

COMMISSION OF THE EUROPEAN COMMUNITIES

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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

(submitted to the Council by the Commission)

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COM 89

M E M O R A N D U M

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I - I N T R O D U C T I O N

This memorandum consists of 61 projects that will form the second part of the ECSC programme of research and development on iron and steel for 1983 for which aid under Article 55, 2(c) of the ECSC Treaty is requested; the first part of the programme consists of 11 projects which are described in memorandum number COM (82) 819f.

After a detailed examination of a total of 200 proposals by the services of the Commission in collaboration with the Iron and Steel Technical Research Committee, these 61 projects along with the 11 contained in the first part of the programme have been selected as first priority for financial support in 1983.

In the evaluation of the proposals, priority has been given to those that correspond most closely to the criteria outlined on the medium term orientation for steel research (1981-1985)(*) and which have the following overall objectives;

- to improve industrial competitiveness by reducing production costs and improving the product and
- to promote steel as an engineering and structural material through studies of the service properties and utilisation of steel.

The technical scope of the total proposed programme of 72 projects covers various aspects of iron and steelmaking technology with the level of funding distributed as follows:

(*) Official Journal C99, Vol. 24, 2 May 1981

ironmaking (13,5%), steelmaking (17,2%), rolling mills and mechanical working (12,2%) measurements and analysis (13,1%), properties and service performance of steel (40,7%) and miscellaneous (3,3%).

In the production and processing sector of the programme, advances in blast furnace technology will be sought aimed at improved furnace operation and at reduced energy costs through substitution. This latter aspect concerns the replacement of oil by pulverized coal in the development of new injection techniques. In continuous casting, now an established means of achieving important energy economies compared with the traditional ingot casting practice, the main preoccupations of the research are to improve the surface and internal quality of cast products and to advance the control and operating performance of casting machines. A major part of this work will be concerned with obtaining a better understanding of the complex phenomena associated with segregation during casting so that the properties of the product may be enhanced. The significance of research in this area is evident from the fact that the continuous casting production potential in the Community has now reached some 80 million tonnes/year and this is envisaged to rise to 90 million tonnes/year by 1985.

The research on rolling mills reflected the growing interest in the development of high strength low alloy steels and the optimisation of steel properties by the adoption of controlled rolling and strip cooling techniques. Furthermore, in the manufacture of steel strip for such applications as automobile construction, ways will be explored to control better shape (flatness) and profile throughout mill processing. Studies of flat rolled products are also proposed in the measurements sector where prototype equipment to assess surface quality will be developed using ultrasonic techniques.

The support proposed for research on the properties and service performance of steels exceeds, for the first time, 40% of the programme's annual budget. The emphasis being given to work in this area indicates the growing importance attached to steel product development and the need to meet the increasingly severe property requirements from the user industries as well as the competition from alternative materials. The technical areas covered range from weldability and formability of sheet steel to special and constructional steels with the corrosion and fracture properties of steels for marine applications receiving particular attention.

In marine corrosion, a second collective programme will be carried out involving five different laboratories in which the role of selected alloying additions in steel will be better defined. The ultimate objective is to develop steel grades possessing enhanced corrosion resistance for such

applications as offshore structures and underwater pipelines. Other projects will deal with corrosion problems encountered in service by sheet and tube products.

In the promotion of steels for gas transmission pipelines, which represents an important market for the industry, the requirement for safety and reliability has focused much attention on the factors governing fracture. While significant progress has been made already with ECSC support in relating steel properties to fracture characteristics, the current interest in raising operating pressures in pipelines has indicated the need for additional costly full-scale testing. Studies of fracture in submerged offshore pipeline steels are also proposed.

The appropriations in the ECSC operational budget for 1983 for financing this steel research programme have been set at 14 M.ECU. This amount is intended for the financing of:

- 55 research projects listed in the summary table attached to the document, except the 6 projects P.1382, P.1387, P.1411, P.1413, P.1364 and P. 1367 and totalling 13.828.950 ECU.
- ancillary expenses and the cost of disseminating information totalling 171.050 ECU.

The six remaining projects totalling 1.306.600 ECU, constitute a reserve to be financed as when additional resources become available.

II. THE RESEARCH PROJECTS

II.1 ORE REDUCTION

II.1.1. Sinter

The aim of project P1307 is to establish association criteria for sinter mixtures on the basis of the inherent properties of the ores.

P1307 Rational composition of sinter mixtures

The main work will consist of laboratory and grade experiments, notably to determine:

- mineralogical composition
- texture
- type of crystallization
- softening and fusion behaviour

- tendency to form micropellets.

The mineralogical structure of the ores and additives will be ascertained by means of an automatic image analyser. The project will be carried out in two stages.

Applicant: CRM - Liège
Budget: 467 000 ECU
Probable duration: 3 years.

II.1.2. Blast furnace

Research project P1317 is designed to apply new findings concerning the upper part of the furnace and the cohesive zone to processes in the lower part of the furnace and at the same time to investigate physical and chemical processes in that area.

Project P1399 will study pulverized coal injection into a large blast furnace so as to determine the optimum injection rate.

P1317 Chemical and physical processes in the fusion zone and their effect on energy consumption and heat loss

The following experiments are planned:

- a) laboratory experiments to determine activities (CaO, SiO₂, FeO etc..), and experiments on the molten pig iron and slag flow
- b) In-service experiments to determine the flow rates of pig iron and slag and the tapping sequences. In addition the slag composition will be monitored as will the heat flow on the bottom and the thickness reduction of the carbon bricks.

Applicant: Thyssen -Duisburg
Amount: 1 738 500 ECU
Probable duration: 3 years.

P1399 Powdered coal injection in a large blast furnace

The following will be investigated:

- the coke replacement ratio up to 100 kg coal/tonne pig
- throat and bosh gases
- blast furnace productivity.

Blast furnace operation will also be adapted to the modified process. The research is being carried out in cooperation with Italsider, Taranto.

Applicant: CSM-Roma
Budget: 601 000 ECU
Probable duration: 3 years.

II.2 STEELMAKING

II.2.1 Casting_and_solidification

All nine projects relate to continuous casting. The first three deal with the solidifying shell. In project P1321 the shell thickness is to be measured automatically, first on billets and later on slabs. In projects P1323 and 1382 the mechanical properties of the shell will be determined experimentally.

In projects P1372 and 1381 the mechanical and thermal behaviour of a number of pairs of rolls will be investigated, together with their influence on the occurrence of internal defects in slabs.

The purpose of project 1322 is to improve surface quality of continuously cast special steels.

Project P1431 plans automatic monitoring of operating parameters and the machine state with a view to improved and more uniform product quality.

Project P1430 aims to improve the control model for continuous casting, incorporating bulging and incorrect adjustment and eccentricity of the rolls.

Under project P1429 an attempt will be made to refine the structure of ingots and continuously cast products by the application of vibrational energy.

P1321 Determination of shell thickness in continuous casting to improve process control

The aim is the further development for industrial use of the instrument for measuring shell thickness designed under Agreement 7210-CA/126.

The first industrial tests will be on billets. Then the measuring pick-ups will be further developed for slabs. An effort will be made to automate the measuring instrument for continuous operation.

Applicant: BFI-Düsseldorf
Budget: 681 500 ECU
Probable duration: 3 years.

P1323 Measurement of high-temperature properties of the shell immediately after solidification

To avoid external and internal cracks in the shell when it is withdrawn, the material properties have to be determined at very high temperatures.

1. A tensile testing machine is to be constructed to test steel immediately below its solidification temperature. Models will be used to transfer the results to the stressing of the casting shell. The preliminary experiments will be carried out on copper.
2. Systematic research on steels.
3. Building of a rheological model covering the mould and secondary cooling zone. Temperature stresses, bulges and deformations will be covered by this model.

Applicant: Krupp-Essen
Budget: 383 000 ECU
Probable duration: 2 years.

P1382 Solidification brittleness of carbon steels

The reasons for steels brittleness in the vicinity of the solidus temperature will be investigated. In particular fracture mechanisms will be studied.

1. Study of C-Mn-Si steels
2. Study of carbon steels from 0.05 to 0.8% C
3. Investigation of the role of the elements S, P and B.

The research will consist mainly of testing tensile test pieces on a gleeble machine and also bend test pieces.

Applicant: IRSID - St-Germain-en-Laye
Budget: 354 000 ECU
Probable duration: 3 years.

P1372 Research on the supporting of continuously cast slabs

Paris of rolls under stress are to be investigated at the critical points of an industrial continuous slab casting machine at Cockerill-Sambre. The research will be carried out on water-cooled rolls.

The programme covers various steels, various casting speeds and various slab widths. Hot and cold tests will be compared. The results will be used for computerized process control.

Applicant: CRM-Liège
Budget: 259 500 ECU
Probable duration: 3 years.

P1381 Mechanical behaviour of the slab in the cooling zone of a continuous casting machine

The research will correlate the internal defects in slabs and the deformation produced by the machine.

Five pairs of rolls in an industrial slab casting machine (Dunkirk) will be instrumented to measure forces. The mechanical and thermal behaviour of the slabs along this measuring section will be monitored simultaneously. The process will be described in a mathematical model. There are also plans to determine the quality of the slabs as regards internal defects and segregation.

The research results will be used to prepare criteria for the control of the continuous casting machine.

Applicant: IRSID - St Germain-en-Laye
Budget: 526 500 ECU
Probable duration: 4 years.

P1322 Relationship between surface quality and casting powder used in the continuous casting of blooms

The research parameters are as follows:

1. Different casting powders.
2. Different steel grade (extra-mild steels containing less than 0.1% carbon, case hardening steels, heat treatment steels, silicon spring steels, cable steels, bearing and tool steels).
3. Different strand dimensions (150 x 150; 240 x 240; 240 x 320 mm²).
4. Different casting speeds.

In the experiments the friction between strand and mould and the surface quality will be determined.

Applicant: Arbed Saarstahl- Völklingen
Budget: 485 000 ECU
Probable duration: 3 years.

P1431 Continuous casting plant engineering control

The operating parameters and machine state of a continuous casting plant will be automatically monitored with a view to improving product quality. The following research is

planned:

Design of a monitoring system for the mould, secondary cooling zone, back-up roll systems and withdrawing and straightening roll systems.

The systems will be tested on industrial scale on the slab casting machines in Lackenby and Scunthorpe.

Applicant: BSC-London
Budget: 345 000 ECU
Probable duration: 2 years.

P1430 Strand deformation in continuous casting

It is planned to adapt an existing control model for a continuous slab casting machine. Using the finite element method, a three-dimensional model will be built for the strand. The creep properties of the steel up to the solidus will be used as a basis. The following will be included in the model:

- the effect of a roll adjustment fault
- the eccentricity of the rolls.

The necessary creep data up to 1450°C will be obtained in laboratory research.

Applicant: BSC-London
Budget: 249 500 ECU
Probable duration: 2 years.

P1429 Structural refinement by vibrational energy

Vibrational energy will be applied either directly in the residual liquid pool (ingots) or through the solidifying skin (continuously cast products) in order to refine the structure. The research will be carried out on 0.05 and 4 tonne ingots and on continuously cast products. Immersion probes operating in the 5-100 Hz frequency range will be used. The experimental parameters are time and steel composition. The frequency range up to 16 Hz will be investigated during experiments on the continuous casting machine.

Applicant: BSC-London
Budget: 287 000 ECU
Probable duration: 2 years.

II.2.2. Steelworks: metallurgy

Project P1324 is designed to investigate the physical laws governing pouring processes in various steel plant.

P1324 Preventing slag from running out of converters with the steel

Theoretical research, model experiments and in-service experiments are planned. The aims are to improve quality, to save raw materials by avoiding degradation and to improve productivity and industrial safety.

The following work is planned:

1. Theoretical studies on turbulence and eddying
2. Model experiments for converters ladles and continuous casting tundishes
3. In-service experiments with the same plant.

The research is being done as part of a joint programme in which Clausthal Technical University, the BFI and Hoesch and Krupp are participating.

Applicant: VDEh-Düsseldorf
Budget: 939 500 ECU
Probable duration: 3 1/2 years.

II.2.3. Steelworks: technology

The purpose of Project P1325 is to determine how electrode consumption in electric arc furnaces is affected by design features, operating practice and electrode properties.

P 1325 Monitoring of electrode quality and reduction in electrode consumption in arc furnaces

The following work is planned:

1. Determination of electrode properties in the laboratory and in service
2. Determination of electrode consumption in service
3. Determination of furnace operating practice
4. Determination of furnace design features
5. Determination of electrode consumption statistics.

Applicant: BFI-Düsseldorf
Budget: 666 500 ECU
Probable duration: 4 years.

II.3 MECHANICAL WORKING

II.3.1 Rolling mills - bars and sections

The aim of Project P1286 is to prevent deformation in the cooling of heavy sections. This will economize on expensive straightening operations. P1387 concerns the automation of an industrial beam mill so as to optimize the rolling process in respect of product tolerances and energy consumption. P1405 deals with the thermomechanical finishing of stainless steel wire rod.

P1286 Selective cooling of sections

The occurrence of deformations is to be prevented by selective cooling. The experiments will be carried out in the large beam mill in Esch-Belval on angles and channels up to 120 kg/m. The parts of greatest mass will be cooled faster than those of lesser mass by water, water/air mixture or air.

It is also planned to investigate the mechanical properties. The CRM in Liège will also cooperate in the research.

Applicant: Arbed-Luxembourg
Budget: 301 000 ECU
Probable duration: 3 years.

P1387 Automation of a universal beam mill

The walking beam furnace, roughing mill, intermediate stand, universal stand and finishing stand are to be automated.

1. Theoretical part: in this phase an existing physical-mathematical model will be adapted to the requirements of automation in real time.
2. Experimental part: here the control algorithms will be used in service (Usinor Valenciennes).

Applicant: IRSID - St Germain-en-Laye
Budget: 540 500 ECU
Probable duration: 4 years.

P1405 Use of residual rolling heat for heat treatment of stainless steel wire rods

The aim is to attain the desired mechanical properties directly from rolling heat, thus eliminating the need for subsequent heat treatment. The research will be carried out on stainless austenitic steels A S 304, 316, 309 and 321 and on ferritic steels A S 430 and 446. Cooling cycles will be simulated. In addition the straining process will be analysed and the material characterized in respect of recrystallization behaviour.

Applicant: CSM-Roma
Budget: 243 500 ECU
Probable duration: 2 years.

II.3.2. Rolling Mills - flat products

Project P1309 is designed to improve plate properties by control of the cooling process and hence of the transformation conditions. The aim is to achieve a fine-gained ferrite by reducing the allotropic transformation temperature.

P1309 Automatic monitoring of sheet microstructure

The following research is planned:

1. Building of a mathematical model (determination of characteristic rolling parameters, the role of the austenite grain, rolling temperatures)
2. Correlation between transformation temperature and mechanical properties
3. Analysis of the thermal behaviour of the plant
4. Construction of the industrial control model
5. Off-line and eventually on-line testing.

Applicant: CRM-Liège
Budget: 418 000 ECU
Probable duration: 3 years.

II.3.3. Cold rolling mills

Project P1389 concerns a new development in rolling, known as asynchronous rolling.

In P1466 the effect of hot strip cooling on shape and profile changes will be investigated. In a second stage

the influence of bell and continuous annealing on shape and profile changes will also be studied.

P1389 Asynchronous rolling

The following work is planned:

1. Building of a model for asynchronous rolling
2. Investigation of metal/roll friction with and without lubrication
3. Study of the influence of roll force, torque and slip on tension change. Study of the influence of asynchronous rolling on rolling stands
4. Test rolling (at first with plasticine).

Applicant: IRSID-St Germain-en-Laye
Budget: 230 000 ECU
Probable duration: 2 1/2 years.

P1466 Form and profile in sheet mills

The following research is planned:

1. Construction of a mobile shape and profile measuring device for hot and cold strip
2. Measurement of hot strip before coiling by laser beams
3. Development of a mathematical model to describe stress and elongation during cooling
4. Measurement of shape and profile after cold rolling and after annealing
5. Building of a mathematical model to describe stress and elongation during annealing.

Application: Hoogovens-Ijmuiden
Budget: 544 500 ECU
Probable duration: 3 years.

II.3.4 Rolling mills - Various

Project P1335 will investigate the influences of tension rollers on strip properties. The aim of project P1437 is to measure the roll profile in hot wide strip mills. Wear at the edges is to be compensated by selective cooling of the rolls to allow a larger throughput of the same width dimension.

P1335 Strip deformation in tensioning rollers

The research will be carried out on an experimental installation. The diameter, arrangement and number of the tensioning rollers and the angle of grip will be varied. The experimental set-up will be on an industrial scale.

Applicant: BFI-Düsseldorf
Budget: 835 000 ECU
Probable duration: 4 years.

P1437 Work roll profile

The aim is to measure roll wear directly in the wide strip mill. The following work is planned:

1. Laboratory work to develop the measuring system
2. Installation of the profile measuring device on the finishing stand of a wide strip mill
3. Collection and evaluation of measurement data during operation.

Applicant: BSC-London
Budget: 226 500 ECU
Probable duration: 2 years.

II.4 MEASUREMENTS AND ANALYSIS

For reasons of quality, safety and economy, enormous importance is attached to projects concerning measurements and analysis for steel in general, whether hot or cold, both during the steelmaking process and the stage of semi-finished and finished products and assemblies. The main concern in the proposed research is to optimize methods associated with the development of sophisticated computerized or robotized techniques.

P1339 Ultrasonic surface inspection of heavy plate

In fabricating and using heavy plate, it is necessary to comply with stringent requirements concerning the absence of structural or surface defects.

The IZfP will construct a prototype inspection instrument using contactless ultrasonic techniques (electromagnetic waves propagating along the surface). The aim is to optimize detection capacity so as to detect cracks a few millimetres in length and about 0.1 mm wide. This method should greatly improve inspection speed and objectivity. It will be possible to store the results automatically. The parameters for

distinguishing between acceptable and unacceptable defects will be processed for direct application.

Applicant: Fraunhofer Institut Für Zerstörungsfreie
Prüfverfahren - Saarbrücken

Budget: 519 000 ECU

Probable duration: 3 years.

P1343 Determination of the metal-alloyed aluminium content
and other oxygen-sensitive elements

Because of its high oxygen affinity, aluminium is continuously subject to oxidizing loss which varies according to different parameters and is due to atmospheric oxygen, slag and ladle linings (secondary effect) and to parasitic oxygen in the ingot mould (tertiary effect).

Consequently precise data on the aluminium content in the ladle immediately after deoxidation and on operating conditions are essential in order to adjust the aluminium content in the finished product. The aim is to design and develop a method for rapid determination of soluble and non-soluble aluminium in molten steel, and to construct a system for sampling in the bath. The tests and experiments will be carried out on an industrial site in a continuous casting machine.

Applicant: Dillinger Hüttenwerke-Dillingen

Budget: 99 000 ECU

Probable duration: 3 years.

P1375 Continuous measurements of the particle sizing of
blast furnace burden materials

Obviously the particle sizing of materials used in plants such as coke ovens or sinter lines and in blast furnaces is very important as it affects the density, permeability and reactivity of the materials.

This project aims to develop a measurement system which, by continuously measuring particle sizing, can ascertain the average distribution of the materials concerned. The research will use a combination of optical systems (television camera and photodetectors). The product will be observed during its fall as it leaves the sampling device, by means of an optical system consisting of a light source, one or more photodetectors and a TV camera. A spectral analysis will then give a representation of the particle size distribution of the product. Depending on results, it is planned to design apparatus which could be useful to the whole industry.

Applicant: IRSID-St-Germain-en-Laye
Budget: 443 000 ECU
Probable duration: 2 years.

P1406 Robotization of cold spot-scarfing for continuously-cast slabs

This is a confirmation of the research done under ECSC agreements 7210.GA/409 (Italsider - CSM). The results will be applied to the development of a method and apparatus for the detection and location of surface defects on slabs using eddy currents.

The aim is to study, design and construct a spot-scarfing robot controlled by this automatic detection system. It will be an industrial prototype tested on site and coupled to a computerized data acquisition system.

Applicant: Italsider-Genova
Budget: 455 500 ECU
Probable duration: 1 1/2 years.

II.5 SERVICE PROPERTIES AND PERFORMANCE

II.5.1. Weldability

There are two main requirements for welding: speed at low cost, while ensuring that the welds produced meet the mechanical strength and safety requirements. These two themes feature in the proposals submitted.

P1299 Improved productivity through metal powder additions to submerged arc welds

The use of metal powders in submerged arc welding of steel to increase metal deposition rates without increasing the energy input is attracting increasing interest as a means of reducing steel fabrication costs. The principle of the method is not new. Metal powders are added to the weld usually either by pouring metal powder into the weld preparation ahead of the weld pool, or by delivery of the powder directly into the weld pool. The aim of the method is based on a better exploitation of the energy of the arc by using the excess heat of the weld pool to melt the powder. Increases in metal deposition rate of 60 - 70% have been reported, although such increases are strongly dependent on the joint preparation, and too much powder addition can produce defects such as lack of fusion. However, there is little quantitative data and the potential benefits of the metal powder addition approach need to be clarified. The objective of the proposed programme is to provide data which show how metal powder additions to submerged arc welds could be safely used to give increased

productivity and hence reduce costs for the Communities' fabrication industry. The following benefits to the European Communities are envisaged as a result of the proposed work:

1. A reduction in costs for fabricating steel structures.
2. As a consequence an increase in competitiveness of steel against other constructional materials.
3. As a consequence an increase in demand for steel.

Applicants: Welding Institute-Cambridge
Institut de Soudure-Paris

Budget: W.I. 164 500 ECU
I.S. 160 500 ECU

Probable duration: 2 years.

P1344 Welding of X8Ni9 steel with filler metal of the same type

This steel, used mainly in the storage and transport of liquefied gas at temperatures as low as -196°C , can at present be welded only with high-alloy, and therefore expensive, filler metal. Further drawbacks are the difficulty in inspecting the weld beads because of the metallographic structures involved and the appreciable difference in mechanical properties in the various zones of the weld.

These difficulties must be overcome if the Community fabricators are to remain competitive with their overseas rivals. The aim is to find a filler metal of the same type as the parent metal which will not only solve these technological difficulties but will also bring down costs. It is planned to make experimental melts of various alloys and to use them for manual submerged arc welding in an inert atmosphere.

Applicant: Thyssen-Duisburg

Budget: 381 000 ECU

Probable duration: 3 years.

UU.5.2. Corrosion and surface protection

Here the emphasis has shifted to studies enabling designers, manufacturers and users to put research results into practical application. Several basic research programmes that have defined methods and demonstrated the role of alloying elements will now be followed by a practical phase involving the production of new grades and research on their performance (resistance to marine corrosion and to corrosion in a hydrogen environment). The same trend is found in research on sheet, where there are plans to study surface protection, mainly with a view to the motor industry market.

P1282 Influence of residual elements on the intergranular stress corrosion cracking of carbon steels

In the programme started last year only one electrolyte (hot nitrate) is used. To cover the overall objective of the study it is necessary to define also the relative effects of the common impurities, P, S, Sn, Cu, and Ni, on the intergranular stress corrosion cracking of carbon-manganese steels in carbonate/hydrogen carbonate electrolytes through surface studies, electrochemical studies and mechanical tests. In Japan, very pure steels are produced, extremely low in phosphorus and other impurities. In this way, the deleterious effects of grain boundary segregants are avoided. However, it is not clear as yet which are the precise conditions and applications that involve strong effects of impurities on the susceptibility of unalloyed steels to intergranular stress corrosion cracking (IGSCC).

Applicant: National Physical Laboratory - Teddington
Budget: 116 000 ECU

P1297 Susceptibility of high-strength steels to stress corrosion and/or hydrogen embrittlement in corrosive environments

In the shielded areas, to which little air penetrates, of offshore structures in service, polluting organic substances can undergo putrefaction processes with the formation of hydrogen /sulphide and pitting can occur with the formation of free acidity. This could create the conditions for the occurrence of two types of damage in which hydrogen appears to play a vital role and which could both in time lead to catastrophic failure: stress-corrosion cracking in the presence of internal or external stresses and hydrogen embrittlement cracks in the absence of such stresses.

The same problems may occur, for example, on materials used for oil welds and/or for geothermal applications and for crude oil and/or gas transport and supply. This project is designed to study the stress corrosion and hydrogen embrittlement cracking mechanisms in welds with a high yield point.

Applicant: Istituto di Ricerche Breda-Milano
Budget: 223 000 ECU
Probable duration: 2 1/2 years.

P1311 Degreasing and phosphate-coating of deep-drawing sheet

For motor vehicle bodywork, deep-drawing sheet is subjected, after forming and assembly, to a finished treatment consisting mainly of alkaline degreasing, phosphate-waiting and painting followed by a finishing coat. A study of industrial practice shows that this alkaline degreasing treatment varies and does not always make due allowance for the surface properties of the sheet to be treated (coil - annealed, continuously annealed, galvanized, etc..). The purpose of the proposed research is to study the effect of various alkaline degreasing treatments used in the motor industry on the quality of the phosphatizing layers.

Applicant: CRM - Liège
Budget: 407 000 ECU
Probable duration: 3 years.

P1313 Sheet surface and bodywork life

One of the current concerns of the motor industry is to provide resistance against corrosion by the salts used on icy roads. The current guarantees offered customers cover only "penetrating" corrosion and in principle are not effective when the corrosion only affects the appearance of the bodywork. The demand for good overall durability will have to be met in the near future and it is therefore necessary to find the answers to the following points, which the proposed research project will address:

- the role of the sheet surface finish
- the desirable limits regarding surface chemistry and roughness
- the simulation of corrosion.

Applicant: CRM-Liège
Budget: 473 000 ECU
Probable duration: 4 years.

P1368 Hydrogen uptake in offshore steels under cathodic protection in the marine environment

It has been found in earlier work that overprotection with cathodic current can cause a significant increase of the crack propagation rate in corrosion fatigue, and this has been attributed to hydrogen pick-up. The problem of hydrogen uptake under cathodic protection may be of particular relevance for offshore pipelines. These pipelines are often designed for sour service, which means that hydrogen uptake must be expected to take place from the inside, causing a hydrogen gradient through the thickness of the wall.

If an offshore pipeline picks up significant amounts of hydrogen from the outside, the general activity of hydrogen in the steel will increase. It is the aim of the present programme to obtain more precise figures for hydrogen activity in various types of steel under natural water under cathodic protection.

Applicant: Korrosionscentralen ATV - Glostrup
Budget: 68 000 ECU
Probable duration: 2 years.

P1394 Research on alloy steel resistant to marine corrosion

The use of steel in offshore applications has expanded considerably in the last twenty years with increased oil exploration, and requirements will probably continue to increase. Earlier work has pinpointed the influence of alloying elements on the corrosion of completely submerged steel. From the practical viewpoint this makes it possible to produce new steel compositions. However, to obtain a complete technical mastery of these materials additional research is proposed in order to:

- optimize grade composition
- examine corrosion in tidal and splash zones
- define welding conditions and ascertain marine corrosion resistance of welded joints.

The research will be conducted in collaboration with the Société Nouvelle des Aciéries de Pompey and the Centre National d'Exploitation des Océans at Brest.

Applicant: IRSID-St Germain-en-Laye
Budget: 260 500 ECU
Probable duration: 2 years.

P1395 Retarded fracture of C-Mn steels in an H₂S medium

Hydrogen embrittlement resulting from the decomposition of hydrogen sulphide (dissolved in aqueous or gaseous solutions) causes problems not only in the oil industry but also in the chemical industry, marine engineering and many other sectors. The problem of retarded fracture in the presence of mechanical stress occurs when steels are used in such environments. Research to identify the metallurgical factors involved must be continued and that is the purpose of this project.

Applicants: IRSID-St Germain-en-Laye
Creusot-Loire - Le Creuset
Budget: I 301 500 ECU
CL 301 000 ECU
Probable duration: 3 years.

P 1410 Development of new precoated materials for the motor industry

Corrosion resistance is today of vital importance for the motor industry. The main incentives to improve it are the keen competition from American and Japanese manufacturers and the growing trend in the motor industry to use substitute materials with an excellent chemical inertness, such as aluminium and its alloys, plastics and composite materials. Conservation of materials has also become a priority objective, not least for social reasons, at a time when raw materials and energy are scarce and expensive. The innovation proposed by the steel industry here focusses on the development of precoated materials, a venture that is enjoying considerable commercial success, in complete contrast to the reduced consumption of almost all the other steel products. The research will concentrate on coated products, especially those with metal coatings on one or both faces. Suitability for stamping and corrosion resistance will also be studied.

Applicant: CSM-Roma
Budget: 455 000 ECU
Probable duration: 2 years.

P1411 Tests on low-alloy steel performance in offshore service conditions

Earlier research in which the laboratory participated furnished definite confirmation of the efficiency and the role played by some steel alloying elements in controlling various possible forms of corrosion when steel is submerged in sea water. Under this new joint programme the CSM proposes to carry out the following work:

- a) production of experimental steels in the hot rolled state
- b) field tests: immersion in polluted sea water exposure of bare test pieces in the tidal and splash zones
- c) simulation tests: immersion in tanks with periodic recording of polarization resistance
accelerated tests to simulate conditions in the splash and tidal zones.

Applicant: CSM-Roma
Budget: 119 500 ECU
Probable duration: 3 years.

P1412 Flash tinning to produce tinplate with a thinner coating

The diffusion layer between the tin and the steel is a vital factor in the corrosion resistance of electrolytic tinplate

because it acts as a barrier and reduces the ferrous substrate surface area to be given sacrificial protection. Many attempts have been made to improve the corrosion performance of electrolytic tinfoil by controlling the FeSn₂ alloy and some processes have been used industrially to obtain better quality tinfoil. The project is designed. Plans are first to verify in the laboratory the possibility of predepositing tin during the neutral electrolytic pickling treatment, giving the steel cathodic polarity in the final pickling stage and using only soluble tin anodes.

Depending on the results, an attempt will be made if necessary to optimize the treatment by making slight modifications to the chemical composition of the pickling bath.

Applicant: CSM-Roma
Budget: 202 000 ECU
Probable duration: 2 years.

P1413 Development of an industrial production technique for thin plating

An experimental cladding method on an industrial scale consists of producing clad plate by hot rolling, the stainless steel plate being prepared by an electrophoretic nickel-plating method. This process, which is extremely economical, has produced plate shown to be optimum by ultrasonic inspection and bending tests, having an adhesive strength of 39 kg/mm² to ASTM 163.

In the proposed research project it is planned further to develop this technique for the production of hot-rolled semi-finished products for subsequent cold rolling, possibly on a strip mill, in order to produce sheet clad on both sides with stainless steel or non-ferrous metal.

Applicant: CSM-Roma
Budget: 218 000 ECU
Probable duration: 2 1/2 years.

P1414 Electrodeposition of complex coatings by high current density
Electrochemical processes in continuous lines

The use of electrochemical processes for continuous treatment of steel strip is steadily growing; their applications include surface polishing, finishing and coating, and protective and decorative finishes. The main problem in electrolytic galvanizing lines is to increase deposition rates in order both to obtain thicker zinc coatings and to increase productivity without need to install a line of dimensions that cause investment problems. To increase line speed it is necessary to use higher current densities. Consequently it is essential to study fundamental relations between the

electrochemical parameters (current density, potential, limit current density, coating thickness, diffusion limit, etc..) and the hydrodynamic parameters so as to find a combination that will be of general validity for continuous electrochemical processes and in particular electrodeposition processes.

Applicant: CSM-Roma
Budget: 308 000 ECU
Probable duration: 2 years.

P1464 Development of HSLA steels for marine applications

Previous results of sea water immersion tests carried out with high strength low alloy steels containing small additions of alloying elements are promising. A final set of alloys containing Al, Cr and Mo has been selected on the basis of these tests. For the application of these alloys it is important to know the behaviour in the splash and tidal zone as well. One alloy containing small additions of Cu, Ni and P with proved resistance to splash and tidal zone conditions has been added. This research proposal relates to the following programme:

- a study of welding the steels on a laboratory scale and produce welded samples for in situ corrosion tests
- in situ immersion tests at 50 m depth in the North Sea
- in situ tests with coated steel exposed in the splash and tidal zones
- a laboratory investigation of the behaviour of the alloys under cathodic protection.

Applicant: Stichting Materiaalonderzoek in de Zee-Delft
Budget: 171 500 ECU
Probable duration : 3 years.

II.5.3 Cold forming

In this sector, which covers the forming of flat products and in particular thin sheet, an area in which research efforts are concentrating on the development of grades with better service properties, it was considered important to carry out work on stamping products, an area in which competition is keen both on the purely commercial level (production costs being lower outside the Community) and on the technical level (substitution materials).

P1312 Pseudo-rimming steels

A low degree of sensitivity to ageing is an important property for deep-drawing steels which is required by the user.

in particular in the automobile industry. The development of deep-drawing grades from basic-annealed grades has enabled the users requirements to be met. However, the situation needs to be reconsidered for continuously-annealed steels. Ageing at ambient temperature is in particular very sensitive to variations in contents of nitrogen and carbon interstitial atoms and thus depends to a large extent on the chemical composition of the steel. Both the effectiveness of the over-ageing heat treatment and the sensitivity to ageing of the final product (sheet) depend on these interstitial variations in carbon and nitrogen content. The main aim of the research project is to examine the conditions (chemical analysis, treatments) which will enable the sensitivity to ageing of pseudo-rimming steels to be reduced and to confer upon them the properties of deep-drawing steels after continuous annealing.

Applicant: CRM-Liège
Budget: 264 000 ECU
Possible duration: 3 years.

P1351 Special steels for cheaper forgings

Semi-products for forging make up a large part of the special steel and quality steel sections market. The quantity of these semi-products manufactured has however fallen during recent years because many stamped parts have been replaced by machined parts for cost reasons. If account is taken of the fact that raw materials costs may reach 50% of production costs, the sole means of recovering the market for these products are the following:

- supplying semi-finished products which are less costly, or
- enabling drop forging plants to manufacture cheaper products, which implies having suitable grades of steel available.

This research proposal therefore concentrates on two points:

- the use of continuously-cast crude billets or lightly wrought billets
- improvement of the strength, ductility and fatigue strength by rapid quenching from the forging temperature.

Applicant: Krupp-Siegen
Budget: 350 500 ECU
Possible duration: 3 years.

P1396 High strength sheet with balanced characteristics

The increasing use in coming years of thin sheet with elevated properties in the automobile industry is a predictable fact. Thus, over the last five years a range of sheet has appeared on the market aimed at meeting the various requirements of this industry (lower weight, increased safety,

reduced consumption). The distinguishing feature about the sheet in the research proposed is the level of values of each of the factors in the ductility/strength range. These values are necessarily the result of a compromise, since the two basic properties to which they correspond are by nature dissimilar. The research projects conducted over recent years to improve the basic grades of extra-mild steel have been concentrated mainly on increasing either the strength or the ductility, but never the two properties simultaneously or to any great extent. The research proposed is aimed at studying the effect resulting from the combination of the mechanisms brought into play by two methods of hardening, precipitation and solid solution, with the added effect of continuous annealing.

Applicant: Irsid - St Germain-en Laye
Budget: 399 000 ECU
Probable duration: 3 years.

P1450 Structure property relationship for high strength strip steels

The objective of the project is to investigate the effect of strengthening mechanism and metallurgical structure on the relationship between the monotonic tensile properties and the cyclic stress strain behaviour and fatigue life for a range of strip mill higher strength steels in order to identify the factors which lead to cyclic softening or cyclic hardening. The effect of strengthening mechanism and structure on the strain rate sensitivity of the tensile properties will also be investigated.

The steels to be covered include those strengthened by precipitates from microalloy additions, grain refinement, elements in solid solution, substructure obtained from low temperature transformation products or from cold work and by the presence of hard second phases such as martensite or bainite as for dual phase steel. The steels will be tested in the as received, strained and aged condition.

The results should lead to further improvement in the overall properties of high strength steel to be supplied to the automotive industry.

Applicant: BSC - London
Budget: 162 500 ECU
Probable duration: 3 years.

P1461 Cold forging steels

The Community steelmakers' market for rod for cold forging especially for fasteners production, is under extreme pressure from Far Eastern imports and is declining. Unless cold forgers can reduce their costs this market may disappear altogether. A reduction in their raw material cost would therefore be a great help to cold forgers, and one possible

means of achieving this is to eliminate the need for sub-critical annealing, by the development of a steel which can be drawn and coldforged from the "as rolled" condition.

This project sets out to define the critical properties of such steels and in particular to determine the applicability of the concept of adiabatic shear instability in cold forging. The research programme will include the preparation of laboratory melts, their processing to rod and some to wire. These materials will then be subjected to backward extrusion and to two blow heading operations using a laboratory based commercial size cold forging machine.

The optimum compositions for an "as rolled" and for a cold drawn cold forging steel will be defined.

Applicant: BSC-London
Budget: 296 500 ECU
Probable duration: 3 years.

II.5.4. Fracture mechanics

Work in the area of fracture mechanics covers safety both from the point of view of welded joints subjected to alternating stresses in a corrosive environment and gas pipelines transporting gases with various chemical compositions under pressures which are becoming higher and higher, or pipes for the extraction of petroleum or of geothermal energy. The studies proposed should lead to a better understanding of the initiation, development and assessing of these cracks as well as the development of steel grades with better properties.

P1346 The toughness of welded joints

The design and fabrication of structures requires their welding even in elements subjected to very high stresses. Thermal stresses in the weld due to welding result in considerable structural modifications. In addition, welded structures, because of local heating due to welding (rapid welding-reduction of number of passes), are the centre of stresses which are likely to bring about brittle fracture because of the multi-axial nature of the stresses. It should also be added that so far it has never been possible to exclude discontinuities or internal defects which may be the origin of cracks.

It is therefore necessary for safety reasons to understand the ductility of welded joints as a function of new high-performance welding processes.

Applicant: Technische Hochschule-Aachen
Budget: 688 000 ECU
Probable duration: 3 years

P1353 Full scale fracture tests on line pipes

Shear fracture propagation in gas pipelines has been a subject on intense research work for more than ten years. In order to ensure energy transport and safety of pipelines there is a great interest in the knowledge about fracture propagation process and full scale fracture tests. The most recent research work mainly concerned requirements of gas transmission pipelines with large diameter pipes and steel grades up to X70. These investigations allow at present to predict with sufficient accuracy the necessary toughness to arrest long running shear fracture in the range of steel grades up to X70 and wall thickness up to 20 mm. The pipe market, however, asks for higher pressure in the line pipe to increase the amount of transported gas and to improve the economic data of a pipe line. Higher pressure leads either to higher circumferential stress or to bigger wall thickness. To investigate these parameters it is envisaged to carry out a full scale test programme:

- two tests shall provide information on fracture behaviour of steel types of grade X80
- one test is to complete previous results from thick walled pipes.

Applicant: European Pipeline Research Group-Duisburg
Budget: 1 497 000 ECU
Probable duration: 3 years

P1418 Full-scale tests on ductile fracture propagation in gas pipelines under offshore conditions

The semi-empirical formul currently applicable to underground pipelines are not necessarily applicable to submarine pipelines, given the differences in backfill and the important role that this plays in the propagation of fracture.

In recent years there has been a continuous increase in the working of submarine deposits and thus far greater use of offshore pipelines. The aim of this project is to develop a full-scale test which will simulate the conditions of ductile fracture propagation in offshore use and to obtain the basic data which will allow the proper design of offshore pipelines and their materials to be achieved.

The following will be studied:

- the fluid dynamics aspects of the phenomenon and approximations to be considered
- the effect of the depth at which the pipeline is laid
- the phenomenon of propagation by sea waves

Applicant: CSM-Roma
Budget: 912 500 ECU
Probable duration: 3 years.

P1421 Relationship between microstructure, composition and service properties of high strength steel for oil field and geothermal use

The development of tubular product for petroleum, natural gas and geothermal energy drilling reflects the trend in the exploitation of deposits situated at great depth (over 6 000 m) in aggressive media. The mechanical strength and toughness of the materials, some of which are designed for use in Arctic zones, must be compatible with satisfactory stability under conditions of use where they are subjected to a series of phenomena of attack from the ambient medium which, in relation to the physical and chemical properties of the latter, in particular composition and temperature, may result in hydrogen embrittlement induced by the presence of H₂S, and to corrosion and stress corrosion produced by liquids with high saline content and by high temperatures.

This proposal aims at describing in systematic fashion and in quantitative terms the microstructure and the second phases of hardened and tempered steels of varying compositions, including some C - Mn steels, low alloy Cr - Mo steels and a stainless steel with 13% Cr, used mainly for the manufacture of casing tubes.

Applicant: CSM-Roma
Budget: 749 000 ECU
Probable duration: 3 years.

P1453 Corrosion fatigue crack growth

Previous research sponsored by ECSC has shown how the rate of advance of a fatigue crack in the presence of an aqueous environment can be quantitatively modelled and predicted. Other research in Europe and USA has demonstrated how the effect of load sequence or stress interaction in variable amplitude loading can be accommodated in fatigue crack growth rate predictions. One of the objectives of the proposed research is to combine these two predictive models into a computer based model for the prediction of corrosion fatigue under variable amplitude loading. The predictions will be compared with test results obtained under a variety of representative loading sequences. This will facilitate the accurate prediction of the remnant life of cracked components and structures in realistic service environments.

Applicant: BSC-London
Budget: 286 500 ECU
Probable duration: 3 years.

II.5.5. High temperature steels

P1357 Susceptibility to graphitization and its influence on the creep rupture strength of welded joints

Various studies have shown that in non-alloy or low-alloy heat-resistant steel subjected to prolonged stresses at temperatures above 430°C a major part of the carbon content is precipitated in the form of graphite and that this process increases in rapidity when the content of aluminium in solution is high. The effects of graphite precipitates on mechanical properties are not very well known. Observation of a chain of precipitates along the heat affected zone in welded joints could lead on to expect a reduction in deformability in a zone where ductility is already limited. The aim of the proposed project is therefore to determine experimentally the types of graphite precipitation which occur in welded joints and to study the way in which they affect creep behaviour.

Applicant: VDEh-Düsseldorf
Budget: 94 000 ECU
Probable duration: 3 years.

II.5.6. Light structures

The structural sector, which covers the research projects on light structures, is one of the keys to the steel market. The position of steel must be constantly defended against competing materials, and to this end steel must be promoted consistently. This effort takes various forms, such as:

- fundamental research on improved evaluation of the performance of joints
- technological and design development of structures
- the distribution of clear and precise instructions on how to work with and use steel products.

P1290 Efficiency improvement of steel bearing piles

A previous research has shown that the steel compression pile may replace economically the concrete pile. This research has indicated that in order to enlarge the bearing capacity of steel H-piles in dense sands, volume-lagging had to be fitted to them, whereas the gain of capacity in clay could be achieved by reinforcements which increase the friction surface. If there exists one "area" where the use of steel could be extended, it is the deep foundations, and even more, the potential increase may be expressed in hundreds of thousands of tons if we are considering the entire

world as market.

So, a coordinated programme is proposed with the following five aims:

- define which are the optimum forms to give to the laggings
- define which are the best materials out of which the laggings could be realised
- define the limits of the practical dimensions of the laggings, taking account of the inertia effects and the dynamic stresses occurring during driving
- as the laggings increase the danger of buckling at the beginning of driving, it will be necessary to analyse very carefully this particular point, in order to propose some solutions
- the obtained bearing capacity will be calculated according to the results of pressuremeter tests, cone penetration tests, dynamic penetration tests and standard penetration tests so that the results may be used on a world wide basis.

Applicants: Arbed-Luxembourg
 BSC-London
 Usinor-Paris
 Stahlwerke Peine Salzgitter-Peine

Budget: 682 000 ECU

Probable duration: 4 years.

P1369 Simple and economic design rules for cold-formed sections

Cold-formed sections and thin-walled constructions offer the possibility of an increased use of steel for structural purposes. Cold-formed sections have opened new opportunities for steel that would otherwise be in other materials such as concrete or wood. Many possibilities for extension of the market are still open. However, further technical and comprehensive design information and acceptance criteria are needed to expand the application of steel in this market in Europe.

In the proposed study the experimental and theoretical work is intended to provide a clear understanding of the problems involved and is focussed on two topics:

- theoretical and experimental investigations to fill gaps in knowledge when necessary
- compilation of research results. The areas investigated will be behaviour of unstiffened elements, edge stiffeners for compression elements, intermediate stiffeners, web crippling, lateral buckling.

Applicant: Stichting Staalcentrum Nederland-Rotterdam

Budget: 160 500 ECU

Probable duration: 3 years.

P1458 Spray applied fire protection

The project highlights various aspects of the application of spray applied fire protection where cost reductions could be realised. Fire protection and painting represent a significant proportion of the cost of the framework in multi-storey buildings, and are main areas where significant economies could be realised.

Steel framework are used for 80% of the multi-storey buildings in North America, whilst in Europe the equivalent market share is 25% or less. Clearly there is scope to expand structural steel sales to this sector through cost reduction at the expense of reinforcing steels.

The modifications to existing practices must be justified technically and various testwork and site visits are proposed. The study will cover three specific areas to substantiate the use of:

- (1) As sprayed protection with irregular thickness
- (2) Avoidance of reinforcement at the mid-depth of the insulation applied to universal sections with deep webs (750 mm).
- (3) Avoidance of paint protection in situations where steel will be used internally.

The successful implementation of these proposals would reduce framework costs by 18% and it is estimated the work could realise an increase in sales of 60,000 tpa in the United Kingdom. Similar trends would be realised in other European countries where more severe problems with both sprayed fire protection and market share are encountered.

Applicant: BSC-London
Budget: 219 000 ECU
Probable duration: 2 years.

P1471 Comparison of methods of measuring residual stresses in hollow steel sections

The need for energy saving has resulted in the development of cold working processes. However, the residual stresses are greater in these products than those obtained by hot working, and the effect of these residual stresses on the stability of bars is very important. It is, therefore, necessary to have a thorough knowledge of residual stresses in order to be able to promote the use of cold sections, especially in cases where a stability problem arises: buckling or warping. The service life of welded joints subjected to fatigue is also affected to a large extent by residual stresses due to welding. Here again a thorough knowledge of the residual stresses would enable a judicious choice of the type of joint to be made. The solution of these problems is the aim of the proposed project which will cover

the behaviour of hollow sections.

The work will be carried out in cooperation with the following laboratories:

- CETIM-Senlis
- Kingston Polytechnic - Kingston-upon-Thames
- TNO-Delft
- the Universities of Karlsruhe, Liège and Naples.

Applicant: Cometube-Levallois
Budget: 59 000 ECU
Probable duration: 2 years.

II.5.7 Alloy and special steels

The subject areas reflect two practical problems of interest to the user which require a thorough knowledge of the relations between the structure of the material and its behaviour during forming and its service behaviour. The effects of boron in two different areas such as machinability and the production of special steels for tubes are therefore seen as essential for the development of these grades.

P1283 Service properties of high-workability steels to replace lead-containing steels

Steels which have a high degree of workability normally contain lead as an embrittling element which is liquid at cutting temperatures. However, the use of lead gives rise to certain problems of an ecological nature in all production cycle phases where lead vapours arise. The search for alternative embrittlement phases has led to the development of steels with a high degree of workability which contain disperse phases of boric anhydride. It is necessary to determine both the workability by means of machining and the mechanical and technical properties of the new steels with a view to making a full assessment of the real possibilities of replacing lead-containing steels. The proposed research will examine low-carbon, heat-treated free-cutting steels and structural steels containing boric anhydride and a combination of boric anhydride with other elements which improve workability (S, Ca, Pb).

Applicant: Industria Acciai Speciali-Torino
Budget: 313 000 ECU
Probable duration: 2 years.

P1424 High toughness heat-treated boron steels with low and medium carbon contents

Boron has been used for some time in high-strength quenched

and tempered steels with medium carbon content. It is only in recent years that the interest in its use (because of its well-known tempering effect) has been extended to other products which require levels of strength and toughness which can be achieved only by developing suitably adjusted acicular microstructures. Areas of use which are very promising in this respect are:

- rolled products for gas pipeline fittings, normalized and tempered products
- seamless tubes in various grades in the quenched and tempered state or if possible, in the normalized and tempered state.

In both cases the aim is to achieve a microstructure which is made up mainly or entirely of acicular ferrite or bainite with relatively poor chemical compositions, whence the low levels of C_{eq} required to ensure good weldability.

The large amount of work carried out in recent years on boron-containing steels has enabled many aspects of their transformation characteristics and strength properties to be determined.

On the other hand, definite and conclusive data on the possible negative effect of boron on toughness in respect of the various microstructures and in particular those obtainable after normalization followed by tempering are lacking.

A systematic study is proposed on the correlation between structure and mechanical properties of boron-containing steels with acicular microstructures for fittings and seamless tubes, with particular attention being paid to the brittle-fracture strength obtainable after normalization and tempering or quenching and tempering.

Applicant: CSM-Roma
Budget: 300 500 ECU
Probable duration: 2 years.

II.6 MISCELLANEOUS

P1364 Technical steel literature

This is a continuation of previous agreements granting ASELT financial assistance for the translation into Community languages of papers on iron and steel subjects published in "difficult" languages (in particular Russian and Japanese).

Applicant: Aselt-Luxembourg
Budget: 175 000 ECU
Probable duration: 1 year.

P1366 LD slag for use in road construction

This is the continuation of work under Agreement 7210.XA/105, during which an embankment was constructed of various mixtures of LD and open hearth slag, blast furnace slag and inert materials. The aging of the slag and the leaching of CaO was studied. This embankment, which was given no protection from leaching by rain water, will be covered to simulate a section of road in order to investigate the behaviour of the materials under conditions close to natural situations.

Applicant: Forschungsgemeinschaft Eisenhüttenschlache
Duisburg
Budget: 51 500 ECU
Probable duration: 1 year.

P1367 Improved utilization of blast furnace and steel plant slag

This is also the continuation of coordinated research undertaken by the FEhS, CRM, Usinor and BSC to upgrade blast furnace slag for the cement industry and steel plant slag for road constructions.

The research will consist of:

- a study of blast furnace slag for cement and lightweight concrete: quenching techniques and hydraulicity (FEhS, BSC, Usinor)
- study of LD slag: accelerated test procedures at temperatures exceeding 100°C (FEhS), accelerated test procedures at temperatures below 100°C (BSC), real-time test procedures depending on ambient conditions (CRM).

Applicants: Forschungsgemeinschaft Eisenhüttenschlache
Duisburg
BSC-London
Usinor-Paris
CRM-Liège
Budget: 654 000 ECU
Probable duration: 3 years (BSC-CRM)
2 years (FEhS-Usinor).

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

Annex

Project No	Title of research	Research proposed			Financial Aid	
		by	Probable duration (years)	Budget ECU (29.10.82)	%	Amount ECU (29.10.82)
	<u>I. ORE REDUCTION</u>					
	<u>I.1. Sinter</u>					
1307	Rational composition of sinter mixtures	CRM	3	467.000	60	280.200
	<u>I.2. Blast furnace</u>					
1317	Chemical and physical processes in the fusion zone and their effect on energy consumption and hearth life	Thyssen	3	1.738.500	60	1.043.100
1399	Powdered coal injection in a large blast furnace	CSM	3	601.000	60	360.600
	<u>II. STEEL MAKING</u>					
	<u>II.1. Casting and solidification</u>					
1321	Determination of shell thickness in continuous casting to improve process control	BFI	3	681.500	60	408.900
1322	Relationship between surface quality and casting powder used in the continuous casting of blooms	Arbed Saar	3	485.000	60	291.000
1323	Measurement of high-temperature properties of the shell immediately after solidification	Krupp	2	383.000	60	229.800
1372	Research on the supporting of continuously cast slabs	CRM	3	259.500	60	155.700
1381	Mechanical behaviour of the slab in the cooling zone of a continuous casting machine	IRSID	4	526.500	60	315.900
1382	Solidification brittleness of carbon steels	IRSID	3	354.000	60	212.400
1429	Structural refinement by vibrational energy	BSC	2	287.000	60	172.200
1430	Strand deformation in continuous casting	BSC	2	249.500	60	149.700
1431	Continuous casting plant engineering control	BSC	2	345.000	60	207.000

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Project No	Title of research	Research proposed			Financial Aid	
		by	Probable duration (years)	Budget ECU (29.10.82)	%	Amount ECU (29.10.82)
1324	<u>II.2. Steelworks : metallurgy</u> Preventing slag from running out of converters with the steel	VDEh	3 1/2	939.500	60	563.700
1325	<u>II.3. Steelworks : technology</u> Monitoring of electrode quality and reduction in electrode consumption in arc furnace	BFI	4	666.500	60	399.900
	<u>III. MECHANICAL WORKING</u>					
1286	Selective cooling of sections	Arbed	3	301.000	60	180.600
1309	Automatic monitoring of sheet microstructure	CRM	3	418.000	60	250.800
1335	Strip deformation in tensioning roller	BFI	4	835.000	60	501.000
1387	Automation of a universal beam mill	IRSID	4	540.500	60	324.300
1389	Asynchronous rolling	IRSID	2 1/2	230.000	60	138.000
1405	Use of residual rolling heat for heat treatment of stainless steel wire rods	CSM	2	243.500	60	146.100
1437	Work roll profile	BSC	2	226.500	60	135.900
1466	Form and profile in sheet mills	Hoogovens	3	544.500	60	326.700
	<u>IV. MEASUREMENTS AND ANALYSES</u>					
1339	Ultrasonic surface inspection of heavy plate	Fhg (IzP)	3	519.000	60	311.400
1343	Determination of the metal-alloyed aluminium content and other oxygen-sensitive elements	Dillingen	2	99.000	60	59.400
1375	Continuous measurement of the particle sizing of blast furnace burden materials	IRSID	3	443.000	60	265.800

Project No	Title of research	Research proposed			Financial Aid	
		by	Probable duration (years)	Budget ECU (29.10.82)	%	Amount ECU (29.10.82)
1406	Robotization of cold spot-scarfing for continuously-cast slabs	Italsider	1 1/2	455.500	60	273.300
	<u>V. SERVICE PROPERTIES AND PERFORMANCE</u>					
	<u>V.1. Weldability</u>					
1299	Improved productivity through metal powder additions to submerged arc welds	W.I. I.S.	2	164.500 160.500	60 60	98.700 96.300
1344	Welding of X8Ni9 steel with filler metal of the same type	Thyssen	3	381.000	60	228.600
1282	<u>V.2. Corrosion and surface protection</u> Influence of residual elements on the intergranular stress corrosion cracking of carbon steels	N.P.L.	-	116.000	60	69.600
1297	Susceptibility of high-strength steels to stress corrosion and/or hydrogen embrittlement in corrosive environments	I.R. Breda	2 1/2	223.000	60	133.800
1311	Degreasing and phosphate-coating of deep-drawing sheet	CRM	3	407.000	60	244.200
1313	Sheet surface and bodywork life	CRM	4	473.000	60	283.800
1368	Hydrogen uptake in offshore steels under cathodic protection in the marine environment	Korr. Cent.	2	68.000	60	40.800
1394	Research on alloy steel resistant to marine corrosion	IRSID	2	260.500	60	156.300
1395	Retarded fracture of C-Mn steels in an H ₂ S medium	IRSID C.L.	3	301.500 301.000	60 60	180.900 180.600
1410	Development of new precoated materials for the motor industry	CSM	2	455.000	60	273.000

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Project No	Title of research	Research proposed			Financial Aid	
		by	Probable duration (years)	Budget ECU (29.10.82)	%	Amount ECU (29.10.82)
1411	Tests on low-alloy steels performance in offshore service conditions	CSM	3	119.500	60	71.700
1412	Flash tinning to produce tinplate with a thinner coating	CSM	2	202.000	60	121.200
1413	Development of an industrial production technique for thin plating	CSM	2 1/2	218.000	60	130.800
1414	Electrodeposition of complex coatings by high current density electrochemical processes in continuous lines	CSM	2	308.000	60	184.800
1464	Development of HSLA steels for marine applications <u>V.3. Cold forming</u>	SM02	3	171.500	60	102.900
1312	Pseudo-rimming steels	CRM	3	264.000	60	158.400
1351	Special steels for cheaper forgings	Krupp	3	350.500	60	210.300
1396	High strength sheet with balanced characteristics	IRSID	3	399.000	60	239.400
1450	Structure property relationships for high strength strip steels	BSC	3	162.500	60	97.500
1461	Cold forging steels <u>V.4. Fracture mechanics</u>	BSC	3	296.500	60	177.900
1346	The toughness of welded joints	R.W.T.H.	3	688.000	60	412.800
1353	Full scale fracture tests on line pipes	E.P.R.G.	3	1.497.000	45	673.650
1418	Full scale tests on ductile fracture propagation in gas pipelines under offshore conditions	CSM	3	912.500	60	547.500
1421	Relationships between microstructure, composition and service properties of high strength steel for oil field and geothermal use	CSM	3	749.000	60	449.400
1453	Corrosion fatigue crack growth	BSC	3	286.500	60	171.900

Project No	Title of research	Research proposed			Financial Aid	
		by	Probable duration (years)	Budget ECU (29.10.82)	%	Amount ECU (29.10.82)
1357	<u>V.5. High temperature steels</u> Susceptibility to graphitization and its influence on the creep rupture strength of welded joints	VDEh	3	94.000	60	56.400
1290	<u>V.6. Light structures</u> Efficiency improvement of steel bearing piles	Arbed BSC Usinor Stahlw. P+S	4	682.500	60	409.500
1369	Simple and economic design rules for cold-formed sections	SSN	3	160.500	60	96.300
1458	Spray applied fire protection	BSC	2	219.000	60	131.400
1471	Comparison of methods of measuring residual stresses in hollow steel sections	Cometube	2	59.000	60	35.400
1283	<u>V.7. ALLOY and special steels</u> Service properties of high-workability steels to replace lead-containing steels	Ind.Ac.Sp.	2	313.000	60	187.800
1424	High-toughness heat-treated boron steels with low and medium carbon contents	CSM	2	300.500	60	180.300
1364	<u>VI. MISCELLANEOUS</u> Technical steel literature	Aselt	1	175.000	100	175.000
1366	LD slag for use in road construction	FEHs	1	51.500	60	30.900

Project No	Title of research	Research proposed			Financial Aid	
		by	Probable duration (years)	Budget ECU (29.10.82)	%	Amount ECU (29.10.82)
1367	Improved utilization of blast furnace and steelplant slag	FEhs	2	255.500	60	153.300
		BSC	3			
		Usinor	2	148.000	60	88.800
		CRM	3			
	Sub-total			25.483.500		15.135.550
	Ancillary costs and dissemination of information					171.050
	TOTAL					15.306.600