Health & safety at work

Assessment, dissemination and measurement of the impact of the fifth research programme on technical control of nuisances and pollution at the place of work and in the environment of iron and steelworks

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Final report

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Employment & social affairs

Health and safety at work

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SUMMARY

The Fifth ECSC Research Programme on "Technical control of nuisances and pollution at the place of work and in the environment of iron and steel works" covered the period from 1984 to 1994. The financial aid totalled ECU 26.8 million. Average funding per research project (of which there were 86 in all) was ECU 300 000, often accounting for 60% of total cost. The average funding per agreement (126 in all) was ECU 200 000.

After setting out the strategic aims and the specific targets of the Fifth Research Programme and examining the main developments in the course of the five programmes over the past 40 years, the results of the Fifth Programme are assessed, first specifically by pollution sector and production sector and second as a whole in the light of various general indicators.

After this assessment, the following conclusions and recommendations are made:

I. The level of industrial involvement (100% of the agreements), trans-European cooperation (53%) and multidisciplinary integration (54%) may be regarded as strengths.

2. Despite the fact that the programme is confined to one sector, approximately 50% of the agreements are of interest to more than one sector, which promises real potential for cooperation with other industrial sectors in the future. However, this also means that, whilst integration of several sectors can be stepped up, 50% of research is currently confined to single-sector themes. Specific financial support will be required if these research activities are to continue in the future.

3. With 64% of the projects having achieved their original objectives, either in full or to a large extent, the management procedures and methods adopted appear acceptable and cooperation between research partners effective.

4. With 16% of the agreements having reached the stage of industrial application in one form or another, there are some grounds for satisfaction. Nevertheless, considering that 64% of the projects achieve their objectives, we must stress that there is a lack of potential for practical application.

   In future, the capacity for putting the results to good use must be enhanced. Without going to extremes, which would inevitably paralyse any initiative or any spark of innovation and enterprise, it is recommended that this be achieved by identifying and quantifying more effectively at the project design stage the practical advantages, the time required for application and the likely scope for exploiting the results and by encouraging greater involvement on the part of partners (users, designers or manufacturers) who are interested in and capable of integrating, utilising and commercialising the results.

5. Since 59% of the research was on curative measures to improve existing techniques for purification and develop new techniques for end-of-line treatment in the short and medium term, there are grounds for concern as to what extent these activities can be sustained by the European Union's Fourth Framework Research Programme.

6. On the other hand, 38% of the research, which was on preventive measures for recycling, upgrading and medium and long-term development of cleaner production techniques, is amply covered by the Fourth Framework Programme.

7. With only 3% of the programme being devoted to basic high-risk research for long or very long-term application, the ECSC industries are proving reluctant to investigate new purification technology such as biotechnology.

Despite the uneven results of the assessment, the Fifth Research Programme has definitely given rise to considerable progress in protecting the health of workers and the general public. Over a quarter of the agreements were directly related to the health of workers and approximately 75% to the health of residents on adjacent properties and the general public.

The salient features with regard to industrial hygiene are as follows:

- more knowledge has been acquired which can help to identify and reduce more effectively the risks at places of work in coking plants,

- much progress has been made in methods for recording exposure of workers: acid mist, ceramic fibres, complex dust conditions and ventilation etc.

- a major methodological breakthrough was made in controlling noise at places of work.

Developments worth mentioning in the promotion of clean technology are the reduction at source of NO_x emissions from coke oven burners and reheating furnaces for semi-finished products, savings on steel pickling and degreasing bath solutions and rinsing water, the promotion of ecologically improved paints and degreasing agents, the development of new drying rolls to cut down on carryover from surface treatment baths, recycling of iron ore sintering fume etc.

Among the most interesting industrial applications are gates for improved detection of radioactivity in scrap, biological purification and nitrification/denitrification of waste coke plant liquor, extension of the service life of degreasing baths, intensive recycling of rinsing water for pickling plant, cyanide abatement in blast-furnace gas scrubbing liquor, new systems for heating coke ovens etc.

ECSC social research and in particular research on control of pollution at the place of work and in the environment of iron and steel works must now enter a new stage.

For several decades it has been a very specific instrument highly suitable for the sector and has proved its effectiveness at European level. It must now be opened up to accommodate the enlarged framework of the European Union's general research policy, whilst still retaining sufficient financial support to cater for the specific needs of the sector and to prevent too great a degree of dispersion in multisectoral and generic research.

It is far from clear that all the future needs and the research targets defined in the course of this evaluation will be transferable and will meet the selection and eligibility targets and criteria for research, technological development and demonstration activities such as defined in the European Union's Framework Research Programme.

As a result it is imperative for bridging funds to be made available at ECSC level to ensure that there are proper arrangements for transfer and integration into the Framework Programme (phasing out/phasing in).

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I. INTRODUCTION

Under the terms of Article 55 of the Treaty of Paris, the European Coal and Steel Community (ECSC) has designated encouraging research as one of its mandatory tasks.

To this effect **five research programmes, each lasting several years** have been devoted to the technical control of nuisances at the place of work and in the environment of iron and steel works.

The most recent - the Fifth Programme - ran from 1984 to 1992. However, as some financing was allocated after 1992, research which is now in progress will last until 1996. **The strategic objectives of the Fifth Programme** are set out in Table 1.

The main objective is, of course to support the policy of the European Union on industrial hygiene and protection of the environment and especially to ensure that ECSC industries comply with directives and regulations which already exist or are in the pipeline.

Preventive anti-pollution activities are naturally the preferred avenue for research. However, since preventive measures generally prove problematic in practice and can be found wanting, the Fifth Programme also supports curative measures. The concepts of lasting growth and sustainable development are not included as such in the Fifth Programme but are reflected in the aim of developing cleaner manufacturing technologies with a major impact on places of work and the environment, producing savings of raw materials, energy and water or generating less waste. Plotting a course between internal and external pollution in factories is one of the main planks of the research programme which is intended to protect the health of workers, residents of adjoining properties and the public at large.

TABLE 1
Strategic objectives of the Fifth Programme

. support for Directives, Regulations, action programmes, protocols of agreement, international agreements etc. concerning industrial hygiene and protection of the environment in the European Union.
. Promoting cleaner manufacturing technologies in the ECSC industries.
. Enhancing at optimum cost the efficiency and reliability of measures to clean up workplaces and end-of-pipe techniques for purifying effluent.
. Combating transfer of pollution from one environment to another.

The concept of BATNEEC (Best Available Technologies Not Entailing Excessive Costs) introduced in Council Directive 84/360/EEC on industrially-generated atmospheric pollution is not mentioned explicitly either, although optimizing the cost of pollution control and maintaining the competitiveness of ECSC enterprises is always a major concern, irrespective of whether the activities are curative or preventive.

A final strategic objective is to combat transfer of pollution from one environment to another, which is in line with the proposal for a Council directive on integrated pollution prevention and control (the IPPC Directive(*)).

The Fifth Programme also sets out various general guidelines on selecting and implementing research projects (Table 2).

TABLE 2
General recommendations of the Fifth Research Programme

. Promote trans-European activities
. Enable the results to be applied in practice quickly
. Take advantage of the potential offered by new technologies (biotechnology, artificial intelligence etc.)
. Analyse the results in financial terms
. Secure the involvement of universities
. Disseminate the knowledge acquired
. Protect innovations (patents)

In line with the **principle of subsidiarity**, the Community's involvement in the programme is intended to give priority to activities which cannot be pursued at local, regional or national level or cannot be put into practice with the same speed and effectiveness, although this principle is not set out in absolute terms.

(*) COM(93) 423 final - OJ No C 311 of 17.11.1993, p. 6.

It is more a recommendation than a criterion of eligibility that the research teams should be **trans-European and multidisciplinary**. The same applies with respect to rapid application of the results. It should in fact be emphasised that there are no stringent limits on the type of research be it more **fundamental** or **applied, precompetitive** or not. The sole requirement is that the research is "likely to be of interest to a large number of enterprises in the Community or a fairly large number of workers in these enterprises".

Another special feature of this research programme is that it is purely sectoral, as the financial support for the research work is provided exclusively by funds from levies on the coal and steel industries.

The general guidelines for the research are supplemented by **specific and precise targets** for each type of pollution (air, water, waste, noise etc.) and each production sector (coking plants, blast furnaces, melting shops, rolling mills, etc.). The specific objectives are explained below in the respective chapters.

Assessment of the Fifth Programme essentially comprises the three phases set out in Table 3. The reporting phase is designed to check compliance with the guidelines and specific criteria mentioned above and to report on the most outstanding results and the strengths and weaknesses of the research. The dissemination phase is intended to publicise the results with a view to integrating them to the full in industry. The consultation and forward study phase is devoted to defining research guidelines and drawing up recommendations to make the ECSC's social research as effective as possible.

TABLE 3
Assessment aims

1.	**Reporting phase**
	- consistency with previous activities - compliance of the new activities - most outstanding results and major practical applications
2.	**Dissemination phase**
	- maximum dissemination and integration of the results in industry - drawing maximum benefit from Community activities
3.	**Consultation and forward-study phase**
	- new guidelines and new research needs - priorities

Given recent events, which appear to be hastening the end of ECSC social research (originally scheduled for 2002), the forward-study phase will henceforth be incorporated in the phasing out/phasing in of specific ECSC research in the European Union's Community framework programmes.

The **assessment methodology** comprised the following steps:

- sending out to each beneficiary an assessment questionnaire accompanied by an individual draft assessment of the results for each project (a list of projects is included in Annex 1 and the questionnaire is in Annex II)

- an exchange of views with the contractors (either in writing, by telephone or, more generally, through on-site visits)

- final assessment of the results of each project (the individual assessment sheets are contained in a separate annex)

- overall assessment of the results of the Fifth Programme (by specific research subjects and in accordance with various general indicators) and preparation of a draft final report

- presentation and discussion of the results and the conclusions to the parties involved at a symposium held in Luxembourg, 9 December 1994

- drawing up and dissemination of the final report taking into account remarks and suggestions, especially those concerning new research requirements and guidelines.

II. EVOLUTION OF THE MULTI-YEAR RESEARCH PROGRAMMES

Before examining in detail the results of the Fifth Programme it would be useful to examine how the five consecutive research programmes evolved technically and financially. This is summed up in Table 4. In order to be able to study the technological evolution more uniformly, the first three programmes with more modest financial resources have been grouped together to form a single unit.

TABLE 4
Evolution of the research programmes

Programme	Period	Budget (in million ECU)	Next number of research activities	Number of contracts	Average funding (in million ECU)	
					per research activity	per contract
I,II,III (amalgamated)	1957-1978	14.6	112	112	0.13	0.13
IV	1979-1983	15	75	87	0.20	0.17
V	1984-1992	23	86	126	0.31	0.21
Financing balances	1993-1994	3.8				
Total or average	± 40 years	56.4	273	325	0.21	0.17

Overall the financial aid for the Fifth Programme and the financing balances is around ECU 26.8 million over a period of ten years (1984 to 1994). The average financing per **research activity** (86 in all) was some ECU 300 000 (which varied between ECU 60 000 and ECU 1 020 000) very often accounting for 60% of total costs. Average funding **per contract** (126 in all) was around ECU 200 000 (and ranged between ECU 25 000 and ECU 655 000).

The number of **trans-European projects** (involving at least two countries), which first made their appearance in the course of the Fourth Programme, increased significantly during the Fifth Programme (Table 5).

TABLE 5
Development of multinational research activities
(as a percentage of all contracts)

Programme	Multinational research activities (involving at least two countries)	National activities of interest to the whole Community
I, II, III (amalgamated)	0%	100%
IV	23%	77%
V (including the financing balances)	53%	47%

If we examine the programmes **by pollution sector** (Table 6) we clearly see that activities relating to **air pollution** predominate but to a lesser extent with the passage of time (falling from 70% to 40% of the agreements). Compared with the problems of industrial smokestack emissions, exposure of workers did, of course, constitute the major concern but again with decreasing importance as the programmes developed. Progressively, **an integrated approach to** the problems of nuisances at the place of work and in the environment had to be adopted, which gave rise to more activity relating to aquatic pollution, waste management, noise pollution and treatment of polluted soil.

This development clearly shows up the need to steer a careful course between the prevention of internal pollution (to which workers are exposed) and external pollution (to which local residents and the general public are exposed) and the desire to manage pollution problems from a multi-environmental point of view.

We should emphasise that if we add the activities to reduce air pollution at work to those to abate noise and olfactory nuisances, the percentage of the contracts **directly affecting workers** over the course of the five research programmes accounted for between 46 and 28% of the projects. We should also make it clear that none of the research programmes established any quotas on financial aid for various types of pollution or a scale of priorities for funding.

Such flexibility enabled the programmes to adapt constantly to the research needs of the ECSC industries, especially to take account of changes to European directives and regulations and technological developments which cannot always be foreseen, without, as is described below, activities becoming fragmented and scattered.

Problems of **water purification** (mainly process water) were thus introduced from the Third Programme and gradually received greater attention subsequently (the share of the research contracts going from 15 to 25%).

TABLE 6
Development of research activities by pollution sector
(as a percentage of the total number of contracts in each programme)

Pollution sectors	Subsectors (main targets)	Programmes I. II. III (amalgamated)	Programme IV	Programme V (including financing balances)
Air pollution	Places of work (including secondary fume)	35.7%	27.7%	15.9%
	Impact on surroundings and environment	4.5%	3.5%	1.6%
	Emissions (smokestack and open air fugitive emissions)	15%	15%	16.7%
	Olfactory nuisances	5.8%	5.8%	5.6%
TOTAL		**69.6%**	**52%**	**39.8%**
Pollution of fresh and salt **water**	Processing water	14.3%	22%	25.4%
	Indirect cooling water	0.9%	1%	0.8%
TOTAL		**15.2%**	**23%**	**26.2%**
Wastes and byproducts	Upgrading/ recycling	8%	8%	15.9%
	Destruction by combustion	0.9%	-	-
	Dumping (including inertisation. leaching and impact on the environment)	0.9%	5.8%	4.8%
TOTAL		**9.8%**	**13.8%**	**20.7%**
Noise	Places of work	4.5%	10.2%	6.3%
	Surroundings	0.9%	1%	0.8%
TOTAL		**5.4%**	**11.2%**	**7.1%**
Soil pollution (including groundwater)	–	–	–	**6.2%**

The same thing happened with regard to **waste management**, with the share of projects going from 10 to 20% during the last three programmes and priority being given to upgrading and recycling processes over dumping.

Soil decontamination was introduced in the Fifth Programme and accounted for 5% of the contracts. Work on noise made up the balance of the research and development activities (accounting for between 5 and 10% of the contracts) priority being given to prevention at places of work rather than in the surroundings.

A breakdown by **production sector** (Table 7) reveals that, besides the considerable volume of research covering several production units at the same time or indeed the entire steelworks (accounting for 25 to 40% of the contracts), **coking plants** were a priority target (accounting for between 10 to 30% of the contracts). Attention was focused on atmospheric pollution and the treatment of waste water from coking plants. Coke oven pollution also accounted for the largest number of multinational research programmes. This situation is justified by the technological complexity of the problems to be solved, the pressure from legislation and the special hazards of coking plant pollution. However, if one looks at the problem in terms of quantity, it is **iron ore sintering** which is mainly responsible for atmospheric pollution from integrated steel plants and this specific sector only accounted for an average of 5% of the projects.

Other production sectors which were focused upon (accounting for between 5 and 15% of the contracts) were oxygen and electric arc melting shops and blast furnaces. Programmes I, II and III mainly covered means of abating **brown fume from oxygen converters** after which attention shifted sharply away from this topic in the course of the subsequent programmes. Electric arc furnaces (which accounted for 7.5 to 15% of the contracts) were constantly in the researcher's eye, especially with regard to noise and atmospheric pollution. Zinc and lead residues (in blast furnace and oxygen steel plant sludges and electric arc furnace dusts) and steelworks slag were a permanent focal point in these sectors.

Apart from the problem of treating sludges containing zinc, olfactory nuisances caused by the granulation and cooling of slag, secondary emissions on the casting platform and the treatment of gas scrubbing water were the main problems addressed in the **blast furnace** sector.

Sectors accounting for between 1 and 5% of the contracts were rolling mills, pickling plant, reheating furnaces and finishing treatment. In the sectors of **rolling mills** (hot and cold), **pickling and metallic coatings**, it was mainly the problems of waste water which were dealt with, other activities being more selective and isolated. In the sectors of **organic coatings** and **reheating furnaces** it was mainly the problems of atmospheric pollution (olfactory nuisances, volatile organic compounds and nitrogen oxides) which were in the foreground. During the Fifth Programme, surface treatments (pickling and coatings etc.) moved up the agenda rapidly (to account for 15% of the contracts).

TABLE 7
Evolution in research activities by production sector
(as a percentage of the total number of contracts in each programme)

Production sector (main target)	Programmes I. II. III (amalgamated)	Programme IV	PROGRAMME V (including financing balances)
Coking plant	12.5%	29.0%	22.2%
Sintering and pelletisation	4.4%	7.0%	5.6%
Blast furnaces	7.1%	6.0%	10.3%
Open-hearth and oxygen steelmaking	16.1%	1.0%	2.4%
Electric steelmaking	10.7%	15.0%	7.9%
Continuous casting and hot-rolling mills	2.7%	8.0%	5.6%
Pickling	1.8%	3.5%	4.0%
Cold-rolling mills	0.9%	-	1.6%
Finishing treatment (coatings, painting etc.)	1.8%	2.0%	11.9%
Reheating furnaces	2.7%	1.0%	2.4%
Multisectoral (without any main target)	39.3%	27.5%	26.2%

Throughout the various programmes a large, although decreasing, part of the activities was also devoted to **metrology**, an indispensable tool for managing environmental activities whether these concern the place of work, ducted or fugitive emissions or the external environment. Between 25 and 10% of the contracts were allocated in this field in the course of successive programmes.

Finally, we should emphasise that in parallel with the ECSC DGV research programmes (on technical control of nuisances at the place of work and in the environment of iron and steel works), other research, technology and development programmes also dealt with some of the above areas of environmental protection such as the ECSC DGXII steel programmes which were mainly devoted to upgrading steelworks slag, control of combustion and pollution in reheating furnaces, treatment of zinc residues, atmospheric pollution in the course of steel production from scrap, and more recently, recycling of iron or sintering fume. It is a pity that there was no formal coordination between these programmes.

III. ASSESSMENT OF THE FIFTH RESEARCH PROGRAMME BY SECTOR

1. CONTROL OF AIR POLLUTION AT PLACES OF WORK AND IN THE ENVIRONMENT - IMPACT STUDIES OF ATMOSPHERIC POLLUTION CAUSED BY THE STEEL INDUSTRY

1.1 *Places of work and emissions in workshops*

18 research projects under the terms of the Fifth Programme are grouped together under this theme, forming a highly interesting and varied whole:

- all the streams of steel production are taken into account and the majority of the main shops are covered

- the research projects virtually all have multiple aims: sectoral (for a given shop), methodological, metrological, conceptual etc.

Nevertheless, two main approaches are discernible: **sectoral research and more general research.**

Two projects on **radioactivity in scrap** were also included in this chapter, taking the number of contracts to 20.

The objectives of this research in relation to the aims of the Fifth Programme and the framework provided by the European Union's regulations are given in Table 8.

1.1.1 Sectoral research

1.1.1.1 *COKING PLANT*

The Fifth Programme saw a substantial amount of research work on coking plant, mainly on coke oven batteries and to a lesser extent, gas treatment equipment. Under the terms of two coordinated research projects, nine contracts were signed to deal with the various aspects of toxic and/carcinogenic compound emission, research being focused on two themes: a) polycyclic aromatic hydrocarbons and b) heavy metals.

a) Polycyclic aromatic hydrocarbons (PAH)

Five research projects (**423, 424, 425, 440** and **471**) concentrated on this field, which constitutes one of the major sources of pollution in the coking process. Work was carried out or is still in progress in several coking plants in the **mining** and **steel industry** in Germany, Spain, France, Portugal and the United Kingdom.

TABLE 8
Control of pollution of the air at places of work and in the environment - impact studies on atmospheric pollution

Places of work and emissions within workshops	Number of contracts 20/126
Aims of the Fifth Programme	
. Support for the directives on exposure to chemical, physical and biological agents (80/1107/EEC - 88/642/EEC - 91/322/EEC), carcinogenic agents (90/394/EEC), metallic lead and its ionic compounds (82/605/EEC), etc.	18/20
Support for Directives 89/391/EEC and 89/654/EEC to encourage improvements in the safety and health of workers at work and on the minimum safety and health requirements for the workplace.	18/20
. Reduction of atmospheric pollution at work	14/20
- in coking plants	9/20
- in blast furnace shops and melting shops	3/20
- in rolling mills and finishing shops (control of aerosols etc.).	2/20
Other action	
. Radioactivity in scrap	2/20
Impact on the surroundings and the external environment	**Number of projects 2/126**
Aims of the Fifth Programme	
. Inventories of emission. Impact studies. (Directives 85/337/EEC on assessment of the impact of certain public and private projects on the environment).	2/2
. Diffusion and transformation of pollutants, forecasting models for dust fall-out.	2/2
. Technological risks (Directives 82/501/EEC - 91/692/EEC on the risks of major accidents of certain industrial activities).	0/2
. Sampling and quantitive analysis methods for pollutants (harmonisation, continuous measurement etc.).	2/2

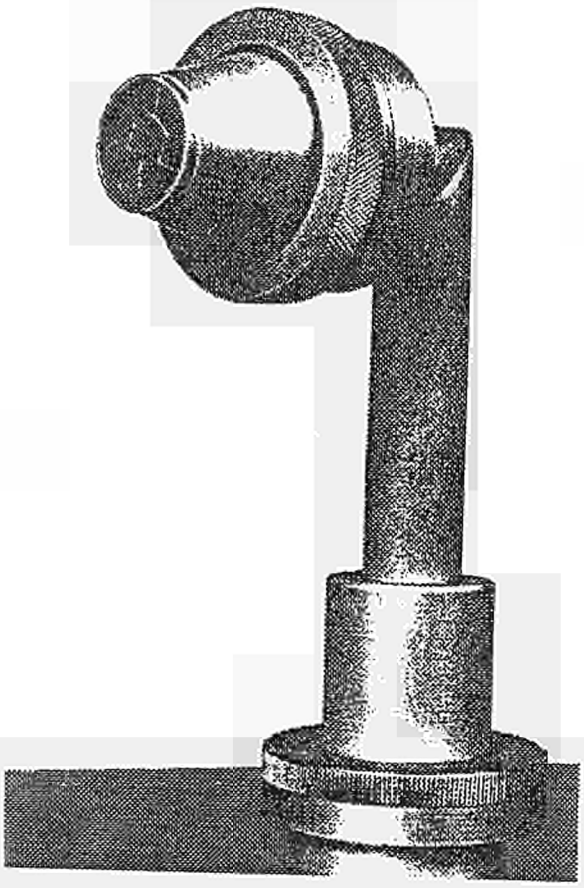
Research projects **423, 424, 425** and **440** were coordinated and in fact constituted the second phase of a project - which was also coordinated - under the Fourth Research Programme. The second phase was intended to make further progress in two respects:

* harmonisation of measurement methods for PAH at places of work and in the environment
* enhancement of knowledge on the impact of PAH emissions.

The last point mainly comprised the following aspects:

- measurement of emissions
- measurements at places of work
- environmental measurements.

The first feature of the four research projects was that they were able to coordinate work effectively. Although some of the goals set in the initial programme were only achieved in part and although the second phase of the research work could not be as innovatory as the first, its principal merit was to have included highly modern coke oven batteries in the measurement process (emissions, places of work, environment). Within the current technological limits, these measurements enabled the limits for reduction of coke oven emissions to be identified, and hence the minimum levels of exposure for workers and the surrounding population. This type of data is indispensable for drawing up future regulations and BAT or BATNEEC documents and also for coking plant managers in the European Union to make arrangements to protect their workers.



R. 423, 424, 425, 440
Innovative sampler for PAH

In the course of the research work, the Institute of Occupational Medicine (UK) was given a contract to design and build a **new sampler** for PAH at places of work and in the environment. This sampler was subsequently tested by the four research teams. This new sampler could provide the technical basis for the standardising authorities of the European Union to promote and streamline correct sampling of PAH.

Project **471** was not coordinated with the foregoing projects. The aim was to compare the concentration of PAH at places of work before and after rebuilding of an old coke oven battery (SEIXAL (P) plant) and, at the same time, to determine additional techniques to be introduced after rebuilding by undertaking modifications in what were considered to be priority areas (modification of processes and design). At present the research appears to be encountering implementation problems.

b) Heavy metals

Four coordinated research projects (**417, 418, 419** and **420**) examined what happened to heavy metals during the process of coking, a study which was prompted by the heavy metal content in coking coal. The research work was conducted in coking plant in the **mining** and **steel industries** in Germany, France and the United Kingdom.

This set of research projects proved a world first in all the fields of investigation:

* development of new methods for taking samples and analysing heavy metals in trace and ultra-trace form in complex matrices (coal, coke and tar)

* multi-environmental measurement (air, water, waste and bi-products) of heavy metals during the process of coking

* study of impregnation of adjoining ground.

The major finding of these four research projects was to demonstrate that emissions of heavy metals due to the coking process were **harmless**. This was very important for the ECSC industry because it enabled problems with this type of pollution, mainly at places of work, to be eliminated.

1.1.1.2 *WORKSHOPS FOR THE PRODUCTION AND TREATMENT OF HOT METAL*

Project **492** was devoted to technico-economic rationalisation of the inertisation of steelmaking equipment to suppress fugitive dust emissions during tapping and transfer of hot metal. Tests were conducted at the PROFILARBED (L) plant. The following metallurgical operations were selected for inertisation:

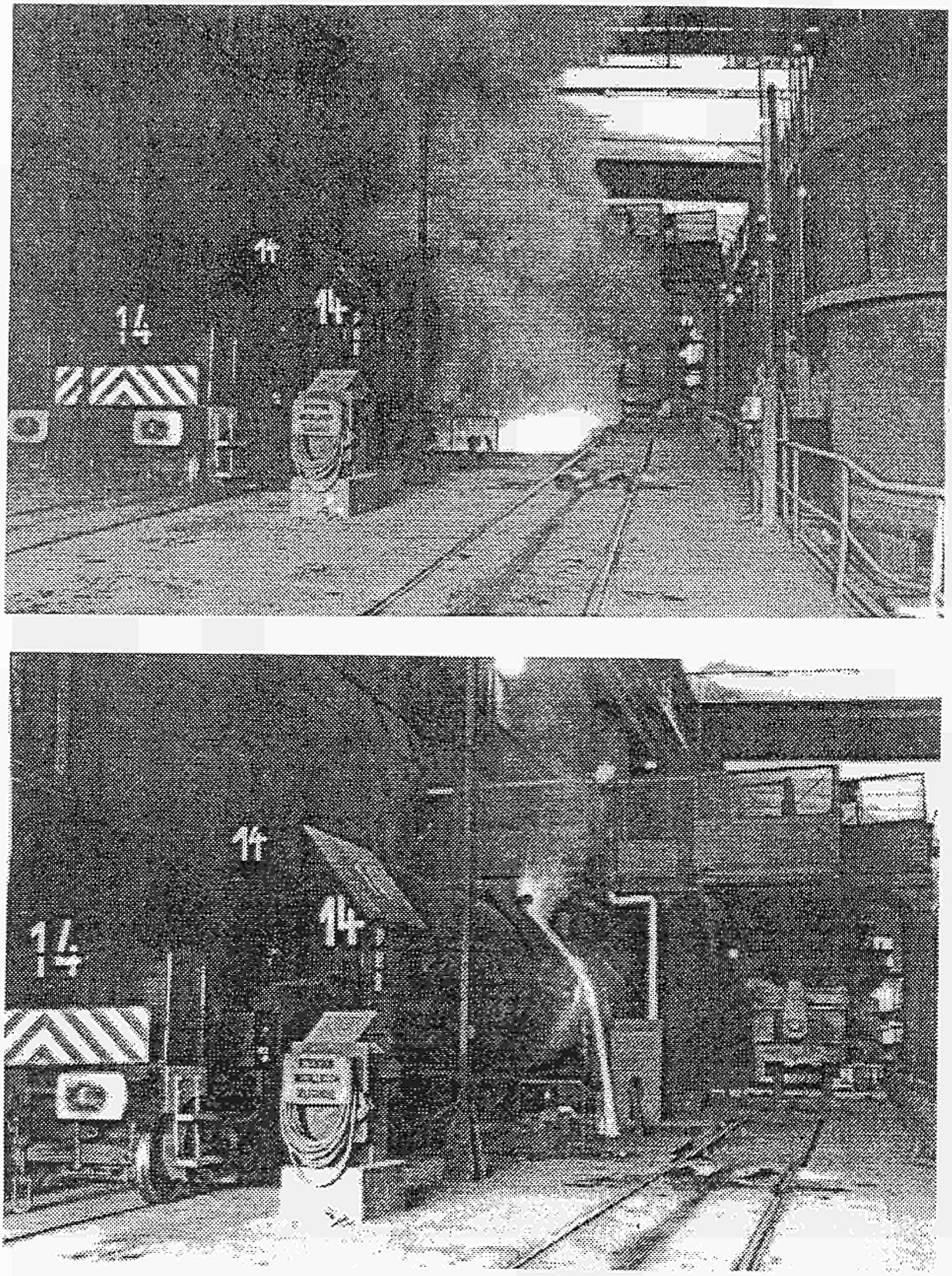
* tapping the hot metal from the blast furnace

* transfer of the hot metal from the submarine ladle to the transfer ladle

* charging of scrap in the OLP converter

* charging of the (phosphoric) pig iron in the OLP converter.

In the first two operations, inertisation was achieved by solid carbon dioxide and, in the OLP converter, by adding anthracite to the oxidised slag and by changing the procedure for charging the converter.



R. 492
Dust emission during a pig iron transfer at the steel plant (without and with a CO_2 fume suppression)

Spectacular results were achieved in abating dust emission at source and as a result improving the quality of air at places of work. The project was supplemented by an economic assessment of CO_2 inertisation at the Esch-Belval and Differdange (L) plants: the costs were 0.675 ECU/t of hot metal tapped and 0.15 ECU/t of hot metal transferred. This type of approach has been taken several times in the steel industries of the European Union but research project **492** is remarkable because it provides a demonstration on an industrial scale of the advantages of inertisation: abatement at source, considerable reduction in pollution at places of work and major savings for the enterprise compared with other techniques.

Research project **448** was aimed at minimising emissions of toxic compounds (especially PAH) when carbon-bonded refractories were being heated up in steel plant (converter, electric arc furnace, ladle metallurgy, transfer ladles etc.). Much of the work was devoted to defining, assembling and optimising a pilot furnace to test various types of refractory in 200 kg batches. The results showed that controlling the oxidation-reduction conditions of the heating burner did enable emissions of benzo(a)pyrene, for example, to be reduced considerably. An industrial scale test at the electric arc melting shop in the Ascometal-Hagondange (F) steelworks confirmed the data obtained with the pilot furnace. Emissions of toxic compounds in melting shops can thus be reduced substantially when refractories are heated up.

The results of research project **448** provided a methodology and a simulation tool to enable refractory manufacturers and users in the steel industry to test this type of refractory and to optimise emissions of toxic compounds.

1.1.1.3. *ROLLING MILLS*

Since asbestos has been replaced by ceramic fibres (alumino-silicates, mullite, zirconia, etc.) as thermal insulators, the question of the potential toxicity of such fibres has been raised. Several theoretical projects have been carried out throughout the world in an attempt to establish whether they were toxic or not. Research project **466** took the opposite approach by:

* identifying and quantifying in the laboratory the potential problems posed by using ceramic fibres as furnace insulators

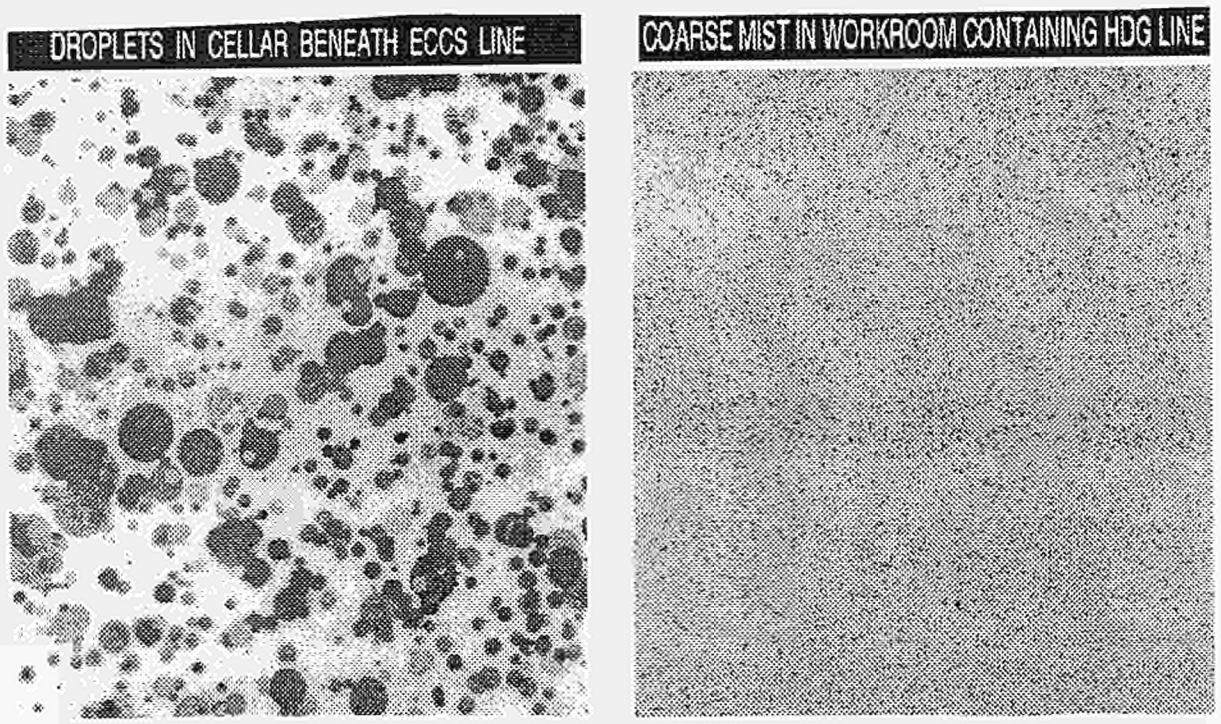
* at industrial sites (British Steel (UK) plants):
  - carrying out measurement campaigns which revealed that maximum exposure values had been exceeded in the UK
  - developing ways of minimising the risks for the workers concerned.

These procedures are now being applied in British Steel works.

The results of this research project are important for the steel industry of the European Union because they are an excellent example of preventive action to protect the health of workers.

1.1.1.4 *SURFACE TREATMENT SHOPS*

Acids are widely used in steelworks for pickling, passivating and plating. Acid mists are suspected to contain carcinogenic compounds. In the first phase of research project **465** conducted at British Steel, new methods for assessing the risks connected with exposure to chromic anhydride and other acid mists were developed. In the second phase, on-site industrial measurement campaigns were carried out to identify the level of worker exposure and to check whether containment measures were effective.



R. 465
Advanced chromatographic monitoring for Cr VI exposure control

The new monitoring method (exposure of chromatographic plates) is absolutely **innovatory**. The results of this research project are very important in terms of worker protection in several respects:

- pollution at places of work in surface treatment shops can be reduced
- conventional methods of sampling and analysing compounds of chrome VI were shown to be unsuitable
- the new monitoring method provided a point of departure for future work in the field of sampling and analysis of dusts or aerosols containing compounds of chrome VI.

1.1.2 More general research

1.1.2.1 *DUST MONITORING AT PLACES OF WORK*

The coordinated research projects **442** and **446** covered monitoring of dust levels in a fairly general context in steelworks.

Research project **442** was intended to monitor dust levels in blast furnace and converter workshops (ENSIDESA plant in Spain) with the aim of establishing risk criteria for assessing the ambient environment: granulometric and mineralogical analysis, chemical analysis, checking for the presence of PAH etc. The results obtained confirmed that there was a risk of the oxides of Fe, Mn, Cr, Mg, Ca, Na and K of being retained in the alveolae. The same applied to PAH in the air. However, the risk of siderosis, sidero-silicosis and graphitosis was ruled out.

Research project **446** was intended to shed light on the risk of workers' dust exposure in two specific situations:

* the presence of PAH on particles of iron oxide which was suspected to cause bronchio-pulmonary cancer

* solid-state analysis of compounds of chrome VI on dust particles.

The dust samples from various plants in the USINOR-SACILOR group in France (integrated steel plant, electric steel plant and production of stainless steel) were analysed by conventional chemical means and by a laser microprobe. The results obtained provide a precise description of the combined presence of PAH and iron oxides in many steel plant workshops. The laser microprobe analysis, backed up by an analytical log which was a **world first**, revealed that large concentrations of chrome VI were often present, confirming once again that conventional analytical methods were not suitable for detecting chrome VI.

These two coordinated research projects were innovatory in several respects: the type of approach adopted, the methods used and the results obtained. They are important for improving the protection of workers in the steel industry because they added to what was known about the risks to workers and because they provide a basis for future work.

1.1.2.2 *SUPPORT FOR EPIDEMIOLOGICAL SURVEYS*

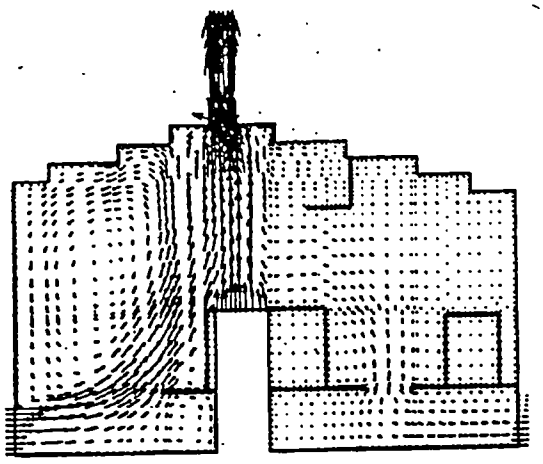
Research project **487** comprises technical support - of the job/exposure matrix type - to two epidemiological surveys (retrospective survey on mortality, and cross-sectional analysis) carried out in the plants of BRITISH STEEL (UK). This enables data obtained in the field

by six teams of industrial hygiene experts (dust, organic fraction, SO_2 oil vapours, heavy metals etc.) to be collated for a large number of workshops in the steel industry. Jobs and exposure are described in terms of the **work area,** which constitutes a new approach. The database has been set up using an information package which allows many different types of statistical processing to be carried out.

The progress made in project **487** is significant and exemplary for the steel industry of the European Union because sophisticated epidemiological surveys are required to identify, and subsequently eliminate, the risks to workers.

1.1.2.3 *AN OVERALL CONCEPT FOR CLEANING THE AIR IN STEEL PLANT*

In the large workshops in the steel industry the quality of the air at places of work is closely linked to the efficiency of collection of the fume emitted by steelmaking plant and the type of air flows in these buildings. The aim of research project **449** was to develop methods of investigation to enable the efficiency of fume collection and ventilation in steelmaking shops to be **optimised overall.** The methods implemented are based on: analysis of fume emissions, analysis of airflow (tracing, three-dimensional anemometry, thermal analysis etc.), analysis of ventilation (flow rate, temperature, recirculation zones etc.) and simulation and forecasting of airflows (hydraulic model using numerical codes etc.).



R. 449
Results from air flow rate model in an EAF shop

The overall approach adopted in research project 449 is innovatory for the steel industry. The results of this research project open up new avenues for improving the quality of air at places of work.

1.1.2.4 *TECHNIQUES FOR DIAGNOSING EXPOSURE*

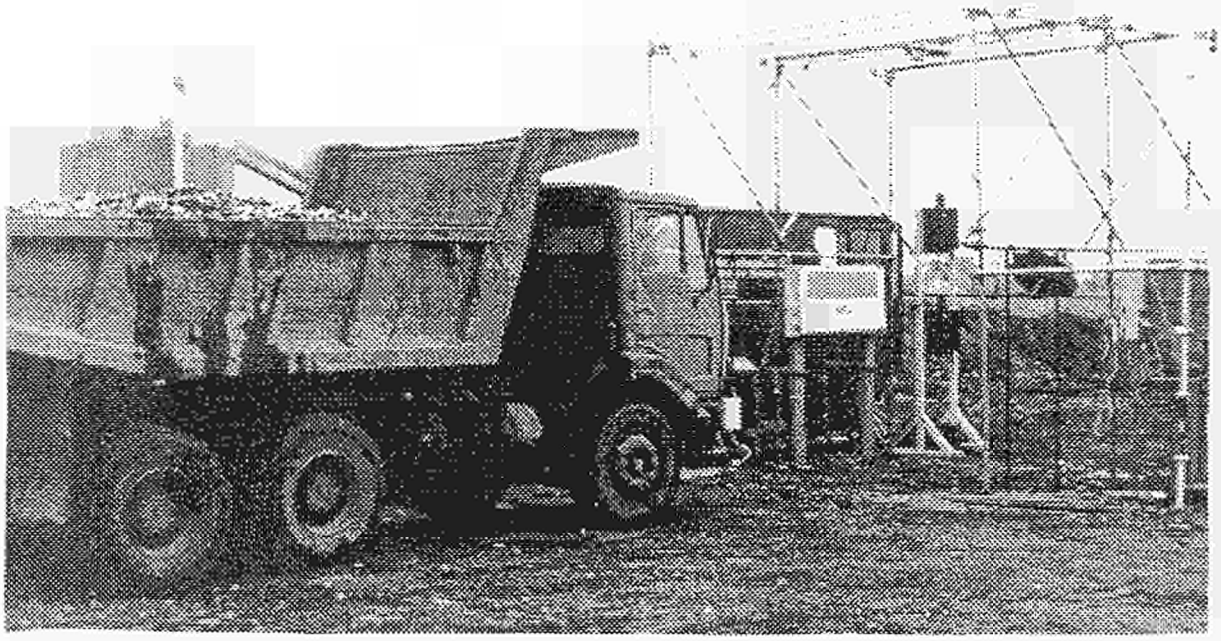
The complexity of steelmaking activities makes it difficult to diagnose worker exposure accurately. Research project **454** had two aims:

* to devise a sampling method
* to develop a computerised system for diagnosing the risk of exposure at work.

106 places of work at the ENSIDESA (Spain) plant were examined for chemical agents, noise and heat. When the extent of the risk (slight, medium and high) at places of work was classified, noise proved to constitute the major nuisance. Contrary to expectations, chemical agents posed few problems. Exposure to heat on coke oven batteries created a local problem of discomfort. The research team subsequently formalised the computerised system for risk diagnosis and it is now operational on a PC.

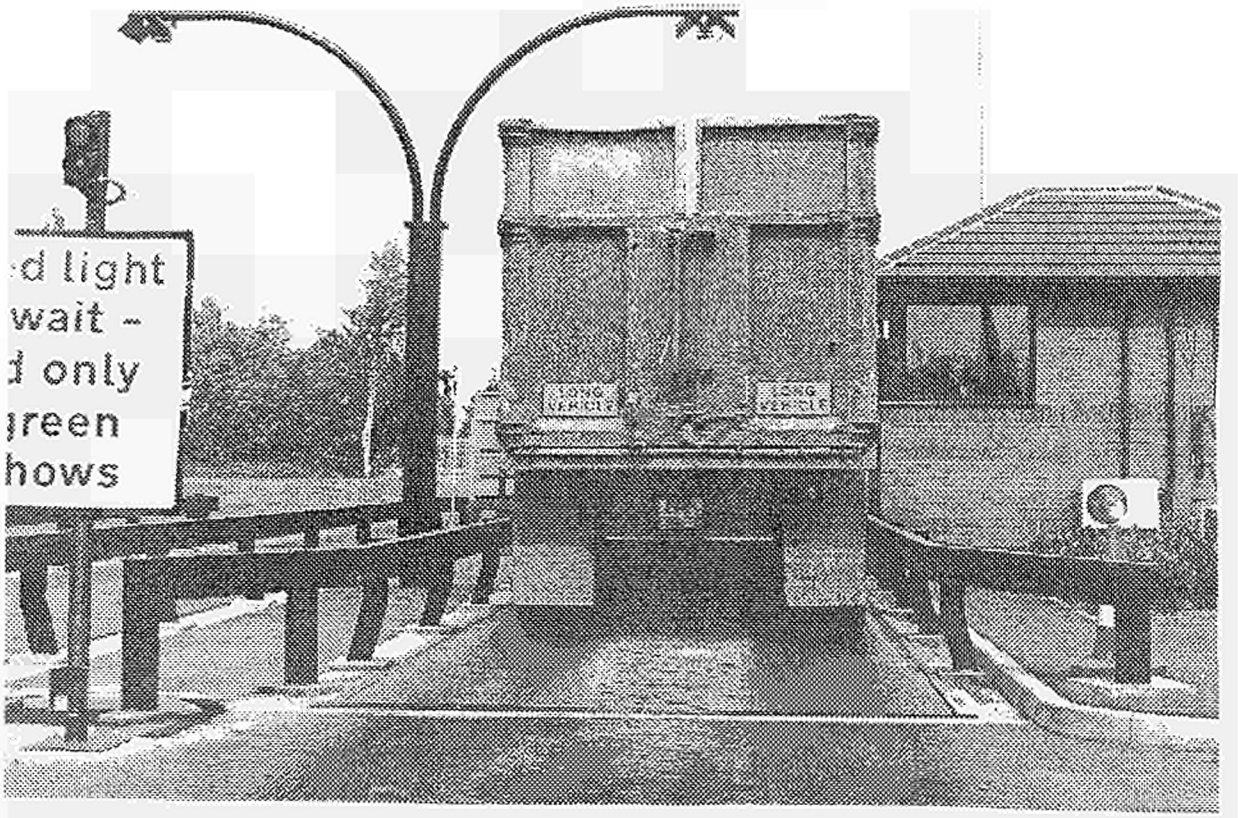
Providing steelworks management with a system for diagnosing the overall exposure to nuisances undergone by the workers is an important factor in managing industrial hygiene. The new ground broken by research project **454** provides an excellent basis for subsequent work in this field.

1.1.3 Detection of radioactivity in steelworks raw materials



R. 467
Experimental monitoring system for scrap radioactivity control

This question, which should have come under a special heading, was incorporated in the section on pollution at places of work because in some respects it is also a cause for concern for workers.



R. 468
Industrial monitoring system for scrap radioactivity control

Despite the strict legal and contractual provisions for monitoring radioactivity, the steel industry must take drastic measures to cope with the increasing risks from radioactive substances when large quantities of scrap arrive at its steelworks. On completion of research projects **467** and **468** conducted in Germany and in the UK, practical recommendations on detector type and architecture, alarm thresholds, a strategy for analysing the results of measurements and general arrangements for radioactivity detection gates for installation at scrap yard entrances were formulated.

Moreover, a prototype of a high-sensitivity radioactive counter with energy spectrum analysis (instead of overall counting equipment) was developed and is currently being marketed.

The two research projects were a major stimulus to action. BS Technical has thus participated so far in installing 14 industrial radioactivity detection gates for scrap throughout Europe. BFI is also very active in the same field. These projects are amongst the most remarkable in the Fifth Research Programme due to their effectiveness, the highly sensitive nature of the subject tackled and the repercussions for and integration in the ECSC industries.

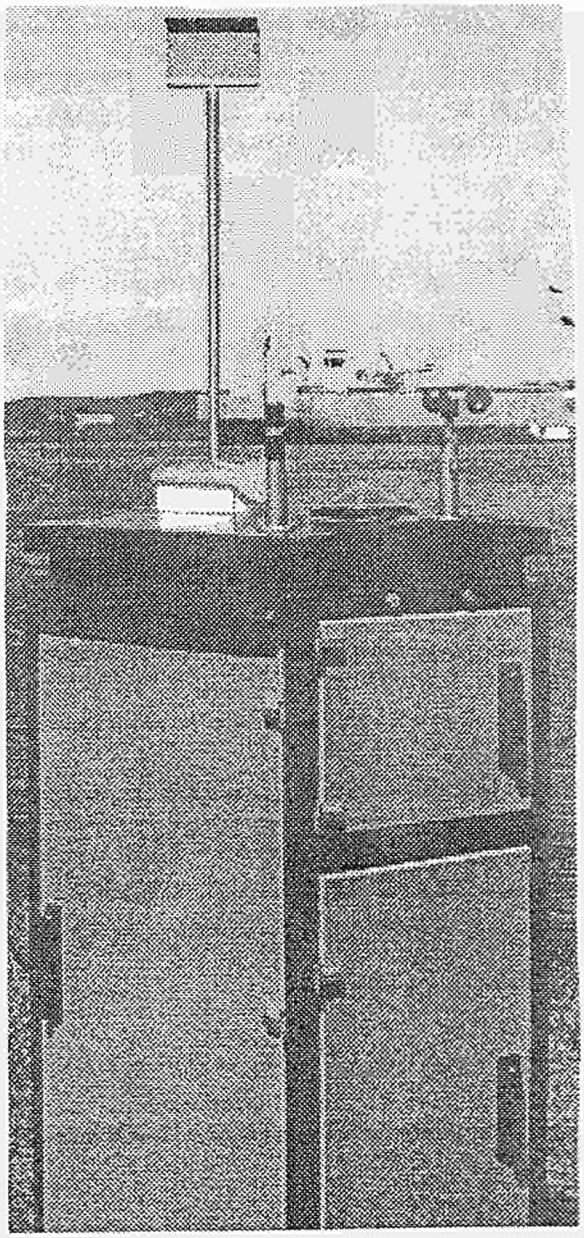
Paradoxically, however, this work in connection with radioactivity in scrap was not covered explicitly by the programme but was prompted directly by a need which emerged after the programme had begun.

1.2 *Impact on surroundings and the environment*

As mentioned in Table 8, two coordinated research projects (**486** and **497**, which are still in progress) are studying the impact of dust emissions, either ducted or fugitive, in buildings or in the open air, on the environment of the integrated steel plants Hoogovens-IJmuiden, Sollac-Dunkerque and Sollac-Fos. These two projects are intended to implement new metrological or atmospheric dispersion simulation methods to determine where responsibility for environmental emissions lies. Special emphasis was placed on dust settlement which caused frequent complaints in the surrounding population. Conventional metrological means of monitoring dust settlement (DIEM plates, deposit gauges etc.) which have too long a sampling time, do not enable a warning system to be set up around steel plants and action to be taken quickly enough to deal with the sources of emissions.

Project **486** was intended to design and develop a network of measurements for dust fall-out, development of a short-term sampling warning system, and establishing where responsibility for steelmaking emissions lay. Two new measurement instruments were used for this purpose.

Project **497** adopted the same approach as the previous project as regards dust deposits and defined a prototype for an automatic short-term sampling deposit gauge. The project was then extended to cover:



R. 497
New generation of automatic and continuous sampler for dust deposition

* development and testing of automatic and continuous measuring apparatus for the emission factor of coal and ore piles

* validation and adjustment of numerical models for the atmospheric transport of suspended sedimentable dust to enable responsibility of steel plants to be simulated.

Projects **486** and **497** were innovatory in respect of monitoring of dust deposition in the environment of steel plant. The same applied to the measurement and self-monitoring apparatus for blow-off from coal and ore piles. These two research projects adopted an integrated approach to the problems of nuisance in the steel industry and should provide it with measurement and forecasting tools to improve dust conditions in the environment of its plants.

1.3 *Ducted and fugitive open-air emissions*

The smokestack emissions which give the greatest cause for concern in the ECSC industries in the Fifth Research Programme are nitrogen and sulphur oxides, organic matter and dusts. The aims and the regulatory framework for controlling these are set out in Table 8(2).

TABLE 8 (2)
Control of ducted and fugitive open-air emissions

Aims of the Fifth Programme	Number of contracts 21/126
. Reduction of pollutants in Annex II of Council Directive 84/360/EEC on control of industrially generated atmospheric pollution (framework Directive).	20/21
Council Directive 88/609/EEC on pollution from large combustion installations (individual Directive).	1/21
. Control of atmospheric dust (storage, handling, transport and preparation of fine materials and powders).	1/21

1.3.1 Coking sector

Coking is the second largest source of nitrogen oxides in integrated steel plants after iron ore sintering.

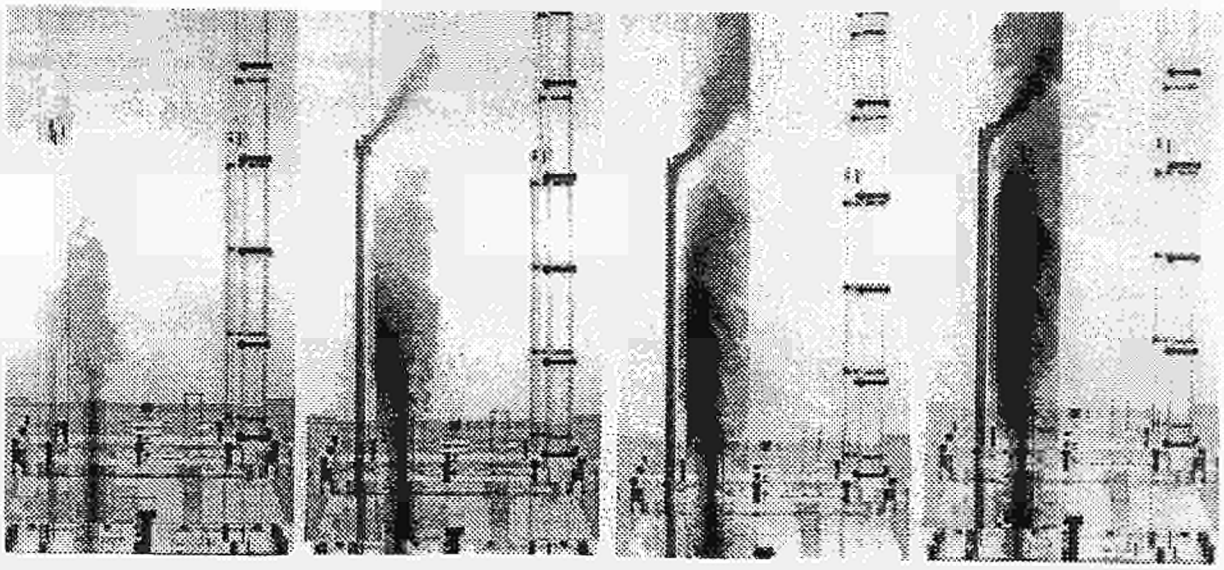
On the basis of investigations conducted mainly in industrial installations in France and Germany (**408, 411, 456**), nitrogen oxide emissions from coking plants were examined in terms of:

– emission factors, which vary considerably with the design and operating conditions of the ovens (average temperature of the battery, local temperatures, excess air etc.).

NO_x emissions from coke ovens		
	mg NO_2/Nm^3 (*)	mg NO_2/MJ
Old generation	300 - 1100	100 - 480
New generation	300 - 550	80 - 160

(*) Recommendation in the TA (technical instructions) on air: 500 mg No_2/NM^3 fume containing 5% O^2

– the main measures to reduce them at source namely:
  - using new heating techniques based on rich gas, multi-stage air supply, internal circulation of fume at the bottom of the flues and external recirculation of the combustion fume;
  - implementing new means of combustion control, reducing heating imbalances in the flues and eliminating hot spots;
  - developing calculation models and simulation tools enabling new generations of heating flues to be designed and optimised and the scope for regulating existing conventional systems to be exploited to improve heating conditions.



R. 456
Gas flow and mixing modelling with liquid dyes

– their impact on the immediate environment.

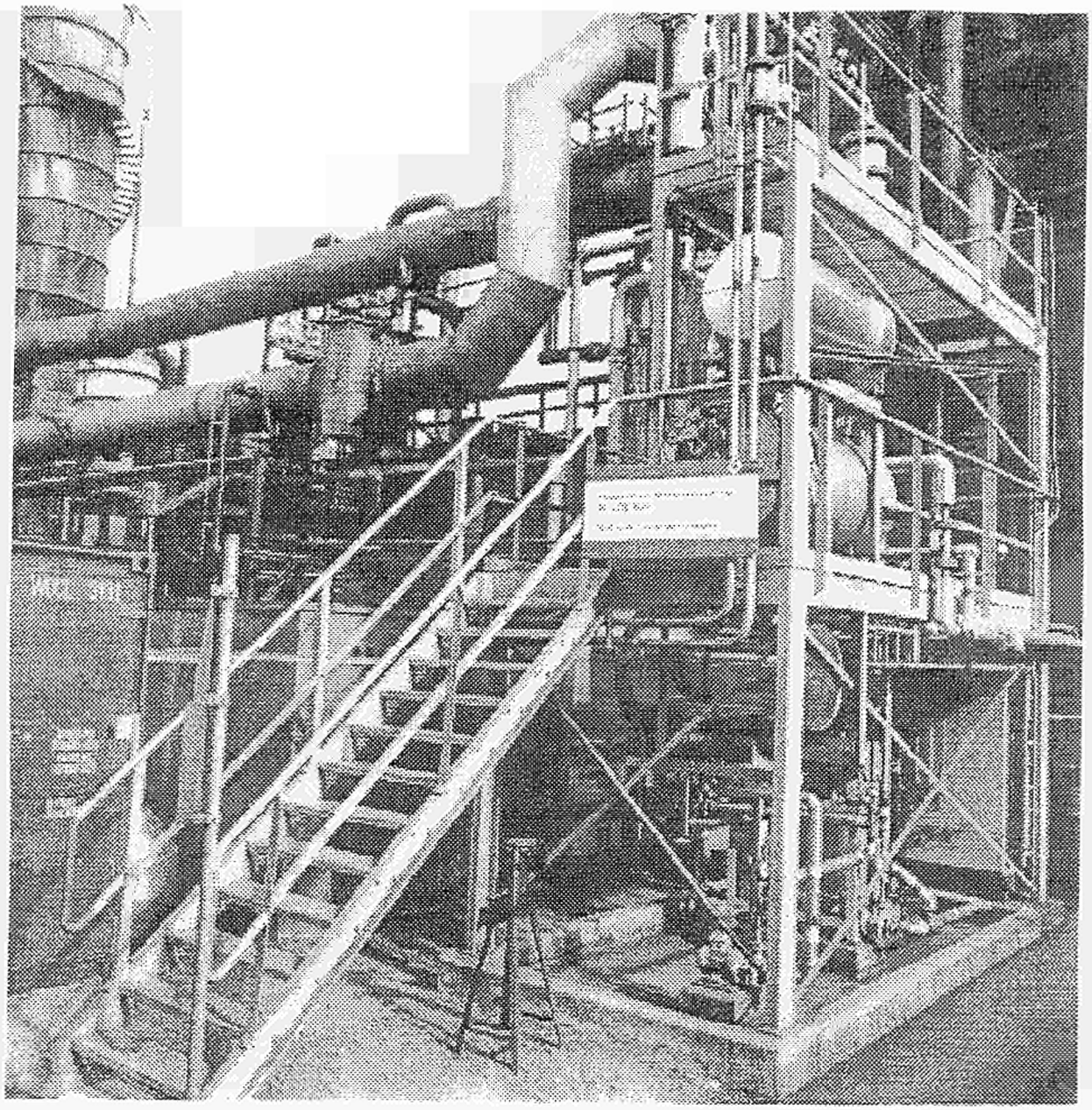
In general, nitrogen oxides generated by a coking plant can be measured within a radius of 2 to 3 km from the source of emissions although the impact of a plume can be discerned at larger distances up to 5 km from the source. Overall, however, this impact is limited, particularly compared with other sources such as traffic.

Two controversial aspects of this problem were tackled: the effect of the type of heating gas and the volume of the oven.

No definite conclusion could be drawn with regard to the influence of the type of heating gas. Nevertheless, using rich gas does appear to have advantages in terms of specific emission factors but not in terms of the concentration of NO_x in the fume, provided that there has been no major disturbance in the combustion process. The same is true for the effect of the volume of the ovens, which remains uncertain, although there is a tendency for NO_x emissions to increase with volume.

This research work identifies the potential of modern heating systems for coke ovens in the light of stringent legislation (like the TA on air), i.e. small ovens (as in the Ruhrkohle plant, Hassel, D) can comply with the legislation and larger ovens may encounter difficulties, depending on the type of fuel used (mixed gases or rich gas) and operating temperatures. This work is at the leading edge of industrial application, at least in the case of the new batteries (such as the project for building battery B 7 at Sollac - Dunkerque (F) for example) and reinforces the world leadership of EU industry in building and operating coking ovens.

One research project (**447**) targeted another crucial problem in operating coking ovens, namely **desulphurisation of coking oven gas**. Solutions based on diethanolamine (DEA) and triethanolamine (TEA) were studied in a pilot unit as an alternative to the desulphurisation procedure using monoethanolamine solutions (MEA) currently used at Hoogovens, Ijmuiden (NL) in the hope of reducing the cost of processing and alleviating maintenance problems (corrosion, soiling and depletion of reagents, etc). The results do not argue clearly in favour of a radical change of the type of reagent and highlight the problems involved in eliminating organic sulphur from coking oven gas.



R. 447
Pilot desulphurisation plant using ethanolamines

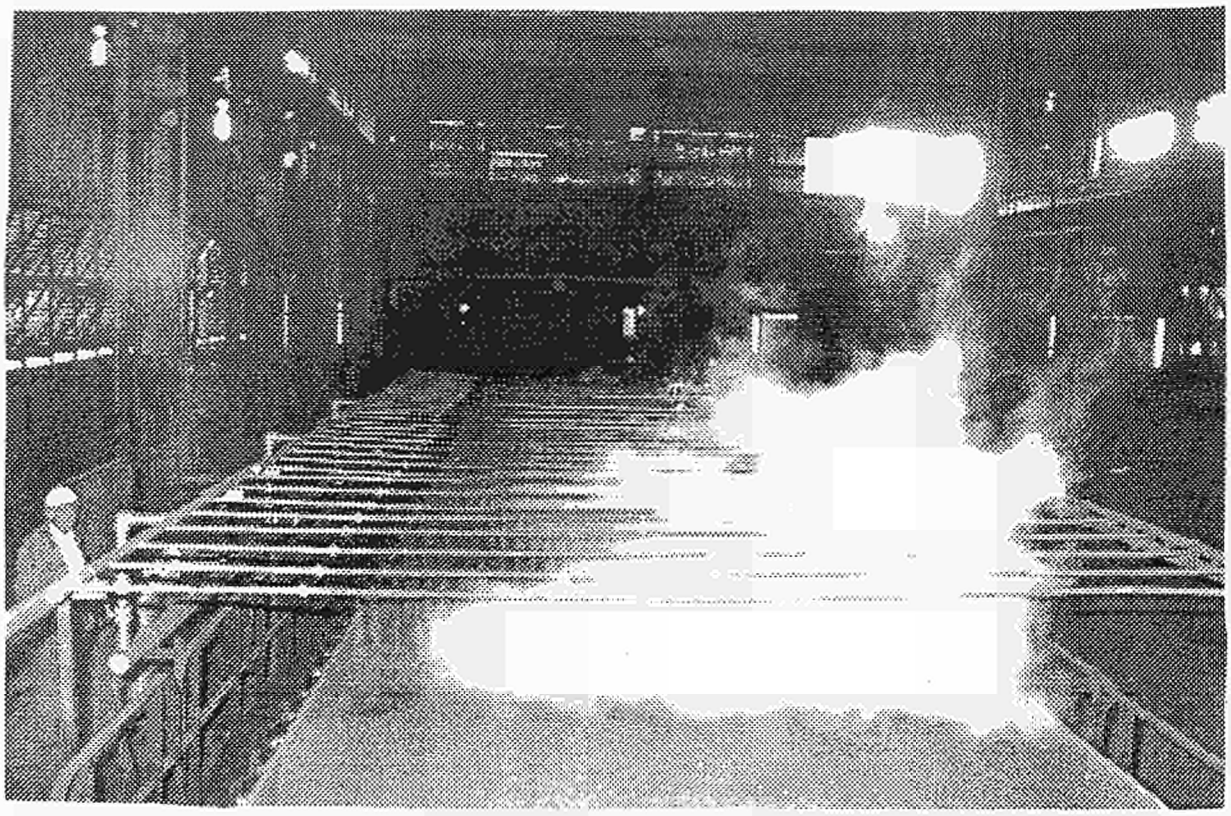
1.3.2 Iron ore sintering sector

In an integrated steel plant, iron ore sintering is the main source of emissions of **sulphur and nitrogen oxides** into the air. Several research projects in this field departed from the end-of-pipe approach, which is too costly for treating large volumes of fume with a low concentration of pollutants. Research projects **410, 450/502** and **414** took the opposite approach of preventing emissions at source.

This research work staked out the first approach to recycling heating fumes through the strand by examining the influence of the contents of O_2 and CO in the oxidising mixture on pollutant emissions, the catalytic effects of various sinter mix additives and the effects of injecting steam into the combustion air. There are at least two potential advantages of recycling the fume:

- smokestack emission volume is cut,
- energy is recovered (sensible heat and combustion of CO) and there is an attendant reduction in the fuel consumption rate.

Tests on recycling the fume are being continued under DG XII ECSC steel research programme on an industrial scale at a demonstration unit at Hoogovens, Ijmuiden (NL). If it is successful, particularly with regard to maintaining an acceptable level of sinter quality and strand productivity, sintering fume recycling could have a decisive impact on the atmospheric pollution generated by integrated steel plants. The European Union would confirm its role as a pioneer and a skilled operator in this field. Economically and ecologically there is much at stake, as the investment to modify and convert a sintering line is around 10 million ecus.



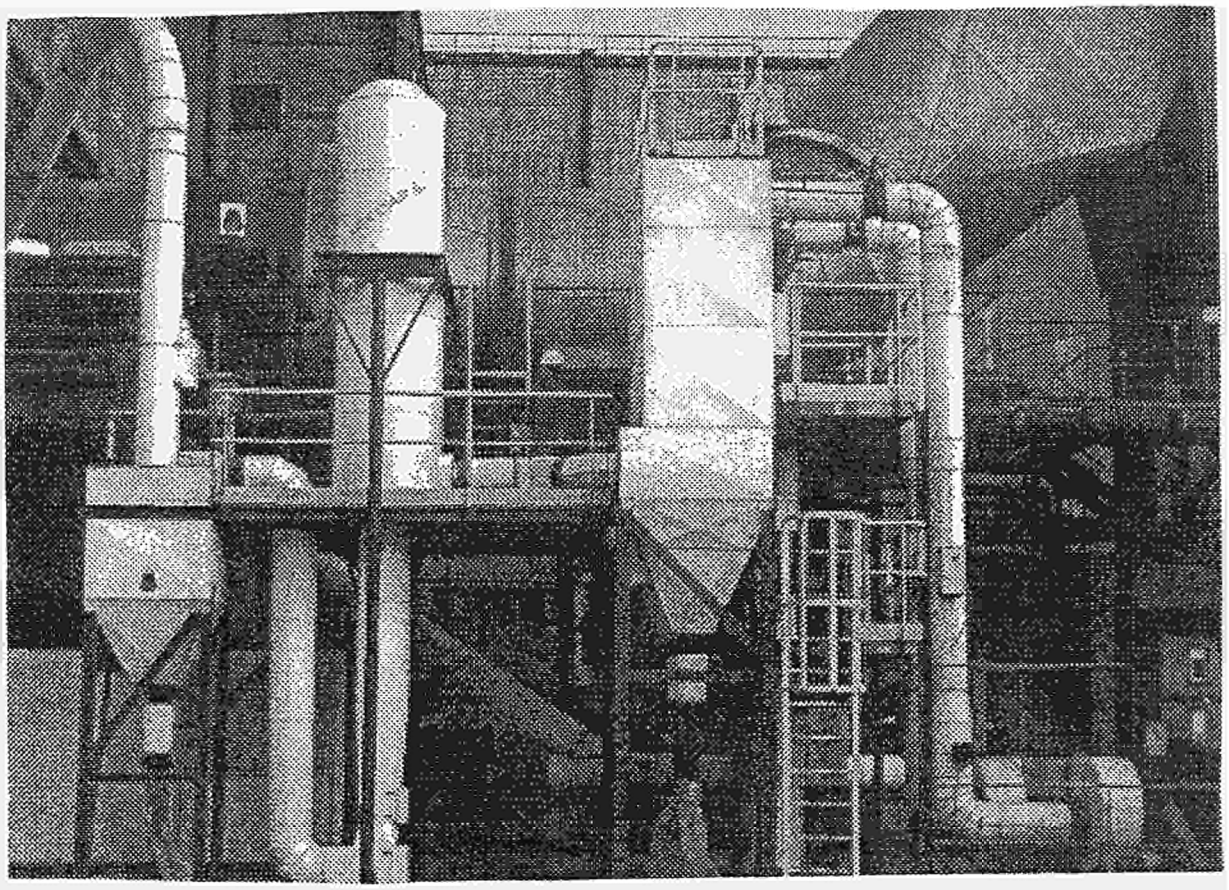
R. 502
Steam injection in aspirated air

Industrial tests on steam injection in the oxidising air are also under way at Ilva Taranto (I) with promising reductions of CO and NO in the fume, which cannot yet be quantified.

In the field of end-of-pipe fume processing, one research project covered selective catalytic reduction of nitrogen oxides by ammonia with pellets produced from iron ore used as catalysts (**470**). In the laboratory, reduction rates above 80% were achieved. This type of catalyst, which is less expensive than conventional ones, can moreover be recycled easily in steel-making plant. Tests on a larger scale are planned at Hoogovens Ijmuiden (NL).

Other curative research projects examined dedusting and desulphurisation using precoated bag filters (**432/455**) and problems of organic emissions connected with fires in electrostatic precipitators (**478**, which is still in progress).

The two research projects **432** and **455** were conducted entirely on an industrial site (Uckange plant, Lorfonte, F) using a pilot bag filtration unit (4 000 Nm^3/h), installed parallel to the main fume circuit.



R. 455
Pilot plant for the dedusting and desulphurisation using precoated bag filters

Excellent results in terms of dedusting (below 10 mg/Nm^3) were obtained with the procedure for precoating the filtration medium with chalk at periodic intervals; moreover, some acid aerosols (HCl, HF, etc.) and organic compounds were captured.

Two reagents (slaked lime and sodium bicarbonate) injected into a reactor upstream of the bag filter pilot unit were tested for desulphurisation of both all the heating fumes and the fume from the wind boxes which emit the most SO_2. The maximum desulphurisation rates were in the order of 80 to 85%

The results achieved by research projects **432** and **455** constituted a preindustrial advance which will be significant if the limit values for waste in iron ore sintering are reduced. Nevertheless, the major problem of dealing with the waste generated by this fume treatment process and the risk of the bags being perforated by incandescent particles still has to be dealt with.

The work in progress in project **478** has two aims:

* to prepare a balance sheet of the organic emissions in the ore sintering process,

* to seek a technical means of eliminating fires in electrostatic precipitators whilst ensuring that there is optimum recycling of byproducts into the line.

The first objective has virtually been achieved now. The same applies to the laboratory study of the mechanisms which trigger the combustion of dust deposited on the electroprecipitation plates. The factor or factors which trigger these fires on industrial sites need to be determined. There is a **real need** for a means of eliminating fires in integrated steel plants to maintain the dedusting efficiency of electrostatic precipitators and to prevent costly repairs.

1.3.3 Steelmaking sector

Organic emissions from electric arc furnaces were studied in research projects **415** and **495**.

Project **415** examined the impact of the scrap preheating process on primary and secondary emissions from electric arc furnaces: the quality of air in the shop, odiferous emissions, organic emissions, and the quality of dust collected in the dedusting equipment. The tests were carried out at the Neuves-Maisons plant (Unimetal, France) equipped with a first-generation scrap reheating unit. The results highlighted:

* the considerable part played by the scrap reheating process in clogging of bag filters

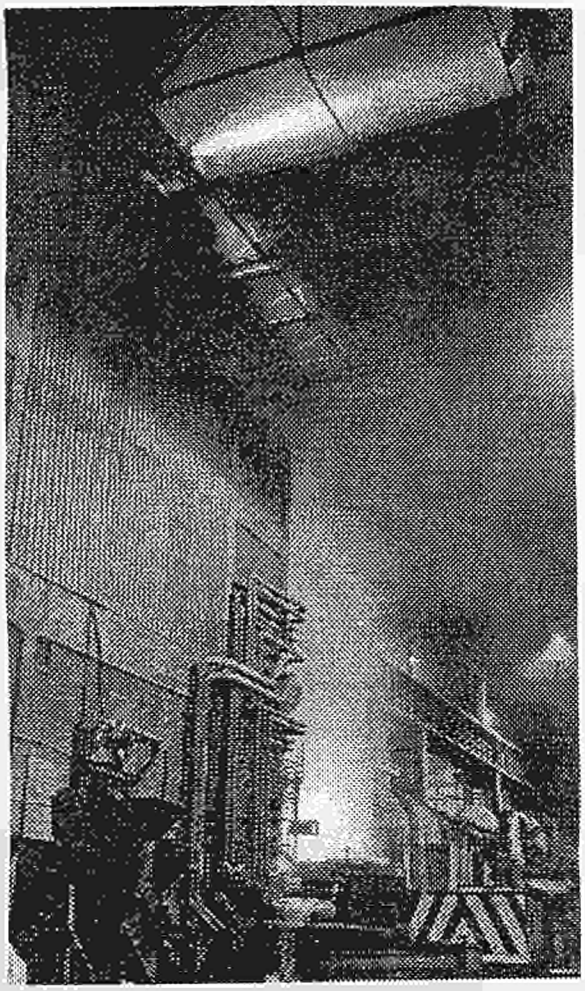
* the significant degree to which the type of scrap determined organic emissions from the furnace

* the existence of odiferous emissions

* the relative harmlessness of the preheater as regards the quality of air at places of work

* the increase in the organic fraction of dusts collected in the bag filters.

The work being conducted in research project **495** in several electric steelmaking plants in the Usinor Sacilor Group (France) is aimed at examining and reducing particulate, gaseous and condensed organic compound emissions present in primary and secondary fume from electric arc furnaces. At the present stage, the results obtained mainly relate to qualitative and quantitative analysis of organic emissions depending on the type of scrap, orientation tests at an industrial site to analyse the factors affecting organic emissions and optimisation of post combustion to reduce organic emissions.



R. 430
Fume obscuration meter in a collecting hood

Project **430** examined optimisation of **electrical energy consumption in the fume collection and dedusting system** in electric steelmaking shops. Tests were carried out at the UES Tempelborough plant (UK) with these aims in view:

* to optimise the signal delivered by special obscuration meters located in the main fume circuit and on the edge of the secondary fume collecting hood to regulate the extraction rate, system pressure and gas flow;

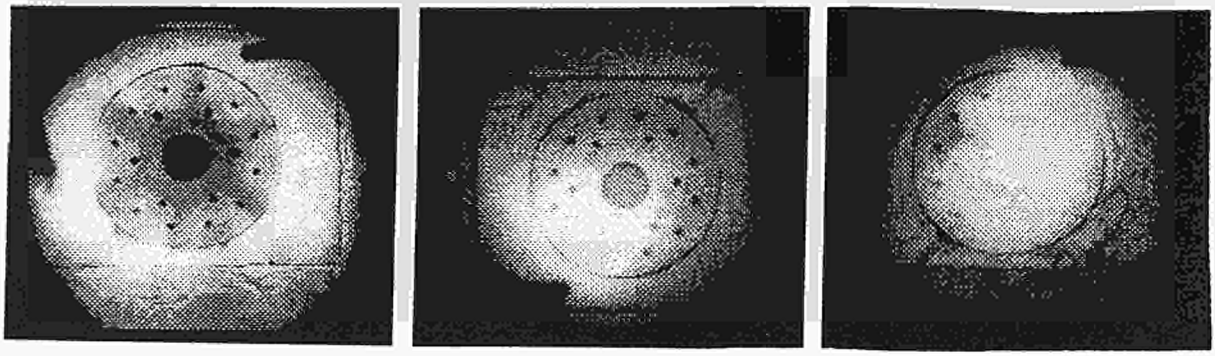
* to devise a control strategy for optimum collection.

The results showed that the model devised was well correlated with the real measurements of energy consumption. The installation set up in the Tempelborough plant enabled annual savings of ECU 36 000 to be made, representing a return on the investment within less than one year. The addition of a variable speed control installation on one of the four fans will take annual savings to ECU 90 000.

Project **499** was designed to devise an artificial intelligence system to optimise collection and dedusting of fume from steelmaking furnaces. The tests were carried out at the Avesta Sheffield Ltd plant (UK) 120 t electric arc furnace, 130 t AOD converter, ladle furnace and continuous casting). In consultation with the management, the research team selected five installation zones to provide data input for the expert system (COGSYS Ltd software) which will operate in real time. Accumulation of data started up in July 1993. If this project is a success, it will have repercussions in several areas, reducing pollutant emissions, reducing pollution at places of work and saving energy.

1.3.4 Reheating furnaces

After iron ore sintering and coking plant, reheating furnaces for semiproducts and products constitute the third largest source of NO_x in an integrated steel plant. These installations are coming under considerable pressure from legislation, particularly as a result of framework Directive 84/360/EEC.

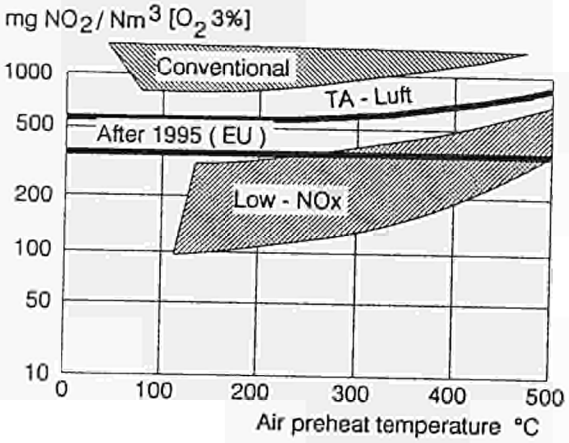


R. 407
Study of heating furnace burners

Tests were carried out in pilot furnaces using various industrial burners (**407/414, 431** and **457**) to establish the effect of the following on nitrogen oxide emissions:

- the type of fuel (particularly the byproduct gases which the steel industry has to use;
- burner design (conventional or low-NO_x);
- operating conditions (excess air, preheating of the air, recirculation of combustion fume and thermal power).

This gave rise to a series of recommendations to comply with the regulations applicable to reheating furnaces. With the low-NO_x burners, with a longer flame and a uniform temperature (mainly due to air staging) and modern combustion control systems (particularly excess air), it is possible to maintain emissions at between 100 and 350 mg NO_x/Nm^3 (expressed in NO_2 corrected to 3% O_2).



R. 407
Performances of heating furnace burners (gaseous fuel)

Reheating furnaces with intensive preheating of the combustion air and high energy recovery - but also increased NO_x emissions - still pose a problem in terms of legislation. Here the dual aims of energy savings and protection of the environment are incompatible. All that remains is to control the furnaces so as to reduce excess air and operate in a less oxidising environment in the soaking zone with an acceptable level of CO emissions.

In order to avoid having to install new burners, Thyssen Stahl (D) carried out laboratory and industrial experiments on controlled injection of steam in the hot air conduit (250°C) supplying conventional burners (with parallel flow) in a furnace heated with coking plant gas (**431**). The concentration of nitrogen oxides in the waste gases was reduced by between 30 and 50%. Thyssen Stahl intends to pursue this line of investigation to assess the performance of this technique in an industrial furnace over a long period of time. Attention will be focused particularly on energy efficiency and potential mechanical problems such as observed with gas turbines where steam injection is already used.

British Steel (UK) is following the same philosophy for reheating burners (**457**). The three techniques which have been assessed are external flue gas recirculation, injection of water into the flame and of ammonia or urea into the waste gas before passing across the regenerator bed. In an experimental furnace the concentration of NO_x in the fume has been reduced by between 50% and 80%, accompanied, however, by deleterious effects such as derating, a drop in energy efficiency and an increase in costs.

1.3.5 Other action

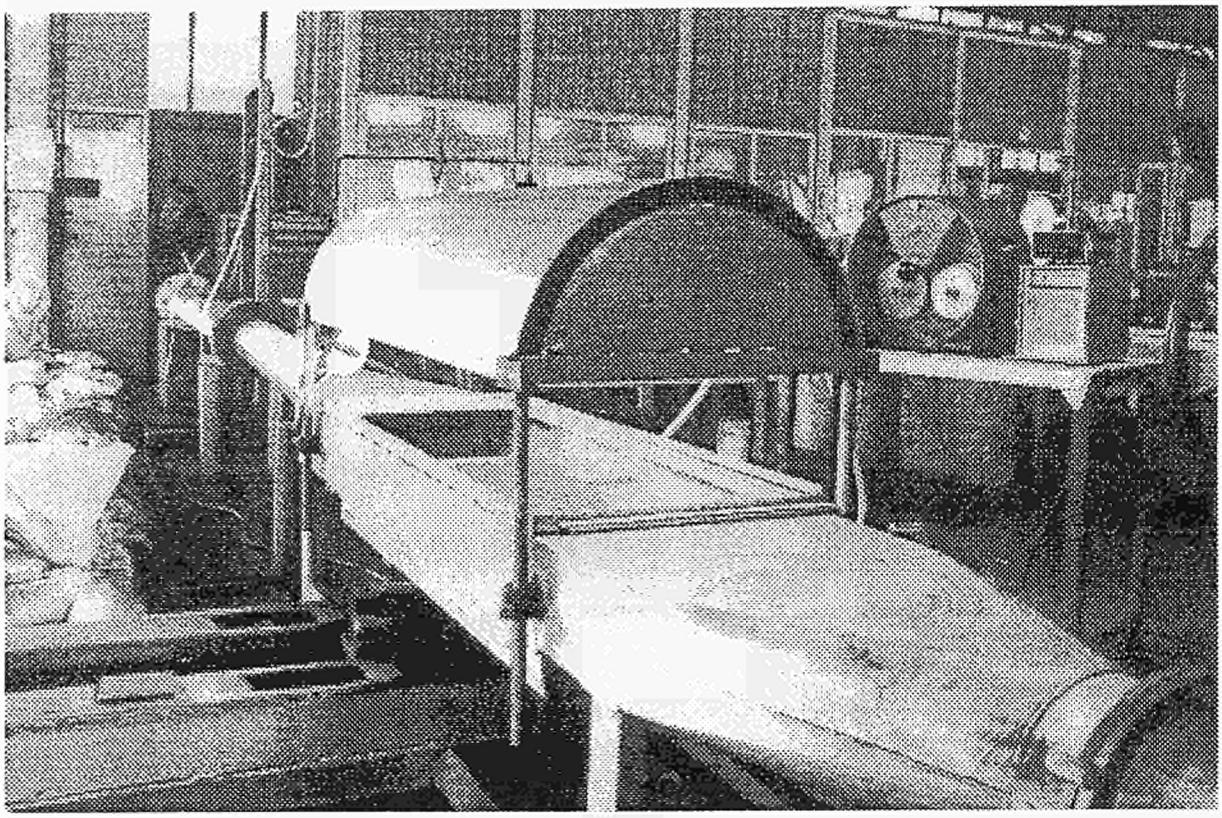
Other action of a more selective nature has been taken to examine:

- control of **nitrogen oxide emissions from integrated power stations at steelworks,** once again, using the byproduct gases of the steel industry (**451**);

- control of dust blow-off in coal and ore stockyards (**421**).

Project **421** concentrated on the prevention of dust blow-off in integrated steelworks' ore and coal stockyards. The approach adopted is undoubtedly a novelty and has been followed by other research organisations in the European Union.

The aim was to use binding agents to prevent blow-off. The research comprised: selection of binding agents, physico-chemical analysis of mineral and fossil materials and in particular, assembly of a wind tunnel to examine the mechanisms of dust blow-off and the effectiveness of binding agents, depending on various parameters such as exposure to the sun, temperature, humidity, weather conditions, and resistance to rain. The results have been applied successfully at the Taranto plant (ILVA, Italy).



R. 421
Experimental blower for the study of open air fugitive dust emission

R. 421
Spraying of surface binding agent

1.4 *Control of olfactory nuisances*

Olfactory nuisances are a special feature of atmospheric pollution and 0industrial hygiene and are the cause of many complaints by workers and local residents. Although regulation of olfactory pollution (as such) has not developed to any great extent in most countries in the European Union, this does not apply to the individual pollutants which cause olfactory nuisances (such as monocyclic and polycyclic aromatic hydrocarbons, hydrogen sulphide, organic solvents, etc.).

Combating olfactory nuisances is explicitly covered by the Fifth Research Programme. The work which has been conducted is summarised in Table 8 (3) and includes the research on electric steelmaking which has tackled the problem indirectly (cf. 1.3.3 research projects **415** and **495**).

TABLE 8 (3)
Combating olfactory nuisances

Work in the Fifth Programme	Number of contracts 7 (+ 2)/126
. Coking	1/7
. Granulation and cooling of blast furnace slag	3/7
. Electric steelmaking shops	(+ 2)
. Painting shops	3/7
(Proposal for a Directive on volatile organic compound emissions from industrial processes).	

1.4.1 Coking sector

Project **409** showed the main sources of odours in coking plants to be gas purification installations and their byproducts (accounting for almost 95% of odiferous products measured). This is where prevention and abatement measures can best be applied in both technical and economical terms.

1.4.2 Blast furnace sector

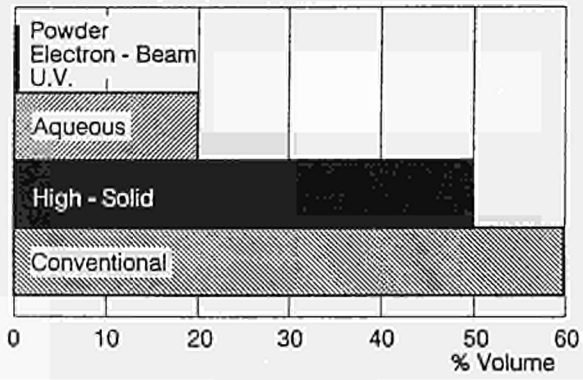
A large international research group was formed (projects **501, 507** and **508,** which are still in progress) in order to develop (after a cognitive phase of analysis and quantification of olfactory nuisances and exposure of workers to H_2S and SO_2) techniques for reducing odours in blast furnace slag granulation and cooling pits.

Alkaline scrubbing and improved condensation of granulation vapours with closed-circuit oxidation of rinsing water are being investigated or optimised. Pilot and industrial tests are being carried out in various steelworks in the European Union. On completion, it is hoped that optimum abatement technology for H_2S emissions can be defined.

1.4.3 Painting shops

After the cognitive phase of analysis and quantification of olfactory nuisances and exposure of workers to VOC, research projects **441, 472** (in progress) and **509** (in progress) focused on techniques for abating emissions in coil coating.

As a curative measure, a technique for catalytic incineration to treat the gases from drying ovens was developed and a project for building a demonstration unit is being discussed. This new technique guarantees better oxidation yields for VOC at lower temperatures (250 to 300°C) and, as a result, major energy savings compared with thermal incineration (≥ 700°C), although the problem of catalyst poisoning is one that still requires great attention. This technique is proving to be most promising as a finishing stage.



R. 509
Content of organic solvent in paints

As a preventive measure, the use of paints containing little or no solvents and magnetic induction drying ovens (which open up the possibility of techniques for recovering solvents, as the temperature of the drying gases does not exceed 55°C) is being investigated.

Unfortunately, the systems generally require major conversion of the manufacturing process as the application and drying method is totally different. Moreover, these systems are not yet suitable for all materials i.e. for powdered paints or for application processes using UV or electronic drying for steel. In the steel coil coating sector, only certain paints with a high solids content (PVC as finishing coat) or aqueous content (which are encountered more in primary and finishing coats) are currently being applied. Another reservation concerning water-based paint arises from the implications in terms of energy (higher specific vaporisation heat).

Through this research work, the European Union is once more establishing an area of international competence and is working towards reducing one of the most worrying types of pollution at the place of work and in the environment, namely pollution by organic solvents. As the work has not been completed, it is difficult to forecast the industrial repercussions but it is probable that they will be significant in such a strategic sector which is so crucial in economic and ecological terms.

2. MEASURES TO COMBAT FRESH AND SEAWATER POLLUTION

The steel industry uses a great deal of cooling, wash and process water. Constant care must thus be taken to maintain the quality and supply of water.

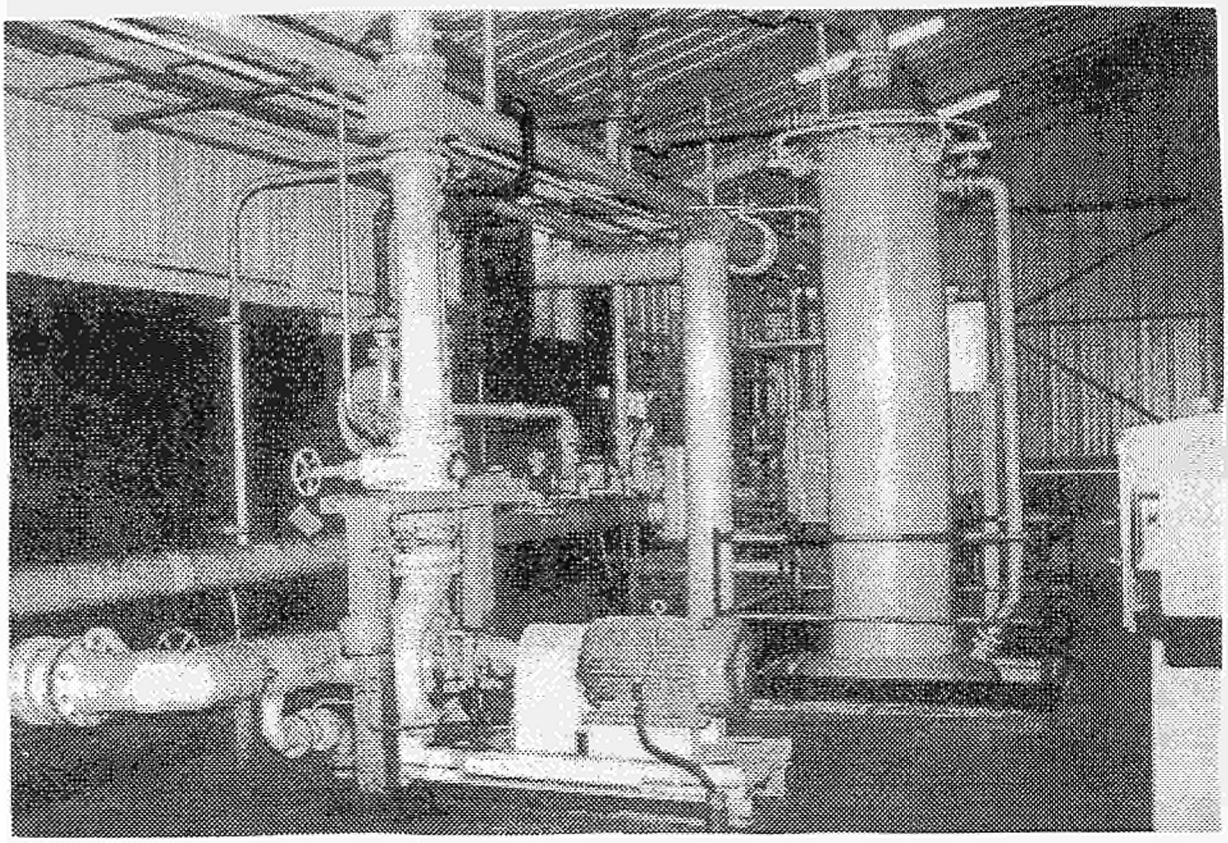
The objectives of the Fifth Research Programme occasioned by concern on this front are set out in Table 9.

TABLE 9
Measures to combat fresh and seawater pollution

Aims of the fifth programme	Number of projects 33/126
• Reduction of pollutants in lists I and II of Council Directives 76/464/EEC and 80/68/EEC (on pollution discharged into the Community's aquatic environment).	33/33
• Recycling and cascade utilisation of waste water	12/33
• Improving purification:	8/33
– of coking plant waste water (e.g. biological nitrification)	5/33
– gas scrubbing water (e.g. blast furnace)	2/33
– hot and cold rolling mill effluent (e.g. oil emulsions)	
– spent bath solutions and rinsing water in surface treatment installations (e.g. heavy metals)	14/33
Other activities	
• Indirect cooling water	1/33
• Levelling out of pollution peaks	1/33
• Analysis and stocktaking of organic micropollutants and nanopollutants	1/33
• Water used in blast furnace slag granulation and cooling pits	see Olfactory nuisances
• Waste leaching	see Waste
• Ground water (on polluted coking plant sites)	see Polluted Soil

2.1 *Coking sector*

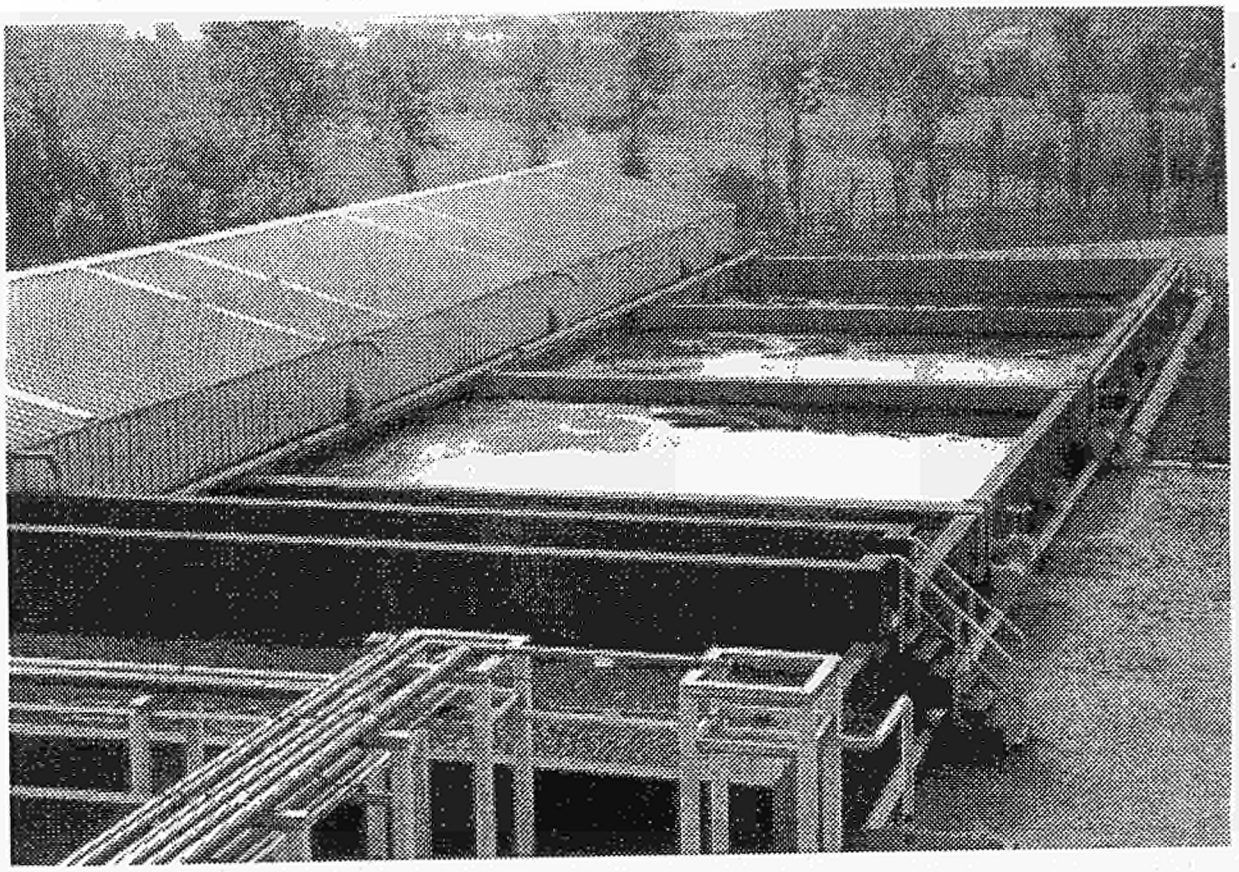
Waste water from coking plants is certainly amongst the most difficult to purify in the steel industry and is targeted by legislation because it is toxic.



R. 434
Pure oxygen saturator

One area investigated was enhancement of biological purification by activated sludge (**416/452** and **434**). The results were spectacular and were applied immediately on an industrial scale. The improvements comprised injection of pure oxygen to aerate the bacteria instead of conventional surface aerators and use of a series of reactors combined with multistage influent feed.

These changes produced a new generation of biological purification installations which not only eliminated the carbonised pollutant load but also allowed nitrification of the ammoniacal load (in the case of the Monckton (UK) and ACZC – Sluiskil (NL) coking plants) or denitrified it (as at the Sidmar (B) coking plant). The exceptional levels and stability of purification achieved at Sidmar puts this installation amongst the world leaders. The total cost of purification (including tar removal and stripping) were around 6–7 ecu per cubic metre of treated water (of which some 25% was accounted for by biological purification).



R. 434
Biological plant with nitrification – denitrification

Projects **493** and **496**, which are still in progress, are studying tertiary treatment. Various finishing processes are being assessed on a pilot scale (dissolved air flotation, oxidation by ozone treatment, micro and ultrafiltration, activated carbon, etc.). In the case of application with coking plant water there proved to be no alternative but to await development of new generations of filtration membranes which guaranteed greater resistance to clogging.

At present, adsorption on activated carbon is proving the technically most acceptable solution for final purification of coking plant waste water (final effluent COD, PAH and suspended solids concentration) but involves an increase in the treatment costs of around 1 ecu per cubic meter of water treated.

In conjunction with previous work in the course of the fourth programme, these two projects have enabled European researchers to establish their knowhow and expertise at international level.

It is in the European Union's coking plants that the most efficient biological installations in the world are to be found. However it is a pity that only curative measures have been studied. The question is whether in series or end-of-pipe purification systems which are increasingly costly and require more and more complex management could not be replaced in the future by cleaner and more innovatory technology. Some, albeit tentative, steps are being made in this direction such as the design of a modified gas treatment system providing for maximum recycling of waste water in the production process.

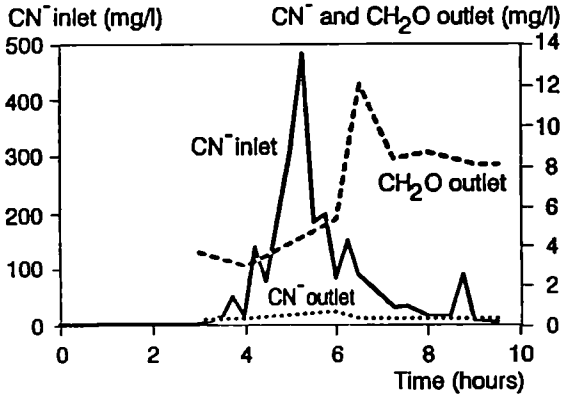
2.2 *Blast furnace sector*

The researchers' attention was focused on two aquatic pollution problems in the blast furnace sector: cyanide emissions and slag cooling.

The problems with **water for blast furnace slag granulation and cooling pits** are examined, at least indirectly, in the chapter on olfactory nuisances (projects **501, 507** and **508**, all of which are still in progress).

It is mainly the problem of **cyanide emissions** which is tackled in this chapter. Production of molten metal in a blast furnace is known to involve emission of cyanide compounds both in unstable daily operating conditions and in the special case of a blowdown. Although local conditions are quite different from one blast furnace to another, depending on the operating conditions, overall emission of cyanides during a blowdown can reach 1 tonne, whilst the concentration in the gas scrubbing water in certain critical circumstances can reach peaks of 50 mg/l during daily operation.

Two approaches were adopted: preventive (**460**) and curative (**412, 413, 458** and **459**).



R. 460
Cyanide abatement with formaldehyde during a blowdown

Systematic examination of irregularities in the operation and the conditions in a blowdown has not identified any action which could actually prevent the formation of cyanide at source, given the complexity of the mechanisms involved. The researchers thus fell back on improving effluent purification and control techniques.

After investigating the problem the researchers came up with an optimised procedure for the abatement of free cyanide with formaldehyde and two process control techniques for continuous adjustment of the quantity of reagent (polarography and oxido-reduction potential).

The formaldehyde cyanide abatement process is now being applied on an industrial scale in Belgium and in Germany both for daily operation and during blowdowns. The technological limits of the process have been established at a free cyanide content of 1 mg/l of treated water. In economic terms, the formaldehyde treatment costs one fifteenth of the previous potassium caroate treatment (in the case of a blowdown).

2.3 *Pickling sector*

During pickling a minimum of 0.3% of the treated metal is estimated to be carried over into spent liquor, rinsing water and sludges. This sector, like all surface treatment, can constitute a complex source of pollution and it is fortunate that the Fifth Programme covered many of these production phases.

The main area of research was the pickling of stainless steel (using molten salts, or electrolytic or chemical pickling), the aim being to:

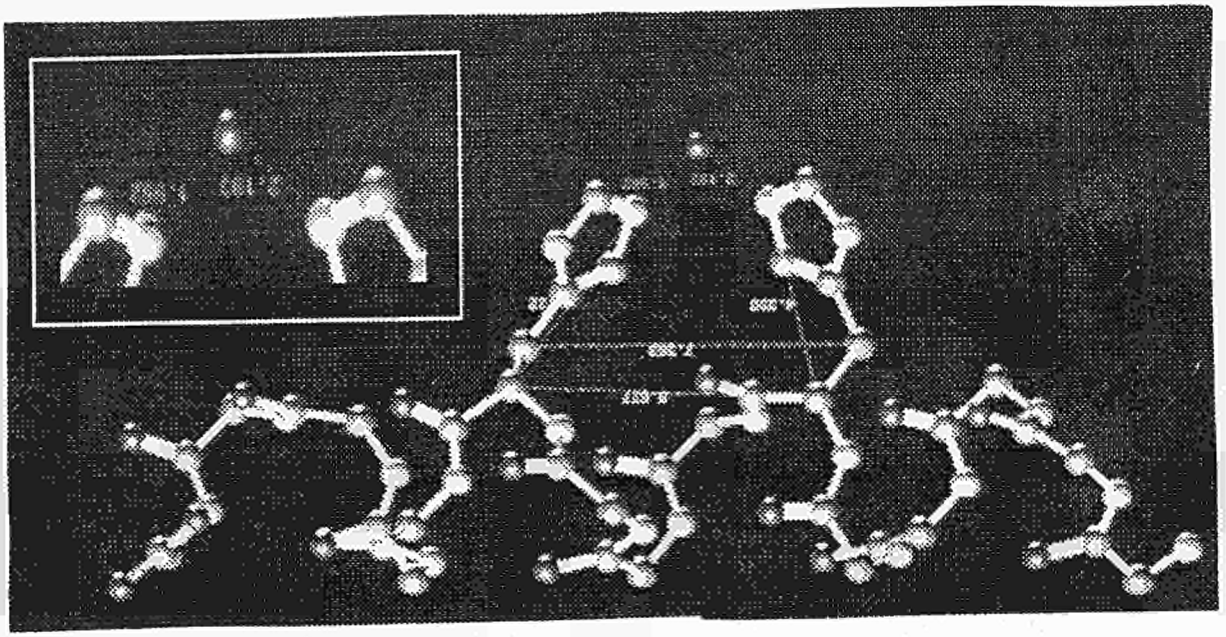
- **regenerate spent liquor and utilise sludges** containing oxides, fluorides and Fe/Ni/Cr hydroxides. One of the aims was to make the Ugine Peroxide Pickling Process (UG3P), which uses oxygenated water instead of nitric acid for chemical pickling of special steels, totally "clean". Despite the considerable deposits of chrome, nickel and fluorine to be recovered, none of the processes examined (427) proved economically acceptable; neutralisation of spent liquor (and rinsing water) with lime remains the normal industrial process, with controlled dumping of hydroxide sludge.

- **reduce carryover from concentrated bath solutions to rinsing water** by optimising brushes and designing new drying rolls. Carryover levels of 5 cm^3/m^2 of wet plate have so far been achieved with a pilot simulation unit, (project **474**, still in progress).

- recycle rinsing water. Water savings and attendant reductions in pollutant waste of 50% were achieved in a recent case of industrial application (Ugine Gueugnon (F)) by using an informatics model with a management programme for closing rinsing water circuits in conjunction with newly developed in-line treatment. Reductions of between 70% and 85% are expected at other sites (project **474**, still in progress).

- treat unavoidable waste. Various methods for reducing hexavalent chrome were examined in the laboratory during project **438** but, in the final event, conventional ferrous iron reduction of spent sulphuric pickling liquor is still being used industrially in the Ugine Imphy and Ardoise (F) plants.

In project **477** spearhead genetic engineering techniques were implemented to design a protein for heavy metals chelation. Its affinity was demonstrated in the laboratory but practical applications can be expected only in the very long term.



R. 477
Tailored protein for heavy metals removal

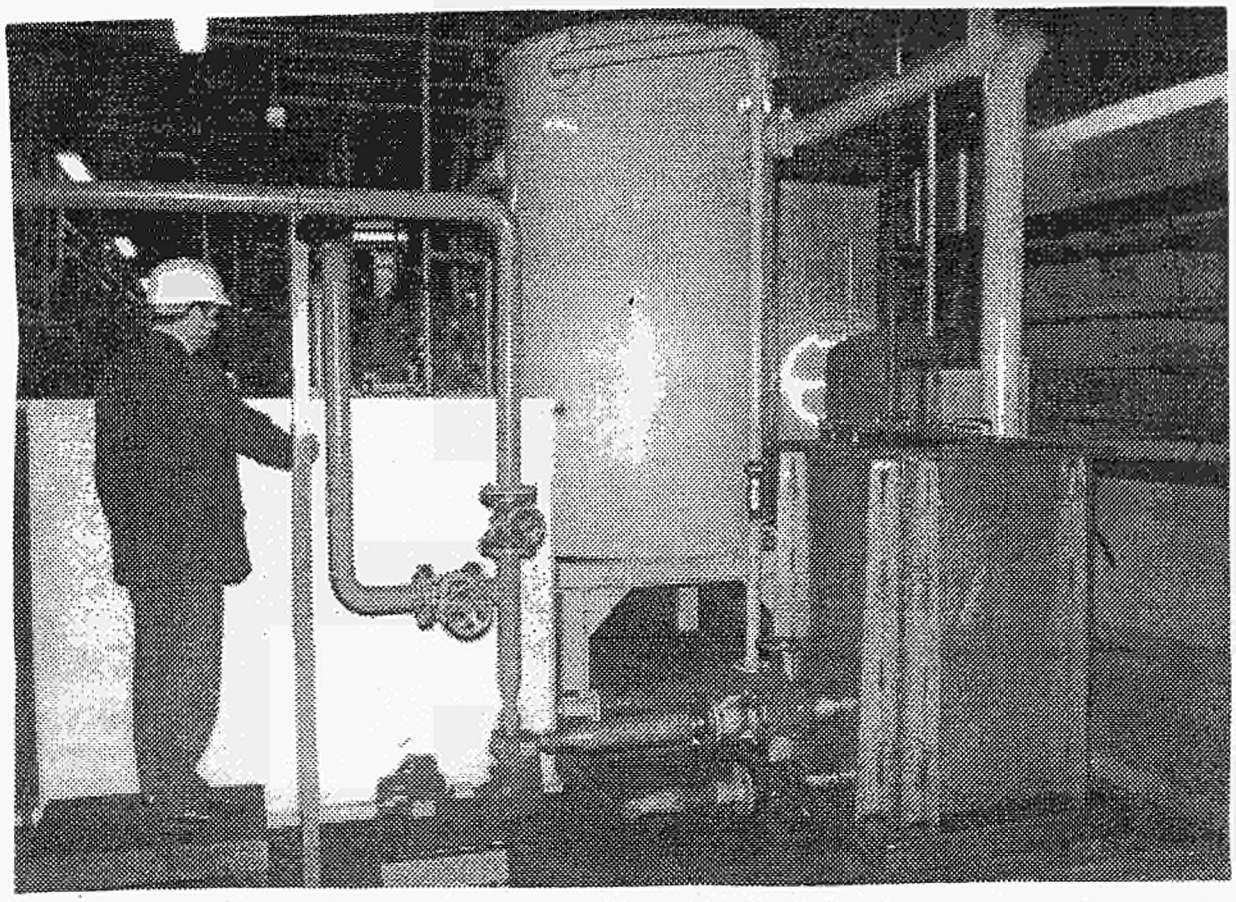
Tests in progress on nitrate waste (project **474**) are not sufficiently advanced for the potential of the processes under investigation to be determined.

A Spanish research project **512** (which is still in progress) studied the biological treatment of spent hydrochloric and sulphuric pickling liquor for recycling and recovery of heavy metals and hydrocarbons. In essence, the programme concentrated on finding new ways of treating waste water from the steel industry by applying recent advances in biotechnology to this sector.

2.4 *Surface treatment sector*

The surface treatment sector encompasses a variety of operations which can cause various types of pollution. As mentioned above, the Fifth Research Programme encouraged activities in this ecologically complex sector.

A large multinational and multidisciplinary research team investigated the impact on the environment of steel plate degreasing and studied preventive action that could be taken to limit pollution (project **473**, which is still in progress).



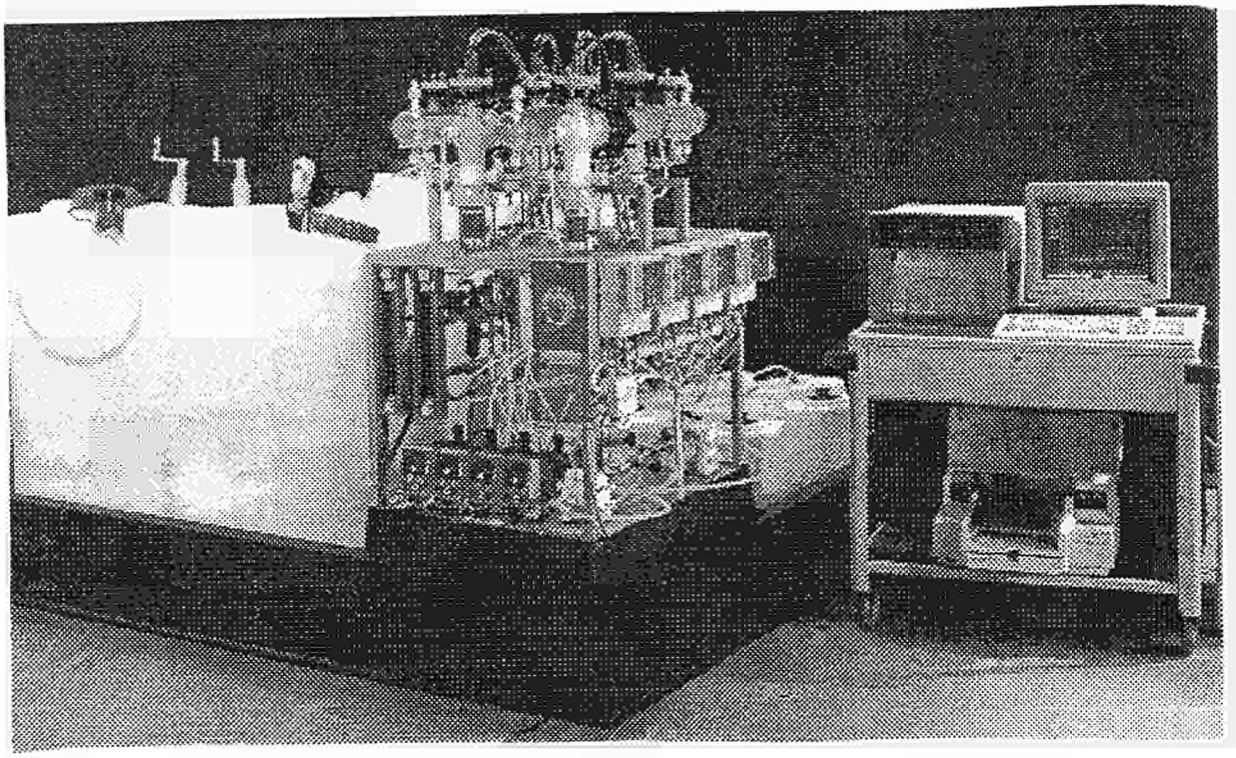
R. 473
Industrial scale plant for oil removal from degreasing bath

Although work is still in progress, it has already had some industrial repercussions. At Ugine Gueugnon (F) the life of a degreasing solution in line 11 was taken from one to 2.5 months by means of continuous oil removal (gravity separation). Two other lines will soon be equipped with the same de-oiling system. The mineral oils which are recovered (in the case of stainless steels) contain between 6 and 10% of water and can thus be used as fuels. The same approach has been adopted at the Terni Acciai Speciali Works (I), producing identical results (increasing the life of magnetic steel degreasing baths from 0.5 to 2 months). Various attempts were also made to regenerate degreasing solutions, introduce more ecological degreasing agents and to recycle rinsing water as far as possible. Tests in progress at Ugine Geugnon show that tangential microfiltration of rinsing waters with a ceramic membrane reduces the hydrocarbon content by a factor of 300 and COD by a factor of between 5 and 10, but the long-term stability of this type of treatment has yet to be demonstrated.

Another focal point was **galvanisation**. At the Italian plant at Ilva-Torino (**464**), the introduction of a code of good practice and good management of bath solutions enabled the zinc losses during electrogalvanisation to be reduced by 60%. A further reduction of between 10 and 15% could be achieved if the neutralisation station sludges were redissolved in sulphuric acid and the $ZnSO_4$ recovered recycled into the line.

This technique, which involves replacing lime by caustic soda in the neutralisation process (to prevent the formation of $CaSO_4$), and installing a resin iron removal unit and effective de-oiling equipment for degreasing operations, has not yet been applied industrially.

Research project **506** had the same aim of recovering and recycling zinc but by means of extraction by organic solvents. In the laboratory, 70% of the zinc in a phosphatisation solution was separated, which is promising. Pilot tests with technical and economic studies are planned at Krupp Hoesch Stahl (D).



R. 506
Pilot plant for metals extraction with organic solvent

Project **433** is concentrating more on end-of-pipe effluent treatment, particularly removal of zinc, chromates (from passivation) and nitrites, but no industrial applications have yet emerged.

Overall we can conclude that these attempts to recover metals and reduce the volume of dangerous waste produced by surface treatments are coming up against economic obstacles, especially since the metals concerned, here mainly zinc, only have a limited market value.

2.5 *Other activities*

Other one-off projects which have been conducted are still in course in the Fifth Programme are:

- the treatment of new high-stability **cold rolling mill emulsions** to recycle the oils and the water. The techniques envisaged are microfiltration, adsorption on activated carbon, thermal demulsification (project **510**, which is still in progress) or coalescence with resin and ultrafiltration (project 511, still in progress). Tests are still under way.

- ultrasonic inhibition of the proliferation of marine organisms in **indirect cooling circuits** as an alternative to chemical biocides. This technique is proving of practical interest only in small pipework (435).

- **smoothing pollution peaks** by dividing the effluent into partial flows supplying parallel non-agitated piston flow tanks with varying residence times (**461**). The technique's feasibility has been demonstrated and the advantages (a more compact and less energy consuming system) over conventional homogenisation tanks have been identified but it has not yet been applied in industry.

- the implementation of analytical logging for the control and inventory of organic micropollutants and nanopollutant waste in the aquatic environment specific to the steel industry (**476**, still in progress). The steel industry, apart from coking plant, does not seem to produce much waste of this type.

Action to treat **leaching products** from waste and tips and purification of ground water in areas of polluted soil in coking plants are described in the corresponding chapters.

3. WASTE AND LANDFILL PROBLEMS– UPGRADING OF BYPRODUCTS – REMEDIATION OF CONTAMINATED SOIL

Steel production generates large quantities of residues. It is imperative that henceforth these are reduced at source, recycled, upgraded and if they are unavoidable, destroyed or eliminated without any harmful effects on the environment and workers. The Fifth Research Programme's activities in this wide field are shown in Table 10.

3.1 *Iron-containing waste with high contents of zinc and lead*

The mass of blast furnace sludge discharged in the European Union is in the order of 250 000 tonnes (dry residue) a year. If we add steel-making sludges and dust, which account for the highest volumes, the figure is well in excess of 1 million tonnes a year. Their high contents of zinc and lead are a major obstacle to recycling them in the production chain.

TABLE 10
Waste and landfill problems
Upgrading of byproducts

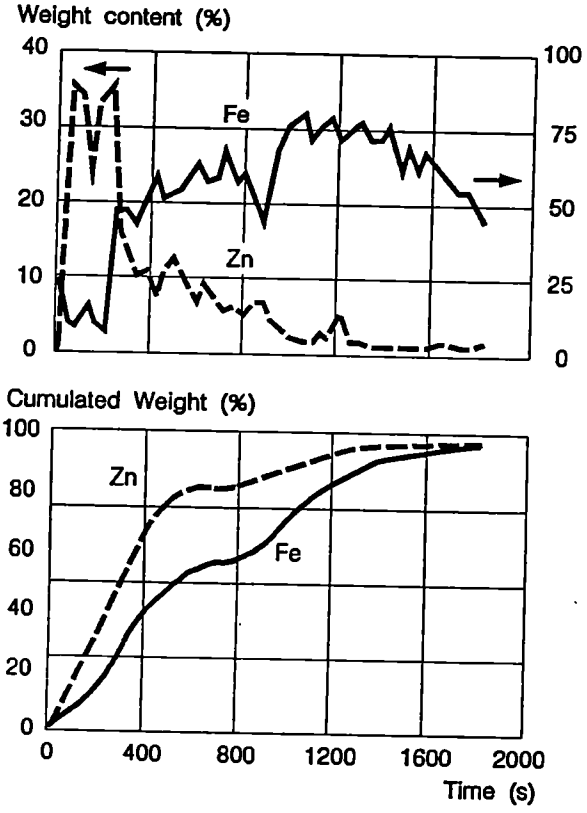
Aims of the Fifth Programme	Number of contracts 26/126
• Efficient management of waste (reduction of volume, treatment, etc.) (Council Directives 75/442/EEC, 91/156/EEC, 78/319/EEC, 91/689/EEC, 75/439/EEC).	26/26
• **Recycling and upgrading** of waste (Council Directives 75/442/EEC and 91/156/EEC).	20/26
• Safe **dumping and landfilling** of unavoidable waste (protection of soil, ground water, atmospheric pollution, etc.)	6/26
(Proposal for a Directive on the landfill of waste COM (91)102 final)	
• **Special activities:** treatment and upgrading	
– blast furnace and steel-making sludges and dusts	
– waste oil	13/26
– oily sludges from rolling mills	0/26
– steel-making slag.	3/26
	2/26
Other activities	Number of contracts
• Upgrading of used dolomitic brick	2/26

A **hydrometallurgical treatment line** for selective extraction of these elements by leaching with spent hydrochloric pickling liquors was developed in Belgium in the laboratory (**428, 453, 463**). The process is efficient for blast furnace sludges (80 to 99% zinc extraction) but is coming up against treatment costs which are too high (between 100 and 150 ecu/tonne of dry matter, including amortisation). Economic calculations at the end of the study show that, in the case of Belgium, treatment costs are twice as high as the costs of controlled landfilling. Using chlorine for oxidising the liquor and the risks of transfer of pollution to the aquatic environment must also to be taken into consideration.

Research project **503** was supposed to examine a second hydrometallurgical treatment line for electric steelmaking dusts, this time in an ammonia environment but the economic problems encountered by the contractor – PME OLS (I) - prevented the project from starting up. An alternative means of completing this research is being examined.

A **pyrometallurgical** approach to thermal zinc removal from electric and oxygen steelmaking dusts by chloridating volatilisation in an oxidising atmosphere in pilot fluidised bed furnace did not prove satisfactory (**485**). Much of the chloride injected (in the form of $CaCl_2$) passes through the furnace or is deposited there without reacting, which limits the zinc extraction rate to only 14% at temperatures of between 870 and 1000°C. A significant increase in the reaction temperature, which might have solved the problem, was not economically viable.

Physical treatment processes concentrated on granulometric or sequential separation of particles with high and low zinc and lead contents. At Krupp Hoesch Stahl (D) the possibility of separating zinc-laden particles emitted during the first two thirds of the oxygen bottom blowing period (**505** and **521**, still in progress) was examined. As dedusting is a wet operation, separation is achieved by moving a valve in the gas scrubbing water circuit supplying two separate decanters. The release of zinc proved to vary greatly from one batch to another particularly depending on the type of scrap charged in the converter and the blowing conditions. As a result, in-line equipment is needed which can measure the zinc in the fume very rapidly and thus generate a signal to reverse the operation. It is too early to say what the chances of this system are of being adopted on an industrial scale but it is hoped that 35 to 40% by weight of the particles containing less than 0.5% zinc can be recovered and recycled in iron ore sintering.



R. 505
Zn content in dust during a LD convertor cycle

An identical approach is being pursued in hydrocyclone treatment of blast furnace sludge (**475**, which is still in progress). In each 20μm size fraction, 70% by weight of low-zinc particles can be separated and recycled in the steelmaking process. This established technique has now been applied on an industrial scale for several years in various plants in Europe.

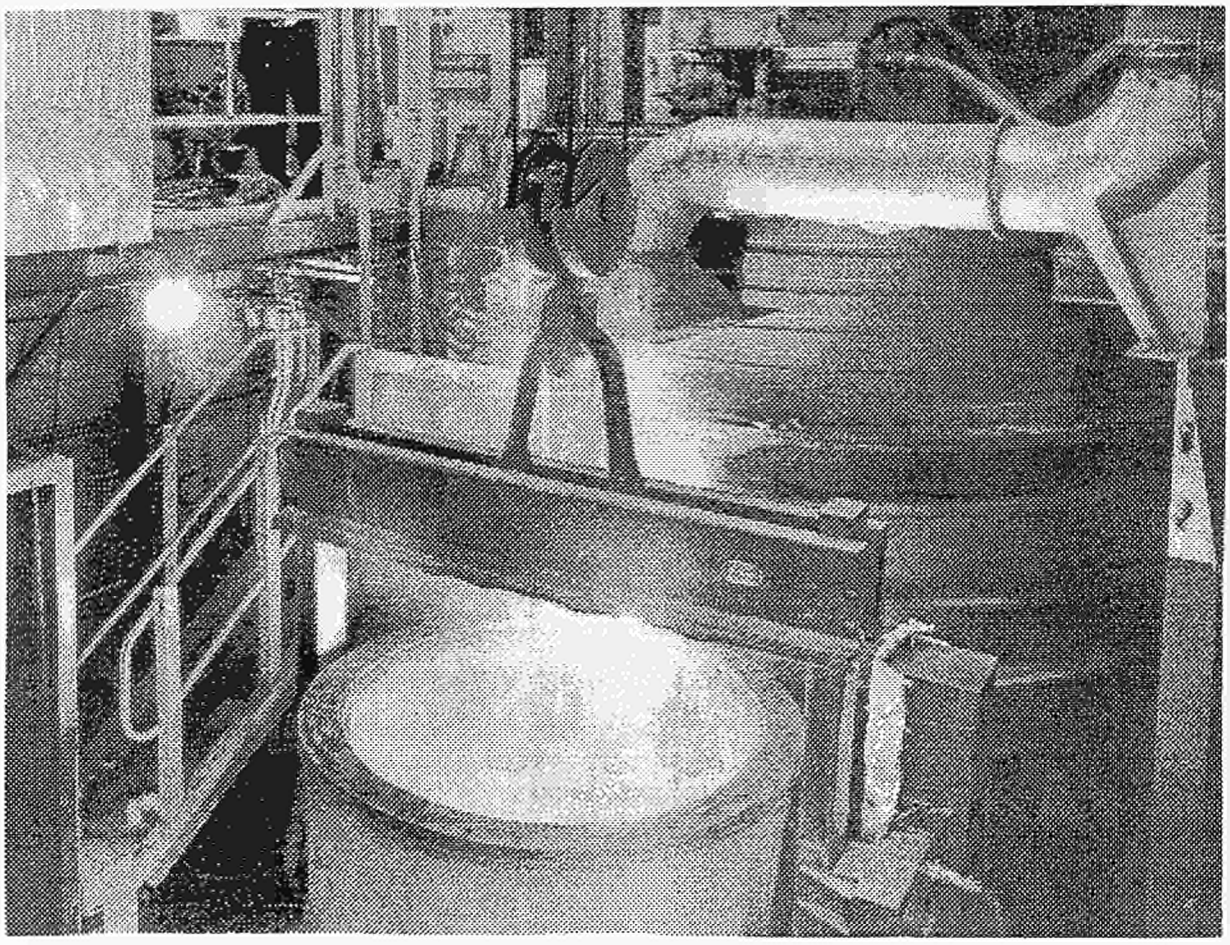
Work has also been carried out on the treatment of sludges and dusts containing zinc under the DG XII Steel Research Programme, namely:

- reduction in a circulating fluidised bed at Thyssen Stahl (D)
- hydrometallurgical sodium treatment at Unimetal (F)
- separation of zinc in LD converter dust at Hoogovens IJmuiden (NL).

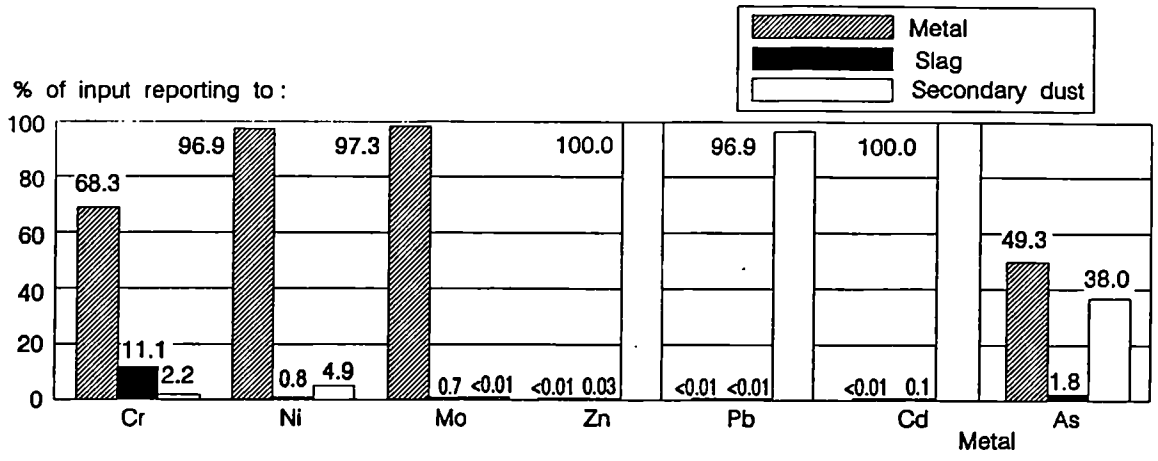
All these research projects bear witness to intensive activity in the field of treatment and upgrading of zinc and lead residues generated by the steel industry.

Despite all this R&D work, there is no getting round the fact that in the European Union at present, only part of the ferriferous residues with high a zinc content (equal to or over 15%) can be treated in centralised rotary-furnace or, as is hoped in the short term, fluidised-bed thermoreduction installations, possibly after initial enrichment by internal recirculation in the steelworks themselves. So far no solution has been found for treating residues with low contents of zinc and lead (between 2 and 15%), at least under conditions which are technically and economically acceptable. Enrichment by recycling may not produce any adverse effects itself. There are in fact grounds for keeping a close eye on the quality of steel and the potential transfers of pollution at the place of work by smokestack-enriched waste dusts and by slag whilst this sort of practice is in progress.

3.2 *Ferriferous residues with high chrome and nickel contents*



R. 437
Smelting furnace for the treatment of Cr-Ni bearing dust



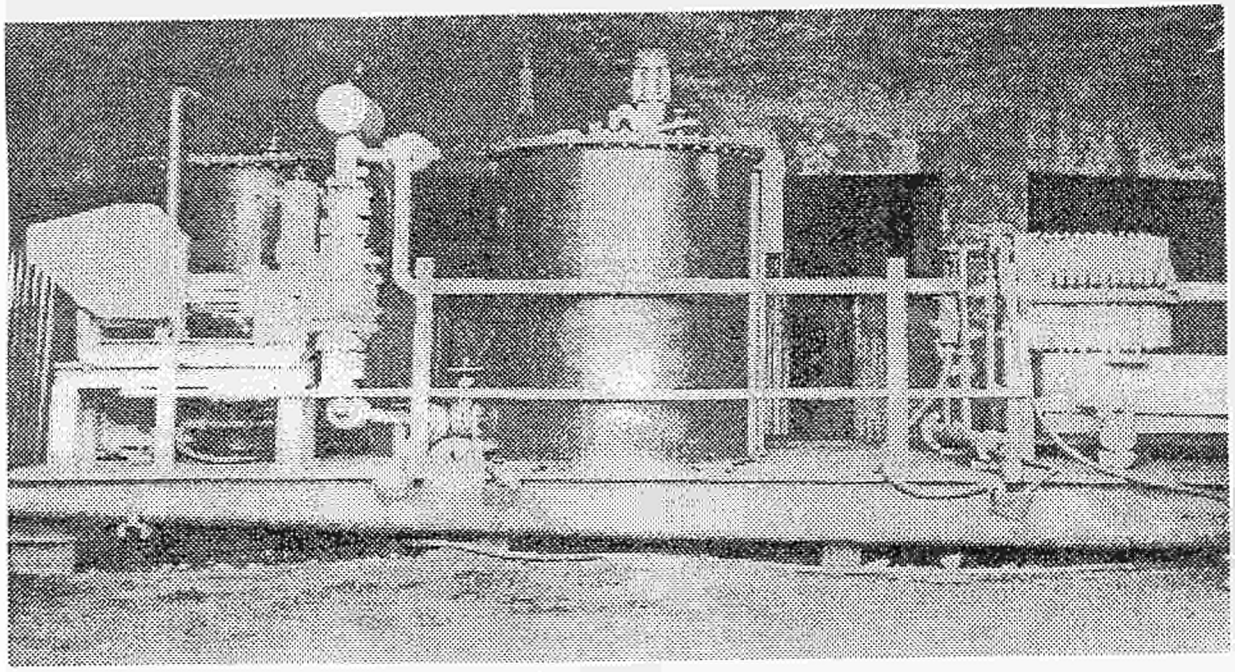
R. 437
Elemental mass balance data

Investigations conducted previously in DG V and DG XII led Avesta Sheffield (UK) (formerly BS Stainless) to build an industrial installation with a capacity of 8 000 tonnes a year to treat dust from steel alloy production which is generally regarded as hazardous waste. The process is based on **reduction by smelting in an electric arc furnace** with a non-immersed graphite electrode. Research project **437** takes this course of action further and is intended to provide knowledge on the ecological and health ratings of the process (stack emissions, exposure at places of work, quality of the slag and upgrading of secondary dusts). Tests on enriching secondary dust by recycling (15% to 20% of the initial load) conducted on a pilot scale produced a zinc content of some 50% but this was accompanied by salts, alkalis and volatile heavy metals which prevented their being reused in the non-ferrous metals industry and represented the weak point of the process. This did not prevent construction of a second industrial installation of this type at Ilva Terni (I) with a capacity of 20 000 tonnes per year. BS Technical and Avesta have pioneered this approach, opting for cleaner recycling technology with a promising industrial and commercial future.

A technical and economical assessment of other pyrometallurgical and electrothermal processes, backed up by exploratory tests on hydrometallurgical processes was also carried out (**439**) but without identifying an alternative solution at present for the treatment of residues containing chrome and nickel. The Ugine group comprising the Ugine, L'Ardoise and Isbergues plants (F) use pelleting of electric arc steelmaking dusts and furnace recycling industrially (**438**).

3.3 *Ferriferous residues with high oil and grease contents*

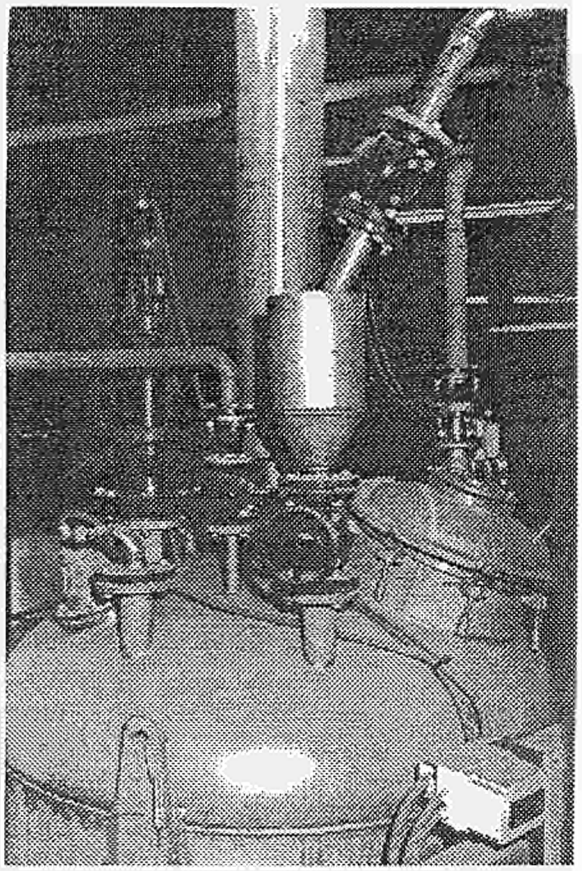
Another of the steel industry's aims is to develop an economic process for recycling or eliminating oily slurries and scale mainly produced by rolling operations. The production in this case is in the order of several kilos of residue per tonne of rolled steel, which corresponds to some 200 000 tonnes of waste in the European Union.



R. 429
Pilot plant for millscale deoiling with surfactants

At Ilva Taranto (I) two treatment processes were assessed on a pilot scale, one based on **surfactant scrubbing** (**429**) and the other on **extraction by organic solvents** (**480**, still in progress). The detergent scrubbing technique came up against high reagent consumption and treatment costs (around 100 ecus per tonne of residue not including amortisation) which were thought excessive. The project has been suspended. Extraction by solvents (hexane in this case) is still being tested.

On the basis of current performance, the extraction yields for oils and greases is around 80%. The quality of the oil recovered is sufficient to warrant their being recycled in production. Once again the final economic analysis will determine the process's future. These examples show once again the economic vulnerability of operations to upgrade residues.



R. 480
Pilot plant for millscale deoiling with organic solvent

At Cockerill Sambre (B) another approach was adopted, namely **thermal briquetting and deoiling and recycling of deoiled briquettes in the blast furnace** (**515**, still in progress). Construction of a pilot unit is being discussed. The overall cost of the recycling operation is estimated at 10 ecus/tonne of oily scale (including amortisation). Recycling in melting shops is also under consideration. After treatment, the scale will be used as a coolant in the oxygen converter (replacing lump ore).

Sollac Fos (F) is pursuing a similar aim with a demonstration unit under the DG XII Steel Programme. The process is based on preliminary pelletting of oily scale before it is charged in the converter.

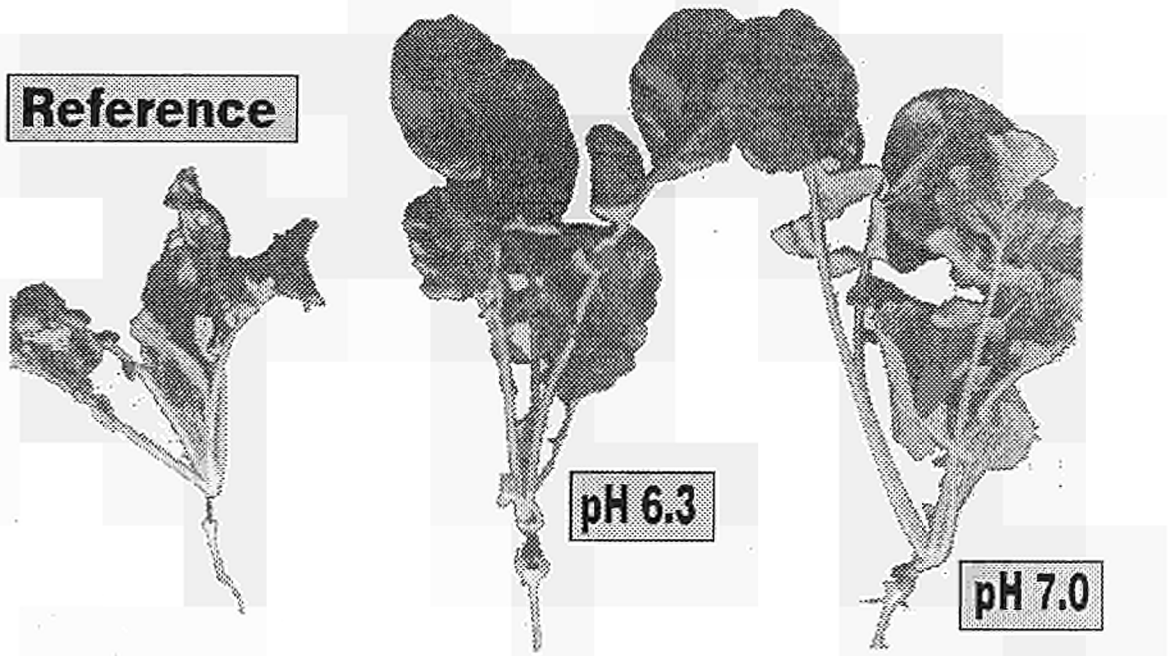
R. 515
Deoiled millscale briquettes

3.4 *Used refractory materials*

Production of used dolomitic refractories is around 6 to 7 kg/tonne of steel. The basic composition is close to that of dolomitic lime except for the presence of bonding agents which are often carbon-based. At Acerinox (E), all the possibilities of upgrading these materials are being examined systematically. After thermomechanical treatment, it seems that they can be used as a **soil improver containing calcium and magnesium oxides and as an acidity corrector (462)**. The quantity of dolomitic refractory which can be used in agricultural applications is around 1 to 4 tonnes per hectare depending on the acidity of the soil and the type of plant. Several experiments to treat fields with dolomitic residues are being assessed in Andalusia.

Another avenue being explored is **neutralising spent fluoronitric pickling liquor**. In this case only fired materials can be used to guarantee the necessary reactivity (30 to 60 kg/m³ of liquor. An industrial neutralisation test was conducted with purification performances identical with lime treatment except for an increase in the volume of sludge by 30%. No decision has yet been taken on industrial application.

Investigations by Acerinox in the field of upgrading dolomitic byproducts are being pursued under the terms of research project **514**. The recycling method envisaged is to replace part of the dolomitic lime in an AOD converter.



R.462
Influence of soil pH on radish growing

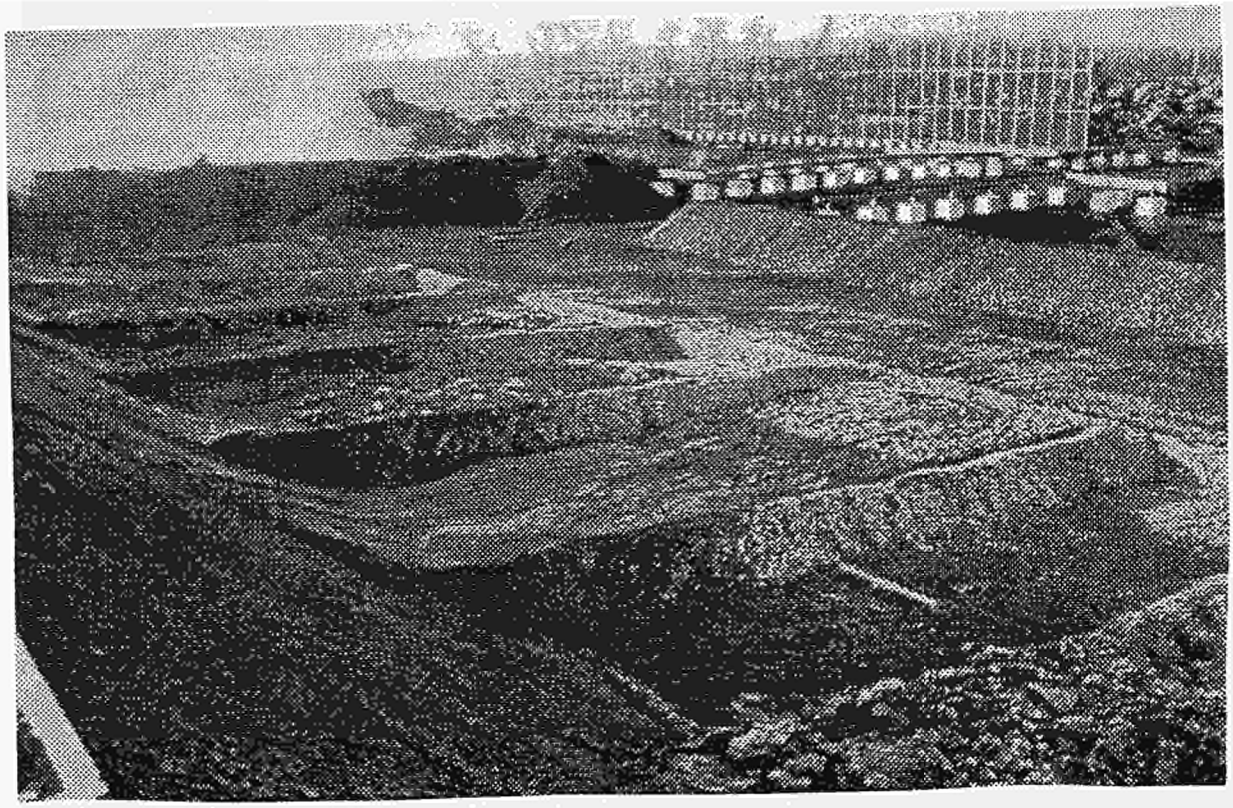
3.5 *Steelmaking slag*

Upgrading of slag, the largest byproduct in steelmaking in terms of volume (100 to 150 kg/tonne steel) after blast furnace slag is another priority if these materials are not to be dumped or to accumulate in stockyards. The amount of slag produced in the European Union is around 14 million tonnes per year. A key aim is to eliminate the deleterious effects of swelling in roadbuilding and civil engineering applications by bringing the free lime content down to under 4% (from as high as between 10% an 15% in some cases). There is not much economic leeway as the product has low commercial value (a few ecus per tonne).

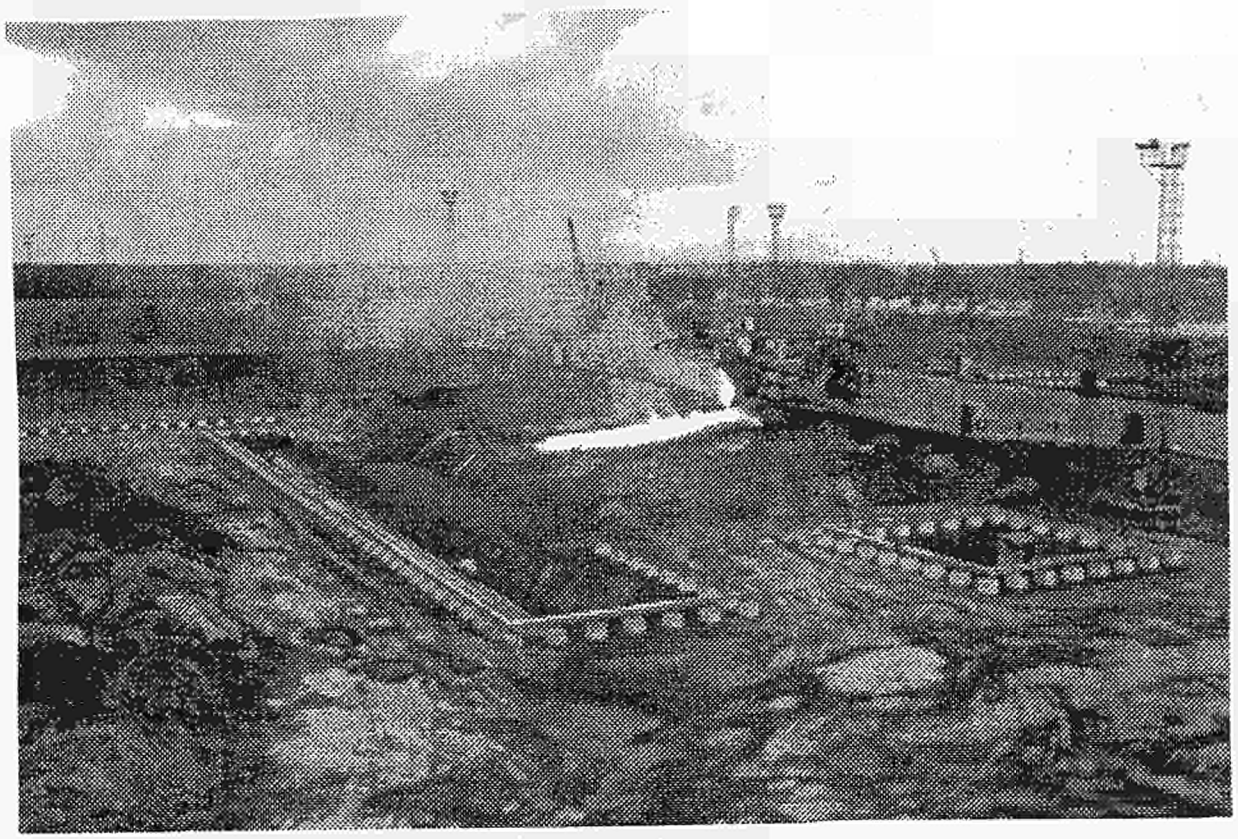
At Ilva Taranto and Terni (I), work is in progress on the possibilities of neutralising free lime by adding waste containing oxides of iron, silicon or aluminium such as alumino-silicate refractories, steelmaking sludge and dusts or asbestos to molten slag. Under laboratory conditions (**494**) the free lime content has been reduced from between 5% and 7% to 0.1% to 0.25%. The iron in the slag and the added waste is precipitated and can be recovered. The vitreous product obtained is being assessed technologically and economically (mechanical resistance, leaching behaviour, thermal uptake reaction time, etc.). It is too early to determine its chances of success in industrial practice but it does have real potential. A large trans-European research team is being formed to pursue these research activities on a large scale.

At Sidmar (B) industrial tests in which between 5% and 7% of crushed glass is added to the slag in the LD converter have shown that it was possible to reduce the free lime content (delta) by between 2% and 3% (**498**, still in progress). The stability of this type of slag must, however, still be assessed as pronounced cleavage was observed in certain batches.

As an alternative to natural ageing, which can be unreliable, and spraying the cooled slag in the pits, which is too slow, research project **498** is also examining the potential of accelerated ageing by spraying the hot slag in the cooling pits. Cooling pits have been specially designed at Sidmar (B) for this application: with thin layer cooling, clay sealing and water collection equipment. An instrument for rapid measurement (analysis time of 5 minutes) of the concentration of free lime in the molten slag is being developed to manage slag distribution in accordance with the initial free lime content. The ageing tests themselves are still under way and it is hoped that they will enable a considerable advance to be made in LD slag quality assurance.



R. 498
Cooling pits for receiving slag of different free lime content



R. 498
Thin layer cooling of molten LD slag

3.6 *Management of controlled tipping*

The measures which have just been described bear witness to the permanent concern of the steel industry to make further progress in upgrading and recycling its waste. However, we should not be under any illusions as to the fact that much of the waste is and will be continue to be dumped. As a result safe and closely monitored conditions for dumping unavoidable waste are key elements in the environmental policy of ECSC industries.

The many activities conducted under the Fifth Research Programme in this field are set out below:

- study of the **retention power of clay** and clay soils for seepage water containing heavy metals (**436**).

- comparative assessment of several **methods for sealing the surface** of an industrial dump during or after it has been in operation (**516** and **517**, still in progress).

- improved management of steelmaking waste tips to minimise the risks of heavy metal migration by **alternating layers of waste and neutralising residues** (**422**).

- **stabilisation and neutralisation** of steelmaking waste using calcium polysulphide (**422** and **518**, still in progress) and clay (**514,** still in progress).

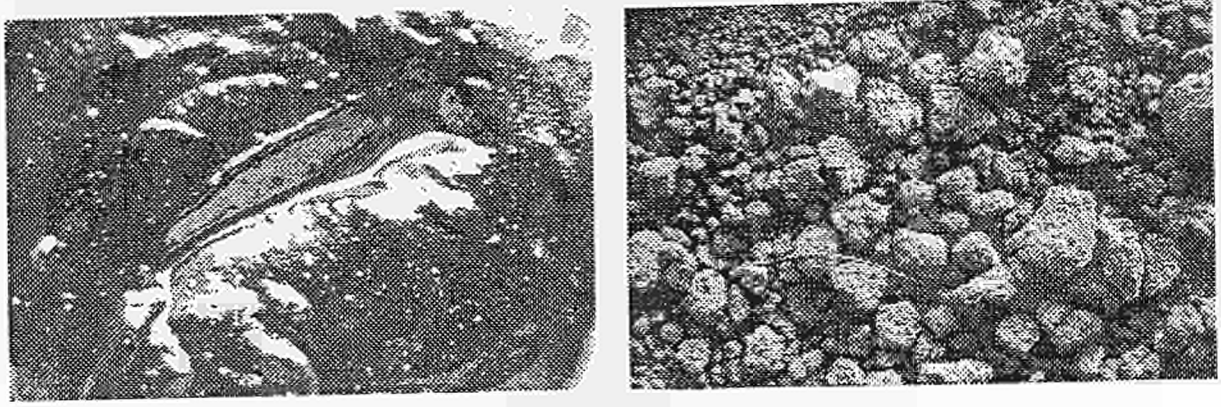
- intensive **dehydration** of blast furnace and steel making sludges before dumping (**475,** still in progress).

- **solidification** of non-upgradable oily sediment with quick lime (**426**).

- technology for identifying and assessing the **impact of steel industry waste on the environment** (**520,** still in progress).

The technique for solidifying oily sediment mentioned above (**426**) was implemented at Sidmar (B) in the process of decontaminating an old oil lagoon and the soil.

Before After



R. 426
Oily sediment conditioning with lime

3.7 *Decontamination of polluted soil*

Pollution of soil and ground water on disused or active industrial sites is a problem fraught with enormous technical and economic difficulties which also affects the ECSC industries, mainly because of coking plants. Eight research projects in the Fifth Research Programme targeted this problem (Table 10b) although this was not originally one of its stated aims.

Projects **479, 481, 482, 483, 484** and **504** are studying coking sites in the mining and steelmaking industries, either disused or active industrial sites in Germany, France, the Netherlands and Portugal. The work is coordinated regularly by the contractors. Several other bodies are associated with the research activities. The programme of work is as follows:

Table 10b
Treatment of polluted soil

Treatment of polluted soil	Number of contracts 8/126
• Treatment of contaminated coking plant soils	7/8
• Treatment of ground water associated with polluted coking plant soil	1/8

* technical monitoring of the state of the art in soil and ground water decontamination

* laboratory and pilot experimentation with biological and physicochemical techniques for the treatment of soil and ground water

* experimentation on contaminated sites of techniques selected in the foregoing phase.

This is mainly aimed at organic contaminants and, to a lesser extent heavy metals.

The achievements of these six research programmes are already considerable:

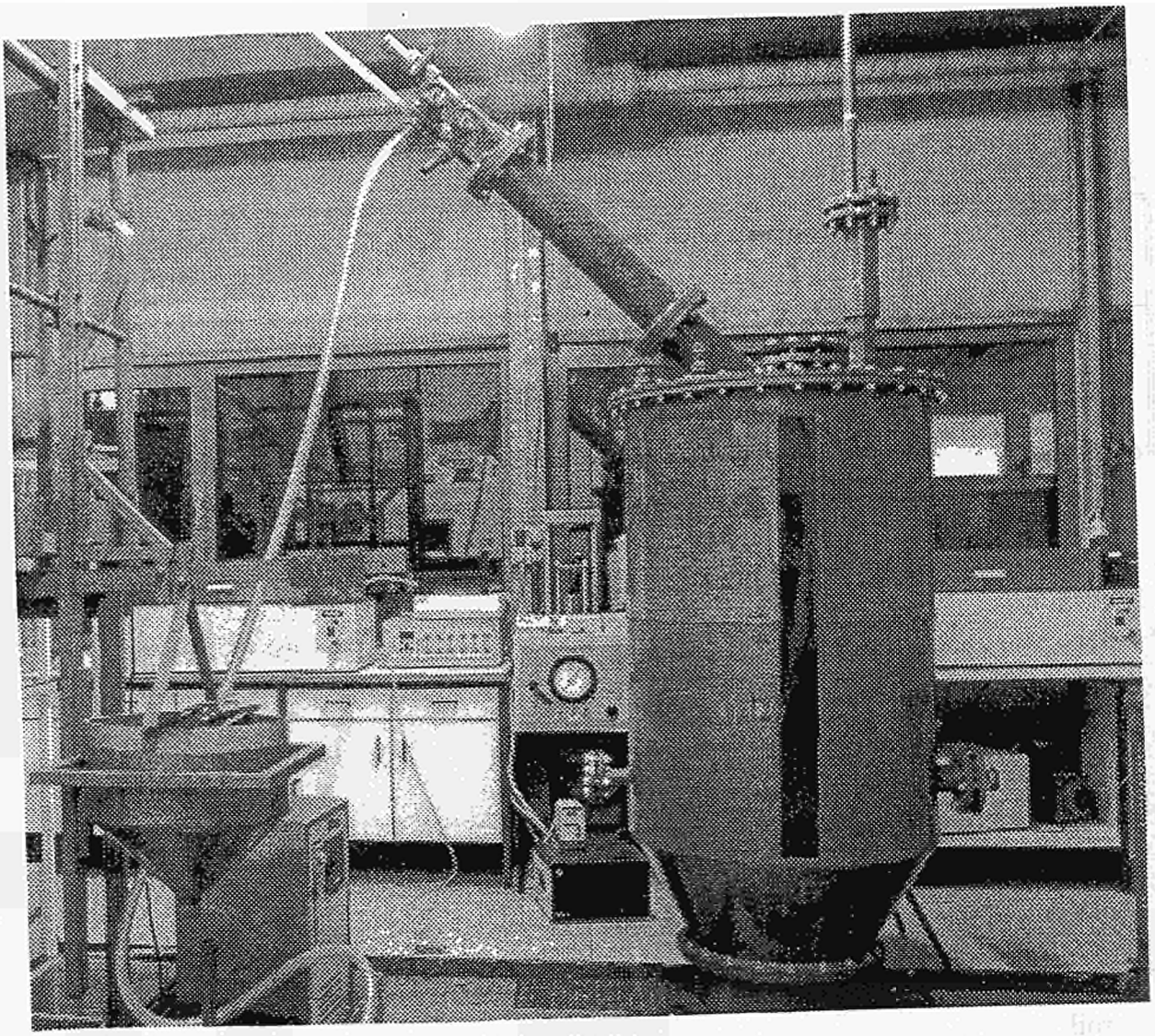
* soil

  - preparation and validation of model sample analysis

  - tests of biological or physico-chemical decontamination techniques either in isolation or combination (in particular development of a pilot flotation/bioreactor combination)

  - decontamination of soil polluted by heavy metals

  - progressive refinement of a technique for decontamination by high frequency on-site heating.



R. 484
Pilot plant for the biological remediation of a coking plant soil

* ground water

- validation of a biological (nitrification/denitrification) rotary-disk pilot unit (Hoogovens IJmuiden, NL)
- assembly in France of a similar fixed-bed unit.

As far as treatment of polluted soil is concerned, one of the original features of these activities is that the suitability of various types of decontamination is analysed in terms of the environment concerned and the way in which types of treatment can be combined and can complement one another. Achievements to date in decontaminating ground water represent an important preindustrial advance as, at least in one case, the work suggests that it might be feasible to build a treatment plant.

Research project **419** arose from the unusual situation at the disused steel plant site in Longlaville (F) where contaminated ground had to be excavated rapidly to enable the site to be redeveloped. The 100 000 m^3 of excavated soil were kept in a dump on geomembrane providing a **new opportunity** in the field of remediation:

* elimination of the source of pollution to permit redevelopment or other activities

* safe storage of contaminated soil, enabling the best technical and economic means of decontaminating it to be sought

* formation of individual piles (with aeration, of low height and with the possibility of recycling leached products, etc.) which lend themselves well to on-site decontamination techniques.

In the main, the programme of work comprises laboratory and on-site testing of various treatment techniques.

Research project **513** focuses on developing new metrological methods for multi-environmental measurement of volatile organic compounds, determining the past or present impact of volatile organic compound emissions from a steel-making plant. This new metrological system is being developed using permeation probes designed for various physical media: air, water and soil, etc. Although the project is looking at several different environments, it will be applied to the investigation of contaminated soils and ground water if it is successful and will considerably facilitate site investigation.

4. MEASURES TO CONTROL ACOUSTIC NUISANCES

Acoustic nuisances are a persistent cause for major concern for steelworks managers. However, the number of research projects (nine contracts) which deal with this aspect of pollution in the Fifth Programme is modest, which is a fair reflection of the situation in many of the Member States.

The aims and the regulatory framework are set out in Table 11. This shows that the main thrust of research is towards protecting workers as provided for by several European directives.

The main research projects covering acoustic nuisances under the 5th Programme pursue two main lines of research:

– controlling noise in the environment and at the workstations in steelworks by finding new ways to improve means of measuring and forecasting propagation of sound and applying these in industry;

– designing new specific methods of reducing sound emission at source in various steelmaking processes.

TABLE 11
Measures to control acoustic nuisances

Aims of the 5th Programme	Number of contracts 9/126
- Improving sound-proofing techniques and measures to control occupational impairment of hearing	9/9
- Directive 80/1107/EEC of 27 November 1980 and Directive 88/642/EEC of 16 December 1988 on the protection of workers against the risks associated with exposure to chemical, physical and biological agents.	
- Directive 86/188/EEC of 12 May 1986 on the protection of workers against the risks due to exposure to noise at work.	
- Helping to localise and identify sources of noise more effectively	3/9
- Directive 85/337/EEC du 27 June 1985 concerning impact studies on the environment of large structures.	

4.1 *Controlling noise at workstations and in the environment of steelworks*

4.1.1 Noise from gas transportation circuits

The aim of research project **445** was to model the noise emitted by gas transport networks in integrated steel plants.

The first phase was devoted to making an inventory of the data for analysing noise from these networks (in the ARBED (L) and Hoogovens-Ijmuiden (NL) plants). The second phase comprised planning the acoustic modelling: analysis of the emission sources and methods of integrating these data in a numerical model.

On-site measurements confirmed that some components of the gas transport circuits in a steel plant generated high sound levels at workstations and in the immediate environment: fans, regulation valves, air-intake ports for fans and compressors, etc. The iron ore sintering process proved particularly noisy.

Numerical modelling of this type of sound emission is difficult because existing models mainly derived from ventilation and air conditioning in buildings are not suitable.

The researchers on project **445** came up with analytical models which need to be supplemented and in some cases validated and computerised. At present work is being continued outside the Fifth Programme. If it is successful, this research work will have broken new ground, not only for the steel industry but also for many other industrial sectors.

4.1.2 Acoustic forecasting

Four coordinated research projects (**443** and **444** / **489** and **490**) conducted by two contractors aimed to improve modern tools for measuring noise and forecasting sound propagation and applying these to reduce noise levels in several steelworks shops. Overall the four projects thus contain a theoretical and an applied part.

Research projects **443** and **444** validated:

* the measurement of sound power from sources of noise in a complex environment by means of sound intensity techniques

* modelling of sound propagation by means of numerical codes for sound rays tracing.

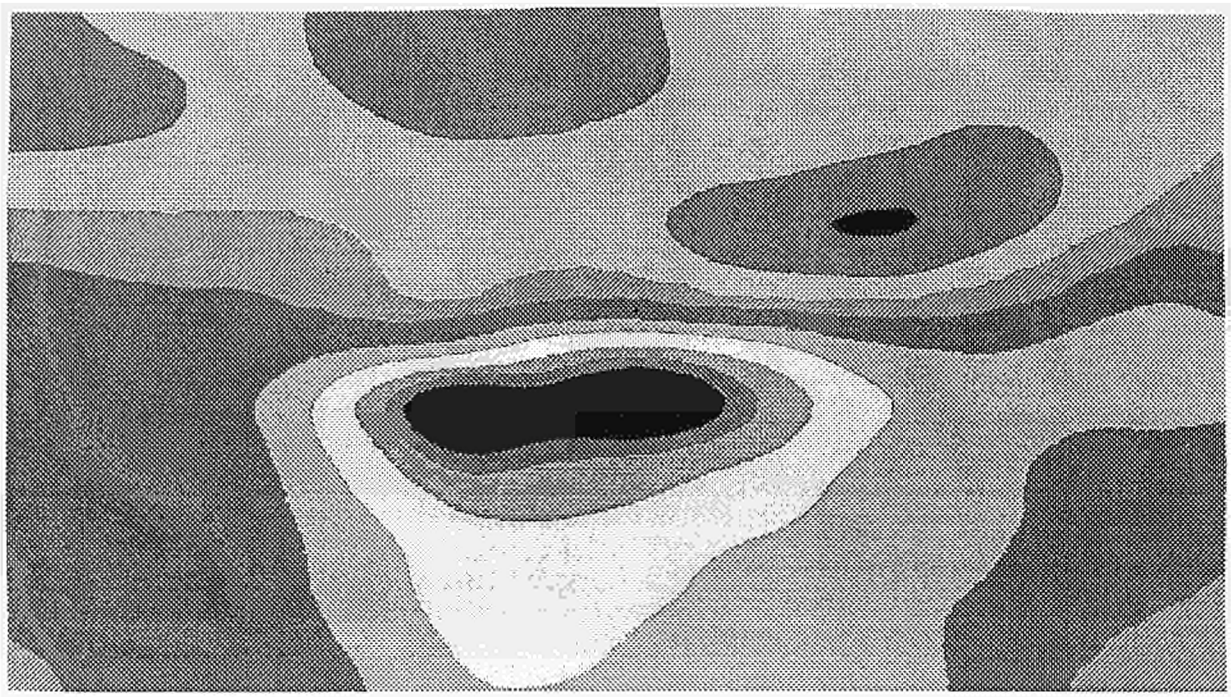
at industrial sites (USINOR-SACILOR (F) and COCKERILL-SAMBRE (B) works).

The results showed that intensity measurement enables the power spectrum of the sources to be defined free of interference by parasitic noise and is accurate to 3dB(A) which is sufficient for industrial engineering studies. Numerical models for sound rays' trajectories also proved suitable for describing sound propagation (with an accuracy in the order of 3dB(A)). The main field of application for this new method is still the design of new shops and is more limited for existing installations as the steelmaking process is fixed and the location of men and machines cannot be changed. These two research projects have achieved a major breakthrough in forecasting and controlling sound levels in steelworks in order to optimise soundproofing measures.

Work under way in research projects **489** and **490** form a logical follow-up to the two previous projects as they are designed to improve two aspects of the forecasting instrument where there were still shortcomings:

* numerical modelling of sound propagation in the environment of steel plants

* *in situ* measurement of the acoustic parameters of materials used in steelmaking plants and of sources of noise (acoustic power of sources, absorption factors and coefficients of attenuation of materials).



R. 489
Modelled map of noise levels in a steel making shop

The simulation software for sound propagation in the environment of an integrated steel plant site is operational and takes account of a large number of parameters: sound emission from the main sources of noise, smokestack directivities, sound from high-output fan ports and housings, screens, type of soil, sound absorption in the air, etc. Three methods are now being tested for *in situ* analysis:

* time delay spectrometry
* impulse method
* the "tone burst" method.

The two first methods have been compared with two other methods: stationary wave tube (Kundt tube) and the reverberation room. These *in situ* methods already show promise but can still be improved.

4.2 *Noise abatement*

4.2.1 Sintering plant - converter steel-making shops

The steel industry uses very large fans which operate without or with inadequate sound attenuation equipment. The sound which they generate is not only considerable but very frequently contains pure tones which greatly increase the nuisance level in the environment.

In project **448** the possibilities of abatement offered by four established techniques for reducing sound are being studied:

* at source
* dissipative technique
* reactive absorption technique
* active cancellation technique.

The initial results of the work on active cancellation are already promising. If this project is a success, it will certainly find an application in reducing the sound emitted by large fans in the steel industry, for which there is a real need in this sector.

4.2.2 Electric steel-making shops

The aim of project **469** was to improve sound levels in a special local context, namely by reducing the noise emitted by the (plasma torch) system for reheating molten steel in the continuous casting tundish in the AOSTE (DELTA COGNE, Group ILVA, I) plant. Conventional methods were used to analyse sound power emissions and then to simulate the sound propagation in the shop and enabled the researchers to ascertain what measures could be taken to change the structure and geometry of the tundish in order to improve the ambient noise levels. As these measures were introduced progressively, the noise at workstations was reduced to close to the higher limits contained in Directive 86/188/EEC (12 May 1986).

4.2.3 Rolling mills

The aim of research project **491** was to reduce exposure to noise of workers in a finishing shop at a hot-rolling plate mill (Gijón (E) plant). During the first phase the sound was analysed (spectral analysis, sound power levels, peak levels, etc.) at places of work. During the second phase the impact of technical abatement methods was simulated (crop end disposal pit, plate inspection, etc.) and finally these were introduced.

The techniques adopted have proved effective and can be transferred to any shop of the same type. Nevertheless it is regrettable that this project, like project **469**, was not conducted with the techniques of sound intensity measurement and sound propagation modelling validated in projects **443** and **444.**

4.2.4 Finishing

Cutting steel occasions considerable exposure to noise in steel-finishing shops. This has never been dealt with properly either in terms of the levels of sound emitted or abatement at source.

Research project **500** is being conducted at two British Steel plc (UK) production sites for long products and is examining ways of determining acoustic emission mechanisms. This new methodological approach deploys modern measuring methods: sound intensity measurement surface vibration of sawing station components and sound power around this station.

IV. ANALYSIS OF THE FIFTH RESEARCH PROGRAMMEThe results of the Fifth

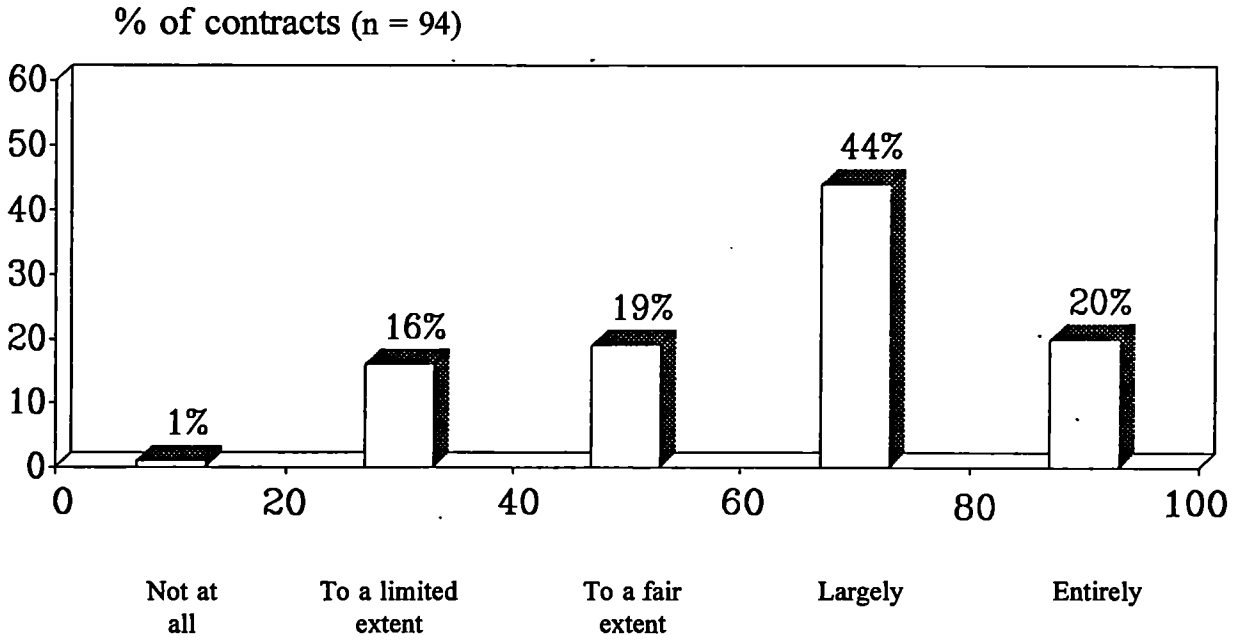
Programme are assessed overall here against a variety of criteria.

1. THE EXTENT TO WHICH THE AIMS WERE ACHIEVED

This criterion is designed to assess how far the scientific and technological aims originally set in each project have been achieved, irrespective of the nature of these objectives (ranging from basic knowledge to industrial application of the results). The fact that the aims change in the course of the research does not mean that the project will be assessed negatively, as long as they are explained and justified. The assessment of course covers only those contracts whose final report has been submitted or at least for which complete results are known at the time when this document was being drafted (94 contracts out of 126).

Figure 1 shows that 64% of the contracts achieved their aims either entirely or largely, which is thoroughly satisfactory.

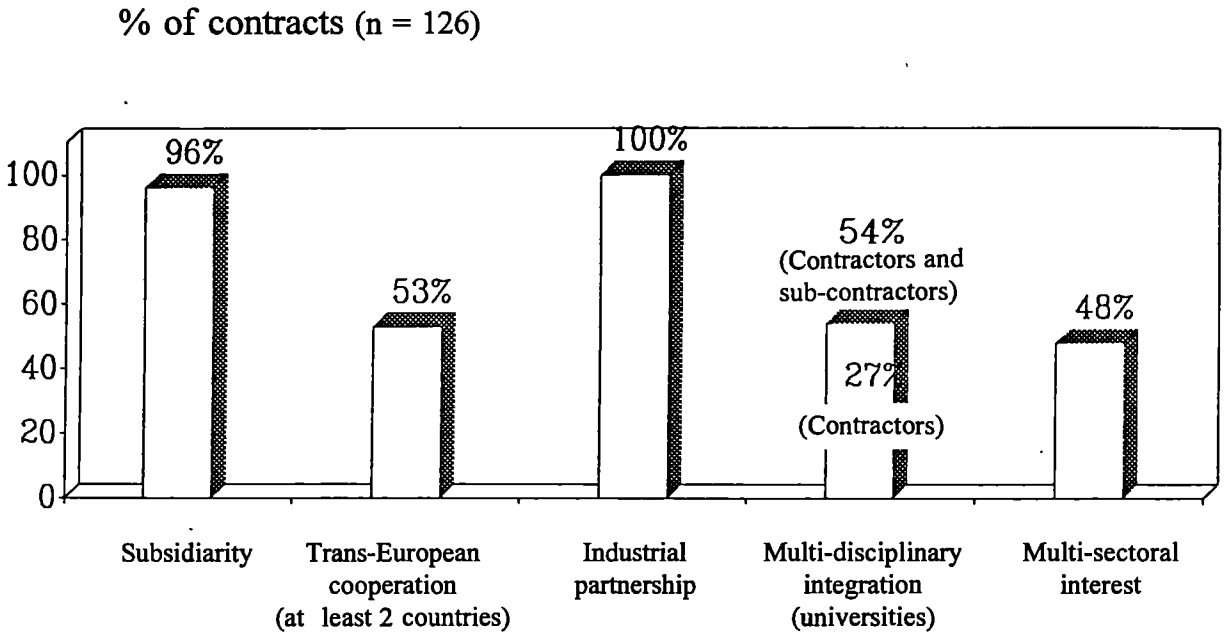
Fig. 1 The extent to which aims were achieved



2. INTEGRATION CRITERIA

The criteria for the Community dimension, multidisciplinary integration and multisectoral interest are set out in Figure 2.

Fig. 2. Integration criteria



As the financial aid granted to the research projects varied between 60 000 and 1 020 000 ecus, the degree of subsidiarity of the Fifth Programme should not automatically be seen in relation to the individual costs of research. The Community contribution should be stressed more in terms of enabling research to progress more quickly, supporting high-risk and long-term activities (such as the introduction of biotechnologies) and the European trademark itself.

Except for five contracts where local or special interest weighed heavier in the balance than general Community interest, all of the 126 contracts were in accord with the spirit of subsidiarity, to a varying degree, depending on circumstances.

Over 50% of the contracts directly involved trans-European cooperation between at least two European Union countries. As the programme was directly linked with industry, it is hardly surprising that all the activities were conducted in close cooperation with it. Table 12 shows that **30%** of the research activities were conducted by enterprises themselves and **43%** by associated research bodies. The balance, i.e. **27%**, was entrusted to independent bodies but in close partnership with industry. This last percentage is doubled (to 54%) if we take into consideration the contracts where universities, public institutes and research centres not integrated in the steel industry played an important part as subcontractors.

These figures bear witness to the fact that the programme was open to multidisciplinary teams. We should point out that in order to prepare the data in Table 12, the research centres which were integrated in the industry at the start of the programme and changed their status subsequently have been counted as integrated bodies, which means that the figures of 27 and 54% mentioned above are in fact underestimates.

Despite the sectoral character of the programme, approximately **half** the projects were of interest for sectors other than the steel industry. Optimisation of burners, detection of radioactivity in scrap, waste disposal management, painting techniques, etc. provide examples of this.

Table 12 also shows that the geographical distribution of aid has no connection with the share of funds generated by the levy, which proves that the activities conducted under the Fifth Programme are based on research priorities.

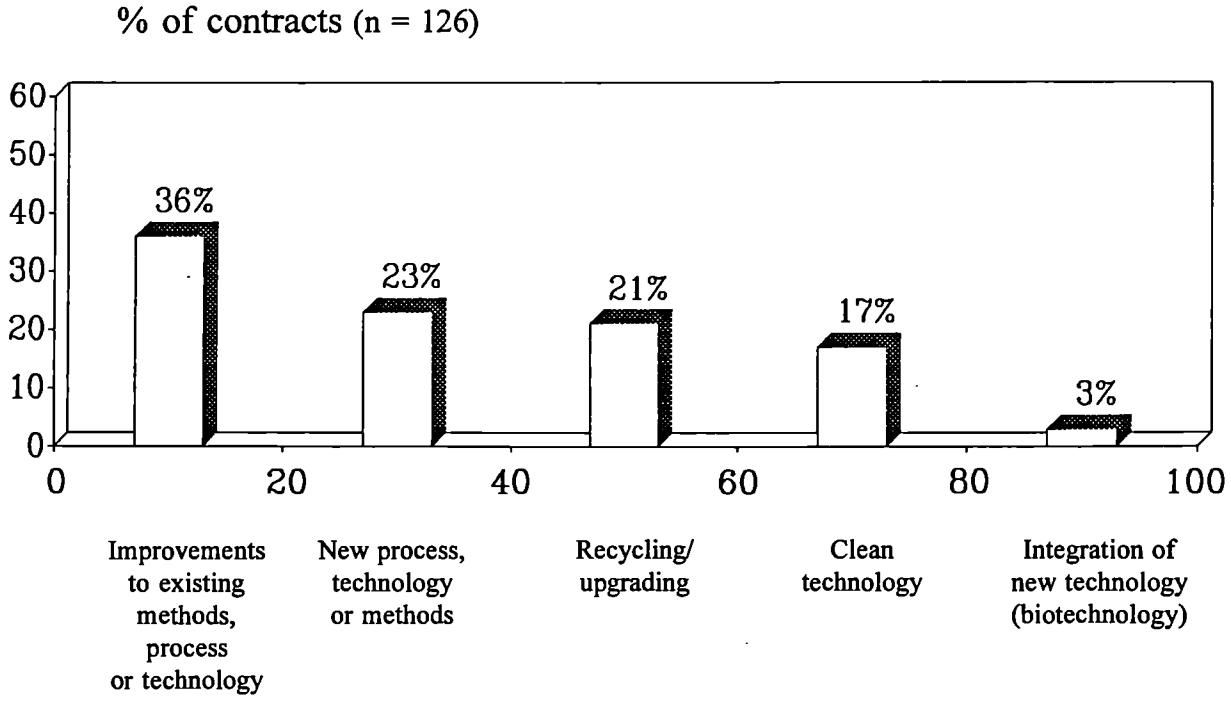
TABLE 12
Distribution of contracts by country and by type of research body

Country	Number of contracts	% of contracts implemented by			
		Steel works and coking plant	Integrated research bodies	Independent research and public bodies	Universities institutes and the like
F	37	13.5 %	54 %	32.4 %	-
UK	15	66.6 %	33.3 %	-	-
D	15	20 %	66.6 %	-	13.3 %
I	15	13.3 %	86.7 %	-	-
E	8	75 %	-	-	25 %
P	2	50 %	-	50 %	-
NL	4	100 %	-	-	-
B	25	8 %	28 %	28 %	36 %
L	4	100 %	-	-	-
DK	1	-	-	-	100 %
GR/EI	0	-	-	-	-
TOTAL	126	29.4 %	43.6 %	15.9 %	11.1 %
%	100	73 %		27 %	

3. EXTENT OF INNOVATION AND ECOLOGICAL IMPACT

Here the emphasis is placed on the effort made to promote innovatory activities, particularly as regards cleaner production technology, recycling and upgrading. Figure 3 shows that **60%** of the contracts covered conventional curative activities (end-of-pipe treatment) and **40%** more innovatory preventive activities. This is a highly satisfactory distribution in a sector of heavy industry such as the steel industry. 3% of the projects were in the field of biotechnology, which indicates a certain amount of reluctance to embark on long-term development projects.

Fig. 3 Extent of innovation and ecological impact

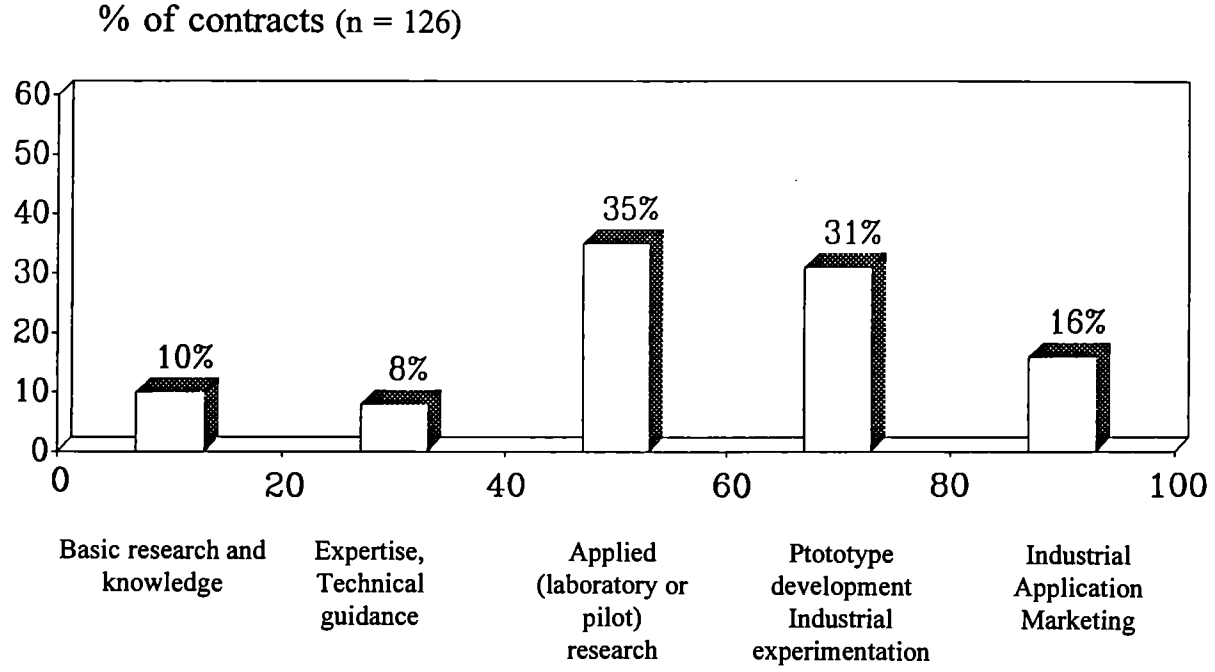


Examples of the promotion of clean technologies are reduction at source of NO_x emissions from reheating furnace and coke oven burners, savings in pickling and degreasing liquor and rinsing water, promotion of improved ecological paints and degreasing agents, development of drying rolls to cut down on carryover from surface treatment baths, recycling of iron ore sintering fume etc.

4. BASIC V APPLIED RESEARCH

The idea here was to assess the distribution of the research projects on a scale ranging from acquisition of new basic knowledge to industrial application.

Fig. 4 Degree to which knowledge is capitalised on and practical application of the results



As **16%** of the projects have already had an impact on industrial practice and almost **a third** of the research work has reached the stage of prototype or industrial experimentation (and are thus close to application) the outcome can be regarded as positive.

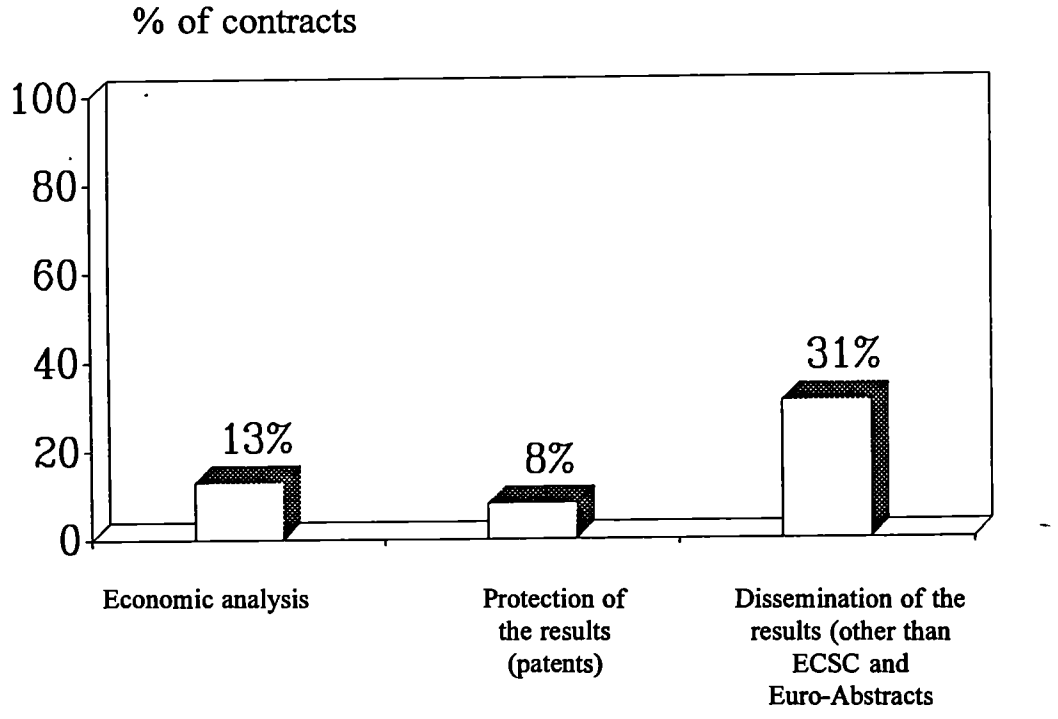
The discrepancy between the number of contracts achieving their aims either largely or entirely (64% - Figure 1 - n = 94) and those whose results have been implemented in industrial practice (16% - Figure 4 - n = 126) does show however, even though the basis for calculation is slightly different, that there is something lacking when it comes to taking practical advantage of the results. Although some projects have not yet been completed, one would have expected in an organisation so close to industry that more of the results would have been put into practice.

The most noteworthy industrial applications include gates for improved protection of radioactivity in scrap, biological purification of coking plant effluent with nitrification/denitrification, increase in the service life of degreasing solutions, intensive recycling of pickling rinsing water, cyanide abatement in blast furnace gas scrubbing liquor and new systems for coke oven heating etc.

5. ECONOMIC ANALYSIS AND PROTECTION AND DISSEMINATION OF THE RESULTS

With regard to the assessment criteria in Figure 5 the following comments need to be made:

Fig. 5 - Economic analysis and protection and dissemination of the results



Only 13% of the research results have been analysed in economic terms, which is clearly inadequate for development work which, even though it is in the social or ecological field, must nevertheless be economically acceptable.

- Only 8% of the results are protected by a patent, which is another shortcoming, although this can be explained plausibly by the social nature of the activities, the cost of patents and the current tendency to keep knowledge under wraps.

- Only 31% of the projects figured in a communication or a scientific article outside the framework of the Programme (ECSC meetings and EURO ABSTRACTS) which highlights the fact that the findings are not being disseminated in a multidisciplinary and multisectoral way.

In the light of these three criteria the results of the Fifth Programme are slightly disappointing. Improvements will have to be made in future.

6. COST BENEFIT ANALYSIS OF THE FIFTH RESEARCH PROGRAMME

Analysis of the technical, social and ecological repercussions of the Fifth Programme was originally to be accompanied by an assessment of its economic significance (either positive or negative) for European industry along the same lines as had been done in DG XII for the BRITE-EURAM Programme[1] (Industrial technology and materials) and for ECSC Steel Research[2].

On closer examination, the methods adopted for this purpose in the two cases above could not be applied to social research. Although economic viability and the desire of ECSC enterprises to remain competitive are also a prime concern of social research, it is the **social and ecological,** rather than the **financial,** benefits which are the main priority.

Council Directive 89/391/EEC of 12 June 1989[3] points this out in the recitals, stipulating that "the improvement of safety, hygiene and health of workers is an objective which cannot be subordinated to purely economic considerations". The same spirit prevails in Council Resolution of 7 February 1983[4] on the continuation and implementation of a European Community policy and action programme on the environment which considers that "environmental policy is a structural policy which must be carried out without regard to the short-term fluctuations in cyclical conditions".

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1 "Economic evaluation of the effects of the Brite/Euram programmes on the European Industry" Report No 53a/EUR, published as a separate annex to report EUR 15070.

2 "Assessment and evaluation of direct financial returns on ECSC-Steel Research Programmes" EUR 15828.

3 OJ No L 183/1 of 29.6.1989.

4 OJ No C 46/1 of 17.2.1984.

Other more pragmatic considerations prompted us to abandon assessment of the financial repercussions of the Fifth Research Programme in terms of quantity, the main being as follows:

- Defining the impact coefficients for research would have been too subjective in this area of nuisances at the place of work and in the environment where the parameters are so varied, interdependent and complex. This would inevitably have resulted in controversy.

- Insufficient time has elapsed for the causal relationship to be established in disciplines such as epidemiology and occupational illness where the response times can be several decades.

- There is no satisfactory method to determine the costs and benefits of preventive measures for nuisances at the place of work and in the environment and it is difficult to translate the consequences of pollution into monetary terms. These problems are underlined in Council Resolution 92/C331/03 of 3 December 1992[5] on the link between industrial competitiveness and protection of the environment, which states that "there is a need for improved and systematic methods for assessing the benefits of measures to protect and improve the environment and their costs and benefits to industry".

Subsequent to the overall cost/benefit analysis of ECSC social research submitted in June 1993 by DG V[6], we can only confirm that the Fifth Programme played an important part in further improving the environmental situation (reducing emission of pollutants) and bringing the health situation under control (containing the occupational illness figures) in the ECSC industries without, unfortunately, having been able to place a specific figure on it.

Nevertheless, it is recommended that in future the cost/benefit ratio is quantified specifically in coordination with more technical assessments.

There is no doubt that the environmental market is a booming market. The recent White Paper from the Commission of the European Communities on Growth, Competitiveness and Employment, the challenges and the way forward into the 21st century[7] stresses this fact heavily whilst the European Parliament Resolution on the same subject[8] emphasises "the importance for competitiveness and the creation of secure jobs of promoting research and development relating to new eco-technologies".

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5 OJ of 16.12.1992.

6 Doc. No 451/1/93 - V/F 93 39824 of 10 June 1993.

7 COM(93) 0700 - C3 - 0509/93.

8 Resolution A 30122/94 - OJ No C 91/124 of 28.3.1994.

V. CURRENT AND FUTURE RESEARCH REQUIREMENTST

wo approaches need to be adopted:

* to establish current and future research requirements in industrial hygiene and the environment in the European Union steel industry.

* to match these requirements with the European Union's Fourth Framework Programme (1994-1998) for research, technological development and demonstration activities with a view to integrating ECSC social research into this Programme.

1. CURRENT RESEARCH REQUIREMENTS

Without claiming to be exhaustive, the brief description given below sets out the main research topics envisaged by steel industry management in the European Union and confirmed at the symposium held on 9 December 1994 (EC Luxembourg).

Measures to control pollution of the air at workstations

* An overall concept creating healthy conditions in steel-making shops by modelling ventilation
* New methods for measuring chemical agents
* Effects of constituents in and additives to rolling-mill oils and lubricants
* Risk assessment for workers exposed to rolling-mill oils and lubricants emissions.

Impact on the surroundings and the environment

* Formulation of a strategy for ecotoxicological surveillance of industrial sites.

Measures to control air pollution: ducted and fugitive open-air emissions

* Extension of abatement to certain pollutants (VOC, organochlorine compounds and dioxins in particular, volatile heavy metals, etc.) in several steel-making shops
* New technologies for purification of iron-ore sintering fume (bag filters, semi-humid electroprecipitation, etc.)
* Improved abatement of NO_x emissions (burners, gas turbines, etc.)
* Improved functioning of treatment units for atmospheric pollution (expert systems)
* Reduction of CO emissions
* Reduction of CO_2 emissions

Measures to combat fresh water and marine pollution

* Minimisation of waste water by increasing recycling, cascade utilisation, development of monitoring, treatment and piping systems
* Tertiary water treatment (heavy metals, nitrogen compounds, fluorine, etc.)
* Treatment of water for slag granulation and cooling pits
* Collection, treatment and recycling of rainwater and drainage water
* Thermal pollution of water

Recycling and upgrading of steel-making wastes and byproducts

* Recovery of solvents, various solutions (from pickling and plating lines, etc.) and oils (cold-rolling mills)
* Promoting improved recycling of waste materials in ore sintering without transfer of pollution
* Recycling of scrap
* Inertisation and vitrification of waste and byproducts
* Recycling of steel-making dust in the melting shop
* Upgrading of various steel-making slags
* New treatment of oily sludges from rolling mills
* Upgrading of used refractories
* Studies of multisectoral synergies to treat waste
* Examination of the deleterious effects of intensive recycling of waste in the steel industry
* Minimisation of sludge production in steel phosphatising processes
* Improvement of dust recycling by selective filtration of fume.

Measures to combat pollution of soil and ground water

* Definition of pollution risks
* Improvement of specific techniques for remediating contaminated steel industry sites.

Pollution of products

* The effects of intensive recycling of steel-making products in the steel industry
* The effects on the user of steel-making products during their entire life cycle

The impact of new processes in the steel industry

* The effects of new processes
* The consequences of eliminating chlorine solvents and CFCs in the steel industry.

Risk management

* Accidental pollution
* Accidental emissions of toxic gases

Radioactivity

* In production of hot metal and steel (wastes and dusts)
* In recycling scrap.

Nuisances at places of work due to physical agents

* Modelling of the propagation of fluctuating noise emissions
* Reduction of noise in finishing shops
* Impact of magnetic and electrical fields
* Reduction of vibrations.

The above list highlights the following:

* An increasing need for research in the field of recycling and upgrading of waste and byproducts in the steel industry. This reflects increasing regulatory pressure on industrial enterprises in the European Union.

* Sustained interest in certain subjects: measures to control ducted and fugitive open-air emissions, measures to combat pollution of water, radioactivity, pollution of ground and groundwater, etc.

* A decline in activity in the following fields: acoustic nuisances, measures to combat air pollution at places of work, impact studies on the surroundings and the environment, and metrology and analysis.

On the other hand, the following new subjects are emerging:

* Pollution of products, i.e. examination of the risks incurred by users of steel-industry products during their entire life cycle

* Management of industrial risks

* The impact of new steel-making processes.

These research requirements often highlight short and medium-term concerns. However, there are several causes for long-term concern (pollution of products, impact of new processes in the steel industry, etc.). Although some research requirements can arise in a multisectoral context, there is a fair number of subjects which are still typical for the steel industry which means that sectoral financing must be maintained.

2. THE EUROPEAN UNION'S FOURTH FRAMEWORK PROGRAMME FOR RESEARCH AND TECHNICAL DEVELOPMENT

The Fourth Framework Programme was adopted on 26 April 1994 by a European Parliament and Council decision. The corresponding document[9] marks the Community's concern to improve the competitiveness of industry **including the mining and steel industries**. In Annex III "Scientific and technical objectives" it refers to the need to take account of the mining and steel industries' research requirements. The Commission's proposal[10] for **specific research programmes** refers to research in the steel and mining industries.

2.1 *Specific programme on "Industrial technology and materials" (BRITE EURAM III)*

In its preamble, this programme made specific reference to the quality of life, respect for the environment and safety as research objectives. The same concerns are found throughout this programme. Table 13 contains a non-exhaustive list of the aims of BRITE-EURAM III on the current and future needs for research in ECSC industries. **It indicates clearly that this specific programme should cover many aspects of ECSC social and environmental research**. It is the first domain (Production technologies) which is the key area in this respect, the second domain (materials and technologies for innovating products) being of interest in respect of minimisation of waste production, recovery and recycling and taking account of the life cycle. A salient feature of the BRITE-EURAM III programme is that it aims to take account of the entire social and environmental "chain of events" involved in industrial activities.

Nevertheless, it is not clear from the existing text of the BRITE-EURAM III programme that all the research needs and targets defined above will be transferable and conform with the aims and selection and eligibility criteria.

2.2 *Specific programme "Environment and climate"*

It is Theme 2 "Environmental technologies" - Domain 2.2 (Technologies for risk assessment, protection and rehabilitation of the environment) which involves ECSC social and environmental research. The following research tasks are especially worth noting:

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9 European Parliament and Council Decision No 1110/94/EC - OJ No L 126 (18 May 1994).

10 COM(94)68 30 March 1994.

TABLE 13

SOME AIMS OF THE "INDUSTRIAL TECHNOLOGIES AND MATERIALS" PROGRAMME

HEADING	AIMS
1. PRODUCTION TECHNOLOGIES	
1.1 INCORPORATION OF NEW TECHNOLOGIES INTO PRODUCTION SYSTEMS	. minimisation of environmental impact . improvement of environmental performance . reduction of energy consumption and waste generation
Short term	. reduction of energy consumption and waste generation
Long term	. development of new approaches for man-oriented production systems, reducing the environmental impact and securing health and safety
1.2 DEVELOPMENT OF CLEAN PRODUCTION TECHNOLOGIES	. minimum production of undesirable byproducts and waste . development of non-pollutant and economic processes . development of technologies for preventing pollution
Short term	. reduction and replacement of dangerous materials used in processes (solvents, heavy metals etc.) . reduction of waste and recycling of materials . new technologies and materials to reduce noise, dust, vibrations, emissions, overall pollution and waste on production sites . adaptation of existing technology (equipment and processes) to comply with current and future regulations on the environment and health

TABLE 13 - (continuation)

HEADING	AIMS
Medium term	. development of ways and means of analysing material flows to identify the possibilities for preventing pollution and opportunities to increase safety and determine how the risks of pollution are developing . development of efficient production techniques and processes to improve environmental protection . optimisation of processes and identification of the most efficient process configurations to reduce waste
Long term	. production processes based on emerging sciences to facilitate major progress in cutting down on pollution and energy consumption
1.3 RATIONAL MANAGEMENT OF RAW MATERIALS	. increase of recovery and recycling of semi-finished materials in the interests of environmental protection and safety of workers . minimisation of waste and coproducts
Long term	. development of new metallurgical production methods and process systems to minimise waste such as processes based on scrap
1.5 HUMAN AND ORGANISATIONAL FACTORS IN PRODUCTION SYSTEMS	
Medium term	. improvement of quality performance health and safety and working conditions in production systems

TABLE 13 - (continuation)

HEADING	AIMS
2. MATERIALS AND TECHNOLOGIES FOR PRODUCT INNOVATION	. taking account of the entire life cycle
2.1 MATERIALS ENGINEERING	
Medium term	. reduction of the costs, energy consumption and waste in mass production (including steel products) . engineering technologies for surface treatment, plating and bonding which are compatible with the environment
2.2 NEW METHODS FOR PRODUCT DESIGN AND MANUFACTURE	
Medium term	. new applications of design aids particularly to verify the impact on the environment and recyclability
2.4 TECHNOLOGIES FOR RECOVERING PRODUCTS AT THE END OF THEIR LIFE CYCLE	
Short term	. development of recovery technology providing environmental protection at the lowest cost
Medium term	. rapid assembly and disassembly to facilitate recycling . techniques for separating materials
	. development of recycling technologies and processes to extract useful materials (including steel)

Methods of estimating and managing risks

* Analysis of the cycles of industrial products and determining their impact on the environment
* Methods for assessing the impact of industrial processes on the environment
* Better understanding of the mechanisms causing accidental emissions of products which are harmful to the environment and health

Technologies to protect and rehabilitate the environment

* Improvement of industrial processes and products to prevent or reduce their impact on the environment
* Development and improvement of integrated technologies to reduce solid, liquid and gaseous emissions as far as possible
* Development and improvement of new materials recycling technologies
* Development of safe processes for treating dangerous waste.

Technologies to protect and rehabilitate historical and industrial sites

* Development of technology for rehabilitate polluted industrial sites

It should be borne in mind that this specific programme covers the following areas: abatement at source and clean technology, waste treatment, recycling, environmental impact studies, risk management, product pollution and rehabilitation of polluted industrial sites. However, it is much more restrictive with regard to end-of-pipe purification technology.

2.3 *Specific programme on "Standards, measurements and testing"*

Theme III ("Measurements related to the needs of society") contains headings relating to monitoring places of work and the environment.

Monitoring of worker exposure

This programme launched an **open** call for proposals to improve measurement methods and to develop reference materials to monitor exposure of workers to chemical, physical and biological agents.

Monitoring the environment

In this area the programme concentrates on comparability of measurements and measurement techniques and the preparation of new and improved methods for analysing various environmental components (air, water, soil, sediments, waste management, toxicological tests, determination of chemical inorganic and organometallic species, microbiological parameters etc.). An **open** call for proposals was launched to support Community policy with the research aims covering development and validation:

- of leaching tests for dangerous waste
- for reference materials for PCDD/PCDF (dioxins) emissions from waste incineration installations at a level of 0.1 pg TEQ/m^3.

This specific programme should encompass certain metrological or methodological developments which the steel industry will need in industrial hygiene and environmental monitoring (emissions, ambient environments etc.).

2.4 *Specific programme on "Life sciences and technologies"*

Part B ("Biomedicine and health research") identifies industrial medicine as one of the research topics. These include risk factors at the place of work, management of safety and environmental factors in the etiology of occupational disease and also cover collection and analysis of statistics and epidemiological data.

This specific programme should encompass research needs related to determining the health risk in the steel industry and supporting epidemiological surveys.

The Fourth Research Programme forms part of an overall Community policy. Applicants for financial support from the Community must meet a certain number of requirements which might differ from those governing sectoral activities such as those covered by the ECSC:

* the research must be precompetitive and must lead to generic developments which are applicable to several industrial sectors
* as the research proposals are submitted within the framework of a call for tenders, the projects are in competition with one another and are selected on the basis of quality criteria related to the scientific and technical field concerned.

However, during the five programmes on "Technical control of pollution at the places of work and in the environment of iron and steel works", steel companies and their partners have learnt how to conduct coordinated research highly effectively. The links which have thus been established ought to enable them to make the transition towards the specific programmes of the Fourth Framework Programme more easily. The way this cooperation works need not, moreover, be restricted to activities with shared costs but could also be based on other options such as concerted action, which could include existing networks for which the Commission would assume the role of a coordinator between public and private research partners.

Nevertheless, there is still considerable uncertainty as to whether the needs relating to end-of-pipe curative treatment (which accounts for almost 60% of the activities of the Fifth Programme) will be covered. The objectives of the Fourth Framework Programme are highly selective and restrictive in this respect.

VI. CONCLUSIONS AND RECOMMENDATIONS

On completion of this assessment of the Fifth Research Programme, the following conclusions and recommendations need to be made:

1. The level of industrial involvement (100% of the agreements), trans-European cooperation (53%) and multidisciplinary integration (54%) may be regarded as **strengths**.

2. Despite the fact that the programme is confined to one sector, approximately 50% of the agreements are of interest to more than one sector, which promises real potential for cooperation with other industrial sectors in the future. However, this also means that, whilst integration of several sectors can be stepped up, **50% of research is currently confined to single-sector themes**. Specific financial support will be required if these research activities are to continue in the future.

3. With 64% of the projects having achieved their original objectives, either in full or to a large extent, the management procedures and methods adopted appear acceptable and cooperation between research partners effective.

4. With 16% of the agreements having reached the stage of industrial application in one form or another, there are some grounds for satisfaction. Nevertheless, considering that 64% of the projects achieve their objectives, we must stress that **there is a lack of potential for practical application**. This is underlined by the low scores achieved in terms of economic assessment of new methods or techniques (13% of the contracts), protection of innovations (8%) and active dissemination of results outside the ECSC (31%).

   Even though some of these shortcomings are mitigated by the fact that some research work has not yet been concluded and that 31% of the projects are likely to be applied in practice in the future, that their added value in terms of expertise and knowledge acquired is considerable, and that many of the projects have resulted in methodological advances, more could still have been expected of a research programme so close to industry.

   In future, the capacity for putting the results to good use must be enhanced. Without going to extremes, which would inevitably paralyse any initiative or any spark of innovation and enterprise, it is recommended that this be achieved by identifying and quantifying more effectively at the project design stage the practical advantages, the time required for application and the likely scope for exploiting the results, and by encouraging greater involvement on the part of partners (users, designers or manufacturers) who are interested in and capable of integrating, utilising and commercialising the results. These criteria are already applied in the Fourth Framework Programme.

5. Since **59% of the research was on curative measures** to improve existing techniques for purification and develop new techniques for end-of-line treatment in the short and medium term, **there are grounds for concern as to what extent these activities can be sustained by the Fourth Framework Programme.** The number of areas excluded from the aims of the Framework Programme prompt a great deal of caution in this respect, particularly as this sentence, which does not augur well for the future, appeared in Euro-Abstracts Vol. 32, Nov. 1994 p. 688:

   "What the Programme will not do is to develop the so-called "end-of-pipe" technologies, such as those required to clean up industrial processes. These developments are clearly the responsibility of private enterprise....".

6. On the other hand, **38% of the preventive measures** for recycling, upgrading and medium and long-term development of cleaner production techniques, are amply covered by the Fourth Framework Programme.

7. With only **3% of the programme being devoted to basic high-risk research** for long or very long-term application, the ECSC industries are proving reluctant to investigate new purification technology such as biotechnology.

Despite the uneven results of the assessment, the Fifth Research Programme has definitely given rise to **considerable progress in protecting the health of workers and the general public.**

The salient features with regard to industrial hygiene are as follows:

- more knowledge has been acquired which can help to identify and reduce more effectively the risks at places of work in coking plants;

- much progress has been made in methods for recording exposure of workers: acid mist, ceramic fibres, complex dust conditions and ventilation etc.;

- a major methodological breakthrough was made in controlling noise at places of work.

Developments worth mentioning in the promotion of clean technology are the reduction at source of NO_x emissions from coke oven burners and reheating furnaces for semi-finished products, savings on steel pickling and degreasing bath solutions and rinsing water, the promotion of ecologically improved paints and degreasing agents, the development of new drying rolls to cut down on carryover from surface treatment baths, recycling of iron ore sintering fume etc.

Among the most interesting industrial applications are gates for improved detection of radioactivity in scrap, biological purification and nitrification/denitrification of waste coke plant liquor, extension of the service life of degreasing baths, intensive recycling of rinsing water for pickling plant, cyanide abatement in blast-furnace gas scrubbing liquor, new systems for heating coke ovens etc.

During the Fifth Programme over a quarter of the contracts were directly related to the health of workers and approximately 75% to the health of local residents and the general public. Even though some adjustment needs to be made, this balance between internal and external pollution must remain one of the benchmarks for future research of activities as must a multi-environmental management approach (to cope with problems of transfer of pollution from one environment to another). The spirit of the proposal for a Council directive on the prevention and reduction of pollution must also be observed

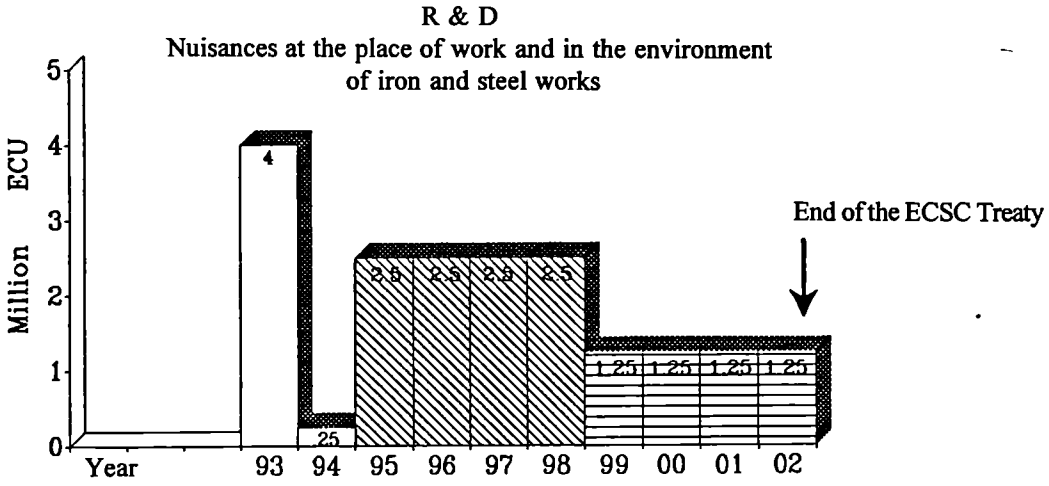
ECSC social research and in particular research on control of pollution at the place of work and in the environment of iron and steel works must now enter a new stage.

For several decades it has been a very specific instrument highly suitable for the sector and has proved its effectiveness at European level. It must now be opened up to accommodate the enlarged framework of the European Union's general research policy, whilst still retaining sufficient financial support to cater for the specific needs of the sector and to prevent too great a degree of dispersion in multisectoral and generic research.

It is far from clear that all the future needs and the research targets defined in the course of this evaluation will be transferable and will meet the selection and eligibility targets and criteria for research, technological development and demonstration activities such as defined in the Framework Programme.

As a result it is imperative for bridging funds to be made available at ECSC level to ensure that there are proper arrangements for transfer and integration into the Framework Programme (phasing out/phasing in), since, as things stand, appropriations are being discontinued too abruptly (Figure 6).

Figure 6. Proposal for the ECSC budget (millions of ECU)



It is recommended that, on the basis of the current 12-member European Union, average annual support of a minimum of ECU 2.5 million is maintained for the period between 1995 and 1998 and a minimum of ECU 1.25 million for the period between 1999 and 2002 for research on technical control of pollution of the place of work and in the environment of iron and steel works instead of the few hundred ecus currently allocated as a management budget to wind up current activities in 1996.

ANNEX I

LIST OF PROJECTS ASSESSED

(individual assessments are contained in a separate document)

Contract N°	Title of the project
7261-01/**407**/04	Pilot furnace study of nitrogen oxide emissions from reheating furnaces in the steel industry and ways of reducing them in the ECSC industries (CSM).
7261-01/**408**/03	Emission of nitrogen oxides in coking plants - Study of their impact on the environment (CPM).
7261-01/**409**/02	Olfactory nuisances in coking: study of methods of prevention and control techniques (SBF).
7261-01/**410**/02	Effect of the operational parameters of iron ore sintering plants on emissions of sulphur and nitrogen oxide to the atmosphere (CRM).
7261-01/**411**/01	NO_x emissions and associated ambient pollution in connection with the heating of coke ovens (DMT).
7261-02/**412**/03	Chemical treatment for the specific destruction of cyanides (IRH).
7261-02/**413**/02	Chemical treatment for the specific destruction of cyanides (CEBEDEAU).
7261-01/**414**/03	Further study of nitrogen oxide emissions from steelmaking plants (LECES).
7261-01/**415**/03	Technical control of nuisances and pollution caused by scrap preheating techniques in electric arc melting shops (LECES).
7261-02/**416**/08	Investigation of the technical and economic benefits associated with the use of pure oxygen in the biological treatment of carbonisation effluents (MONCKTON COKE & CHEMICAL CO, Ltd / BCRA).
7261-04/**417**/01	Coking plant pollution - Balance and fate of heavy metals during the process of coal carbonisation (DMT).

Contract N°	Title of the project
7261-04/**418**/02	Coking plant pollution - Balance and fate of heavy metals during the process of coal carbonisation (DMT).
7261-04/**419**/03	Coking plant pollution - Balance and fate of heavy metals during the process of coal carbonisation (LECES).
7261-04/**420**/08	Coking plant pollution - Balance and fate of heavy metals during the process of coal carbonisation (CPL).
7261-03/**421**/04	Reduction of dust blow-off in steelworks or in coal stockyards by the use of binding agents (CSM).
7261-03/**422**/03	Binding of heavy metals in steelworks wastes by suitable control of dumping (LECES).
7261-04/**423**/01	Pollution in coking plants - Measurement of polycyclic aromatic hydrocarbons in and around coking plants - Phase II (DMT).
7261-04/**424**/08	Pollution in coking plants - Measurement of polycyclic aromatic hydrocarbons in and around coking plants - Phase II (CPL).
7261-04/**425**/03	Pollution in coking plants - Measurement of polycyclic aromatic hydrocarbons in and around coking plants - Phase II (LECES).
7261-03/**426**/03	Physical/chemical treatments of unusable oily sludges (IRH).
7261-03/**427**/03	Elimination of pollution and utilisation of waste products from the pickling of stainless steel (UGINE ACG).
7261-03/**428**/02	Study of the possibilities of treating simultaneously steelmaking waste rich in Zn/Pb and depleted hydrochloric pickling baths - Phase I (CRM).

Contract N°	Title of the project
7261-03/**429**/04	Treatment of oily sludge by chemical processing and physical separation of the ferrous fraction which can be reincorporated into the steelmaking cycle (CSM).
7261-01/**430**/08	Energy savings through improvements in fume control methods for melting-shop extraction systems (BS).
7261-01/**431**/01	Reduced emission of nitrogen monoxide through the injection of water during the combustion process THYSSEN STAHL AG).
7261-01/**432**/03	Research into the use of bag filters to reduce particulate and gaseous pollutants in process fumes from iron ore sintering plants - Phase A (LECES).
7261-02/**433**/04	Elimination of heavy metals, in particular zinc and nitrate ions, from industrial gas scrubbing water (ZINCOR ITALIA SPA)
7261-02/**434**/03 7261-02/**434**/02	Improving the stability and performance of biological treatment facilities for coking plant effluent (IRH / LSGC-CNRS / CRM / CEBEDEAU).
7261-02/**435**/04	Testing and pilot-scale development of an ultrasonic system for non-pollutant anti-fouling treatment of cooling water in steelworks (CSM).
7261-03/**436**/01	Retention capacity of posidonia shale in respect of seepage water containing heavy metals from flue dust dumps (FRIDERICIANIA UNIVERSITY, KARLSRUHE).
7261-03/**437**/08	The behaviour of toxic metals during the plasma smelting of stainless steel-making dust and development of viable disposal practices (BRITISH STEEL TECHNICAL).
7261-03/**438**/03	Prevention of pollution from aqueous solutions generated by the manufacture and processing of stainless steel (UGINE ACG).

Contract N°	Title of the project
7261-03/**439**/03	Recycling of steel industry wastes containing chromium (LECES).
7261-04/**440**/14	Study of the criteria which determine occupational exposure to PAH in coking plants. Characterisation and quantification of the risk factors (ENSIDESA).
7261-04/**441**/02	Olfactory nuisances in cold steel shops: preventive measures and control techniques (Phase I) (SBF).
7261-04/**442**/14	Characterisation of the health risk caused by the inhalation of particulate matter from iron and steel manufacturing processes (ENSIDESA).
7261-05/**443**/03	Control of acoustical environment in steelworks by means of sound intensity measurement and predictive modelling (LECES).
7261-05/**444**/02	Use of noise prediction techniques to optimise noise abatement in steel shops (CEDIA).
7261-05/**445**/03	Noise from gas transport circuits in the steel industry (INRS).
7261-01/**446**/03	Analysis and prevention of complex dust contamination in iron and steel manufacturing plants (LECES).
7261-01/**447**/06	Coke oven gas desulphurisation using multiple alkanolamines (HOOGOVENS B.V.).
7261-01/**448**/03	Study and prevention of emissions from carbon- bonded refractories in iron and steel works (LECES / IRSID).
7261-01/**449**/03	Characterisation and improvement of the ventilation of steel plant bays (LECES).

Contract N°	Title of the project
7261-01/**450**/04	Reduction of CO, NO_x and SO_2 emissions from sintering plants by modifying the charging and process parameters - Phase I (CSM).
7261-01/**451**/04	Reduction of nitrogen oxide emissions from steel industry power plant (CSM).
7261-02/**452**/08	Investigation of the technical and economic benefits associated with the use of pure oxygen in the biological treatment of carbonisation effluents (MONCKTON COKE & CHEMICAL Co, Ltd / BCRA).
7261-03/**453**/02	Study of the dissolution of low-soluble zinc and lead compounds in waste generated by the steel production cycle (CEBEDEAU).
7261-01/**454**/14	Design of a methodology, sampling strategy and results processing system to determine, evaluate and diagnose the risk of occupational exposure to contaminating agents at the place of work in iron and steel works (ENSIDESA).
261-01/**455**/03	Use of bag filtration to reduce particulate and gaseous pollutions from iron ore sintering fume - Phase B (LECES).
7261-01/**456**/01	Reduction of CO and NO_x emission in coke ovens with new multivalent heating techniques (RAG).
7261-01/**457**/08	An investigation into NO_x formation and the means of its reduction from regeneratively fired burners used in the steel industry (BS TECHNICAL).
7261-02/**458**/02	Optimisation of formaldehyde treatment to remove cyanide from blast furnace scrubbing water (CEBEDEAU).

Contract N°	Title of the project
7261-02/**459**/03	Optimisation of formaldehyde treatment to remove cyanide from blast furnace scrubbing water (IRH).
7261-02/**460**/02	Study of blast furnace cyanide emissions, under daily operating conditions and blowdown (CRM).
7261-02/**461**/03	Smoothing pollution peaks to optimise the functioning of steel industry effluent treatment installations (IRH).
7261-03/**462**/14	Use of dolomitic refractory waste from converter linings as soil correctors and for neutralising acid pickling solutions (ACERINOX).
7261-02/**463**/02	Study of the possibilities of simultaneous treatment of steel industry waste with high contents of Zn/Pb and spent hydrochloric pickling solutions - Phase 2 (CRM).
7261-03/**464**/03	Study and development of means of recovering and recycling waste from electrogalvanising lines (CSM).
7261-04/**465**/08	Study of the sampling of acid mists in order to assess their impact on exposed personnel and to study exposures of personnel in different types of process (BS TECHNICAL).
7261-04/**466**/08	An investigation into the health and environmental implications of using ceramic fibre products as linings in high temperature furnaces (BS TECHNICAL).
7261-04/**467**/01	Detection of radioactive contamination in steel plant raw materials (VDEh).
7261-04/**468**/08	Detection of radioactive sources in steel plant raw materials (BS TECHNICAL).
7261-05/**469**/04	Reduction of noise from plasma torches used in continuous casting tundishes (CSM).

Contract N°	Title of the project
7261-01/**470**/06	Selective catalytic reduction of NO_x in fume using iron ore pellets (HOOGOVENS B.V.).
7261-01/**471**/15	Investigation of the environmental impact of installing latest emission control technology in tall coke ovens and the benefits to be gained from further control of residual charging, pushing and oven leakage emissions (ICTM / SIDERURGIA NACIONAL).
7261-01/**472**/02	Olfactory nuisances in cold steelworking installations: a study of methods of prevention and abatement techniques (Phase II) (SBF).
7261-02/**473**/03 7261-02/**473**/09 7261-02/**473**/04	Characterisation, prevention and reduction of pollutants produced during degreasing of steel sheet (IRH / UGINE ACG / IPU-Institut for Produktudvikling / CSM).
7261-02/**474**/03 7261-02/**474**/04	Methodological study of the elimination of dilute liquid wastes from steel pickling lines. Validation by application to the pickling of stainless steels (IRH / UGINE ACG / CSM).
7261-02/**475**/02 7261-02/**475**/03 7261-02/**475**/05	Innovatory techniques for intense dewatering of iron metallurgy sludges with a view to utilisation (IRH/ CEBEDEAU / LECES / ProfilARBED).
7261-02/**476**/02	Problems with organic micropollutants in the waste water from the iron and steel industry (CRM).
7261-02/**477**/02 7261-02/**477**/03	Use of metal-chelating proteins for control of nuisances and pollution in the iron and steel industry (UGINE ACG / LIEGE UNIVERSITY).
7261-02/**478**/03	Organic pollutants in iron ore sintering. Impact on electrostatic precipitator operation (LECES).

Contract N°	Title of the project
7261-02/**479**/06	Purification of coke oven site ground water by means of biological treatment (HOOGOVENS B.V.).
7261-02/**480**/04	Study of treatment of oily steelworks sludge at demonstration plant level for recovery of ferrous phase and lubricating oils (CSM).
7261-03/**481**/02	Experimental evaluation of remediation techniques for contaminated coke oven sites (CRM).
7261-03/**482**/03	Experimental evaluation of remediation techniques for contaminated coke oven sites (LECES).
7261-03/**483**/03	Study of soil contamination and remediation in dismantled coke oven plants (INERIS).
7261-03/**484**/01	Experimental evaluation of remediation techniques for contaminated coke oven sites (DMT).
7261-03/**485**/01	Thermal treatment of steel mill dust containing heavy metals by chlorinating volatilisation of heavy metals in a fluidised bed (BFM - BETRIEBSFORSCHUNGSINSTITUT METALLURGIE GmbH).
7261-04/**486**/06	Monitoring ambient air coarse dust concentration and deposition in the Hoogovens Ijmuiden area (HOOGOVENS B.V.).
7261-04/**487**/08	Environmental studies to provide job exposure information relating to epidemiological data in the steel industry (BS TECHNICAL).
7261-05/**488**/02	Control of the noise generated by large fans in steel plants (CEDIA).
7261-05/**489**/02	Forecasting and control of noise in and around steelmaking shops (CEDIA).

Contract N°	Title of the project
7261-05/**490**/03	Forecasting and control of noise in and around steelmaking shops (LECES).
7261-05/**491**/14	Design of noise abatement measures in hot rolling mills for flat products (ENSIDESA).
7261-01/**492**/05	Reduction of dust emission during metallurgical operations by inertisation of the ambient atmosphere (ProfilARBED).
7261-02/**493**/08	Coke oven effluent purification: an examination of methods for improving effluent quality after biological treatment (BCRA).
7261-03/**494**/04	Use of waste materials for stabilising steelmaking slags (CSM).
7261-01/**495**/03	Study and reduction of emissions of organic compounds in electric arc steelmaking fume (LECES).
7261-02/**496**/02	Identification and abatement of residual soluble COD of biologically-purified coke oven waste water (SIDMAR).
7261-03/**497**/03	Development of a monitoring strategy to identify the responsibility of steelworks for dust conditions in the environment (LECES).
7261-03/**498**/02	Accelerating ageing of LD-slag. Comparison of water spraying during cooling with water spraying after deferrisation (SIDMAR / CRM).
7261-04/**499**/08	Expert system for improved operation of steelworks pollution control plant (BS TECHNICAL).
7261-05/**500**/08	In situ measurement of sound emission from the surface of steel-bladed saws and work pieces during the cutting of cold and hot steel sections and appropriate measures to reduce noise emissions during sawing (BS TECHNICAL).

Contract N°	Title of the project
7261-01/**501**/02	Olfactory nuisances in the steel industry: emissions in blast furnace slag granulation (SBF).
7261-01/**502**/04	Reduction of CO, NO_x and SO_2 emissions from iron ore sintering plant by modifying the charge and the process (Phase II) (CSM).
7261-03/**503**/04	Functional recycling of dust in electric steelmaking fume for total waste elimination and recovery of upgradable materials (O.L.S. S.p.A. - Officine Laminatoi Sebino).
7261-03/**504**/15	Experimental evaluation of remediation techniques for contaminated coke oven sites (SIDERURGIA NACIONAL S.A.).
7261-03/**505**/01	Direct recycling of BOF filter dust and sludge contaminated with zinc (Phase I) (KRUPP HOESCH STAHL AG).
7261-03/**506**/01	Metal recovery from waste waters from electrolytic strip galvanising (BFI).
7261-01/**507**/08	Control of emissions of sulphur compounds during the treatment of blast furnace slag (BS TECHNICAL).
7261-01/**508**/01	Control of emissions of sulphur compounds during the treatment of blast furnace slag (VDEh-BFI).
7261-01/**509**/02	Reduction of olfactory nuisances and volatile organic compounds in coil-coating works. Comparative study of the application of paint systems based on organic solvents and those with low solvent content, especially water-base paints (SBF).
7261-02/**510**/01	Improvement of the treatment and recovery of oily waste emulsions in the steel industry (VDEh).
7261-02/**511**/14	Improvement of the treatment and recovery of oily waste emulsions in the steel industry (UNIVERSIDAD DE OVIEDO).

Contract N°	Title of the project
7261-02/**512**/14	Recovery and recycling of heavy metals and hydrocarbons by use of biotechnological processes (CENIM - Spain / ITGE - Spain / ISQ - Portugal / ENSIDESA - Spain / AHV - Spain).
7261-02/**513**/03	Integrated multi-medium approach to the measurement of VOC in the atmosphere and environment of iron and steel plants and connected establishments (IRH / LECES).
7261-03/**514**/14	Use of residues from stainless steel production as raw and auxiliary materials (ACERINOX).
7261-03/**515**/02	Recycling of oily sludges and millscale from the steel industry (CRM).
7261-03/**516**/01	Cover sealing of a blast furnace dust dump. A comparative evaluation of *in situ* field tests (UNIVERSITÄT TRIER).
7261-03/**517**/05	Cover sealing of a blast furnace dust dump. A comparative evaluation of *in situ* field tests (ProfilARBED SA).
7261-03/**518**/03	Inerting of waste products prior to upgrading and tipping (LECES / SOLLAC).
7261-03/**519**/03	Feasibility study of processes for decontaminating large deposits of excavated industrial soil (UNIMETAL / LECES).
7261-03/**520**/05	Technology for the detection and evaluation of the environmental impact of waste deposits in the iron and steel industry (ARBED S.A.).
7261-03/**521**/01	On-line zinc analysis of hot converter exhaust gas - Phase II (KRUPP HOESCH STAHL A.G.).

ANNEX II

EVALUATION QUESTIONNAIRE

EUROPEAN COMMISSION
DIRECTORATE GENERAL V
EMPLOYMENT, INDUSTRIAL RELATIONS AND SOCIAL AFFAIRS
Public health and safety at work
V/F/4

FIFTH ECSC RESEARCH PROGRAMME
on Technical Control of Nuisances and Pollution at the Place of Work and in the Environment of Iron and Steel Works

---

EVALUATION QUESTIONNAIRE

I. NUMBER AND TITLE OF CONTRACT

II. BENEFICIARIES

III. NAME, ADDRESS, TEL. NO. AND FAX NO. OF PROJECT LEADER(S) (for any practical information about the project)

IV. NATURE OF PROJECT

Check the following details and correct as necessary:

IV.1 Parties involved

(identity of any firms / scientific bodies / universities / manufacturers etc. directly involved in the project)

IV.2 Site of research

(laboratory/pilot project/industry)(give details if different from beneficiary)

IV.3 Other previous or current research or "pilot and demonstration" projects for DG V or DG XII directly linked to this project

Number and title of contract(s)

Summary of results or aims

V. COMMUNITY ADDED VALUE ASSOCIATED WITH THE PROJECT

V.1 Improved compliance with Community Directives and Regulations or International Conventions on nuisances at the workplace and in the environment

Give details

V.2 Social and ecological benefits of the project

- major impact on occupational health in ECSC industries
  the health of the general population
  the immediate environment of ECSC industries
  the global environment
- nuisance prevention (clean technology) or cure (abatement technology)

V.3 Technical/scientific benefits of the project - innovative nature

- acquisition of new knowledge, skills, expertise, methods
- technological guidance
- improvement of existing technologies
- innovative use of new processes or products/scientific and technological breakthrough

V.4 Economic benefits of the project

- reduction in waste treatment costs (investment - operating costs)
- reduction in environmental taxes
- savings in raw materials and energy
- new market/stimulation of employment
- economic viability - cost/effectiveness analysis of project results

V.5 Image-related benefits of the project (for the industry, the ECSC sector, the firm/reduction in the number of complaints in or outside the firm/etc.)

V.6 Other benefits (specify)

VI. OPTIMISATION OF BENEFITS OF PROJECT

VI.1 Practical and industrial applications - References - Prospects

VI.2 Marketing - References

VI.3 Acquisition of data and knowledge for preparing the BAT and BATNEEC directives

VI.4 Basis for further work / transfer of knowledge / technology transfer

VI.5 Multi-sector applications (in non-ECSC industries)

VI.6 Patents taken out - References

VI.7 Conferences / publications / scientific or environmental prizes - References

VI.8 Other ways of optimising benefits (specify)

VII. PROVISION OF A SELECTED PHOTO/DIAGRAM/TABLE/SLIDE

(if possible in black and white for the final evaluation report and a colour slide to be shown at the final information day on 9/12/1994) to illustrate the results of the project.

Other information or documents illustrating the approaches adopted or summarising the project or its theme.·

VIII. FUTURE ACTION - PRIORITIES FOR THE FUTURE

(definition of new approaches and identification of new R&D requirements in industrial and environmental hygiene, particularly with a view to combining ECSC research with EC research).

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European Commission

EUR 17584 — Assessment, dissemination and measurement of the impact of the fifth research programme on technical control of nuisances and pollution at the place of work and in the environment of iron and steelworks — Final report

C. Josis, F. Klein

Luxembourg: Office for Official Publications of the European Communities

1998 — X, 104 pp. — 21 x 29.7 cm

ISBN 92-828-2406-3

Price (excluding VAT) in Luxembourg: ECU 13.50

The fifth ECSC research programme on technical control of nuisances and pollution at the place of work and in the environment of iron and steelworks covered the period from 1984 to 1994. The financial aid totalled ECU 26.8 million. Average funding per research project (of which there were 86 in all) was ECU 300 000, often accounting for 60 % of total cost. The average funding per agreement (126 in all) was ECU 200 000.

After setting out the strategic aims and the specific targets of the fifth research programme and examining the main developments in the course of the five programmes over the past 40 years, the results of the fifth programme are assessed, first specifically by pollution sector and production sector and second as a whole in the light of various general indicators. The most spectacular results it achieved and its strengths and weaknesses are reported on and current and future research needs are described. The mechanisms, potential and uncertainties of the processes of transfer and integration (phasing out/phasing in) of specific ECSC research in the EU Community framework research programmes are examined from the point of view of action relating to control of pollution at places of work and in the environment of iron and steelworks.

Recommendations have been made to promote and propagate research more effectively in the future. The final recommendation is for continuing, though gradually decreasing, financial support to cover the specific needs of the ECSC sector and to ensure that there is proper transfer and integration.

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