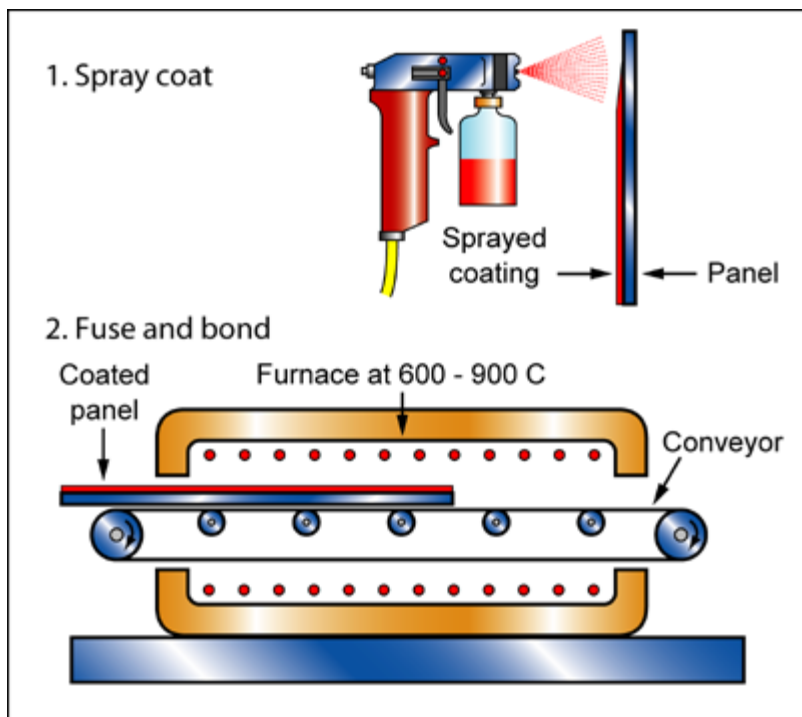


## Description

### Process schematic



**Figure caption**

Enameling

### The process

ENAMELLING is painting with glass. The enameled masks of the Pharaohs of Egypt look as bright, vibrant and perfect today as they did when they were created over 3000 years ago (Tutankhamen, BC 1358 - 1340). A thin layer of glass powder with binder and coloring agent is applied to the object to be enameled by painting or screen printing; the layer is then fused to the object, generally made of cast iron, pressed steel, copper, silver or even - in the case of Tutankhamen - of gold, creating a continuous, strongly-bonded coating of colored glass. It is a hot process - the object being enameled must be heated to the melting temperature of the glass powder - limiting it to use on metals and ceramics.

### Material compatibility

Ceramics	✓
Glasses	✓
Metals - ferrous	✓
Metals - non-ferrous	✓
Polymers - thermoplastics	✓

### Function of treatment

Corrosion protection (aqueous)	✓
Corrosion protection (gases)	✓
Corrosion protection (organics)	✓
Wear resistance	✓
Thermal insulation	✓

Electrical insulation	✓
Decoration	✓
Color	✓
Reflectivity	✓

### Economic compatibility

Relative tooling cost	low
Relative equipment cost	medium
Labor intensity	medium

### Physical and quality attributes

Surface roughness (A=v. smooth)	A
Curved surface coverage	Good
Coating thickness	19.7 - 39.4 mil
Surface hardness	430 - 550 Vickers
Processing temperature	1.12e3 - 1.66e3 °F

### Process characteristics

Discrete	✓
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### Supporting information

#### Design guidelines

Enamel coatings have exceptional hardness, wear and corrosion resistance, and can be made in an unlimited range of colors.

#### Technical notes

The glass used for enameling must flow easily, wet and bond to the metal surface, and have an expansion coefficient that differs only slightly from that of the underlying metal. This is achieved by using a glass rich in boric oxide (up to 35%), which also yields strong bonds and lustrous colors. In practice enameling usually marries two different kinds of glass: the base coat includes cobalt and nickel oxides, which help to form a strong bond with the metal; the second coat carries color and decoration. The result is extremely durable coating that is able to withstand thermal shock.

#### Typical uses

In the home: baths, washing machines, dishwashers, heaters, stovetops, fireplaces, gas and electric cookers, clock faces and cook ware. In places you can't see: hot water services, storage tanks, car exhaust systems, printed circuits and heat exchangers. In places you can see: street signs, railway signs and murals. In the building industry: interior and exterior architectural panels, fascias, spandrels and partitions.

#### The economics

Enameling is not cheap - it is both slow and energy intensive. Its choice relies on the balance between quality and cost - its durability and aesthetic qualities are unequalled.

#### The environment

The process requires high temperatures, but is otherwise environmentally benign. Enameled surfaces are easily cleaned (even graffiti can be removed without damage), scratch resistant and exceptionally hygienic.

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## Links

MaterialUniverse

Reference

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