

Information Sheet

Proficiency Test Particle Measurements on Stoves

1. Location

Hessisches Landesamt für Naturschutz, Umwelt und Geologie
(Hessian Agency for Nature Conservation, Environment and Geology)

Dezernat I3 – Luftreinhaltung: Emissionen
(Department I3 – Air Pollution Control: Emission)

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2. Contact

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3. Participants

The proficiency test for particulate measurements on stoves is intended for test laboratories wishing to offer measurements on stoves for the determination of the number concentration of ultrafine particles (UFP) as part of type tests and similar investigations, as well as for all other test laboratories active in the field of emission measurements on stoves and similar systems.

A maximum of 6 participants (test laboratories) can take part in the proficiency test at the same time. No more than 2 people per participant should be in the measurement room at the same time.

4. Task

The aim of the proficiency test is to measure the number concentration of ultrafine particles (UFP) in the flue gas of a wood-burning stove.

The proficiency test programme is based on the test procedure according to the award criteria for the Blue Angel eco-label for wood-burning stoves (DE-UZ 212).

5. Measurements

5.1 Measurement Room and Sampling Ports

The measuring room is located on the ground floor of the HLNUG building (room 16) and has an area of approximately 4 m × 6 m. There are 3 steps (each 17 cm high) in front of the entrance to the building. The door to the measuring room has a passage width of 74 cm.

The inside diameter of the flue gas duct is 15 cm. A total of 8 sampling ports with a 1" internal (female) thread (according to ISO 228) at a height of approximately 2 m are provided for the participants to carry out the proficiency test. The allocation of the sampling ports is determined by the HLNUG staff. Each participant can be guaranteed the use of at least one sampling port. Depending on the number of participants, the remaining sampling ports can also be used.

5.2 Execution of the Measurements

The following points must be observed when carrying out the measurements:

- The participants in the proficiency test must carry out the sampling with their own measuring equipment.
- Sampling shall be performed on the same cross-section for all participants, but on different axes at a distance of 4 cm from the duct wall. The sampling probes used must be adapted to the internal diameter of the flue gas duct of 15 cm.
- Only solid particles larger than 23 nm remaining after a volatile particle remover (VPR, e.g. thermodenuder or catalytic stripper) are considered.
- The temperature of the VPR shall be such that no elemental carbon is formed from hydrocarbons. The VPR must achieve a separation efficiency of at least 90% for tetracontane aerosols.
- An impactor or cyclone should be installed upstream to remove coarse particles. This should have a 50 % cut-off for an aerodynamic particle diameter of 0.7 to 1.5 µm.
- The measuring range must cover at least a particle number concentration in the flue gas of $1 \times 10^4 \text{ cm}^{-3}$ to $3 \times 10^7 \text{ cm}^{-3}$. Before entering the measuring instrument, the sampled exhaust gas shall be diluted by one or more dilution stages to give a number concentration within the calibrated range.
- The sampling device and the sampling line up to the dilution stage must be designed to prevent condensation of water and volatile substances. This can be achieved, for example, by heating the sampling line or by heating the dilution air. Sample lines must be anistatic. The sampling line should not be moved during the measurement.
- A supply of clean, dry compressed air is available in the measurement room. To avoid bottlenecks, the compressed air requirement must be specified at the time of registration.
- A total of 2 combustion series (one per measurement day) of 5 combustion processes each shall be performed. In each series (or on each day of measurement) 2 combustion processes are performed and measured in the ignition phase and 3 combustion processes in the nominal load phase.

- The particle number concentration is measured from the cold start phase (this includes the first two combustion processes) to the last measurement over 5 combustion processes.
- For each measurement day, the participants determine the average particle number concentration over all 5 combustion processes as well as the corresponding average value for each of the 5 combustion processes.
- In addition, a 6th measurement is offered on the second measurement day: The stove is operated with an electrostatic particle filter during the entire first day of measurement and during the first 5 combustion processes on the second day of measurement. After the 5th combustion process on the second measurement day, the ESP is switched off, so the additional measurement of the 6th combustion process on the second measurement day takes place without a particle separator.
- The start and end times of each combustion process will be determined by HLNUG and communicated to the participants.
- The concentrations of the gaseous exhaust components (O₂, CO₂, CO, NO_x, H₂O) are measured continuously by the HLNUG. The measurement data will be made available to the participants within two weeks.
- The measurement results are converted to dry flue gas under standard conditions (273 K, 1013 hPa), taking into account the selected dilution.

Participants will have the opportunity to participate in the proficiency test using two instruments operating in parallel to determine the particle number concentration. The following points must be observed:

- The use of a second instrument must be registered in advance. The participant will receive a second ID code for the second analyser.
- The results obtained for each of the two instruments must be submitted. It is not permitted to average the results of the two instruments.
- Depending on the number of participants in the proficiency test, not all interested participants may have access to a second measuring port for the installation of a second probe. In this case both instruments must be connected to the same probe.
- Even if two instruments are used, the number of people allowed in the measurement room is limited to 2 per laboratory.

6. Submission of results

All measurement results must be given in relation to normal conditions, dry (273 K, 1013 hPa) and must be submitted without conversion to the reference oxygen concentration.

The measurement results of the proficiency test shall be sent by e-mail to the following address:

pt@hlnug.hessen.de

using MS Excel-files provided by HLNUG.

Each participant may submit only one result per combustion process or combustion process series and measurement device. An exchange of results or collusion between participants before the deadline for the submission of the measurement results is not permitted. If this is violated, the results will be marked accordingly.

All participants must submit their results to HLNUG no later than six weeks after the last day of the proficiency test. Results submitted later will not be considered unless HLNUG is responsible for the late receipt.

In addition to the measurement results per combustion process or combustion process series, participants submit the raw data of their measurements (particle concentration as a function of time). These data will not be evaluated, but will be used for a possible investigation of the causes of deviations between the measurement results of the participants in the proficiency test.

7. Evaluation of measurement results

7.1 Basics of the result calculation

The evaluation of the proficiency test is carried out following the z-score procedure. No rounding is performed when calculating z-scores and their mean values. However, the numerical values are rounded in result notifications and reports.

The evaluation is carried out according to DIN ISO 13528:2020, calculating the robust mean x^* , the estimated value for its uncertainty $u(x^*)$ and the robust standard deviation s^* from the measured values of all participants for each measurement according to Annex C of the standard (Algorithm A). For the evaluation, the robust mean value x^* is used as the assigned value X_i , and the robust standard deviation s^* is used as the criterion for proficiency assessment σ_i . For the relationship between σ_i and the uncertainty of the assigned value X_i , the following criterion applies according to this standard:

$$\sigma_i \geq \frac{10}{3} \cdot u(X_i)$$

The following minimum values also apply:

$$\sigma_i \geq 0.25 \cdot X_i$$

$$\sigma_i \geq 12500 \text{ cm}^{-3}$$

The criterion for proficiency assessment σ_i is therefore basically the robust standard deviation s^* of the participant results, but it is at least 12500 cm^{-3} , at least 25% of the assigned value X_i , and at least $10/3$ times the standard uncertainty of the assigned value $u(x^*)$ if one of these values is higher.

To assess the results of the individual measurements, a z-score value z_i is determined for the i -th measured value x_i :

$$z_i = \frac{x_i - X_i}{\sigma_i}$$

Here, X_i is the assigned value of the corresponding measurement and σ_i is the criterion for proficiency assessment. According to the scheme described here, z-scores are calculated for the combustion process series as well as for the individual combustion processes.

7.2 Interpretation of z-score values

The following scheme applies to the interpretation of all z-score values determined:

$ z_{ijk} \leq 2$	satisfactory performance (no signal)
$2 < z_{ijk} < 3$	questionable performance (warning signal)
$ z_{ijk} \geq 3$	unsatisfactory performance (action signal)

Generally, for each measurement resulting in a z-score of more than two, a causal research should be conducted.

8. Communication of the evaluation

The results will be communicated to the proficiency test participants in the form of an overall summary no later than 6 weeks after the deadline for submission of the participants' results. The personnel involved in the measurements will be named in the results communication.

In addition, the results will be summarised in a report, in which the participants will be pseudonymised.

9. Objections and complains

Objections and complaints shall be addressed to the organiser of the proficiency testing scheme if they relate to the invitation, the conduct of the proficiency testing scheme, the communication of results and the results themselves. Various aspects of the proficiency testing scheme may be temporarily subcontracted. If subcontracted, it will be to a competent subcontractor for whose work the HLNUG is responsible. Deadlines for objections are specified in the respective notices and communications.

10. Costs

The participation fee for this proficiency testing scheme is € 1900. There is an additional fee of € 250 for the use of a second measuring device in the same proficiency test.

11. Schedule

On the following page you will find the time schedule for the proficiency test. The adherence to the specified times depends, among other things, on the rapid and smooth performance of the measurements by the participants in the proficiency testing scheme. Therefore, the organiser cannot guarantee that the time schedule will be adhered to. Depending on the actual progress of the individual items, there may be shifts in the schedule.

Schedule

Proficiency Test Particle Measurements on Stoves

Tuesday (day 1)

- from 11:00** Arrival and set-up of the measuring instruments
till 18:00 Preparations and device test for the measurements on the following day

Wednesday (day 2)

- 09:00** Preparation of the measurements
10:00 Start of combustion process series for measurement day 1 (5 combustion processes)
15:00 Approximate end of measurements for day 1
17:00 End of the first measurement day

Thursday (day 3)

- 09:00** Preparation of the measurements
10:00 Start of combustion process series for measurement day 2 (6 combustion processes)
15:30 Approximate end of measurements in the proficiency test
17:00 End of the second measurement day

Friday (day 4) (optional)

- from 09:00** Dismantling of the measuring instruments, departure of the participants
Note: Dismantling the equipment on Friday is optional. After the end of the measurements on the second measurement day (scheduled for around 15:30), it is of course possible to dismantle the instruments and leave by 17:00 on Thursday.