REVISION OF DANISH GUIDELINES FOR AIR EMISSION CONTROL

Ole Schleicher, dk-TEKNIK ENVIRONMENT & ENERGY
Erik Thomsen, Danish Environmental Protection Agency
Lars K. Gram, dk-TEKNIK ENVIRONMENT & ENERGY

ABSTRACT

In 2001 the Danish EPA will publish the first revision of the guidelines for controlling air emissions from stationary sources. In a simple and structured way, the guidelines sets up all necessary terms for controlling the emission of air pollution. The authorities should always evaluate if it is possible to reduce the pollution by cleaner technology based on BAT principles. Secondly the degree of demands on emission control, stack height and control program can be fixed, based on a series of limits for every single compound.
The keys in the guideline is the use of mass flow, mass flow limits, ELV (Emission Limit Values) and C-values (Contribution values for emission concentrations). If the mass flow for the single emitted compound exceeds the mass flow limit for that group of compounds, the emission shall be reduced beyond the ELV (Emission Limit Values). From a simple scheme the control program can be fixed to be either Performance monitoring, Spot-test measurements and/or AMS (Automatic Measuring Systems). The guideline specify in details how to perform the different emission monitoring and control systems, defining the regulating parameter, the monitoring period, the average time, and setting up clear rules on how to decide whether the ELV is fulfilled or not. The necessary stack height is calculated using the OML model (Operational Meteorological Air Quality model), to assure that the C-value can be fulfilled.

INTRODUCTION

In Denmark the local authority performs the environmental approval to regulate the emission from stationary sources. The local authority is either the municipalities or the county council, depending of the type and size of the production. The Danish Environmental Protection Agency (EPA) is converting the environmental legislation into rules and guidelines, which is the operational tool for the local authorities in preparing environmental approvals. To facilitate and homogenize the environmental work, a new type of guidance for controlling air emissions from stationary sources was published in 1990. In a simple and structured way, this guideline sets up all necessary terms for controlling the emission of air pollution from stationary sources.

Caused by changed legislation for environmental approvals, and a wish to simplify and facilitate the environmental work performed by the local authorities, the guideline is under revision. It expects to be published within this year.

1 THE GUIDELINE

The guideline contains a collection of descriptions on how air emissions from stationary sources can, or has to be, regulated. Municipal and hazardous waste incinerators and new large combustion installations, is not regulated by this guideline, due to specific EU directives covering that type of plants. How to use the guideline according to the environmental legislation is briefly described in this paper.

The Danish Environmental Protection Act is basically founded on the principle, that any pollution should be prevented or minimized as much as possible. The total pollution, air pollution, wastewater and noise, from any plant should be evaluated together with the waste created at the enterprise, and the necessity to save nature resources and energy. Moving the pollution from the air to the water or soil – or opposite, should not be used to solve any environmental problem.

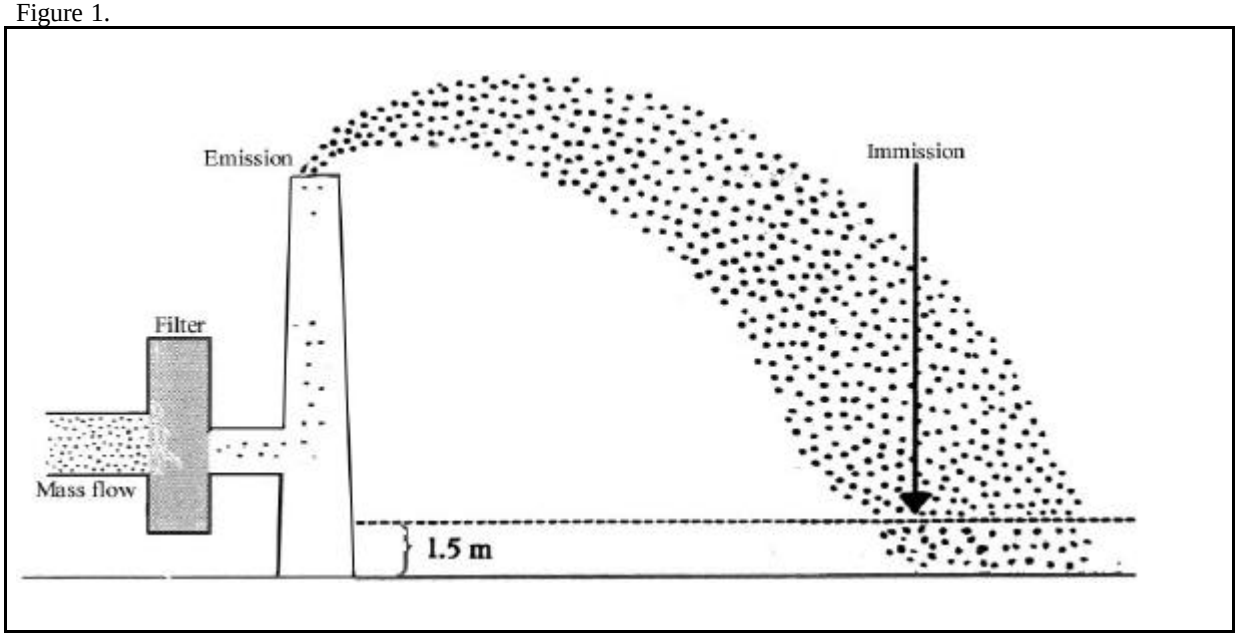
Based on that principle, the Environmental Protection Acts demands, that any enterprise should use the best available technology (BAT), to reduce the pollution to the lowest possible level.

That's means, that the local authority first of all must evaluate the potential for reducing the pollution by BAT technology. When evaluating what is BAT technology, preventing of pollution to arise should have the highest priority. Secondly the inevitable pollution should be limited by BAT technology.

The essence of the guideline is the use of:

- Mass flow
- Mass flow limit values
- ELV (Emission Level values)
- AMS control limit values
- C-values (Contribution values)
- OML model (Operational Meteorological Air Quality model)

Figure 1.



2 DEFINITIONS AND EXPLANATIONS

1. **Mass flow** is the amount of substance per unit of time that would constitute a company's total emission, if no emission limitation were implemented. Mass flow is therefore determined before the cleaning equipment, but after the processing plant. An average mass flow is reached on the basis of a working shift (7 hours).

2. **Mass flow limit** is a limit used to decide, whether the ELV should be fulfilled or not. If the mass flow is exceeding the mass flow limit, it should lead into implementation of emission limitation so that the ELV can be fulfilled. The mass flow limit is not a limit for the allowable mass flow, but only a limit for deciding whether a company has to fulfil the ELV or not.

3. **ELV (Emission Level Value)** is the limit value for the concentration of any given substances in the discharged air (the emission concentration) that must not be exceeded if the mass flow limit value is exceeded. The limit is applicable for each chimney/outlet, and is given in mg/norm. m^3 or, in other words, as the total emission of pollutants in mg during a set of time where a plant is operational, divided by the number of cubic meters of emitted gas converted to the reference condition (0°C, 101,3 kPa, dry gas) for the same period.
When dealing with combustion process emissions, the reference point is dry flue-gas 10% O_2 converted to normal conditions (0°C, 101,3 kPa).
A company must not be allowed to meet emission level requirements by "thinning", using unproportional large volume of air to dilute a discharge.

4. **AMS-limit** is a limit used to decide, when to demand AMS (Automatic Measuring System) to control the emission. The mass flow for each chimney/outlet is compared to the AMS limit value. If the AMS limit value is exceeded, AMS control must be installed to control the emission. If AMS is not possible, spot-test measurements should be used instead.

5. **C-value** is the maximum contribution to the immission value of any pollutant, which is allowed from a company. Fulfilling of the C-value is calculated with the computer based OML model. C-values in mg/m³ is set by the Danish EPA, based on a set of principal procedures for defining limit values for chemical compounds.
   The stipulated C-values are applicable irrespective of background concentrations, and they must not be mixed up with air quality standards. The EPA is continually setting C-values for new compounds and revising existing C-values. The list expects to be revised every second or third year. The C-values are an expression of the Agency's knowledge of the substances at the time of publication.

6. **The OML model** is based on the Gaussian smoke plume model. The model is calculating the concentration of one or several substances in a series of defined receptor points in the surroundings, on a one-hour basis in a whole year.
   To evaluate whether the C-value is fulfilled or not, a calculation with the OML model should be performed, using the ELV and the maximum airflow limit. In certain occasion with no set ELV, the calculation shall be based upon the maximum hourly emission that normally occurs. In these calculations the C-value is compared to the calculated average one-hour value in the surroundings, that must not be exceeded more than 1% of the period of time i.e. no more than seven hours of a month's total number of hours (99%-fractil).
   For smaller emissions, where the dispersion factor is less than 250 m³/s the emission need only to be led to an upward pointing outlet at least one meter above the roof. The dispersion factor is defined as the source strength in mg/s of the substance in question, divided by the C-value in mg/m³ for the same substance.
   The necessary chimney height can be fixed, by performing calculations with different heights, resulting in finding the height, where the maximal 99%-fractil is lower or equal to the C-value.
   The OML model uses the following information in the calculations: source strength, quantity of air or flue gas, temperature, chimney diameter and height, geographical conditions, the source's immediate surroundings, and meteorological data from a given period of time. On the basis of these data, the model can calculate a similar period of time in mean hourly values for concentrations at a series of chosen points (receptor points) in the surroundings.
   The resulting concentration figures are then adjusted so that each month of the year indicates 99%-fractile of the mean hourly values at each receptor points. The maximal 99%-fractile has to be lower or equal to the C-value.

2 GROUPING SUBSTANCES AND THEIR LIMIT VALUES

The guideline divides pollutants into two main groups.

Substances belonging to **Main Group 1** are chemicals that are known to be especially injurious to health or especially dangerous to the environment.
For dust emissions, cleaning should normally first occur in a filtering process with a relatively low filter surface load, followed by an absolute filter with a retention degree of not less than 99,97%. This cleaning technique results in emission concentrations being brought well below 0,01 mg/norm. m³.
Cleaning for emission of combustible substances should normally be carried out by thermal combustion or a similarly effective method, if necessary combined with absorption or adsorption methods.
If neither absolute filters nor incineration are applicable, the recommended mass flow limits in table 1 should be applied.

The **Main Group 2** contains all those substances hazardous to health and to the environment that are not classified as Main Group 1 substances. Main group 2 substances are divided into six groups, and some of these groups are further divided in up to four classes.
The division into classes is based partly on knowledge of the substances' health effect and the harmful effect on the environment, and partly on the technical and economic scope for emission reduction.

Table 1. Grouping substances and their limit values.

Main Group	Substance group	Class	Mass flow limit g/h	Emission limit mg/m³	C-value mg/m³	AMS control limit kg/h
1. Very dangerous	Only one	I	0.5	0.25	0.001	2
		II	25	2.5	> 0.001	
2. Dangerous	Dangerous types of inorganic dust	I	1	0,1	*0.0001*	2 (Selected substances)
		II	5	1	*> 0.0001 & 0.001*	
		III	25	5	*> 0.001*	200 (all other)
	NO_x		5,000	400	0.125	200
	SO_2		5,000	400	0.25	200
	Vapours or gaseous inorganic substances	I	10	1,0	*0.001*	
		II	50	5	*> 0.001 & 0.01*	
		III	500	100	*> 0.01 & 0.1*	
		IV	5,000	500	*> 0.1*	
	Organic substances	I	100	5	0.01	25 (Measured as TOC)
		II	2,000	100	> 0.01 & 0.2	
		III	6,250	300	> 0.2	
	Other forms of dust		500	300	0.08	200
			> 500 & 5,000	50		
			> 5,000	10		

Deviations from the shown relationship between mass flow limits, ELV and C-values can occur. The values given in the newest C-value list should always be followed.
There are special rules and limits for special substances, ex. Dioxines, asbestos, formaldehyde, PAH and wet dust.
Special ELV is valid for small combustion plants up to 50 MW, depending on size and fuel.
Other forms of dust are valid for dust types not referred to in other sections of the guidelines.
The C-values should always be fulfilled, disregarding the emitted amount and the location of the enterprise.

3 TERMS FOR EMISSION CONTROL

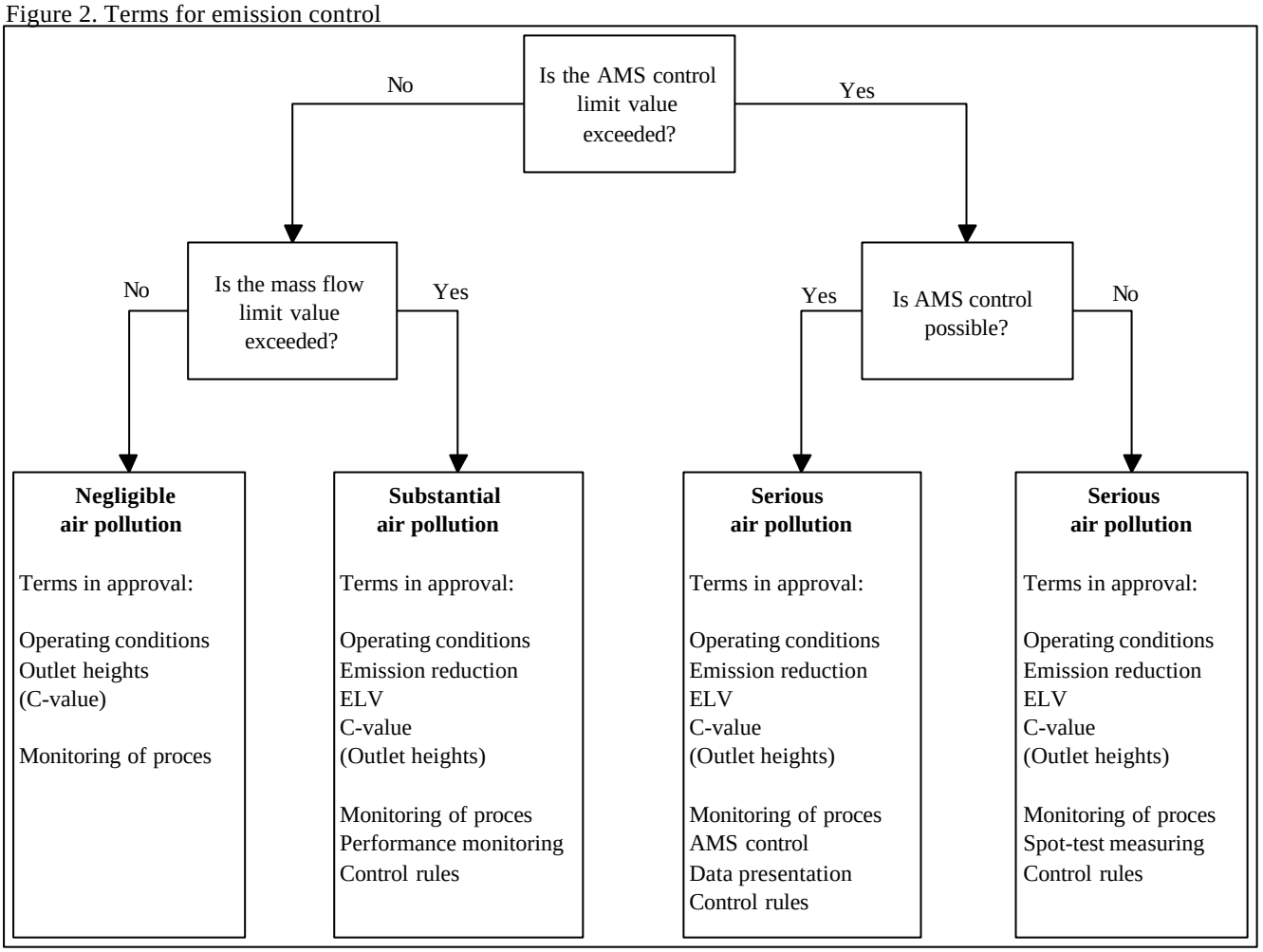
By calculating or measuring the mass flow before cleaning equipment, and the emission concentration in all discharge points for a given substance from an enterprise, together with the C-value and the limits from the table, all the types and necessary terms for regulating the air pollution can be set by using figure 1.

The different type of terms depends of the type and magnitude of the emissions. Enterprises can be placed in one of four categories:

1. Enterprises with **negligible air pollution** are enterprises where the mass flow is below the mass flow limit for the substance or substances in question. These are not normally required to carry out emission measurements, and monitoring can be limited to effective operational monitoring.

2. Enterprises with **substantial air pollution** are enterprises where the mass flow is above the mass flow limit for the substances or substances in question, but below the AMS control limits.
   In approving such enterprises, the company should be required to carry out daily monitoring – several times a day if necessary – to determine whether the operating regulations which are important for the limitation of air pollution are observed and whether important polluting-limiting facilities operate correctly.
   Similarly, such enterprises should be required to carry out emission measurements, in the form of performance monitoring, normally performed as 3 one-hour emission samples once a year.

Figure 2. Terms for emission control



3. Enterprises with **serious air pollution** are enterprises where the mass flow is above both the mass flow limit and the AMS control limit. This type of enterprises must have AMS to control the emission. For AMS control, automatic measuring and recording instruments are used continuously when the polluting process is in operation.

4. Enterprises with **serious air pollution** where AMS is not possible, emissions control should be performed as spot test. Spot-test monitoring is normally performed as 2 one-hour emission samples taken at a randomly chosen time, six times a year.

4 EMISSION REQUIREMENTS

The terms laid down in environmental approvals must in general be unambiguous, and they should be controllable with a reasonable amount of resources. Terms should be followed up with control to verify that the limits are fulfilled. The degree of control should be adapted to the potential impact on the environment.
Terms for emission should as minimum fulfil the following:
1. Relevant limit values for relevant pollution parameter are set.
2. Clear, unambiguous administrative limit are set..
3. That limit can be monitored with reasonable and manageable resource consumption.

Controlling terms imply control rules, which specify conditions for fulfilment of terms.

Terms for emission should give limits for air volume and the concentration for substances emitted to the air as one-hour average. The limit is set as described earlier, plus from evaluating what a technically well functioning and economically attainable cleaning devise of the actual type can fulfil. A suitable addition should be given to compensate for wear and tear and other normal operating conditions.

An emission term shall together with terms for maximum airflow and stack height assure that the C-value can be met.

The emission requirements must include the following factors:

- The regulating parameter (normally a substance or group of substances)
- The required value for the regulating parameter
- The monitoring period
- Average time
- Type of emission monitoring control system
- Number of samples
- Operating conditions during sampling (only for performance monitoring).
- The regulating feature
- How to randomly chose the time for sampling (only for spot measuring).

Terms for stack height and/or C-value has to assure, that the C-value can be fulfilled. Stack height can be calculated with the OML model.

Enterprises with only a few stacks should normally have terms for the height of the stacks, assuring that the C-value will be fulfilled as long as the ELV and maximum airflow are not exceeded.

For enterprises with many stacks or discharges, it can be reasonable to give terms for fulfilling the C-values. It gives the company the possibility to choose the most suitable selection of stack heights. The ELV should still be valid for each discharge.

Performance monitoring is used in enterprises with substantial air pollution, where the mass flow limit is exceeded, but AMS control limit is not exceeded. Performance monitoring should be performed with at least 3 one-hour samples once a year.

AMS-control is used in enterprises with serious pollution, where both the mass flow limit and the AMS control limit is exceeded. AMS control is normally based on continuously measuring and registration instruments. With AMS control it should be assured that:

- The quality of the instrument is adequately documented (sensitivity, zero point operation, measuring uncertainty, time constant) or that the instruments have been approved by the supervising authority before application.
- The instrument is correctly mounted at the measuring point.
- The instrument is serviced and maintained regularly by qualified personnel in accordance with the instructions of the manufacturer.
- The instrument is regularly calibrated, by the company itself or by an authorized laboratory.
- The measurement data is stored on a suitable medium and is properly processed for use by the supervising authority.
- The measurement data in a suitable form is accessible to the operating personnel at their normal place at work.

Spot-test monitoring is used in enterprises with serious pollution, where both the mass flow limit and the AMS control limit are exceeded, but AMS control is not possible. Spot-test monitoring is normally performed as 2 one-hour emission samples taken at a randomly chosen time, six times a year. With spot-test monitoring it should be assured that:

- The number of spot-test measurements in each monitoring period is defined.
- The procedure for selecting measuring times is defined.
- The method for sampling and analysis is defined.
- It has been stated whether sampling and analysis may/must be carried out by the company itself or by an authorized laboratory outside the company.

The **monitoring period** is the period during which the emission is to be assessed. The monitoring period is normally set to:

- 3 hours for performance monitoring
- 1 month for AMS-control.
- 1 year for spot-test measuring.

The monitoring period must be long enough for an assessment of a representative part of the emission – in other words, random short-term high or low values must not have a substantial influence on the assessment. The monitoring period must also be short enough to allow assessment of whether the requirement has been fulfilled within a reasonable period.

The **average time** is the period during which the emission is considered as a whole. The establishment of this period is essential if the requirement is to be unambiguous.

- By performing monitoring the average time is normally set to one-hour ore more, depending on the substance to be measured.
- By AMS control, the lowest possible average time depends on the instrument, and is normally less than a minute. In praxis it is normally set to one hour, which gives a good time resolution and the volume of data will not be to overwhelming for suitable statistical processing.
- By spot-test measuring the average time is normally set to one hour, depending on the substance to be measured.

It is recommended always to use the average time of one hour. If deviation from one hour is used, it shall be reasoned with special conditions in the process or the measuring system.

Table 2.

	Monitoring period	Average time	Number of samples
Performance monitoring	3 hours	1 hour	At least 3 /year
AMS control	1 month	1 hour	720 /month
Spot-test measuring	1 year	1 hour	2 x 6 /year

Operating conditions during measuring.
It is very important to have the operating conditions during performance monitoring fixed in the approval. It should be stated at which production type and level the monitoring should be performed. If there is large variation in the emission, it should be assured, that the monitoring is performed when the emission is maximum.

Measuring method.
In the control terms should be stated which measuring method should be used. If measuring by an authorized laboratory is demanded, it should be assured that such a laboratory is available.

5 MONITORING RULES

Performance monitoring
The ELV is considered to be fulfilled, when each measurement is less than, or equal to the ELV.

AMS control
The ELV is considered to be fulfilled, when the arithmetical average of all measurements during the monitoring period (normally one calendar month) is less or equal to the ELV.
If a single one-hour measurement exceeds the ELV by a factor of tree, the supervising authority must be notified. At the same time the company must state the reason why the value has been exceeded and specify the measures that have been or will be implemented to avoid future violations of the limits. In addition, monitoring of the pollution-limiting equipment must be intensified in ways to be agreed in more details with the supervising authority.

Spot-test measurements
Spot-test measurements will only provide very limited documentations of real emission.
The EPA has therefore drawn up a calculation method for considering when the ELV may be fulfilled. Spot-test measurements are normally 2 samples taken on each of 6 days during the monitoring period of one year. The result of one spot-test measurement is the average of the two samples.

Control rules

If we designate

- K as the limit value,
- M_1 as the monitoring limit value for the measured emission,
- M_2 as the monitoring limit for the number of spot-tests,
- M as the mean value of the measurements,
- N as the number of spot tests,

we can state the following two rules for whether the limit value has been exceeded, and whether the number of spot-test is high enough.

1. The limit value rule:
The limit value (K) are fulfilled, if the measured value (M) is less than the monitoring limit value for the measured emission, calculated as follows:

$$\mathbf{M_1 = K \times 37^q}$$

where q (the geometrical dispersion) is calculated as follows:

$$q = \sqrt{\frac{SUM \log^2 M_i - \frac{1}{N}(SUM \log M_i)^2}{N(N-1)}}$$

M_i stands for the individual measurements.
log is the logarithm to base 10.

2. The spot-test rule:
The number of spot-test is sufficiently high if M is less than the monitoring limit value for the number of spot-tests, calculated as follows:

$$\mathbf{M_2 = 2 \times K \times 19^{-q}}$$

If this is not the case, the recipient requirement has not been fulfilled, and the number of spot-tests for the next period must be increased by three.
It must be emphasized that the emission limit value is only fulfilled if both rules are fulfilled.

If the limit value is not fulfilled, although the spot-test rule is fulfilled, the emission is considered to exceed the limit value.

If neither the limit value nor the spot-test rule is fulfilled, the number of spot-test in the next monitoring period should be increased, and measures should be implemented to reduce the emission of the parameter in question.

If the limit value is fulfilled, but the spot-test rule is not fulfilled, this should entail, besides an increase in the number of spot-test in the next monitoring period, increased supervision of the pollution-limiting equipment.

If it is evident from at least two sets of measurements that the measured emission are below 50% of the limit values, the number of measurements per monitoring period may be reduced from six to four. Repeating this criterion, the number of measurements per monitoring period may be reduced further from 4 to 2, and finally to one yearly performance monitoring. Exceeding the limit value the control must return to the originally spot-test 6 days a year.

6 CONCLUSION

With the new revision of the Industrial Air Pollution Control Guideline, it will be easier to evaluate the pollution from an enterprise, and to set up the necessary terms for controlling the air pollution, and demanding it to be reduced to the lowest BAT level. With the help of a few samples or calculations of the mass flow and emission concentrations from an enterprise, the enterprise can be classified in one of 4 groups, from the significance of the air pollution. For each group, the minimum necessary terms to be set up for controlling the air pollution, is set.

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BIOGRAPHICAL DETAILS OF THE AUTHOR

Ole Schleicher, Project manager, M.Sc. Chem. Eng.
dk-TEKNIK ENERGY & ENVIRONMENT
Gladsaxe Møllevej 15
DK-2860 Søborg
Denmark.
Tel: +45 39 555 999
Fax: +45 39 696 002
E-mail: osc@dk-teknik.dk
Web: www.dk-teknik.com

After graduating from the Engineering Academy of Denmark in 1982 with a Master of Science degree in chemistry, Schleicher spend a couple of years working out MSDS’s. During 14 years from 1985 Schleicher was responsible for all the external environmental work at the largest wood industry in Denmark. In 1999 Schleicher joined dk-TEKNIK, where one of his activities is planning and performance of emission measurement programmes and evaluation of results in relation with guidelines for air pollution regulation. Schleicher has a big experience with the connection between environmental legislation, measurement methods, methods limitations and measurement standards.