MONITORING INDUSTRIAL EMISSIONS: A SUCCESSFUL INSTRUMENT FOR ENVIRONMENTAL ENFORCEMENT

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SUMMARY

Starting with an outline of the legal prescriptions for the monitoring of industrial emissions in Germany, details of the monitoring practice and the state of emission measurement technology are given. Notwithstanding the fact that the set of emission standards and the monitoring procedures can be considered to be rounded off in a general perspective, there are still some deficits in detail and in the enforcement. Possible solutions to some of these problems are presented.

1 INTRODUCTION

The high industrial and residential density in the Rhine-Ruhr region particularly at the beginning of the 1960s resulted in a degree of regional air pollution which was directly perceivable for every citizen. The situation then, with average annual levels of sulphur dioxide and dust pollution which were practically a magnitude higher than today, was approximately comparable with the poor quality of air in the south of the former German Democratic Republic (GDR) just before reunification. Figure 1 and Figure 1a show as examples the development of SO_2, Suspended Particulate, and lead levels in ambient air from 1964 to today.

This success in air conservation was influenced to a considerable extent by the development of a comprehensive set of standards for emission protection, consisting among others of the Federal Emission Control Act (BImSchG), various ordinances belonging to the Federal Emission Control Act, together with “Technical Instructions on Air Quality Control” as most important elements for controlling

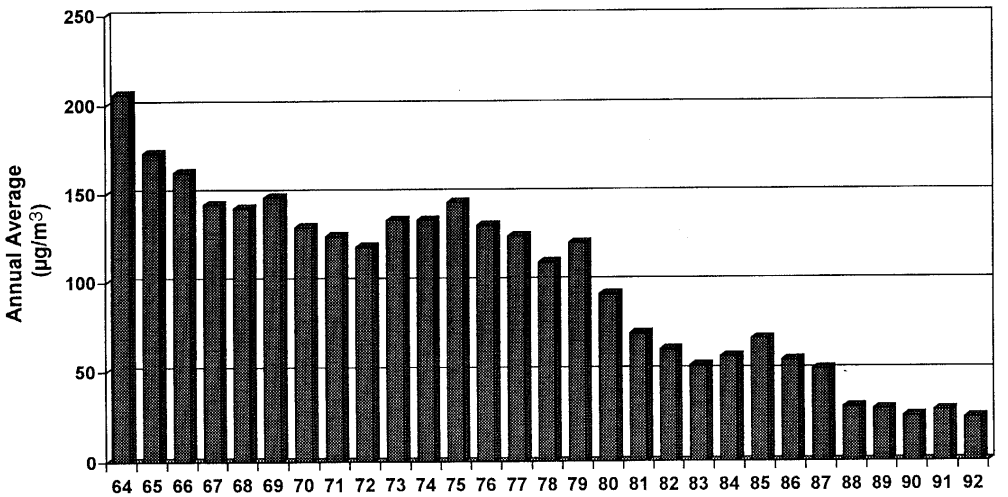


Figure 1. Trend of sulfur dioxide concentration in Rhine-Ruhr area.

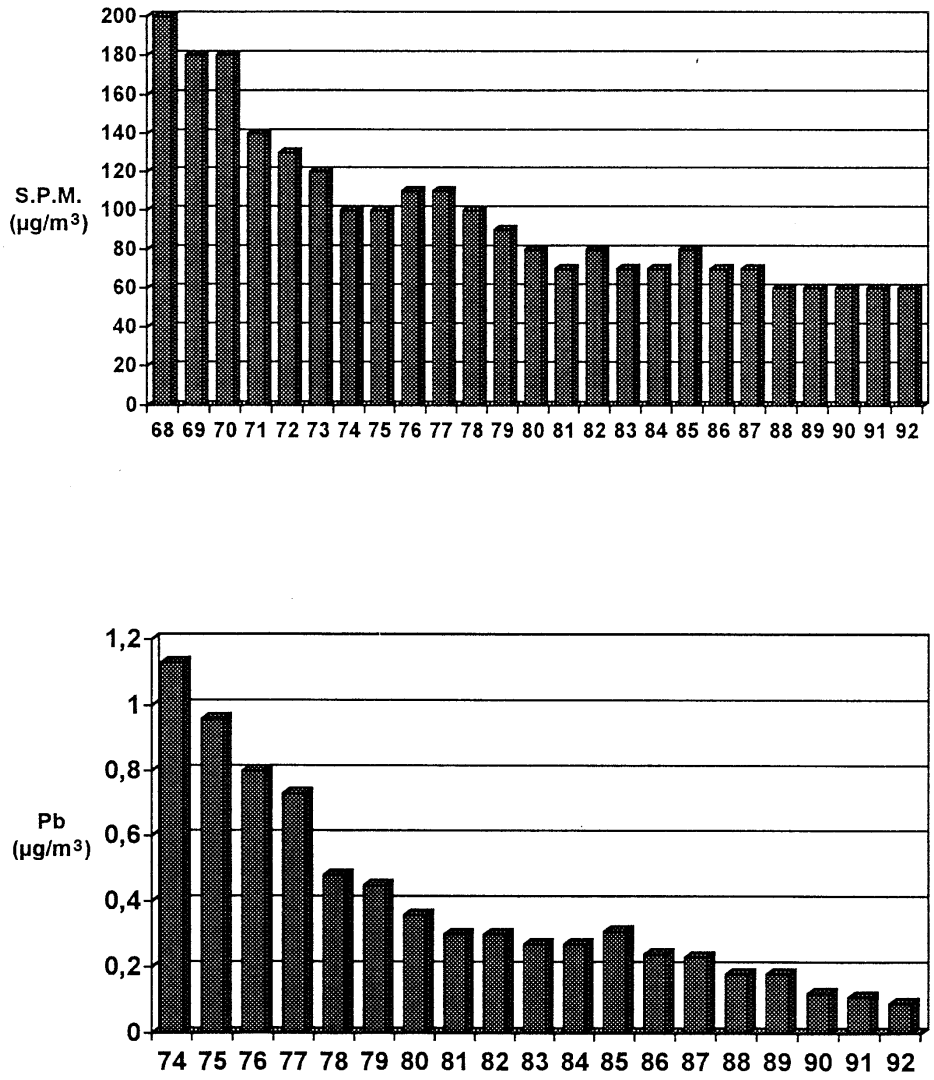


Figure 1a. Trends of suspended particulates (S.P.M.) and lead concentration in ambient air in Rhine-Ruhr area.

air conservation. Today it can be said that this set of standards for classical emission protection can be considered to be rounded off and complete.

One basic element of the regulations on air quality control consists of the emission limit values for industrial plants, based on the principle of prevention, as contained in the "Technical Instructions on Air Quality Control" (re-enactment dated 1986), in the 13th ordinance for large-scale furnaces (1983), and in the 17th ordinance for refuse incineration plants (1990). The emission limit levels are intended not only to safeguard from harmful effects on the environment in the catchment area of the industrial plant but also, according to the principle of prevention, to reduce the emission of pollutants into the environment as far as possible, or at least as far as current state-of-the-art technology will allow. For example, the "Technical Instructions on Air Quality Control" contains emission limit levels

for approximately 35 inorganic, 150 organic, and 20 carcinogenic air pollutants; these levels have then substantiated state-of-the-art technology.

The emission control regulations have played a pioneering role on an international scale, particularly when it comes to stipulating emission limits for preventative reasons, also for older plants which need to be gradually adjusted to reach the requirements for a new plant. For example, the Clean Air Act in the United States did not complete this step until the beginning of this decade.

But what is the situation in practice, when it comes to enforcing or, more precisely, monitoring whether the emission limits are also observed under practical conditions? Limit values on paper alone without any monitoring controls are of precious little use, as we have learned from the ecological disaster in certain regions of the former Eastern bloc. Certain air quality criteria were considerably stricter than their Western counterparts; however, there were no financial means available to enforce or monitor these levels, or such activities were prevented for reasons of economic policy.

The best means of controlling emission limit levels is by monitoring emission concentrations at the source or monitoring waste gas mass flows. This can be carried out most effectively by continuous or at least consecutive (eg, daily) measurements, so that the behaviour in time of discontinuous production processes (eg, batch operating modes) can also be taken into consideration.

Therefore, I illustrate here the requirements made by legislation and regulations of technical monitoring methods, together with current possibilities for technical monitoring. Subsequently I turn to the question of deficits—Is the measurement of industrial emissions an effective instrument of environmental enforcement? To conclude, I draw attention to certain progressive developments.

2 LEGISLATIVE REGULATIONS

The requirements contained in the Administrative Regulation on Air Conservation for technical monitoring of emission limits are indicated in Diagram 1.

The regulation requirements are based here both on the principle of relativity—more extensive requirements for larger mass flows and/or greater toxicity of the emitted substance(s)—and, by means of necessity, on the technical possibilities.

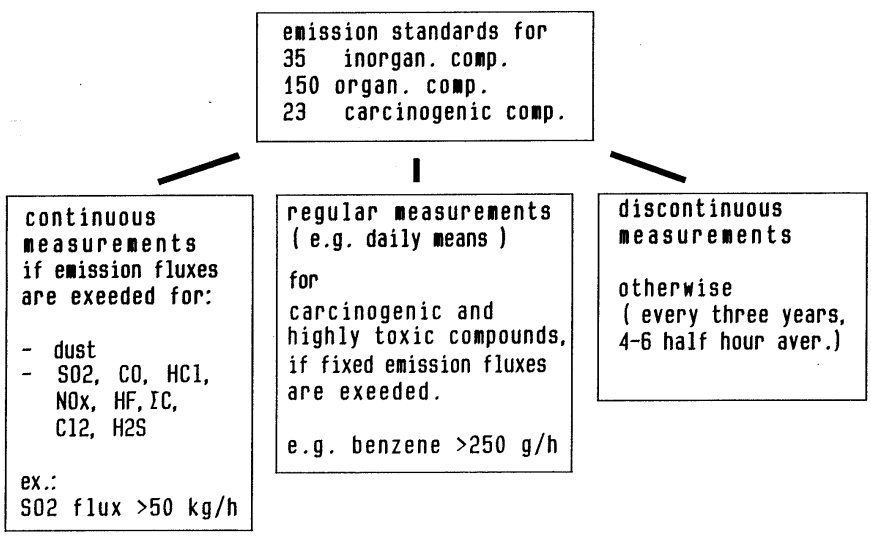


Diagram 1. Monitoring of emissions (TA Luft).

Continuous measurements are prescribed when levels are exceeded in certain mass flows for SO_2, $N0_x$, CO, chlorine and fluorine compounds, H_2S, and for the sum of organic gases and vapours. Consecutive measurements (eg, daily methods) are required for carcinogenic and particularly toxic substances (eg, benzene) and certain heavy metal compounds (eg, cadmium and arsenic) in certain emission mass flows. Continuous measurements would actually be necessary here too, but these are not technically possible at the moment, as it has not been possible to automate the sampling and analyzing procedures; so, the stages of sampling, sample preparation (eg, digestion to get heavy metals into solution, desorption and clean-up of organic compounds), and analytic determination have to be performed manually.

In all other cases, discontinuous measurements are prescribed when the plant starts operations and on a recurring basis every 3 years (as a rule 4 to 6 individual measurements). The 17th Federal Emission Control Ordinance contains supplementary regulations for measuring 13 heavy metals and non-metallic elements and for random sample measurements of dioxins and furans (on at least 3 days at yearly intervals).

The measured results are referred to standard conditions (O_2 level, moisture, pressure, temperature) in order to ensure that the emission limit levels are not met by simply diluting the waste gases with fresh air while the emission mass flows remain constant.

The legislation also contains a series of requirements concerning quality assurance of the measured data. For example, wherever possible, reference is made to standardized measuring procedures which as a rule are specified in VDI. A further element of quality assurance for the measuring procedures is the stipulation that the measuring instruments used for continuous emission monitoring must have passed a special suitability test according to prescribed test plans at certain test institutes (numbering 6 at present) and are acknowledged to be suitable by the Federal Ministry of the Environment.

These regulations are necessary to ensure that the plant operators are treated equally when it comes to technical monitoring.

And finally, certain measuring tasks required as part of the Federal Emission Control Act may only be carried out by measuring institutes that have been tested and certified for these measuring tasks by the individual federal states. The reason for this is that when it comes to measurements the influence of market forces tends generally to lower prices rather than improve the quality of the measurements, as the quality cannot be assessed on the basis of the result but only by an expert while carrying out the measurements. However, more complicated quality assurance, eg, meticulous calibration or measuring procedures, makes the measurements more expensive without resulting in immediate advantages for the plant operator.

Quality assurance also includes calibration of continuously operating measuring instruments on the plant operator's premises by certified measuring institutes, together with annual function controls which are required in addition to the function controls to be performed by the plant operator.

3 STATE OF EMISSION MEASUREMENT TECHNOLOGY: CURRENT DEFICITS

What is the current state of emission measurement technology? Can the very detailed, far-reaching legislative requirements be fulfilled?

Table 1 summarizes the current measuring possibilities for continuous emission monitoring together with the measuring principles. In addition, the table contains the number of continuous emission measuring instruments installed in North Rhine Westfalia in order to give an impression of the scope involved in continuous emission monitoring for just one federal state.

A rough comparison of Table 1 with the statutory requirements could lead to the initial presumption that the requirements for continuous measurements are completely covered by state-of-the-art measuring technology. However, this superficial impression only arises when further important boundary conditions, such as the detection limits of the measuring procedures and their suitability for certain plant types, are not taken into consideration. For certain components and uses,

Table 1. Measuring Procedures for Continuous Emission Monitoring of Air Pollutants

Component	Measuring Principle	No. of Suitability Tested Instruments Types	No. of Measuring Instruments Used in North Rhine Westfalia
Dust (smoke density)	Waste gas clouding	3	908
Dust (concentration)	Radiation absorption (photometer) scattered light	7	622
Soot number	Scattered light	2	
SO_2	IR, UV absorption, electrochemical	15	376
NO_x	Chemiluminiscence, IR, UV absorption	14	376
CO	IR absorption	12	456
Hydrocarbons	Flame ionization	8	70
Gaseous chlorine compounds (HCl)	Electrochemical IR absorption	5	60
Gaseous fluorine compounds	Electrochemical	1	48
Other			253

the stricter emission limit values in the "Technical Instructions on Air Quality Control" and the 17th Federal Emission Control Ordinance have resulted in problems with insufficient detection limits, particularly under the frequently adverse measuring conditions in industrial plants. In addition, as a rule emission measurements produce a complex waste gas matrix with high levels of water vapour and some chemically aggressive interfering substances frequently present in higher concentrations than the components being measured. This waste gas matrix and the interfering influences differ from plant to plant, particularly where different kinds of industrial plants are concerned. An instrument which has been certified as suitable for gas furnace plants cannot be used without further ado for refuse incineration plant.

Table 2 takes the mentioned boundary conditions into consideration and provides an overview of the currently existing deficits in measuring technology for continuous emission monitoring according to the requirements of the "Technical Instructions on Air Quality Control".

There are also considerable technical problems in discontinuous measurements and in consecutive measurements for carcinogenic and particularly toxic substances. The reason for these problems lies mainly in the scope of the approximately 120 single organic components in Appendix E of the "Technical Instructions on Air Quality Control". Figure 2 refers to the single organic components according to 3.1.7 and the 15 gaseous carcinogenic pollutants according to 2.3 of the "Technical Instructions on Air Quality Control" and indicates the relations between components for which tested measuring procedures are available in the form of VDI directives and those pollutants which currently cannot be measured. Accordingly, there are only tested measuring procedures for less than 15% of the substances named in Appendix E and for approximately one third of the carcinogenic gaseous substances.

4 POSSIBLE IMPROVEMENTS: PERSPECTIVES

To summarize, it can be said that both legislation in the field of air conservation and measuring techniques for controlling emissions have reached an advanced state which has played a decisive

Table 2. Measuring Deficits and Problems in Continuous Monitoring of Emission Limit Values According to the Technical Instructions on Air Quality Control (TAL)

TAL Number	Plant Type	Component/Problem
3.3.1.4.1	Combustion engines	Dust (particularly soot)
3.3.1.5.1	Gas turbines	Dust (soot number)
3.3.2.4.1	Plants for baking bauxite or chromite bricks	(Fluorine compounds: measuring range)
3.3.2.8.1	Production of glass, fibreglass	SO_2, problems with H_2SO_4, condensing particles when preparing gas for measurements
3.3.2.10.1	Firing ceramic products	SO_2, problems with H_2SO_4, condensing particles when preparing gas for measurements
3.3.2.11.1	Melting mineral substances	SO_2, problems with H_2SO_4, condensing particles when preparing gas for measurements
3.3.4.1	Aluminium smelting plants	Chlorine
3.3.4.1d.1	Chlorine production	Chlorine
3.3.3.9.1	Galvanizing plants	HCl, separating particles containing chlorine from HCl gas
3.3.21.1	Production of lead batteries	Sulfuric acid
3.3.4.1a.2	Production of SO_2, SO_3, H_2SO_4	SO_3
3.3.4.1b.1	Production of Al	HF, measuring range
3.3.6.3.1	Production of wood fibre boards, wood chipboards	Dust (resin, ex-risk)
3.3.7.24.1	Refining sugar	Dust (waste gas oversaturated with water)
3.3.8.3.1	Recovery from solid substances by burning (see also 17th Federal Emission Protection Ordinance)	HF, measuring range HCL, measuring range

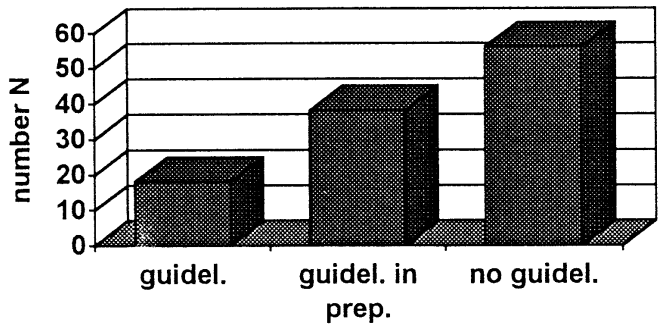
role in the clear reduction in industrial emissions of major air pollutants in the last decade. In this way, emission measurements have thus become a valuable instrument in enforcing air conservation regulations. However, there are still deficits in the measuring procedures and in implementation thereof. Countermeasures have already been introduced for some of these deficits in order to improve the instrument of emission monitoring even further:

- The inspectorates for air pollution control in North Rhine Westfalia have set up measuring and testing services which carry out ad hoc random sample measurements of major air pollutants in industrial plants. In addition to improved clarification of complaints and incidents, this improves the inadequate degree to which seldom random sample measurements represent the true state of the emissions.

Research and development projects commissioned by MURL have simplified the sampling procedures even for dioxins, furans, PCBs and PAHs to such an extent that in the future these components can also be controlled by means of random samples carried out by the measuring and testing services of the inspectorates. For example, in some cases control measurements can detect dioxin emissions in certain industrial plants where they were previously not anticipated; thus, measures to reduce these emissions can be introduced.

- Based on pilot tests in Lower Saxony, North Rhine Westfalia and Lower Saxony have started to establish widespread, remote emission control facilities (EFÜ). The

a) **Measurements of single organic components according to 3.1.7 TAL**



b) **Measurements of organic carcinogenic substances according to 2.3 TAL**

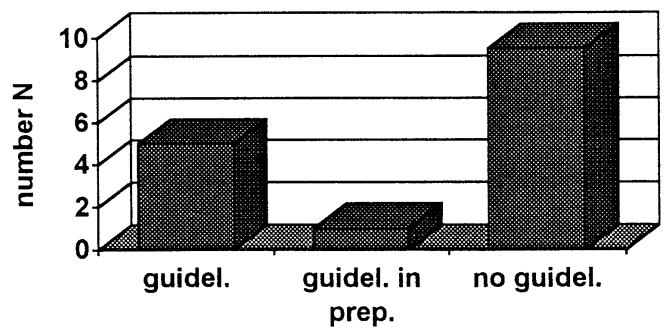


Figure 2. Share of tested emission measuring procedures in the form of VDI guidelines in the measuring tasks prescribed by the Technical Instructions on Air Quality Control (TAL).

continuous measuring instruments installed with plant operators are linked by means of intermediate computers and the telephone network to the computers in the inspectorates so that current data concerning measurements made by the emission measuring instruments can be transferred at any time. The inspectorate can obtain an overview of the current emission situation at any time, so that time-consuming research in the event of complaints is no longer necessary. In addition, the EFÜ-system also gives plant operators the possibility of optimizing operation of their plant with regard to the lowest possible pollutant emissions, as measuring and auxiliary parameters are constantly displayed in the measuring control station. Over and above controlling emission limit values, monitoring by measurements can therefore also contribute directly to reducing emissions.

Basically, this repeats a development which was already introduced to Japan at the beginning of the 1980s. For example, back in 1983 in Japan, the industrial emissions at 45 locations were telemetrically monitored in 23 prefectures and 10 major cities. However, there are technical limits to using this instrument—at the moment, only continuously measurable pollutants can be monitored (see Table 1).

- Finally, further development of statutory regulations to be met by emission monitoring, particularly the increasingly important EC regulations, must take account of enforcement requirements and the limited resources of the enforcing authorities. Regulations which may not be perfect but are capable of being enforced and controlled throughout the EC must be given preference over regulations which are perfect on paper only, particularly with regard to efficiency and to equality in the European domestic market.