COMMISSION OF THE EUROPEAN COMMUNITIES

COM(77) 614 final.

Brussels, 24 November 1977.

MEMORANDUM OF THE COMMISSION

Financial aid under Article 55 (2 c) of the ECSC Treaty for a research project on the factors causing molten-metal/water explosions

COM(77) 614 final.

MEMORANDUM

'financial aid under Article 55 (2 c) of the ECSC Treaty for a research project on the factors causing molten-metal/water explosions.

---

01. Aid requested by

Dr. F.M. PAGE, Professor of Chemistry, the University of Aston in Birmingham, Gosta Green, Birmingham B4 7ET.

This application is sponsored by the British Steel Corporation, Corporate Engineering Laboratory, 141 Battersea Park Road, London SW11 4LZ

02. Introduction

It is well known in the steel industry that explosions, sometimes with violent projections, can occur when molten metal or slag are poured on to water or wet surfaces, and many precautions are taken in all works to avoid such explosions. But they still happen and have frequently caused serious and extensive burns and sometimes fatalities. A typical example was the accident which occurred in a melting shop when a ladle containing molten steel was accidentally tipped as it passed over a cooling basin on a travelling crane. When the steel came into contact with the water there was an extremely violent explosion. At the time there was a group of visitors standing on a special visitors' catwalk; 17 of them were injured by projected material and the operator of the travelling crane carrying the ladle was killed.

Pouring water on to molten metal or slag is, on the other hand, considered to be relatively safe as long as the amounts of water are small, and is also routine practice, for example when cooling iron pigs cast by machine or in pits.

But there may be a third situation, where water comes into contact with hot metal in a confined space, as in the case of the extremely serious accident which occurred at the British Steel Corporation's works at Scunthorpe on 4 November 1975.

The plug of a hearth cooler had been corroded due to an electrolytic reaction and had been loosened and dislodged from its socket by the force of the water under pressure.

This accident occurred during tapping of the blast furnace; one torpedo ladle had already been filled with molten iron and another was in the process of being filled. But by an unfortunate combination of circumstances, the plug had fallen out of the hearth cooler of the tuyere next to the taphole and had done so at a time when another technical hitch was being dealt with - the blast/blow pipe adjacent to the hearth cooler from which the plug was dislodged had started to burn down and was being sprayed to control the effects of the burn-down.

Access to the water leak in the hearth cooler was impossible because of the open taphole and the molten iron pouring from it, on one side, and the burning blow pipe on the other, and nothing could be done to stop the flow of water because the stopcock was located newt to the hearth cooler. As a result, a quantity of water estimated at 1 800 litres poured over the floor of the cast house, into the iron runner, and then into the torpedo ladle filled with molten iron which was waiting to be removed at the end of the tapping operations.

When it was realized that water was entering the torpedo ladle, a locomotive was fetched and coupled up to the ladle in order to remove it from the source of the water.

It is believed that the water had cooled the surface layer of the metal in the torpedo ladle, so helping to form a solid crust, and that the jolting of the ladle associated with the coupling up operation, together with subsequent movement of the ladle away from the runner, caused the metal/slag surface in the ladle to break up, thus trapping some water beneath the surface of the iron.

This led to a violent explosion which expelled approximately 90 tonnes of molten metal and some of the refractory lining out of the ladle, causing extremely severe injuries and several fires. Eleven people were killed in this accident and a further eight were seriously burned; there was extensive plant damage.

An accident of this kind should not be considered as exceptional as far as the causes are concerned, for iron and steel works use large quantities of water to cool metal and slag and there are many possibilities of accidental or intentional contact between hot metal/slag and water.

One of the conclusions of the report on the accident at Scunthorpe was that research should be earried out on the mechanisms of such explosions.

03. Present state of knowledge

No systematic research has yet been carried out on the causes of water/molten metal explosions. However, following an extremely serious explosion in an aluminium foundry in the United States (which was reckoned to be equivalent to the explosion of 250 kg of TNT) ALCOA conducted 3 000 experiments which resulted in the enunciation of safety criteria for the continuous casting of aluminium.

Also, in 1973, the University of Aston in Birmingham was commissioned by the Health and Safety Executive (a body grouping together the various official inspection services, with the object of harmonizing health and safety legislation in the United Kingdom) to carry out a series of tests, initially with reference to aluminium only, but subsequently also for other non-ferrous metals. Both laboratory tests and pilot scale tests were conducted and they showed, among other things, that contrary to expectations a considerable hazard of copper/water explosions existed; a modified set of safety criteria were established for that metal.

The fact that explosions can result whatever molten metal is poured - tin, lead, brass, aluminium or copper - prompted the University of Aston to carry out tests on more metals. In one such test an explosion was obtained when 5 kg of molten iron were poured into 15 cm of cold water. This explosion was of sufficient violence to tear one face of the water container (a 6 mm thick steel tank with welded seams) away from the rest and to throw it 30 m.

This observation , and the Scunthorpe incident, emphasized the need to obtain more information on explosions caused by contact between ferrous metals and water.

04. Research to be carried out by the University of Aston

The work to be done on the causes of metal/water explosions would be in two parts - work in the laboratory and work in the field.

In the laboratory, the following is planned :

- measurement of heat transfer from molten metal to coolant
- determination of the surface tension and contact angle of drops on various container surfaces and empirical categorization of the effect of such surfaces (because it has been found that the type of surface coating has an effect on explosions)
- study of the kinematics of the fall of hot bodies through coolant
- study of the inverse effects when a drop of coolant is injected into a hot material, and a correlation of these effects with other results.

The pilot scale tests in the field would be carried out at the Summerfield test site, operated by Imperial Metal Industries for the Ministry of Defence, where modifications would have to be made to adapt the equipment to the higher temperatures of molten metal (between 1200 and 1700°C).

The aim of the experiments would be :

- observation of the occurrence or otherwise of explosions as a function of the main industrial variables (metal and coolant temperatures, height of fall through air and coolant; container shape, surface condition of container, mass of metal and coolant)
- study of the fall of hot metal through the coolant and the development of any interaction
- the development and use of methods of recording transient pressures developed in interacting systems.

The benefits anticipated from this research project are primarily :

- a contribution to the theory of molten metal/water interactions as a basis for safety precautions to be taken when the two are in close proximity as part of the normal operations or are used simultaneously
- the drafting of recommendations on precautions to be taken and improvements in working conditions in the iron and steel industry
- improvement of design criteria for plant in which water is systematically brought into contact with iron, steel or slag (pit and machine casting of iron in pigs, continuous casting of steel, granulation and quenching of slags, quenching-off and breaking-up of ferro-alloys on cooling)
- work towards a clearer definition of what is or is not hazardous in operations where water is inadvertently or intentionally present on top of molten metal
- improved knowledge of the possibilities for reducing the risk of explosions by alterations in the conditions of the cooling water.

05. <u>Benefits of the research for the Community as a whole</u>

This research is of value to all the iron and steel works in the Community producing iron and/or steel, whatever the type of furnace used, for there is always a danger of accidental contact between molten metal and water.

The criteria for improved safety at work that will emerge from this research project can be applied at all these works.

06. Duration and cost of work - financial aid requested

Duration :	3 years
Commencement of research :	3 months after approval by the Commission of the European Communities
Total cost of project :	377 703.10 EUA
Financial contribution proposed (60%)	226 680 EUA

Conclusion

The project described above comes within the scope of Article 55 (2c) of the ECSC Treaty.

In view of the approval of this project by the competent professional bodies, the Commission envisages grant financial aid equivalent to 60% of the total cost of research, to a maximum of 226 680 EUA, made up to 233 480 EUA (i.e. including an additional 3%, or 6 800 EUA, to cover publication costs and miscellaneous expenses) and to authorize the entry of this sum under the relevant fund.

This expenditure is in conformity with the anticipated commitments in the ECSC operational budget for 1977.