



GUIDELINES for Coating Application

- (I) Artificially Aged Traditional
Tin Bronze
- (II) Black Patinated Modern
Silicon Bronze

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Project partners:

	Acronym	Full name	Country	Funding agency
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2	S-Geida	Geida d.o.o.	Slovenia	MIZS
3	I-UNIBO	Alma Mater Studiorum University of Bologna	Italy	MIUR
4	I-UNIFE	Corrosion and Metallurgy Study Centre "Aldo Daccò", University of Ferrara	Italy	MIUR
5	I-ECAM	ECAMRICERT S.R.L.	Italy	MIUR
6	F-TOU	TRACES Laboratory (CNRS UMR 5608), CIRIMAT Laboratory (ENSIACET, CNRS UMR 5085) and Raimond Castaing microcharacterisation Centre (UMS 3623) of the Toulouse University (F-TOU), France	France	RMP
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1. Introduction

The present guidelines are established for the applications of protective coatings on bronze exposed in outdoor conditions. These coatings have been developed and tested during a two-year investigation within M-era.Net framework project B-IMPACT.

After a careful screening of anticorrosive properties based on electrochemical, weight losses and other scientific tests, two protective coatings have been selected. One coating was developed for traditional tin bronze, usually found in ancient sculptures. The other coating was developed for modern art silicon bronze with modern (artificial) patination, here based on classical black K₂S patination.

Coating for modern silicon bronze (black patinated) has been tested according to these Guidelines by end-users from three different countries involved in this program: France, Italy and Slovenia.

It must be underlined that these Guidelines are corresponding to the first transfer of information and are corresponding to a Technology Readiness Level (TRL) 5 for which the validation of the product have been integrated in a simulated operational environment by professional end-users (see Annex 1) – at this point we would like to thank them for their kind support and professional work performed. The evaluation of the feedbacks received by the selected end-users, with the addition of the cost benefit and market analyses is reported in the Deliverable D5.3 (Cost benefit and market analyses, necessary corrections according to market responses and pre-industrial product formation, feasibility report).

In these Guidelines, two different application protocols are defined. They take into account the two typical cases of exposed bronze monuments investigated within the framework of the B-IMPACT project.

- **The first protocol** for coating application is considered for **traditional cast-tin bronzes** submitted to outdoor corrosive conditions. Here we considered that the surface is cleaned of dirt particles as well as non-adherent patinas (such as the green pale products in areas exposed to rainfalls). To achieve that, usual cleaning methods can be applied: either by abrasion with walnut-shell particles which are more recommended than sand blasting; by applying chemical products (complexing agents) on surfaces, followed by demineralised water rinsing; by laser cleaning, but its impact is not yet entirely known on the long-term behaviour of the bronze surfaces.

Here for this type of naturally patinated bronze, exposed in atmospheric conditions, the selected coating is based on the mixture of fluoroacrylate and silane modified methacrylate polymers.

- **The second protocol** is adapted for coating application on roughest surfaces of **modern silicon bronze**, freshly patinated and submitted to atmospheric conditions. Here the typical K₂S black patination, applied since the 19th century, has been considered. The patinated surface should be “as received” before coating application. In the case of fat residual surface, including fingerprints, degreasing with usual organic solvents (such as ethanol, acetone, etc.) could be applied prior coating application.

This coating is based on silane polymers dispersed in a non-toxic solvent and is suitable for application on rough surfaces (with roughness of maximum mm variation).

Selected coatings were investigated in laboratory conditions and then tested in operational conditions by professional end-users (incl. conservators, restorers, foundries and artists). The suitable application protocol for both coatings is defined in these Guidelines in four different languages: English, French, Italian and Slovenian.

2. Guideline for Coating Application on Artificially Aged Traditional Bronze

English

The product, developed within the B-IMPACT project (M.ERA-Net), is coating formulation based on mixture of fluoroacrylate and silane modified methacrylate polymers in a mixture of organic solvents. Applied coating on the surface of historical bronze possesses strong anti-corrosion properties with strong adhesion to the bronze substrate. It exhibits hydrophobic and oleophobic properties to minimise dirt adhesion.

Product conservation

Important: Store in the gas sealed glass or plastic container below 23 °C.


Surface Preparation Tips

- Surfaces must be clean, without dust, grease or non-adherent particles.

Application Tips

- Application mode: **Soft brushing is preferred. Carefully fill cavities or defects in order to avoid discontinuities. Wipe the excess coating material from cavities.**
- Number of layers: **1 layer**
- Time for final drying: **At least 1 day**
- Washing brushing materials: **Ethyl acetate, white spirit**

General recommendation

- Keep out of reach of children
- Avoid direct contact with skin and eyes. Do not ingest.
- Work under aerated environment.
-  **Flammable: Keep away from open flame or hot objects**

Français

Le produit, développé dans le cadre du projet B-IMPACT (M.ERA-Net), est une formulation de revêtement à base de mélange de polymères de fluoroacrylate et de méthacrylate modifié par un silane dans un mélange de solvants organiques. Le revêtement appliqué sur la surface du bronze quaternaire (Cu-Sn-Pb-Zn) possède de fortes propriétés anti-corrosion et une excellente adhérence au substrat de bronze patiné. Il présente des propriétés hydrophobes et oléophobes pour minimiser l'adhérence de particules de poussières.

Conservation du produit

Important : Conserver dans un récipient en verre ou en plastique scellé à des températures inférieures à 23 ° C.

Conseil de préparation des surfaces

- Les surfaces doivent être propres, exemptes de poussière, de graisse ou de particules non adhérentes.

Conseil d'application

- **Mode d'application :** Le brossage doux est préférable. Remplissez soigneusement les cavités ou défauts afin d'éviter les discontinuités. Essuyer le surplus de matériau de revêtement des cavités.
- Nombre de couches: **1 couche**
- Temps de séchage final: **Minimum 1 jour**
- Lavage des matériaux de brossage: **Acétate d'éthyle, white spirit**

Recommandation générale

- Lavage des matériaux de brossage: Acétate d'éthyle, white spirit
- Garder hors de la portée des enfants
- Éviter tout contact direct avec la peau et les yeux. Ne pas ingérer.
- Travailler dans un environnement aéré.



- **Inflammable: Tenir à l'écart des flammes nues ou des objets chauds**

Italiano

Il prodotto, sviluppato nell'ambito del progetto B-IMPACT (M.ERA-Net), è una formulazione di rivestimenti a base di una miscela di polimeri fluoroacrilato e metacrilato modificato con silani in una miscela di solventi organici. Il rivestimento applicato sulla superficie di un bronzo quaternario (Cu-Sn-Pb-Zn) possiede grandi proprietà anti-corrosione con forte adesione al substrato in bronzo. Presenta proprietà di idrorepellenza e oleorepellenza per ridurre al minimo l'adesione di sporco.

Conservazione del prodotto

Importante: Conservare in contenitori sigillati in vetro o plastica a temperature inferiori a 23 ° C.

Preparazione della superficie

Le superfici devono essere pulite, senza polvere o particelle non aderenti

Suggerimenti per l' applicazione del prodotto

- **Modalità di Applicazione:** Preferibilmente mediante pennellatura morbida. Riempire con cura le cavità o i difetti superficiali presenti, per evitare discontinuità nel film. Ripulire il materiale di rivestimento in eccesso dalle cavità.
- **Numero di strati:** 1 strato.
- **Tempo per l'asciugatura finale:** Almeno 1 giorno
- **Lavaggio del materiale utilizzato per l'applicazione:** etilacetato, acquaragia.

Raccomandazioni finali

- Tener lontano dalla portata dei bambini
- Evitare il contatto diretto con pelle ed occhi. Non ingerire.
- Utilizzare in ambiente aerato.



Infiammabile: tenere lontano da fiamme libere o oggetti caldi.

Slovensko

Izdelek, ki je bil razvit v okviru projekta B-IMPACT (M.ERA-NET), je premaz na osnovi zmesi fluoroakrilatnega ter s silanom modificiranega metakrilatnega kopolimera v mešanici organskih topil. Prevleka na površini zlitin tradicionalnega bronu zagotavlja učinkovito protikorozijsko zaščito z močno adhezijo na bronasto podlago, hkrati pa izkazuje hidrofobne in oleofobne lastnosti, ki preprečujejo oprijem nečistoč.

Hranjenje izdelka

Pomembno: Hraniti premaz v zrakotesni embalaži pri temperaturi pod 23 °C.

Nasveti za pripravo površine

- Površine morajo biti čiste, brez prašnih ali drugih neoprijetih delcev

Nasveti za uporabo

- Način uporabe: **Nanaša se z mehkim čopičem. Potrebno je skrbno zapolniti vse vdolbinice, da je celotna površina prekrita s prevleko. Iz vdolbinic je nujno odstraniti odvečen premaz.**
- Število slojev: **1 sloj.**
- Čas za končno sušenje: **Vsaj 1 dan.**
- Čiščenje čopiča (materiala za nanašanje): **Etil acetat, white spirit**

Splošna priporočila

- Hraniti izven dosega otrok
- Izogibati se neposrednemu stiku s kožo in očmi. Ne zaužiti.
- Uporabljati v prezračevanem okolju.
- Vnetljivo! Ne uporabljaj v bližini odprtega plamena ali vročih predmetov!

3. Guideline for Coating Application on Black Patinated Modern Bronze

English

The product, developed within the B-IMPACT project (M.ERA-Net), provides a coating with high protectiveness against the corrosion of bronze monuments exposed outdoors. It is based on silane polymers dispersed in a non-toxic solvent and is suitable for application on rough surfaces and on artificially patinated black surfaces. The product is easily applicable by brush or spray.

Product conservation

Important: Store the coating formulation at 4 °C (refrigerator)

Surface Preparation Tips

- Surfaces must be clean, without dust or non-adherent particles.
- On new adherent patinated bronzes, the product can be applied without any additional preparation.

➔ **On black patinated bronze the product has to be applied at room temperature.**

Shake before the use.

Application Tips

Application mode: **Shake before the use. Apply the product at room temperature. Both soft brushing and spraying are adequate. Carefully fill cavities or defects in order to avoid discontinuities. Light heating by hair-dryer will help curing (temperature < 60°C).**

- Number of layers: **2 layers are sufficient. Increasing the number of layers (thickness of the coating), the protective efficiency of the coating will increase.**
- Time of drying between each application layer: **6 hours minimum – drying time can be shortened by light heating application (<60°C)**
- Time for final drying: **At least 1 day;**
- Washing brushing materials: **Ethyl alcohol (ethanol)**

General recommendation

- Keep out of reach of children
- Avoid direct contact with skin and eyes. Do not ingest.
- Work under aerated environment.

Français

Le produit, développé dans le cadre du projet B-IMPACT (M.ERA-Net), est un revêtement hautement protecteur contre la corrosion des monuments en bronze exposés à l'extérieur. Son constituant de base est formé par des polymères de silane dispersés dans un solvant non toxique. Il convient pour une application sur des surfaces rugueuses et artificiellement patinées, notamment sur des surfaces noires. Le produit est facilement applicable à la brosse ou au pistolet.

Conservation du produit

Important: La formulation du revêtement est à conserver à une température de 4°C (au frigidaire)

Conseil de préparation des surfaces

- Les surfaces doivent être propres et exemptes de poussières et de particules non adhérentes
- Pour les bronzes nouvellement patinés, le produit peut être appliqué sans préparation

→ le revêtement doit être appliqué sur la patine noire du bronze à température ambiante. Bien agiter avant emploi.

Conseil d'application

- Mode d'application : **Bien agiter avant emploi. Appliquer le produit à température ambiante au pinceau ou par pulvérisation.** Il est recommandé d'éviter toute discontinuité du revêtement en veillant à remplir les espaces creux (porosités...). **Un chauffage léger (par sèche-cheveux par exemple) aide au durcissement (température <60 ° C)**
- Nombre de couches: **2 couches sont suffisantes. En augmentant le nombre de couches (épaisseur du revêtement), le rendement protecteur du revêtement augmentera.**
- Temps de séchage entre chaque couche d'application: **6 heures minimum - le temps de séchage peut être raccourci grâce à un léger chauffage (<60 ° C) de la surface**
- Temps de séchage final: **Au moins 1 jour**
- Lavage des matériaux de brossage: **Alcool éthylique (éthanol)**

Recommandation générale

- Garder hors de portée des enfants
- Éviter tout contact direct avec la peau et les yeux. Ne pas ingérer.
- Travailler dans un environnement aéré

Italiano

Il prodotto, sviluppato nell'ambito del progetto B-IMPACT (M-era-Net), permette di ottenere rivestimenti per opere in bronzo esposte all'aperto, dotati di elevata protettività contro i fenomeni di corrosione. Questo prodotto, basato su polimeri silanici dispersi in solvente non tossico, è adatto per l'applicazione su superfici rugose e superfici nere patinate. Il prodotto è facilmente applicabile sia a pennello che a spruzzo.

Conservazione del prodotto

Importante: Conservare la formulazione a 4 ° C (ad esempio in frigorifero)

Preparazione della superficie

- Le superfici devono essere pulite, senza polvere o particelle non aderenti.
- **Su nuove sculture in bronzo con patine aderenti, il prodotto può essere applicato senza alcuna preparazione ulteriore.**

→ **Su bronzo nero patinato il prodotto deve essere applicato a temperatura ambiente. Agitare prima dell'uso.**

Suggerimenti per l' applicazione del prodotto

- Modalità di Applicazione: **Agitare prima dell'uso. Applicare il prodotto a temperatura ambiente. Sia la pennellatura che la spruzzatura sono adeguati. Riempire con cura le cavità o i difetti superficiali eventualmente presenti, per evitare discontinuità nel film. Un leggero riscaldamento dopo l'applicazione (con asciugacapelli, temperatura < 60 ° C) contribuirà a migliorare la reticolazione.**
- Numero di strati: **2 strati sono sufficienti. Aumentando il numero degli strati (spessore del rivestimento), si migliorerà l'efficacia protettiva del rivestimento.**
- Tempo di asciugatura tra le applicazioni: **almeno 6 ore – il tempo di asciugatura può essere ridotto grazie a riscaldamento leggero (<60°C)**
- Tempo per l'asciugatura finale: **Almeno 1 giorno**
- Lavaggio del materiale utilizzato per l'applicazione: **Alcol etilico (etanolo)**

Raccomandazioni finali

- Tenere fuori dalla portata dei bambini
- Evitare il contatto diretto con la pelle e gli occhi. Non ingerire.
- Applicare in ambiente aerato

Slovensko

Proizvod, ki je bil razvit v okviru projekta B-IMPACT (M-ERA.NET) je prevleka, ki zagotavlja visoko protikorozijsko zaščito izpostavljenih bronastih spomenikov, izpostavljenih na prostem. Temelji na silanovih polimerih, dispergiranih v nestrupenih topilih in je primerna za uporabo na grobih in umetno patiniranih črnih površinah. Prevleka se enostavno nanaša s čopičem ali pršenjem.

Hranjenje proizvoda

Pomembno: Proizvod hranite pri temperaturi 4 °C (v hladilniku).

Nasveti za pripravo površine

- Površine morajo biti čiste, brez prašnih ali drugih neoprijetih delcev.
- Na novih oprijemljivih patiniranih bronih proizvod lahko uporabljate brez dodatne priprave površine.

→ Na črno patiniran bron nanašajte proizvod pri sobni temperaturi. Pretresite pred uporabo.

Nasveti za uporabo

- Način uporabe: **Pretresite pred uporabo. Proizvod nanašajte pri sobni temperaturi. Zadostuje nežno ščetkanje, vendar je potrebno skrbno zapolniti vse vdolbinice, da je prevleka prisotna na celotni površini. Nežno segrevanje s sušilcem za lase bo olajšalo sušenje (temperatura < 60 °C).**
- Število slojev: **Zadoščata 2 sloja.**
- Čas sušenja med posameznimi sloji: **najmanj 6 ur - čas sušenja se lahko skrajša z nežnim segrevanjem (< 60 °C).**
- Čas za končno sušenje: **Vsaj 1 dan.**
- Čiščenje čopiča (materiala za nanašanje): **Etilni alkohol (etanol).**

Splošna priporočila

- Hranite izven dosega otrok.
- Izogibajte se neposrednemu stiku s kožo in očmi. Ne zaužijte.
- Uporabljajte v prezračevanem okolju.

Annex 1

List of professional end-users involved in the testing of selected coating for black patinated modern bronze. Application of the coating was tested according to these Guidelines.

Partner	End-user	End-user type	Country	e-mail address	Full address	Telephone (mobile) number
S-ZAG	Livartis d.o.o.	Art foundry	Slovenia	info@livartis.si	Volavlje 13, 1000 Ljubljana, Slovenia	+386 41 662 934
S-ZAG	Akademski kipar Mirko Bratuša, s.p.	Sculptor	Slovenia	mirko.bratusa@guest.arnes.si	Lokarje 31 C, 1217 Vodice	+386 41 692 516
F-TOU	FONDERIE DE BRONZE LAURAGAISE	Art foundry	France	nicolas.parc@fonderie-lauragaise.com clarisse.fabre@fonderie-lauragaise.com	9 rue clos des Rieux 81 700 BLAN - FRANCE	+33 (0)5 63 75 22 86 / + 33 (0)6 86 20 20 00
F-TOU	Anne-Marie GEFFROY	Restorer	France	amgeffroy@yahoo.fr	11 rue de la Verrerie 44100 Nantes	+33 06 68 09 10 70
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ITALY	Archè Restauri Snc	Restorer	Italy	archerestauri@libero.it	VIA Chiavari 18/A 43100 Parma	+39 0521 293430