Informal document GRPE-89-25
89th GRPE, 30 May – 2 June 2023
Agenda item 12

Status Report of the

VIAQ (Vehicle Interior Air Quality)

Informal Working Group

Geneva, 30 May – 2 June, 2023

Chair: Andrey KOZLOV, Russian Federation

Co-Chair: Inji PARK, The Republic of Korea

Secretary: Andreas WEHRMEIER, BMW

ToR for the Third Stage

Terms of reference and rules of procedure for the IWG on Vehicle Interior Air Quality

Background. The group considered the inclusion in the scope of interior air pollutants from outside sources as a possible extension of the mandate at third stage. As an extension of the existing Mutual Resolution on VIAQ, this will take into account not only interior air emissions generated from interior materials and exhaust gases from the vehicle entering into the cabin but also outside air pollution sources. The list of outside air pollutions could include CO, NO, NO_2, SO_2, O_3 volatile organic compounds (VOC), aldehydes, aromatic and aliphatic hydrocarbons, particulate number (PN) and mass (PM) and microbiological substances, e.g. allergens, fungi, bacteria and viruses. As an extension of the existing Mutual Resolution on VIAQ, this will take into account not only interior air quality but also the air cleaning efficiency of the vehicle air handling & treatment system.

Objective. This proposal expands on the issues of the vehicle interior air quality, addressing outside air pollutants entering into the vehicle cabin and the interior air cleaning efficiency, to develop a test procedure in a recommendation by including Part 4 in the Mutual Resolution No. 3.

Scope and work items. Outside air pollutants entering into the vehicle cabin and their cleaning efficiencies

(a) Collect the information and research data on relevant air pollutants and similar issues, and understand the current regulatory requirements with respect to vehicle interior air quality in different markets.

(b) Review, assess and develop new test procedures suitable for the measurement methods of air pollutants entering into the vehicle cabin and their cleaning efficiencies (including test modes, sample collection methods and analysis methods, etc.)

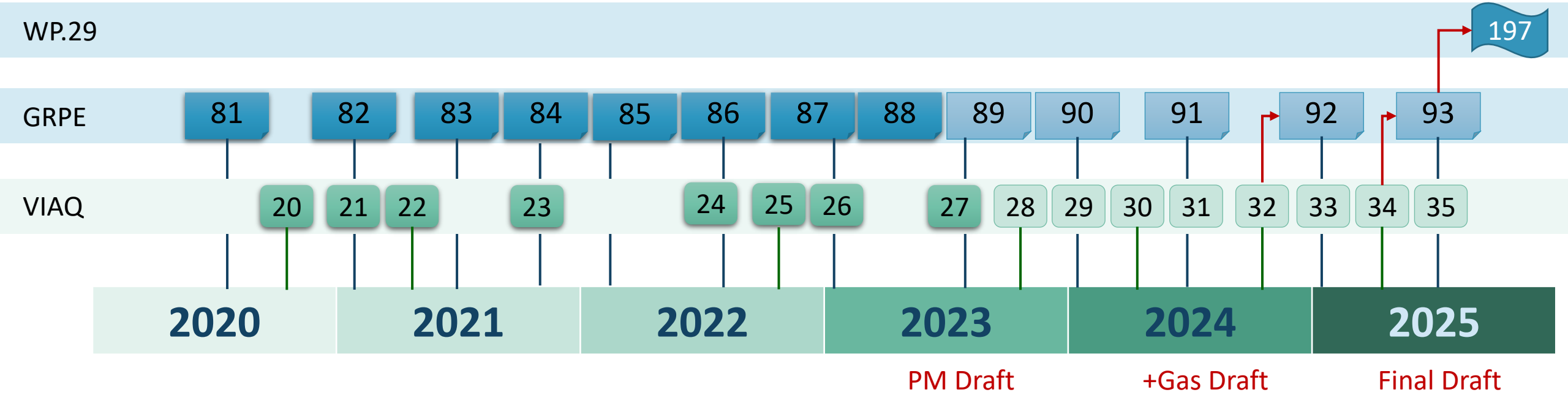
(c) Discuss the potential of air pollutants in the vehicle interior air with toxicologists.

(d) Develop a draft for test procedures in a recommendation.

VIAQ IWG Meetings since the last GRPE session

- **27th VIAQ IWG Meeting (hybrid)**
  - Geneva, Switzerland, 25th May, 2023
  - One day

Timeline



Data collection → Analysis of existing test procedures → Tests by VIAQ IWG members → **Developing of harmonized test procedure**

Stage 3. Phase 1

Stage 3. Phase 2

Information presented 27th meeting

Company	Presenter Name	Document Title	Document No.
Freudenberg filtration technologies	Ulrich Stahl	Procedure for artificial aging of cabin air filters	VIAQ-27-06
NAMI	Zinaida Bulycheva	Assessment of nitrogen oxide and dioxide content in the internal space of the vehicles with various types of engines when tested in a busy traffic flow	VIAQ-27-07
OICA	Andreas Wehrmeier	Evaluation of draft test procedure - Measurements and recommendations by OICA	VIAQ-27-10

Discussion of working items

The items

1. Vehicle Category
2. Criteria for excluding a vehicle from tests
3. Test Vehicle age/millage
4. Meteorological Conditions
5. Test Conditions
6. Sampling Points/Sampling Lines
7. Ambient air concentration level ($PM_{2.5}$)
8. Cabin air filter age
9. PM and gas components to be Measured
10. Measurement Methods
11. Test equipment requirements
12. Gas Analysers Calibration
13. Test Modes
14. HVAC Modes
15. Test Procedure
16. Test Protocol

Draft of Part IV of the Mutual Resolution (M.R.3)

Draft document (VIAQ-27-04) and Template for comments (VIAQ-27-05) were sent to all VIAQ IWG members

We received comments from members (VIAQ-27-08):

- OICA
- CLEPA; Europe
- Palas; Germany
- MANN+HUMMEL GMBH; Germany
- Donnay Detoxicology LLC (DD); USA

In total about 80 comments

Draft of Part IV of M.R.3 on VIAQ

Draft document (GRPE-89-26)

Contents

Draft of Part IV of M.R.3 on VIAQ

1. Purpose

The part IV of the Mutual Resolution contains the provisions and harmonized test procedure for the measurement of interior air quality and the interior air cleaning efficiency concerning the protection of the driver and passengers from harmful emissions entering the vehicle cabin with outside air pollutants.

2. Scope and application

This part of Mutual Resolution applies to category 1-1 vehicle, as defined in the Special Resolution No. 1.[1]

3. Definitions

For the purpose of this part, the following definitions apply:

3.1. "*Test vehicle*" means the new vehicle from series production to be tested, mileage from 3,000 – 15,000 km;

3.2. "*Test substances*" means the substances to be measured and are fine particulate matter ($PM_{2.5}$), nitrogen monoxide (NO), nitrogen dioxide (NO_2) carbon dioxide (CO_2);

3.3. "*Background concentration*" means the test substance concentration at the vehicle air intake at the start of the test;

3.4. "*Real driving test*" refers to the test in which test substances are sampled from the outside and interior air of a test vehicle moving at urban roads;

3.5. "*Sampling point*" means a point where the test substances are sampled.

4. Abbreviations

4.1. General abbreviations

VIAQ	Vehicle Interior Air Quality
HVAC	Heating, Ventilation and Air Conditioning

4.2. Chemical symbols and abbreviations

$PM_{2.5}$	Fine particulate matter
NO	Nitrogen monoxide [CAS#: 10102-43-9]
NO_2	Nitrogen dioxide [CAS#: 10102-44-0]
CO_2	Carbon dioxide [CAS#: 124-38-9]

5. General provisions

5.1. When instructed to include this test procedure in national standards, Contracting Parties are invited to adopt this part of Mutual Resolution regarding the comparison of internal measurement of air pollutants entering into the cabin and measurement of pollutants in outside air.

5.2. This part of the Mutual Resolution does not hold regulatory status within Contracting Parties. Contracting Parties refer to the VIAQ recommendation when used for the assessment on vehicle interior air quality with the technical prescriptions of their own standards or regulations.

5.3. There are several test methods available for assessing vehicle interior air quality and this Mutual Resolution takes into account these existing standards.

5.4. This part of Mutual Resolution will encourage the improvement of vehicle body and air cleaning and heating, ventilation and conditioning system design to increase air quality inside the passenger cabin.

5.5. Due to the different levels of development, different regional cultures, and the costs associated with interior air quality control technology, the regulatory stringency is expected to be different from region to region for the foreseeable future. The setting of interior pollutant concentration limit values, therefore, is not part of this recommendation for the time being.

6. Normative references

6.1. ISO 16000-1:2004 Indoor air – Part 1: General aspects of sampling strategy.

6.2. UN Regulation No. 83 - Rev.5 – Uniform provisions concerning the approval of vehicles with regard to the emission of pollutants according to engine fuel requirements (Annex 4a - Appendix 7).

6.3. Proposal for a new UN Regulation No. [XXX] on uniform provisions concerning the approval of light duty passenger and commercial vehicles with regards to real driving emissions (RDE) (Working document ECE/TRANS/WP.29/GRPE/2023/3).

6.4. CWA 17934:2022 - Real drive test method for collecting vehicle interior air quality data.

7. Requirements for the test vehicle

7.1. Test vehicles should only be new vehicles from serial production. Used vehicles are not included. The selection of vehicles should be based on a worst case to minimize testing cost. For the purpose of emissions entering into the cabin with outside air equipment for air purification is only allowed in the test cars if it is serial equipment.

7.2. The new vehicle should have been run in for between 3000 and 15000 km and have age more than one month.

7.3. General inspection of the test vehicle should be performed before testing.

7.4. The vehicle should be excluded from the test in case of a positive answer to any of the criteria below:

(a) Does the vehicle not have a full service history?

(b) Is there a Malfunction Indication Light showing on the vehicle instrument panel?

(c) Has the vehicle had unauthorised vehicle repairs?

(d) Has any part of the vehicle's heating and ventilation system replaced with non-original parts?

(e) Through visual inspection of the vehicle, are there any damaged ventilation system relevant components?

(f) Are there any obstructions to the vehicle air intake path?

(g) Is the vehicle not in overall safe operating condition?

(h) Is there any damage to the body of the vehicle, including but not limited to doors, windows and the rear?

7.5. The test vehicle should be equipped with OEM-approved cabin air filter artificially aged to 3000 km. Filter type needs to be documented.

7.5.1. The filter aging procedure.

8. Requirements for the test apparatus, instrument and equipment

8.1. Test substances. During the tests concentrations of substances listed below should to be measured:

(a) Fine particulate matter ($PM_{2.5}$) inside and outside vehicle cabin;

(b) Nitrogen monoxide (NO) inside and outside vehicle cabin;

(c) Nitrogen dioxide (NO_2) inside and outside vehicle cabin;

(d) Carbon dioxide (CO_2) inside vehicle cabin only.

8.2. Sampling points and lines requirements.

8.2.1. The interior sampling point should be a head-height between the front headrests. Sampling tube should be directed to the rear of the vehicle to avoid affect of driver and passenger breathing to the CO_2 measurement.

8.2.2. The external sampling point should be as close as reasonably possible to the ventilation air intake.

8.2.3. The sampling lines to the analyser should be:

(a) as short as possible;

(b) line lengths must be identical and not more than 2 m;

(c) as straight as possible;

(d) with few bendings as possible;

(e) with no sharp bendings;

(f) made of antistatic materials for particles measurement;

(g) made of PTFE for gases measurement;

8.3. Test substance concentration measurement methods.

8.3.1. For fine particles ($PM_{2.5}$): optical particle counter.

8.3.2. For nitrogen oxides (NO, NO_2): non-dispersive ultra-violet chemiluminescent detector, and for NO_2: iterative cavity-enhanced differential optical absorption spectroscopy.

8.3.3. For carbon dioxide (CO_2): Non-dispersive infra-red detector.

8.4. Test substance concentration measurement limits.

8.4.1. The measuring equipment should provide the lower and upper limits of measurable concentrations of the test substances at the presence of other components as in the table below.

Test substance	*Detection limit of measurement, not less than*	*Accuracy of measurement, not more than*
Fine particles $PM_{2.5}$	2.0 $\mu g/m^3$	TBD
Nitrogen monoxide NO	2 ppb	±1%
Nitrogen dioxide NO_2	2 ppb	±1%
Carbon dioxide CO_2	100 ppm	±3.0% of reading or ±50 ppm

8.5. Time resolution of measurement equipment should be less than 5 seconds and measurement data during the test should be saved on internal or external memory.

8.6. Test equipment should be suitable for mobile application.

8.7. Test equipment should fulfil common safety regulations.

8.8. Additional measurement equipment.

8.8.1. For tests using additional measurement equipment the following are to be used: thermometer, relative humidity meter, barometer. Limit of permissible basic error for the above-mentioned equipment is presented in the table.

Parameter	*Limit of permissible basic error*
Temperature	±1°C
Relative humidity	±2.5%
Atmospheric pressure	±0.1 kPa

9. Test procedure, test mode, and test conditions

9.1. The preparation procedure.

9.1.1. Take out cabin air filter and replace by new artificially aged one. Check correctness of air flow direction of the filter when replacing.

9.1.2. Check vehicle for tightness (sealings, windows, doors, trunk, roof). A vehicle with defective components should not be tested.

9.1.3. Ensure exhaust pipe is representative of serial production. Visually check exhaust pipe for tightness.

9.1.4. Before testing substance concentration, the measurement equipment and sampling system should be placed inside the test vehicle and warmed up ahead of the test start time in accordance with the equipment manual.

9.2. Meteorological conditions.

9.2.1. Ambient temperature in the range from +5°C to +25°C.

9.2.2. Relative humidity from 40% to 80%.

9.2.3. Atmospheric pressure from 85 to 110 kPa

9.2.4. Weather condition should be: no rain, fog, snow or standing water on the carriageway.

9.3. Test conditions.

9.3.1. The VIAQ performance shall be demonstrated by testing vehicles on the road, operated over their normal driving patterns, conditions and payloads. The test shall be conducted on paved roads (e.g. off-road operation is not permitted).

9.3.2. Background air pollution level:

(a) fine particles $PM_{2.5}$ concentration should be not less than 15 µg/m^3 and not more than 500 µg/m^3;

(b) NO tbd;

(c) NO_2 tbd;

(d) CO_2 tbd.

9.3.3. Windows, doors, sunroof or convertible soft top must be closed at all times. Heated or cooled seats should not be used.

9.3.4. When cleaning the vehicle prior to testing, only a damp cloth should be used. Fragrances and air fresheners should be avoided.

9.3.5. There should the driver and one passenger present in the vehicle for the duration of the test. No passengers should be on the rear seats. Clothing should cover both arms and legs. All outer clothing and shoes should be clean to minimize particle generation. This also applies to the vehicles interior such as seats or carpets. Fragrances and fresheners must not be active.

9.3.6. The occupants should avoid applying any fragrances or make-up prior to or during the test. Further, occupants should not have smoked the same day to avoid to add pollution to the test.

9.3.7. The trip shall consist of approximately 55 per cent urban and 45 per cent expressway speed bins. ‘Approximately’ shall mean the interval of ±25 per cent points around the stated percentages. The urban speed bin however can never be less than 40 per cent of the total trip distance.

9.3.8. Urban speed bin is characterised by vehicle speeds lower than or equal to 60 km/h.

9.3.9. Expressway speed bin is characterised by speeds above 60 km/h and up to 100 km/h.

9.3.10. Local speed limits remain in force during a test, notwithstanding other legal consequences. Stop periods, defined by vehicle speed of less than 1 km/h, shall account for 6-30 per cent of the time duration of urban operation. Urban operation may contain several stop periods of 10 s or longer.

9.3.11. The trip duration shall be between 60 and 90 minutes.

9.3.12. The minimum distance of each, urban and expressway speed bins shall be 16 km.

9.3.13. The start and the end points of a trip shall not differ in their elevation above sea level by more than 100 m. In addition, the proportional cumulative positive altitude gain over the entire trip and over the urban operation shall be less than 1,200 m/100 km.

9.4. Vehicle conditioning.

9.4.1. Before testing, the vehicle shall be preconditioned in the following way: The vehicle shall be driven, preferably on the same route as the planned real driving testing, or for at least 10 min for urban operation or 30 minutes with a minimum average velocity of 30 km/h. The vehicle shall subsequently be parked with doors and bonnet closed and kept in engine-off status within moderate or extended altitude and temperatures, in accordance with paragraph 9.2, for between 6 and 72 hours. Exposure to extreme atmospheric conditions (such as heavy snowfall, storm, hail) and excessive amounts of dust or smoke should be avoided.

9.4.2. Before the test start, the vehicle and equipment shall be checked for damages and the presence of warning signals that may suggest malfunctioning. In the case of a malfunction the source of the malfunctioning shall be identified and corrected or the vehicle shall be rejected.

9.5. HVAC system settings:

for automatic mode: temperature 22˚C, if possible, adjust manually: fan speed 50%/medium;

for manual mode: fan speed 50%/medium, temperature 50%/medium, fresh air mode;

air conditioning: switched ON;

ventilation flaps: fully open and directed straight ahead;

if a vehicle has manufacturer-installed air quality sensors, these should be left in the predominant mode.

9.6. Real driving test procedure.

9.6.1. Measure ambient air temperature, relative humidity, pressure and background air pollutants concentration listed at 9.3.2.

9.6.2. Start the engine, adjust HVAC operation mode, switch on the PM analyzers and drive for at least 10 min.

9.6.3. Drive to the beginning of the test route, start PM analyzers, GPS logger.

9.6.4. Drive on the route urban and expressway parts.

9.6.5. Park the car, stop the PM measurement, GPS logger.

9.6.6. Switch off PM analyzer and the engine.

9.6.7. Save measurement protocols from PM analyzers and GPS track from logger to the computer.

9.6.8. Take another background measurement according to paragraph 9.6.1. Vehicle real driving test is complete.

10. Calculation, presentation of results, precision and uncertainty

10.1. Calculation of results.

10.1.1. Calculate the fine particles cleaning efficiency by formula:

$$\eta_{pm} = \left(1 - \frac{C_{pm}^{in}}{C_{pm}^{out}}\right) \cdot 100\%$$

where:

C_{pm}^{in} is the average inside $PM_{2.5}$ concentration [µg/m^3],

C_{pm}^{in} is the average outside $PM_{2.5}$ concentration [µg/m^3].

10.2. Data reporting shall use the format in Annex 7. Additions to the report should be agreed on between the client and the laboratory.

11. Performance characteristics

11.1. Calibration procedure.

11.1.1. Calibration should be done according to GTR 15.

11.1.2. Calibration and linearization of the equipment shall be performed according to manufacturer recommendations prior to the commencement of measurements.

11.1.3. After the equipment is installed in the vehicle, a dynamic calibration shall be performed. The dynamic calibration ensures that the paired instruments are measuring the same concentrations. The dynamic calibration should be run each time: before the test series; if there is a new or changes to an existing test equipment installation on a vehicle; and after the first test to ensure in correct measurement. For the purposes of this calibration test, a stainless steel Y-piece should be used to split the air from the exterior sample probe equally between the interior and exterior measurement instruments. At the end of the calibration, the Y-piece should be removed and the installation returned to the test configuration.

11.1.4. The dynamic calibration test should be run for at least 30 minutes and expose the vehicle to concentrations in the range defined in paragraph 9.3.2. The Pearson correlation coefficient between the data points from each matched pair of measurement devices shall be calculated. For a valid calibration, the r^2 on all devices should be at least 0.98.

11.1.5. The drift of the zero response of the particle number instruments, defined as the mean response to HEPA filtered air at the inlet of the sampling line during a time interval of at least 30 seconds, shall be tested prior to each test and shall be less than 3 µg/m^3.

11.1.6. The drift of the zero response of the carbon dioxide instruments, defined as the mean response to ambient air at the inlet of the sampling line during a time interval of at least 30 seconds, shall be tested prior to each test.

11.1.7. Annual calibration following supplier recommendation.

12. Quality assurance/quality control

12.1. The tests proceeded in accordance to paragraph 9. of part IV are valid if all quality requirements listed in this paragraph are fulfilled.

12.2. Quality control requirements for real driving test are listed in the table below.

Subclauses	*Description*	*Criterion*	*Frequency*	*Comments*
9.2.1	Ambient temperature	+5 to +25°C	Each test	Control at the beginning and at the end of each test
9.2.2	Relative humidity	40 to 80%	Each test	Control at the beginning and at the end of each test
9.2.3	Atmospheric pressure	85 to 110 kPa	Each test	Control at the beginning and at the end of each test
9.3.2	Background $PM_{2.5}$ concentration	15 to 500 µg/m³	Each test	Control at the beginning and at the end of each test

Annex 7

Test report of emissions entering to the vehicle cabin with outside air pollutants and the interior air cleaning efficiency

Reporting Format and Data Exchange

The data exchange file shall be constructed as follows. Test substance concentrations as well as any other relevant parameters shall be reported and exchanged as a csv-formatted data file. Parameter values shall be separated by a comma, ASCII-Code #h2C. The decimal marker of numerical values shall be a point, ASCII-Code #h2E. Lines shall be terminated by carriage return, ASCII-Code #h0D. No thousand separators shall be used.

Headers of the Reporting and Data Exchange File

Line #	*Parameter*	*Basic Data Type [A=Alpha or N=Numeric (max length, fractional digits)]*	*Data Type [Enumeration String, Decimal, Integer]*	*Total Digits*	*Fractional Digits*	*Minimum Value*	*Maximum Value*	*Allowed Values for: Enumeration or Description or Units*
1	Process Code	N(2)	Integer			0	99	Version of Test Report. 1st dataset is N=0, highest value is the latest correction of existing dataset
2	Name of Witness	A(250)	String					Only if applicable. Full name of witness, company name and contact information for certification of test. Use "Self-Certified" if no
50	Urban Bin Part	N(2,1)	Decimal	3	1	0.0	99.9	[%]
51	Expressway Bin Part	N(2,1)	Decimal	3	1	0.0	99.9	[%]
52	Trip Distance Urban Part	N(2,1)	Decimal	3	1	0.0	99.9	[km]
53	Trip Distance Expressway Part	N(2,1)	Decimal	3	1	0.0	99.9	[km]
54	Trip Duration	N(3,1)	Decimal	4	1	0.0	999.9	[min]
55	Elevation Above the Sea Level at Start	N(3,1)	Decimal	4	1	0.0	999.9	[m]
56	Cumulative Altitude Gain	N(3,1)	Decimal	4	1	0.0	999.9	[m]
57-59(1)	…	…	…					…
60	Fine Particulate Matter (PM2.5) – Inside – Average	N(4,1)	Decimal	5	1	0.0	9999.9	[µg/m^3]
61	Fine Particulate Matter (PM2.5) – Inside – Maximal	N(4,1)	Decimal	5	1	0.0	9999.9	[µg/m^3]
62	Fine Particulate Matter (PM2.5) – Inside – Minimal	N(4,1)	Decimal	5	1	0.0	9999.9	[µg/m^3]
63	Fine Particulate Matter (PM2.5) – Outside – Average	N(4,1)	Decimal	5	1	0.0	9999.9	[µg/m^3]

Proposals for Organizing of Interlaboratory Tests

Target: to check draft procedure for consistency, repeatability, reproducibility and accuracy in different laboratories and different conditions

Tasks are to check:

1. **Test procedure clarity and consistency**
2. **Repeatability and reproducibility of test results in different laboratories and different ambient, driving and air pollution level conditions**
3. **Test equipment requirements and applicability**
4. **Reliability of measurements (test methodology allows to achieve reliable results)**

As a result: to revise test procedure according to obtained checking results

Proposals for Organizing of Interlaboratory Tests

I stage

To carry out tests of different cars in different countries in different conditions to check firs of all test methodology clarity and consistency and repeatability of test results INSIDE THE SAME LABORATORY

Time schedule: June – October 2023

II stage

To carry out tests of the same cars in different countries to check firs of all reproducibility of test results obtained IN DIFFERENT LABORATORIES

Time schedule: April – October 2024

Proposals for Organizing of Interlaboratory Tests

Possible participants:

- **KATRI (Korea)**
- **ESTACA/UTAC (France)**
- **NAMI (Russian Federation)**
- **OICA (BMW)**

Reporting:

Test results and comments to improve the test procedure could be reported to the VIAQ informal working group

List of tasks

Working Item	Tasks
5. Test Conditions	Finalize urban speed limit (now 60 km/h; proposed 50 km/h)
6. Sampling Points/Sampling Lines	Investigate the influence of sampling line length to PM measurement accuracy
7. Ambient air concentration level	The group need to set background levels to all measured components (regarding item 9) $PM_{2.5}$ background concentration level agreed
8. Cabin air filter age	Define artificial filter aging procedure
9. PM and gas components to be Measured	Nitrogen Oxide inclusion to the scope have to be discussed
11. Test equipment requirements	Finalize specification for test equipment
14. HVAC Modes	Finalize HVAC modes for test procedure (proposed to add mode with recirculation ON)

Next VIAQ IWG Meetings

- **28th VIAQ IWG Meeting (TBD)**
  - Paris, France, November, 2023
  - Two days

  OR

  - On-line meeting, November, 2023
  - One day