

EUREKA PROJECT E!2210 - EUROCARE BRONZART

1. General description

Project	E! 2210 - EUROCARE BRONZART	Status	Announced - 23-JUN-2000
Title	Artistic Bronzes: Selection Of Alloys, Protective Evaluation Using Conventional And Advanced Techniques		
Class	Sub-Umbrella	Technological area	New Materials
Start date	01-OCT-2001	End date	01-OCT-2004
Duration	36 months	Total cost	2.93 Meuro
Partner sought	Yes		
Summary	Analysis Of The Behaviour Of Different Bronze Alloys And Coatings And Corrosion Inhibitors As A Function Of Natural And Simulated Environments. Innovative Techniques, Tla And Ecn, Applied For Degradation Measurements.		

Budget and duration

Phase	Budget(Meuro)	Duration (Months)
Definition phase	0.97	12
Implementation phase	1.96	24
Total	2.93	36

Member contribution

Member	Contribution	Position	Since
Italy	75.00%	Contact Member	16-JUN-2000
Austria	19.52%	Participating Member	28-JUN-2002
Czech Republic	.87%	Participating Member	28-JUN-2002
Portugal	4.61%	Participating Member	28-JUN-2002
Spain	.00%	Notified Withdrawn	08-NOV-2001
Sweden	.00%	Notified Withdrawn	08-NOV-2001

Participants

Company	Country	Type	Role
Fonderia Artistica Venturi Arte	Italy	SME	Main
Svuom Praha A.S.	Czech Republic	Research Institute	Partner
Montanuniv. Leoben/Inst.F.Allgemeine Und Analytische Chemie	Austria	University	Partner
Tecminho - Associacao Universidade-Empresa Para O Desenvolv.	Portugal	Research Institute	Partner
Cariatides - Producao De Projectos E Eventos Culturais Lda.	Portugal	SME	Partner
Tu-Wien/Atominstitut Der Oesterreichischen Universitaeten	Austria	University	Partner

2. Project outline

Project description

In the framework of activities related to the conservation of outdoor bronze artefacts, there is an ever greater tendency to remove ancient statues from outside and replace them with copies. While the original artworks are generally located in specific museums to prevent further damage, the copies, located outside, assure the original integrity of the urban environment and people can still enjoy them. The expected features of these 'new artefacts' are the maintenance of the aesthetic values and increased corrosion resistance.

To date, no standard reference exists as to the composition of artistic bronze alloys as a function of their properties under different climatic and environmental conditions, so the primary objective of this project is the development, evaluation of properties and validation of new bronze alloys to be used for replicas and modern sculptures. The result will be the final selection of new materials, with improved aesthetic features and greater resistance according to different environmental parameters.

Although this work addresses enterprises producing bronze artefacts, such as artistic foundries and contributes to the development of advanced materials, at the same time it can provide solutions to problems related to the safeguarding of cultural heritage.

A systematic selection of the bronze alloys and their relevant, protective materials as a function of the different European environments, produces data which can be helpful in terms of conservation needs. A wide range of investigations are required for the project to be achieved. Besides evaluation of the environmental behaviour of bronze alloys, a systematic analysis of the efficiency of protective material will be included. The proper bronze alloy/protection can in fact assure the best conditions for conservation.

The project addresses several enterprises partially or totally involved in the field of outdoor bronze artefacts, including artistic foundries, companies producing protective materials or electronic instruments for degradation measurements. Within the project, the enterprises will interact with public and private scientific institutions, mainly devoted to research, where a wide range of expertise is available (metallurgy, corrosion science and advanced analytical techniques). The work will be carried out by the application of conventional and innovative techniques such as Electrochemical Noise (ECN) and Thin Layer Activation (TLA). Owing to their specific properties, ECN and TLA show a promising application in the field of Cultural Heritage.

The work will be performed in the following steps:

- a) a preliminary microsculptural and chemical evaluation of several ancient and modern outdoor sculptures
- b) production and evaluation of bronze alloys with respect to casting, welding properties and corrosion resistance (improvement of the technical properties of materials)
- c) chemical patination of bronze alloys and evaluation of
- d) copying methodologies of original artefacts
- e) artificial weathering of bronze specimens and small

statues for evaluation of the influence of specific corrosive reagents (SO₂, NO_x and marine spray)
f) exposure of bronze specimens and small statues in different European sites representative of specific climates: urban, industrial and marine
g) testing of mixtures of new and traditional corrosion inhibitors with protective coatings
h) evaluation of the degradation processes of alloys and evaluation of the protective efficiency using conventional and innovative techniques (ECN, TLA)
Keywords: bronze alloys, corrosion, protective.

Technological development envisaged

The interest of this project resides in the fact it addresses innovative bronze alloys which is why the relevant practical application refers to copies of monuments and modern sculptures. To date, no standard reference exists as to the composition of bronzes for artistic purposes, so the preparation of new bronze alloys and their validation, through the analysis of their behaviour in different corrosive environments, represents a contribution for the application of new metallic materials in the field of Cultural Heritage. Moreover, the development of new corrosion inhibitors and protection, specifically prepared for bronzes and the analysis of their chemical and physical properties, in terms of the relevant protective capabilities, can be considered a step in the right direction in the field of materials used for conservation purposes.

Among the analytical techniques used in this work, TLA and ECN after a promising approach at national level, will be applied for the first time in the field of Cultural Heritage on a European scale.

Moreover, the project includes the setting up of innovative apparatus to be used in the field for non-destructive corrosion monitoring of metallic works of art.

Markets application and exploitation

The participation in this project of an artistic foundry operating worldwide testifies to the interest shown in the production of new bronze alloys for use for outdoor works of art.

Enterprises a part of whose activities are related to the production of protective materials may well be interested in the development and validation of specially prepared products.

The production of a portable apparatus prototype for corrosion measurements, may well interest enterprises operating in this specific sector, especially of its utility can be demonstrated in a wide ranging study such as that proposed in this project.

Project codes

BSI

AB/AI

standardization

BSI

AUC
AUY
BMS.M
BNN

surfaces
conservation
test laboratories
environmental testing

NACE

275
33201

Casting of metals
Manufacture of electronic instruments and appliances for
measuring, checking, testing, navigating and other purposes, e

3. Main participant

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Organisation type SME
Participant role Main

Contribution to project

Preparation of bronze alloys/evaluation of casting and patination properties. Evaluation of intrinsic casting parameters. Production of bronze coupons/artefacts for exposure to natural exposure/artificial weathering. Samples.

Expertise

Expertise: in the mid Sixties, Gianpaolo Venturi, the son of an industrial foundry worker, decided to open his own artistic foundry. An expert in the art of casting and very interested in innovation, he started to get involved in the latest techniques of that time: the technique of casting in lost wax in refractory ceramic material. This emanated from military research and was tested in the USA to achieve high precision steel casting. Venturi began experiments to set up an artistic casting of bronze process with Marshall, an American test engineer. This process was patented and called the 'Plycast Venturi System'. Venturi then started to produce high quality bronze casting using techniques unknown in ITALY. Due to his remarkable capabilities, he got several famous Italian sculptors involved. They created 'Multicultura', a collection of multiples which bear witness to a particular casting quality. The first 'Multicultura' exhibition took place in 1971 in ITALY. In 1972, VENTURI ARTE took part in the International Art Exhibition in Basel. Through international exhibitions, Venturi succeeded in displaying the extent of his skill to the artistic milieu. In that period, artists and art editors were on the lookout for experts capable of achieving the best quality output of bronze multiples. Artists such as Dali, Wotruba, Berrocal and Paul trusted VENTURI ARTE and established a mutually profitable relationship. They started exporting bronzes marked "VENTURI FOUNDRY" all over the world. In the meantime, art editors such as Volker Huber (GERMANY), EURO ART (Vienna), Ernst Hilger (Vienna) and ART CURIAL (Paris) committed their output to the VENTURI FOUNDRY which ended the Seventies improving its organisation and deserving its worldwide fame. In 1979 in Venice, the VENTURI FOUNDRY arranged a didactic/ artistic exhibition of works with an explanation of the advanced process they used. In the same year when Venturi died, his wife Gabriella, who had always worked with him, decided to take over the management of the foundry, assisted by her sister Tiziana and a number of employees. Having taken on this responsibility, Gabriella Venturi proved her professional skill by increasing the organisation yet again and stepping up the foundry's output. After diffusing the sculpture edition and multiples, it was necessary to increase the foundry's productivity. In this context, the production of large-size works using a new process was carried out with remarkable results as is the case of 33 large works committed by M.

Abakanowicz. From that time on, monumental works were flanked by lost wax casting sculptures. 1987 saw the beginning of a collection of furniture accessories called 'Le Forme del Fuoco', produced mostly by the sculptor G. Kruft. This collection, promoted and distributed by VENTURI ARTE, is still an important part of the foundry's output.

4. Partner

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Organisation type Participant role	Research Institute Partner

Contribution to project

Evaluation of the corrosion behaviour of bronze alloys by accelerated tests and by tests on atmospheric corrosion tests sites (industrial, urban, rural).

Expertise

Expertise: company transformed in 1999 from the NATIONAL RESEARCH INSTITUTE FOR THE PROTECTION OF MATERIALS founded in 1952. The Atmospheric Corrosion and Environmental Engineering Group has been part of the former research institute since its foundation 45 years ago. From the 1960s the theoretical basis of the new approach to the mechanisms of atmospheric corrosion, now generally accepted, was developed by this research group. Their activity covers general and applied problems of the atmospheric corrosion and protection of metals and the evaluation of influence of the environment on technical products. Specialists are participating in standardization activities at both the national and international level (ISO, IEC). Svuum was coordinator and leading research centre of COMECON countries on topic of atmospheric corrosion. The activity of the research group is also oriented to the methodological investigation and development of laboratory and field tests. To realize the requirements of the research projects and industry, the well equipped testing laboratories as well as the network of permanent field test sites at selected environments are utilized and methodological managed by the research group. temporary test sites in various microclimates can be used. An important research area forms national and regional activities oriented to the investigation and corrosion prevention of the materials in museums and storage environments including temporary protection problems. SVUOM, as a partner in the COPAL project, performed considerable research and testing on copper and bronze including patination and testing of protective efficiency of layers with and without inhibitors. Database (cca 200 examples) of corrosion behaviour and defects on bronze statues and copper art objects was elaborated. The research group (Atmospheric Corrosion Department) is the place of secretariat of ISO/TC 156/WG 4 Corrosivity of Atmosphere, a leading organization of the ISO CORRAG collaborative program performed in the framework

of the activity of ISO/TC 156/WG 4 and sub-center for the structural metals of the UN ECE collaborative program on Effects on Materials Including Historic and Cultural Monuments. The participation in international projects is extensive and includes: - EUREKA E! 640 Environmental Effects on Corrosion in Indoor Locations, basis for assesment of risk of damage and counter-measures (WetDry Dep) (1992-1997). - Evaluation of economic losses caused by atmospheric pollution on historic and buildings (1990-1992). -EUREKA E! 316 Technologies for conservation of copper alloy monuments (COPAL) (1992-1999). -ECE UN ICP of Effects on Materials including Historical and Cultural Monuments (1987-2002) - 4 BP Rationalized Economic Appraisal of Cultural Heritage (REACH) (1998-2001) ENV 4-CT98-0708. Contribution: Choice and evaluation of the protective efficiency of long- term and temporary protective measures. Complex evaluation of characteristics of layers of corrosion products on metals.

4. Partner

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Organisation type	University
Participant role	Partner

Contribution to project

Electrochemical measurements of different alloys in as cast conditions in different media, determination of free corrosion potential, potentiostatic and potentiodynamic measurements,

Expertise

Expertise: Over 30 years of experience in corrosion research, joint research projects with SHELL OIL (The NETHERLANDS), SIEMENS, (GERMANY), BUNTMETALL AMSTETTEN, (AUSTRIA), HILTI, (LIECHTENSTEIN), MAGNA,(AUSTRIA), BOHLER-UDDEHOLM, (AUSTRIA), VOEST-ALPINE, Linz and Leoben, (AUSTRIA), GERMAN COPPER INSTITUTE. special research fields over the years: electrochemical measurements of metals in various aqueous solutions, measurement of corrosion potentials, current density-potential curves, potentiostatic measurements, dissolution behaviour of metals, investigation of passive layer of different metals, almost all types of corrosion of non-ferrous metals, stainless steels and carbon steels, stress corrosion cracking, corrosion fatigue cracking, pitting corrosion Current research topics: stress corrosion cracking of copper tubes, improved corrosion resistance of cemented carbides, new corrosion resistant materials for automotive fuel systems, corrosion behaviour of magnesium-rare earth alloys, hydrogen embrittlement of bainitic steel fasteners, improved corrosion resistance of high corrosion-resistant steels, high temperature corrosion of nickel base alloys. Contribution: outdoor exposure of bronze specimens to industrial atmospheres, electrochemical measurements of exposed specimens in

different media.

4. Partner

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Organisation type Research Institute
Participant role Partner

Contribution to project

Responsible for: chemical and microstructural characterization of the alloys used in ancient Portuguese sculptures.

Expertise

Expertise: private association of interface of MINHO UNIVERSITY through the promotion of services in the fields of innovation and development of new technologies. TECMINHO promotes technology transfer activities, the participation of companies in RTD projects, technical support to clients in the preparation and consultancy services in the fields of innovation. Through Laboratory of Metallurgy, TECMINHO has been working in research areas such as: - brass properties and the development of new brass alloys for special purposes; - phase equilibria studies in Cu-Zn-X systems, where X represents one or more metals (Fe, Al, Sn, Ni, Pb, etc.) - properties of Cu-Ni-Al bronzes for propellers applications: optimization of chemical composition for the improvement of several properties (mechanical properties, corrosion resistance, etc.). - recycling of residues from non-ferrous processing operations. Contribution: - study of corrosion behaviour of developed alloys by exposure of bronze specimens and small statues in PORTUGAL sites of specific climates: urban, industrial and marine.

4. Partner

Company **Cariatides - Producao De Projectos E Eventos Culturais Lda.**
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Organisation type SME
Participant role Partner

Contribution to project

Responsible for: - survey of Portuguese bronze sculptures (in particular in the North of PORTUGAL);

Expertise

Expertise: the company promotes services on the following areas: - technical consulting for restoration and rehabilitation of cultural heritage: * domains of services rendered: architectural drawing; diagnosis and study of pathologies in historic buildings (laboratory support); expert reports and studies for conservation and restoration projects in the following areas: frescos, oil-painting, wood (carving), metals, stone; cataloguing and inventorying of cultural heritage. - production of cultural projects; - production and distribution of objects and editions with artistic appearance. Contribution: - construction of a file for each sample with description, date, style, author, etc. - cooperation with TECMINHO, in the corrosion studies, by establishing contacts with local entities (Town Hall, Natural Parks, Marine Plants, etc.) to determine sites for the exposure of new sculptures (replicas) made with the developed alloys.

4. Partner

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Organisation type University
Participant role Partner

Contribution to project

Qualitative and quantitative chemical analysis of new alloys both for the main components and trace elements.

Expertise

Expertise: The x-ray group has a long and fruitful experience in the development and application of x-rays fluorescence analysis. The main working areas: Total Reflection X-Ray fluorescence analysis (TXRF) Energy dispersive X-Ray Fluorescence Analysis (EDXRF) TXRF of Low Z elements Synchrotron Radiation excited TXRF (SR-TXRF) Application of XRF to the investigation of environmental samples Application of XRF on the investigation of cultural heritage Ultra trace element analysis of Silicon wafer surfaces Sample preparation methods for ultra trace analysis by electrochemical deposition ED measurement of the spectral distribution of an x-ray tube X-ray optics: focussing of x-rays Special x-ray sources Characterisation of thin layers and implantations by TXRF Microanalysis of human bone with SR-XRF In particular, in the field of cultural heritage the group has been involved in the analysis of bronzes from the awarian grave field of Leobersdorf (Lower Austria), and celtic glass artefacts from the La Tene period. The equipment available include: TXRF spectrometer with vacuum chamber for trace analysis TXRF spectrometer with vacuum chamber for low-Z elements TXRF attachment module TXRF spectrometer with vacuum chamber for surface analysis of 100 mm wafer TXRF spectrometer for wafer surface analysis up to 200mm wafer with sample changer X-ray generators for 60 and 100 kV operation Energy Dispersive detectors with Be entrance window Energy Dispersive X-ray detectors with ultra thin window for low energy detection Special windowless X-ray tube with Si anode Special fine focus X-ray tube with Au anode for 100 keV operation EDXRF spectrometer with Rh low power tube/sample changer Microanalysis spectrometer with polycapillary optics (50µm spot size). Contribution: The analysis will be carried out non destructively, using standard energy dispersive XRF, for the major matrix elements and when necessary TXRF for the trace elements. Analysis of different areas of the sample with a microbeam will be performed in order to verify the homogeneity of the samples. The ATOMINSTITUT DER OESTERREICHISCHEN UNIVERSITAETEN will collaborate with INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)-SEIBERSDORF LABORATORY. The IAEA Laboratories at Seibersdorf have expertise in development of laboratory and portable XRF spectrometers for multi element and non destructive analyses of environmental, geological, biological materials. The expertise also includes development of software packages for quantitative XRF analysis. The XRF laboratory operates with conventional energy dispersive XRF spectrometers with X ray tube and radioisotopes excitation, total reflection XRF spectrometer, X ray microfluorescence spectrometer and portable XRF spectrometers based on liquid nitrogen cooled and thermoelectrically cooled semiconductor detectors. Research in the laboratory deals with improvement in accuracy and extension of applicability range of various XRF techniques. The laboratory is also equipped with major sample preparation facilities required for conventional, total reflection and microfluorescence XRF analysis.