NL, BE: Data logging: Shall depend on the measurement programme.

DE, EGEA: i) "withstand the exhaust gas temperature" Define it better, ii) "be electrically grounded and of electrically conductive materials or otherwise shielded or protected to prevent electrostatic effects and designed to minimize deposition of the particles" This should be defined neutral e.g. the construction of the probe should not have influence to the PN concentration. Also NL proposes to leave these choices to the

manufacturer, iii) Guide for aerosol sampling is vague and excludes technologies like ejector diluters, iv) PN equipment is not necessary that guides the user and logs data but also another device could do this, v) Sampling probe not 0,3 m, vi) Proposal to not count hours of operation but instead define all self-check routines, vii) Add the dilution unit (DE)

BE: Sampling lines shall not be short for PTI application

EGEA: Leak test: No this not the way to do. Leak test is done by sealing inlet and out let and by putting under pressure the system

NL: OIML D11 and D31 for interface requirements (also Welmec 7.2?)

Reply

DE and EGEA asked for specification of the exhaust gas temperature. We didn't find a similar definition in the existing national regulations and OIML R99 so we did not change the original text. The specific particle sampling specifications were removed after request of many MS/Organizations (DE, EGEA, BE, NL) in order to leave to the manufacturer the freedom to design the sampling system with different aerosol technologies. Only a general provision for the minimization of particle losses remained. The sampling probe length was changed in agreement with the "Description of the instrument" paragraph. In the new version, the data logging is possible to be done either by the PN-PTI instrument or by a device equipped with a relevant software (DE) and the data logging is done according to the measurement procedure as suggested by CITA, NL, BE. After a proposal of DE, time counting is optional in the revised guidance. Clarifications and changes to the internal checks moved to the next sub-section (see below). In addition to the gas flow measurement that monitors the good operation of the PN-PTI instrument we added that also other important factors should be monitored to ensure the appropriate functionality according to the measurement principle. Furthermore, (when applicable) the dilution unit was required to have constant dilution factor.

A new provision was added for the critical internal temperatures that if not respected the PN-PTI instrument shall indicate a warning and the measured value shall not be indicated. Furthermore, he PN-PTI instrument interface shall respect the OIML D 11 and D 31 requirements (NL) but the confirmation of M/S on this point would be helpful.

Requirements for ensuring correct operation

NL: Software requirements shall be according WELMEC software Guide 7.2 (DE, EGEA) or OIML D 31

Reply

All internal checks description moved at this sub-section. Three common self-checks, one that applies to specific measurement principles, and one optional are now included in the guidance.

The OIML D 31 and Welmec 7.2 references were added. We kindly ask the MS to confirm the reference.

6. Metrological controls

Type examination

CITA, NL, BE: What are the additional tests? (CITA,NL,BE)

DE, EGEA: Compliance cannot be declared by the manufacturer

DE: Disturbances MPE is not understood

NL: i) Include all type approval tests (NL), ii) Very unusual value in Metrology. Propose 25000 1/cm³ at nominal concentration of 100000 1/cm³

Reply

Type approval was replaced by type examination.

The “rated operating conditions” and “disturbances” tests done during type examination were initially described as “additional tests”. The term “additional tests” was removed and all this part moved to the MPE definition paragraph. Moreover, the parenthesis regarding the compliance declared by the manufacturer was removed. This possibility was initially given for minor checks that the manufacturer can declare compliance but we deleted it in order to avoid misunderstandings. The type examination tests were not further specified as they are reported in the “Metrological requirements”.

Initial verification

DE: During the initial verification, the PSD used for the linearity test shall not be bimodal. Moreover the GMD must not be determined with 2 CPCs, ii) Reference system uncertainty shall be ~20%, iii) MPE shall be 50% because 25% is ambitious and hard to fulfil for traceability chain 2. Or 3. level, iv) Response time check shall be done for at least two concentration levels

DK: Add the repeatability test during initial verification

NL: i) The tolerance of 70+/-20 nm is very large, ii)For materials different than soot, a correction factor shall be applied (also EGEA), iii) Replace CPC with counter, iv) Reference system cut-off size at 23 nm (NL), v) Replace the proposed concentrations with values related to the limit, vi) They propose to add the NMi at possible places of initial verification and also 25000 1/cm3 or 25% for MPE

EGEA: Include the limit in the linearity test

Reply

According to a comment received from DE, the GSD of the PSD used for the initial verification was defined to be maximum 1,6 and the two CPCs method was removed. NL considers the GMD variation very high and in the new version this was changed to 70 +/- 10 nm. With GMD 70 nm and max GSD 1,6 we calculated a sub-23 nm fraction of <5%. Following the suggestion of NL, we added that for materials different than soot a correction factor can be used, we replaced CPC as reference with particle detector, we defined the reference system cut-off size lower or equal to 23 nm and we expressed the concentrations used for the test with regards to the limit. Regarding the used material JRC is concerned about possible high differences of some PN-PTI sensors but also reference systems counting efficiency with different materials/setups. For this reason, in the revised guidance we require that the entire setup (generator and reference system) are checked by the NMi (the exception of manufacturers with ISO 17025 was removed) and a correction factor is defined for the particles used during the initial verification with regards to the type examination test taking under consideration also the reference system efficiency. The correction factor shall be constant over the tested concentration range and its value is recommended to be in the range 0,65 to 1,5.

Another change done in the revised document is that after the first approval of the reference setup done by the NMi, new approval is required if the setup changes.

We didn't include NMIs as a possible place for initial verification as we believe that this is impossible for the entire production of instruments. However, if some companies want to send to the NMIs their instrument and the NMIs can afford this, then we are open to discuss it.

Regarding the MPE and the uncertainty of the reference system there are two different suggestions. NL suggests MPE 25% and uncertainty of 8,3% while DE proposes MPE of 50% and believes that uncertainty of 12.5% cannot be achieved. For now, we keep the uncertainty of 12,5% for the reasons described in the Linearity paragraph.

After DK request a repeatability test was optionally added. DE proposed to perform the response time check at two concentrations. This option was added at the type examination test.

According to OIML 99, we added that during the initial verification "a visual inspection to determine conformance with the approved type, a check of the power supply voltage and frequency at the location of use to determine compliance with the specifications on the measuring instrument's label, leak (or zero) check (as described in the operating instructions)" shall also take place. Finally, the zero-level test was added at the additional initial verification tests (if it differs from the leak test).

Subsequent verification

DE: Remove the operational hours criterion for subsequent verification. DE proposes to define the self-control routines (CITA, DE, EGEA, BE)

CITA, NL, BE: Define the concentrations in relation to the limit. EGEA proposes to have 5e4, 2.5e5, 5e5

DE: i) Improve the PSD control information (DE), ii) High concentrations cannot be checked by any NMI. 25% uncertainty is very low, iii) Traceable PN-PTI if used, iv) Define PN-PTI instrument family

NL: i) Maximum uncertainty shall be 1/3 of the MPE (16.6%), ii) Define MPE 25000 or 25% whichever is greater, iii) add NMi as place of subsequent verification and exclude the use of a PN-PTI instrument

Reply

After proposal of CITA, DE, EGEA, and BE the operation hours criterion for subsequent verification was removed. Moreover, the concentrations used for the test were expressed with regards to the limit. The GMD of the PSD changed to 70 +/- 10 nm and the GSD ≤1,6 was added. DE and NL propose different reference system uncertainty limit. In the revised document we propose reference system maximum uncertainty of 20% because lower uncertainties are difficult to be achieved at on-site verifications. If manufacturers achieve lower uncertainties, then we are open to discuss this value. The portable reference setup is composed of a portable generator and a portable reference system (traceable particle counter with cut-off at 23 nm and optionally traceable diluter). Similar to initial verification the entire setup is tested at a NMi.

The MPE at this test is similar to rated operating conditions. The possibility to perform the subsequent verification at an NMI was not added for the same reason as for initial verification.

Self-control routines were defined in the "Technical requirements" section (DE, EGEA). The option for response time check at two concentrations was added in the type examination testing.

Similar to the initial verification, we added also other checks according to OIML 99 and the zero-level check.

7. Measurement procedure

CITA: i) “Before the start of a measurement, the following data shall be entered” Depending on the PTI software installed in the PTI station. In many cases this is managed by the IT systems of the centre, rather than by the instrument, ii) During 3 measurements of 15 s it is possible that the EGR will close (e.g. Renault in 45 s) iii) 5 minutes of accelerations is not practical and executable in a PTI station, especially not in a decentralized system

DE: i) In DE BASt is responsible for the measurement procedure of the vehicle. And the software for this measurement procedure is tested by TÜV / DEKRA., ii) Testing temperature in the national emissions testing directive >60oC (DE), iii) Change the 30 cm definition and the word shall (and PL), iv) Two tailpipes may have different concentrations. Proposal to include both (and NL), v) Additional data is useful like VIN and type approved emission level etc., vi) Limit should not be entered and shall be always the same, vii) Preconditioning not needed if T>60oC, viii) Print or store the result

PL: In our opinion, there is no justification for performing three measurements of 15 seconds each. For more than 95% of the cases, the result will be either below 50,000 particles / cm3 or above 1,000,000 particles / cm3. This result gives an unambiguous answer about the particulate filter after the first measurement and continuing the measurements is a waste of time (nothing will change, the positive or negative qualification will not change). In case of emissions above 1,000,000 particles / cm3, it may be harmful to the device. It is extremely rare that the filter is already initially damaged and the emission is in the range of 200,000-300,000, and then the triple measurement and the mean average could be binding. At this point please also note that the evaluation criterion of 250,000 particles / cm3 was set arbitrarily and is quite liberal, the emission at the level of 250,000 particles / cm3 proves that the filter is no longer fully efficient. So let us assume that the limit is OK, but in the vast majority of cases one measurement is sufficient.

DK: i) How do we verify that a vehicle is not regenerating?, ii) Maybe the limit should be increased because if the following test shows a value below the limit then the vehicle can pass the test.

HR: Increase the limit to 1000000 for EURO 5 vehicles and thus for all provisions in section 7.

NL: i) Wording changes for not testing during regeneration (Kadijk), ii) Concerns about the stringiness of the test (limit) in combination with EGR open. Moreover, EGR state may change during the test, iii) To add a fast fail option

AT: Printout, transmission and storage of the results shall be extended and kept in the specifications

EGEA: T sensors is not obligatory

Reply

The most important change in this section was the duration of the measurement. After the proposal of CITA, NL, and PL instead of 3 measurements of 15 s the PN-PTI test requires minimum total measurement duration of 15 s. JRC studies show that a single 15 s test is enough for determining the PN emissions of a vehicle. The 3 repetitions approach had small benefits for the uncertainty reduction. Note that EGR status change shall be avoided during the test.

The vehicle can be either hot or cold at the first PN-PTI test. The PN-PTI test is repeated if the vehicle fails. A fast fail option was added for concentrations higher than 2 times the limit. If the vehicle fails, it is preconditioned with free accelerations or driving for at least 5 minutes. This procedure is proposed for cases that a DPF has just finished its regeneration and shall be filled to a level that its trapping efficiency increases to normal operation levels. At the second test the engine coolant temperature shall be >60 °C (instead of 70 °C) (DE proposal).

Other changes done at the initial document are the following: i) the minimum length of the sampling probe was changed in agreement with previous sections, ii) if a vehicle has more than 1 tailpipes then all of them shall be tested and the higher PN concentration is also the vehicle's test result, iii) registered data was better defined, iv) results are not necessarily printed but can also be stored, v) the vehicle regeneration identification by OBD was added, vi) absolute concentrations were expressed as a function of the limit, vii) the PN-PTI shall be able to measure only if all self-checks are ok

According to a comment received by AT, in the "Technical requirements" section the interface requirements were defined according to OIML D 11 and R 99.

8. PN-PTI limit

HR: Add the option of 1e6 1/cm3 for EURO 5 (HR)

BE: For 2.5e5 to 1e6 have a warning message instead of fail. At least for a transition period

Reply

JRC proposed a limit of 250 000 1/cm^3 considering experimental findings that correlate low idling to regulatory PN emissions as well as the uncertainty of the test. Since the guidance remains non-binding, Member States have the possibility to apply different limits, even if not recommended. The procedures described in the guidance may be applied for limits up to 1 000 000 1/cm^3.