PEMs 4Nano

Portable Nano-Particle Emission Measurement System

EUROPEAN COMMISSION

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Publishable Executive Summary

The PEMs4Nano project addresses the development of both a new portable device and a laboratory system to detect particles down to sizes as small as 10 nm together with a robust procedure to measure these particles. Achieving robust and reliable measurements technology and procedures supports the automotive industry to reduce vehicle emission. In addition, this project will provide a contribution to future regulation on particle emissions as well as a better understanding of particle emissions below 23 nm (with the threshold of at least 10 nm).

IDIADA, as a WP 4 leader, will perform a complete testing using the technology developed in the WP 2 “Measurement technology” through physical testing in laboratory with the final objective to ensure the correct operation of the PN measurement system to measure small particles down to 10 nm. Furthermore, additional objectives can be foreseen:

- Implementation of the final calibration procedure of the equipment for particles down to 10 nm.
- Definition of the testing protocols using the developed equipment
- Final validation of the measurement procedure and equipment & robustness evaluation

According to the previous explanation, the aim of this deliverable D4.1 is to contribute with the implementation of the calibration procedure that is defined in WP 2 from the equipment developers. This implementation includes mainly the validation of the calibration procedure in terms of linearity and efficiency of the developed equipment. This calibration assessment is done as stated by the criteria defined in the deliverable D1.2 [1] of this project (section *2.1 Criteria for internal impact assessment/Calibration*).

Hence, the main objective of this first activity of the WP 4 is to demonstrate and validate that the calibration protocol can be implemented in a standard laboratory and that it can be performed by an equipment end user. To do that, the different requirements of the new equipment have to be provided by the partners of WP 2 so as to define the operation procedure itself.

Finally, the mentioned implementation of the calibration procedure and the definition of the operation procedure will be performed on the equipment developed: the one for PN 10 nm laboratory measurement, called from now on as “PEMs4Nano LabSystem”, and the one for the PEMS PN 10 nm measurement or “PEMs4Nano PEMS System”.

As a summary of the major conclusions of this report, the operation procedure for both the *PEMs4Nano LabSystem* and the *PEMs4Nano PEMS System* has been defined. Following the requirements sent by the partners within the WP 2, several checks and maintenance actions have been established. These requirements have been divided in different actions to do before each test, daily, monthly and even yearly. There are no variations between this operation procedure to the one already implemented for 23 nm lab and on-board systems. The calibration protocols needs to be modified and adapted regarding the particle size of sub 23 nm.

Concerning the validation of the calibration procedure, it has been reviewed the calibration of both equipment performed by TSI and Horiba. The results are suitable in terms of efficiency, linearity and PCRF factor although as a conclusion of the results regarding the on-board system, following Horiba’s indications, a system calibration would be more effective rather than calibrating CPC and the whole system separately.

Contents

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1 Introduction

The PEMs4Nano project addresses the development of both a new portable device and a laboratory system to detect particles down to sizes as small as 10 nm together with a robust procedure to measure these particles. Achieving robust and reliable measurements technology and procedures supports the automotive industry to reduce vehicle emission. In addition, this project will provide a contribution to future regulation on particle emissions as well as a better understanding of particle emissions below 23 nm (with the threshold of at least 10 nm).

IDIADA, as a WP 4 leader, will perform a complete testing using the technology developed in the WP 2 "Measurement technology" through physical testing in laboratory with the final objective to ensure the correct operation of the PN measurement system to measure small particles down to 10 nm. Furthermore, additional objectives can be foreseen:

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Hence, the main objective of this first activity of the WP 4 is to demonstrate and validate that the calibration protocol can be implemented in a standard laboratory and that it can be performed by a usual final equipment user. To do that, the different requirements of the new equipment have to be provided by the partners of WP 2 so as to define the operation procedure of it.

Finally, the mentioned implementation of the calibration procedure and the definition of the operation procedure will be performed on the equipment developed: the one for PN 10 nm laboratory measurement, called from now on as "*PEMs4Nano LabSystem*", and the one for the PEMS PN 10 nm measurement or "*PEMs4Nano PEMS System*".

2 Validation of the calibration procedure

In this chapter the validation of the calibration procedure is presented. The mentioned validation is focused on the linearity and efficiency of the measurements done by the new equipment developed. The criteria definition for both *PEMs4Nano Lab System* and *PEMs4Nano PEMS System* was defined in the deliverable D1.2 [1] according to the current standard regulation and equipment manuals established for measuring particles above 23 nm. In addition, it will also consider additional requirements taking into account the measurements of sub-23 nm particles.

The implementation will also include the assessment of the particle concentration reduction factor (PCRF), following the PMP requirements.

The first section of this chapter sets the focus on the validation of the new calibration procedure for the *PEMs4Nano LabSystem* whereas the second section shows the validation for the *PEMs4Nano PEMS System*.

Before starting with the assessment of the calibration procedure in terms of linearity and efficiency as well as the PCRF validation, the calibration itself of the new equipment has been validated. A standard and traceable calibration method has been performed by the partners in WP 2 in order to ensure a good measurement of the particles both above and below 23 nm. The R-83[2] and GTR-15[3] Regulation for the lab system as well as the RDE-3[4] Regulation for the portable system, together with the equipment developer manuals has been used to ensure a standard method for the calibration of the *PEMs4Nano LabSystem* and the *PEMs4Nano PEMS System*. In addition, the calibration procedure of the CPC (both Lab and mobile system) has followed the ISO 27891[5].

2.1 PEMs4Nano LabSystem validation

In this section, the calibration procedure of the new laboratory system to measure particles sub-23 nm to at least 10 nm will be validated in terms of linearity and efficiency. The PCRF-factor will also be validated because of its importance for the dilution and particles losses.

The assessment of this system will be carried out by checking the results of the calibration procedure defined by the project partners of the WP 2 in the deliverable D2.4 [6].

2.1.1 Linearity and efficiency of the equipment

The calibration of any PEMS system [7] is performed component by component. Focusing on the new PEMs4Nano LabSystem system, the Condensation Particle Counter (CPC) is the component which has to be validated in terms of efficiency and linearity.

The results of the new CPC's calibration were shown by the WP 2 in its public deliverable report D2.2 "Calibrated CPC with D50 ≤ 10 nm for laboratory use – together with the documented calibration procedure" [8]. In the following table and figure, the detection efficiency is shown:

	Initial detection efficiency measurement			
Particle diameter (nm)	10 nm	15 nm	23 nm	55 nm
Detection efficiency (%) w/o k-factor	**70.5**	**90.1**	**94.4**	**96.4**
Rel. uncertainty (%, k=2)	3.95	4.14	3.52	3.58
k-factor	1.0327			

Detection efficiency (%) with k-factor	72.8	93.0	97.5	99.6

Table 2-1: Data for the determination of the size dependent detection efficiencies of the 10 nm lab CPC for PAO calibration particles

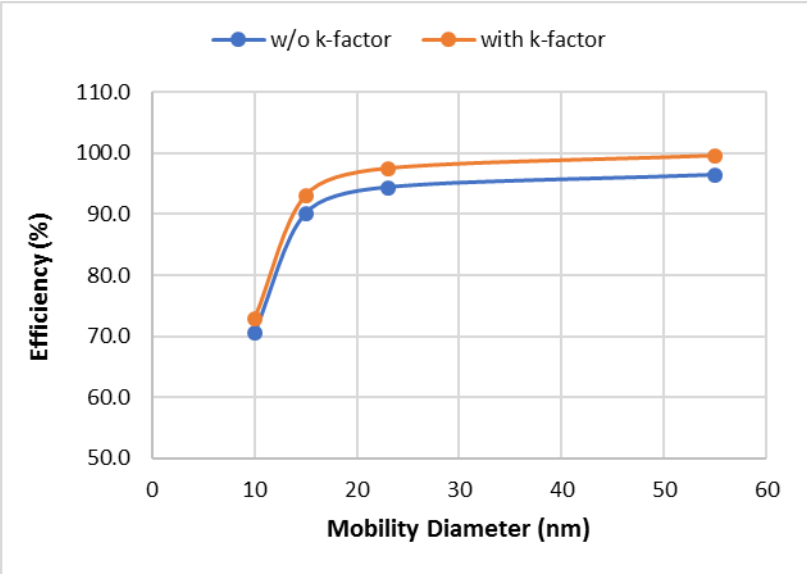


Figure 1: Size dependent detection efficiencies of the 10 nm lab CPC for PAO calibration particles with and without k-factor.

The assessment of the calibration is done in the following terms:

- **Detection efficiency or cut-off (%):** According to the R-83[2] Regulation and the HORIBA MEXA-2100SPCS Instruction Manual [9], the counting efficiencies at particles sizes of 23 nm (±1 nm) and 41 nm (±1 nm) should be of 50 % (±12 %) and > 90 % respectively. In addition, deliverable D1.2 [1] establishes a target of 50 % or more counting efficiency of 10 nm particles and a 90 % for 15 nm particles. The results show above affirmed that all the requirements are accomplished regarding the efficiency of the equipment.
- **Linear Response:** Deliverable D1.2 [1] requires that the new *PEMs4Nano LabSystem* has a linear response with a R^2 close to 1. As it is shown in the **Error! Reference source not found.** $R^2 = 0.99997$ and, as a consequence, the equipment is well-calibrated in terms of linearity.

2.1.2 PCRF validation

The PCRF-factor describes the ratio of particle number concentrations before and after the passage through the Volatile Particle Remover (VPR) of the particle number counting system (PNCS) at different particle diameters. Thus, the PCRF includes both the selected dilution factor as well as losses located inside the PNCS before the particles come into the CPC.

According to PMP specifications, the allowable ratios of the small particle sized PCRF-values compared to PCRF (100 nm)-values are:

$$0{,}95 \leq PCRF(50\text{nm}, Dil_{\text{SPCS},i}) \;/\; PCRF(100\text{nm}, Dil_{\text{SPCS},i}) \leq 1{,}20. \quad \text{(Eq. 5-1)}$$

$$0{,}95 \leq PCRF(30\text{nm}, Dil_{\text{SPCS},i}) \;/\; PCRF(100\text{nm}, Dil_{\text{SPCS},i}) \leq 1{,}30. \quad \text{(Eq. 5-2)}$$

Furthermore, it was defined at the deliverable D1.2 [1] an additional condition suggested by JRC:

$$0{,}95 \leq PCRF(15\text{nm}, Dil_{\text{SPCS},i}) \;/\; PCRF(100\text{nm}, Dil_{\text{SPCS},i}) \leq 2. \qquad \text{(Eq. 5-3)}$$

The ratios above have been used as criteria for the assessment of the PCRF calibration of the PEMs4Nano LabSystem. The results of the PCRF-factor calibration were published in the deliverable D2.4 [6] and the following figure will illustrate them as a summary:

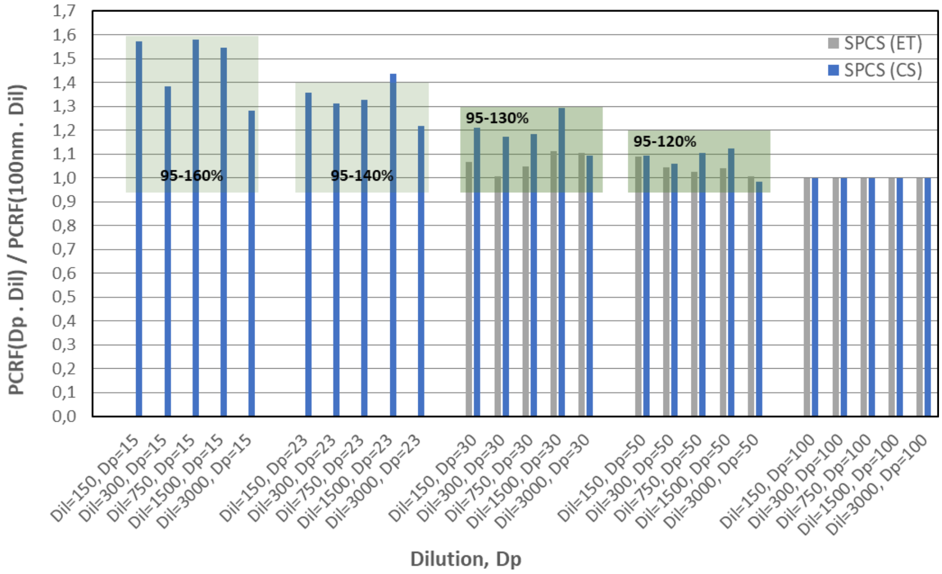


Figure 2 PEMs4Nano LabSystem – PCRF calibration – PCRF100-normalized values over all dilution-settings (Dil) and particle size (DP) (normalized to PCRF (100nm, Dil)).

From the figure above it can be concluded that the new equipment developed perfectly matches the criteria established at the beginning of the project for the PCRF-factor calibration. The common requirements for PMP systems are achieved (Eq. 5-1 and 5-2) and it is also achieved the suggested ratio (light green boxes) for the particles with a diameter of 23 and 15 nm.

2.2 PEMs4Nano *PEMS System* validation

As it was done in the previous section 2.1, the calibration procedure of new equipment to measure particles below 23 nm (to at least 10 nm) will be validated. In this case, the OBS system will be evaluated in terms of linearity and efficiency. The assessment of this system will be carried out by checking the results of the calibration procedure defined by the project partners of the WP 2 in the deliverable D2.07 [10].

2.2.1 Linearity and efficiency of the equipment

The calibration results of the PEMs4Nano PEMS System are presented in the following lines. In terms of linearity the device has achieved the initial target established in the deliverable D1.2. The criteria state that the equipment shall have a linear response with a R^2 close to 1 (the target was a $R^2 > 0.95$). According to the deliverable D2.05 [11] presented by TSI within the WP 2, the linearity of the equipment, looking at the CPC calibration, has a $R^2 = 0.9999$ so it can be concluded that the target has been achieved.

In terms of efficiency, the new OBS system has been calibrated and the results were presented as a part of WP 2 task. In this section, the results will be shown together with some challenges observed. In the following figure, the detection efficiency of the new equipment's CPC will be shown:

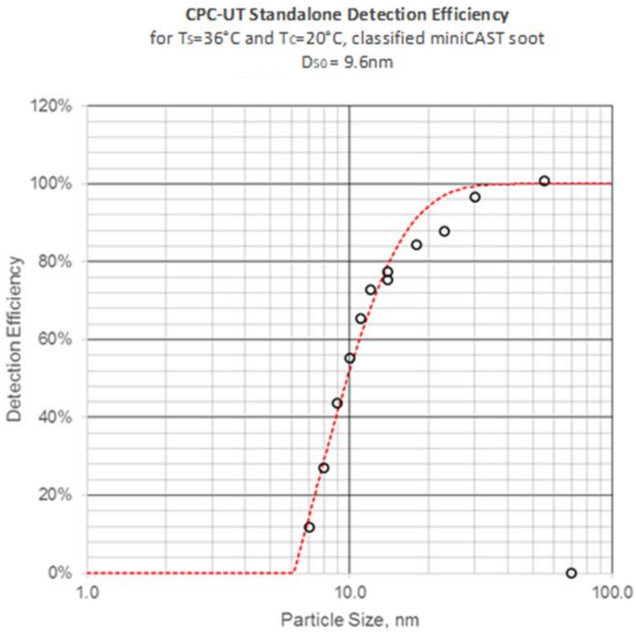


Figure 3 Detection efficiency of the 10 nm PEMS CPC

The criteria established in the deliverable D1.2 [1] states that the counting efficiency of 10 nm particles has to be at least 50 % and for 15 nm particles the value should increase to at least 90 %. As can be seen in the Figure 3, the detection efficiency at 10 nm is 52 % (the D_{50} is at 9.6 nm). At 15 nm, the efficiency is about 80%, which means that the result is slightly suitable with the criteria defined.

2.2.2 C0-factor & PCRF validation

For the PEMs4Nano PEMS System the C0-factor & PCRF calibration is done at 200 nm only because there is no regulation for the portable systems to evaluate the PCRF/C0 at a defined particle size. The results of the calibration were shown in the deliverable D2.07 [10] and summarized in the following picture:

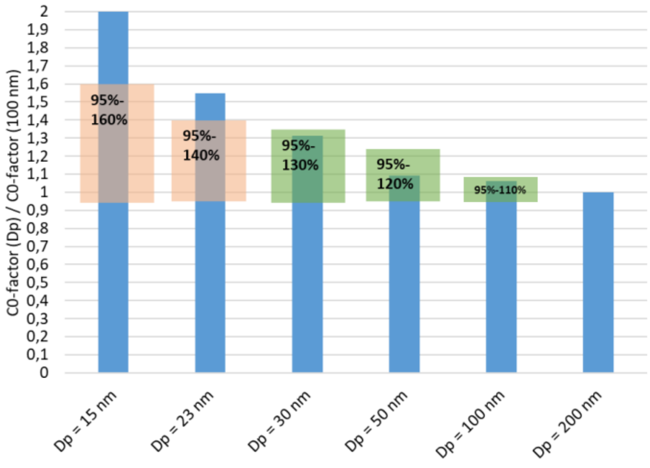


Figure 4 C0-200 nm normalized values over particles sizes (Dp)

As it can be seen, the common requirements for PMP systems are achieved. Going down to 23 nm the initial set target defined in the D2.4 [6] of 140 % would not be enough to achieve. However, according to the criteria (referring to D1.2 [1]) JRC suggested a PCRF 15 nm / PCRF 100 nm target below 2 and the results show a value of 2, which is a slightly suitable result.

3 Definition of the operation procedure

The main objective of the task 4.1 of the WP 4 is to demonstrate and validate that the calibration protocol can be implemented in a standard laboratory and that it can also be performed by an equipment end user. In this chapter, the requirements needed to follow this calibration protocol and the operation procedure will be defined in the equipment developed: the one for PN 10 nm laboratory measurement and the one for the PEMS PN 10 nm measurement.

To accomplish the implementation mentioned above, the equipment supplier and WP 2 partner, Horiba, has delivered the calibration equipment requirements to follow for both equipment developed. In the following sections, these requirements will be described.

3.1 Operation procedure for the new SPCS

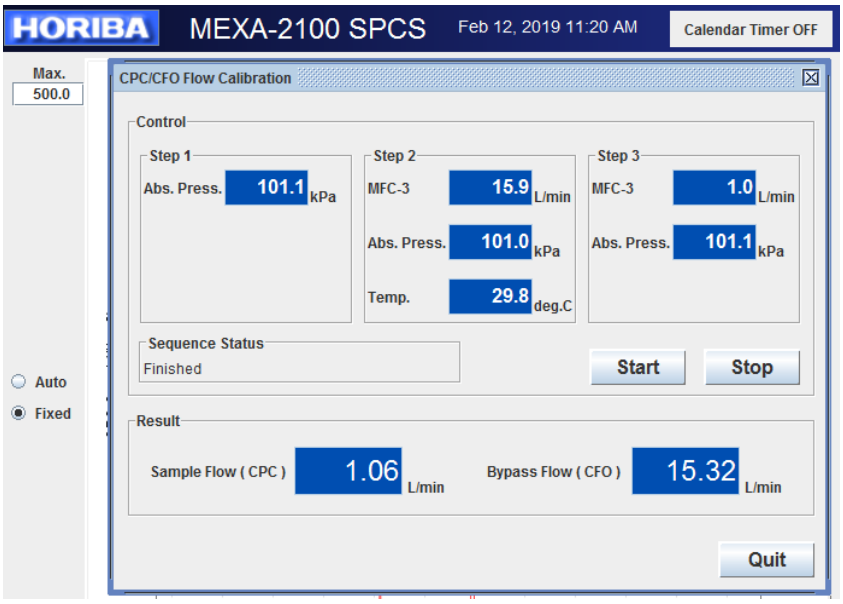
In this section, the definition of the operation procedure for the *PEMs4Nano LabSystem* will be done. Basically, the maintenance activities and the checks to be done for this new equipment are the same as the standard SPCS for measuring particles above 23 nm and it follows the HORIBA MEXA-2100SPCS Instruction Manual [8]. The major changes applied in this equipment developed are related to the calibration of the CPC and they were explained as part of the WP 2 activities in the deliverables D2.2 [8] and D2.4 [6]. They do not affect the protocols of the SPCS 10 nm device.

The maintenance to perform in the *PEMs4Nano LabSystem* has been divided in: checks before each test, daily, monthly and yearly (in this last case, the device has to be recalibrated at equipment supplier facilities).

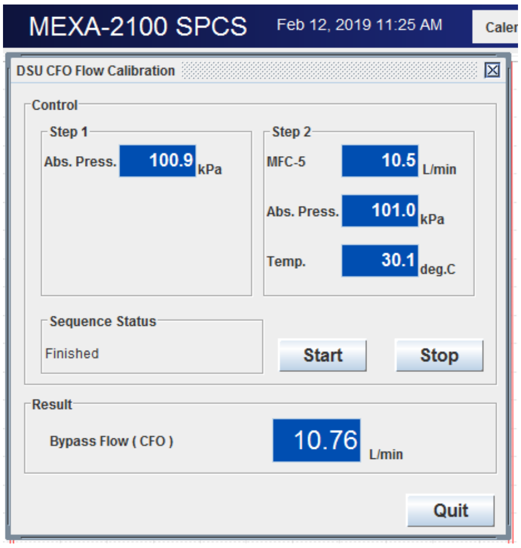
<u>**Device checks before each test**</u>

At the beginning of any test to be performed in the emissions laboratory, there will be some pre-checks of the new equipment before starting the measurement of the particle number in order to ensure the measurements are correct:

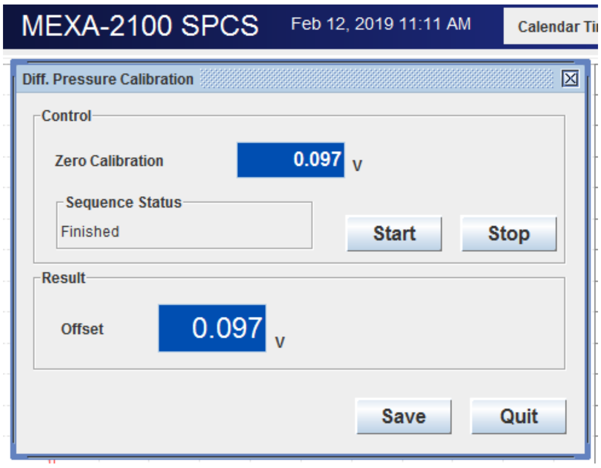
- *CPC / CFO Flow calibration:* The sample flow (CPC) as well as the Bypass Flow (CFO) must be checked.



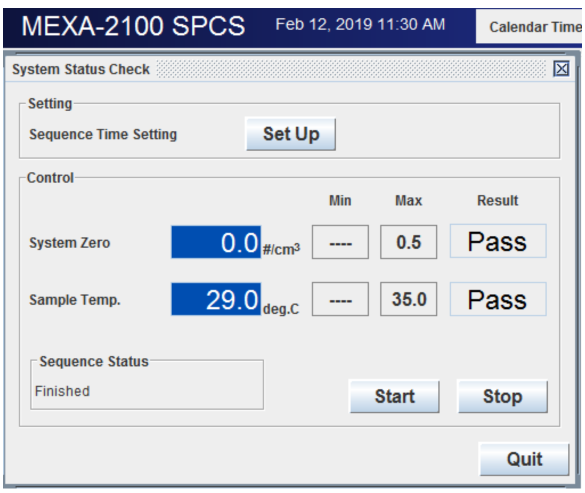
- *DSU CFO Flow calibration:* The flow of the Direct Sampling Unit (DSU) has to be checked.



- *Differential pressure calibration:* Before each test it is also necessary to verify the differential pressure to see the offset result (it should be recommended a value around 0.1V).



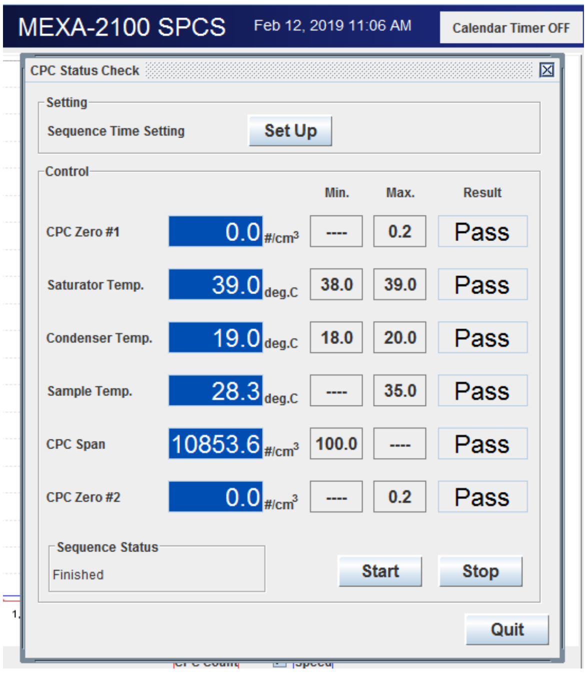
- *System-status-check:* This check is very important to verify that the system zero and the sample temperature values are between the correct ranges.



Daily check

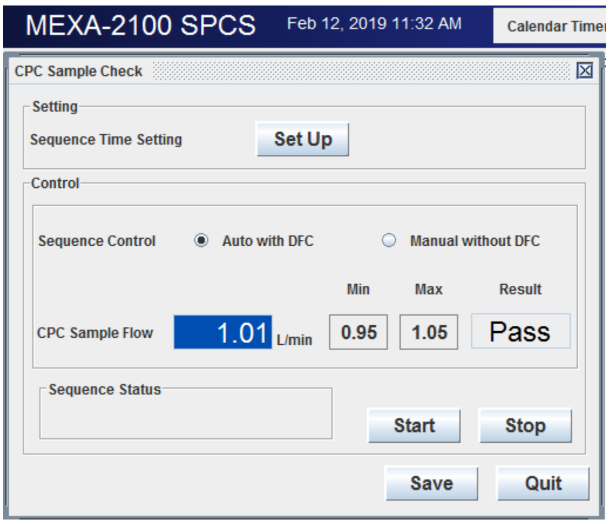
Following with the operation procedure of the new *PEMs4Nano LabSystem*, there is a need to implement a daily-check, whether the equipment is going to measure an emission test in the laboratory or not:

- *CPC-status-check:* The status of the Condensation Particle Counter (CPC) it is highly important to check every day due to the fact that it is the component responsible of the particle measurement. The CPC zero as well as the saturator and condenser temperatures have to be checked. In addition, the sample temperature has to be below 35 Celsius degrees.



Monthly check

The status of the CPC has to be continuously checked. For that reason, every month a CPC-sample-check must be done and the CPC sample flow is verified (it has to be between 0.95 and 1.05 L/min).



Yearly check - Recalibration

Finally, as a general maintenance, the new *PEMs4Nano LabSystem* has to be sent to the equipment supplier facilities in order to be recalibrated.

The maintenance work to do in this equipment comprises the calibration of the SPCS as well as the CPC. During the recalibration, the equipment supplier must follow the calibration procedure described in the WP 2 of this project (specifically, deliverables 2.2 [8] and 2.4[6]).

3.2 Operation procedure for the new OBS

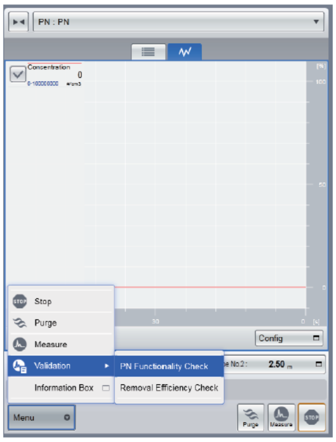
In this section, as it was done for the new SPCS in the previous section, the definition of the operation procedure for the *PEMs4Nano PEMS System* will be done. In the case of this equipment, the maintenance activities and the checks to be done are also the same as for the standard OBS-ONE PN (PMP system) for measuring particles above 23 nm and it follows the OBS-ONE PN Instruction Manual [12]. The major performance changes applied in this equipment developed are related to a change and re-calibration of the CPC including the adjustment of the saturator and condenser temperatures as well as a catalyst stripper enhancement and they were explained as part of the WP 2 activities in the deliverables 2.05[11] and 2.07[10]. They do not affect the protocols of the OBS-ONE PN 10 nm device.

The maintenance to perform in the *PEMs4Nano PEMS System* has been divided in the following parts:

Device's check before each test

Before every test or every 4 hours (maximum time the following operation will have validation), a usual equipment user will perform the following checks in the OBS PN 10 nm equipment:

- *IPA filling:* The isopropyl alcohol has to be filled to the cartridge for at least 2min so as to the wick works properly.
- *Batteries charge status:* A previous check before starting the test must be done.
- *Dryer:* The dryer humidity has to be checked and it should be dried after 3 tests or if the mass is above 500g (the dryer have to be between 480 and 500g for a good performance). The dryer has to be changed every 3 months due to its deterioration.
- *Sample line leak check:* Before and after each test a leak check has to be done, verifying that the sample line measures zero particles at the beginning and at the end of the test. To do that, a HEPA filter is needed and the "PN Functionality Check" option in the PN device (into the Horiba software for OBS) has to be selected:



6-month check

The wick, which is the responsible to make larger particles coming from the sampling tube before the CPC detects them and it is located inside the cartridge, has to be replaced every 6 month, although it is recommended to do it before each measurement campaign.

Yearly check - Recalibration

As it happens with the PEMs4Nano LabSystem, the on-board system has to be recalibrated once a year by sending the device back to the equipment supplier facilities.

The activities to do in this equipment's general maintenance are the maintenance and the calibration of the whole OBS as well as the CPC. During the recalibration, the equipment supplier must follow the calibration procedure described in deliverables D2.05 [11] and D2.07 [10], inside the WP 2 of this project.

Extra-check (if needed)

Apart from all the requirements described during this section, there are two more things to take under consideration for the operation of this device:

- *TPA (or pitot tube):* This component used as an exhaust flow meter has to be cleaned in case that the sample line leak check, described in this section, detects the average of particles measured is above the limit for this requirement (100 particles/cm^3).
- *Inlet Flow Check:* As well as TPA check, if the sample line check fails, the flow can be checked by putting a flow-meter in front of the heated sample tube. The value of the flow should be near to 0.7 L/min; otherwise it might have a leakage.
- *Cyclone:* When stored coarse particles are observed within the cyclone, a cleaning of it must be done. It has to be careful with the humidity and control it as well.

4 Conclusions & Recommendations

In this report, the operation procedure for both the new *PEMs4Nano LabSystem* and the *PEMs4Nano PEMS System* has been defined. Following the requirements sent by the partners within the WP 2, several checks and maintenance actions have been established. These requirements have been divided in different actions to do before each test, daily, monthly and even yearly. There are no variations between this operation procedure or calibration protocols in a standard laboratory and the one already implemented for 23 nm lab and on-board systems.

Concerning the validation of the calibration procedure, it has been reviewed the calibration of both equipment performed by TSI and Horiba. The results of the assessment are shown in the following table:

	PEMs4Nano LabSystem					**PEMs4Nano PEMS System**				
Criteria	**Target**	**Qualitative Assessment scale: how the measurement technology is with respect to the criterion considered.**				**Target**	**Qualitative Assessment scale: how the measurement technology is with respect to the criterion considered.**			
		suitable	**slightly suitable**	**not suitable**			**suitable**	**slightly suitable**	**not suitable**	
		☺	😐	☹	**RESULT**		☺	😐	☹	**RESULT**
Calibration method	Traceable	totally	partially	non-traceable	☺	Traceable	totally	partially	non-traceable	☺
Linear response	$R^2 > 0.97$	$R^2 > 0.97$	$R^2 > 0.95$	$R^2 < 0.95$	☺	$R^2 > 0.95$	$R^2 > 0.95$	$R^2 > 0.92$	$R^2 < 0.92$	☺
Counting efficiency of 10 nm particles	50% or more	≥50%	≥40%	<40%	☺	50% or more	≥50%	≥40%	<40%	☺
Counting efficiency of 15nm particles	50% or more	≥90%	≥80%	<80%	☺	50% or more	≥90%	≥80%	<80%	😐
PCRF	PCRF 15 nm/ PCRF 100 nm < 2	<2	<3	>3	☺	PCRF 15 nm / PCRF 100 nm < 2	<2	<3	>3	😐

Table 2-2: Criteria definition for PEMs4Nano LabSystem and PEMs4Nano PEMS System - Results

5 Deviations from Annex 1

There are no deviations in terms of time or content.

6 Bibliography

[1] PEMs4Nano deliverable D1.2 "Report on criteria for project internal impact assessment - IDIADA

[2] European Regulation: Addendum 82: Regulation No. 83 - Annex 4a – Appendix 5(E/ECE/324/Rev.1/Add.82/Rev.5; E/ECE/TRANS/505/Rev.1/Add.82/Rev.5).

[3] GTR No. 15: Addendum 15: Global technical regulation No. 15: Worldwide harmonized Light vehicles Test Procedure (ECE/TRANS/180/Add.15).

[4] “European Regulation of Real Driving Emissions (RDE) 2016/46. Additional updated information about the PN 23 nm equipment requirements can be found in the Amending Regulation RDE 4th package.

[5] ISO 27891-2015: Aerosol particle number concentration - Calibration of condensation particle counters

[6] PEMs4Nano deliverable D2.4 "Calibrated-Solid-Particle-Counting-System-LabUse" - HORIBA Europe

[7] B. Giechaskiel, Real Driving Emissions (RDE): Particle Number (PN) Portable Measurement Systems (PEMS) calibration, EUR 29036 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-77482-9, doi:10.2760/553725, JRC110424

[8] PEMs4Nano deliverable D2.2 "Calibrated CPC for lab use with calibration procedure" - TSI

[9] The HORIBA Solid Particle Counting System MEXA-2100SPCS Instruction manual of Installation and Maintenance.

[10] PEMs4Nano deliverable D2.07 "Calibrated PEMS particle counting system" - HORIBA Europe

[11] PEMs4Nano deliverable D2.05 "Calibrated CPC with D50 10 nm for PEMS use - TSI

[12] The HORIBA On-board Emissions Measurement System OBS-ONE-PN 23 nm - Instruction manual of Installation and Maintenance was used to consult some maintenance requirements

7 Acknowledgement

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

Project partners:

#	Type	Partner	Partner Full Name
1	IND	HORIBA	Horiba Europe GmbH
2	IND	Bosch	Robert Bosch GmbH
3	IND/SME	CMCL	Computational Modelling Cambridge Limited
4	IND	TSI	TSI GmbH
5	HE	UCAM	The Chancellor, Masters and scholars of the University of Cambridge
6	HE	ULL	Université des Sciences et Technologies De Lille – Lille I
7	IND	IDIADA	Idiada Automotive Technologie SA
8	IND	HORJY	Horiba Jobin Yvon S.A.S.
9	IND/SME	UNR	Uniresearch BV

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Appendix A – Quality Assurance

The following questions should be answered by all reviewers (WP Leader, peer reviewer 1, peer reviewer 2 and the technical coordinator) as part of the Quality Assurance Procedure. Questions answered with NO should be motivated. The author will then make an updated version of the Deliverable. When all reviewers have answered all questions with YES, only then the Deliverable can be submitted to the EC.

NOTE: For public documents this Quality Assurance part will be removed before publication.

Question	WP Leader	Peer reviewer 1	Peer reviewer 2	Technical Coordinator
	Rosa Delgado	Juergen Spielvogel	Andreas Manz	Marcus Rieker
1. Do you accept this deliverable as it is?	Yes	Yes	Yes	Yes
2. Is the deliverable completely ready? If not, please indicate and motivate required changes.	Yes	Yes	Yes	Yes
3. Does this deliverable correspond to the DoW?	Yes	Yes	Yes	Yes
4. Is the Deliverable in line with the PEMs4Nano objectives?	Yes	Yes	Yes	Yes
a. WP Objectives?	Yes	Yes	Yes	Yes
b. Task Objectives?	Yes	Yes	Yes	Yes
5. Is the technical quality sufficient?	Yes	Yes	Yes	Yes

Appendix B – Abbreviations / Nomenclature

Table B-1 List of Abbreviations / Nomenclature.

Symbol / Shortname	
C0	Size independent loss correction factor for particles
CFO	Critical Flow Orifice
CPC	Condensation Particle Counter
CS	Catalytic Stripper
D50	Cut-off size where 50% of the particles are detected by the CPC
Dil	Dilution setting
DP	Particle Diameter in nm
DSU	(HORIBA) Direct sample unit
HEPA-filter	High Efficiency Particulate Air filter
IPA	Isopropyl alcohol
OBS	On-board system
PAO	Poly-Alpha-Olefin (here: a calibration aerosol material)
PCRF	Particle Count Reduction Factor
PEMS	Portable Emission Measurement System
PMP	Particle Measurement Programme
PN	Particulate Number
PNCS	Particle number counting system
R^2	Coefficient of determination
SPCS	Solid particle counting system (HORIBA PNCS)
TPA	Tail-pipe attachment
UUT	Unit under test
VPR	Volatile Particle Remover