

# HILLMAN

## COMMISSION OF THE EUROPEAN COMMUNITIES

COM(76) 236 final.

Brussels, 26 May 1976.

UNIVERSITY OF  
PITTSBURGH  
LIBRARIES  
AUG 2 1976

### MEMORANDUM

on the implementation of an iron and steel  
research programme, with a view to obtaining  
financial aid under Article 55 (2) (c) of the  
ECSC Treaty

COM(76) 236 final.



7.

COMMISSION  
OF THE  
EUROPEAN COMMUNITIES

MEMORANDUM

on the implementation of an iron and steel  
research programme, with a view to obtaining  
financial aid under Article 55 (2) (c) of the  
ECSC Treaty

INTRODUCTION

The research proposals on iron and steel contained in this document have been submitted to the Commission of the European Communities requesting financial aid under Article 55, 2 (c) of the ECSC Treaty ; these proposals constitute the first train of research in the iron and steel sector for 1976.

The proposed programme deals with various aspects of iron and steel technology ranging from production and processing to the properties and utilization of steels. The projects have been selected to meet priority requirements within the producer and user sectors of the Community's steel industry and much of what is proposed represents an extension or an intensification of work currently receiving ECSC financial support. Topics of major importance included in the programme concern energy and raw materials, the assessment and control of the quality of steel products, the exploitation of steels for advanced structural applications together basic research directed at the generation of fundamental information that will influence opportunities for technical innovation in the longer term.

In the field of iron ore extraction, it is essential that continued effort is made to sustain the viability of local mines in view of the Community's heavy dependence on external sources of high-grade material. Thus research is proposed with the objective of applying new techniques to improve economic efficiency in the mining of lean ores in the Salzgitter region (P 326).

Due to the energy-intensive character of the industry, research on fuel utilization (efficiency, substitution, etc.) continues to be a vitally important aspect of the programme. Furthermore, since the ironmaking process accounts for as much as 70 % of the total energy requirements it is appropriate that substantial support is proposed on further blast furnace research. In particular, effort will be devoted to a study of the properties of coke in relation to blast furnace performance to establish appropriate quality specifications for given practices (P 302) while another investigation will be concerned with the performance of coke produced from non-coking coals in full-scale blast furnace trials (P 228). In striving to reduce the consumption of coking coal, a study will be carried out on the feasibility of charging various non-coking coals directly into the blast furnace (P 307).

In the steelworks sector, a major investigation on fuel economy will involve the utilization of waste gases from an electrical arc furnace plant to preheat the furnace charge (P 253/1) ; the research assumes particular significance in view of the substantial growth in electric arc furnace capacity within the Community in recent years coupled with the favourable impact that current interest in direct reduction will have on the future expansion of this steel-making process.

The steady growth in continuous casting in the Community, due largely to the advantages of improved yield and a concomitant saving of energy, is proving to be a stimulus to research into the metallurgical aspects of the process ; two projects proposed in this area (P 265 and P 344) are aimed at achieving better product quality - both surface and internal - of cast steel billets.

The three proposals on rolling mill research have quite different objectives relating to the rolling of sections (P 222/2) reduction in wear of strip mill components (P 323) and the pickling of hot-rolled strip (P 263). The latter project will explore the use of electrolytic methods to enhance the surface quality of treated sheet, to avoid pollution problems associated with present day practice and to improve the economies of the pickling process.

The continuing need for improved quality assessment and control methods in steel production and processing poses considerable challenges in measurement research. In particular, there are opportunities for the further exploitation of existing and the development of new techniques of non-destructive testing to evaluate geometric size and shape and to characterise imperfections in steel products and fabricated parts ; this is reflected by the number of projects in the programme dealing with this aspect of testing. A substantial part of the proposed research will involve studies of acoustic emission (P 237, P 264 and P 283) directed at evaluating the potential benefits of this relatively new technique to the steel industry.

The large projects on the service properties of steel relate to the drawability of sheet steel (P 336) and the fracture behaviour of steels used in gas transmission pipelines (P 287). The Community is a leading producer of both these grades of steel thus making the research appropriate for ECSC support. The main objectives of the former collective project are to investigate means of simplifying production methods and thereby reduce costs and to assess the advantages of enhanced steel purity attainable by modern steelmaking methods. The pipeline investigation represents an extension of earlier work on evaluating the mechanics of cracking so that means can be devised to avoid possible failure in service. Other proposals cover studies of weldability (P 252, P 255) and the corrosion behaviour of tinsplate and galvanized steels (P 258).

The proposed research on the utilization of steel ranges from studies of its application in building construction (P 149/b, P 299) to the fatigue behaviour of heavy engineering structures (P 288/2, P 324). Of particular significance is the major Community

investigation proposed on the fatigue behaviour of offshore steel structures ; the project will generate performance data on large scale tests that will aid in predicting the service life of these technologically advanced structures for which current design rules are probably inadequate. This research has important implications for the further use of steel in marine applications and where, in certain instances, competition from concrete is considerable. Furthermore, the project will contribute to the enormous effort being directed at the exploitation of undersea energy resources both within the Community and elsewhere.

On a programme of this type it is both desirable and necessary to support some basic scientific work which will contribute to future technological advance within the steel industry. The research proposed under physical metallurgy concerning studies of the mechanical properties of steels (P 269) and of the mechanism of oxide film formation on electro-technical steel strip fall into this category. In addition, fundamental studies covering the assessment of thermo-chemical data (P 218/2) and the physical properties of slag are contained in the steelworks sector of the programme.

After examination by the Services of the Commission in collaboration with committees of experts and the Iron and Steel Technical Research Committee, (TRC) it was decided to propose these projects for ECSC financial aid.

THE RESEARCH PROGRAMME

I - "IRON ORE" Programme

In the European Community, the problem of recovering the best ore from deposits with a relatively low iron content is currently of importance because of the competition from high-grade foreign ores.

The development of a new mining method, and later a new ore preparation process, is designed to bring production costs down low enough to make these ores competitive.

In addition to the development of a selective winning method, the programme includes the study of mechanized cutter-waders, a subject of great interest for the Community iron mines.

What is more, if the research project is successful working can be continued in the Haverlahwiese mine and its closure postponed. The project will therefore help to maintain jobs in a mining region whose future is in jeopardy. It will also provide a supply of domestic raw material which could have a useful economic effect on iron ore supplies from non-member countries.

II - "PIG IRON PRODUCTION" Programme

The seven projects concerning pig iron production come under the following headings :

- (a) coke (P 319, P 302 P 228 and P 307)
- (b) sinter (P 322, P 276)
- (c) blast furnace (P 312)

a) Coke

The common objective of all the proposals in this field is to widen the range of raw materials for blast furnace coke. However, they are all concerned solely with the use of the coke and not its manufacture.

Project P 319 is a study designed to obtain rapidly for Community steelworks the statistical data required for a specific research policy. The results are intended to provide guidance for the longer term projects and any future projects.

The purpose of project P 302 is to investigate the discrepancy sometimes noted between the hot and cold properties of coke. In practical conditions it has repeatedly been observed that coke grades with the same physical behaviour when cold have very different reactions in the blast furnace. The coke tests used at present may have to be improved or supplemented by others.

Project P 228 concerns the use in the blast furnace of coke grades to which 15-40 % of non-coking coal has been added. The method of manufacturing this coke is new. Unlike briquetted coke, it can be made in conventional coking plant. The non-coking constituents are merely compacted cold with a suitable binder before being added to the mixture.

Finally, P 307 concerns the charging of non-coking coals at the furnace throat. Plans are to use anthracite and lean coals with a maximum of 18-20 % volatile matter and to replace 5-15 % of the coke by coal in stages.

The first two projects will have no direct effects from the labour aspect. If projects P 228 and P 307 produce useful results, they could improve marketing conditions for some domestic grades of coal and thus help to stabilize jobs.

b) Sinter

The life of hot screen linings (P 322) in sinter plant is very unsatisfactory (3-6 months). Consequently it is planned to investigate the factors affecting service life and to draw conclusions for the design and operation of hot screens.

The aim of P 276 is to control the sinter plant through the sinter quality. The degree of oxidation of the sinter is a suitable parameter as it has a theoretical relationship with many other sinter properties. The degree of oxidation is to be determined indirectly

from the  $CO/CO_2$  ratio in the waste gas and from the waste gas temperature. This measurement will then be used as a control parameter for the sinter belt instead of measurement of flame penetration through the sinter, the method generally used at present.

These two research projects have no foreseeable repercussions in the labour sector.

c) Blast furnace

Project P 312 comes under this heading. It is planned to test a kinetic-dynamic simulation model for the blast furnace. The normal blast furnace models used for process control are either mathematical-statistical models or balancing models. In addition to the mass and energy balance, this model takes account of the real reaction rates of the chemical processes in the individual zones of the blast furnace. It thus represents a "mathematical experimental blast furnace" which provides the desired experimental results in real time. The chief value of the project lies in the fact that it can reduce to a minimum the generally very costly technological experiments in the blast furnace itself.

In the introduction of new technologies, preliminary experiments on the simulation model will also enable critical operating states to be avoided and operating safety to be increased.

III - "STEELWORK" Programme

The ten projects come under the headings of theoretical metallurgy, casting and solidification, oxygen steel plant, electric melting shops and refractories.

(a) Theoretical metallurgy

The two applications P 218/2 and P 300 supplement the project approved a year ago on the compilation of thermochemical data in the field of ferrous metallurgy. In addition to binary metal systems, data will be collected for the most common slag systems.

The research projects have no repercussions as regards labour.

(b) Casting and solidification

There are three applications under this heading. Project P 236 aims to investigate the precipitation of oxides, sulphides and metals (Pb and Bi) during the solidification of free-cutting steels as a function of the cooling rate over the ingot cross-section. In general sulphides are undesirable in steel as they adversely affect the mechanical properties. However, certain sulphides improve machinability and are therefore added for that purpose. The same applies to oxides and to lead and bismuth, which are insoluble in steel.

The type, concentration and distribution of these substances are therefore of very great importance.

The other two projects relate to continuous casting : complete automation of the continuous casting process with control based on product quality is the aim of P 265. The setting of nozzle valves and pouring speed will be controlled by a computer to give optimum operation for the particular product. The mathematical model required will be designed.

Project P 344 plans to test in industrial operation an ultrasonic method, developed in an earlier ECSC research project, for the measurement of steel level and detachment in the continuous casting mould. Continuous measurement of the steel level is particularly important for automation purposes and the project will therefore complement the earlier research.

Observation of the detachment of the casting from the mould wall provides information on the cooling process in the mould can and is therefore useful for adjustment of withdrawal speed. The theoretical basis for the method is the fact that there is a clear difference in the reflected pulse height from an "attached" casting and a "detached" casting.

Project P 236 has no direct influence on labour in the steelworks.

Projects P 265 and P 344 both relate to automation of the continuous casting process. The aim is not to save labour but to optimize the process. In both projects, this means a reduction in the risk of breakdown and accident.

(b) Oxygen steel plant

P 261 comes under this heading. Its aim is to automate the OBM converter and it comprises the following stages : precise advance calculation of the charge, dynamic control of the refining process and accurate prediction of end point.

In addition to better control of the process itself, this project will mean greater safety for operating personnel as splashing and overflow from the converter will be prevented.

(d) Electric steel plant

The first of the three projects under this heading (P 298) is the continuation of an existing project in which a theoretical model and measuring method for electrode erosion have been developed and basic research carried out into the heat transfer mechanism in electric arcs. One important aspect was the mutual influence of the three arcs on each other, particularly as regards the direction of the arc flame, which can cause hot spots in the lining.

The current project plans to transfer the findings made with laboratory equipment to industrial conditions and to verify them. The aim is to reduce electrode consumption and to obtain maximum heat utilization and minimum refractory wear.

The research has no direct effects in the labour sphere.

Project P 239 concerns the testing of a flat roof on an electric arc furnace. The principle of flat suspended roofs is known from the openhearth furnace. They have the advantage of a longer service life than self-supporting roofs, and in addition

basic linings can be used. A substantial reduction in electric arc furnace operating costs is expected.

In project P 253/1, the charge for an electric arc furnace will be preheated to 1000-1200°C in a rotary kiln. The energy for preheating will come mainly from the waste gas from two furnaces operating in tandem. Charging (with light scrap, pellets and granulated pig iron) will be continuous. The rotary kiln can be pivoted to serve both electric furnaces. The installation will be controlled so that the load on the power supply system remains constant.

The method will always be economically advantageous when there is a certain price difference between electricity and alternative fuels (gas, oil).

As regards working conditions, the noise nuisance will be greatly reduced in comparison to a UHP furnace of the same capacity (as only one-third of the normal power is used).

(e) Refractories

Project P 296 concerns the patching of refractory linings by spraying. Numerous refractory units in the iron and steel industry suffer severe local wear. In such cases patching by spraying mixtures can greatly increase their life before relining becomes necessary. Experience in Japan and the US and preliminary research in the Community have shown that, for example, an LD lining can last for up to 2000 blows.

The main parameters in this technology will be investigated in the project.

IV - "ROLLING MILLS AND PROCESSING" Programme

A number of research projects are currently being carried out on flat rolled products and it is necessary to await the results of the studies before considering any new ventures in this field. Having submitted a wire rod project, the rollers are continuing their work on long product with a proposal for a research project on beam rolling (P 222/2).

Modern rolling mills are subjected to enormous stresses, which lie at the root of considerable deterioration resulting from wear or deformation. The purpose of Project P 323 is to pinpoint the causes of this wear and tear and to come up with a remedy.

Lastly, the aim of Project P 263 is to combat water and atmospheric pollution by replacing the present (highly polluting) hydrochloric and sulphuric acid pickling process by a non-polluting neutral electrolytic process.

#### V - "MEASUREMENT" Programme

As steelmaking, fabricating and processing methods change, it is necessary to develop new methods and/or adapt old methods of non-destructive testing and inspection.

It has long been known that when a metal is deformed there is an acoustic emission and this technique (projects P 237, P 264 and P 283) has recently undergone extensive development in both laboratories and production shops. At the present time, however, processing of the information contained in the signal is still semi-empirical despite the often very sophisticated equipment used. These projects will concentrate on investigating a number of uses of acoustic emission and selecting applications, mainly from the following aspects :

- acoustic emission due to different mechanisms in order to obtain a wide variety of "acoustic signatures"
- practical interest of the method for various future industrial applications.

Non-destructive tests are not used solely to observe structures. Examination of surface defects is also very important and here again it is essential to meet extremely stringent acceptability standards and to seek new methods of doing so. This is the aim of research projects P 249/2 and P 345 which should lead to the development of a wide-scan device for the very rapid detection of surface defects on strip that will provide technically usable readings.

It goes without saying that improvement of product quality has important economic implications and that the safety of certain assemblies depends on it.

## VI - "USED PROPERTIES" Programme

### a) Weldability

The proposed research projects on weldability are aimed at increasing basic knowledge and developing applications by fabricators in two specific fields : underwater welding and friction welding (without filler metal). These two techniques are necessary and are currently becoming more widespread, in particular for large load-bearing structures of steel.

### b) Corrosion

Tinplating and galvanizing each of which have very specific applications, have proved to be efficient ways of protecting steel.

Present economic circumstances indicate that these two products are likely to continue to develop in their respective sectors. For galvanized steel, this development is justified by the need to ensure that equipment has longer service life in increasingly corrosive environments. In the case of tinplate, its use in the packaging industry may be expected to expand because of the rising costs of petroleum products and derivatives thereof.

### c) Formability

If one considers the progress made in recent years by ferrous materials metallurgy, it may be noticed that two factors clearly emerge :

- 1) the possibility was ascertained of manufacturing steels with a purity level that was unthinkable in the past ;
- 2) the present trend is to shorten and simplify the manufacturing cycles, with a view to saving energy and, more generally, to reducing factory costs.

As concerns point 1 it should be stated that users have received that novelty with enthusiasm, and this can be easily understood inasmuch as a higher purity usually means a reduction of the practical difficulties connected with the use of the materials. Some exceptions to this rule do however exist, as in the case, for instance, of structural steels, the adverse effect of an exceedingly low S content on the Fracture Apparent Transition Temperature (FATT) and on the propensity to cold cracking during welding operations. In view of this circumstance, it may be safely stated that so far the users' demand for ferrous materials with a higher degree of purity was often indiscriminate and sometimes in conflict with other essential prerequisites.

The problem thus exists of making the effort for qualitatively improving to products exactly consistent with the actual requirements for use ; and it may be indeed observed that in the field of high strength steels and in that of structured steels much has been done (and much is being done also in the Community framework) in order to afford the economically most convenient answers to a whole series of technical problems.

In the field of steels for small-thickness products, both hot- and cold-rolled, the work has hardly begun and, in particular, it is still to be established for what specific uses an increase in the purity of the material is actually advantageous, and for what other uses it may instead represent a waste, if not an inconvenience.

d) Brittle fracture

Continuous research is required into the phenomenon of brittle fracture in order to prevent its occurrence and ensure the safety and optimum use of large-scale welded components (e.g., load-bearing structures, pressurized vessels and tubes). It is well-known that fracture in this type of construction can rapidly assume disastrous proportions.

## VII - "PHYSICAL METALLURGY" Programme

The research proposed in this sector involves mainly further effort on the generation of background information on the mechanical properties of low carbon steels and an investigation of the formation and properties of oxide layers on electrotechnical sheet steel.

The former project is aimed at gaining further data on the relationship between steel composition, thermal treatment, mechanical properties and microstructure ; this work will include trials at an industrial level to assess the transferability of the results obtained on a laboratory scale to production conditions.

The study of electrotechnical sheet steel (non-grain oriented type) relates to a need for a better basic understanding of the formation of oxide layers with the ultimate aim of improving product quality. The significant growth in production of this grade of steel within the Community in recent years emphasis the importance research in this area.

## VIII - "UTILIZATION" Programme

### a) Light application

The use of steel for building is inhibited both by vigorous competition from the concrete industry and also by a certain amount of ignorance in the construction industry about the properties of steel structures.

One research proposal (P 350) aims to remedy the latter state of affairs by disseminating as widely as possible in the relevant circles a manual giving information on the durability of steel structures in relation to atmospheric corrosion.

Another proposal (P 259) tackles the problem of the fire rating of hollow concrete-filled sections.

A further two projects (P 149 and P 299) aim to make it easier and more economical to use steel by developing composite steel-concrete beams and a multipurpose cast steel joint to simplify the erection of steel structures.

b) Heavy application

The improvement of the performance and safety of installations in steelworks is an ever-present subject of concern to manufacturers and users of heavy plant and machinery whether for handling or producing purposes.

A survey already carried out within the ECSC has enabled a number of projects on these lines to be selected.

There is also concern about the safety of load-bearing structures such as steel bridges and marine structures (drilling platforms) where the conditions of use expose components to alternating stress and corrosion phenomena that might jeopardize their stability.

IX - "MISCELLANEOUS" Programme

Slag dumps have always been a problem as far as disposal and pollution are concerned. After studying the use of blast-furnace slags in road construction, the iron and steel industry is now putting forward a project (P 355) to enable steel plant slags to be used for road-surfacing purposes.

CONCLUSION

The total budget for the selected research programmes amounts to 37,684,500 E.U.A. (conversion rates of 2.1.1976). The ECSC's financial commitment will be 17.725.054 E.U.A., of which 17.208.790 E.U.A. will go to cover its participation in the research costs and 516.624 E.U.A. to cover the cost of disseminating information and related costs.

---

S U M M A R Y T A B L E

Annex 1

Project n°	Titel of the research	Proposed Research			Financial Aid	
		By	Duration Years	Amount in E.U.A. (2.1.76)	%	Amount in E.U.A. (2.1.76)
P 376	<u>IRON ORE MINE</u> Improvement of economic efficiency in the mining of lean domestic iron ores	Salzg. Erzbergbau	2 1/2	819.000	60	491.400
P 319	<u>PIG IRON PRODUCTION</u> a) <u>Coke</u> Study of coke grades Degradation of coke and its relationship with coke properties and blast furnace performance Tests of cokes produced by mixtures containing non-coking coals Direct charging of coal at the blast furnace throat	B.F.I.	1/2	23.500	100	23.500
P 302		B.S.C.	3	1.000.000	60	600.000
P 278		C.R.M.	4	1.510.000	75	377.500
P 307		A R B E D	2 1/2	651.000	60	390.600
P 322	b) <u>Sinter</u> Investigation of hot sinter screening machines Thermal optimization of the sintering process as regards sinter quality	B.F.I.	4	483.500	60	290.100
P 276		C.S.M.	3	314.000	60	188.400
P 312	c) <u>Blast furnace</u> Introduction of new burden variation technologies to blast furnace operation	V.D.E.h.	2	405.000	60	243.000
P 218/2	<u>STEELWORK</u> a) <u>Theoretical metallurgy</u> Review and compilation of thermochemical data Physical properties of slag	I R S I D	4	268.500	60	161.100
P 300		Nat.Phys.Lab.	3	166.000	60	99.600
P 236		b) <u>Castings and solidification</u> Determination of the distribution of non-metallic inclusions in steel from reaction of insoluble or partly soluble metals at the solidification front	V.D.H.h.	2	265.500	60

Project n°	Titel of the research	Proposed Research			Financial Aid	
		By	Duration Years	Amount in E.U.A. (2.1.76)	%	Amount in E.U.A. (2.1.76)
P 265	Metallurgical inspection in continuous casting plant	C.R.M.	3	610.000	60	366.000
P 344	Determination of the steel level and casting detachment process in the mould of a continuous casting machine	B.F.I.	3	219.500	60	131.700
P 261	c) <u>Oxygen steel plant</u> Control of pure oxygen refining with bottom blowing	C.R.M.	3	437.500	60	262.500
P 298	d) <u>Electric steel plant</u> Basic properties of high-intensity arcs and steelmaking	B.S.C.	2	406.500	60	243.900
P 239	Experiments with flat suspended roofs on electrical steelmaking furnaces	S A N A C	1 1/2	71.000	60	42.600
P 253/1	Preheating of the charge in an electric arc furnace	Nuova Ceretti	2	10.506.500	16	1.681.040
P 296	e) <u>Refractories</u> Repair of steel furnaces by spraying	I R S I D	3	314.500	60	188.700
P 222/2	<u>ROLLING MILL AND PROCESSING</u> Beam rolling	I R S I D	4	717.500	60	430.500
P 263	Continuous neutral electrolytic pickling process	C.S.M.	3	338.500	60	203.100
P 323	Reduction of wear on roller tables and coilers	B.F.I.	3	616.000	60	369.600
P 224/2	<u>MEASUREMENT</u> Non-destructive methods for hairlinecracking	T.N.O. Inst. Breda Creusot-Loire	1 1/2	20.000 40.000 40.000	60 60 60	12.000 24.000 24.000
P 234	Method of measuring the surface temperatures of rolling stock and rolls and its use for thermal flatness control	B.F.I.	3	182.000	60	109.200
P 235	Development and testing of short load cells	B.F.I.	2	130.000	60	78.000

Project n°	Titel of the research	Proposed Research			Financial Aid	
		By	Duration Years	Amount in E.U.A. (2.1.76)	%	Amount in E.U.A. (2.1.76)
P 237	Collaborative studies on stress wave emission	Weld. Inst.	2	166.500	60	99.900
P 248	Automatic non-destructive testing for the assessment of steel quality	Dan. Weld. Inst. Round Oak. St.	2	166.500 264.000	60	99.900 158.400
P 249/2	Advancement of surface inspection instrumentation for cold-rolled steel strip	B.S.C.	2	376.000	60	225.600
P 264	Use of acoustic emission techniques to investigate metallurgical phenomena	Creusot-Loire I N S A	2	333.500	60	200.100
P 273	Electromagnetic-acoustic scanning applied to hot steel semis	C.R.M.	3	292.000	60	175.200
P 283	Detection and location of defects in welds and in the parent metal of welded pipelines by means of acoustic emission analysis	Inst. Prüf. Saar. B.A.M.	2	333.500	60	200.100
P 285	Continuous measurement of coating thickness on sheet	C.R.M.	2 1/2	264.500	60	158.700
P 286	Application of optical telemetry to the inspection of hot-rolled sheets and beams	C.R.N.	2	375.500	60	224.100
P 327	Industrial application of the hot ultrasonic testing process to the inspection of rimming steel slab shearing	I R S I D Hoogovens	2	167.000 320.000	60	100.200 192.000
P 333	Continuous measurement of dissolved oxygen in steel melts using E.M.K. probes	V.D.E.h.	3	344.000	60	206.400
P 337	Purchase of an electromagnet	FIAT	-	10.500	60	6.300
P 345	Inspection device for detection of surface defects on cold strip with appropriate signal processing	B.F.I.	3	321.000	60	192.600
	<u>USED PROPERTIES</u>					
	a) <u>Weldability</u>					
P 252	Investigation of the properties of welds made under-water	Weld. Inst.	2	325.000	60	195.000
P 255	New techniques for joining steel	Weld. Inst.	3	299.000	60	179.400

Project n°	Titel of the research	Proposed Research			Financial Aid	
		By	Duration Years	Amount in E.U.A. (2.1.76)	%	Amount in E.U.A. (2.1.76)
P 258	b) <u>Corrosion</u> Study of passivation phenomena on timplate and galvanized steel	C.R.M.	3	261.000	60	156.600
P 336	c) <u>Formability</u> Drawability of cold rolled sheet	C.R.M. V.D.E.h. C.S.M.	} 2 1/2	515.000 430.000 350.000	60 60 60	309.000 258.000 210.000
P 270	d) <u>Brittle fracture</u> Safety conditions for welded structures using wide-plate tests	I R S I D T.U. Delft C.S.M.		3	200.000 100.000 387.000	60 60 60
P 287	Fracture behaviour of gas transmission pipelines. Further full-scale and laboratory tests	B.S.C. V.D.E.h. T.N.O.	} 1	753.000 63.500 103.000	60 60 60	451.800 38.100 61.800
P 269	<u>PHYSICAL METALLURGY</u> Relation between microstructure and mechanical properties	C.S.M.		2 1/2	500.000	60
P 317	Formation conditions and properties of oxide films on non-oriented electrical strip, effect on material quality	Stahlw. Bochum	3	619.000	60	371.400
P 354	Metallographic atlas	I R S I D		40.000	60	24.000
P 149/b	<u>UTILIZATION</u> a) <u>Light application</u> Composite steel-concrete beams	C I S I A	2	52.000	60	31.200

Project n°	Titel of the research	Proposed Research		Financial Aid		
		By	Duration Years	Amount in E.U.A. (2.1.76)	%	Amount in E.U.A. (2.1.76)
P 259	Determination of the fire rating of concrete-filled hollow sections	C I D E C T	2	211.000	60	126.600
P 299	Multi-purpose steel joint for steel structures for the building industry	C I S I A	2	123.500	60	74.100
P 350	Manuel on the durability of steel structures in relation to atmospheric corrosion	Cent. Inf.Acier B L F D I GB NL	2	10.500 2.500 18.500 16.500 10.000 9.000 25.000	80	8.400 2.000 14.800 13.200 8.000 7.200 20.000
P 288/2	Measurement and interpretation of dynamic loads on bridges b) Heavy application	B.S.C.	2	126.500	60	75.900
P 321	Optimization of the alternating stress of drive systems	B.F.I. T.U. Berlin	3	411.000	60	246.600
P 324	Improvement of calculation and design data for heavy engineering components liable to fatigue failure	B.F.I. Lab. Darmstadt T.U. Clausthal T.U. Karlsruhe	2 1/2	557.000	60	334.200
P 362	Fatigue and corrosion fatigue behaviour of offshore steel structures	Dpt. Enerrie GB B.S.C. Harwell I R S I D V.D.E.h. S.M.O.Z.	3	2.780.500 223.000 247.500 958.000 982.000 986.000	50 60 60 60 60 60	1.390.250 133.800 148.500 574.800 589.500 591.600

Project n°	Titel of the research	Proposed Research			Financial Aid	
		By	Duration Years	Amount in E.A.U. (2.1.76)	%	Amount in E.A.U. (2.1.76)
P 355	<u>MISCELLANEOUS</u> Investigation of I. D slags for use in road construction	B.S.C.	} } 3	200.000	60	120.000
		Forsch. Eisenh.		200.000	60	120.000
		C.T.P.L.		150.000	60	90.000
		C.R.M.		150.000	60	90.000
	Total			37.684.000		17.208.790
	Cost of dissemination of information					516.264
	E C S C Commitment					17.725.054

THE RESEARCH PROJECTS

I - "IRON ORE" PROJECTS

P 326 - Improvement of economic efficiency in the mining of lean domestic iron ores

Solely in the parts of the Haverlahwiese mine now being worked, there are about 82 million tonnes of ore with an average iron content of 32 % (dry basis). More than half of this, some 45 million tonnes, is in stratified formations of varying thickness with iron contents of 35-40 % or more.

The working method currently in use is block caving with "L.H.D." technic. This does not allow selective winning of certain parts of the ore.

The research project aims to improve economic efficiency by abolishing ore dressing since the additional transport and Fe losses involved make this a high-cost operation.

The research programme embraces the prospecting of deposits to find the higher-grade sections and the development of the selective working method.

The cutting method that is to be used for selective winning is already in operation in a few mines with predominantly level deposits at relatively shallow depths. The planned research should extend the application of this mining technology to enable it to be used under difficult geological conditions (steep dip, greater depth and more heavily faulted strata of the deposit).

The research programme is planned to last 2 1/2 years and will be carried out in the Haverlahwiese mine of Salzgitter Erzbergbau AG in Salzgitter (D).

## II - "PIG IRON PRODUCTION" PROJECTS

### a) Coke

#### P 319 - Study of coke grades

In the European Blast Furnace Committee, a representative statistical survey of the characteristics of the cokes charged will be made. A correlation will then be drawn between the characteristic values and the practical blast furnace results obtained.

The results will provide useful guidance for the Commission and for the works concerned, such as briquetted coke manufacturers and users.

The study is being carried out on behalf of the Commission of the European Communities. The Verein Deutscher Eisenhüttenleute in Dusseldorf (D), is to be commissioned with the work, which is expected to take about 6 months.

#### P 302 - Degradation of coke in the blast furnace and its relationship with coke properties and blast furnace performance

The experiments will be conducted in various blast furnaces in countries of the European Communities. The blast furnaces will be selected on the basis of the results of the study referred to above.

Cokes made from various coals or coal mixtures will be investigated. The first point to be studied is the influence of drum hardness (coke used : M (Micron) 40-60 to M 40-85).

Furnace size is another parameter to be investigated. The same coke will be tested in furnaces of 5-14 m hearth diameter.

Finally, the influence of the ore constituents will also be taken into account by replacing sinter with pellets, for example.

The applicant is the British Carbonization Research Association of the BSC in London (GB).

The probable duration is three years.

P 228 - Tests on cokes produced from mixtures containing non-coking coals

The experimental stages described here are preceded by two stages which concern the manufacture of the coke and therefore come under the heading of "Coal research".

In the blast furnace experiments, it is planned to replace good quality coke in stages by increasing quantities of the new coke grade (0-25-50-100 %) in an 8 m blast furnace. After every variation the furnace will be allowed to reach equilibrium before measurements of consumption, permeability,  $\mu$  values, etc., are made.

The applicant is the Centre des Recherches Métallurgiques in Liège (B).

P 307 - Direct charging of coal at the blast furnace throat

It is planned to use three types of coal : an anthracite, a lean coal and a semi-bituminous coal. Lump size will be between 30 and 120 mm and 5, 10 and 15 % (referred to coke weight) of each type of coal will be added to the charge.

The experiments call for special measurements and instruments on the blast furnace, e.g., measurement of coal particles and tar in the top gas. Permeability will also be determined at various levels in the furnace by means of probes.

The reducibility and hot disintegration of the sinter are two further parameters that will be observed.

The applicant is ARBED in Esch-sur-Alzette (L).

The research is estimated to require 2 1/2 years.

b) Sinter

P 322 - Investigation of hot sinter screening machines

The life of hot screen linings is principally governed by the following factors :

Design

Material properties

Sinter quality

Operating temperature

Machine characteristics (vibration)

First the data required will be collected for a range of screening machines and weighted according to their effect on service life. On the basis of this assessment, suitable materials will then be selected for testing under industrial conditions. The results should help to improve specifications for ordering and acceptance purposes.

The applicant is the Betriensforschungsinstitut der Verein Deutscher Eisenhüttenleute in Dusseldorf (D).

The research will probably take 4 years.

P 276 - Thermal optimization of the sintering process through sinter quality

Operating data will first be collected and analysed at the sinter plant in Cornigliano. This will include various temperature measurements, gas analyses and data such as the speed of the sinter belt, the depth of the sinter bed, the quantity of returns, the addition of coke breeze and the sinter properties. During this period, programmed variations will be made (e.g., changes in sinter bed depth, density, proportion of returns). The variations will be displayed by a continuous gas analyser and additional temperature probes in the ignition zone. After a calibration and running-in period an attempt will be made to incorporate CO/CO<sub>2</sub> measurement in the waste gas into a control model.

The applicant is the Centro Sperimentale Metallurgico in Rome (I). The research will be carried out in close cooperation with Italsider's O. Sinigaglia works in Genoa-Cornigliano. It is planned to last about one year.

c) Blastfurnace

P 312 - Introduction of new burden variation technologies to blast furnace operation

First the model will be used for concomitant calculations, as in ARBED's current ECSC project on the charging of briquetted coke into the blast furnace. If the calculated values agree well

Annex 2

with the results determined experimentally, the model will be used to calculate operating states in advance for the introduction of new technologies. One example is the blowing of pulverized brown coal into the blast furnace. Finally, the effects of changes in regulating variables in the blast furnace, e.g., blast volume, will be calculated in advance. The applicant is the Verein Deutscher Eisenhüttenleute in Dusseldorf (D).

The research is estimated to take 2 years.

III - "STEELWORK" PROJECTS

a) Theoretical metallurgy

P 218/2 - Review and compilations of thermochemical data

After coordination with the project already in hand (P 148), the following research programme is planned :

- (a) in liquid binary systems of iron, the alloying elements manganese, aluminium, cerium and calcium still have to be investigated ;
- (b) in binary and ternary systems, partial and complete thermochemical data will be obtained with the elements molybdenum, tungsten, niobium and tantalum ;
- (c) in the field of metallurgical slags, binary, ternary and quaternary systems with alkali oxides, there are as yet no thermochemical data available for certain systems. They have to be determined experimentally. The data obtained under the various ECSC agreements are to be published in the form of a reference work.

The applicant is the Institut de Recherche de la Sidérurgie Française in Maizières-les-Metz (F). The work will be carried out in collaboration with the Laboratoire de Thermodynamique et Physico-Chimie Métallurgiques in Saint-Martin-d'Hères and the National Physical Laboratory in Teddington. It will take about three years.

P 300 - Physical properties of slags

The following research programme is proposed :

- (a) ESR slags.

Determination of the solubility in water of  $\text{CaF}_2$  slags in the

temperature range 1300-1600°C

Determination of enthalpy, heat of fusion, emission coefficient and thermal conductivity of ESR slags on a basis of  $\text{CaF}_2/\text{Al}_2\text{O}_3$  with additions of CaO and  $\text{SiO}_2$  at temperature up to 1600°C.

(b) LD slags

Measurements of enthalpy, heat of fusion heat and emission coefficients up to 1600°C are to be carried out on LD slags.

The applicant is the National Physical Laboratory in Teddington (GB).

The project is expected to take three years.

b) Castings and solidification

P 236 - Determination of the distribution of non-metallic inclusions and precipitation of metals insoluble in steel at the solidification front as a function of the cooling rate over the ingot cross-section

The experimental melts will be prepared in a 100 kg medium-frequency furnace. Two different cooling rates will be obtained by pouring into normal moulds and into water-cooled copper moulds. The solidification structure will then be determined at various points by means of quantitative image analysis, the electron microscope or X-ray.

The applicant is the Neunkirchener Eisenwerk in Neunkirchen-Saar (D).

The experiments are expected to take two years.

P 265 - Metallurgical control of continuous casting plant

To obtain maximum productivity in a continuous casting machine, a control system is to be developed to regulate the water throughput in the secondary cooling system in such a way as to maintain a constant heat profile along the casting.

Using a solidification model, schematics for a specific secondary cooling heat profile that are suitable for use on any machine

will first be calculated.

The individual valves will be controlled by a computer.

Monitoring of the heat profile will be done by suitable surface temperature measurements.

The applicant is the Centre de Recherche Metallurgique (CRM) Liège (B).

The work should take about three years.

P 344 - Determination of the steel level and casting detachment process in the mould of a continuous casting machine

The design problems involved mounting the ultrasonic generator in the mould must first be overcome.

Then the measuring principle will be improved to make it insensitive to disturbance factors (vibration, shock, etc.).

A further point for study is signal processing, which must be done in such a way to obtain reliable data on the steel level and casting detachment in industrial operation.

The work will be carried out in cooperation with manufacturers and users of continuous casting machines.

The applicant is the Betriebsforschungsinstitut des VDEh in Dusseldorf (D).

The research is planned to take three years.

c) Oxygen steel plant

P 261 - Control of pure oxygen refining with bottom blowing

The research is to be carried out in a new converter shop containing three 150 t converters which is to be commissioned in the second half of 1976. Oxygen will be blown in through the bottom

and powdered limestone introduced through a lance.

The research covers three points :

1. Conversion of the existing charging model (originally designed for OBM basic Bessemer converter) to the new operating conditions
2. Dynamic control, for which gas sampling, gas analysis and sound recording equipment is necessary. Whereas the charging model calculated absolute input values (scrap, oxygen, limestone, etc.) the dynamic model provides metering as a function of time.
3. Measurement of the exact end point of the refining process by acoustic methods.

The applicant is the Centre de Recherches Métallurgiques in Liège (B).

The research should last three years.

d) Electric Steel plant

P 298 - Basic properties of high intensity arcs and steelmaking

The programme consists of two main parts :

1. Studies of erosion

Using a special photographic technique, erosion on electrode tips will be investigated in a large number of production furnaces. Core samples will then be taken from the industrial electrodes investigated and inserted into the electrode tip of the test equipment in the research station. At the same time thermal expansion, modulus of elasticity and strength up to 2000°C will be determined.

2. Heat transfer measurements on the arc. The effect of the arc flame on lining wear will be investigated over a wide range of arc characteristics. Specific operating conditions such as furnace atmosphere and metal/slag effects will also be taken into account.

The applicant is the British Steel Corporation in London (GB). The work will be carried out in the Special Steels Division's Swinden Laboratories and the Arc Research Section, Moorgate, Rotherham.

It will probably last two years.

P 239 - Experiments with flat suspended roofs on electric steelmaking furnaces

The flat roof will first be tested on a 40 t furnace. The experiments will extend over six furnace campaigns using three different refractories (chemically-bonded chrome-magnesite, direct-bonded chrome-magnesite and fired bricks containing 80 % alumina).

The same programme will then be repeated on a 150 t furnace.

The applicant is the firm SANAC of the Finsider group in Genoa (I).

The project will be carried out in collaboration with Dalmine, Bergamo and the CSM in Tome.

The research is estimated to require 1 1/2 years.

P 253/1 - Preheating of the charge in an electric arc furnace

The research will be carried out in Ceretti's new melting shop containing :

- A. A pivoting rotary kiln for preheating the materials to be charged (25 m long, 2.5 m in diameter, 80 tonnes per hour).
- B. Two electric arc furnaces of 5.5 m diameter and a capacity of 25 MVA per furnace.
- C. Conduits to transfer the hot waste gases from the electric furnace to the rotary kiln.
- D. A central process control computer.

The installation is by way of a prototype and contains the following novel features to be tested :

- 1. Preheating of the charge materials to 1.200°C.
- 2. Simultaneous use of waste gases from two furnaces.
- 3. Slow rotation of the electric furnace during charging to obtain better distribution of the charge. This enables the bath temperature to be kept lower and there is thus less wear on the refractories.

4. Tandem operation of the two electric furnaces in such a way that the load on the power supply system remains absolutely constant. This avoids the repercussions of switching operations on the main power supply.

According to theoretical advance estimates, specific operating costs will be as follows :

Electricity	300 Kwh/t	(550)
Methane	15 m <sup>3</sup> /t	(0)
Electrodes	3.2 kg/t	(5.5)
Refractories	6 kg/t	(15)

The figures in brackets are those for a conventional UHP installation.

The data will be verified experimentally.

The applicant is the firm Nuova Ceretti S.p.a. in Villadossola (I).

The research should take about two years.

#### e) Refractories

##### P 296 - Repair of steel furnaces by spraying

###### 1. Laboratory experiments

There are at present too many refractory spraying mixtures on the market.

These products will first be classified according to their properties (flame hardening, physical and mechanical properties, behaviour when exposed to molten metal and slag).

The various spraying methods will then be investigated and the most suitable determined.

The next step will be research into the adhesion mechanism.

###### 2. Industrial experiments

The best products and methods will then be tested under

industrial conditions in IRSID's 6t converter.

The applicant is the Institut de Recherches de la Sidérurgie Française in Maizières-lès-Metz (F).

The research will last about three years.

#### IV - "ROLLING MILL AND PROCESSING" PROJECTS

##### P 222/2 - Beam rolling

Little research has been carried out to date on the mechanisms of beam rolling, which, in this respect, would appear to be something of a poor relation when compared with flat product rolling.

One of the features of the beam market is the very keen competition from concrete, the use of which is becoming increasingly widespread, even in the light construction sector where it was previously little used.

If this trend is to be reversed, it is now essential to acquire a better understanding of the geometrical properties of beams and to reduce the dimensional tolerances and production costs. The present research project should enable these aims to be achieved through :

1. a better knowledge of the basic mechanisms of rolling ;
2. better criteria for regulating the stands ;
3. a reduction of idle time.

It should be noted that the beam is a product which represents some 5 % of rolled production in Europe and that construction in steel uses five times as much steel per square metre as does construction in reinforced concrete.

This research project, which will last four years, will be carried out by Institut de Recherches de la Sidérurgie Française, Maizières-lès-Metz (F).

P 263 - Continuous neutral electrolytic pickling

Of all the operations carried out in a steelworks, the pickling of hot-rolled strips constitutes one of the most dangerous sources of environmental pollution, since this process requires the use of substantial tonnages of strong acids which are subjected to numerous handling operations. Despite the recent appearance of new (very costly techniques for regenerating the acids, the danger of serious ecological damage persists and it is now imperative to devise a process which is absolutely harmless to the environment.

Neutral electrolytic pickling, a process which is well-known on a theoretical level and which is already used in the rolling of stainless steels, meets the required criteria and also seems to be acceptable from a cost efficiency standpoint.

Accordingly, it is proposed that this research project be undertaken with a view to defining all the technical, technological and economic conditions for a neutral electrolytic pickling plant to treat hot-rolled steels in large quantities.

This research project, which will last three years, will be carried out by Centro Sperimentale Metallurgico S.p.A., Rome (I).

P 323 - Reduction of wear on wide-strip mill components

Wear on wide-strip mill components due to friction and impact is a substantial item in the operating costs of a rolling mill and hence in the cost of the plate produced. Furthermore, the down-times necessary for the replacement of worn or damaged parts result in a not insignificant drop in productivity.

Over the last few years tribological studies have been extended to various fields, but no systematic research has yet been undertaken.

The aim of this project is threefold : to make a systematic study of the causes of wear, to pinpoint these causes and to devise methods of reducing the deterioration.

Annex 2

The research will be carried out under normal wide-strip mill operating conditions so as to ensure that the findings are of immediate practical use.

The project, which will last three years, will be carried out by Verein Deutscher Eisenhüttenleute, Düsseldorf (D).

P 224/2 - Non-destructive techniques for tracing dimensional changes in defects subjected to thermal and mechanical cycles

Research Agreement n° 6210 G.A./6/602-4/402-3/302 ("Study of Cracking and Crack-Detection Methods"), which is being carried out by TNO (Breda) and Creusot-Loire, is playing a major part in the development of a non-destructive method of detecting and locating defects under the/<sup>rustproof</sup>lining of pressure vessels. Another phase of this study is concerned with the determination of changes taking place in the cracks when subjected to thermal and mechanical cycles such as those that occur in reactor operation. The purpose of the research is to evolve a non-destructive examination technique by which changes in the cracks can be observed during and/or at the end of each cycle without damaging or harming the material. The method must also permit high precision inspection and measurement of the cracks.

Several approaches will be investigated :

- radiography
- Ultrasonics
- Electrical and magnetic methods.

Apart from its immediate application to the work in progress, this research would most likely have other applications. The work will be shared by the Instituto di Ricerche Breda, Milan (I), Creusot-Loire Laboratory at Creusot (F) and Metaalinstytut TNO at Appeldoorn(NL).

The period involved is likely to be one and a half years.

P 234 - Method of measuring surface temperatures of rolling stock and its use for thermal flatness control

In the cold rolling of strip, it is essential to obtain sheet

of regular thickness with a smooth surface. After plastic deformation, the strip must have a regular microstructure and be devoid of undulations, bulges and any other flatness defects which appear when the extension of the strip is not uniform. During the rolling operation, the temperature of the rolls increases in an irregular fashion, thus causing the appearance of anomalies.

The proposed research is aimed at determining the effect of the heat-exchange coefficient and at establishing an appropriate method of measuring the temperature.

The programme comprises, in the following order :

- In-laboratory study and development, under contract, of a temperature measuring system (thermoscopy combined with infrared detectors) ;
- adaptation of a type of infrared camera ;
- prototype development - and tests on a experimental mill ;
- study of the effect of the emissive power of the strip ;
- investigation of the optical characteristics of the object to be measured and of the process fluids situated within the trajectory of the beams ;
- collection and recording of the values measured ;
- transposition of the results to perform industrial-scale tests on a cold rolling mill.

The work will take three years and will be carried out at the Betriensforschungsinstitut at Düsseldorf (D).

#### P 235 - Development and testing of short load cells

This research work consists in studying and developing robust load cells of small dimensions, capable of resisting transversal stresses.

The prerequisites for designing such load cells are :

- the study, selection and testing of the conductor type ;
- choice of tests for the pressure transmitter ;

Annex 2

- development and testing of the pressure transmitter ;
- development and testing of the high-pressure piston gasket ;
- development of a penetration for electrical purposes for use under high pressure.

Experimental programme :

- development of gauges for test series (for loads up to a maximum of 50 to 2.500 tonnes) ;
- in-laboratory operational verification, and installation in a plant ;
- long-term in-plant static and dynamic test measurements ;
- establishment of fundamental and ancillary specifications and of optimization criteria.

Final development of wire load cells for loads of 50 to 2.500 tonnes. Development of a standardized series suitable for widespread use and marketing.

All of this work will be carried out at the Betriebsforschungs-institut in Düsseldorf - (D), over a period of two years.

P 237 - Collaborative studies on stress wave emission (acoustic emission) assessment

Inspection by means of acoustic emission is becoming increasingly widespread as a non-destructive method and diagnostic instrument, principally in the following fields :

- (a) inspection of nuclear installations, off-shore structures and pipelines
- (b) tests under load, inspection of pressure vessels
- (c) fabrication and inspection of welded structures to detect lamellar tearing, cracking and any other defects
- (d) fracture mechanics, deformation of materials.

The joint project of the Welding Institute and the Danish Welding Institute concerns the study of the phenomena involved in these

various applications :

- elimination of noise and interpretation of the signals recorded
- definition of situations in which acoustic emission can be adequately detected :
  - (a) during and after welding
  - (b) on test pieces under load
  - (c) during or after heat treatment
  - (d) in-service inspection
  - (e) study of attenuation
- comparison of the results with those of other methods such as ultrasonics and radiography.

The research will be carried out over two years in close collaboration by the Welding Institute in Cambridge (GB), and the Danish Welding Institute (DK)

P 248 - Automatic ND testing for the assessment of steel quality

This research project is in practice a continuation of the research programme carried out under ECSC agreement n° 6210.60/8/802, which yielded extremely positive and somewhat unprecedented results.

It is therefore proposed :

- (1) to make use of experience with ultrasonic inspection by means of an electromagnetic probe without contract, and to install a probe in a plant so that actual tests can be carried out ;
- (2) to determine the effect of the temperature of the bar under study on the signal amplitude ;
- (3) to construct an automatic ultrasonic inspection line, eliminating the effect of scale (hot internal and surface inspection) ;
- (4) to automate the identification of the defect discovered (software development) ;
- (5) to acquire a visual display unit for the computer output data.

The programme will be carried out at the Round Oak Steel Works Limited, Brierley Hill, West Midlands (GB), over a period of two years.

P 249/2 - Advancement of surface inspection instrumentation for cold-rolled steel strip

There is a growing demand for more precise measurement of the surface quality of cold-rolled steel strip at ever higher production speeds. The existing inspection equipment is unable to detect all defects.

The purpose of this proposal is to improve inspection instrumentation by further developing optical scanning and automated detection techniques.

It will also provide a technical description and performance specifications for equipment suitable for automatic inspection of material surfaces in an annealing installation or on an inspection line.

The programme covers the following points :

1. Study of the improvement of optical contrast
2. Signal delimitation and extraction
3. Derivation and measurement of parameters
4. Methods of recognizing potential defects
5. Definition data for the development of instrumentation

This research is expected to last two years. It will be conducted jointly by BSC in London (GB) by SIRA (Scientific Instruments Research Association) in London and by the City University of London.

P 264 - Use of acoustic emission techniques to investigate metallurgical phenomena

In basic research it has been found possible to relate acoustic emission phenomena to the dynamics of dislocations. However, the information contained in the signal remains semi-empirical despite the equipment used.

The project proposed jointly by Creusot-Loire and INSA is of particular interest as a number of applications of acoustic emission will be investigated.

The possible applications were selected on the basis of two main factors :

1. Acoustic emission due to different mechanisms in order to obtain a wide variety of "acoustic signatures".
2. Practical interest of the method either for future industrial applications or for measurements in a metallurgical laboratory.

The proposed programme, which is the first stage, is made up as follows :

- (a) Design and development of the high-frequency chain for signal acquisition and processing.
- (b) Study of the acoustic emission associated with the plastic deformation of steel.
- (c) Research on an industrial scale.
- (d) Observation of the development of cracks, use of measurements.
- (e) Definition of a plate as regards the risk of lamellar tearing.

This two-year programme will be carried out in cooperation by Creusot-Loire in Creusot (F), and the Institut National des Sciences Appliquées in Lyon (F).

P 273 - Electromagnetic-acoustic scanning applied to hot steel semis

The purpose of this research is to detect internal defects in semis such as blooms, billets, slabs for plate and beams at temperatures above 400° C by an electromagnetic-acoustic method.

The aim is to develop a contact less non-destructive testing method performing two essential functions :

1. Study and determination of the influence of temperature on an industrial probe.  
Construction of an efficient and economic probe.
2. Study of the role and effect of scale.  
Industrial tests on different products.

The ultimate aim is to develop an industrial unit that is as versatile as possible and can easily be installed in a steelworks.

The development work will be directed in particular towards the construction of a sensor for the scanning of products with parallel faces.

The expected results will help to improve steel products and will therefore be economically advantageous. The work will take three years and will be carried out at the Centre de Recherches Métallurgiques in Liège (B).

P 283 - Detection and location of defects in welds and in the parent metal of welded pipelines by means of acoustic emission

Welded pipelines for the carriage of inflammable liquids and gases are subject to strict quality control. The materials used must not exhibit any defects.

However, defects (slag inclusions, etch marks, porosity, pores, cracks, to name the principal ones) may appear during welding and must be detected.

The aim of the proposed work is to detect welding defects by acoustic emission.

Analysis of the acoustic signals must have the following aims :

1. Indication of the extent of the defects by acoustic emission - in particular, distinction between acceptable and unacceptable heterogeneities.
2. Discrimination between useful signals and noise.
3. Location of the defect.

The work will be carried out in two stages :

- (a) the first should make it possible to ascertain the prospects of success of the proposal method under given experimental conditions ;
- (b) the second will only be undertaken if the first is successful and will consist of actual measurements during hydraulic tests in the workshop (semi-industrial).

The work will take two years ; the experimental part will be carried out by the Institut für Zerstörungsfreie Prüfverfahren in Sarrbrücken (D), and the tests will be conducted in the Peine-Salzgitter steelworks of Hoesch and Mannesman.

P 285 - Continuous measurement of coating thickness on sheet

It is important to know the thickness of coatings of all types in order to avoid inadequate protection or the expense of excessive coating material.

The research project relates to non-magnetic coatings. The measurement method is an electromagnetic one.

The research is aimed at the development and the industrial adaptation of a device for continuous measurement of the coating thickness on sheet without impairing the surface of the coating inspected.

The work will comprise two phases :

- (a) The first will be carried out in the laboratories of the Centre de Recherches Métallurgiques at Liège, and concerns tests on stationary samples and on samples rotating on mandrels ;
- (b) The second stage will be carried out in S.A. Cockerill's works and involves the construction of a prototype apparatus suitable for installation on a finishing line.

This work is of interest to every manufacturer of coated sheet. The apparatus will enable efficient production control to be carried out and economies to be made the coating material.

This work will be carried out at the Centre de Recherches Métallurgiques at Liège (B) and in the works of S.A. Cockerill at Liège (B).

A period of two and a half years will be required.

P 286 - Application of optical telemetry to the inspection of hot-rolled sheet and beams

This research is the logical sequel to earlier work carried out with ECSC financial assistance.

- Agreement 6210-52/0/70 - Research C. 23
- Agreement 6210-60/0/70 - Research C. 40

This work contributed to the development of two methods of measurement by triangulation ; the first led to the construction of a thickness gauge, and the second relates to precise flatness measurements in wide-strip mills.

The research proposed thus consists in further development and, in particular, adaptation for industrial use of two optical gauges based on the method developed earlier.

No gauge is currently capable of measuring flatness defects simultaneously at several points on the strip. This is precisely the objective of this research work.

The economic impact can be twofold.

- Manufacture a better-quality product ;
- Possibility of being able to correct stand adjustment immediately and to reduce loss of tonnage.

The work will be carried out at the Centre de Recherches Métallurgiques at Liège (B) and at certain affiliated plants. The period required is estimated as two years.

P 327 - Industrial application of a hot ultrasonic testing process to the inspection of rimming steel slab shearing

This research project is really a follow-up to the IRSID-Hoogovens research undertaken under ECSC agreement GA 3/303-6/601 which gave very satisfactory results.

The aim is to complete the final stage in the development of hot ultrasonic inspection method for slabs using the IRSID technique. A prototype industrial installation will be constructed by Hoogovens. This will be operated for long enough to enable performances to be assessed, and the improvements to be made for a permanent industrial installation to be defined on the basis of experience.

At the same time the effect of rolling conditions on the performance of the ultrasonic method will be studied.

This two-year research project will be carried out by Hoogovens at IJmuiden (NL) with the cooperation of the Institut de la Sidérurgie Française in St Germain-en-Laye (F).

P 333 - Continuous measurement of dissolved oxygen in steel melts using EMF probes

The metallurgical reactions occurring during steelmaking from the refining and desulphurisation operations up to solidification depend on the presence of dissolved oxygen in the molten steel. Probes designed for the rapid measurement of dissolved oxygen by immersion in the steel have been developed and are in industrial use. A method for the continuous or long-time measurement of oxygen content, which has numerous advantages over quick measurements, has so far proved impossible to develop. This is the aim of the project, the programme being made up as follows :

1. Research into solid electrolytes suitable for long-time measurement
2. Production of solid samples
3. Study of reactions in mixtures
4. Study of comparative reactions between electrolytes and mixtures
5. Study of the effect of pouring speed or temperature gradient
6. Influence of electrolyte-molten metal reactions
7. Design and construction of a measuring head.

This research will be carried out in cooperation by the Max-Planck-Institut für Eisenforschung GmbH in Dusseldorf (D), and the Institut für Gesteinshüttenkunde of the Aachen Technical University (D). Work on the research project will be carried out at Thyssen Niederrhein.

The project will last three years.

P 337 - Non-destructive analysis of steel defects by means of small-angle cold neutron scattering

This concerns the purchase of an electromagnet required in order to continue and follow up the research work done under Agreement 6210.GA-4/401 (E 13/74). No provision was made for this equipment

Annex 2

in the initial project but in view of the very useful results obtained it has now proved essential for the continuation of the work.

The purchase will be made by FIAT's central laboratory in Turin (I).

P 345 - Inspection device for the detection of surface defects on cold strip with appropriate signal processing

A preliminary stage of the work was undertaken under Agreement 6210-60-1-101 (E 10/73). It consisted of seeking the simplest possible inexpensive method of detecting surface defects. The work was mainly done in the laboratory and the results were satisfactory.

The aim of this research project is to make use of the knowledge acquired to develop industrial equipment capable of detecting a maximum of surface defects in materials. Simple and inexpensive, the device must be able to discriminate between defects and analyse selected signals. This study will include a comparison phase in order to choose between :

- hard-wired signal processing
- signal processing by programmable computer

It is also planned to test several modes of transmitting signals to the production control pulpits and to the sorting station.

This research will be carried out by the Betriebsforschungsinstitut in Dusseldorf (D), over a three-year period.

VI - "UDED PROPERTIES" PROJECTS

a) Weldability

P 252 - An investigation of the properties of welds made under water

The progressive development of static underwater installations has created the necessity for permanent repairs to be made underwater.

Annex 2

This increased interest in underwater welding is reflected in a rapidly expanding literature on this topic.

In general the background is understood : the presence of water causes the weld to cool at rates considerably higher than those encountered on land and the dissociation of water in the arc atmosphere creates a high level of hydrogen in the weld zone. When both of these phenomena occur simultaneously, the risk of hydrogen-induced cracking is very high.

In detail however the problems are not well understood. A proposed investigation into the properties of welds made by the manual metal arc process under conditions of "wet" and "habitat" welding is given below.

1. Manual metal arc wet welding

Objective

To study the effect of a water environment and pressure on the properties of manual metal arc welds.

The important properties which could be affected by a water environment and which will be examined include :

- (1) The resistance to hydrogen cracking of the weld metal and HAZ.
- (2) The mechanical properties and fracture toughness of the weld and HAZ (Heat Affected Zone).
- (3) The resistance to stress corrosion cracking.
- (4) The fatigue life of welded joints.

2. Manual metal arc habitat welding

Objective

To study the effect of pressure and atmosphere composition on the composition, risk of hydrogen cracking, microstructure and mechanical properties, including fracture toughness and fatigue, of welds made with the MMA process.

The effect of the following factors on weld metal composition, weld hydrogen level, microstructure and mechanical properties will be examined for the pressure range 1 to 20 bars.

Annex 2

- (1) Consumable type and composition and hydrogen potential.
- (2) Atmosphere composition (mixtures of argon, helium and oxygen gases).
- (3) Atmosphere humidity.
- (4) Welding technique and parameters.

This two-year programme will be carried out by the Welding Institute - Cambridge (GB).

P 255 - New techniques for joining steel

Welding by fusion has now virtually replaced all other methods of joining in the assembly of steel plate and sections. This dominant position of fusion welding is the result of its great convenience, simplicity and low cost of application. However, almost from the moment of its adoption into industry, fusion welding began to introduce a host of problems : cracking, fissuring, lamellar tearing, etc. The solutions to these problems impose further limitations on steelmaking and further complications in fabrication.

For the fabricator, the difficulties of satisfying the requirements of the various codes and inspection authorities have become even more onerous. For instance : joint preparation, preheating or postheating ; control over dryness and cleanliness of filler materials, etc.

It is not suggested that alternatives to conventional fusion welding will be as convenient, as simple or as economical ; the impression should not be given that looking for alternatives will be an easy task that could be quickly brought to fruition. Further, it would not be expected that the use of alternative would rapidly be adopted by industry. But, without a systematic investigation, it is most unlikely that further non-fusion welding processes besides those already in existence (friction, flash and pressure welding, and diffusion bonding) will be developed or indeed that their areas of application can be enlarged.

The following programme is designed to prospect the general conditions for solid-phase bonding and might at least point the way

Annex 2

towards new developments of surface phenomena with the aim of exploiting their potential for the deliberate joining of metallic surfaces on an engineering scale.

The first phase of the work will be largely occupied by the design and manufacture of equipment ; during this period, a comprehensive survey of the literature will be carried out, and visits will be made to other laboratories where work of a relevant nature is in progress.

1. Investigation of surface cleaning

- a. ion bombardment
- b. mechanical cleaning in a gettered gas
- c. chemical cleaning

2. Joining parameters

The vacuum system used for cleaning and treating the specimens will also allow them to be joined in situ under controlled temperatures pressures and rates of pressure application.

Given an adequate degree of surface cleanliness, there are, on the basis of existing knowledge, five agents which are likely to have a primary influence on the ease and extent of bonding that can be achieved. These are :

- a. surface quality
- b. pressure
- c. temperature
- d. time
- e. chemical agents,

but the last aspect cannot be considered on the present budget.

This two-year research project will be carried out by the Welding Institute, Cambridge (GB) with the assistance of the Institute für Schweißtechnische Fertigungsverfahren, Aachen (D) (Prof. Eichhorn) and the Laboratorium voor Weerstand van Materialen, Ghent (B) (Prof. Soete).

b) Corrosion

P 258 - Study of passivation phenomena on tinfoil and galvanized steel

This purpose of this research is to obtain a better knowledge of the oxide films that form on tinfoil and galvanized steel in order to clarify a number of uncertainties that still exist in the use of electrochemical techniques.

The research will aim to determine the thickness of the films, their transverse homogeneity with a resolution close to a micron, the evolution of concentrations and the valency of the element or elements present as a function of the thickness of the passivation film.

1. Tinfoil

A study will be made of oxide films formed :

- (a) by heat at temperatures between ambient and 200°C, the oxides formed in this way being termed "natural" ;
- (b) by an electrochemical process in a dichromate medium, these oxides being termed "artificial".

2. Galvanized steel

An effort will be made to define the natural oxide film found on the industrial product after galvanizing.

Laboratory tests will enable a study to be made of several passivation media likely to give a protective film having the required properties, in particular good compatibility with paints and good resistance to the formation of white rust.

This research will take three years and will be carried out by the Centre de Recherches Métallurgiques, Liège (B).

c) Formability

P 336 - Drawability of cold rolled sheet

For the reason mentioned earlier, the following three subjects have been adopted, after discussion with experts, as the guidelines

Annex 2

for a coordinated programme that will last 2 1/2 years :

- (a) influence of metal cleanness on formability and sccherability of sheet steels ;
- (b) study of the behaviour of cold rolled steel sheets when subjected to short annealing cycles ;
- (c) experimental and/or theoretical studies on the plasticity of anisotropic steel sheet.

After examination, it is proposed that the following research work be done :

1. P 336-A

Proposal P 260

Formability of hot-rolled sheet and strip.

This research will be carried out by the Centre de Recherches Métallurgiques in Liège - (B).

Proposal P 336 a

Influence of sulphide formation on the forming properties of hot- and cold-rolled sheet.

This study, for which the Verein Deutscher Eisenhüttenleute in Dusseldorf (D), is responsible will be carried out by August-Thyssen Hütte and Hoesch.

Proposal P 336 b

Work to complement the previous proposal to be carried out by Stahlwerke Peine at Salzgitter (D).

Proposal P 336 c

Influence of inclusions on formability, stampability and schearibility of sheet.

This will be carried out by the Centro Sperimentale Metallurgico in Rome (I).

2. P 336-B

Proposal P 336 d

Study of the properties of cold-rolled sheet as a function of reduction ratio and the changes in these properties during annealing operations.

This research will be carried out by the Institut de Recherches de la Sidérurgie in St Germain-en-Laye (F).

Proposal P 336 e

Metallurgical factors affecting the mechanical properties of rimming steels for stamping subjected to short annealing cycles.

This research will be carried out by the Centro Sperimentale Metallurgico in Rome (I).

Proposal P 336 f

Study of the effect of short annealing cycles on the deep drawing<sup>3</sup> properties of cold-rolled strip.

This research will be carried out by the Technische Universität in Clausthal (D).

3. P 336 C

Proposal P 336 g

The quantitative assessment of formability of low-carbon hot- and cold-rolled sheet steels through the yield loci and limiting dome height method.

The research, for which the Verein Deutscher Eisenhüttenleute in Dusseldorf (D) is responsible, will be carried out by the Stahlwerke Peine at Salzgitter (D).

Proposal P 336 h

Studies on the textures of cold-rolled sheet steels and their origin. This research will be carried out by Delft University (NL).

Proposal P 336 i

Study of the workhardening of low-carbon steel subjected to various strain states and its application to formability limits.

This will be carried out by the Centre de Recherches Métallurgiques in Liège (B).

d) Brittle fracture

P 270 - Safety conditions for welded structures using wide-plate tests

For some years detailed studies have been carried out on fracture mechanics with the aim of suggesting a rational basis for assessment to the organizations responsible for acceptance standards in connection with defects in welded structures.

The present state of the art permits a sufficiently strict procedure only when the yield points and thicknesses of the materials under investigation are suitable for the application of the theories of fracture mechanics in the elastic range. In other instances where the theory of fracture mechanics beyond the elastic limit has to be applied (in fact the majority of standard applications), it is the unfortunate case that research has not yet produced satisfactory conclusions. It is, therefore, necessary to improve current knowledge by further research on some essential points concerning the metallurgical and methodological aspects and practical applications as follows :

Work plan

(a) methodological aspects

- correlation in elementary structures, between COD in relation to defects and external loading conditions as a function of the type of defect and of thickness ;
- correlation, in terms of critical COD, between small test pieces and elementary structures.

(b) metallurgical aspects

- correlation, in elementary structures, between COD in relation to defects and external loading conditions

- as a function of the work-hardening characteristics of the material ;
- effect of stress-relieving treatment the critical dimensions of the defects.

(c) practical applications

- checking the correlation between samples of actual structural components and the theoretical models.

This study will take three years and will be carried out by the Centro Sperimentale Metallurgico in Rome (I).

P 287 - Studies on the fracture behaviour of pipelines

A study on the fracture behaviour of pipelines is near to completion and demonstrates the extent of basic and industrial knowledge which still has to be acquired on the processes of crack initiation, propagation and arrest. The technical aspect (safety of people and of structures and the economic aspect (cost of replacing the equipment and cost of the fluid energy sources carried) of this problem are both very important.

The following studies are proposed as an effective supplement to the work in hand :

A. Fracture behaviour of steels for gas pipelines

The previous programme was based on the evidence that the two main influencing factors were pipe diameter and working pressure. So far, bursting tests have been carried out on four 38" dia. pipes and on two 48" dia. pipes of X 60 and X 70 steel. In the tests, the circumferential pressure in the pipes was varied between 55 and 80 % of the creep stress. After analyzing the results obtained so far, the research team is of the opinion that the tests need to be supplemented by further tests on 48" dia pipes before valid conclusions can be drawn. It is therefore proposed to carry out, as a supplementary

Annex 2

programme, three further bursting tests on large 48" dia. pipes of X 70 steel, which will help to confirm or clarify the information obtained from the first programme.

Work plan

This test programme is designed to lead, with good prospects of success despite the small number of tests, to the specification of impact strength requirements for steels in order to prevent cracks.

The test conditions will, as far as possible, simulate the characteristic service conditions for gas pipelines. The experimental piping will, therefore, be embedded in earth. Further tests will be carried out in Britain, at ambient temperatures not below 0°C. The pressure agent will be the standard natural gas used in Britain. The test bed will consist of three pipe sections and, in addition, pressure vessels. Each pipe will be sufficiently instrumented to measure the speed of crack propagation as this is essential to the understanding of fracture behaviour. In addition, the rate of pressure drop will be recorded.

The study will last one year and will be carried out by the Verein Deutsche Eisenhüttenleute, Dusseldorf (D).

B. Fracture behaviour of gas transmission pipelines

Expertise and understanding has progressed since the programme was initially conceived and designed, and it is now generally considered that more information is required on the mechanics of the propagating crack.

The objectives are the following :

- a) an assessment of the influences of certain of the secondary pipeline parameters, viz diameter and thickness ;
- b) an assessment of any effects of significant microstructural features attributable to specific progress routes ;
- c) a deeper exploration into the mechanics of the complicated arrest/propagation processes.

The parameters to be investigated are the effects of pipe thickness and diameter. The parameters to be investigated are the effects of pipe thickness and diameter. The proposed tests, n° 2/1 and 2/2 should provide a fairly sensitive check on the general validity of such theories. These two tests will be done in Italy at the Sardinian Test Site.

It is still uncertain as to whether microstructure difference associated with different process routes will have any significant effects on propagation behaviour. Test n° 2/3 and 2/4 have been incorporated to examine this point.

In an attempt to further elucidate the mechanics of complicated arrest processes, and in particular the stress/deformation conditions in the crack tip region, another two tests, n° 2/5 and 2/6 will be selected. Proposals for test n° 2/6 give the option of a 48" or 36" diameter pipe. The final selection of pipe size, type and test parameters will be determined in relation to the results of the preceding tests.

The study will last one year and will be carried out by the British Steel Corporation, London (GB).

### C. Laboratory tests for the application of fracture mechanics to brittle behaviour in pipelines

In order to draw valid conclusions from the studies described above, a larger number of results are required to enable an effective statistical study can be made of the correlation with the full-scale tests.

Thus further measurements will be made in tests of the following types :

- Large plate test Battelle (wedge loaded)
- large plate test (compact tension or central notched)
- instrumented pendulum notch impact tests
- determination of yield strength (Hopkinson bar tests)
- instruments drop weight tests.

This extension of the studies in hand will last one year and will be carried out by the Metallinstituut TNO, Apeldoorn (NL).

VII - "PHYSICAL METALLURGY" PROJECTS

P 269 - Relationship between microstructure and mechanical properties in low-carbon acicular ferrite steels

The extensive work already carried out on the mechanical properties of micro-alloyed steels has demonstrated the dominant role played by the micro- and sub-structures developed during thermo-mechanical treatment. This background information, partly generated on the ECSC research programme, should now permit an extension of this work to optimize the properties of steels with acicular microstructures and to investigate the transferability of this knowledge from the experimental to the industrial scale.

This project will be concerned with low carbon Mn-Cr steels which are capable of developing fully acicular microstructures after natural or forced cooling. The particular compositions to be investigated will fall into the following three ranges :

- (1)  $C \leq 0.045 \%$ , Mn = 2 %, Cr = 1 to 3 %, Nb  $\leq 0.1 \%$
- (2) C = 0.06 to 1.0 %, Mn = 1.5 %, Nb  $\leq 0.1 \%$
- (3) C = 0.04 to 0.06 %, Mn = 2 %, Mo = 0.25 to 0.5 %, Nb  $\leq 0.1 \%$

These alloys will be prepared as experimental melts with selected compositions being produced within industry so that a direct comparison can be made of the influence of scale on resulting properties.

The experimental programme will commence with the thermomechanical treatment of the cast ingots and will be followed by :

- determination of the state of recrystallisation of austenite as a function of amount of deformation, temperature and time
- study of the hardenability as a function of polygonal austenite grain size
- characterization of the final microstructure after different heat and thermomechanical treatments in the austenitic condition
- study of the origin and development of directionality of mechanical properties in the hot-rolled condition.

Annex 2

The work will be carried out by the Centro Sperimentale Metallurgico, Rome, and is expected to take 2 1/2 years.

P 317 - Formation conditions and properties of oxide films on non-grain oriented electrical strip and their effects on material quality

The production of electrical sheet in the Member States of the Community of Six as originally constituted increased from 687 000 tonnes in 1969 to 895 000 tonnes in 1973. Furthermore, the shortage of energy together with rising prices will inevitably lead to an increasing demand for high-grade electrical strip with low hysteresis losses. This means that intense efforts must be made to improve quality. There are various ways of doing this since the magnetic properties of the end-product are brought about through the interaction between volume effects and surface effects in the production process. Whereas the volume effect is determined mainly on the basis of the alloy composition, it is the non-metallic protective layers formed during the final heat treatment which determine the surface effects through stresses and grain-growth inhibition.

The research proposed in this sector concentrates particularly on the effects of surface layers formed during the production process on non-oriented electrical sheet. The proposed research has the following objectives :

1. Clarification of the reaction kinetics during the formation of non-metallic phases on cold-rolled electrical strip, using a thermal balance.
2. Clarification of the morphology with the aid of a scanning microscope ; recording of depth-versus- concentration profiles of chemical compositions by Auger electron analysis and determination of the level of oxidation of the elements contained in the layer structure as a function of the conditions which led to the formation of the non-metallic phases.

Annex 2

3. Correlation between the adhesive strength of the layer and the parameters defined in objectives 1 and 2.
4. Correlation between the magnetic properties and the parameters examined in objectives 1, 2 and 3.

The results of the proposed investigation will lead to better understanding of the processes involved in the formation of non-metallic phases on non-oriented electrical strip and their effects on the magnetic properties and the adhesive strength.

The research is to be carried out at the Stahlwerk Bochum AG in cooperation with the working party on surface physics and the Ruhruniversität Bochum and is expected to take three years.

P 354 - Metallographic Atlas

Since 1959, the ECSC has provided funds to support the preparation and publication of a series of volumes on metallography entitled "De Ferri Metallografia". The objective of this work has been to provide an exhaustive documentation of current knowledge in the following aspects of the subject :

- Vol. I Fundamentals of Metallography (published in 1966)
- Vol. II Structure of Steels (published in 1966)
- Vol. III Solidification and deformation of steels (published in 1967) and
- Vol. IV Metallographic techniques and the structure of welds.

The work on Volume IV is now complete but for the translation to make it available in three languages (English, French and German) as in the case of the three previous volumes. While the cost of translation was already envisaged in the contract covering the preparation of this volume, two important factors have created a need for a relatively small supplementary fund to complete the work :

- there has been an increase in costs since the project was originally proposed in 1970
- this volume is considerably larger than was originally anticipated being approximately twice the size of the previous volumes.

While the preparation of this volume has been executed on a collective programme involving the Max Planck Institut, Dusseldorf, the Institut de Soudure, Paris and the Centre de Recherches Métallurgiques, Liège, the final stage of the work will be co-ordinated by the Institut de Recherches de la Sidérurgie Française, Maizières-les-Metz. (F)

### VIII "UTILIZATION" PROJECTS

#### a) Light applications

##### P 149/b - Composite steel-concrete beams

The first part of this project has already been approved. The second part, covered by this proposal, is an essential complement to it.

The research comprises a series of static tests, over a range of loads, on composite beams in different configurations. These tests will supplement those carried out in the first part so as to obtain a series of homogeneous results.

The programme will be carried out by the Centro Italiano Sviluppo Impiego d'Acciaio in Milan (I), and the Centre de Recherches Scientifiques et Techniques de l'Industrie des Fabrications Métalliques (CRIF) in Liège (B). It will take two years.

##### P 259 - Determination of the fire rating of hollow concrete-filled sections

Several studies have been carried out, or are in progress, on the fire resistance of steel frameworks, covering both vertical and horizontal load-bearing members.

In the range of steel products used for building, there is a type of section that could offer a new solution to the problem of the fire resistance of vertical load-bearing members : this is

the hollow type. Because of their special form, hollow sections are particularly suited to take an internal filling, giving the column better fire resistance. This filling may be water for flooded structures or concrete for composite steel-concrete beams.

The planned research project is limited to hollow columns or sections filled with concrete.

The research is expected to take two years and will be carried out by Cométude in Paris (F).

P 299 - Multipurpose cast steel joint for steel structures

Very great technological progress has been made in recent years in many industrial sectors in the way of rationalizing work and improving productivity. In the construction sector, on the other hand, there has merely been an improvement in site equipment while retaining traditional building techniques.

This is one of the reasons why steel is losing ground in this sector.

This project will help to reduce construction costs for steel structures by supplying users with a range of joints in cast steel that will facilitate erection and can be produced at low cost.

The project will last two years and will be carried out by the Centro Italiano Sviluppo Impieghi Acciaio in Milan (I).

P 350 - Manual on the durability of steel structures in relation to atmospheric corrosion

The main obstacle to the use of steel for construction purposes is its liability to corrosion. This drawback aggravated by an ignorance on the part of all but the experts, of the mechanisms of atmospheric corrosion (type, intensity) and of the various methods of protection against it.

This proposal aims to present in a form accessible to all users practical knowledge of the phenomena of atmospheric corrosion

and the best methods of protection.

It will be distributed as widely as possible to architects, design offices, builders, public authorities and technical colleges.

The manual will be edited and published by the following Steel Information Centres : Stichting Staalcentrum Nederland in Amsterdam (NL), Centre Belgo-luxembourgeois d'Information de l'Acier in Brussels (B), ARBED in Luxembourg, Beratungsstelle für Stahlverwendung in Dusseldorf (D), Office Technique pour l'Utilisation de l'Oeuvre in Neuilly-sur-Seine (F), Centro Italiano Sviluppo Impieghi Acciaio in Milan (I) and Constrado in Croydon (GB).

The work will take two years.

b) Heavy application

P 288/2 : Measurements and interpretation of dynamic loads on bridges

The calculations made in preparing the loading and fatigue design rules are conservative, that is, the design will be an underestimate of the service life. However there is little experimental evidence to support this conclusion, nor have the analytical methods made full use of the data now available. The consequences appear to be that, in comparison with concrete, steel bridges are penalized economically without achieving complete safety from fatigue because of this philosophy. It is intended that the outcome of this project should be to redress the balance so that safer and more economical steel structures can be designed, particularly in the range of intermediate span lengths where steel and concrete are in close competition.

The literature will be reviewed to ensure that past experience is taken into account. Selected bridges will be studied, over a period of two years. They will be chosen to represent types commonly constructed in steel and will be on heavily trafficked routes.

When the literature survey, experimental and analytical programmes have been completed, the results will be analysed and compared with the data from other research done in other countries of the Community, to be related to design of steel highway bridges.

This two-year project will be carried out by the Road Research Laboratory in Crowthorne, (GB).

P 321 - Optimization of the alternating stress of drive systems

Like all machines, drive systems for steelworks plant are subject to a very considerable amount of dynamic (alternating) stress, the size and characteristics of which have a crucial effect on the service life of the components. Up to now, allowance has normally been made for these dynamic stresses by means of overall "shock factors" to be interpreted in the light of safety considerations. This method is already obsolete in other sectors of technology and now no longer meets the requirements of the iron and steel industry as within the same plant it can lead to both over- and under-dimensioning.

So far no satisfactory solution has been found for the design of dynamically stressed components. Amongst other things, characteristic stress-time functions for structural components or plant are not sufficiently well known ; in particular, there are no practical methods for the systematic reduction of stresses in drive chains so as to lengthen the service life of components.

In this research project it is planned, on the basis of the principles already evolved and with the use of existing software, systematically to reconstruct and optimize the stress phenomena occurring in drive systems for steelworks machinery.

The research will be carried out on selected categories of drives. Systems of particular importance from the economic aspect and having a high failure frequency will be chosen.

A further criterion for the choice of drives is the need to be able to apply the results as widely as possible. For example : roll drives, crane drives, converter drives, drives for finishing shops. The research will be divided into a theoretical and a practical part. In the theoretical part in order to simulate vibration behaviour, mechanical models will be constructed and functions determined for the technological input parameters ("input functions"). Various parameters denoting the load-time function calculated will be taken as a basis for optimization of the stressing process.

The practical part of the work will entail measurement of the load-time processes occurring in practical operation in order to verify the mechanical simulation systems and input functions.

This three-year research project will be carried out by the Betriebsforschungsinstitut of the Verein Deutscher Eisenhüttenleute in Dusseldorf (D).

P 324 - Improvement of calculation and design data for heavy engineering components liable to fatigue failure

The aim of the project is to establish by systematic research the principles and necessary data for the safe dimensioning of heavy engineering structural components.

In research agreement 6210-89/1/011 of 27 December 1973 between the ECSC and the VDEh, the ECSC agreed to support the project, originally planned to extend over two two-year periods, and granted aid for the first stage of the work. This work is practically completed and has already yielded vital data on load factors and material behaviour in the heavy engineering sector.

In order to achieve the aim of the project, i.e., the provision of design data for the major categories of heavy engineering components liable to fatigue failure (an aim already recognized by the ECSC as meriting aid) it is essential to determine the loading processes for at least one more type of plant and to ascertain fatigue data for a second material used for highly-stressed components. On the basis of these results, it will then be possible to verify damage hypotheses

sufficiently thoroughly, to establish design specifications for components of various types and to produce design data in a form suitable for use by designers. For this purpose, the following work must be carried out in the second stage of the research :

- (a) determination of characteristic load data for at least one more type of plant ;
- (b) determination of fatigue data for steel 42 Cr Mo 4 (those for steel Ck 45 were determined in the first stage) ;
- (c) verification of service life formulate in practical operation for additional welded components and continuation of the operating calculations started in the first stage ;
- (d) establishment of design specifications and preparation of design data in a form suitable for use by designers for all the materials and components investigated.

This research will take 2 1/2 years and will be carried out by the Betriebsforschungsinstitut of the Verein Deutscher Eisen-Hüttenleute in Dusseldorf (D).

P 362 - Fatigue and corrosion fatigue behaviour of offshore steel structures

The exploitation of offshore gas and oil fields constitutes large environmental hazards, due to danger to human life and due to the effects of an oil or gas spillage. The steadily increasing number of offshore structures in recent years and the recent movement of offshore structures to deeper and rougher areas (low air and sea temperature, high windage and severe marine conditions) than have been exploited so far have increased substantially the probability of failure. The risk of failure of offshore structures should be kept to a minimum, in particular in these newly exploited areas, because they are usually surrounded by countries with a high population density.

The large amount of steel being used in the offshore structures and the special problems associated with the use of thick plate steels in these structures justify further research work.

The design of such offshore structures must be such that there is a margin of safety against failure in one or a combination of the following failure modes :

- Brittle Fracture

The marine conditions (in particular low air and sea temperature) increase the probability of brittle fracture.

- Corrosive Attack

Corrosive attack (e.g., pitting, stress corrosion) may be considered of great importance to the reliability of offshore structures especially in combination with such factors as fatigue loading.

- Fatigue Cracking

The marine environment (seawater) has a detrimental effect on the fatigue behaviour (fatigue strength) of steels. Since offshore structures are mostly subjected to fatigue loading and corrosion simultaneously, not only the normal fatigue cracking but also corrosion fatigue is of interest. Corrosion fatigue cracking is probably the most important failure mode relevant to offshore structures.

- Overloading by Static or Dynamic Loads

The recently exploited offshore areas require very large structures with correspondingly thicker plate steels and sometimes the use of quenched and tempered low-alloy high yield strength steels.

The thick plate steels require more tightly controlled welding procedures in order to achieve adequate fracture toughness properties and in order to reduce the increased risk of introducing defects on welding (e.g., lamellar tearing, hydrogen cracking, solidification cracking).

A research programme is proposed that will extend the current knowledge about the (corrosion) fatigue behaviour of critical members (e.g., joints) in offshore structures.

The research programme proposed should make it possible to assess better than has been possible so far, the potential fatigue life of critical members (e.g., joints-tubular joints) in offshore steel structures.

Ultimately it should lead to the construction of rules (guidelines) for the design of offshore structures. The contributions in the research programme from the various participating countries, France, Germany, the Netherlands and the United Kingdom have been set up in line with the UK Offshore Steels Research Project.

The research programme is :

(a) UK Offshore Steels Research Project

The various proposals have been developed taking account of research proposed in the UK Offshore Steels Research Project. Generally the influence of the various parameters will be assessed separately. However, if synergistic effects are to be expected, combined effects will also be investigated.

Test data will be obtained mainly from two types of tests :

- endurance tests (S - N curves)
- crack propagation tests.

The programme will provide information as to the validity of Miners' Law for the assessment of cumulative damage ; in addition, it will yield the underlying data for the application of a fracture mechanics approach to offshore structures.

(b) BSC/Harwell project

The primary objective is to study the mechanism of corrosion fatigue of steels in a marine environment.

The main factors that will be considered in this research are :

- effect of material (mechanical strength properties, composition, microstructure)
- effect of loading (frequency, wave shape, hold time, R-ratio)
- effect of environment (temperature, pH, dissolved gases).

(c) IRSID project

The primary objective is to study the effect of loading conditions (uniaxial loading versus biaxial loading) on fatigue crack growth. Other factors that will be considered in this research are :

Annex 2

- (a) effect of **microstructure** (in welded joints)
- (b) effect of loading spectrum
- (c) effect of plate steel thickness (in particular with respect to welded joints).

(d) VDEh\_projects

The primary objective is to compare the (corrosion) fatigue behaviour of several types of steels having different mechanical strength properties, viz :

- (a) normalized steels (e.g., steels according to Euronorm Fe 355)
- (b) low pearlite steel
- (c) quenched and tempered steel.

The work will be concentrated on welded joints. Other factors that will be considered in this research are :

- effect of plate steel thickness
- effect of cathodic protection (danger of overprotection).

(e) SMOZ\_project

The primary objective is to study the effect of some welding parameters and of the loading spectrum on the (corrosion) fatigue behaviour of joints. The welding parameters that will be considered in this research are :

- (a) effect of welding method
- (b) effect of weld metal composition
- (c) effect of weld geometry
- (d) effect of welding sequence (stress relieving, cathodic protection - overprotection)
- (e) effect of surface quality conditions.

The load spectra to be utilized are :

- . constant amplitude loading
- . random loading
- . programmed loading.

This three-year research programme will be carried out by the following bodies inclose cooperation :

- P 362 a = Department of Energy in London (GB)
- P 362 b = British Steel Corporation Swinden Laboratories in Rotherham (GB) and Harwell Corrosion Service at AERE Harwell, (GB)
- P 362 c = Institut de Recherches de la Sidérurgie Française in St Germain en Laye (F)
- P 362 d = Verein Deutscher Eisenhüttenleute in Dusseldorf (D)
- P 362 e = Stichting Material Onderzoek in Zee in Delft (NL)

#### IX - "MISCELLANEOUS" PROJECTS

##### P 355 - Use of LD slags in road construction

Blast-furnace slags have been in use for a long time, mainly in road construction, and no longer present the steel industry with any significant storage problems.

LD steel plant slags, on the other hand, are relatively little used and their storage presents a problem which will grow over the years. The reason for this is the poor volume stability of these slags (due to their free lime content). Hence it has now become a matter of urgency to find major outlets for the LD slag, and at present the only potential customer is the road-building industry.

Accordingly, this project is submitted with the aim of upgrading LD slag. The programme will involve research on the composition of the slags, studies on methods of treating the slags to make them suitable for road construction and, lastly, tests on sections of road built with slags of various compositions (with special reference to the free lime content).

The research, which will extend over three years, will be carried out jointly by the British Steel Corporation in London (GB), the Forschungsgemeinschaft für Eisenhüttenenschlacken in Duisburg (D), the Commission Technique et de Promotion des Laitiers in Paris (F) and the Centre de Recherches Métallurgiques in Liège (B).