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<th>Title</th>
<th>TMS: Thermal metal spray coatings</th>
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Executive summary

This report has been prepared as an outcome of discussions within the Institute of Corrosion’s Corrosion Engineering Division (CED) Coatings Working Group where it was agreed to produce a number of technical guidance documents and make them available through the members’ area of the Institute of Corrosion website. This document is intended to give a brief insight into Thermal Metal Spray coatings. The document seeks to address the basic questions regarding the nature of thermal metal spraying, the surface preparation required, the types of metal spray available, spray application methodologies, specific characteristics of thermal metal spray (including water permeability), when, where and why thermal metal spraying might be used, whether it can be used without the addition of organic coatings, where thermal metal spray might not be recommended and where the user can obtain further advice regarding thermal metal spraying.
## Contents

1 Introduction  
   1.1 Context and definition  
   1.2 Process of thermal metal spraying  
   1.3 Surface preparation standards  

2 Methods for applying thermal metal spray coatings  
   2.1 Flame spray  
   2.2 Arc spray  

3 Properties  
   3.1 Permeability of thermal metal spray to water  
   3.2 Abrasion resistance  
   3.3 Galvanic protection  
   3.4 Longevity  

4 Use of thermal spray coatings  
   4.1 Without the addition of organic coatings  
   4.2 Situations where metal spray systems are not recommended  
   4.3 Duplex system  

5 References  
   5.1 Standards  
   5.2 Further information  

6 Acknowledgements
1 Introduction

1.1 Context and definition

Thermal metal spraying is a process in which coiled metal wire is melted and, by various methods, fired onto a suitably prepared substrate surface according to the standard EN/ISO 2063. Most commonly the metals sprayed are zinc and aluminium. The types of metal spray can be quite extensive but can be broken down into two main categories:

- Protective coatings used for their anti-corrosive properties
- Engineering coatings such as wear resistant and thermal barrier coatings.

Thermal spraying is carried out in a wide range of anti-corrosion and engineering markets, which include oil and gas, construction, petrochemical and marine, and rail infrastructure. The benefits of thermal spraying are the lack of heat input to the steel, thereby minimising potential distortion, and the fact that products of any size can be coated.

1.2 Process of thermal metal spraying

Thermal spraying involves the projection of small molten particles onto a prepared surface where they adhere and form a continuous coating. To create the molten particles, a heat source, a spray material and an atomisation/projection method are required. Upon contact, the particles flatten onto the surface, freeze and mechanically bond, firstly onto the roughened substrate and then onto each other as the coating thickness is increased.

As the heat energy in the molten particles is small relative to the size of the sprayed component, the process imparts very little heat to the substrate.

As the temperature increase of the coated parts is minimal, heat distortion of the steel is not normally experienced.

1.3 Surface preparation standards

A suitably prepared substrate surface is one that has been blast cleaned to enable the thermally sprayed metal to satisfactorily bond to the substrate. BS EN ISO 8501.1 - SA 2.5 and SA3 provide acceptable standards for thermally sprayed zinc and aluminium; however SA 3 will give the best adhesion, especially with flame-sprayed aluminium.

2 Methods for applying thermal metal spray coatings

For normal corrosion protection purposes, coatings are applied by flame spray or arc spray. These processes are detailed below.

2.1 Flame spray

In the flame spray process a wire (e.g. aluminium or zinc) is fed by a driven roller system through the centre of an oxy-fuel gas flame where it is melted. An annular air nozzle then applies a jet of high-pressure air, which atomises and projects the molten material on to the steel surface. The aluminium coating acts as a corrosion protection barrier coating. Flame-sprayed zinc, which is predominantly used on new steel structures, provides both barrier and sacrificial protection. Zn/Al and Al coatings can be used; Zn or Zn/Al is typically used for urban areas, whereas Al is often specified for saline/coastal areas and splash zones. The flame spray process is generally agreed to be slower to apply than the arc spray method but it is still a common method used for application to steelwork.
2.2 Arc spray

In the arc spray process, two electrically charged wires are driven and guided so that they converge at a point and form an arc. An air nozzle atomises the molten metal produced and projects it towards the work piece. The driving of the wires typically employs either an air motor or electric motor and gearbox arrangement. Typically defined as a corrosion protection barrier coating, arc sprayed Zn/Al has a bond strength that is approximately 2.5 times higher than flame sprayed aluminium. As with flame spray Zn, Zn/Al and Al can be used. This application process is predominantly used on new steel structures and it is generally agreed that it is quicker to apply than the flame spray method.

3 Properties

3.1 Permeability of thermal metal spray coatings to water

There is a general perception that a thermal metal spray (TMS) coating is permeable. This is in fact the case because when it has been applied the coating is not homogenous and there are a considerable number of vacuoles in the coating. To overcome this, the metal spray is often used as part of a duplex system (see Section 4.1).

3.2 Abrasion resistance

Thermal metal spray coatings are relatively hard with a degree of malleability. Therefore they have good abrasion resistance.

3.3 Galvanic protection

Zinc and aluminium thermal spray coatings are anodic to steel (albeit to different degrees) and therefore they offer cathodic protection to the underlying metal. Zinc is normally more effective in this respect than aluminium.

3.4 Longevity

When combined with organic paints the resultant system has been proven to provide excellent longevity properties, exceeding those of paint systems alone, although there is no real data to indicate the level of improvement. The life of thermal metal spray coatings has in some cases been extended by fixing suitable sacrificial anodes to the thermally metal sprayed structure. Specialist advice is recommended with respect to this approach.

4 Use of thermal spray coatings

4.1 Without the addition of organic coatings

Unsealed thermal metal spray coatings have been used where there is no requirement to provide a colour coating on the structure. In these circumstances the thickness of the thermal metal spray has been increased. Exposure to the atmosphere causes the voids in the coating to close up because of the formation of zinc or aluminium oxides.

4.2 Situations where metal spray systems are not recommended

Applications of TMS coatings are varied but they tend to be used for large solid objects, including wind turbine towers, bridges and boats. It has been found that on bridges where road salting for de-icing is frequently carried out in the winter months, the salt can permeate its way through any breaches in the coating system. These breaches can be chips in the paintwork caused by roadstones from passing cars, joints in the deck, and/or holidays within the coating system. Where the system is breached considerable coating breakdown can occur. This could also occur where there is a possibility of tidal sea water splashes at coastal locations. In general, metal spray systems should not be used on open or lattice-like structures.
4.3 Duplex system

The general view is now that thermally sprayed coatings should not be used as part of a duplex system. Rather, a thermally sprayed coating with a thin organic sealant is the generally preferred option with a life to first maintenance of 20 years being achievable.

5 References

5.1 Standards

EN/ISO 2063: 2005 - Thermal spraying -- Metallic and other inorganic coatings -- Zinc, aluminium and their alloys


5.2 Further information

For further information the Thermal Spraying and Surface Engineering Association can be contacted at http://www.tssea.co.uk/

6 Acknowledgements

The original version of this document was authored by Ray Peters. The present version contains further contributions from Desmond Makepeace (Elcometer Ltd), Martin Hilliard, Stuart Milton (Association of Metallisation) and Colin Arrow (Association of Metallisation).