

## **Part 2 - Metrological controls and performance tests**

### **1 Metrological controls**

#### **1.1 General**

In general (depending on national or regional legislation), legal metrological control can consist of type evaluation, initial and subsequent verification, and metrological supervision. This Part gives general guidelines for each of these steps.

#### **1.2 Responsibility for compliance with the requirements**

**1.2.1** Notwithstanding the kind of legal metrological control in a country, the manufacturer (or its formal representative) has the full responsibility that the instruments comply with the requirements in Part 1 at the moment they are delivered to the user.

**1.2.2** After assignment, the owner of the instrument has the responsibility that the instrument is well maintained and complies with the requirements in Part 1 as long as the instrument is in use. The operational presence of the instrument at the owner's premises is considered as "in use".

#### **1.3 Reference PN sample**

A reference PN sample is generated by a particle (aerosol) generator with a reference instrument. The reference instrument measures the reference value of the sample because the generator usually can only approximate a particle concentration. The particles should be close to soot. Other particles (such as salt or oil) may be used provided that correlation is available. The applied aerosols are considered to be thermally stable.

The reference instrument shall be traceable to national, regional or international standards. The particle size distribution can be monodisperse or polydisperse. For the error curve a polydisperse aerosol should be used in order to reach high concentrations. For the counting efficiency a monodisperse aerosol shall be used.

#### **1.4 Uncertainty of the reference**

**1.4.1** Each test comprises measurements applying harmonized test setups for the verification of compliance with requirements. Measurement uncertainty is an attribute of each measurement.

**1.4.2** The uncertainty associated with the test method shall be taken into account in the decision on the applicability of the test method.

When a test is conducted, the expanded uncertainty of the reference used for the determination of errors on indications shall be less than or equal to one-third of the MPE.

**1.4.3** The estimation of expanded uncertainty is calculated according to the Guide to the expression of uncertainty in measurement [1] applying a coverage probability which corresponds the application of a coverage factor  $k = 2$  for a normal distribution and which comprises approximately 95 % of the measurement results.

## **1.5 Type evaluation**

### **1.5.1 Documentation**

When applying for type evaluation, the documentation supplied by the manufacturer for an instrument shall include:

- a) A description of its general principle of measurement;
- b) A list of its essential components with their characteristics;
- c) A description of its essential components with drawings and diagrams that are necessary for testing and maintenance;
- d) General information on the software;
- e) The operating instructions that shall be provided to the user.

Along with an application for type evaluation, the manufacturer shall provide any data or other information that may support the assertion that the design and construction of the instrument comply with the requirements of this Recommendation.

### **1.5.2 General requirements**

Type evaluation shall be carried out on at least one unit, which represents the definitive type. The evaluation shall consist of the tests specified in clause 2 and checking the requirements for which no test is available by inspection and/or functional checks.

Specified nominal concentrations have a tolerance of  $\pm 20\%$  unless otherwise specified, provided by a particle generator with reference instrument.

### **1.5.3 Inspection and tests**

The inspection and testing of instruments is intended to verify compliance with the requirements of clauses 5, 6 and 7 of Part 1 of this Recommendation.

As a rule, tests should be carried out on the complete instrument according to its specifications without (software) modifications.

**1.5.3.1** An instrument shall be given a visual inspection to obtain a general appraisal of its design, construction, and conformity to the documentation submitted for type examination.

In particular, the requirements of Part 1 not covered by tests shall be evaluated.

**1.5.3.2** The EUT shall be submitted to the performance tests specified in clause 2 to determine its correct functioning.

**1.5.3.3** A measurement concerns the end result of a cycle as performed by the instrument in its normal operation mode. The length of the cycle may depend on applicable legislation. For the type evaluation the shortest cycle as defined by the manufacturer should be used. For verification the cycle for the applicable legislation should be used.

## **1.6 Initial verification**

### **1.6.1 General requirements**

A new instrument shall undergo initial verification only after type evaluation. The verification shall be carried out using suitable testing means and a particle generator with reference instrument.

### **1.6.2 Inspection**

Before starting the tests, the following inspections shall be performed:

- a) A visual inspection to determine conformance with the approved type;
- b) 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.

### **1.6.3 Tests**

The tests to determine the errors of the instrument shall be carried out under rated operating conditions.

- a) Before starting the tests, adjust the instrument according to the routine adjustment procedure described in the manufacturer's operating instructions.
- b) Check the air-tightness of the system by performing a leak check as described in the manufacturer's operating instructions.
- c) Check for the activation of the low gas flow device, and also for the low flow lockout, by restricting the gas flow supplied to the probe while sampling ambient air.
- d) After the instrument has warmed up, determine the error curve according to clause 2.1 with the reference samples defined in 1.6.4.  
The errors observed shall be within the maximum permissible error for each measurement.
- e) Check the response time.

### **1.6.4 Reference PN samples to be used for initial verification**

Initial verification shall be performed with 5 reference samples including the minimum and maximum of the measuring range and the point where the MPE changes from absolute to relative (100 000 particles/cm<sup>3</sup>) and 2 intermediate values. Nominal values + / - 30% provided by generator with reference instrument.

## **1.7 Subsequent verification**

### **1.7.1 General requirements**

The subsequent verification shall be carried out using suitable testing means and a particle generator with reference PN instrument.

The interval for subsequent verification is subject to national or regional legislation. The suggested interval is 1 year.

### **1.7.2 Inspection**

Before starting the tests, a visual inspection shall be performed to determine the validity of the previous verification and the presence of all required stamps, seals and documents.

### **1.7.3 Tests for subsequent verification**

The tests to determine the errors of the instrument shall be carried out under rated operating conditions.

- a) Before starting the tests, adjust the instrument according to the routine adjustment procedure described in the manufacturer's operating instructions.
- b) Check the air-tightness of the system by performing a leak check as described in the manufacturer's

operating instructions.

- c) Check for the activation of the low gas flow device, and also for the low flow lockout, by restricting the gas flow supplied to the probe while sampling ambient air.
- d) After the instrument has warmed up, determine the error curve according to clause 2.1 with the reference samples defined in 1.7.4.  
The errors observed shall be within the maximum permissible error for each measurement.

#### **1.7.4 Reference PN samples to be used for subsequent verification**

Subsequent verification shall be performed with at least 3 reference samples including near to zero, 100 000 particles/cm<sup>3</sup> and 1 000 000 particles/cm<sup>3</sup>. Nominal values + / - 50% provided by generator with reference instrument.

## **2 Performance tests for type evaluation**

Prior to the type evaluation tests and when specified in the manufacturer's operating instructions provided under 2.1.1, the instrument shall be adjusted according to these instructions.

Except for the parameter being tested, the reference conditions specified in Part 1, 5.6.1 apply.

### **2.1 Check of the error curve (linearity)**

This test shall be carried out under reference conditions.

The errors of the instrument shall be determined for at least 10 concentrations within the measuring range including the minimum and maximum of the measuring range and the point where the MPE changes from absolute to relative (100 000 particles/cm<sup>3</sup>) and 7 intermediate values.

The measurements shall be performed successively. During this test, the errors shall not exceed the maximum permissible error.

### **2.2 Stability with time or drift**

This test shall be conducted for a period of 12 h following the warm-up time. Measurements shall be performed at least every hour using a nominal concentration of 100 000 particles/cm<sup>3</sup>.

During this test, the errors shall not exceed half the maximum permissible error.

### **2.3 Repeatability**

The requirement specified in Part 1, 5.11 shall be tested with a nominal concentration of 100 000 particles/cm<sup>3</sup>. Between each measurement ambient air is offered to the instrument.

## 2.4 Effect of influence quantities

As a rule, only one influence quantity should be varied during a test while all the others are kept at their reference values.

An acceptable alternative for the reference instrument can be a second EUT kept at reference conditions. In this case the difference in indication of the two EUT's at reference conditions shall be corrected.

For each influence quantity test:

Test procedure	At each of the value(s) of the influence quantity:  Adjust the EUT as close to zero indication as practicable prior to the test. The EUT shall not be readjusted at any time during the test.  After stabilization, apply at least 5 concentrations including the minimum and maximum of the measuring range and the point where the MPE changes from absolute to relative (100 000 particles/cm <sup>3</sup> ) and 2 intermediate values and record:  a) date and time; b) temperature; c) relative humidity; d) measurands; e) indications; f) errors; g) functional performance.
Precondition	Normal electrical power supplied and "on" for a time period equal to or greater than the warm up time specified by the manufacturer.
Condition of the EUT	Power is to be "on" for the duration of the test.
Acceptance criteria	All functions shall operate as designed. All errors shall be within the maximum permissible error.

### 2.4.1 Temperature

Applicable standard	IEC 60068-2-1, IEC 60068-2-2, IEC 60068-3-1
Stabilization	2 hours at each temperature under "free air" conditions.
Temperature sequence	Reference temperature; Specified low temperature; Specified high temperature; Reference temperature.

### 2.4.2 Damp heat, steady state (non-condensing)

Applicable standard	IEC 60068-2-78
Condition of the EUT	The EUT shall be handled such that no condensation of water occurs on it.
Test	The EUT is kept at 40 °C, 85 % RH during 2 days (48 h). At the end of this period and still under this condition, apply the test procedure.
Notes	This test is applicable if intended for closed location.

### 2.4.3 Damp heat cyclic (condensing)

Applicable standard	IEC 60068-2-30, IEC 60068-3-4
Condition of the EUT	Condensation of water is expected to occur.
Test	<p>Exposure to cyclic temperature variation between 25 °C and the appropriate upper temperature while maintaining the relative humidity above 95 % during the temperature change and the low temperature phases and at or above 93 % RH at the upper temperature phases.</p> <p>The 24 h cycle comprises of:</p> <ul style="list-style-type: none"> <li>- temperature rise for 3 hours,</li> <li>- temperature maintained at upper value until 12 hours from the start of the cycle,</li> <li>- temperature lowered to lower temperature level within a period of time of 3 to 6 hours, the declination (rate of fall) during the first hour and a half being such that the lower temperature level would be reached in a 3 hours period,</li> <li>- temperature maintained at the lower level until the 24 h period is completed.</li> </ul> <p>The stabilizing period before and recovery after the cyclic exposure shall be such that all parts of the EUT are approximately at their final temperature.</p> <p>Test sequence:</p> <ol style="list-style-type: none"> <li>1. Measurements during rise of the temperature</li> <li>2. Measurements during high temperature</li> <li>3. Measurements during lower temperature level</li> </ol>
Notes	This test is applicable if intended for open location.

### 2.4.4 Atmospheric pressure

Applicable standard	No applicable standard known
Test	Exposure of the EUT to the specified upper and lower atmospheric pressures limits.

### 2.4.5 Voltage and frequency variation

Applicable standard	IEC 61000-2-1, IEC 61000-2-2 and IEC 61000-4-1	
Test	Exposure of the EUT to the specified upper and lower voltages and frequencies.	
Test level	Mains voltage	$U_{nom-high} + 10 \%$ $U_{nom-low} - 15 \%$
	Mains frequency	$f_{nom-high} + 2 \%$ $f_{nom-low} - 2 \%$
Note	The values of $U_{nom}$ and $f_{nom}$ are those marked on the EUT. If no range is specified the low and high values are equal.	

### 2.4.6 Road vehicle battery voltage variation

Applicable standard	ISO 16750-2	
Test	Exposure of the EUT to the specified voltages.	
Test level	$U_{nom} = 12 \text{ V}$	$U_{nom} = 24 \text{ V}$
Lower limit	9 V	16 V
Upper limit	16 V	32 V

#### 2.4.7 (Internal) battery voltage variation

Applicable standard	No applicable standard known
Test	Exposure of the EUT to voltages within the specified limits and below the specified lower limit. Reduce the power voltage until the EUT clearly ceases to function properly according to the specifications and metrological requirements. Also check just above this voltage.
Note	If an alternative power source (standard power supply with sufficient current capacity) is used in bench testing to simulate the battery, it is important that the internal impedance of the specified type of battery also be simulated.

#### 2.4.8 Particle size

Applicable standard	No applicable standard known
Test	Exposure of the EUT to particles with different sizes to check the counting efficiency is within the specified limits. The test is performed with one nominal concentration smaller than or equal to 100 000 particles/cm <sup>3</sup> .  Determine the (reference) indication with polydisperse aerosol with particle size distribution of 80 nm.  Determine the indication with monodisperse particle size distribution at the particle sizes specified in Part 1, 5.6.3.  Check that the indications comply with the requirements in Part 1, 5.6.3.
Note	Due to limited capabilities to generate monodisperse particle size distributions the nominal concentration may be down to 30 000 particles/cm <sup>3</sup>

## 2.5 Disturbances

An acceptable alternative for the reference instrument can be a second EUT kept at reference conditions. In this case the difference in indication of the two EUT's shall be corrected.

For each disturbance test:

Test procedure	At each of the value(s) of the disturbance: Adjust the EUT as close to zero indication as practicable prior to the test. The EUT shall not be readjusted at any time during the test. After stabilization, apply 1 concentration at the point where the MPE changes from absolute to relative (100 000 particles/cm <sup>3</sup> ) and record: a) date and time; b) temperature; c) relative humidity; d) measurands; e) indications; f) errors; g) functional performance.
Precondition	The EUT shall not be re-adjusted at any time during the test except to reset if a significant fault has been indicated.
Condition of the EUT	Power is to be "on" for the duration of the test unless otherwise specified.
Acceptance criteria	Either significant faults do not occur, or significant faults are detected and acted upon by means of a checking facility.

### 2.5.1 Mechanical shock and vibrations

#### 2.5.1.1 Mechanical shock

Applicable standard	IEC 60068-2-31
Condition of the EUT	Power is to be "off" for the duration of the test.
Test	The EUT, standing in its normal position of use on a rigid surface, is tilted along one bottom edge and is subsequently allowed to fall freely back on to the test surface. The height of fall is the distance between the opposite bottom edge and the test surface. However, the angle between the bottom and the test surface shall not exceed 30°. After the shocks, the EUT shall be switched on and, after a stabilization time equal to or greater than the warm-up time specified by the manufacturer, apply the test procedure.
Test level	Height of fall 50 mm, 1 fall on each bottom edge

### 2.5.1.2 Vibration

Applicable standard	IEC 60068-2-47, IEC 60068-2-64, IEC 60068-3-8
Condition of the EUT	Power is to be "off" for the duration of the test.
Test	After having been switched off (or the electrical power being disconnected), the following vibration level shall be applied on 3 mutually perpendicular axis during 2 minutes per axis, the EUT being mounted on a rigid fixture by its normal mounting means so that the gravitational force acts in the same direction as it would be in normal use. After the vibrations, the EUT shall be switched on and, after a stabilization time equal to or greater than the warm-up time specified by the manufacturer, apply the test procedure.
Test level	Total frequency range : 10 Hz to 150 Hz Total RMS level : 1.6 m.s <sup>-2</sup> ASD level 10 Hz- 20 Hz : 0,05 m <sup>2</sup> .s <sup>-3</sup> ASD level 20 Hz- 150 Hz : - 3 dB/octave

### 2.5.2 Mains voltage dips, short interruptions and reductions:

Applicable standard	IEC 61000-4-11, IEC 61000-6-1, IEC 61000-6-2			
Test	A test generator suitable to reduce the amplitude of the AC mains voltage for the required period of time is to be used. The performance of the test generator shall be verified before connecting the EUT. The mains voltage reduction tests shall be repeated 10 times with intervals of at least 10 s between the tests.			
		Test Level		unit
Voltage dips	Test a	Reduction	100	%
		Duration	0.5	cycles
	Test b	Reduction	100	%
		Duration	1	cycles
	Test c	Reduction	30	%
		Duration	25/30	cycles
Short interruptions	Reduction	100	%	
	Duration	250/300	cycles	

### 2.5.3 AC mains harmonics

Applicable standard	IEC 61000-2-2, IEC/TR 61000-2-5, IEC 61000-4-13		
Test	Harmonic voltages at test levels from 3 % and higher, up to the ninth harmonic, shall be applied using a phase shift of both 0° and 180° with respect to the positive zero-crossing of the fundamental. The test shall be performed up to the 40th harmonic.		
Test level	Harmonics	Harmonic order $n$	% of $U_{nom-high}$
	Odd, non-multiples of 3	5	12
		7	10
		11, 13	7
		17, 19, 23, 25	6
		29	5
		31, 35, 37	3
	Odd, multiples of 3	3	9
		9	4
		15	3
		21, 27, 33, 39	2
Even	2	5	
	4	2	
	6 - 40	1,5	
Note	The value of $U_{nom-high}$ is that marked on the EUT.		

### 2.5.4 Bursts (transients) on AC mains lines

Applicable standard	IEC 61000-4-4		
Test	Both positive and negative polarity of the bursts shall be applied. The duration of the test shall not be less than 1 min for each amplitude and polarity. The injection network on the mains shall contain blocking filters to prevent the burst energy being dissipated in the mains.		
Test level	Amplitude (peak value)	2	kV
	Repetition rate	5	kHz

### 2.5.5 Bursts (transients) on signal, data, and control lines

Applicable standard	IEC 61000-4-4		
Test	Both positive and negative polarity of the bursts shall be applied. The duration of the test shall not be less than 1 min for each amplitude and polarity. A capacitive coupling clamp as defined in the standard shall be used for the coupling of the bursts into the lines.		
Test level	Amplitude (peak value)	1	kV
	Repetition rate	5	kHz

### 2.5.6 Surges on AC mains power lines

Applicable standard	IEC 61000-4-5		
Test	At least 3 positive and 3 negative surges shall be applied. The surges shall be synchronized with the AC supply frequency and shall be repeated such that the injection of surges on all the 4 phase shifts: 0°, 90°, 180° and 270° with the mains frequency is covered.		
Test level	AC line to line	1	kV
	AC line to ground	2	kV

### 2.5.7 Surges on signal, data and control power lines

Applicable standard	IEC 61000-4-5		
Test	At least 3 positive and 3 negative surges shall be applied. The surges shall be synchronized with the AC supply frequency and shall be repeated such that the injection of surges on all the 4 phase shifts: 0°, 90°, 180° and 270° with the mains frequency is covered.		
Test level	Line to line *	1	kV
	Line to ground	2	kV
Note:	* Line to line does not apply to shielded and symmetrical lines.		

### 2.5.8 Electrostatic discharges

Applicable standard	IEC 61000-4-2		
Test	At least 10 discharges per preselected discharge location shall be applied. The time interval between successive discharges shall be at least 1 second. An EUT not equipped with a grounding connection shall be fully discharged between discharges. Direct application: In the contact discharge mode to be carried out on conductive surfaces, the electrode shall be in contact with the EUT before activation of the discharge. On insulated surfaces only the air discharge mode can be applied. The EUT is approached by the charged electrode until a spark discharge occurs. Indirect application: The discharges are applied in the contact mode only on coupling planes mounted in the vicinity of the EUT.		
Test level *	Contact discharge	6	kV
	Air discharge	8	kV
Note:	* In this case "level" means: "up to and including" the specified level (i.e. the test shall also be performed at the specified lower levels in the standard).		

### 2.5.9 Immunity to radio frequency electromagnetic fields

#### 2.5.9.1 Conducted (common mode) currents generated by RF electromagnetic fields

Applicable standard	IEC 61000-4-6		
Test	An RF EM current, simulating the influence of EM fields shall be coupled or injected into the power ports and I/O ports of the EUT using coupling/decoupling devices as defined in the referred standard. The characteristics of the test equipment consisting of an RF generator, (de-)coupling devices, attenuators, etc. shall be verified before connecting the EUT. If the EUT comprises several devices the tests shall be performed at each extremity of the cable if both of the elements are part of the EUT.		
Test level	Conducted 10 V (e.m.f.), 0.15 – 80 MHz, modulated 80 % AM, 1 kHz sine wave		

### 2.5.9.2 Radiated RF electromagnetic fields

Applicable standard	IEC 61000-4-3, IEC 61000-4-20
Test	<p>The EUT is exposed to electromagnetic fields with the required field strength and the field uniformity as defined in the referred standard.</p> <p>The level of field strength specified refers to the field generated by the unmodulated carrier wave.</p> <p>The EUT shall be exposed to the modulated wave field. The frequency sweep shall be made only pausing to adjust the RF signal level or to switch RF-generators, amplifiers and antennas if necessary. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value.</p> <p>The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the EUT to be exercised and to respond, but shall in no case be less than 0.5 s.</p> <p>Adequate EM fields can be generated in facilities of different type and setup, the use of which is limited by the dimensions of the EUT and the frequency range of the facility.</p> <p>The expected most critical frequencies (e.g. clock frequencies) shall be analyzed separately. <sup>(b)</sup></p>
Test level	Radiated 10 V/m, 80 (26) <sup>(a)</sup> MHz – 6 GHz, modulated 80 % AM, 1 kHz sine wave
Notes	<p><sup>(a)</sup> For an EUT without any cabling the lower frequency limit is 26 MHz.</p> <p><sup>(b)</sup> These frequencies can be expected to correspond to the EUT emitted EM field frequencies.</p>

### 2.5.10 Mains frequency magnetic fields

Applicable standard	IEC 61000-4-8		
Test level	Continuous field	100	A/m
	Short duration (1 s to 3 s)	1000	A/m

### 2.5.11 Instruments powered by a road vehicle battery

#### 2.5.11.1 Electrical transient conduction along supply lines

Applicable standard	ISO 7637-2	
Test	Exposure of the EUT to the specified pulses along supply lines.	
Test level for pulse	$U_{nom} = 12\text{ V}$	$U_{nom} = 24\text{ V}$
2a	+112 V	+112 V
2b	+10 V	+20 V
3a	-220 V	-300 V
3b	+150 V	+300 V

#### 2.5.11.2 Electrical transient conduction via lines other than supply lines

Applicable standard	ISO 7637-3	
Test	Exposure of the EUT to the specified pulses along other than supply lines.	
Test level for pulse	$U_{nom} = 12\text{ V}$	$U_{nom} = 24\text{ V}$
a	-60 V	-80 V
b	+40 V	+80 V

### 2.5.11.3 Load dump

Applicable standard	ISO 16750-2			
Test	Exposure of the EUT to 2 variants of pulse B on supply lines.			
Test level	$U_{nom} = 12\text{ V}$		$U_{nom} = 24\text{ V}$	
$U_s$	79 V	101 V	151 V	202 V
$U_s^*$	35 V		58 V	
$R_i$	0.5 $\Omega$	4 $\Omega$	1 $\Omega$	8 $\Omega$
$t_d$	40 ms	400 ms	100 ms	350 ms
$T_3$	10 ms			

## 2.6 Tests for conformity to other technical and metrological requirements

The instruments shall be tested for conformity to the following requirements:

### 2.6.1 Removal of volatile particles from the sample

The instrument should remove volatile particles from the sample and the remaining solid particle concentration of the sample should be determined (Part 1, 6.1.11). The instrument must remove > 95 % of 30 nm tetracontane (  $\text{CH}_3(\text{CH}_2)_{38}\text{CH}_3$  ) monodisperse aerosol, with an inlet concentration of  $\geq 10\,000$  per  $\text{cm}^3$  , by means of heating and reduction of partial pressures of the tetracontane.

The tetracontane is added to ambient air. The increase of the indication with tetracontane shall be not greater than 5% of the actual tetracontane concentration.

The tetracontane concentration may be measured by a (modified) reference instrument.

Alternative method is to generate a high concentration (for example 500 000 particles /  $\text{cm}^3$ ) and check the indication to be at most 5% of this concentration.

### 2.6.2 Warm-up time

At 5 °C (or the specified low temperature) , the warm-up time test to verify compliance with 5.9 shall consist of the following steps:

- Stabilize the instrument at 5 °C (or the specified low temperature);
- Let the instrument warm up;
- Immediately after the automatic warm-up lockout has been deactivated, perform a measurement (with any necessary internal adjustment being performed prior to this measurement) using a reference PN sample with nominal concentration of 100 000 particles/ $\text{cm}^3$ ;
- At time intervals of 2 min, 5 min and 15 min after warm-up, perform a measurement with the same reference PN sample as in step c).

The difference between any of the four measured values in c) and d) shall not exceed the maximum permissible error.

### 2.6.3 Response time

A measurement shall be taken to determine the time required for an instrument to respond to a reference PN sample with a nominal concentration of 100 000 particles/ $\text{cm}^3$  after sampling ambient air supplied at the probe. A means shall be employed for instantly changing from sampling ambient air to sampling reference PN sample through the probe. The gases shall be supplied at the probe at ambient pressure (to within 8 hPa). The response time shall not exceed the appropriate values specified in Part 1, 5.8.

#### **2.6.4 Low flow**

A measurement shall be performed with a reference PN sample with a nominal concentration of 100 000 particles/cm<sup>3</sup> that is initially supplied to the gas handling system at a gas flow rate greater than the minimum required by the tested instrument. During the measurement, the gas flow rate shall be reduced until the low flow indicator responds according to the requirements of Part 1, 6.1.6.

#### **2.6.5 Leakage**

An adjustable leak shall be artificially introduced into the gas handling system where a leak of an appropriate orifice size will have the greatest effect on the measurement. With this artificial leak closed, a reference PN sample with a nominal concentration of 100 000 particles/cm<sup>3</sup> shall be supplied at the probe at ambient pressure.

While sampling the reference PN sample, record the indication and then adjust the leakage rate so that the indication of the reference PN sample differs from the value indicated previously (without the leak) by an amount equal to the requirement of Part 1, 6.1.7. Without disturbing the artificial leak, remove the reference PN sample supplied at the probe, and conduct the leakage test procedure as described in the manufacturer's operating instructions.

#### **2.6.6 Water condensation**

The prevention of condensation shall be checked as follows:

Expose the instrument to water saturated ambient air supplied to the gas handling system and to the reference. The instrument shall remain within MPE or detect the occurrence of condensation.

#### **2.7 Practical test**

The instrument shall be tested with at least three vehicles, two with diesel engine and one with petrol engine. The engines shall be at normal operating temperature. Each vehicle shall be used for 5 measurements. The indication of the instrument shall be compared with the indication of the reference instrument. The errors shall comply with the maximum permissible error.

#### **2.8 Source of power for type evaluation**

If applicable, the appropriate source of power for field use of instruments shall be specified in the manufacturer's operating instructions. If a source of power is specified in addition to the mains, for example a battery or portable generator, then the instrument shall undergo relevant type tests with each source of power with which it is intended to operate.

Each test specified shall be started and completed without changing or recharging the power source.

### **3 Standards and reference documents**

- [1] *Guide to the expression of uncertainty in measurement (GUM)*, (1995): Joint publication by the BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, and OIML

Other references see Part 1, clause 2.

**Annex**  
**Procedure for routine testing**  
(Informative)

A routine test of the instrument should consist of at least the following:

- a) Perform an internal adjustment check after start-up and warming up of the instrument;
- b) Perform a leak check at least once a day. Repair any leaks and conduct a successful leak check before testing any vehicle;
- c) Use a HEPA filter to check zero;
- d) Check if the reading of fresh ambient air is plausible.