3.7 Monitoring emissions

3.7.1 Introduction

Verification and types of monitoring
If the permit specifies emission requirements on the basis of the NeR then these must be monitored and controlled. Monitoring emissions in this context means assessing emissions on the basis of measurements or on the basis of the level of control over emission relevant parameters or over the correct functioning of emission abatement facilities. Values are considered to be emission relevant parameters if there is a direct or indirect correlation between those values and the emission being assessed.
If the permit specifies emission requirements, the licensing authority, after consultations with the operator, must establish the most efficient type of monitoring on a per source basis. This is done on the basis of the classification system, further details of which are given below.
Based on emission and process characteristics, this chapter provides a guideline for the method of verifying compliance with the requirements in the permit. The method of verifying compliance, insofar as this is possible and practical, must be laid down in the permit for all sources concerned.

Within the framework of the NeR the following types of verification are distinguished:
- regular inspection to verify the proper functioning of the abatement means;
- individual measurements with a pertinent frequency;
- monitoring of emission relevant parameters (ERPS), and;
- continuous measurements.

Selection of the monitoring regime
In the classification system used in the NeR the type of monitoring and the frequency of inspections are based on the size of the untreated emission in combination with the controlling technology utilised. In this context any potential increase in emission levels in the case of malfunction of the controlling technology will be a key consideration. This emission is referred to as the failure emission. Depending on how harmful the emission in question is, a monitoring regime is decided on. Please refer to §3.7.2.

Verification method in the permit
The implementation of the monitoring procedures must meet certain quality requirements to be specified by the competent authorities. To this end, it will be necessary that, in addition to the requirements for emissions to air, the permit also specifies how compliance with the requirements will be monitored. This may be done, for example, by reference to a standardised method of taking measurements or documents in which the actual verification methods are specified.

The method of implementation of the verification must be approved in advance by the competent authorities.
Wherever possible, arrangements which allow reliable verification must already be taken into account in the design phases of individual pieces of process equipment.

If the permit does not specify requirements based on the NeR, this must not be taken to mean that monitoring is not required in this case. For, checks or measurements can also take place on other grounds than NeR requirements, for example, in order to monitor emissions for the purpose of an environmental annual report. The procedure for this verification method is not, however, discussed in the NeR.
A new understanding on the basis of verification procedures into the scale and variability of emissions may prompt the type and frequency of monitoring to be adjusted.

3.7.2 NeR monitoring regime and associated types of monitoring

Implementation of the monitoring regime
Selection of the most efficient type of monitoring is done on the basis of the NeR monitoring regime that applies to the source in question. Both are given in table 1.
The selection of the monitoring regime is determined on a per source basis, taking into consideration how severely the emission abatement measures failed to function. The yardstick for the severity of malfunction is the ratio between the 'failure emission' and the mass flow check value.

If post-fitted cleaning equipment is present, the volume of the failure emission is equal to the difference between the untreated mass flow and the permissible mass flow of the source quoted in the permit. If it can be demonstrated that the additional emission, even in the case of complete malfunction of the equipment, will be smaller than this difference, this maximum additional emission will be taken to constitute the failure emission.
If emission reduction is done by means of process integrated measures, the untreated mass flow will be assumed to be the maximum emission occurring in the case of malfunction of these measures.
The mass flow check value is an indication for how harmful the released substances are. The mass flow check value has been determined on a per substance class basis and is quoted in table 2.

The monitoring regime is determined on the basis of the ratio F between the failure emission and the mass flow check value.

There are five different monitoring regimes, numbered 0, 1, 2, 3 and 4. For each monitoring regime the types of monitoring are indicated. In the case of the more stringent monitoring regimes 3 and 4, several types of monitoring are indicated, the most efficient of which should be selected. Per monitoring regime it is indicated how often at least measurements must be taken, or which category of ERPs must be controlled as a minimum.

Table 1

Monitoring regime	F*	Potential types of monitoring
0	F < 1	• ERP cat. 2/3
1	1 < F < 10	• Single measurement +ERP cat. 2/3
2	10 < F < 100	• Measurement once every 3 years +ERP cat. 3 or periodic measurement +ERP cat. 2
3	100 < F < 1000	• Measurement once a year +ERP cat. 3 or periodic measurement +ERP cat. 2 • In the case of strong fluctuations continuous measurement of ERPs cat. 1 or 2
4	1000 < F	• (semi) continuous measurement of ERP cat. 1 • periodic measurement +ERP cat. 2

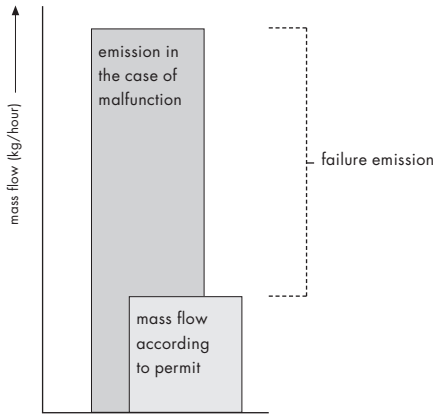
$$* \ F = \frac{\text{failure emission in (g/h)}}{\text{mass flow check value}}$$

Periodic measurement in the case of using ERPs cat. 2
Where ERPs are used, the purpose of taking measurements is to establish or check the correlation between the emission and the ERP. For this purpose a one-time measurement may suffice in the case of the more relaxed monitoring regimes. As the risk posed by malfunction of the equipment becomes larger, and therefore a more stringent monitoring regime applies, it is recommended that the correlation be kept under tighter control.
The frequency of the measurements depends on the reliability of the ERP. There are ERPs of category 2 or combinations of ERPs which exhibit such a strong correlation with the emission requirement that it can be established with great confidence whether those requirements are being met by monitoring the ERPs.
As this correlation becomes more pronounced, the frequency of periodic measurements can be reduced in principle to a one-time assessment by way of a single measurement also in the case of the more stringent monitoring regimes.
If such a correlation is less pronounced then it may be necessary to step up the frequency of the monitoring measurements to a measuring frequency which in severe cases may be at most the same as the measuring frequency which, in the schedule in question, applies in the case of monitoring ERPs of category 3.
In monitoring regime 4, in the case of a less pronounced correlation between an ERP of category 2 and the permit requirements, a measuring frequency of in principle twice a year will apply. On the basis of measurements performed it will be possible to establish whether this frequency must be increased or can be reduced.
If it should transpire under the actual conditions that the emission in the case of malfunction is lower than calculated, the measuring frequency can be reduced on the basis of these findings.

An example of a pronounced correlation between an ERP of category 2 and the emission is the monitoring of an incinerator. If the temperature and the CO content are being controlled, the process conditions exhibit little variability, and a reliable maintenance and inspection schedule has been implemented, then there is a combination of measures which results in a strong correlation between ERPs and emission. In such cases it may be justifiable to reduce the number of measurements.
An impeccable record for performing (scheduled) measurements can also occasion a reduction of the number of measurements.

Monitoring of emissions of substances subject to a requirement to minimise emissions
If the permit contains emission requirements for extremely hazardous substances and carcinogens without a threshold value, monitoring regime 4 applies. If continuous monitoring is not possible a mandatory measuring frequency of at least twice a year applies. If no methods of taking measurements are available for these substances, the operator must demonstrate that the requirement to minimise emissions of these substances is being met by the continuous updating of the ERPs.

Figure 1 Failure emission



Other kinds of ERP
Key figures which are utilised for determining the untreated mass flow are sometimes also called 'ERPs'. This concerns, however, other parameters than the ERPs referred to here. The ERPs mentioned within the framework of §3.7 of the NeR are parameters which are utilised for verifying compliance with the emission requirements included in the permit on the basis of the NeR.
In Decrees such as BEES, occasionally ERPs are also mentioned. These ERPs are not intended (nor referred to) in the NeR, but may nonetheless in some cases be used to advantage.

Verifying odour emissions
In verifying 'odour requirements' (in many special regulations the presence of technical facilities is required to this end) ERPs can often be utilised. For verifying permit requirements for odours please refer to §2.9 and §3.6.

Complaints
Complaints cannot be considered to constitute an ERP within the framework of the monitoring regime pursuant to the NeR. Complaints can of course be used as an indication for the competent authorities that something may be amiss.

Selection of the verification method

By 'verification method' in this context the method of verifying emissions referred to in the authorisation permit is meant. Specifying a certain verification method may be based on the same data that were used in drawing up the emission requirements. The selection of the verification method can be divided into a number of phases:
a Establishing the failure emission;
b Determining F and the monitoring regime;
c Establishing the pertinent types of monitoring;
d Deciding on the verification method.
These four steps are discussed in detail in the text frames.

Starting verification
Every source or processing unit which falls under monitoring regime I will, following commission or any non-trivial modification of the installation which is expected to have drastic consequences for the emission concentration or mass flow, be checked at least once within the framework of the NeR monitoring regime by means of a measurement.

This requirement to carry out measurements does not apply if in the opinion of the competent authorities it can be ascertained by different means with a sufficient level of confidence whether the installation functions correctly and whether the emission is in compliance with the requirements of the permit.
If continuous monitoring is prescribed, verification will start immediately as soon as the emission requirement becomes applicable and/or the parts of the installation concerned are put into commission. In the case of individual verifications, the first verification will be carried out as quickly as possible – but at the latest within 6 months – after the emission requirement has come into force.
For existing operators, the emission situation must be examined in detail. Based on available emission data or estimates, an interim regulation may have to be worked out.
Until such time as conformance has been established, a monitoring regime must be implemented on the basis of the existing emission situation.
The implementation of the monitoring procedures must meet certain quality requirements to be specified by the competent authorities. In future – and certainly as far as enforcement is concerned – the goal must be to have measurements carried out exclusively by institutions which are certified to perform this type of work.
If there are any uncertainties regarding the expected emission, (continuous) measurements of the components concerned may be prescribed for a trial period (this is referred to as 'further research').

If a permit contains requirements which are not based on the system used for classifying purposes in the NeR, the monitoring regime does not apply. The competent authorities must then determine on a per individual case basis how compliance with this type of requirements must be validated.

Table 2 Mass flow check values for selecting the type of monitoring

Category/class		Mass flow check value (g/h)
Ext	Extremely hazardous compounds, see §3.2.1	
C	carcinogenic compounds	
	class C.1	0.5
	class C.2	5.0
	class C.3	25
S	particulates	1000
sA	inorganic compounds in particulate form	
	class sA.1	1,0
	class sA.2	5,0
	class sA.3	25
gA	inorganic gaseous or vaporous compounds	
	class gA.1	10
	class gA.2	50
	class gA.3	300
	class gA.4	5000
sO	organic compounds in particulate form	
	class sO.1	100
	class sO.2, sO.3	250
gO	organic gaseous or vaporous compounds	
	class gO.1	100
	class gO.2	2000
	class gO.3	3000
Odour	see §3.6	

a Establishing the failure emission

The monitoring regime is determined on a per source of emission basis. This is done on the basis of the failure emission. This is the difference between the untreated (or the uncontrolled) mass flow and the mass flow according to the permit.

If the untreated mass flow is not known or cannot easily be measured, it is acceptable to work from an estimate, for example on the basis of a mass balance or on the basis of the efficiency of cleaning specified by the supplier.

For the purpose of determining the verification method, the following information will be necessary:

- nature of the emission (which components, NeR substance category, odours, etc.);
- volume of the failure emission (the maximum additional emission). This cannot exceed the mass flow of the untreated emission per substance class minus the emission stated in the permit.
- physical characteristics of the emitted substance(s) (gas, solid, aerosol, liquid);
- waste gas parameters (mass flow, temperature, humidity, etc.);
- how the emission takes place (fugitive, point source, emitted from surface);
- emission pattern (variability of the emission (continuous, in peaks, intermittent).

b Determining the failure emission F and the monitoring regime

The monitoring regime is established on the basis of the scale and harmfulness of the maximum additional emission occurring in the case of a malfunction. If it is known which substances are released, it is possible using the classification in the NeR to find the associated mass flow check value. This is an indication of how harmful the emitted substance(s) is (are).

By dividing the volume of the failure emission in g/h by the mass flow check value, the failure emission F is obtained. This will provide an indication of the severity of the ineffectiveness of the emission abatement facilities. Based on this key figure the monitoring regime (and thereby the strictness of monitoring) must be established using Table 1. This strictness may vary from the use of an ERP of category 3 in the case of a limited risk to continuous measurements in the case of a major risk.

c Establishing the pertinent types of monitoring

In order to be able to verify an emission requirement accurately (i.e. quantitatively) it will generally be necessary to perform measurements. For example, after the delivery or adjustment of a process installation or emission abatement facility measurements will always take place, even if there is only a limited risk that levels in excess of the limit value will occur (monitoring regime 1 or higher).

The necessity for performing measurements will subsequently depend on the monitoring regime and on the available emission relevant parameters (ERPs). Taking measurements can be a costly and time consuming business. If there are parameters that can be determined by some simple means that have an unambiguous correlation with the volume of the emission, it will be possible to verify the emission based on these ERPs.

The NeR stresses the possibility of using other types of monitoring instead of performing measurements. In every situation the added value of (continuous) measurements must be balanced against the option of (a more simple) verification on the basis of emission relevant parameters. These parameters can be relevant for both the correct operation of the treatment plant and for the process or waste gas conditions that directly determine the emission. A parameter for the correct operation of a device may, for example, be the pressure drop over a bag filter. A parameter for the waste gas condition may, for example, be the temperature of the gas. If it should drop below the dew point, condensation will occur, causing the purification technology employed to not perform well enough.

The presence of an effective inspection and maintenance regime - possibly within the framework of an environmental protection scheme - can also be qualified as an ERP. Depending on the extent to which the operator has a better environmental protection scheme at his disposal with a monitoring regime to match, the necessity for stipulating measurements may be less acute and it may be feasible to endorse such a monitoring regime.

d Deciding on the verification method

After the monitoring regime for the source in question has been established and the possible types of monitoring have been considered in detail, the method of verification to be stipulated in the permit can be laid down. In the most simple case (monitoring regime 0) it will suffice to monitor/control ERPs of category 3. In the most hazardous situations the choice will be between continuous measurements or monitoring / controlling ERPs of category 1 and/or 2.
In fixing how stringent the mandatory inspections shall be there is everything to be said for taking the reliability of the installation into consideration. If technologies of proven reliability are used together with the availability of an effective inspection and maintenance regime or an environmental protection scheme, it can be considered to relax the monitoring regime. Especially in existing situations the proven reliability of the measures can be taken into consideration in establishing the monitoring regime.
A growing understanding on the basis of measurements into the scale and variability of emissions may prompt the type and frequency of monitoring to be adjusted. If it transpires from the measurement results recorded over time that the installation functions correctly without nonconformances, the number of mandatory measurements can be reduced. Conversely, the measurement regime may be made more stringent if the measurement results recorded over time indicate that the installation has repeatedly exceeded the (emission) requirements. In the case of special regulations, too, the rule applies that if measures or emission concentration related requirements are specified therein in order to limit emission(s), it may be feasible to verify these using ERPs.

3.7.3 Verification through ERPs

If a verification method is based on the use of emission relevant parameters the ERP yielding the most reliable results (the one exhibiting the highest level of correlation) in the given situation must be specified, assuming that this information is available or can be obtained reasonably easily. As an ERP of category 1 yields a reliable quantitative indication of the emission, monitoring/controlling such an ERP will suffice. As ERPs from categories 2 and 3 only provide qualitative information or a rough indication of the volume of the emission, it is recommended in such situations to monitor / control all available ERPs.

(New) situations may exist where it is not yet quite clear which value of the ERP must be laid down, or what the correlation is between the ERP and the emission concentration. In such a situation it may be decided to perform measurements for verification purposes, until it has been demonstrated (a time frame must be set for this) that verification can be achieved just as effectively using ERPs.

Classification of ERPs

ERPs have been classified into three categories 1 to 3, characterised by increasingly less 'hard' information being produced

ERPs of Category 1:
These provide a reliable quantitative description of the emission and can, after calibration and periodic re-calibration, replace the measurements of a specific component or components entirely (also for monitoring purposes).
Examples of category 1 ERPs are:

- measuring 'total of hydrocarbons' in a waste gas flow (instead of the individual components), as long as the composition of the waste gas flow does not change;
- the composition of raw materials or additives if a direct correlation with the emission exists.

ERPs of Category 2:
These provide a reliable qualitative insight into the composition of the waste gas. They provide sufficient information for licensing and enforcement purposes regarding an emission that they can replace measurements entirely or partially.
Examples of ERPs of category 2 are: temperature of an incinerator or forced cooling installation (possibly together with the mass flow).
The examples provided demonstrate that what is obtained is not an exact figure but a reliable correlation with the emission. In many cases it will be possible, on the basis of the known correlation between ERP and emission, to establish the emission level with sufficient accuracy.

ERPs of Category 3:
These provide an indication of whether an installation or a process is functioning according to its design or in the desired manner, and thereby give a good indication of the emission level(s). On the grounds of earlier measurements or experience it may be assumed that as long as a given parameter has not reached a certain value or does not exceed it, the emission limit value mentioned in the permit will not be exceeded.
Examples are: the temperature of (a waste gas flow beyond) a condensor, a pressure drop, a mass flow, a pH value, the moisture content of a compost filter, measurement of hydrocarbon levels instead of measuring odour levels in the case of biologically active filters, the pressure drop (together with visual inspection) over a dust filter, the temperature of a reactor, the presence of an effective inspection and maintenance regime etc.

Combining ERPs may yield more reliable results and therefore such a combination will constitute a less ambiguous ERP. Thus several ERPs of category 3 taken together may constitute an ERP of category 2. More examples of ERPs are given in Tables 3 and 4.

Types of Emission Relevant Parameters for various processes and technologies

Commissioned by the Ministry of Housing, Spatial Planning and the Environment, DHV has drawn up lists of potential ERPs for a number of emission limiting technologies.* The result has been summarised in Table 3.

In addition to the ERPs mentioned, other ERPs are conceivable, for example based on organisational measures. In table 5 several additional ERPs are quoted. The tables make no claim to being exhaustive. Combining ERPs may yield more reliable results and therefore such a combination will constitute a less ambiguous ERP. On a per case basis it must be investigated which parameters of what ambiguity level are possible.

* Emission relevant parameters for waste gas cleaning techniques, DHV 1994, reg. No. DHV MT-RE943647.

Table 3 Classification of ERPs according to DHV Waste gas cleaning techniques with associated ERPs and components

Waste gas cleaning techniques	ERP [1]	Components
Thermal incineration	1 a, 1/2 b, 2 c, 3 d e f	VOC, odours
Catalytic incineration	1 a, 1/2 b, 2 c, 3 d e f	VOC, odours
Adsorption	1 a, 3 c d g f h i	VOC, odours
Absorption	1 a, 3 d f o p n	VOC, odours
Biological cleaning	1 a, 3 c d f o p q r s t	VOC, odours
Forced cooling	1 a, 2 c, 3 d n	VOC
Membrane separation	1 a, 3 d f g	VOC
Cyclone	3 d f v	Aerosols [2]
Dust filter	2x, 3 d f i x	Particulates [3]
Electrostatic dust separator	3 d y x	Aerosols
Wet dust separator	3 d f i n	Aerosols
Deep bed filter	3 d f g	Aerosols
Ceramic filter	3 d f i g	Particulates
Dry flue gas cleaning	3 d i z	Inorganic substances
Fluid-based gas cleaning	3 d f n aa	Inorganic substances
Gas cleaning using ozone	3 d y ab	Odours

[1] '1a' here means: an ERP of category 1, where the 'a' refers to the associated parameter in table 4.
[2] 'Aerosols' in this context means: dry, moist and wet particulates.
[3] 'Particulates' in this context means: dry particulate matter

Table 4 ERPs for monitoring waste gas cleaning techniques

	ERP	
a	C_xH_y	Total hydrocarbon concentration (e.g. FID, PID) beyond gas cleaning installation
b	CO	Concentration of CO
c	T	Temperature of combustion chamber/adsorption vessel/biologically active filter/coolant
d	ϕ_{src}	Mass flow of waste gas flow to be treated/ incinerated
e	ϕ_{gas}	Mass flow or consumption of fuel used for supplementary heating (usually gas)
f	δP	Pressure drop over reactor, membrane
g	T	Operating period/useful life (of filter material)
h	RH_{src}	Relative humidity of waste gas flow
i	T_{src}	Temperature of waste gas flow to be treated
j	T_{reg}	Regeneration temperature
k	t_{reg}	Regeneration time
l	ϕ_{sec}	Mass flow of secondary waste gas flow
m	T_{sec}	Temperature of secondary waste gas flow
n	ϕ_{liquid}	Mass flow of liquid circulated
o	$T_{gas,out}$	Temperature of waste gas flow to be treated beyond the gas cleaning facility
p	pH	pH of washing fluid/biologically active filter/active silt tank/buffer tank
q	H_{bioac_flt}	Moisture content of biologically active filter
r	H_{src}	Moisture content of waste gas before the cleaning facility
s	$Particulates_{src}$	Particulate content of waste gas before the cleaning facility
t	T_{bioac_flt}	Maximum temperature of the biologically active filter over time
u	C_{tox}	Concentration of toxic mineralisation products in biologically active filter
v	Elimination of dust	Adequate elimination of dust from hopper
w	$C_{particulates,\ out}$	Monitoring of particulate content in the outlet of the filter
x	Vibration/ cleaning	Verification of proper functioning of the vibrating (cleaning) mechanismy
y	V/I	Electrical voltage or current over equipment
z	ϕ_{add}	Value to be added in the case of dry matter (kg/hour) or suspension (m^3/hour)
aa	$C_{reagent}$	Concentration of the reagent in the hydrogen
ab	C_{ozone}	Ozone concentration in waste gas emitted from gas cleaning facility

Table 5 Supplementary ERPs

Environmental protection	
• Adequate inspection and maintenance regime	cat 3
• Limiting production (for example, if the production remains less than value x, then the emission stays below value v)	cat. 2
• Composition of raw materials (for example, feedstock oil for carbon black plants)	cat. 1
• Composition of fuel (for example content in S of coal used at fodder dehydration plants; content in S of coke oven gas)	cat. 1
• Mass balance for verifying a mass flow per hour requirement (for example in the case of a chemical nickel plating bath)	cat 1 or 2
• O_2- and T (for example in the case of the Special Regulations for incinerating wood parings)	cat. 2 or 3
Thermal (regenerating) incineration:	
• bed temperature(T_{Bed})!	cat.2
in the case of more than one bed:	
• switchover times ($t_{switchover}$)	cat. 3
Catalytic incineration:	
• the temperature of the catalyst bed together with the condition of the catalyst material (age, degradation over time or through contamination)	cat. 3
Adsorption of reactive hydrocarbons (for example: MEK) Out of safety considerations (i.e. not primarily for the purpose of monitoring emissions!) the following parameters are controlled:	
• Temperature	cat. 3
• CO_2 content	
Absorption of gases in washing column/scrubber	
• Concentration of the liquid being absorbed in the washing agent ($C_{substance}$)	cat. 3
• Concentration of the reagent in the washing agent ($C_{reagent}$) (aa)	cat. 3
Absorption (in the case of a wet dust separator)	
• visual check observation	cat. 3
Cyclone	
in the case of product cyclones:	
• Level monitoring	cat. 3
• Weight monitoring	cat. 3
• Qualitative indicative monitoring of a substance	cat. 3
Dust filter	
• Qualitative indicative monitoring of a substance	cat.2/3
• Visual check/observation of dust emissions (for example, visible dispersion of dust when cleaning envelope-type filters)	cat. 3
NO_x abatement (catalytic reduction of NO_x)	
• Monitoring of NH_3	cat. 2
• Amount of NH_3 being added	cat. 3
• Temperature of catalyst.	cat. 3
• Mass flow	cat. 3

3.7.4 Verification by measurement

Emission requirements stipulated on the basis of the NeR are concentrations averaged over a period of 30 minutes (mg/m_o^3). This can be verified by referring to ERPs, but also by quantitative verification methods such as measurements. Measurements are carried out by a body approved by the competent authorities. This 'body' may be the operator himself.

Measurements performed within the framework of enforcement may not be performed by the operator concerned, unless the operator happens to be the only body qualified or certified to carry out such measurements.

If both the operator and the competent authorities approve, the operator himself may carry out the measurements.

Verification vs. enforcement
Emissions can be monitored through measurements. The results are intended for use by the operator and the competent authorities, in order to assess whether the permit requirements are being met. In addition, the requirements quoted in the permit must be enforced by the competent authorities. Because of the legal consequences, the measurements performed for enforcement purposes must meet more stringent requirements than the measurements for normal verification purposes.
From the body of legal precedents it must be concluded that measurements carried out by the operator himself can in principle not be used for enforcement of the permit requirements.

Selecting methods of taking measurements
In implementing a measurement regime, where possible standardised methods of taking measurements must be selected (please refer to Annex 4.7). It is possible to allow other than standardised methods of taking measurements, provided that it has been demonstrated that the method of taking measurements that will be used yields similar and equally reliable results to the standardised method of taking measurements.
In cases where standardised methods of taking measurements which are tailored to the situation at hand are unavailable, other relevant methods of taking measurements can be utilised.
Determining the required reference values (such as the waste gas parameters mass flow, temperature, moisture content, etc.) must also be done using standardised methods of taking measurements.

Selecting the method of taking measurements (sampling, processing of the sample and method used for analysis) must be geared to the form in which the components are or may be emitted (as an aerosol, as particulates, droplets, fumes/vapours or a gas).
In formulating permit requirements involving (compulsory) verification through individual measurements, the necessary sampling duration for the measurements in question must also be taken into account.
If it concerns variable waste gas flows, the concentrations in the waste gases must be specified as mass flow corrected averages.

Individual measurements
The method of taking measurements must be determined in accordance with the rules given for suitable types of verification in §3.7.2.
An individual measurement consists of a series of independent constituent measurements. A constituent measurement involves a single sample.

Measurements for the purpose of establishing emission levels must be carried out in such a way that the readings are typical for the emissions from the source or processing unit in question, occurring in the case of the operating conditions to which the requirement that must be verified appertains.
Emission requirements are based on periods during which the greatest emissions occur. For this reason the measurements must be targeted at the situations in which the highest emissions may be expected. In most cases the greatest emission will occur when the production unit is working at its maximum capacity. In cases where the permit holder can demonstrate that this maximum capacity is used for less than approx. 10% of the time (for example for less than a month per year) it may be agreed to perform measurements under normal operating conditions. Note, though, that the emission requirement still applies fully even in the case of emissions under maximum capacity conditions.

The sampling duration of every constituent measurement will be 30 minutes, unless:
- a longer sampling duration (period over which the concentrations found are averaged) is required in order to obtain a sufficient quantity of the substance being sampled;
- a longer sampling duration is required in order to obtain a typical sample of the waste gases involved;
- a shorter sampling duration is necessary due to operating cycles that last (charges that are processed for) shorter than half an hour.

Periods in which, due to a lull in processing activity or other abnormal operating conditions, no emission takes place may not be chosen as a time to take samples.

Required number of constituent measurements
The number of independent constituent measurements, and thereby the number of samples that, with a view to the potential variability of the emissions, is necessary in order obtain sufficient insight into the emission within the time that one individual measurement lasts, depends on the emission pattern. In this context it is important whether the emissions are more or less continuous or exhibit considerable variability over time (refer also to §2.4.2). Depending on the emission pattern the following considerations apply:

- *Continuous emission pattern*
  In the case of sources of which it may be expected that mostly operating conditions will occur which remain the same over time, at least three independent constituent measurements must be done under conditions of uninterrupted, continuous operation where the greatest emissions occur or can be expected.
- *Variable emission pattern*
  In the case of sources with on the whole (envisaged) operating conditions that are variable over time, a sufficient number (but at least three) constituent measurements must be performed under operating conditions during which the greatest emissions are likely to occur. The number of constituent measurements must be at least six if for a series of samples, the results of which are averaged for a 30 minute period, values are found such that the highest and lowest value (can conceivably) differ by more than a factor 2, and where in addition to this individual concentrations in excess of 0.75 times the emission requirement are encountered.

Continuous measurements
The method of taking measurements must be determined in accordance with the rules given for suitable types of verification in §3.7.2.
If continuous measurement of a specific substance is not possible on technical grounds inherent in the measurement method, the option of continuous measurements of the substance class or category must be considered.

Where the substances in the waste gas that cause air pollution occur in a more or less fixed ratio, continuous measurement may be limited to one of the substances that is both quantitatively significant and can be detected easily (a so-called indicator substance). In this case the emission levels must be calculated based on the known ratios between the substances involved, or else expressed in terms of levels of the indicator substance. The ratios assumed for the purpose of the calculations must be confirmed at least once every three months through a separate measurement, unless it can be argued on the basis of specific process characteristics that the variability of the ratios is likely to be so limited that a lower frequency is justified.

Determining the reference values
Sources the emissions of which must be monitored continuously must be equipped with monitoring devices which continuously monitor the waste gas parameters (such as temperature, mass flow, humidity, oxygen content, etc.) necessary for evaluating and assessing the continuous measurements, unless these reference values can be determined by other means with at least the same level of confidence.
There may be occasion to decide against continuous measurement of these waste gas parameters if it has been found that the parameters in question are invariable, are not critical for assessment of the emission, can be determined with a sufficient level of confidence by other means or cannot be continuously measured.

Processing of the measurement results
Every half hour the average concentration found in the waste gases during the preceding half hour is determined on a per source basis.
The values averaged over a 30 minute period, if necessary after correction for the reference values concerned, are classified into at least 20 different classes and stored as a frequency distribution.
It must be possible to read out the frequency distributions at any given time and they must be recorded once daily. Periods in which, due to a lull in processing activity or other abnormal operating conditions, no emission takes place may not be included in the calculations. Operators are required to keep the records for two years.

Calibration
The measuring regime (the processes of sampling, processing of the sample and analysis taken together) used for determining the concentrations by mass in the waste gas continuously and for recording these must be calibrated by a body approved by the licensing authority immediately when the installation in question is commissioned and its reliable operation must be confirmed.
This verification must be carried out at least once every five years, as well as following every substantial change to the process.
Calibration is done by a separate measurement of the concentrations found in the waste gases or sometimes by comparing the readings with those obtained using a different method for taking continuous measurements (cf. ISO/CD 10849.2).

In addition to the calibration of the entire procedure once every five years, the monitoring equipment must be checked at least once a year for efficient operation. The operator must continuously ensure the proper functioning of the monitoring equipment installed, for instance, by carrying out regular maintenance and by regularly adjusting the monitoring equipment using (calibration) gases of known composition.

Measuring point
The permit must specify where and how measuring points are to be installed. In specifying requirements for measuring points the applicable standardised methods of taking measurements must be taken into consideration.

Inaccuracy of the readings
The permitted inaccuracy of the method of taking measurements is the 95% confidence interval to both sides of the nominal value for the measurement in question.
The inaccuracy must be calculated on the basis of the standardised measurement procedure for the measurement concerned. The measuring inaccuracy is caused by compound errors during sampling, processing of the sample and analysis.

If it is not possible to perform the measurements according to the standard or directive, or where the instructions for performing the measurement in accordance with the standard cannot be adhered to due to the fact that the values fall outside the intended scope of the method, an estimate which is as accurate as possible must be made on a per situation basis, in consultation with the licensing authority, of the inaccuracy of the measurement involved.
In the case of measurements within the framework of enforcement this estimate must be made by an independent expert. A discussion of the inaccuracy of the measurements must be part of all measurement reports.

3.7.5 Assessment of the results of the measurements in reference to the emission requirement

In the case of individual measurements, the result of all individual measurements must yield lower values than those specified in the permit.

In the case of continuous measurements, individual results of the measurements may incidentally yield values in excess of those specified in the permit. For every period of 4 consecutive quarters the rule applies that:
- every day the concentrations averaged over that day must be lower than the emission requirement stated in the permit;
- 97% of the concentrations averaged over a period of 30 minutes may not exceed the emission requirement by more than 20%; and
- none of the values averaged over a 30 minute period may exceed the emission requirement stated in the permit by a factor 2 or more.

Measurements and constituent measurements
For the purpose of verifying individual measurements, the results of the constituent measurements must be averaged. The average obtained must be taken as the result of the individual measurement. This is the value which will be validated against the emission requirement.

In verifying readings against the emission requirements the inaccuracy of the method of taking measurements must be taken into account. This is done by subtracting the inaccuracy of the method of taking measurements from the readings concerned.
In this way the inaccuracy of the measurements is interpreted in such a way that the operator gets the benefit of the doubt.

The emission requirement is considered to have been met if the result of the measurement, less the inaccuracy of the method of taking measurements, does not exceed the emission requirement.

Reports
The period over which reports must be submitted and the details to be included in the reports will be agreed between the licensing authority and the operator when he applies for a permit; the agreement will be made formal by including the details in the permit.