COMMISSION OF THE EUROPEAN COMMUNITIES

Technical control of air pollution in the iron and steel industry

Research Progress Report
30th June 1972

General Directorate "Social Affairs"

Edited by the Directorate General for "Dissemination of Information"
Centre for Information and Documentation - CID
Luxemburg, October 1972

EUR 4921 d,f,i,n,e

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Preface

About three years have now passed since the publication of the first report of the Commission of European Communities dealing with the results of ten years' research work carried out with the financial support of the European Coal and Steel Community for the control of air pollution in the iron and steel industry. The lively reception which has been accorded to this report within and without the Community and the fact that, in general, a wider section of the public nowadays participates to a greater extent in the problem of air pollution gives encouragement to the Commission to report in the present publication on further subsidised research which it has since carried out in the above-mentioned field.

Through this information, the Commission of European Communities hopes to provide interested circles with an insight into one of its fields of activity which it considers very important in the social sector.

Undoubtedly still greater efforts need to be made by all those involved in this field in order to provide the worker with purer, healthier air at his place of work as well as within his living space, which is necessarily associated with it.

This knowledge, which is at the same time a challenge, is certainly relevant not only to the iron and steel industry but also to a wide range of other sources of emission of unpleasant or even dangerous air pollutants.

The knowledge gained in combating dusts and waste gases from iron and steel works will certainly be useful to many.

1. Introduction

1.1 First research programme

The first summary report [1] of the Commission of European Communities (CEC) on the research carried out within the framework of the first research programme[2, 3] and based on detailed decisions with the financial support of the European Coal and Steel Community (ECSC) for combating air pollution in the iron and steel industry contains various information and suggestions of basic interest in addition to the results of 30 investigations. The sources of these air pollutants are shown in a number of diagrams and their significance and problems are dealt with as well as dust and gas measurement and the control of brown fumes, other dusts and waste gases.

1.2 Second research programme

The present report concerns the second ECSC outline research programme for the technological prevention and control of air pollution caused by the iron and steel industry[4]. This programme, for whose execution 4 million EEC units[5] have been made available, is to extend over 5 years. It commenced virtually in 1969 and permits financial supports to be granted for research work and studies in the following problem fields:

A) Applied research

1. Determination of the kind and extent of air pollution within iron and steelworks and their immediate vicinity.

2. Evaluation of new, and development of existing, methods, plants, machinery or materials which are intended for:

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1) Publication No.15444/1/69 of the Office for Official Publications of the European Communities
2) Official Gazette of the ECSC, Vol.6,No.37, p.610 of 16.12.1957
3) Official Gazette of the European Communities of 20.9.1958,pp.379/80
4) Official Gazette of the European Communities of 26.6.1967,pp.2748/49
5) Units of account of the European Monetary Agreement

2.1 Suppression or reduction of generation dusts, fumes, vapours or gases

2.2 Reduction of the hazards due to the dusts, fumes, vapours or gases which are unavoidably generated in certain processes

2.3 Collection and precipitation of dusts, fumes, vapours or gases at or near the locations where they are generated

2.4 Removal of floating suspended pollutants in the plant buildings as well as dust deposits in them

2.5 Guaranteeing of physical protection on working in an atmosphere which could lead to hazards or annoyance to the working personnel due to its dust, fume, vapour or gas content.

B. Research of basic aspects

1. Studies and investigations for improving and harmonising of the measuring thechnology (process and instruments) with respect to the collection of samples and analysis of dusts, fumes, vapours and gases within and without the iron and steelworks.

2. Studies and investigations for extending knowledge about the

2.1 Basic aspects of collection and separation of dusts, fumes, vapours and gases

2.2 Basic aspects of personal dust and gas protection

2.3 Basic aspects of distribution of the air pollutants within the iron and steelworks and in its immediate vicinity.

1.3 Execution of the second research programme

At the start of the examination of research projects handed in in 1968 there were in total 47 grant applications for about 5.8 million units of account. By the middle 1972 25 new applications had arrived with requests for grants of a total of approximately 3.3 million units of account. After carrying out the usual consultation [6] the CEC had granted up to then, with five approvals, in total about 2.7 million units of account for 41 projects. Since 6 applicants later abandoned the execution of their research plans

6) Bulletin No.60 of ECSC

the number of the supported research projects on 30.6.1972 was 36 and the total of the grants approved for this purpose was about 2.5 million units of account.

By the middle of the year 1972 there were

- 33 research contracts concluded
- 3 research contracts in preparation
- 7 researches concluded
- 26 researches in process.

The distribution of research grants to different problem fields of the program is shown in Table 1 :

Research group	Number of studies	Assistance in units of account
A 1	8	243 644.80
A 21	2	122 950.81
A 22	1	54 644.81
A 23	8	1 723 644.64
A 24	-	-
A 25	-	-
A	19	2 144 905.06
B 1	12	230 565.19
B 21	2	68 702.99
B 22	1	12 622.07
B 23	2	67 814.21
B	17	379 704.46
A + B	36	2 524 609.52

2. Work in the field of the measurement of air pollutants

2.1 Determination of the kind and extent of air pollution within the iron and steelworks and within their immediate vicinity

The influence of the air pollutants of an iron and steelworks on the people engaged in work as well as their influence on near and remote surroundings can be of decisive importance for the

existence of an iron and steelworks. In the past many and not especially carefully based discussions have been held about the assumed or actual extent and effect of air pollution. The purpose of the series of research activities which are carried out with the support of the CEC is to gain basic knowledge about the kind and extent of those extraneous materials which on the one hand have an effect on the people working in an iron and steelworks and on the other hand have an effect on the immediate vicinity of such a plant. Only basic knowledge of this kind can ultimately be used as a guide as to which emittants require special regulations in order to limit damaging effects on the environment or to eliminate them altogether.

The precondition for rational measurements and results which can be compared is naturally that suitable instruments and processes are available. For this reason investigations of existing measuring instruments and methods, and also for developing new ones were carried out within the framework of the first research programme. This work was continued in the second research programme.

In this section however measurement results are first reported without discussing the specific measuring methods.

Especial value was placed on the coordination of comparative studies.

This coordination extends to the working places to be investigated as well as to methods and instruments for collecting samples, measurement, analysis and evaluation.

2.1.1 Systematic determination of different air pollutants from a coking plant in an iron and steelwork complex

(Centre Belge d'Etude et de Documentation des Eaux, Study PS 140)

Undoubtedly the coking plants are among the chief sources of emission in an iron and steelworks complex. Up to now there have

been only a few conclusive investigations about the kind and quantities of different emissions. For this reason the purpose of this investigation on the one hand is the systematic determination of emissions due to the operation of a coking plant in an iron and steelworks and on the other hand the investigation of the distribution and development of pollutants in the immediate vicinity of the plants.- The following emission sources are investigated:

coal loading ramp
coal mixing station
coal transporter belt
filling truck
coke oven cover
coke chute
quenching tower
coke ramp
coke screening plant

In all the emission sources mentioned above the emission varies greatly within a short period of time; emissions are moreover dependent on the variation of the weather conditions. Hence only a large number of samples and measurements which have to be spread over a longer period of time can lead to valid conclusions.

In the case of gasous emissions the contents of SO_2, H_2S, NH_3, CO, CO_2, CS_2 and hydrocarbons are of special interest for this study.

The last are investigated for:

- heterocyclic hydrocarbons
- polycyclic hydrocarbons
- aromatic and aliphatic hydrocarbons
- light hydrocarbons

In dust emissions the following determined:

- gravimetric concentration in mg/m^3
- concentration of the grain size fraction <5 µm in percentage by weight
- number of particle $<$µm per ml of air
- chemical composition

At first the dust samples are taken from different emission sources by means of dust collecting instruments (Liège balls[+]); these samples are analysed in order to gain basic knowledge about the kind of pollutants which occur and which are to be considered in a systematic investigation. At first suitable sample collection and analysis methods had to be developed for various air pollutants, especially for hydrocarbons, eg. :

- a spectometric method for polycyclic hydrocarbons for determining the hydrocarbon content
- a gas chromatographic method for aromatic hydrocarbons; suitability of this method for determining of aliphatic hydrocarbons is still being investigated
- a gas chromatographic process also for light hydrocarbons; this is complemented by a check by flame ionisation.

The working places of a coke oven plant may be devided into three main groups: coal-handling, the coking process itself and coke-handling.

In the first group of working places (where the coal is unloaded, blending plant, coal-grinding plant, the area of the conveyer belt) the amount of pollution through particles of solid matter is relatively low. In the second group (on the charging larry, the oven-top, the coke guide) there is pollution from dusts, gases and fumes from hydrocarbons. In the third group (coke-crushing and screening plant) there is considerable pollution, mainly through particles of solid matter.

[+] Vaseline-coated aluminium spheres of diameter 12 cm which are fastened on bars at a height of 3 m

In this study the amount of dust was determined in all these places. There was between 0.5 and 1 mg/Nm^3 at the working places of the first group, between 3 and 20 mg/Nm^3 at those of the second group.

At the working places in the second groupe gaseous air-pollutants were found in the following concentrations:

- in the cab of the charging larry: during the charging a CO concentration of 10 - 260 p.p.m.
- at the oven top: a CO concentration in general of the order of 15 p.p.m., an extremely variable SO_2 content, depending on very local condions, of between 50 and 900 /ug/Nm^3, a H_2S content of between 65 and 750 /ug/Nm^3, a CS_2 content constantly below 5 /ug/Nm^3, of liquid hydrocarbons 1mg/Nm^3 benzene, 1,5 - 5 mg/Nm^3 toluene, 1 - 7 mg/Nm^3 xylene and 2 - 60 mg/Nm^3 naphtalene. The dusts collected at the oven top were submitted to special analyses, to determine in particular the 1.2 benzopyrene content. It was present at a concentration of 1 mg/g of dust.

Automatic instruments for sampling dust and gas were installed in and around the area of the coking plant, as well as an automatic instrument for registering wind-direction and speed. The evaluation of the series of measurements of SO_2 and dusts containing tar made it possible to analyse the effects of the coking plant in the SERAING iron and steelworks complex.

At a distance of 100 metres from the coking plant the average SO_2 concentration was 250/ /ug/Nm^3, at 500 metres NE of the plant it was 135 /ug/Nm^3 and 75 /ug/Nm^3 at 500 metres SW.

The quinoline index, which is directly related to the concentration of substances containing tar, is 3 600 at 100 metres from the furnace, 400 at 500 metres NE of the coking plant and only 250 at a distance of 1 kilometre to the NE.

2.1.2 Determination of air pollution within a coking plant and evaluation of the biological consequences for those employed there

(Laboratory for Medical Chemistry, Toxicology and Hygiene of the University of Liège, Study PS 190)

This investigation which, however, could not be completed, was closely connected with the already mentioned study PS 140.

The main purpose of the investigation was to test which relationships exist between the evaluated emission and ground level concentration values of a coking plant and what is known as the "biological profile" of those employed there.

For this purpose it was planned to evaluate and compare the biological profile of a group of coking plant workers and a group of persons in this plant who are not exposed to the air pollution found in this plant.

2.1.3 Investigation of air pollution at different places of work in Luxembourg iron and steelworks and in their immediate environment

(Mineralogical Laboratory of the Natural Sciences Museum, Luxembourg, Study PS 181)

Within the framework of this investigation which is coordinated with investigations PS 184 and PS 189 different gas and dust collection methods as well as the associated analytical methods are subjected to comparative investigation. Since the delivery of various specified instruments was appreciably delayed, only the dust samples were collected with the conventional Bergerhoff containers.

In the course of the investigation work it was also possible to use the originally specified dust sample collection instruments. It was seen from this that the handling of the Porticon

instruments[+] and thermal precipitator[++] presented no difficulties. The Gravicon instrument[+++] owing to its weight and size, was found to be less suitable for mobile application on various working locations.

Dust precipitation measurements with Bergerhoff instruments[++++] were carried out at 10 different positions. The instruments are installed around the factory between 600 and 1250 metres from the centre. In addition to various other plants the work also comprises:

- a sinter plant
- several blast furnaces
- a Thomas steelworks
- An LD-AC steelworks
- several rolling mills
- a slag grinding plant

The following were measured:

1. The collected quantity of rainwater
2. The insoluble precipitated dust
3. The soluble precipitated dust

The dust samples are investigated by X-ray diffraction and with electron microscopic method.

Results up to now: Three measuring periods (2nd half 1971, 1st quarter 1972 and 2nd quarter 1972) yielded the following average figures for precipitated dust (after incineration) :

0.28 - 2.50 g/m^2 day
0.27 - 3.40 g/m^2 day
0.30 - 2.35 g/m^2 day

+) Portable carried on the back.The new model weighs about 6 kg.The development of this dust collection instrument dates back to the study PS 139 in the framework of the first research programme.The instrument has a battery powered electrical blower with an air throughput of about 12 m^3/h, it is equipped with an arrangement for measuring quantities of air and it has a flexible suction inlet part which facilitates the collection of air samples within the breathing zone of the worker involved in activities with frequent change of position.

++) The thermal precipitator is based on the principle of thermal diffusion and it is used for numerical determination of concentration(evaluation of the number of dust particles per cubic centimetre of air).

+++) Transportable instrument with a stand with adjustable air throughput between 15 and 40 m^3/h for collection of larger dust particles in a shorter time than it is possible with the "Porticon";blower motor with external supply (connected to supply grid).

++++) Cylindrical collection container of 1.5 l capacity and a free opening of 8.9 cm (domestic preserve jar to DIN 5071) in a wire protecting basket (also a bird protection)which is attacked by a simple clamp on a steel tube so that the opening of the jar is 1.50 m above the ground.

At a distance of 600-750 metres the figures varied between 0.80 and 3.40 $g/m^2/day$, whereas in the area 750-1250 metres from the centre they were in the region of 0.27 - 0.80 $g/m^2/day$.

The content of the dust precipitates was:

Ash	10 - 18 %
Iron oxides	35 - 65 %
Lime	5 - 15 %
Insoluble in HCL	10 - 25 %

X-ray diffraction analysis showed the preponderance of iron oxides and calcite as well as small quantities of quartz in the insoluble dust precipitates.

Calcium sulphate (probably from the blast furnace), phosphate (in the vicinity of sinter plant and slag grinding plant) and calcite (in the vicinity of the Thomas steelworks)were found in the soluble components.

Electron microscopic investigation showed in the first results the existence of magnetite, calcite and haematite in the insoluble parts as well as calcite, calcium hydroxide and calcium solphate in the soluble parts.

2.1.4 Determination of the kind and extent of air pollution in Belgian iron and steelworks and in their immediate vicinity

(Centre belge d'étude et de documentation des Eaux-CEBEDEAU - Liège, Study PS 184)

The object of the study is the evaluation of the kind and extent of the air pollutants of a number of adjacent iron and steelworks and the time variation of these pollutants. The kind and concentration of extraneous matter in the air in the working locations within the steelworks as well as in the close vicinity of these works are investigated here.

Only such an extensive investigation will yield material data for answering the query about the proportion contributed by the iron and steel industry to the whole air pollution of a certain area.

This specification of the problem results in the following investigation programme:

1. Investigation of the air pollution of some selected working locations:
   a) coke screening
   b) breaking the lining of steel and iron holding ladles
   c) reconditioning of steel and iron holding ladles
   d) emptying of mould boxes
   e) Fettling of castings
   f) flame hood of the sinter plant
   g) unloading of the sinter belt
   h) furnace platform in electric steel plant

The following analyses are carried out at the abovementioned locations:

   a) determination of dust particles to 5 um size (in particle s/ml)
   b) total dust concentration (in mg/m^3)
   c) determination of the inhalable proportion in the total dust quantity (in mg/m^3)
   d) chemical analysis of the dust

2. Investigation of air pollution in the vicinity of the iron and steelworks complex.

On an area whose extent is 15 km^2 a total of 22 measuring points were established at which the dust and SO_2 concentration were measured. The composition of the total dust should enable conclusions to be made as to what proportion of the emission is caused by the iron and steelworks.

3. Investigation at selected emission sources.

In order to check the conclusions made under 2. about the total air pollution it is necessary to investigate closer some main

emission sources with respect to the kind of pollutant issued.
As main emission sources

a) sintering plant
b) steelworks

were selected.

Results up to now:

A. Investigation at working places

The above mentioned working places may be devided into various categories:

1. Working places where the concentration of total dust, inhalable dust and inhalable quartz is considerable.

   This is particularly the case when pouring ladles are being broken out and relined. The total dust concentration at these places can be as high as 50 mg/Nm^3. The inhalable portion very often constitutes 30 % of the total dust. The quartz content in the fine dust varies between 20 and 35%.

   When castings are emptied out and polished in the foundry the total dust concentration is 10 - 20 mg/Nm^3 and the concentration of inhalable dusts is 10 - 25% of the total dust. The inhalable quartz can in certain cases form 40% of the fine dust.

2. Working places where the concentration of total dust and fine dust is higher, but that of inhalable quartz is relatively light.

   The working places of the coke screening plant fall into this category. The total concentration of dust can be as high as 45 mg/Nm^3, of which 10 - 20% will be inhalable dust. The concentration of inhalable quartz in the fine dust fraction is, by contrast, seldom as high as 4%.

3. Working places where the total concentration of dust is considerable, but the fine dust and inhalable quartz contents are relatively low. The working places and the sintering plant

and the electrical steel plants come into this category.

At the working places of the sintering plants total dust concentrations were found of the order of 35 mg/Nm^3. The fine dust constitutes on average 5% of the total dust. The inhalable quartz in the fine dust fraction does not exceed 4% .

In the electric steel plant the total concentrations of dust in the area near the furnace vary between 10 and 20 mg/Nm^3. The fine dust on the average amounts to 15% of the total dust. The inhalable quartz is seldom as high as 4% .

B. Investigations in the surrounding district

The figures obtained by measuring dust and SO_2 in certain places show significant variations from one investigation to another, but all the same they permit a comparative study of the differences between the amounts of dust and SO_2 collected, under well-defined conditions of wind-direction and speed.

With prevailing winds from WSW between force 2 and force 6 m/sec total dust quantities of 25 - 45 mg/day were recorded at the measuring points within the manufacturing complex. The dust-measuring points positioned 1 and 2 kilometres upwind of the main plant yielded only 5 - 10 mg/day respectively, as compared with about 15 mg of dust per day at measuring points 1 kilometre downwind.

The quantities of SO^2 recorded by the LIESEGANG-LECLERC measuring apparatus in the manufacturing complex are anything from 2 - 5 mg/day, about 2.5 mg/day at 1.5 km downwind, and about 1 mg/day at one km upwind.

The average SO_2 concentration in the iron-manufacturing complex amounts to some 130 µg/Nm^3, with maxima of 400 µg/Nm^3. 1.5 km downwind in the path of the prevailing wind the SO_2 concentrations averaged approximatively 115 µg/Nm^3 with maxima

of 300 $\mu g/Nm^3$. Two km. upwind the SO_2 concentrations averaged 60 $\mu g/Nm^3$ and the maxima were 100 $\mu g/Nm^3$.

The concentration of fine dust averaged 60 $\mu g/Nm^3$ on the site, 45 $\mu g/Nm^3$ at a distance of 1.5 km. downwind, and 20 $\mu g/Nm^3$ at a distance of 2 km. upwind.

2.1.5 Determination of health-damaging air pollutants at various working places of the iron and steel industry in the Netherlands

(Institut voor Gezondheitstechniek TNO , Delft, Study PS 189)

This investigation is aimed mainly in the measurement of siliceous dusts at places of work but it extends also in special cases to the determination of some hazardous gaseous materials.

The following working field was selected for the investigation:

- at the coke classification screening of the coking plant
- at the side of the sinter belt and the sinter unloading position
- on electric furnace platform during the process
- on breaking out of casting ladles
- on processing of firebricks with stationary separation saws and grinding arrangements
- on emptying the casing moulds as well as on cleaning and fettling of castings
- on electrical welding with different electrodes.

A large suction device[+] was used for gravimetric determination of concentration; for the numerical concentration determination a long-term (Hamilton) thermal precipitator was used. At the same time some employees carried an individual Casella air sample collector[++] during a whole or half a working day. Finally a Sinclair-Phoenix dust concentration recorder was set up in order to record the time variation of the dust concentration.

Results up to now:

- In the coking plant there was danger of silicosis [+++] at two locations out of 10 measuring locations
- investigation of the working places in the sinter plant showed that there was no danger of silicosis[+++] at any of the measuring positions
- the investigation of the working places on breaking down the pouring ladles shows an excess above the allowed limited values[+++] at almost all measuring points
- no silicosis[+++] danger was established by measurements at brick sawing and grinding machines
- on investigating the electrical welding working places the air was investigated for CO, NO_2, CO_2, and O_3 content as well as for the dust content. Apart from a single short duration CO peak the measuring results show no values in excess of the MAC values nor of the abovementioned gaseous air pollutants nor of the manganese, iron oxide and fluorides (CaF_2) found in the dust samples.

+) "Gromoz" instrument, designed by Delft with constant air throughput of 50 m^3/h and precipitating dusts on Microsorban filter.

++) The "Personal-size selecting gravimetric dust sampler" is a sample collection instrument which weighs about 1.5 kg. with an air throughput of 1.9 l /min. It has a preseparator for particles <7 µm at a density of 1 and <5 µm of a density of 2.65 (quartz).

+++) Calculated according to the formula developed by Prof.A.WINKEL of the Staubforschungsinstitut der Gewerblichen Berufsgenossenschaften, Bonn: see the first report of the CEC for the studies for technological control of air pollution in the iron and steel industry which was financially supported by the ECSC , section 2.21 (publication No.15 444/1/69/1).

2.2 Study and investigations for improvement and harmonisation of measuring technology with respect to sample collection and analysis of dusts, fumes, vapours and gases within and without iron and steelworks

Even before the first study programme had begun and especially during its execution it became clear that the multiplicity of the methods of sample collection and analysis of air pollutants have to be compared with eachother in order to discover to what extent the measurements which are made at different locations by different institutes are comparable with eachother.

These new or developed methods can then be introduced as standard methods for all investigations of air pollution in the iron and steel industry.

2.2.1 Grain analysis of dusts with grain size less than 1 µm

(Institut für Mechanische Verfahrenstechnik der Universität Karlsruhe, Study PS 157)

Many properties of solids depend on their fineness of division. Examples of this are:

separability in filters and cyclones

absorption capacity

adherence capacity on other surfaces

colour and coating power of pigments

dissolving rates

inhalability

magnetic properties

spraying capacity

sinking rate in gases and liquids

The measurement of the fineness of the solide is hence of great interest to many industries. In the grain size range above 1 µm there are a number of measuring methods which are widely used. However, only a few methods are suitable for measurements in the range below 1 µm. Moreover their accuracy and ease of working is not systematically investigated owing to experimental difficulties. Depending on the experimental methods the same material yields different results.

Methods suitable for grain sizes less than 1 µm are the light scattering methods, counting of electron microscopic photographs and sedimentation in the centrifugal field.

For optical reasons scattered light methods only operate down to 0.3 um grain size. Furthermore they are only suitable for measurement of aerosols in original state because unavoidable agglomeration of the particles on separation and deposition cannot be controlled at present.

The counting of electromicroscopic photographs is very time-consuming since in order to achieve an adequate statistical certainty very many particles - well over a thousand- must be counted.

The automatic apparatus on sale for this purpose is very expensive with resolution power not yet adequate for grain size analysis.

Sedimentation in the centrifugal field makes possible a reliable dispersion of the particles and -after development of the corresponding technology- conducting of experiments within a short time

The greatest difficulty in carrying out experiments is in the measurement of concentration of the rotating suspension.

The slightest influence on the sedimentation produces absorption measurements of electromagnetic radiation (light and gamma radiation). The present study will, for this reason, deal with the investigation of the absorption of this radiation in suspensions of very fine particles which are deposited at first in the field of gravitational force and then also in the centrifugal field. Complementary comparison measurements by alternative grain size analysis methods are necessary such as, for example, conventional sedimentation methods in the gravity field in the range 1 - 10 µm by counting of electron microscopic photographs below 1 µm. In addition the dispersion capacity is considered and investigations are carried out for sedimentation process in the centrifugal field. The purpose is to obtain quantitative data for carrying out reproducible sedimentation analysis which can be compared with other methods in the centrifugal field.

Results up to now :

Comparison experiments were carried out between an ultracentrifuge and a sedimentation balance. The material used was limestone particles in the grain size range 1 - 5 µ m.

Experiments with the sedimentation balance showed that these were not suitable in their original form for long-term experiments longer than 50 hours. It was necessary to develop a new electronic apparatus. Even after introduction of a new electronic apparatus comparison measurements did not yield any satisfactory agreement between the sedimentation balance and ultracentifuge. The reasons for this must be found by further research work. In principle the grain size determinations can be carried out by sedimentation in the centrifugal field. The experimental technology developed up to now must be built up in order to be used in routine industrial work.

2.2.2 Continuously recording measurement of the solids in gas-dust mixtures with the Konitest

(Betriebsforschungsinstitut des Vereins Deutscher Eisenhüttenleute. Study PS 159)

On using gaseous oxygen for melting steel and on flame scarfing of ingots large quantities of "brown fumes" are generated which must be collected and dust must be removed from them.

The classical discontinuous processes of dust sample collection and analyses are not suitable for industrial monitoring of the dust removal plants.

Instruments working on various principles, for the continuous measurement of the dust concentration have existed for quite a long time, but so far little is known about their suitability for use before and after the cleaning of the flue-gas from flame scarfing plants, converters and similar plants.

The purpose of this study is thus the testing and further development of a relatively simple dust measurement instrument, the "Konitest" . This appears to offer, on the basis of the earlier research work supported financially by ECSC,prospects of success in the attempted continuous measurement of the concentration of "brown fumes".

Application of the Konitest instrument with continuous sample collection of the brown (iron-oxide-laden) gas-dust mixture which occurs in the metallurgical processes requires building of a modified Konitest instrument with high gas throughput. Comparison measurements with the Microsorbanfilter downstream of the Konitest are used simultaneously for determination of the content of any toxic components of the collected dusts such as e.g. lead and arsenic.

The test experiments are carried out in a dust experimenting section with pure iron oxide fumes as well as with mixed dusts by adding e.g. lime dust as it appears in the converter fumes.

After corresponding calibration and testing of the instrument in this test section further investigations are carried out on the raw gas as well as on the clean gas side of the dust removal plants in the oxygen-blown converters and open hearth furnaces.

The measuring value in the Konitest for concentration of solids in a gas-dust mixture is the energising current. This is generated by contact electrical processes between the solid particles and an energiser tube through which the investigated gas-dust mixture is drawen. A charge partition occurs between the particles of the solid and the enegeriser tube. The charges removed from the energiser tube yield an energising current whose magnitude is 10^{-11} to 10^{-8} A, depending on the existing conditions.

In preliminary experiments in a flame scarfing plant the recordings of the energising current showed such a close sequence of separate indicator deflections that an accurate evaluation was not possible. Experiments with this system will be resumed only after the conclusion of the dust channel experiments.

In the investigations with the dust channel the flow characteristics of the energiser tube were evaluated first so that it would be suitable also for the measurement of the volume flow rate.

The investigations are carried out with the purpose of obtaining reliable characteristic curves for gas-dust mixtures with iron oxide and limestone as solids. In future different materials will also be investigated for their suitability for use as energising tube materials.

2.2. 3 Development of a microdynamic process for measurement of concentration of dusts

(Institut National de Recherche Chimique Appliquée, Paris, Study PS 162)

The purpose of this study is the development and investigation of a new process for continuous dust measurement in air or gases which is based on the determination of the kinetic energy of the dust particles in a flowing gas-dust mixture.

The instrument developed on this principle which can be designated as a microdynametric aerosol detector consists chiefly of a capacitor. One capacitor plate is a thin steel sheet. The gas-dust mixture is blown on this sheet through a nozzle. This changes the position of the sheet and with it the capacitance of the capacitor. The change of capacitance depends on the dust content of the gas-dust mixture and on the grain-size distribution of the dusts. The nozzle mentioned above can basically be of two types. On one type all the particles, large and small, are made to travel at the same speed, thus enabling measurements of dust concentrations to be made regardless of the grain-size distribution.

With the other type it is possible to make the particles strike the sheet at measurably different speeds according to their size. If the total concentration is already known from another source (e.g, from a measuring process such as previously mentioned) the figures for particle size can then be determined. The repetition of this measuring process with varied speed parameters (other nozzles) then gives the grain-size distribution. The microdynamometric aerosol detector can thus be used for measurement of the mass concentration and also as a granulometric measuring instrument. Experiments show that dust concentrations of 10-15 mg/m^3 can be measured continuously with the microdynamometric method .

2.2.4 Rapid oxidation of SO_2 to sulphuric acid in the presence of iron oxide in moist air

(Institut National de Recherche Chimique Appliquée, Paris, Study PS 163)

The total amount of SO_2 emissions from a number of processes in the iron and steel industry is quite considerable, examples of such processes being the operation of a coking plant, a sintering plant, power plants, open-hearth steel plants, annealing furnaces etc.

This SO_2 which is given off combines with emissions of dust having a high iron-oxide content. It can thus be assured that this creates certain conditions favourable to the rapid oxidation of SO_2 to sulphates. The rate of oxidation SO_2 to the considerably more aggressive SO_3 and eventual formation of H_2SO_4 in moist air is a condition for the formation of acid fogs (smog).

While the catalytic effect of iron salts in the oxidation of SO_2 solutions has been well studied, little is known about the behaviour of iron oxides when exposed to heat and moist air..

Under normal atmospheric conditions the iron-oxide is coated with a film of adsorbed water. Therefore the oxidation of SO_2 solutions in the presence of iron-oxide suspensions was investigated on a laboratory scale in the course of the present study. In SO_2 concentrations of 2 - 3 millimols per litre -which corresponds to a solution in equilibrium with a heavily-polluted atmosphere- the oxidation of approximately 90% of the SO_2 content was observed to take place within a few hours, viz. in the presence of Fe_2O_3 annealed at 700 - 1000° C. The very slow rate of oxidation when the reagents are first brought into contact increases as the iron ions go into solution.

From the following reaction mechanism may be postulated:

- Attack of the Fe_2O_3 through the SO_2 solution and the formation of ferrous salts
- catalytic oxidation of SO_2 in the presence of dissolved ferrous salt

As the pH value was lowered (in experiments with SO_2 and H_2SO_4 solutions) a reduction was observed in the rate of this oxidation. A similar effect of the degree of acidity had previously been observed elsewhere when investigating oxidation in the presence of ferrous and manganese salts.

3. Investigation of the relationship between dust content and pollutants Pb, Zn, SO_2 in the sinter waste gas on the application and operating conditions of a sinter plant

(Rheinstahl AG - Schalker Verein, Study PS 218)

The control of air pollution by dusts and gases emitted by the sinter plants of the iron and steel industry presents a number of technological and economical problems.

One of these problems is the dependence of the dust content and the physical properties of the dust in the sinter waste gases on the application and operating conditions of the sinter plant.

The main purpose of this investigation is hence to evaluate favourable operating conditions which will lead to a reduction of the dust emission.

The basis of the investigation is hence an extensive measuring programme. The investigations are carried out by taking into account:

composition of the sinter mixture

rust layer

layer thickness

sinter belt speed etc.

The following investigations are carried out:

Measurement of the dust content in the waste gas (before and after cleaning in the cyclone separators)

Measurement of the electrical resistance, the wetting properties and granular composition of the dust (with regard to the dust separation by electrical dust separating process)

Measurement of the pollutants SO_2, SO_3, Pb and Zn.

Results up to now:

It was established that a high proportion of the flue dust and oxidising losses in the sinter mixture lead to higher dust content in raw and clean gas. The higher dust content of the clean gas is based, in addition to the raw gas dust content, also on the reduced separation efficiency of the cyclone dust separator at these dust proportions.

A start will be made with the measurement of the pollutants SO_2, SO_3, Pb and Zn shortly after some basic changes in the methods of operating of the sinter plant are completed.

3.1. Evaluation of the kind and quantity of the emission on operation of open-hearth furnaces in relation to the melting process

(Betriebsforschungsinstitut des Vereins Deutscher Hüttenleute, Düsseldorf, Study PS 215)

The commercial need for increasing the smelting capacity of the open-hearth furnace runs directly counter to the increasingly stringent official regulations of the limiting of emissions which pollute the atmosphere.

There are technical and commercial obstacles to the construction and operation of expensive plants for cleaning waste gases, particularly in older open-hearth steel plants, which would call into question the future use of these smelting units, and therefore attempts must be made to achieve an adequate reduction of emissions through certain modifications of the process.

But to achieve this -which is the object of this research- calls for a more precise knowledge of the characteristic values governing the nature and amount of the emissions.

From earlier experiments the following are known as significant influencing factors:

- furnace performance
- checker heating chamber condition
- cross section and length of flue gas path
- scrap composition
- oxygen for the refining process.

The effect of refining with gaseous oxygen is not investigated by this study, since with open-hearth furnaces operated in this way it is essential to de-dust the abundant emission of brown smoke. On the other hand particular attention is to be given to the composition of scrap.

It is also intended to measure the concentrations of SO_2 and nitrous oxides in the exhaust gas stack as well as the dust content of the exhaust gases from the open-hearth furnace. These measurements will be carried out at each stage of the process (charging, melting and boiling).

4. Reduction of the danger level of the dusts, fumes, vapours or gases which are unavoidably generated in certain processes.

Even though the iron and steel industry makes efforts to prevent or reduce generation of dangerous air pollutants at the source these efforts will meet their limitations. If it is not possible to change the technological process to such an extent, or if it is not economical to select process conditions in such a manner that damaging emissions can be avoided, then, in order to protect the environment, these emissions must be collected and converted in such a manner that they can be either reused without danger or they can be deposited at suitable locations so that they do not endanger the invironment.

4.1 Neutralisation of cyanide bearing dusts, slurries and waste water from blast furnace gas cleaning

(Hessische Berg-und Hüttenwerke AG, Wetzlar, Study PS 183)

On making pig iron in blast furnaces a gas is generated which must be thoroughly cleaned of dust not only before its utilisation as fuel for gas engines and for heating but also before burning at the flare stack in the atmosphere.

In the case of finish cleaning processes which are used nowadays for this purpose (mostly wet scrubbing in electric filters or dry cleaning in bag filters) a dust generation of 5 - 15 g/Nm^3 of blast furnace gas or about 1 - 5% of the pig iron quantity produced must be reckoned with.

These dusts contain, depending on the pig iron schedule or blast furnace campaign, 0.1 to 1% KCN and NaCN (cyanide). They are at present deposited on dumps by all iron and steelworks in wet or dry form. From the viewpoint of hygiene this is, however, extremely undesirable because the poisonous cyanide compounds can reach the groundwater and hence also the drinking water supply. The same is valid for diverting of cyanide-containing scrubbing water into draining ponds or rivers.

Hence means must be found which are satisfactory from the point of view of hygiene and economy for reduction of these dangers.

The discovery of suitable means and their development into fully operational state for reducing the hazardous nature of the cyanide-bearing dusts, slurries and sewage which are involved in the cleaning of blast furnace gases form the purpose of this investigation

The following solution appeared to offer the best prospects on the basis of studies and preliminary investigations:

a) dewatering of the blast furnace gas slurry to minimise possible water content

b) subsequent thermal treatment of the dewatered slurry

The dewatering is carried out in a chamber filter process. At a pressure of 15 Kg/cm^2 the residual water content reached can be about 25% depending on the composition of the solids. Experiments on heat treatment of the dewatered sludge were carried out in an oilfired heating drum. It was seen that a cyanide content of about 1500 mg/kg slurry could be reduced by a heat treatment at 750°C and a treatment time of about 30 minutes to a residual cyanide content of less than 5 mg/kg slurry. Leaching out experiments with this heat-treated material yielded a total cyanide content in the leaching liquid of 0.1 mg/l maximum.

An increase of the heat treatment temperature above 750°C did not yield any significantly lower residual cyanide content. At temperatures of about 1050°C sintering and the formation of lumps started in the drum. - The large scale application of the heat treatment of blast furnace gas slurry requires still further investigation, especially with respect to the optimum construction of the heating furnace and with respect to the manipulation of the blast furnace gas slurry before charging in the heat treatment furnace. The investigations carried out show, however, that a heat treatment process is basically suitable for decyanising of the slurries formed in blast furnace gas cleaning by a wet method to such an extent that the residual materials can be dumped without any danger.

5. Collection and precipitation of dusts, vapours or gases at or near their place of generation

A number of technological processes cannot be carried out at the moment in such a manner that the development of air pollutants could be avoided from the start.

In addition to the study of basic problems of dust generation and dust control an appreciable proportion of the financial resources earmarked for dust control in the iron and steel industry is utilised for development, building and testing of large scale operational plants and processes whose purpose is to collect and as far as possible to precipitate dusts, vapours or gases as near as possible to the location of their generation.

5.1 Application and development of a special coke quenching car to fully operational state

(Italsider S.P.A., Genoa, Study PS 193)

Air polluting coking plant emissions occur chiefly on filling of coke ovens as well as on pushing and quenching the coke.

On applying different processes it has become possible in recent years to reduce appreciably the emissions ocurring in filling the ovens and on quenching the coke. However, the attempts to control the especially marked air pollution which occurs on pushing the coke and on its transport to the quenching tower have not been successful.

This unsatisfactory state of affairs was to have been remedied by this investigation.

Its purpose was to apply and to develop to fully operational state a coke quenching machine (special car for coke quenching) which has not been built yet anywhere. This car combines the functions of the coke transporter, the quenching car with locomotive, the quenching tower, coke ramp and the coke quenching water clarification plant. It removes in a closed system most of the dust from the exhaust gases in a scrubber or in a dry dust remover before their exit into the atmosphere.

This machine was to remove and precipitate the dust particles and tar-mist generated at the ramming and quenching stages.

The machine consists basically of :

- door lifter with electrical or pneumatic door locking as well as cleaning arrangements for doors and chamber frames
- extending coke transporter
- container for the pushed out coke
- rotating quenching drum with scrubbing arrangement
- dust remover
- coke remover
- multiaxle chassis
- central driver position

Various details of the planned plant are already known but they have not been tested in the combination now prescribed and not under the conditions described here. The questions to be answered by the study are especially the following, taking into account functional suitability, coke quality and economy:

- most advantageous ducting of flue gases and quenching vapours
- best possible sealing of the system
- most useful design, mechanical equipment and material of the coke collecting container
- optimal dimensioning, inclination and rotating speed of the quenching drum
- must suitable positioning of the quenching nozzle system
- most advantageous coke removal
- dust removing efficiency achieved
- improvement obtained in the dust emission.

Unfortunately this research did not get beyond the planning stage, because of special difficulties (mainly accomodation problems and problems of alignment and maintenance of rails for the coke quenching machine) in the existing coking plant.

These difficulties and the solutions proposed for overcoming them by the machine designer are being considered separately by the two parties (maker and user).

At the time of writing these lines, July 1972, it must be assumed that ITALSIDER'S investigation will not be continued. Nevertheless the ideas developed by the manufacturer of the coke-quenching machine, H. KOPPERS, in Essen/Ruhr, are still thought to be of interest by the experts of the Commission of the European Communities. It therefore seems possible that there are other companies in existance who are willing to take up this investigation and complete it.

5.2 Improvement of scrubbing of CO rich waste gases from LDAC converters

(Hoesch Hüttenwerke AG, Werk Phoenix,Dortmund-Hoerde, Study PS 132)

This study is the continuation of the investigations and work which were carried out with the support of the ECSC within the framework of the first study programme of the Dortmund-Hörder Hüttenunion under the title "Scrubbing of the LDAC converter waste gases with suction before combustion".

The problems which are to be solved now are specially:

- Improvement of water separation upstream of the exhauster or before the outlet of the waste gases into the atmosphere,

- optimisation of steam blowing, which has been only provisionally fitted up to now, with the purpose of reducing the steam consumption or for reducing the load on the suction system and perhaps for using a smaller suction system; for this purpose investigations of the physical processes and the establishment of calculation data are carried out;

- dust removing investigations with a single annular element with steam blowing,
- determination of the combustion properties of the waste gases at the flare stack by reserving steam blowing for the purpose of emitting minimum possible quantities of CO,
- evaluation of the cause of the phenomenon of absence of wear of the boiler tubes -apart from the mechanical wear at certain locations- in the waste heat boiler on the waste gas side in the plant at HOERDE,
- improvement of the process of slurry dewatering with a recently developed coarse slurry drier.

The converter waste gases are collected into a water cooled conical gas collecting hood and ducted over the converter stack into a preliminary scrubber into which water is sprayed through swirler sprayers. The final scrubber has a venturi tube and a single swirler nozzle which is connected to the narrowest part of the venturi tube. This nozzle sprays a curtain of water against the waste gas stream. Steam is blown into the inlet diffuser of the venturi tube in the direction of the flow through an injecting Laval nozzle.

This combination has proved itself as the simplest and most effective method for maintaining the clean gas with a maximum dust content of 150 mg/Nm^3 , as required by the competent authorities.

The best scrubbing efficiency was found for a certain "optimum" position of the Laval steam nozzle. Further investigations should explain the influence of the venturi tube geometry on the extent of dust removal.

The replacement of the venturi tube by an annular slot scrubber showed unfavourable dust removal efficiencies. This can be assumedly ascribed to the fact that in the preliminary scrubber the injected water can only be inadequately separated downstream of the final scrubber.

Adequate water removal is the basic condition for faultless functioning of the annular scrubber. The investigation of the annular slot scrubber for replacing the venturi tube was not pursued any further since water separation by the existing plant cannot be improved owing to the geometrical relationships.

The converter waste gas contains varying quantities of CO. As much as possible must be removed by the time the gas leaves the flare stack. The effect of the high water content is such that the waste gas does not burn at lower CO contents. Long term experiments with different water separation systems led finally to installation of an axial flow water separator below the flare mouth. The water separation could be improved by this to such an extent that about 50% of the total CO in the waste gas could be burnt.

The scrubbing requires an extensive slurry and water treatment plant, In the existing plant the fine slurry is separated in a circular flocculator, dewatered in two vacuum filter drums and pelletised in a rotating tubular furnace. These dust pellets are used in the sinter plant. To the pellets which come from the rotating tubular furnace is added the coarse slurry which is removed before the circular flocculators in a gravity separator. A dewatering drum with internal blades for lifting out of the dewatered slurry was developed.

5.3 Dust removal from CO_2-containing waste gases from oxygen blowing converters by means of electric filters

(Stahlwerke Peine-Salzgitter AG,Werk Salzgitter, Study PS 199)

In order to keep the costs of dust removing plant used for prevention of air pollution by oxygen blowing converters as well

as its operating costs as low as possible methods were worked out which make it possible to prevent the access of air by suitable collection and suction of the converter gases. This also prevents the combustion which leads to a temperature and/or volume increase of the flue gases to be cleaned.

Owing to the explosion danger of the CO-containing gases collected in this manner only scrubbers have been used up to now. However, for precipitation of the converter fumes, these wet scrubbers require a great deal of power and expensive water and slurry tratment is necessary.

In thoroughgoing experiments with a 3 t experimental converter it became possible to develop a method which even at abnormal charging variation appears to work safely with a dry electric filter even with converter gases with high CO content.

The transfer of these experiments to industrial scale forms the object of the present study.

On normal charging it is expected that owing to the steelmaking process in connection with a constant waste gasflow rate due to suction no gas mixtures which could present an explosion hazard occur in the whole plant.

In case of faulty operation, for example interruption of the blowing process at the point of the maximum carbon burnout rate (entry of large quantities of air into the exhausting system, filled with CO rich gas) or ignition lag at the start of blowing (enrichment of the exhausting system with oxygen and subsequent entry of spontaneously generated large quantities of CO rich gas), the possibility of occurence of explosive gas mixtures must be considered. For this safety measures are used which prevent danger to personnel and destruction of the plant by explosion.

The following questions are asked about the dust removing plant which is subject to this study:

1. what is the effect of the new straight form of the cooling stack lower part without gas collecting hood on operating with suppressed combustion on gas removal by induced draught ?

2. At which point can the first water injection point for optimal conditioning of waste gas be built without suppressing the further reaction of the converter gas-air mixture by using temperatures lower than ignition temperature?

3. To what extent is the oxygen of the entrained air consumed on suppressed combustion in the cooling stack?

4. Are separate gas streams formed in the gas flow path?

5. What is the gas composition with regard to inertisation in relation to the temperature of the gas before water injection at the inlet to the electric filter?

6. What is the gas composition at various parts of the plant in the framework of disturbances intentionally introduced into the test programme?

7. Can the generation of the oxygen bubbles during the blowing process be prevented by monitoring of the slag viscosity?

8. Is it necessary to use additional extraneous inertisation at the beginning and end of each blowing period?

9. What measure must be taken with respect to the switching on duration and the switching on time of the blowing in order to prevent formation of explosive gas during the blowing pauses?

10. What is the effect of operational contamination on the flow properties of the flue gases in the critical locations of the gas path?

11. How do the test gases detrrmined in 6 behave in laboratory tests on introducing an ignition source under given operating conditions?

12. How are the explosion limits and combustion rates of the $CO-H_2-O_2$ gas mixture changed in relation to temperature, pressure, water vapour and dust content?

13. At what gas composition, especially at what H_2O proportion is the flare-stack ignited, and what is the influence of the ignition potential?

14. How does the development of dust behave with respect to quantity, chemical composition, grain distribution etc. during a charge in relation to the process?

15. To what extent is the collected dust pyrophoric and how does this influence its transport?

16. How does the moisture content of the dust separated in the filter influence its transportability and how can a continuous control and also recording of the moisture content be carried out?

The first investigations deal with the effects of the cooling stack lower part which is inclined to the converter axis on the gas removal by suction. For the two conditions:

a) as limited as possible combustion of CO-containing converter gases, i.e. the minimum access of air to the gases, and

b) prevention of spreading of the converter gases into the converter hall

a compromise solution must be found.

A minimum air factor $n = 0.3$ at which the whole converter gas can be collected without overflow was established by experiments.

The possibility of reducing the air factor still further by blocking air suction and for obtaining thence the theoretical minimum gas quantity for the dust removing system was deliberately not pursued since this process at present is associated with appreciable problems with respect to the life of the necessary outer and inner hoods and with respect to the suction control.

The first operational experiments are carried out with a tubular electrode filter with four parallel connected fields.

Explosions occurred repeatedly during this work. It was realised that the main cause of this was the uneven flow distribution in the filter.

The arrangements used for protection against explosions were effective; the uneven flow distribution, however resulted in an unsatisfactory degree of dust removal.

Since attempts to improve flow distribution significantly were not successful it was not possible to guarantee the legally required clean gas maximum dust content of 150 mg/Nm^3 on continuous operation.

Further investigations were hence carried out with a three stage plate electrode filter.

An uneven flow distribution was also detected in the filter.

The ratio of the raw gas duct cross section to the free filter area was 1: 19.4. Since no improvements were achieved in the flow distribution by modifications to the filter inlet the conical transition piece of the raw gas duct before the

filter was expanded so that the ratio of the areas at the filter inlet is 1: 8.8 . The measurements gave the following dust contents:

Electric fields in operation	Steelmaking process LD mg/Nm^3	Steelmaking process LDAC mg/Nm^3
1+2+3	70.7	59.8
1+2	161.5	146.8
1+3	97.0	77.0
2+3	115.5	81.0

These are average values over a complete charge. After the removal of a bypass flow in the Redler channel which has a bad influence on the dust removal it was possible to achieve even the following values in the acceptance test:

		LD	LDAC
Raw gas dust content	g/Nm^3	124	121
Clean gas dust content	mg/Nm^3	23.4	12.3

These values show that the requirements of the competent authorities can be satisfied in all cases with the three stage electric filter. Even in case of failure of a field the separation performance is still adequate. In contrast, in a 4 field tubular electrode filter the clear gas dust content reached was 12 g/Nm^3 when one of the fields failed.

These results have led to the decision to replace the tubular electric filter by a 3 stage plate electrode filter.

5.4 Removal and combustion of CO-rich waste gases generated in austenitic process arc furnaces on refining with gaseous oxygen. Cooling of these gases and their cleaning by bag filters

(Gebr.Böhler & Co. AG, Düsseldorf, Study PS 160)

On refining austenite with gaseous oxygen in the arc furnaces an especially large quantity of brown fumes is generated. This is associated with very high gas temperatures and with very high proportion of CO. A technologically and economically satisfactory practical solution of the problem of dust removal from such arc furnace flue gases has not been known up to now.

Scrubbing methods require a bulky and expensive slurry treatment, In addition they cannot be allowed to flow out into the open without further consideration owing to discontinuous operationsince at outside temperatures below zero there exists a serious danger of frost damage.

Of the dry separation methods, cyclones have to be excluded because they are not able to separate fine particles of the brown fumes adequately.

In the case of an electric filter the danger of ignition of explosive gas mixtures must be considered.

Fabric filters do not have any of the abovementioned disadvantages; however, they are sensitive to higher temperature (burning, disintegration) and mechanical loads (tearing, abrasion) as well as against temperatures below dew point (clogging, adhesion).

Apart from the difficulties of the actual dust removal there exist technological and economical problems of a special nature in transporting the very hot flue gases from the furnace to the dust removal plant under the given conditions.

The purpose of this study is the testing and development to fully operational state of a bag filter plant including the ducting leading from the furnace to the filter in which a purified gas dust content of 150 mg/Nm^3 or less can be guaranteed.

The plant in which the research work is carried out operates as follows:

The hot CO-containing fumes are sucked away from the domed cover. The quantity to be removed this way is determined by the hearth chamber pressure. The fumes must be cooled before they reach the fabric filter. This cooling is carried out in a regenerative manner in two ceramic coolers which in principle are comparable with Cowpers for blast furnace blast heating. This cooling and cleaning plant is used as a common dust removing plant for 2 arc furnaces (20t and 10t); the arc furnaces make austenitic steels.

Results up to now :

It appeared necessary to line larger areas of the flue gas duct with fireproof lining in order to prevent destruction of ducting by the action of heat.

A water-cooled regulating valve in the ducting bend could not resist the temperatures due to oxygen refining. It was replaced by a water-cooled sliding valve which is completely withdrawn from the gas stream at the time when the maximum temperature occurs.

It was seen that the cooling action of the ceramic cooler must be regulated over a wide range. An inadequately regulated cooler enables the temperature peaks to be accomodated but at times of low heat input it passes too cold a flue gas into the bag filter so that temperatures will fall below the dew point.

This situation was remedied by swiching over the cooler not at fixed intervals of time but in relation to the temperature of the gases downstream of the cooler.

Lime particles in the dust led at first to difficulties with the filter fabrics used. In the end filter cloths made from flameproofed polyester fabric appeared the least liable to faults. This fabric can withstand temperatures up to 150°C.

The clean gas dust contents achieved were less than 50 mg/Nm^3. The gas temperatures in the filter were 50 - 100°C.

5.5 Removal of the solvents in the waste air from strip coating plants

(Stahlwerke Peine-Salzgitter AG, Werke Salzgitter, Study PS 212)

The purpose of the study is to test and develop to the fully operational state a new process for elimination of solvents in the waste air from a strip coating drying oven.

In the strip coating plant to be investigated the coating of wide strip is carried out in two stages in which the first stage is used for basic coating and the second stage is used for finish coating. Each stage is terminated by a drying oven. The drying oven consists of four zones, i.e. the required partial quantity of air has to be heated four times in the oven; part of its heat is transferred to the belt, the solvent is absorbed and drawn away.The solvents evaporate mainly

in the first two zones of the oven.

In the interests of safety at work and working hygiene the waste air which is loaded with solvents must not be ducted directly into the atmosphere. The solvents can be burnt directly at high temperatures or catalytically at lower temperatures and then exhausted into the atmosphere. In order to improve economy a catalytic afterburner system is installed since the reaction temperatures in this case are much lower and hence the heat supply for heating the outlet air is lower than in the case of direct combustion.

Up to now the heat exchanger has been installed for preheating the fresh air and the heat in the waste air has been recovered. In this case each zone has its own afterburning system.

In the coating plant which is to be investigated only one afterburner system is used for two zones of the drying oven and a part of the cleaned air is recycled to the oven in order to improve economy with respect to the investment costs and heat recovery.

The study is intended to provide an answer especially for the following questions which are of decisive importance for the practical application of the decribed process:

1. How large can the quantity of recirculated air be so that the H_2O and CO_2 concentrations in the furnace will not have a damaging effect on the surface quality of the coated strip?

2. How great is the extent of maximum recirculation in relation to various adhesives and solvents, disturbances in the afterburner system and the delay period of the measuring and control system so that no danger of explosion can occur?

A final solution has so far no yet been found for the oven pressure control system. A 50% fume gas recirculation is attempted. At first it was attempted to control the economic performance of the oven by an oven pressure regulation with the adjustable magnitude "fresh air supply".

The whole oven hall must be kept under excess pressure owing to the requirement for dust-free environmental air for the coated steel strip. Pressure variations in the hall cause either large uncontrolled quantities of air to flow into the oven or solvent-bearing air to reach the hall from the oven. At present it is attempted to control the fume gas economy of the oven by balancing the gas quantities at the oven inlet and outlet. Evaluation of the explosive limits in the various fume gas mixtures has not been possible up to now.

5.6 Removal of the fumes generated on welding by induced draught

(Ministry for Social and Peoples Health of Netherlands, General Directorate Work, Voorburg, Study PS 77)

On electrical welding are generated fumes from very fine dust. This dust is formed in the arc and it consists mainly of iron, iron oxide and dusts which originate from the electrode coating. Additional extraneous materials are developed on welding of steel plates which are covered with a zinc-bearing primer for protection against corrosion.

Welders complain of great discomfort due to welding fumes, especially during welding in enclosed rooms.

The purpose of this study is to establish acceptable conditions for welders by removing welding fumes by means of induced draught.

Measurement of air pollutants in the breathing zone of the welder should prove the success of the development work. A suction plant which appears most suitable for the given purpose draws welding fumes directly from the position where they are generated and either passes them through a filter into surrounding air or the unfiltered welding fumes are ducted away from the building and exhausted at some other location.

Results up to now:

The experiments with direct filtering of the sucked welding fumes were not successful. The filtering material available had to be replaced after using about 20 electrodes, otherwise the flow resistance of the filter became so high that the necessary exhaust fan became too heavy for a transportable arrangement.

Ultimately a suction hood was developed which could be attached with magnets directly to the welding location. The welding fumes are transported by a hose to a fan and exhausted into the open atmosphere. The suction hood is about 8 m/s. The quantity transported by the fan is 7.5 m^3/min. The suction hood is effective over a radius of 35 - 50 cm.

Subsequently a common suction plant is going to be developed for a number of working positions. In this case it is necessary to investigate whether the sucked-away welding fumes can then be exhausted into the atmosphere in an unfiltered state.

6. Studies and investigations for improving the knowledge of the collection and separation of dusts, fumes, vapours and gases

The influence of various chemical or physical conditions on the dust removal and gas purification processes in many cases requires thorough theoretical investigations. In a number of the processes applied at present the equipment and operation of the full scale plants are determined by empirically evaluated data. In order to achieve an optimum mode of operation and the economically best solution it is unavoidable that these empirically evaluated principles are confirmed and supplemented by investigation of the theoretical relationships.

6.1 Fluorine separation in dry dust removing process of CO-laden waste gases in steelmaking

(Friedr. Krupp GmbH - Forschungsinstitut, Study PS 180)

The complete combustion of CO-containing gases generated on steelmaking in a converter generates in turn large quantities of hot waste gases. Dust removal from these requires large and consequently expensive plants.

In order to reduce these disadvantages the access of air is reduced in a minimum gas process or in a process with suppressed combustion with the result that the combustion is largely or to a certain extent suppressed; in this case smaller quantities of waste gases require dust removal which results in reduction in the space and outlay in the necessary plant.

The wet process of cleaning CO-containing waste gases was used almost exclusively first. This was because of its greater safety against explosion which in comparison with the dry dust removing process requires a larger quantity and additional plant for slurry water treatment.In any case there is practically

no danger in this plant that fluorine-containing particles can reach the atmosphere.

Clarification of the fluorine problem assumes special importance since meanwhile knowledge has been gained which makes dust removal possible by a dry method which is free of explosion hazard even for unburnt or partially burnt converter gases.

It can be assumed that on addition of fluorspar during the blowing process a proportion of the escaping fluorine or hydrofluoric gas is deposited on the dust.

The purpose of this study is to establish to what extent the fluorine is held by the dust by the CO-containing flue gases in the various converter steelmaking processes and what proportion can be separated by a dry dust removing process using an electric filter.

The investigations necessary for achieving this purpose are mainly

a) analysis of the gases and dusts in the raw and clean gas

b) analysis of the separated dusts

c) determination of the separation efficiency for dusts, fluorine and fluoride.

The experiments were carried out in a top blowing converter of 3 t capacity. Dust is removed from the waste gas in a scrubbing plant. A tubular electrode filter for dry extraction is fitted into the ducting which bypasses the main dust extractor. The waste gas plant makes possible the adjustment to suppressed or full combustion.

Results up to now:

The first investigations were made for the selection of suitable sample collection and analysis methods. The samples for gas analysis and dust investigation were collected separately from the gas stream. The fluorine balance established by the analyses showed a maximum error of 10%. This shows that the selected methods for sample collection and analysis are basically suitable for the investigations specified.

Further experiments should give information about whether the main gasstream and the bypass stream have the same gas composition and dust content in order to investigate the fluorine-containing waste gas components which are separated by the electric filter from the bypass flow.

6.2 Filtering at high temperatures through fibre filters

(Institut National de Recherche Chimique Appliquée, Paris, Study PS 165)

At the present state of gas cleaning technology hot gases must in general be cooled at first below 150° C before they can be passed through fibre filters.

Filtering of the flue gases in ceramic, glass fibre, carbon and zinc filters at higher temperatures would have the following advantages:

1. The expenses for waste gas cooling can be reduced
2. The hotter waste gases have a higher buoyancy. This enables the emissions to be better distributed in the atmosphere under otherwise equal technological conditions.

The purpose of this study is to investigate theoretically and practically the reliability of fibre filters at higher temperatures, about which little is known at present.

In the framework of the study a test rig had first to be developed and built for high temperature filtering. The following problems had to be solved in this case:

In contrast to investigations at normal temperature special measures have to be taken in a test rig for a high temperature filter in order to ensure that upstream and downstream of the filter there are as large as possible isothermal zones. Isothermal conditions are necessary in order to eliminate concentration variations due to thermophoresis i.e. deposition due to temperature differences. In order to avoid sedimentation the ratio between the length anddiameter of the test rig must be made as small as possible.

Owing to the requirement of the isothermal conditions the test rig must however, be accomodated into as long as possible heated room (oven); these are requirements which are not simultaneously satisfied.

Since the sedimentation laws are known, attention must mainly be paid to isothermal conditions on the design of the test rig.

Leakages in the filter or between the filter and the filter housing have especially adverse effect owing to the necessarily small dimensions of a test rig so that special attention must be paid to the sealing.

It was possible to evaluate a number of relationships by means of this study. The degree of separation is reduced at rising temperature at constant flow speed; if,however, the energy consumption of the filter is reduced at rising temperature then the degree of separation is increased with increasing temperature.

For example, at constant flow speed a glass fibre filter retains 70% of the iron oxide control aerosol at a temperature of 20° C, but only 40% at 330° C.

However, if the energy consumption, i.e. the Reynolds number, is held constant (which leads to an increase in the flow speed as the temperature increases) an increase is observed in the degree of separation as the temperature increases, from 70% at 20° C to as much as 82% at 330° C. However, the study was unable to establish a theoretically satisfactory formula relating the variation in pressure loss to variation in temperature.

7. Studies and investigations for extending the knowledge about the principles of personal dust and gas protection

In factories and at jobs where extraneous materials are unavoidably generated in health-damaging concentrations and which can reach breathing air but where effective collective measures are not possible the persons employed must be protected by a suitable equipment for personal protection against damage. It is very important that the user of such items of equipment for personal protection should be able to rely on their efficiency.

7.1 Investigation of the efficiency of the personal protective filter equipment against gases and vapours

(Institut de Recherche Chimique Appliquée, Study PS 168)

Protective masks with filter cartridges are frequently used as personal breathing protection.

The purpose of the study is to develop a method which enables the efficiency of various types and makes of filter cartridges for breathing protection masks to be tested. The method to be developed must be easy to operate and above all it must provide reproducible results.

The problem was solved in two steps:

1. Establishment of certain investigation standards. The investigation conditions were established by considering the absorption of the poisonous materials in an air stream on activated carbon. It was attempted to match the investigation conditions as closely as possible to the actual conditions of a working place.

The following experimental conditions were established:

1.1 Air throughput through the investigated filter cartridge 30 m/min and 180 l/min

1.2 Air temperature 25° C.

1.3 Air moisture content 30% and 80%

1.4 Poisonous material concentration 1 g/m^3 and 5 g/m^3

2. Development of a test rig

A test rig was developed which enabled the experimental conditions listed above to be adjusted and maintained with precision.

The pollutant concentration downstream of the filter-cartridge was measured with Dräger test tubes. At concentrations approaching the maximum permitted value for a working place (MAC value) these test tubes give quite useful and reproducible values.

The following criteria are hence found for judging the filter cartridges:

a) Harmful material concentration in the filtered air in relation to the duration of the air throughput

b) Maximum harmful material quantity absorbed by the filter.

A large number of filter cartridges were investigated in the test rig.

Air pollution control in the iron and steel industries

8. SUMMARY

From the beginning of 1969 up to the middle of 1972, some 2.5 m units of account are made available for 36 projects under the second 5-year ECSC research programme for air pollution control in the iron and steel industry. Of this sum 84% was assigned to 19 applied research projects and 16% to 17 projects qualifying as basic research.

An account is given of the results obtained to date from 21 projects, most of which, however, have not yet been completed.

In the field of applied research five projects are concerned with determining the type and extent of air pollution in iron and steelworks or their immediate vicinity.

An interim result of this research which can already be established is that all those whose objective is the reduction of air pollution by ironworks will continue for some time yet to focus their attention on the problem of emissions from coking plants.

To obtain generally valid information on the extent of emissions which would lead, if possible, to recommendations for the limitation of these emissions, careful coordination of research done in this field will be necessary, together with critical comparison of its findings.

Two research projects are under way for the prevention or limitation of dust, fumes, vapours or gases.

Both projects are still in the initial stage and it is precisely at this juncture that measures which might prevent

emissions are often found to require wide-ranging changes to the basic methods of a manufacturing process, the later consequences of which must first be investigated in great detail.

One of the projects is concerned with reducing the hazard presented by dust, fumes vapours or gases arising out of certain working processes.

This research, aimed at converting into biologically harmless materials the waste substances with a cyanide content which are inevitably generated during the blast furnace process has revealed certain basic methods which might be applied to the solution of this problem. Considerable technical experiments are still essential, however, before an economically viable solution can be put forward.

Six projects are presented which are connected with the collection of dust, fumes or gases at the place they arise or close to it.

One of these investigates possibilities of reducing emissions from coking plants during pressing and quenching of the coke.- A theoretical method of eliminating these emissions was devised but could unfortunately not be put into practice because of restrictions imposed by the special conditions prevailing at the site provided for the experiment.

Three projects are concerned with control of the "brown fumes" arising during steel production. Three different de-dusting systems are being examined: wet de-dusting, dry de-dusting by means of an electrostatic filter and bag filtering. All three systems can today be equipped so that dust contents in clean gas are less than 150 Nm^3, i.e. below the maximum admissible level. This research, however, still has a considerable number of questions

to solve in connection with the adaptation of filtering apparatuses to the requirement of specific technical procedures.

One project is concentrating on the elimination of solvents from the exhaust air of a strip-coating plant. The solvents are burned by catalysis. Research is still continuing on the effect of varnish components as catalyst poison and the avoidance of explosive gas mixtures in the exhaust air.

Under another project extractor cowls were developed, through which the fumes given off during electric welding can be exhausted and safely led off.

Three projects under the basic research programme are devoted to dust sampling and analysis in the iron and steel industry.- One of these is concerned with particle size analysis techniques for fine dusts with a particle size of less than 1 um. The techniques investigated so far can only be applied on an experimental scale.

Another is devoted to the further development of a continuous dust emission monitor, as there is to date no robust device suitable for use as a continuous particle size dust monitor.

The third project in this field has resulted in the experimental development of a procedure based on the continuous measurement of the kinetic energy of dust particles in gas flows.

One project is investigating the fast oxidation of SO_2 to SO_3 in the presence of metal oxides.

Investigation of the principles for dust separation and collection is the subject of two projects.- One of these is experimenting with the separation of fluoride by dry de-dusting of high CO content waste gases produced during steel manufacture.

The second research project in this group deals with high-temperature filtering procedures. Research under the first programme has shown that improved knowledge of the theoretical principles of high temperature filtering could be extremely useful in carrying out practical experiments in large-scale technical plants.

One project was devoted to the question of personal protection against dust and gas. Test equipment was devised to check the suitability of various personal breathing apparatuses for industrial use.

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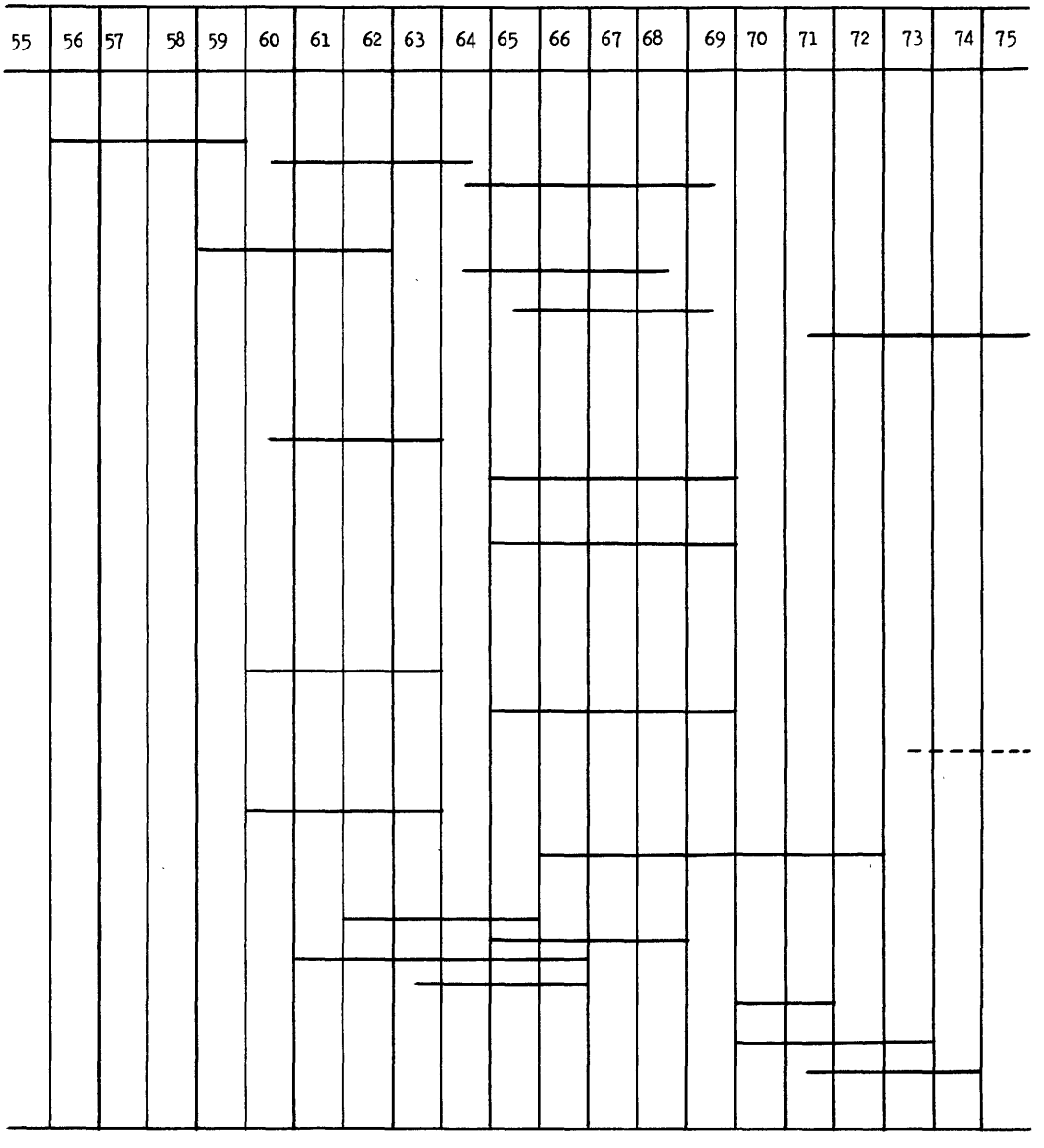
ANNEXES

PROGRAMME OF RESEARCH IN INDUSTRIAL MEDICINE, HYGIENE AND SAFETY, UP TO 31 DECEMBER 1971

Field covered and designation	Decision of :	Budget (round figures, in units of account)	
		Total budget	Research contracts signed
A - INDUSTRIAL MEDICINE AND HYGIENE			
a) Physiopathology and clinical medicine			
1st programme (industrial medicine)	5-10-1955	1 200 000	1 200 000
2nd programme (industrial medicine)	7- 4-1960	2 800 000	2 856 000
3rd programme (physiopathology and clinical medicine)	28- 4-1964	3 000 000	2 680 000
b) Traumatology and rehabilitation			
1st programme (rehabilitation) (1)	5-12-1957	500 000	500 000
2nd programme (traumatology and rehabilitation)	19- 6-1964	1 800 000	1 100 000
3rd programme (burns)	18- 5-1966	1 500 000	560 000
4th programme (chronic respiratory dideases)	13-10-1970	2 500 000	60 000
			8 956 000
B - INDUSTRIAL PHYSIOLOGY AND PSYCHOLOGY			
a) Human factors and safety			
1st programme (human factors and safety) (1)	5-12-1957	1 000 000	1 000 000
2nd programme (human factors and safety) (2)	4-11-1964	1 200 000	
b) Ergonomics			2 416 000
1st programme (physiology and organization of work) (2)	4-11-1964	2 000 000	
			3 416 000
C - INDUSTRIAL HYGIENE			
a) Measures against dust in mines			
1st programme (technical measures against dust in mines) (1)	5-12-1957	900 000	900 000
2nd programme (technical measures against dust in mines)	21-12-1964	6 000 000	5 236 000
3rd programme (health in mines)	28- 7-1971	4 500 000	-
b) Technical measures against dust in steelworks			
1st programme (technical measures against dust in steelworks) (1)	5-12-1957	600 000	600 000
2nd programme (technical measures against airpollution in steelworks	14- 6-1967	4 000 000	2 295 000
c) Separate research projects			
Red fumes in convertors	18- 7-1961	1 000 000	1 000 000
Red fumes in convertors (3)	19- 6-1964	1 825 000	1 025 000
Climatic factors in mines	16- 3-1966	116 000	116 000
Defluorization of gases	16- 3-1966	66 875	65 000
d) Large-diameter drilling to rescue trapped miners	19-12-1969	70 650	68 590
e) Stopping erected	19-12-1969	250 039	242 756
f) Roadway fires and underground combustion	28- 7-1971	502 267	487 635
			12 035 981
TOTAL :		37 330 831	24 407 981

(1) This programme is part of a single budgeting plan, under the general title of "Safety", and comprising four programmes.
(2) This programme is part of a single budgeting plan, under the general title of "Human factors and ergonomics", and comprising two programmes.
(3) Extension requested until 30 June 1968.

Duration initially envisaged for the overall programmes



Legend :

——— Programmes completed or in progress

- - - - - Programmes in preparation

A - Applied Research

Research Group A 1 : "Determination of the nature and extent of atmospheric pollution in and around the factory"

1	2	3	4	5	
Project reference	Research undertaken by	Subject of research	Scheduled dates for commencement and completion of research	Maximum aid as % of research cost -in national currency- in u.a.	Remarks
PS 140	Centre Belge d'Etude et de Documentation des Eaux (CEBEDEAU) 2, rue Armand Stévart B 4000 LIEGE	Systematic determination of atmospheric pollutants emitted by the operation of a coking plant in a steel works.	01.09.69 31.08.72	33.50 % 2,000,000 BF 40,000 u.a.	
PS 158	Bayerisches Landesinstitut für Arbeitsschutz D8 MUENCHEN 22 Pfarrstrasse 3	Continuous measurement and recording of dust levels in steel works by yhe KONITEST method and determination of the toxicity of certain dust samples.	01.09.71 31.08.74	75.00 % 120,000 DM 32,787.88 u.a.	
PS 169	Staubforschungsinstitut D 53 BONN Langwartweg 103	Systematic determination of dust levels in various steel works at certain work places known to involve particularly heavy exposure to dust.	01.07.70 30.06.74	41.45 % 80,000 DM 21,857.92 u.a.	
PS 179	Istituto di Igiene dell'Università di Genova Via Pastore 1 I 16121 GENOVA	Systematic determination of SO_2 diffusion, dust in suspension and sedimentation dust in an extensive residential district in the municipality of Genoa situated close to an integral cycle steel works.	01.01.72 31.12.73	22.40 % 6,250,000 Lit 10,000 u.a.	

PS 181	Laboratoire de Minéralogie et de Microscopie Electronique du Musée d'Histoire Naturelle Marché aux Poissons, 80 LUXEMBOURG	Determination of dust levels at a number of work places and of dust and SO_2 immission in the production halls and in the immediate vicinity of two steel works.	01.09.69 31.08.73	53.57 % 1,350,000 BF 27,000 u.a.	
PS 184	Centre Belge d'Etude et de Documentation des Eaux (CEBEDEAU) 2, rue Armand Stévart B 4000 LIEGE	Determination of the nature and extent of atmospheric pollution in four steel works and in their immediate vicinity.	01.09.69 31.08.72	48.88 % 3,150,000 BF 63,000 u.a.	
PS 189	Instituut voor Gezondheidstechniek T.N.O. Schoemakerstraat 97 NL DELFT	Determination of the concentration of toxic pollutants in the atmosphere at various work places in the steel industry.	01.01.70 31.12.74	47.86 % 41,180 Fl 39,000 u.a.	
PS 190	Laboratoire de Toxicologie de l'Université de Liège 151, Bd de la Libération B 4000 LIEGE	Determination of the composition of the ambient atmosphere at various work places in a coking plant and measurement of the resorption and metabolic conversion of toxic substances in workers.	01.09.69 31.08.70	41.00 % 500,000 BF 10,000 u.a.	

A - Applied Research

Research Group A 21 : "Prevention or limitation of the production of dust, smoke, vapours or gas"

1	2	3	4	5	6
P oject reference	Research undertaken by	Subject of research	Scheduled dates for commencement and completion of research	Maximum aid as % of research cost - in national currency- in u.a.	Remarks
PS 215	Verein Deutscher Eisenhüttenleute (VDEh) D 4 DUESSELDORF Breite Strasse 27	Determination of the influence of the capacity and method of operating openhearth furnaces on the emission of dust, SO_2, NO and NO_2.	01.04.71 31.03.73	66.10 % 200,000 DM 54,644.81 u.a.	
PS 218	Rheinstahl AG Bau- und Wärmetechnik D 465 GELSENKIRCHEN Hohenzollernstrasse 2-4	Creation of favourable feed and operating conditions for an agglomeration plant with a view to reducing dust emission and determining the concentration of the toxic substances SO_2, SO_3, Pb, Zn in the waste gases.	01.03.71 28.02.74	65.00 % 250,000 DM 68,306 u.a.	

A - Applied Research

Research Group A 22 : "Reducing the toxicity of the dust, smoke, vapours or gas inevitably generated during certain operations".

1	2	3	4	5	6
Project reference	**Research undertaken by**	**Subject of research**	**Scheduled dates for commencement and completion of research**	**Maximum aid as % of research cost - in national currency- in u.a.**	**Remarks**
PS 183	Hessische Berg- und Hüttenwerke AG D 633 WETZLAR Eduard-Kaiser-Strasse 38	Decontamination of cyanogenic dust, sludge and waste water produced by blast-furnace gas purifying installations.	01.07.69 30.06.71	29.63 % 200,000 DM 54,644.81 u.a.	

A - Applied Research

Research Group A 23 : "Interception and precipitation of dust, smoke, vapour or gas at or in the vicinity of the place at which they are generated"

1	2	3	4	5	6
Project reference	Research undertaken by	Subject of research	Scheduled dates for commencement and completion of research	Maximum aid as % of research cost - in national currency in u.a.	Remarks
PS 132	Hoesch AG. Hüttenwerke D 46 DORTMUND-HOERDE Hörder-Burgstrasse 15-17	Improvement of wet dedusting of waste gases with a high CO content generated by LDAC converters.	01.02.70 28.07.71	23.20 % 540. 000 DM 147,540.98 u.a.	
PS 160	Gebr. Boehler and Co. AG D 4 DUESSELDORF-OBERKASSEL 1 Hansa-Allee 321	Extraction and combustion of waste gases with a high CO content formed during the refining of austenitic steel by gaseous oxygen in electric arc furnaces, cooling of these gases and removal of dust by bag filters.	01.02.69 31.01.72	23,42 % 248,000 DM 67,759.56 u.a.	
PS 177	Directoraat-Generaal van de Arbeid NL VOORBURG Balen van Andelplein 2	Development of a method, acceptable to welders, of extracting welding fumes in encloses areas.	01.10.69 30.06.72	61.50 % 20,000 Fl 5,525 u.a.	
PS 193	Italsider S.p.a. Via Corsica 4 I 16100 GENOVA	Use and development of a special coke-quenching trolley to prevent the emission of atmospheric pollutants when coke is removed from the furnace and quenched.	01.04.70 31.03.73	35.46 % 375,000,000 Lit 600,000 u.a.	

PS 199	Stahlwerke Peine-Salzgitter AG D 3150 PEINE	Industrial trial and application of a new method of extracting dust from waste gases with a high CO content from LD and LDAC converters using dry electro-filters.	01.07.69 30.06.73	34.00 % 2,094,000 DM 572,131.15 u.a.	
PS 212	Stahlwerke Peine-Salzgitter AG D 3150 PEINE	Use and development of a new method of eliminating solvents from the waste air of a coated strip drying furnace by catalytic combustion and partial recycling of the waste air.	01.02.69 30.06.72	42.53 % 189,000 DM 51,639.34 u.a.	
PS 219	Centre d'Etudes et Recherches des Charbonnages de France (CERCHAR) 33, rue de la Baume F 75 PARIS (8e)	Development of devices to reduce dust, smoke and gas emission on charging coal preheated in coking plants into a furnace (Wendel-Sidelor coking plant at Hagondange).	01.04.71 31.03.74	70.00 % 350,000 FF 63,015,50 u.a.	
PS 220	Société des Aciéries de Lorraine (SACILOR) Usine de Candrange F 57 AMNEVILLE	Use of a technique combining the low pressure loss Venturi method with a new high throughput method of electrostatic dust elimination to extract dust from the red smoke emitted by a Kaldo steel works.	01.01.72 31.12.74	60.00 % 1,200,000 FF 216,053.11 u.a.	

B - Basic Research

Research Group B 1 : "Improvement and harmonisation of measuring techniques (methods and instruments) for sampling and analysing dust, smoke, vapour or gas".

1	2	3	4	5	6
Project reference	Research undertaken by	Subject of research	Scheduled dates for commencement and completion of research	Maximum aid as % of research cost - in national currency in u.a.	Remarks
PS 157	Institut fur mechanische Verfahrenstechnik der Universitat Karlsruhe D 75 KARLSRUHE 1 Richard-Willstätter Allee	Granulometric analysis of dust with grain size below 1 µm.	01.12.70 01.12.73	26.00 % 150,000 DM 40,983.61 u.a.	
PS 159	Verein Deutscher Eisenhüttenleute (VDEh) D 4 DUESSELDORF Breite Strasse 27	Testing and development of the KONITEST dust measuring instrument for continuous measurement and recording of 'red smoke' concentration.	01.05.69 30.09.72	62.50 % 100,000 DM 27,322.40 u.a.	
PS 162	Institut National de Recherche Chimique Appliquée (IRCHA) 12, Quai Henri IV F 75 PARIS (4e)	Design of a continuous dust sampling instrument based on the principle of recording the kinetic energy of particles.	02.02.69 31.01.70	48.00 % 44,433 FF 7,999.91 u.a.	
PS 163	Institut National de Recherche Chimique Appliquée (IRCHA) 12, Quai Henri IV F 75 PARIS (4e)	Study of the rapid oxidation of SO_2 into SO_4H_2 in the presence of iron oxide in a humid atmosphere.	02.02.69 30.09.72	48.22 % 103,677 FF 18,661.45 u.a.	

PS 167	Institut National de Recherche Chimique Appliquée (IRCHA) 12, Quai Henri IV F 75 PARIS (4e)	Use of count efficiency curves to improve the accuracy, reproducibility and comparability of dust concentration measurements in factories.	01.10.71 30.09.72	65.00 % 92,300 FF 16,618.09 u.a.	
PS 175	Instituut vor Gezondheidstechniek T.N.O. Schoemakerstraat 97 NL DELFT	Study of the influence on dust counts of the partial overlap of particles and the environment in which the dust is situated during the count.	01.07.71 30.06.73	65.00 % 31,200 Fl 8,618.79 u.a.	
PS 194	Institut National de Recherche Chimique Appliquée (IRCHA) 12, Quai Henri IV F 75 PARIS (4e)	Comparative study of methods of determining the grain size of a dust sample.	01.10.71 30.09.72	65.00 % 35,750 FF 6,436.59 u.a.	
PS 208	Instituut voor Gezondheidstechniek T.N.O. Schoemakerstraat 97 NL DELFT	Study of the possibility of determining the number of quartz particles (0.5 - 5 µm) in a dust sample by means of microscopic interference methods.		65.00 % 39,000 Fl 10,773.48 u.a.	

Research Group B 1 : (continuation)

1	2	3	4	5	6
Project reference	Research undertaken by	Subject of research	Scheduled dates for commencement and completion of research	Maximum aid as % of research cost - in national currency in u.a.	Remarks
PS 209	Instituut voor Gezondheidstechniek T.N.O. Schoemakerstraat 97 NL DELFT	Determination of the size and distribution of particles suspended in air by holographic methods.	01.01.71 31.12.73	65.00 % 82,550 Fl 22,803.87 u.a.	
PS 210	Instituut voor Gezondheidstechniek T.N.O. Schoemakerstraat 97 NL DELFT	Study of the influence of the size of dust particles on determination of the dust content of air by means of an extraction probe.	01.04.71 31.03.75	65.00 % 173,550 Fl 47,942 u.a.	
PS 216	Laboratorio di Igiene Industriale della Clinica del Lavoro dell'Università di Milano - Via S.Barnaba 8 I 20122 MILANO	Determination of fluorine in steel works emissions and immissions using the specific analysis electrode for the fluorine ion developed by the Orion Research Corporation.	01.11.70 31.10.72	59.80 % 5,500,000 Lit 8,800 u.a.	
PS 217	Laboratorio di Igiene Industriale della Clinica del Lavoro dell'Università di Milano - Via S.Barnaba 8 I 20122 MILANO	Comparison of the numerical and weighted concentrations of free silicogenic silica in a steel works atmosphere.	01.07.72 30.06.74	60.00 % 8,500,000 Lit 13,600 u.a.	

B - Basic Research

Research Group B 21 : "Improvement of knowledge of the principles of interception and precipitation of dust, smoke, vapour and gas".

1	2	3	4	5	6
Project reference	Research undertaken by	Subject of research	Scheduled dates for commencement and completion of research	Maximum aid as % of research cost - in national currency in u.a.	Remarks
PS 165	Institut National de Recherche Chimique Appliqueée (IRCHA) 12, Quai Henri IV F 75 PARIS (4e)	Study of filtration at temperatures up to 500 ° C.	02.02.69 31.01.70	35.00 % 49,370 FF 8,888.78 u.a.	
PS 180	Fried. Krupp GmbH Krupp Forschungsinstitut D 43 ESSEN 1 Münchenerstrasse 100	Study of the precipitation of fluorine in dry dedusting processes for residual gases containing CO generated by the various converter methods of steel production.	01.03.71 31.03.73	65.00 % 218,920 DM 59,814.21 u.a.	

8 - Basic Research

Research Group B 22 : "Improvement of knowledge of the principles of individual protection against dust and gases".

1	2	3	4	5	6
Project reference	Research undertaken by	Subject of research	Scheduled dates for commencement and completion of research	Maximum aid as % of research cost - in national currency in u.a.	Remarks
PS 168	Institut National de Recherche Chimique Appliquée (IRCHA) 12, Quai Henri IV F 75 PARIS (4e)	Study of measuring methods used to assess the value of individual protection devices against gas and vapours. Development of a test bench to evaluate the effectiveness of new or used protection masks against SO_2, H_2S, CO and hydrocarbons.	02.02.69 31.07.70	49.02 % 70,705.40 FF 12,622.07 u.a.	

B - Basic Research

Research Group B 23 : "Improvement of knowledge of the principles of propagation of atmospheric impurities in and around factories".

1	2	3	4	5	6
Project reference	Research undertaken by	Subject of research	Scheduled dates for commencement and completion of research	Maximum aid as % of research cost - in national currency in u.a.	Remarks
PS 176	Instituut voor Gezondheidstechniek T.N.O. Schoemakerstraat 97 NL DELFT	Study of the diffusion of atmospheric pollutants in factories under the action of air currents produced by heat, wind and fans.	01.09.70 28.02.74	29.55 % 72,400 Fl 20,000 u.a.	
PS 204	Verein Deutscher Eisenhüttenleute (VDEh) D 4 DUESSELDORF Breite Strasse 27	Study, on models and in practice, of the emission of dust by materials deposited in bulk.	01.09.71 28.02.74	62.50 % 175,000 DM 47,814.21 u.a.	