Measurement of VOC emission from stacks of installations

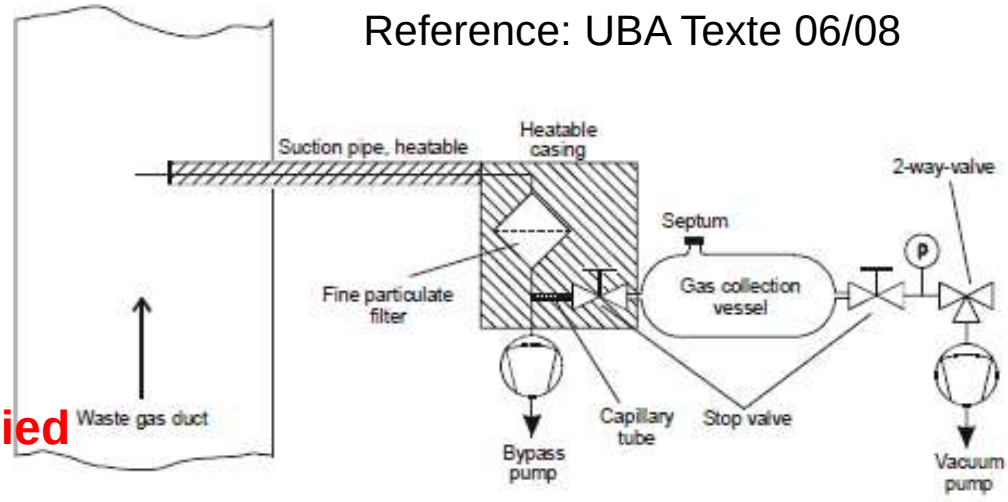
Table of contents

Why emission measurements at stacks of VOC installations?

Definition:

Monitoring =
Control of emissions

Reference: UBA Texte 06/08



- Verification
  that emission limit values are **complied**
- Operational self-control
  and documentation of function of installations to reduce emissions
- Quantification of input/output flows
  for total mass balance; especially relevant to VOC Directive: Quantification of VOC according to solvent mass balance:
  Attention in case of determination of efficiencies: Simultaneous measurements in raw and clean gas necessary!
- Gain of information on relevant pollutants emissions
- Reduction of emissions

Why emission measurements at stacks of VOC installations?

Chapter V IED – Annex VII Part 2 – Emission limit values for stack emissions

Petrol Stage I – Vapour Recovery Units

PART 2

Thresholds and emission limit values

The emission limit values in waste gases shall be calculated at a temperature of 273,15 K, and a pressure of 101,3 kPa.

	Activity (solvent consumption threshold in tonnes/year)	Threshold (solvent consumption threshold in tonnes/year)	Emission limit values in waste gases (mg C/Nm³)	Fugitive emission limit values (percentage of solvent input)		Total emission limit values		Special provisions
				New installations	Existing installations	New installations	Existing installations	
1	Heatset web offset printing (> 15)	15—25 > 25	100 20		30 (1) 30 (1)			(1) Solvent residue in finished product is not to be considered as part of fugitive emissions.
2	Publication rotogravure (> 25)		75	10	15			
3	Other rotogravure, flexography, rotary screen printing, laminating or varnishing units (> 15) rotary screen printing on textile/cardboard (> 30)	15—25 > 25 > 30 (1)	100 100 100		25 20 20			(1) Threshold for rotary screen printing on textile and on cardboard.

Reference of emission limit values

Emission mass concentration is generally referred on dry waste gas in norm state (273.15 K and 101.3 kPa) after subtraction of humidity content

In some cases: waste gas (wet) under standard conditions (273.15 K and 101.3 kPa) before subtraction of the water vapour content

Continuous monitoring/point monitoring and representativeness issues

Obligation for continuous monitoring is a result of legal requirements:

Petrol Stage I Directive

Requirements according to Annex II for loading and unloading of mobile containers at terminals

Vapour Recovery Unit

- The **mean concentration of vapours** in the **exhaust from the vapour recovery** - unit corrected for dilution during treatment may not exceed **35 g/Nm³ for any hour**
- Competent authorities must ensure that the **measurement and analysis methods and their frequency are established:** -> determination by authorities
- Measurements over the **course of one full working day** (seven hours minimum) of normal throughput
- **Continuous or discontinuous measurements**. If discontinuous: at least four measurements per hour
- **Overall measurement error** due to the equipment used, the calibration gas and the procedure used must **not exceed 10 %** of the measured value
- Equipment used must be capable of measuring concentrations at least as low as **3 g/Nm³**
- **Precision** must be at least **95 %** of the measured value

Chapter V IED: Monitoring Art. 60:

Emission Monitoring Annex VII, Part 6, No 1:

Continuous emission monitoring at exhaust gas channels with abatement equipment and an emission flow **> 10 kg C/h**

Emission Monitoring Annex VII, Part 6, No 2:

In all other cases continuous or periodic measurements

(at least 3 single measurements (readings))

that means for installations with abatement equipment with an emission flow ≤ 10 kg C/h

Emission Monitoring Annex VII, Part 6, No 3:

Measurements are not required in the case where end-of-pipe abatement equipment is not needed to comply with this Directive.

Germany:

No 5.3 TA Luft: Measurement and Monitoring of Emissions

Possibilities of emission monitoring

- 5.3.2: Individual Measurements
- 5.3.3: Continuous Measurement
- Proof by equivalent methods (No 5.3.3.1)
  - Composition of fuel/input material
  - Efficiency of installations for emission reduction
  - Process conditions
- Implementation and enforcement by conditions in permit

Germany – Continuous Monitoring

Note:
Generally for VOC installations under Chapter V IED **no continuous monitoring** at stacks are required (emission mass flows after VOC waste gas abatement generally << 10 kg C/h!)

Germany: TA Luft 5.3.3.2 Emissions Mass flow thresholds for continuous monitoring

Dust	
Control of functioning of waste gas abatement unit: 1 ≤ Q ≤ 3 kg/h	Control of dust concentration: Q > 3 kg/h
Special provisions for individual substances in dust	
Gaseous emissions	
SO_2: Q > 30 kg/h	NOx (as NO_2): Q > 30 kg/h
CO as lead substance for evaluating the efficiency of combustion processes: Q > 5 kg/h	CO otherwise: Q > 100 kg/h
HF: Q > 0,3 kg/h	HCl: Q > 1,5 kg/h
Cl_2: Q > 0,3 kg/h	H_2S: Q > 0,3 kg/h
Total C: Q > 2,5 kg C/h	Organic Substances No 5.2.5 class I: Q > 1 kg C/h

- **Cont. measurement of relevant sources from a defined emission mass flow of total installation**
- **Definition of relevant source: Q > 20 % of mass flow of total installation**

Emission mass flow:

total emission level occurring in one our of due operation of a facility under operating conditions which are most unfavourable to the maintenance of air quality

- Not avoidable waste gas have to be captured at their origin!
- „Dilution" has to be considered during assessment of compliance to emission limit values

Germany: No 5.3.3 TA Luft 2002: Continuous Measurement

- Measurement Programme
- Mass flow thresholds for continuous monitoring
- Reference Values
- Selection of Instruments to Determine Emissions
- Calibration of measurement devices every 3 years as well as after significant changes of an installation
- Annually periodic function test of measurement devices
- Continuous Determination of Special Substances
- Evaluation and Assessment of Measurement Results:

⇒ Measurement data assessment calculator

⇒ Operation time

⇒ Annual assessment report

Compliance is given if
a) None of **daily medium average values** (formed by ½ hourly average values) in normal operation **exceeds emission limit values** (without turn-on/off the installation)
and
b) **any half-hourly mean values do not exceed twice**

Continuous Measurement Obligations- CEN Standard

Quality assurance of automated measuring systems
Specifies procedures for establishing **Q**uality **A**ssurance **L**evels (QAL)

QAL 1 Conti. Measurement system is suitable (**notification**)

http://www.qal1.de/en/index.htm

CEN EN 14181

QAL 2 **Installation** of the AMS (Part of QAL 2) / **calibrating AMS** at plant (verify required uncertainly allowance)

QAL 3 **demonstration during normal operation**, whether the AMS works within the required specification

AST (**Annual Surveillance Test**) functual test by certificated Companies

Continuous monitoring of effectiveness of waste gas abatement units

Germany: TA Luft 5.3.3.1: Equivalent methods instead of continuous emission monitoring

Continuous emission measurements may be waived if the fulfilment of emission standards can be sufficiently proved by applying other tests, e.g.

- continuous efficiency demonstrating the effectiveness of emission reduction facilities like
  - by measuring the combustion chamber temperature in a thermal post-combustion facility instead of measuring the mass concentration of organic substances
  - by determining the differential pressure in fabric filters instead of measuring the mass concentration of the particles in waste gas
- composition of fuels or raw materials
- processing conditions

Germany – Discontinuous Monitoring

Germany: TA Luft No 5.3.2: Individual Measurements (discontinuous) for „other“ installations

Principle: Measurements may be carried out only by authorized and notified measurement institutes (§ 29b BImSchG)

Goal: Emission measurement of the operation situation with the highest emissions

⇒ individual („spot“) emission measurement of clean gas

⇒ but determination of crude gas composition can be required in some individual cases (e.g. for determination of abatement efficiency)

Determination of operation situation with highest emissions:

- Information from literature (e.g. emission factors)
- Information exchange with operator and if required with responsible authority as well as an on-site visit of the installation;
- Knowledge about type of installation and emission behaviour due to carried out emission measurements at relevant installation or comparable installations

Measurement point - requirements

EN 15259 (October 2007)

„Air quality – Measurement of stationary source emissions – Requirements for measurement sections and sites and for the measurement objective, plan and report“

Annexes A to C and E to G are not mandatory but only informative

- Annex A Design and construction of measurement sites
- Annex B Measurement planning
- Annex C Conversion to reference quantities
- Annex D (normative) Sampling strategy
- Annex E Examples for determining homogeneity of waste gas profiles
- Annex F Example form of emission measurement report
- Annex G Theoretical basis for the determination of the mean concentration in the measurement plane

Measurement Points

DIN EN 15259

- Measurement of stationary source emissions
- Requirements for measurement sections and sites and for the measurement objective, plan and report

Requirements:

- Sufficient big, easily accessible, clear signed
- As far as possible undisturbed flow in measuring section
- Installation of appropriate lockable opening for measurement
- Measurement must be representative for installation and technical correct

EN 15259

Measurement plane shall be situated in a section of the waste gas duct (stack etc.) where homogenous flow conditions and concentrations can be expected;

angle of gas flow less than 15° with regard to duct axis	Yes	No
no local negative flow		
minimum velocity depending on the flow rate measuring method used (for Pitot tubes a differential pressure larger than 5 Pa)		
ratio of the highest to lowest local gas velocities less than 3:1		
Measurement section		
a) at least five hydraulic diameters of straight duct upstream of the measurement plane		
b) two hydraulic diameters downstream (five hydraulic diameters from the top of a stack).		

Representativeness issues of emission monitoring

Discontinuous (individual) emission measurements

Note: Measurements only by an authorised measurement institute!

Target: Measurement technical recording of operation state with **highest emission**

⇒ emission measurements on spot tests of clean gas

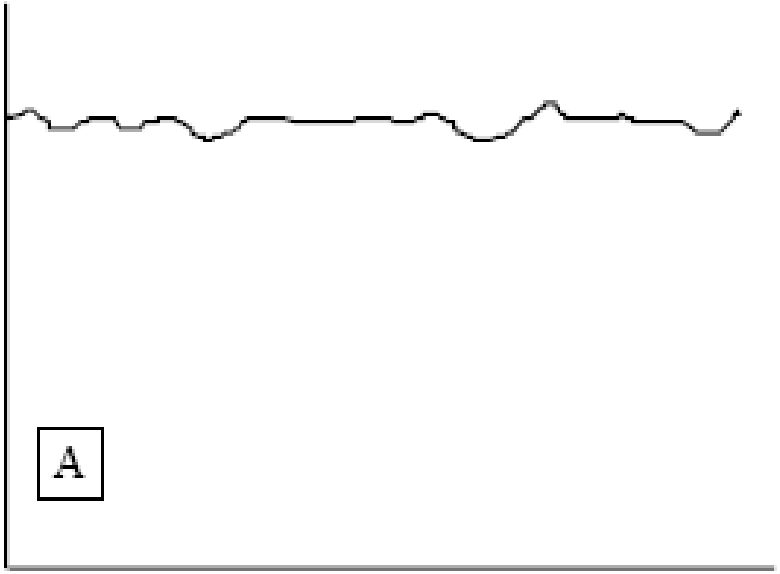
⇒ but: determination of raw gas load can be necessary – e.g.

Determination of cleaning efficiency of abatement installation

Measurements during different temporal operation conditions (referring to DIN EN 15259 Annex B and CWW-BREF):

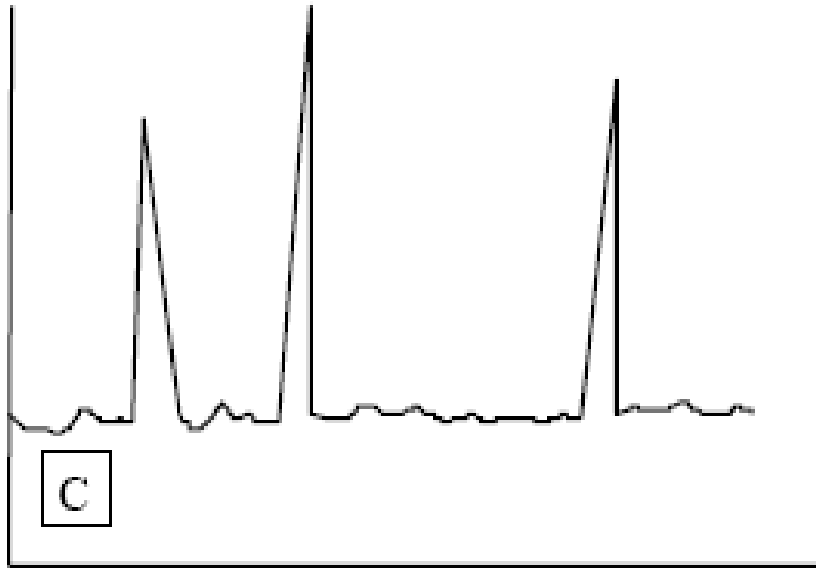
1. <u>Continuous processes:</u>

- Material properties of input fuels or in process handled substances as well as the operation of the installation are almost constant over a longer time period
- Mostly temporally constant emission behaviour
- -> timing of emission monitoring free selectable
- Examples: drying, coating installations



2. Continuous processes with temporarily influences:

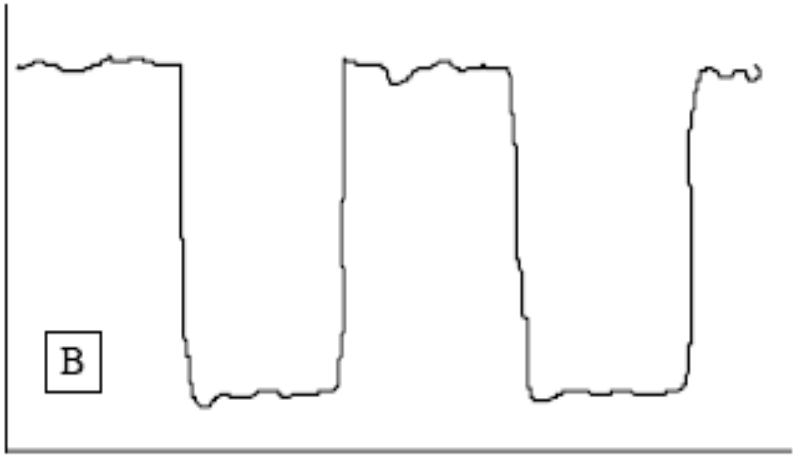
- Almost constant material input
- Time dependent process step can influence the emission behaviour
- -> timing of emission measurement must respect temporarily changes in emissions behaviour in an appropriate way
- Example: sintering processes



Here: Stabile process with peaks
If peaks are relevant for compliance of ELV - > time-resolved measurement necessary!

3. Charge processes:

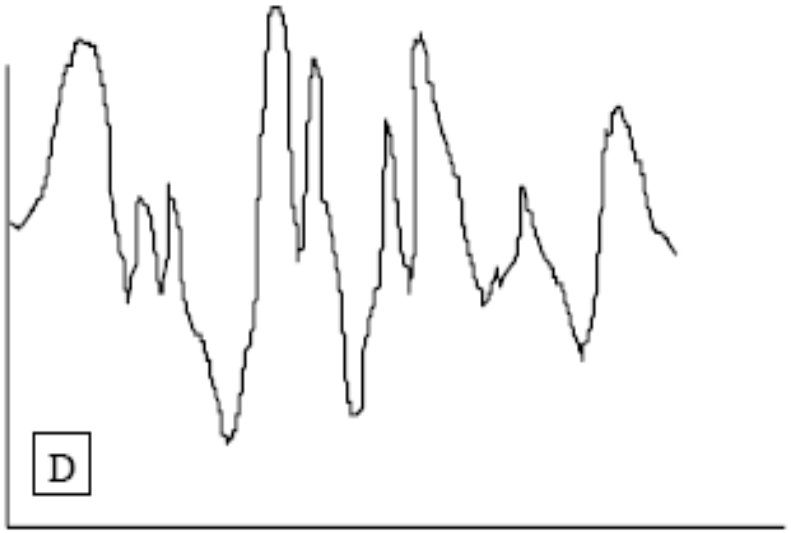
- Control of emission behaviour by changing material related and/or temporarily operation influences
- -> Timing of measurement must respect temporarily changes in emission behaviour in an appropriate way



- In very short emission events it must be checked if several similar emission events can be concentrated in one sampling
- Timing and period of sampling can limited on phases where the batch process is running
- Even average emissions over total cycles can be the point of interest e.g. in case of estimation of emission load/emission factors
- Sampling can be continuous or discontinuous
- Example: Batch processes

4. Strong fluctuating process

- Timing of sampling is crucial in case of discontinuous measurement techniques!
- If peaks are relevant for emission limit compliance: -> time-resolved measurement necessary!



- Short sample period permits inspection of peaks; a longer period the inspection of total load;
- Continuous measurement technique compared to a discontinuous has the advantage of delivering a larger number of measured data
  - > time-resolving of measurement

Germany: TA Luft 2002 No 5.3.2.2:

Requirements to sampling period

Accurate specification of timing requirements for measurements necessary (timing, average times, frequencies):

- Where operating conditions remain unchanged to a great extent in terms of time, a minimum of **3 individual measurements** shall be carried out during fault-free operation with a maximum emission level

and

- a minimum of **one measurement** each shall be carried out for states of operation occurring regularly with a floating emission behaviour, e.g. for cleaning or regenerating work or during relatively long start-up or shut-off processes.

Where operating conditions are subject to **change in terms of time**:

- a sufficient number of measurements shall be carried out,
- as a minimum, however, **six measurements** shall be carried out during states of operation which can cause maximum emission levels by experience**.**

Handling of measurement commissions

Operator: awards commission to authorized measurement institute

<u>Measurement institute:</u>

- **Collection of installation related pre-knowledge, operation states, emission behaviour, on-site visit**
- **Together with operator and authority: Elaboration of a measurement plan with selection of sampling strategy: net monitoring, representative point or any measurement point**
- **Together with operator: Preparation of measurements**
- **Measurements according to individual standards for each component**
- **Collection of all data (including operational data)**

Measurement institute:

- Determination of results, validation, explanation of deviations to measurement plan
- Elaboration of a monitoring report according to DIN EN 15259 Annex F
- Submission to operator: Check on discrepancies
- Operator submits final measurement report to responsible authority to verify compliance to emission limit values

TA Luft 2002 No 5.3.2.2: Planning of Measurements:

Before carrying out the measurements:

⇒ Drawing-up of a task-orientated measurement plan necessary:

- Information on cause of measurement and measurement task
- Agreement of measurement plan with competent authority

During the measurement it must be guaranteed:

- Monitoring of all relevant measurement parameters
- Operation of installation during the measurement in state of highest capacity and maximum emissions at undisturbed production process
- Monitoring of timely alterable operation conditions (start and shut-down, changes of recipes, cleaning cycles etc.) that are typical for installation
- Installation of appropriate sample places; use of appropriate measurement methods and equipment

Database in Germany with all authorized emission monitoring institutes

http://www.resymesa.de/resymesa/ModulStelleStart.aspx?M=4

Modul Immissionsschutz | Notifizierte Stellen

Sie befinden sich hier: Startseite / Immissionsschutz Stellen / Recherche Ergebnisliste

Rechercheergebnisse - Suche nach Kriterien

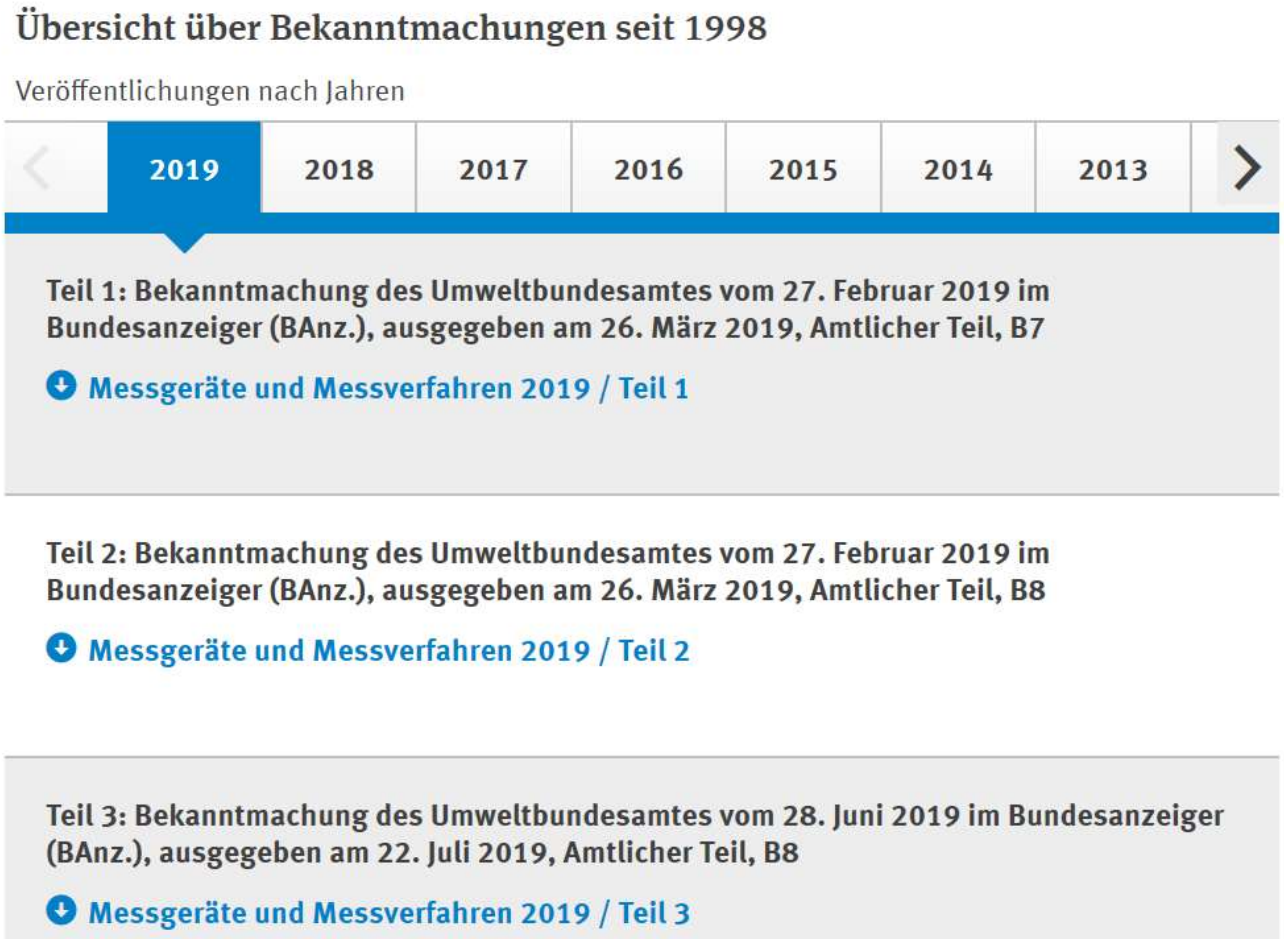
Sie haben nach diesen Kriterien gesucht:

Geschäftssitz in Bundesland (ODER) : BY
Notifizierung in Bereich (UND) : A, L

	Nummer	Name	Ort
☐	IST227	InfraServ GmbH & Co. Gendorf KG	Burgkirchen
☐	IST46	Institut für Umwelt- und Arbeitsplatzanalytik Burkon GmbH	Nürnberg
☐	IST52	LGA Immissions- und Arbeitsschutz GmbH	Nürnberg
☐	IST189	Modern Testing Services (Germany) GmbH (MTS)	Augsburg
☐	IST53	Müller-BBM GmbH	Planegg b. München
☐	IST61	TÜV Süd Industrie Service GmbH	München

Germany: Application of notified measurement devices for emission measurements

Centralized notification of authorized emission measurement devices by federal environmental agency UBA



http://www.umweltbundesamt.de/themen/luft/messenbeobachtenueberwachen/messgeraete-messverfahren/bekanntgabe-eignungsgepruefter-messeinrichtungen

Centralized notification of authorized emission measurement devices by federal environmental agency UBA

http://www.qal1.de

Certified measuring- and evaluating-systems according to EN 15267

Components overview

Emission	Reference Values	Ambient air
• Dust concentration • Dust monitor (qualitative) • Carbon monoxide - CO • Nitrogen monoxide - NO • Nitrogen dioxide - NO_2 • Nitrogen oxide - NOx • Dinitrogen monoxide ($laug_2O$ • Sulfur dioxid - SO_2 • Anorganic gaseous chlorine compounds - HCl • Anorganic gaseous fluorine compounds - HF	• Oxygene - O_2 • Humidity - H_2O • Carbon dioxide - CO_2 • Velocity / Volume flow • TABZ	• Particular matter - PM 10 • Particular matter - PM 2.5 • Carbon monoxide - CO • Nitrogen monoxide - NO • Nitrogen dioxide - NO_2 • Nitrogen oxide - NOx • Sulfur dioxid SO_2 • Ozone - O_3 • TOC - CnHm (without CH_4) • Benzene - C_6H_6
	Digital Data Transfer	

Other parameters to monitor (waste gas flue gas, O2, T, humidity…)

Standardisation of measured emission mass concentration to norm state:

Determination of reference parameters necessary:

- Waste gas temperature,

- static pressure in waste gas,

- ratio of water vapour in waste gas,

- atmospheric pressure

For determination of emission mass flow m from measured emission mass concentration c

Measurement of waste gas volume flow V necessary: **m = V*c**

Compliance with ELV

Compliance Assessment in case of individual measurements (Reference: BREF CWW)

Reference: BREF CWW

ELV = Emission Limit Value

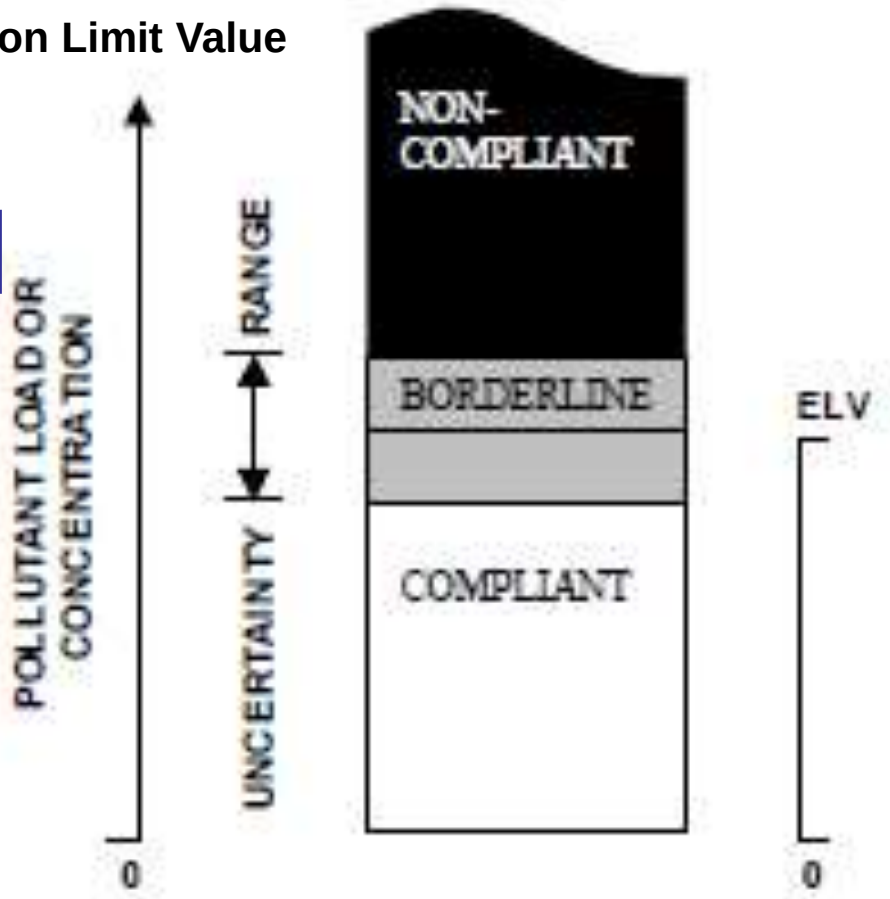
a) **Compliant:** Measured value + uncertainty < ELV $Em + \mu \leq ELV$

b) **Borderline:**

(ELV – uncertainty)
< measured value
< (ELV + uncertainty)

c) **Non-compliant:**

measured value >
(ELV + uncertainty)



IED Art. 61 and Annex VII Part 8 No 1 – continuous measurements:

Compliance according to continuous measurements, if

a) Each of 24 h average value under normal operation ≤ emission limit value

b) Each of 1 h average value ≤ 1.5 *emission limit value

IED Art. 61 and Annex VII Part 8 No 2 – periodic measurements

Compliance in case of periodic measurements if

a) average of all single measurements (readings) ≤ emission limit value

b) All 1 h average values ≤ 1.5 * emission limit value

Germany: TA Luft:
Assessment for compliance for individual measurements

The plant is not objectionable in terms of emissions if the result of each individual measurement plus the measurement uncertainty does not exceed the emission limits specified in the permit

No 5.3.2.4 TA Luft 2002: Assessment of measurement results – rule of rounding

Determination of the corresponding measured and calculated variables with one decimal place more than the numerical value for the assessment (limit value).

Rounding of the final result in the last decimal place as well as indication in the same unit and with the same number of digits as the numerical value (limit value).

Example 1:

Check on compliance of the emission limit value for captured waste gas:

Emission limit value for captured waste gas: 50 mg /Nm^3

Max. mean value of individual measurement at discontinuous measurement: 50,49 mg /Nm^3

Rounding according rule of rounding: 50 mg /Nm^3

Result: Emission limit value for captured waste gas is complied with!

Example 2:

Emission limit value TA Luft: 0,5 mg/m³

Measured value: 0,549 mg/m³

Proceeding:

Third decimal place is negligible: 0,54

Second decimal place has to be rounded:

-> resulting measured value: 0,5 mg/m³

Example 3:

Measured value: 0,551 mg/m³

Proceeding:

Third decimal place is neglible: 0,55

Second decimal place has to be rounded:

-> resulting measured valued: 0,6 mg/m³

Example 3:

Emission limit value = 50 mg/Nm^3

Measured values: 42 mg/Nm^3, 45 mg/Nm^3, 49 mg /Nm^3

Measurement uncertainty: 3 mg/Nm^3

Result:

Max. measured value (49 mg/Nm^3) + measured uncertainty (3 mg/Nm^3) = 52 mg/Nm^3

Exceedance of emission limit value is given

- Review of the measurement method complies with Best Available Technique
- If compliance is given to BAT: Testing of there exist plant-specific causes with options for a further emission optimization
- In this case: Additional order for a additional measures to reduce the emissions is not possible because measurement uncertainty here counts in favour for the operator

Example 4:

Emission limit value = 50 mg/Nm^3

Measured values: 42 mg/Nm^3, 45 mg/Nm^3, 58 mg /Nm^3

Measurement uncertainty: 3 mg/Nm^3

Result:

Max. measurement result: 58 mg/Nm^3

- Exceedance of emission limit value is given
- Testing of there exist plant-specific causes with options for a further emission optimization
- Here: Additional order for further emission reduction measures are now possible:

By taking into account the measurement uncertainty in favour to the operator:

58 mg/Nm^3 – measurement uncertainty 3 mg/Nm^3 = 55 mg/Nm^3 > emission limit value)

Emission Measurement Report for Individual Measurements

Measurement report for individual measurements

Harmonized report according to DIN EN 15259
Requirements on quality of a measurement report:
see Annex B.3 of EN 15259

Summary with a description of the work and results including

- the name of the operator and the address of the facility at which the measurements were taken,
- name and address of the test laboratory,
- name of the person responsible for the project,
- auxiliary staff measuring task,
- substances measured in the exhaust gas,
- measurement date (day, month and year) ,
- Measurement uncertainties,
- measurement methods used,
- deviations from the measurement plan and
- measurement results in SI units and for the specified conditions;;

Measurement report DIN EN 15259

- Definition of the project by definition of the measurement task;
- Description of the plant and the substances used;
- Information on the measuring section and the measuring station;
- Information on the measuring methods and the devices, taking into account the respective standards;
- Operating conditions of the installation including the emission control system during the measurements
- Information on the availability of the original data and their use for the purpose of verification;
- Measurement results and other relevant data needed to interpret the results
- Presentation of the results with date and time of the measurements

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