

Information sheet

Stack Emission Proficiency Tests Dust and Gas

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)

HLNUG – I3
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D-34121 Kassel
- GERMANY -

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Please note: The sampling takes place on the 1st and 3rd floor of the HLNUG building. A lift is not available.

2. Contact

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3. Participants

HLNUG's stack emission proficiency tests were designed for laboratories authorized to perform measurements in accordance with §29b BImSchG (Federal Immission Control Act), as well as applicants for authorization in accordance with BImSchG. Nevertheless, other laboratories, manufacturers of equipment, industrial departments engaged in emission monitoring etc. are welcome to participate, too.

Please note: Due to the limited space around the flue duct, without prior affirmation by the organizer for each laboratory only two persons can participate in the sampling on site.

The total number of participating laboratories per round is limited to 8.

4. Task

The proficiency test programme simulates installations with predominantly time-varying operating conditions with regard to the emitted mass concentrations, at which at least six individual measurements are required according to TA Luft (Technical Instructions on Air Quality Control). The ability to correctly determine the mass concentrations of total dust and the heavy metals listed in Table 3, as well as the gaseous substances in emissions listed in Table 4, using the overall procedure consisting of sampling and analysis, is considered to be directly relevant for authorization in accordance with §29b BImSchG.

5. Execution of measurements

5.1 ESA measuring planes

The measurements take place on the 1st and the 3rd floor of the HLNUG building (room 130, and 371, respectively), approx. 5.0, and 12.5 m, respectively, above ground level and at the end of a 6.5/14 m long vertical flue duct. To carry out the proficiency test, sampling ports conforming to standard (DIN) ISO 228 are available in the following sizes and numbers:

Table 1: Available sampling ports

Floor	3" internal thread (G3)	2" internal thread (G2)
1 st floor	8	5
3 rd floor	6	7

The allocation of the sampling ports to the participants is determined by HLNUG staff on site. The sampling probes used by the participants must be adapted to the inner diameter of the system of 40 cm. During the proficiency test, the system is operated with a gas flow velocity of > 4 m/s. Participants using fixed, automatically operating measuring devices installed in a measuring van will require a sample gas line with a length of approx. 50 m from the sampling port to the measuring van.

5.2 Determination of gas flow conditions

The ESA is operated in fresh air mode with preheating and, if necessary, humidification of the outside air. The volume flow is set in a range between 2000 and 6000 m³/h (standard conditions, dry). The system parameters are - as far as possible - kept constant during a measuring day. The gas flow conditions are selected so that droplet formation in the stack is prevented.

During the proficiency test, the following parameters of gas flow conditions shall be measured for each test day, conforming to (DIN) EN 15259:

Table 2: Value ranges for gas flow conditions and specified rounding of the measured values.

No. (k)	component	value range	decimal places
R1	volume flow	2000 – 6000 m ³ /h (nc, dry)	0
R2	mean flow velocity	4 – 15 m/s (oc, wet)	2
R3	temperature	20 – 50 °C	1
R4	water vapour concentration	0 – 50 g/m ³ (nc, dry)	2
R5	static pressure	0 – 10 hPa	2

When measuring the gas flow conditions, the participants shall use the measurement methods normally used by them on comparable installations. The measurement of the gas flow conditions takes place on each day of the proficiency test under different operating conditions.

5.3 Performance of samplings: Dust

- Each participant carries out the determination of the mass concentrations of particulate substances in accordance with (DIN) EN 15259 and the standards listed in Table 3 in their current version. For the application of other sampling or analysis methods in the case of participations in connection with the 41st BImSchV, a proof of equivalence in accordance with (DIN) EN 14793 must be provided.
- Sampling takes place simultaneously for all participants. The following components are determined using the following measurement procedures:

Table 3: Measuring methods and concentration ranges for total dust and heavy metals

No. (k)	component	compulsory method	concentration range
P1	total dust	(DIN) EN 13284-1	1 to 15 mg/m ³
P2	Cadmium		1 to 200 µg/m ³
P3	Cobalt		1 to 200 µg/m ³
P4	Chromium	(DIN) EN 14385	1 to 200 µg/m ³
P5	Copper	<i>Note: In deviation from the standard, participants may execute the sampling without the use of washing bottles.</i>	1 to 200 µg/m ³
P6	Manganese		1 to 200 µg/m ³
P7	Nickel		1 to 200 µg/m ³
P8	Lead		1 to 200 µg/m ³
P9	Vanadium		1 to 200 µg/m ³

- The procedure used by the participant in the proficiency test must correspond as far as possible to the standard procedure routinely used at comparable real plants. For organisational reasons, only the following deviations are necessary or permissible:
 - No continuous measurement of the volume flow: This is kept constant and continuously monitored by the organizer.
 - Carrying out the grid measurement using the tangential method on two measuring axes: It is generally not possible to use the general method.
 - No use of washing bottles: Only dusts made of blast furnace slag doped with heavy metals (main components: SiO_2 , Al_2O_3 , Fe_2O_3 , CaO , amorphous iron and aluminosilicates) are used. In case of sampling in conformity with the standards, due to the grain size distribution the heavy metal portions that can pass the filter are negligible compared to the portion retained by the filter.
- The participants in the proficiency test must carry out the sampling with their own measuring equipment.
- The sampling set-up must be designed in such a way that sampling of exhaust gases with high water vapour contents is possible.
- The duration of the individual measurements is 30 minutes, with an interruption after 15 minutes for changing the measuring axis.
- 10 individual measurements (one introductory measurement without dust dosing as well as nine measurements at different dust mass concentrations) are carried out.
- Sampling protocols and other relevant records of the participant on the measurements carried out shall be handed over to the HLNUG at the end of the proficiency test before departure as digital copies on suitable data carriers. If records are only available in paper form, copies will be made by the HLNUG.

5.4 Performance of samplings: Gas

- Each participant carries out the determination of the mass concentrations of gaseous substances in accordance with (DIN) EN 15259 and the standards and guidelines listed in Table 4 in their current version. For the application of other sampling or analysis methods in the case of participations in connection with the 41st BImSchV, a proof of equivalence according to (DIN) EN 14793 must be provided.

- Sampling takes place simultaneously for all participants. The following components are determined using the following measurement procedures:

Table 4: Measuring methods and concentration ranges for gaseous components.

No. (k)	component	compulsory method	concentration range [mg/m ³]
G1	NO _x as NO ₂	(DIN) EN 14792	60 to 450 (referring to NO ₂)
G2	CO	(DIN) EN 15058	10 to 100
G3	TOC	(DIN) EN 12619	4 to 100
G4	SO ₂	(DIN) EN 14791	20 to 150
G5	formaldehyde	VDI 3862 Part 2, 3 or 4	2 to 20
G6	ethylbenzene	(DIN) CEN/TS 13649	1 to 40
G7	toluene	(DIN) CEN/TS 13649	1 to 40
G8	xylene (sum of isomers)	(DIN) CEN/TS 13649	1 to 40 (isomers as well as sum)

- The methods used by the participant in the proficiency test must correspond as far as possible to the standard methods routinely used at comparable real plants.
- The participants in the proficiency test must perform the sampling with their own measuring equipment.
- The sampling duration or integration time for all measurements is 30 minutes.
- For each component, 9 measurements are carried out at different concentrations. In addition, one measurement without dosing is offered on each day of the proficiency test to determine blank values.
- The xylene isomers (*o*-, *m*- and *p*-xylene) are determined as a sum.
- Raw data of all continuous measurements, including all adjustments made, shall be handed over to the HLNUG as a digital copy on suitable data carriers at the end of the proficiency test before departure. The same applies to sampling protocols and other relevant records of the participant concerning the measurements performed. If records are only available in paper form, copies will be made by HLNUG.
- The HLNUG offers to check the span gases of the participants by comparing them with reference gases of the HLNUG. The check is performed with reference gases of the following composition:
 - NO in N₂
 - CO in N₂
 - C₃H₈ in synthetic air

For further information please read the "*Information Sheet - Span Gas Verification*".

6. Submission of results

6.1 Basics

All measurement results shall be stated in relation to standard conditions, dry (273.15 K and 1013.25 hPa).

The results of the dust proficiency test and the gas proficiency test are submitted and evaluated separately. Please note the different submission deadlines for the two proficiency tests.

For both proficiency tests the results are to be sent by e-mail to the following address:

pt@hlnug.hessen.de

For this purpose, the measured values shall be entered in Excel files, which can be downloaded from the HLNUG website at

<https://pt.hlnug.de>

Each participant can only submit one result per measurement and component. The measured values submitted by the participants are checked for plausibility by the HLNUG using the data collected during the proficiency test. If this plausibility check reveals doubts about the determination of measured values in conformity with the respective standards, the participant concerned will be asked to provide a detailed explanation of the determination of results. If a participant is not able, upon request, to reconcile the submitted measurement results in a comprehensible and standard-compliant manner with the raw data and other records produced within the framework of the proficiency test, the components concerned will be assessed as "not evaluated", in deviation from section 8. In this case, a corresponding note will be added to the communication of results. An exchange of results among participants before the deadline for submission of the measurement results or other collusive behaviour is not permitted. In the event of a violation of this regulation, all affected components will also be assessed as "not evaluated" and a corresponding note will be added to the communication of results.

Communication of the result evaluation to the participants in the proficiency test is made in the form of an overall summary no later than 6 weeks after expiry of the deadline for submission of the participants' measurement results.

6.2 Dust proficiency test

Dust concentrations must be stated in mg/m^3 and heavy metal concentrations in $\mu\text{g}/\text{m}^3$, in each case related to standard conditions dry. All values must be given with two decimal places.

The results of the dust proficiency test must be submitted to HLNUG no later than six weeks after the last day of the dust proficiency test. Unless HLNUG is responsible for the late receipt, results submitted later will not be taken into account. In this case, the proficiency test is assessed as "failed".

6.3 Gas proficiency test

All results must be expressed in mg/m^3 with reference to standard conditions, dry. All values shall be given with two decimal places.

The results of the gas proficiency test must be submitted to the HLNUG no later than four weeks after the last day of the gas ring test. Unless HLNUG is responsible for the late receipt, results submitted later will not be taken into account. In this case, the proficiency test will be assessed as "failed".

6.4 Gas flow conditions

The measurement results for the gas flow conditions shall be reported in the units and rounded to the number of decimal places specified in Table 2.

The submission deadline for the proficiency test part "gas flow conditions" depends on the deadline for the submission of the measurement results for the other components in the respective proficiency test. Unless HLNUG is responsible for the late receipt, results submitted at a later date will not be taken into account. In this case, the proficiency test part "gas flow conditions" is assessed as "failed".

7. Assessment of single measurement results

7.1 Basics of the calculation of results

The evaluation of the proficiency tests is carried out according to the specifications ("*Durchführungsbestimmungen*" status May 2019) for stack emission proficiency tests that were acclaimed by the Conference of Ministers for Environment (UMK) and the Federation/Federal States Working Group on Immission Protection (LAI). The evaluation is carried out in the form of z-scores and class numbers. Before z-scores are calculated, the assigned values are rounded to the same number of decimal places as the measured values to be submitted by the participants. No rounding is performed when calculating z-scores and their mean values. However, the numerical values are displayed rounded in result notifications and reports.

For the uncertainty u_k of the assigned values, the following condition must be fulfilled with regard to the criterion for the performance evaluation σ_k :

$$\sigma_k \geq 3 \cdot u_k$$

If, in a proficiency test, the relative uncertainty of the assigned value is greater than the permissible value, the criterion for the performance evaluation for the component concerned shall be adjusted in accordance with guideline VDI 4221 Part 2. In doing so, the criterion for performance evaluation for the components P1 – P9 and G1 – G8 is raised to the next higher value with one decimal place which meets the requirements of the guideline. For component R1, the next higher integer value is selected which fulfills the requirement of the guideline. The participants will be informed about this increase at the latest with the result notification.

To assess the results of the individual measurements for the components P1 – P9 and G1 – G8, a z-score value z_{ijk} is determined for the i -th measured value of the j -th concentration stage of the k -th component, x_{ijk} :

$$z_{ijk} = \frac{x_{ijk} - X_{ijk}}{\sigma_k \cdot X_{ijk}}$$

Here X_{ijk} is the assigned value of the corresponding measurement and σ_k is the criterion for performance evaluation. The assigned value is derived from the measurement data of the dosing system and the volume flow.

7.2 Total dust and heavy metals

The performance evaluation criteria for the components of the dust proficiency test are as follows, provided that the uncertainty of the assigned value fulfils the above conditions:

Table 5: Evaluation criteria for total dust and heavy metals.

No. (k)	Component	criterion for the performance evaluation σ_k in %
P1	total dust	7,0
P2	Cadmium	10,0
P3	Cobalt	10,0
P4	Chromium	10,0
P5	Copper	10,0
P6	Manganese	10,0
P7	Nickel	10,0
P8	Lead	10,0
P9	Vanadium	10,0

7.3 Gaseous components

The performance evaluation criteria for the components of the gas proficiency test are as follows, provided that the uncertainty of the assigned value fulfils the above conditions:

Table 6: Evaluation criteria for gaseous substances.

No. (k)	Component	criterion for the performance evaluation σ_k in %
G1	NO _x as NO ₂	3,1
G2	CO	3,6
G3	TOC	3,3
G4	SO ₂	3,4
G5	Formaldehyde	3,6
G6	Ethylbenzene	4,1
G7	Toluene	4,1
G8	xylene (sum of isomers)	4,1

7.4 Gas flow conditions

To evaluate the measurement results for the volume flow (component R1), a z-score value z_{ik} is determined for the i -th measured value of the k -th component, x_{ik} :

$$z_{ik} = \frac{x_{ik} - X_{ik}}{\sigma_k}$$

Here X_{ik} is the assigned value of the corresponding measurement and σ_k is the criterion for performance evaluation. The assigned value is determined by the continuous measurement devices of the HLNUG. The criterion for performance evaluation is 140 m³/h (nc, dry) for component R1, provided that the uncertainty of the assigned value meets the above conditions. No z scores are calculated for components R2 to R5. Here instead, the deviations of the participants' measured values from the assigned values are compared informatively with the usual standard deviation for these measurements. For this purpose, the quotient is calculated from the deviation of the participants' measured values from the assigned values and the usual standard deviation for the measured parameter in question. The corresponding comparison values are shown in Table 7.

Table 7: Usual standard deviations for gas flow conditions.

No. (k)	Component	usual standard deviation
R2	mean flow velocity	0.30 m/s (oc wet)
R3	Temperature	0.9 °C
R4	water vapour concentraion	0.74 g/m ³ (nc, dry)
R5	static pressure	0.21 hPa

7.5 Interpretation of z-score values

After normalization to the criteria for performance evaluation, the following scheme applies to the interpretation of all determined z-score values:

$ z_{ijk} \leq 2$	result satisfactory
$2 < z_{ijk} < 3$	result questionable
$ z_{ijk} \geq 3$	result insufficient

As a general rule, every measurement leading to a result that was evaluated with a z score of more than two should be investigated to identify the reasons for the deviation.

8. Evaluation of components

8.1 Total dust and heavy metals and gaseous components

For the evaluation of a component, the amounts of the z-scores of the n results of a concentration level (usually $n = 3$) of a component are averaged:

$$z_{jk} = \sum_{i=1}^n \frac{|z_{ijk}|}{n}$$

and each concentration level is assigned a class number K_{jk} depending on this mean z-score according to the following scheme:

$z_{jk} \leq 2$	equals: $K_{jk} = 1$
$2 < z_{jk} < 3$	equals: $K_{jk} = 2$
$z_{jk} \geq 3$	equals: $K_{jk} = 3$

For assignment to concentration levels, the 9 evaluated measurements are sorted according to their assigned value and 3 consecutive values are assigned to each concentration level.

In the next step, the sum of the class numbers K_k is formed for each component k over all m concentration levels (usually $m = 3$):

$$K_k = \sum_{j=1}^m K_{jk}$$

A component was successfully determined if the corresponding sum of the class numbers is less than or equal to 6. In this case, the participant receives the assessment "passed" for the component. If the sum of the class numbers exceeds the permissible value, the participant receives the assessment "failed".

If only measured values for two concentration levels are submitted, the component is assessed as "passed" if the sum of the class numbers is 4 or less. If sampling or measurements

were performed for a component but the minimum number of six measured values was not submitted, the component is assessed as "failed" regardless of the assessment of the individual results. If the participant has completely waived the performance of sampling or measurements for a component in the proficiency test, the component will be marked "no participation".

8.2 Gas flow conditions

For the gas flow conditions, only two measured values per component are submitted and evaluated. The interpretation of the z-score values described above applies. Here the amounts of the z-scores of the n results (usually $n = 2$) of a component are averaged:

$$z_k = \sum_{i=1}^n \frac{|z_{ik}|}{n}$$

The component "volume flow" is evaluated as "passed" if the condition

$$z_k < 3$$

is fulfilled, otherwise the component is evaluated as "failed". If no measured values were submitted, the component is indicated as "no participation".

9. Overall evaluation of the proficiency test

9.1 Dust proficiency test

If all components P1 – P9 were evaluated with "passed", the participant receives the overall evaluation "passed" for his participation in the proficiency test. If at least one of the components P1 – P9 was assessed as "failed", the participant receives the overall rating "failed" for his participation in the proficiency test. If at least one of the components P1 – P9 was not participated in the proficiency test, or if for other reasons no assessment could be made for one of these components, while the other components were assessed as "passed", the participant receives the overall assessment "failed (incomplete participation)" for his participation in the proficiency test.

If applicable, the significance of this evaluation is pointed out with reference to §16 IV 7a of the 41. BImSchV (41st Federal Immission Control Ordinance).

9.2 Gas proficiency test

If all components G1 – G8 were evaluated with "passed", the participant receives the overall evaluation "passed" for his participation in the proficiency test. If at least one of the components G1 – G8 was assessed as "failed", the participant receives the overall rating "failed" for his participation in the proficiency test. If at least one of the components G1 – G8 was not participated in the proficiency test, or if for other reasons no assessment could be made for one of these components, while the other components were assessed as "passed", the participant receives the overall assessment "failed (incomplete participation)" for his participation in the proficiency test.

If applicable, the significance of this evaluation is pointed out with reference to §16 IV 7a of the 41. BImSchV (41st Federal Immission Control Ordinance).

9.3 Gas flow conditions

The proficiency test part “gas flow conditions” is evaluated as “passed” if component R1 was evaluated as “passed”. If component R1 was evaluated as “failed”, this proficiency test part is evaluated as “failed”. If component R1 was not participated, the proficiency test part “gas flow conditions” is indicated as “not evaluated”.

10. Communication of results

For both proficiency tests, the results are communicated to the participants in the proficiency test in the form of an overall summary by no later than 6 weeks after the deadline for submission of the participants' results. In the communication of results, the personnel involved in the measurements and sampling at ESA shall be mentioned by name. The obligation of the authorized measuring bodies to inform the authority responsible for their authorization directly about the results of the proficiency test (§16 IV No. 7 of the 41. BImSchV) is pointed out.

In addition, the results of the proficiency tests of one year are summarised in an annual report, whereby the participants are pseudonymised.

11. Theory test

A 30-minute written test is conducted in each of the dust and gas proficiency tests. The contents of this test are the requirements of the standards and guidelines applied in the respective proficiency test. As this theory test is currently offered only in German, interested participants are asked to refer to the German version of this document for details.

Participation in the theory test is not mandatory.

12. Objections and complaints

Objections and complaints should be addressed to the organizer of the proficiency testing scheme, if they relate to the invitation, the conduct of the proficiency testing scheme, the communication of results, or the results themselves. Various aspects of the proficiency test programme may be subcontracted at times. In case of subcontracting, this is done to a competent subcontractor, for whose work the HLNUG is responsible.

Objections and complaints should be addressed to the authority responsible for authorization under national law, insofar as they relate to measures derived from the results (e.g. a request to repeat the proficiency test, withdrawal of the authorization, etc.).

The time limits for objections are regulated in the respective notices and notifications.

13. Costs

The participation fee is charged in accordance with the currently valid administrative cost regulations (Verwaltungskostenordnung) for the division of the Hessian Ministry for the Environment, Climate Protection, Agriculture, and Consumer Protection (Hessisches Ministerium für Umwelt, Klimaschutz, Landwirtschaft und Verbraucherschutz).

14. Timetable

On the following pages you will find the timetable for the proficiency tests. A prerequisite for the observance of the specified times is, among other things, the smooth and swift performance of the measurements by the participants. The organizers cannot therefore guarantee that the times will be adhered to. Depending on the actual course of the performance of the individual items, there may be delays in the schedule. In the event of deliberate disruptions to the schedule by individual participants, they may be excluded from the proficiency test.

Timetable dust proficiency test

Monday (day 1)

- from 08:00** Arrival and setup of the measuring instruments for dust measurements
- 10:00** Pre-meeting dust (**room 258**)
- 10:30** Theory test dust
- 11:15** **1st floor: Measurement of gas flow conditions;** 3rd floor: Lunch break
- 12:00** 1st floor: Lunch break; **3rd floor: Measurement of gas flow conditions**
- 12:45** Measurement of components **total dust, Cd, Co, Cr, Cu, Mn, Ni, Pb** and **V**:
– **one** introductory measurement (30 min)
– **four** measurements (30 min each)
- 16:30** End of day 1

Tuesday (day 2)

- 08:00** 1st floor: Preparations; **3rd floor: Measurement of gas flow conditions**
- 08:45** **1st floor: Measurement of gas flow conditions;** 3rd floor: Preparations
- 09:30** Measurement of components **total dust, Cd, Co, Cr, Cu, Mn, Ni, Pb** and **V**:
– **five** measurements (30 min each)
- from 13:15** Transfer of raw data and protocols to HLNUG,
removal of the measuring instruments dust, departure of the participants.
- 14:00** End of the proficiency test

Timetable gas proficiency test

Tuesday (day 1)

- from 14:00** Arrival and setup of the measuring equipment for the following day
Delivery of the span gases into room 126
(Please observe the „*Information Sheet – Span Gas Verification*“)
- 14:30** Pre-meeting gas (**room 258**)
- 15:00** Theory test gas
- until 16:30** Preparations for the measurements the following day

Wednesday (day 2)

- 08:00** **1st floor: Measurement of gas flow conditions;** 3rd floor: Preparations
- 08:45** 1st floor: Preparations; **3rd floor: Measurement of gas flow conditions**
- 09:30** Measurement of components **SO₂, TOC, toluene, ethylbenzene** und **xylene:**
– **one** introductory measurement (30 min)
– **four** measurements (30 min each)
- 12:45** Lunch break
- 13:30** Continuation of the above mentioned measurements:
– **five** measurements (30 min each)
- 17:30** End of day 2

Thursday (day 3)

- 08:00** 1st floor: Preparations; **3rd floor: Measurement of gas flow conditions**
- 08:45** 1st floor: Preparations; **3rd floor: Measurement of gas flow conditions**
- 09:30** Measurement of components **formaldehyde, CO** and **NO_x:**
– **one** introductory measurement (30 min)
– **four** measurements (30 min each)
- 12:45** Lunch break
- 13:30** Continuation of the above mentioned measurements:
– **five** measurements (30 min each)
- from 16:45** Transfer of raw data and protocols to HLNUG,
removal of the measuring instruments, departure of the participants..
- 17:30** End of the proficiency test