International Fertilizer Industry Association

ISMA* Technical Conference

Sandefjord, Norway

8-11 September 1970

**In 1982, the name of the International Superphosphate Manufacturers' Associations (ISMA) was changed to International Fertilizer Industry Association (IFA).*

ATMOSPHERIC POLLUTION REGULATIONS IN FERTILISER PLANTS IN THE GERMAN FEDERAL REPUBLIC

By :

K. Trobisch

Farbwerke Hoechst AG
W. Germany.

1. VDI-Commission "CLEAN AIR MAINTENANCE" Guides

In Germany nitrogen and phosphate fertiliser plants require approval under industrial regulations. In connection with these laws, an administrative measure was issued in 1964, which is referred to as the "Technical Guide for Clean Air Maintenance" (TAL).

The subjects covered include :

- The control of soot and dust discharge from furnaces,
- The control of the dust content of polluted air from screening, crushing and filling installations, or similar emission sources,
- Maximum permissible immission concentrations for gases and non-toxic dusts,
- Directions on the measurement of SO_2 immissions and for the statistical evaluation of the test results,
- Minimum requirements for stacks, as considered necessary to avoid immission damage,
- Minimum requirements for specific installations.

The basis for these official regulations was work for the guides prepared and published by a Commission of the Verein Deutscher Ingenieure (German Engineers' Association) entitled "Clean Air Maintenance"*. This Commission is composed of approximately 450 experts from industry, administrative bodies, official institutes and various associations and unions.

Numerous committees and working groups are preparing guides in the following fields :

Emission of gases and dust

Effect of gases and dust

---

* "Reinhaltung der Luft"

Spread of air contaminants

Dust and gas measurement techniques

In this paper, those guides relevant to the fertiliser industry are considered.

2. CRITICAL EMISSION VALUES

The VDI guides concerning dust and gas emission are subdivided according to the type of installation. There are, in addition, special guides,prepared recently, for certain waste gas purification processes eg. for the catalytic oxidation of organic contamination. All guides consider the current state of technology, especially in relation to the methods and equipment used for the purification of waste gases, and include critical values for the discharge of dust and gases. The various working groups include experts from the ranks of plant operators, plant builders and representatives of the authorities.

The following VDI guides concern* the fertiliser industry.

- No. 2295 "Nitrous end-gases from nitric acid installations"
- No. 2298 "Sulphur dioxide and sulphur trioxide from sulphuric acid plants".

Guide No. 2295 first came out in July 1963 and limits the discharge of nitrous gases - calculated as NO - to 4 gm NO/m^3 and, in high pressure installations, to 3 gm NO/m^3.

In the meantime, a new version, dated August 1968, has become available. In this, the emission value for new installations is lowered to 2 gm NO/m^3. For existing installations the existing state of their technology is characterised by the following emission values :

Low pressure plants (0.5 to 0.6 atm. excess pressure)
4.0 gm NO/m^3

Medium pressure plants (2.0 to 3.5 atm. excess pressure)
3.0 gm NO/m^3 to 1.5 gm NO/m^3

High pressure plants (7.0 to 8.0 atm. excess pressure)
2.5 gm NO/m^3 to 1.0 gm NO/m^3

* VDI guides can be obtained from Beuth-Vertrieb GmbH., Berlin & Cologne.

A subsequent alkaline end absorption stage is considered in the guide only if the nitrite solution can be used immediately within the plant site itself. The discharge of larger quantities of nitrite solution into rivers is not possible due to the toxicity of nitrites.

Catalytic processes for reducing the nitrous gases with hydrogen, hydrocarbons or ammonia are considered to be, as yet, beyond the existing state of technology in the Federal Republic of Germany.

Regulation No. 2298, concerning discharge limitation in sulphuric acid plants, was also first issued in 1963. At that time, in relation to the contact process, in continuous operation using pyrites or zinc blende as raw material, a sulphur dioxide conversion value of 97.5% was required, and, in respect of plants using sulphur, a value of 98%. After the double contact process was developed the guide had to be revised. The new issue, of June 1968, gives as critical values :

a) contact process with intermediate absorption (double contact process) : 99% SO_2 - minimum conversion with continuous operation ; sulphuric acid aerosol-discharge 0.6 kg SO_3 per tonne sulphuric acid

b) contact process without intermediate absorption : 97.5% SO_2 - minimum conversion with continuous operation ; sulphuric acid aerosol-discharge below 0.6 kg per tonne sulphuric acid

c) wet catalytic process : 97.5% SO_2 - minimum conversion ; sulphuric acid aerosol-discharge 2 kg/tonne sulphuric acid

d) chamber process : below 5 mg SO_2/Nm^3, below 1.2 gm NO_2/Nm^3 in the end gas.

Another guide concerning the limitation of ammonia-emission is being prepared at present. Emission values between 100 mg NH_3/m^3 and 2 gm NH_3/m^3 are being considered. In view of the high water solubility of ammonia, the critical values finally required should scarcely exceed 200 mg/m^3. Wash water, containing ammonia, may not, however, be discharged in larger quantities into waterways, due to the toxicity of the free ammonia. Thus, discharge of wash water will entail additional problems in many places.

There is no regulation as yet for waste gases containing hydrogen fluoride from chemical installations. Because of the unusually high toxicity of hydrogen fluoride for certain types of plants, such gases must be carefully purified. To date, critical values have been worked out only for aluminium smelters in VDI guide 2286. In this case, hydrogen fluoride emission must not substantially exceed the value of 0.005 gm F/Nm^3. It must, of course, be taken into account that the quantities of waste gas in such installations are relatively large.

The dust contained in the waste gas of screening, crushing and packing installations or similar emission sources is limited in TAL to 150 mg/Nm^3, with continuous operation. This applies to non-toxic dusts, with no abrasive properties. There is no clear regulation in the Federal Republic for the limitation of a possible silicic acid content, either for emitted dust or for the air inhaled in the plant.

3. EFFECT OF GASES AND DUSTS

The VDI Commission is also concerned with the effect of gases and dusts on man, animals, plants and property. For this purpose, MIC values (MIC = maximum immission concentration) have been established, which are defined as open air concentrations in layers near the ground or, in the case of dust, also those amounts precipitated on the land, which, as far as is known to date, can generally be considered harmless to man, animals or plants when subjected to them for a certain duration and frequency. In the case of gases, the MIC values refer to average concentrations over a time interval of 30 minutes. The critical value for continuous effect (MIC_L) is differentiated from that, which may be exceeded at certain times. The limit for this higher level is given by the critical value for short-period effect (MIC_S).

VDI guide 2108 includes the following MIC-values for sulphur dioxide :

MIC_L : 0.5 mg $SO_2/m^3 \approx$ 0.2 cm^3 SO_2/m^3

MIC_S : each half hour within two hours value of 0.75 mg $SO_2/m^3 \approx$ 0.3 cm^3 SO_2/m^3

These values are based on the effect of SO_2 on vegetation. They are the result of gas tests, which e.g. were carried out at the Hoechst factory, using equipment including 26 small glass house specially built for this purpose. The continuous value for SO_2 immission in TAL differs from that of the VDI guide and is reduced to 0.4 mg SO_2/m^3.

VDI guide 2105 discusses, on sheet 1, immissions of nitrous gases. Operative values given are :

MIC_L : 0.5 cm^3/m^3 = 1 mg NO_2/m^3

MIC_S : an average half hour value three times daily of 1.0 cm^3/m^3 = 2 mg NO_2/m^3

These values are based on the effect of nitrous gases on man. Plants can usually withstance higher concentrations, which lie in the region of the MWC-value (MWC : maximum concentration in the working-place), i.e. at 5 cm^3/m^3 = 10 mg NO_2/m^3.

The concentrations measured in the locality of fertiliser factories are, in most cases, considerably below the given critical values.

Sheet 2 of guide 2105 gives the limits for the immission of nitric acid vapour as the following critical values ;

MIC_L : 1.3 mg $HNO_3/m^3 \approx$ 0.5 cm^3 HNO_3/m^3

MIC_S : average half hour within two hours value respectively of 2.6 mg $HNO_3/m^3 \approx$ 1.0 cm^3 HNO_3/m^3

To date no MIC-values have been fixed for ammonia. According to tests at Hoechst it can be assumed that plants are damaged only at concentrations from 5 to 10 mg/m^3.

An immission regulation for hydrogen fluoride is being prepared. Owing to the already mentioned high toxicity to plants of hydrogen fluoride, very low critical values must be expected. A MIC_L-value of 0.003 mg F/m^3 and a MIC_S-value of 0.005 mg F/m^3 are under consideration. Measurement of such low concentrations causes considerable difficulty. In addition thereto it is not possible, with the methods of determination used to date, to distinguish clearly between gaseous fluorine compounds and fluorine-containing dust, the latter being less dangerous for plants and grazing animals.

The deposition of dust is discussed in VDI guide 2305, which is in draft-form. For non-toxic dusts - this expression is not further defined - the following critical values are prescribed :

Average annual value : 0.42 gm/m^2 per day (average value from 12 monthly average values)

Average monthly value : 0.65 gm/m^2 per day

The values apply to measurements obtained with Bergerhoff equipment described in VDI guide 2119. In areas of industrial concentration deposits of dust which are twice as high are allowed. However, what is to be described as an area of industrial concentration is left open.

There are no critical values for saliferous dusts, as emitted e.g. from fertiliser plants. In the case of such dusts it must be taken into account that encrustment can occur sometimes on plants, and so full advantage is not normally taken of permissible deposition values for non-toxic dusts.

In non-industrial regions with a low population density, a dust deposition of approximately 0.1 gm/m^2 per day is assumed to be a normal dust deposition.

4. AIR-HYGIENE REQUIREMENTS FOR STACKS

The critical immission values mentioned above are essentially based on observations from experiments. When determining the emission values, technical and economic aspects were taken into consideration.

The calculations for heights of stacks in the Federal Republic of Germany, required by law in order to avoid excessive emissions, were established in quite a different way.

Based on a formula by Sutton, Wippermann and Klug developed a relationship for the calculation of the maximum average half-hour immission value :

$$s = \frac{(2r)^r (1+m) z_o^m \; G^{2r-1} . Q}{\pi e^r . \bar{u} \; (z_o) \; h^{2r+m} . F}$$

s = level of the immission maximum on the ground (mg/m^3)

Q = magnitude of source (kg/h)

$\bar{u}$ = average wind speed (m/s)

z_o = anemometer level (m)

h = effective source height (m)

$F = 0.263 \; m^{0.33}$; $f = 0.67$

$G = 0.188 \; m^{0.3}$; $g = 0.7$

$r = (f+g)/2g$

$m = 0.18$

If the constants are combined, the following simplified relationship is obtained :

$$s = k_1 \frac{Q}{\bar{u} \; . \; h^{k_2}}$$

The effective source height h is composed of the constructional height of the chimney and of chimney superelevation caused by the thermal draft and discharge velocity. The superelevation is calculated according to an empirical formula by Holland, which was revised by Stümke, who examined the exhaust gases quantity, the exhaust gas and environmental temperature as well as the inside diameter of the chimney.

Taking the above mentioned relationship as a basis, a nomogram was determined in the VDI guide 2289 "Stack heights on flat, unbuilt-up land", from which there can be derived the required constructional heights for chimneys with a predetermined immission concentration and related to the emission requirements. The nomogram is also included in TAL.

In view of the plurality of very different methods (for the calculation of chimney heights) as published by different authors, which lead to very different results, from the outset it was to be expected that there would not be a satisfactory degree of consistency between the German method of calculation and practice. We, in Hoechst, checked the precision of the nomogram with reference to a sulphuric acid plant. Evaluation of over 30,000 average half-hour values of SO_2-concentrations, which were measured in lee of the 108 m high stack of this plant, gave as characteristic values for the immission :

99% value : 0.347 mg SO_2/m^3

97.5% value : 0.267 mg SO_2/m^3

95% value : 0.213 mg SO_2/m^3

However, according to the TAL nomogram, the following maximum SO_2 emissions are expected :

0.82 mg SO_2/m^3 at an average wind speed of 2 m/s

0.78 mg SO_2/m^3 at an average wind speed of 3 m/s

If a basic level, from all other sources, of 0.2 mg SO_2/m^3 is added to the above values, then the resultant theoretical immission value for the Hoechst site is 1 mg SO_2/m^3.

This means, looked at in another way, that, with a predetermined immission concentration, the stack height derived from the nomogram is much too high. In the Hoechst sulphuric acid plant example, a stack height calculated from the measured immission values is almost twice as high as the actual constructional height.

Further inadequacies of the German mathematical method cannot be discussed within the scope of the present short review. We have discussed this in the journal "STAUB" (Sept. 1969).

On sheet 2 of guide 2289, which has been published in draft form, stack construction and vegetation in the locality of an immission source are taken into consideration. The constructional height of a stack, calculated for flat land, incurs an additional height and this applies particularly with low stacks.

On sheet 3 an attempt is made to determine stack heights taking account of uneven land contours. According to this, the stack height ascertained for flat land must be provided with a correction factor, which depends on the height of the contours of the land in the locality of the emission source.

5. MEASUREMENT TECHNIQUES FOR DUST AND GAS

For the measurement of dust and gases the following guides, which are applicable to the fertiliser industry, have been published, edited partly by the VDI "Dust Technology" team of experts.

No. 2031 "Fineness determination for technical dusts (Oct. 1962)

No. 2066 "Performance measurement for dust removal appliances" (May 1966)

No. 2119 "Dust deposit measurement" (Sept. 1962)

No. 2260 "Technical guarantees for dust removal appliances" (May 1963)

No. 2266 "Measurement of the dust concentration in the working-place (Aug. 1968)
- Sheet 1 : Measurement with the thermal precipitator
- Sheet 2 : Measurement with the konimeter

No. 2449 "Data sheet of the criteria for analytical methods for immission measurement" (draft) (Sept. 1968)

No. 2451 "Measurement of sulphur dioxide immission (Aug. 1968)
- Sheet 1 : Absorption method (silica gel)
- Sheet 2 : Conductivity method (Ultragas 3*)
- Sheet 3 : Photometric method (tetrachloromercurate method)
- Sheet 4 : Conductivity method (Picoflux**)

No. 2452 "Measurement of fluorine immission"(Dec. 1963)

No. 2453 "Measurement of nitrogen dioxide immission" - summary and modified Saltzman-method (draft) (June 1969)

Another guide for determining NO immission will be published shortly.

---

* Manufacturer : Messrs. Wösthoff oHG, Bochum

** Manufacturer : Messrs. Hartmann & Braun AG., Frankfurt (Main)

6. CONTROL OF EMISSIONS AND IMMISSIONS

Depending on the size and location in the Federal Republic of the fertiliser plant, surveillance is effected in different ways. With immission measurements, the decisive factor is the determination of the sulphur dioxide concentration and of the dust deposits. In many areas there is a more or less concentrated network of suitable measuring points. Furthermore, the determination of fluorine emission is becoming increasingly important in concentration areas.

In addition thereto, local measurement programmes are carried out, in which other air pollution materials may be included and which are also concerned with emission measurement. Larger chemical firms have set up special divisions or groups, which are concerned with environmental hygiene and whose scope also includes air surveillance.

In the Hoechst plant we have started with test papers, which colour considerably in the presence of sulphur dioxide, nitrous gases or chlorine. For exact quantitative measurements, three air-conditioned recording stations were erected on the boundaries of the factory. Using physical and chemical micro-analytical methods, the amount of sulphur dioxide, nitrogen dioxide, ammonia, chlorine, organic air contaminants and carbon dioxide in the air is continuously checked. The determination of carbon dioxide is used only to determine whether the sulphur dioxide as determined originates from carbon dioxide - containing flue gases or from (carbon dioxide-free) chemical exhaust gases.

On the roof of the measurement station, there is a funnel which determines dust deposition. In order to test the effect of the air on vegetation, crop plants, e.g. cereals, lucerne, rape, fir trees, pines, larches or gladioli, are planted. Corresponding plant species are planted for comparison in clean air at a research station. The air surveillance system of the Hoechst plant also includes two gas-measurement vehicles. Volkswagen-Kombis are used, suitably fitted for housing the measuring equipment. They are equipped with a source of electricity for operating the equipment and with heating means for carrying out measurements in winter. A radio station ensures continuous communication between the measurement vehicle and laboratory. Using these vehicles, measurements are carried out in various factories as well as in the locality of the works, e.g. the sulphuric concentration in the air is determined regularly at 28 measurement points, which are up to 3 km away from the boundaries of the works.

The vehicles can also be used day and night in the event of a fault causing an unusual generation of waste gas. For such eventualities they are equipped with special measuring appliances, which permit, in a simple and rapid manner, a rough measurement of all components which are recognised as important in air pollution.

A television camera is installed in the sky-scraper administrative block for the factories in order to survey visually the air above the plants and in the locality of the works, and this is connected to a receiver in the exhaust gas laboratory. This installation checks all emission points of the plants and, in bright weather, can even observe the stacks of another plant located 4 km away. In particular gas emissions, caused by improper or negligent operation of the equipment, should be recognized immediately, so that immediate action can be taken against them.

From the laboratory the camera can be pivoted and tilted by means of an audio-frequency emitter. A zoom lens, which is also remote controlled, makes possible continuous field angle adjustment between 4° and 27°. Stacks which are more distant and small roof outlets can thus be "zoomed in", i.e. can be reproduced sufficiently enlarged on the projection screen of the receiver.

The observations and measurement results from this air surveillance are available in regular reports for the management of the plants and for all heads of production divisions. Evaluation of the results is carried out taking account of meteorological factors. Hence we have also established a weather-station within the works.

Apart from a few mishaps, it has been possible to comply to date with the critical values prescribed in the clean air maintenance guides for the Federal Republic.

concentrations in a theoretical manner by arranging for an appropriate stack discharge height.

I am sceptical of this approach as a means of protecting man, animal or plant, partly, I suspect, as a result of the natural British objection to standards and regimentation. In pollution matters we adopt the "Best Practical Means" of prevention, and this includes a necessity to adopt proven, advanced treatment processes, providing that the economic penalty of doing so is not excessive. It implies a continuing improvement as old plants are replaced and as we can be persuaded to introduce the results of advances in suppression technology. As in Germany a simple formula is used to relate stack height to ground level concentration, but in our case the applicable ground level concentration is not a set maximum which life in the area will stand, but a small part of that which can be safely added to that which exists without harm, and still have room for more. Perhaps Dr. TROBISCH will explain how the approach he has outlined can be used to ensure safe living conditions in an area receiving a number of waste gases, all of a different chemical but nevertheless toxic nature, arriving in approximately the same fall-out area, bearing in mind that the discharges may be from different companies and different locations. How does this system allow for future plant and factory extensions ?

I am opposed to any permissible levels for ammonia or alkaline discharges. We must consider the possibility of mist formations after discharge from the stack. Acid emissions can never be fully trapped. Alkaline ones are simply and completely dealt with by acid rather than water scrubbing. While on the subject of mists, the establishment of a chemical standard for acid mists, be they sulphur trioxide or phosphoric oxides, is, I submit, neither realistic nor practical, since their hazard and persistence is dependent largely on particle size. This is a clear case for an optical visibility standard. Perhaps under mists we should also include the vapours from water cooling towers. Non-toxic, non-corrosive certainly, but also unsightly and is it not possible that they are the medium for atmospheric ionic reactions leading to the production of chemicals perhaps potentially of chronic toxicity. I should appreciate Dr. TROBISCH's views of these aspects of the control of mists.

I am intrigued, too, at the assessment of the results. This seems to suggest, for dust and also for toxic vapours, that it is quite permissible to poison the population for some of the time providing that, on average, one complies with the limits. Acceptance of the fact that, as with all other process equipment, the performance of atmospheric protection processes will vary from time to time is realistic, but I believe that it is wrong to include that variability in a standard and that infringement levels for conditions influencing human health must be on a positive "go or no go" principle. I should appreciate Dr. TROBISCH's comments on the administration and enforcement of the principles he has outlined by the German authorities.

Perhaps I have been too critical of this approach. If I have, I apologise, but I speak from the background of the British system, which has resulted in less atmospheric pollution from industry, in major industrial areas, than in any comparable area in the world, and has, moreover, stood the test of time. We in the U.K. fertiliser industry have worked our processes under control and inspection for over a 100 years. Nevertheless I should like to congratulate Dr. TROBISCH's Company on their extremely responsible approach to the protection of the environment, as exemplified by the establishment of their static and mobile ground level monitoring stations.

Dr. TROBISCH : "Ambient Air Standards" or not ?

From our discussions in Germany we concluded that, above all, we ought to protect man, animal, and plant, by laying down effective limits for concentrations to which living organisms may be exposed, based on those concentrations that correspond to a given degree of damage. In consequence, I am able to say that nowadays it is a good thing to have these "Ambient Air Standards". Towards the end of your comments you pointed out that we could be polluting the air over that period of time before which the limiting value has been reached. In the case of gases these "Ambient Air Standards" are the average value over a half-hour period, and for dusts it is the monthly average, and this naturally raises a problem. For toxic dusts there is also an additional restriction based on the dust content of the air over a much shorter period of time. The "Ambient Air Standards" have served us well at Hoechst. We manufacture nitric acid in rather old-fashioned plants that give off clouds of brown or reddish-brown fumes and these create a most unfavourable visual impression. Only a few days ago I came across a newspaper cutting from 1937. At that time the brown plume was a matter for pride, as it reflected a high level of production. It is no longer the same today. We no longer appreciate such clouds of fume, but on the basis of the "Ambient Air Standards", we have been able to show that the problem is purely psychological. The concentrations actually determined at ground level are much lower than the values that have been shown to be inadmissible from research on plants and animals. In such cases as these, the "Ambient Air Standards" we have are of service.

In addition to the "Ambient Air Standards", we have a supplementary limit for the emission of pollutants ; even if, in the region, it is not thought that the permitted ground level concentrations will be exceeded by a factory, it is still required to conform, as far as is technologically possible, with the "Best Practical Means", even though the factory is already working to the limiting emission values (of the "Ambient Air Standards").

When, as referred to in the other part of your question, you have several sources of pollution in the same area, you find yourself in the same difficulty with the "Ambient Air Standards" as with the "Best Practical Means". These difficulties apply also where the factories are not in the same vicinity. The "Ambient Air Standards" apply to individual gases, which are certainly affected by the presence of appreciable concentrations of other pollutants, but in Germany we are concerned at what are known as the combined effects of pollutants. We reckon that some day our MIC values will be corrected to cover the situation where some other substance is already present in the air at a concentration beyond that which is set for given compounds.

When undertaking the necessary calculations prior to the construction of new factories, we take into account the level of pollution that has been observed in relation to the height of the existing stacks, and the new stacks are laid out on a particular pattern depending on the nature of the fumes they are likely to emit. This system seems to us to avoid the risk of a small number of new factories exhausting the possibilities of an entire industrial area. It must also be mentioned that, even if fumes were emitted from a flue at ground level, provided the gas is cold, only a very limited area of ground would be affected, and this would vary from one minute to the next. However, the area affected by a cloud of fume is fairly restricted and consequently the risk of two clouds overlapping in the vicinity of a chimney stack is not as great as it is supposed to be.

I entirely agree with you that we should lay down stringent limits for the discharge of ammonia, otherwise severe fogs will occur in large industrial areas. At Hoechst we have set a limit of 100 mg. per cubic metre. Although this is a low concentration we are able to keep to it on account of our efficient scrubbing facilities. Some people in Germany have considered that it would be appropriate to have a limit of 2,000 mg. per cubic metre, and they maintain that a wash liquor containing ammonia gives rise to difficulties when it is discharged into a watercourse. It is obvious that such limits are not realistic, and, in my opinion, not something that one could ask for at present time. Nevertheless, it is a fact that, as a general rule, 5 kg of a substance released into the air creates much more difficulty than the same quantity discharged into a watercourse. As such low concentrations of pollutants create such difficulties, we no longer build our fertiliser factories near streams.

Your last question also relates to the formation of mist. This is an important matter, which we do not yet know how best to tackle, since any limits would depend also on the meteorological conditions, especially humidity ; if one wishes to lay down limits to prevent the formation of mist, one must quote standard meteorological conditions, which is clearly a difficult matter. Undoubtedly water vapour creates problems as well, but if on the one hand, one wishes to avoid warming up the watercourses, one must have cooling towers, and consequently one cannot avoid the release of water vapour, to say nothing of the cooling of the air. Clearly the use of cooling towers is even more troublesome in areas where fog is particularly dangerous, and they should not be adopted in the vicinity of airfields or similar localities. Up to now, at Hoechst, we have paid little attention to the question of water vapour, although in terms of quantity it is the product we emit most abundantly from our cooling towers.

I am aware that the calculation of the height of stacks is very important, and that there are more than 50 methods for doing this, with differences of the order of ten. I would not pretend that our method is particularly accurate, and I would not wish to quote it here. It is highly problematic whether such a formula can be used to calculate the height of a factory chimney. The meteorologists who worked out the formula for us are aware of this, but unfortunately, this often does not apply to the people who use the formula for calculating these heights. They believe that the formula will enable them to calculate the height accurately, almost to the last centimetre. On occasions this has been taken to the extent of considering the height of the trees in the neighbourhood when deciding on the safe height for an emission. In the case of a sulphuric acid plant at Hoechst, they even sought to include in the calculation the rate of growth of the trees over the next 50 years.

Dr. J.J. MULCKHUYSE (Mekog-Albatros N.V., Holland) : I should like to know a little more about the sampling methods which are used in Germany.

It is a well-known fact that to have a good control it is in principle necessary to have a good sampling method for the stack gases. The sampling of such gases is a very difficult thing, especially when they carry small droplets and dust.

Do you know if this point has been cleared in Germany ?

Dr. TROBISCH : The need to measure gaseous substances in admixture with liquid droplets or dust particles is a great problem. In the case of certain gases we have worked out rules for the techniques of measurement. The field of application of these rules has been described in the paper, but this is a problem which in all its aspects has not yet been solved in an entirely satisfactory manner. Thus we are obliged in part, to work with the traditional methods.