

# TECHNICAL SPECIFICATION FOR ZINC ALUMINIUM METALLISATION OF STRUCTURAL STEEL

1. **General:** It is considered that Zn-Al alloy possesses the advantage of both Al and Zn, making it a good coating material for corrosion protection. A sacrificial layer of metal e.g. zinc alloy is provided on the surface of the parent metal. This layer is lost due to corrosive action, microbial attack, acidic/ alkaline attacks, while the base metal (steel) remains unaffected. There is only one layer of Zn-Al coating followed by sealer coat.

## 2. Scope:

This specification covers equipment requirements, qualification of the equipment, quality control in-charge, operator, surface preparation, methodology for zinc metallization, sealer coating, maintenance of coated layer, retreatment of defective areas, Test and documentation, safety precautions and welding procedure of zinc- aluminium coated structural steel.

## 3. Highly Corrosive Areas

The said bridge is in high corrosion zone and this treatment has been recommended.

## 4. Introduction

In metallized protection, a sacrificial layer of metal e.g. Zinc-Aluminum alloy (Zinc 85%-Al 15%) is provided on the surface of the parent metal. This layer is lost due to corrosive action, microbial attack, acidic/ alkaline attacks, while the base metal remains unaffected. Zinc- Aluminum alloy in the form of pre alloyed wires is fed into electric arc spray equipment and the molten metal is atomized in a stream of compressed air and sprayed on to the previously prepared surface.

## 5. Qualification and Equipment Requirements

The following equipments are recommended for spraying:

- i. Abrasive Blasting Equipment
- ii. Electric arc spraying equipment (refer figure 1) with pistol or gun
  - Arc Wire (Feedstock material)
  - DC Power Supply
  - Power supply
  - Contact post
  - Contact tube
  - Contact tip
- iii. Necessary Safety Equipment
- iv. List of equipments for localized work: Portable equipments for conducting in-situ work.

5.1 **Qualification of the equipment:** The contractor shall provide blasting and spraying equipment and ancillary equipment which is fit for the purpose. The continued proper functioning of the equipment shall be proven through inspection reports or results of successfully applied tests as per standard. The contractor is also responsible for providing an adequate calibration and validation of the instruments for measuring, testing and for supervision. The results of the tests, calibration and maintenance shall be documented.

5.2 **Qualification of the Quality control in-charge:** The manufacturer of the sprayed coating shall employ qualified **Quality control in-charge** having minimum 24 months of cumulative

experience over the last five years with application or inspection of sprayed coating and minimum certification required shall be NACE CIP Level II or higher.

**5.3 Qualification of the Operator:** Each operator shall meet the following requirements:

- i). Bend test shall be performed in accordance with para 10.1.
- ii) He must demonstrate the knowledge of how to verify the correct feedstock, load the Zn/Al alloy wire, operate the coating equipment, blast cleaning process, spray techniques etc.

**6. Surface Preparation**

All the steel surfaces in contact with the concrete for composite action shall be masked as it shall not be metallized. The masking material shall withstand the cleaning solvents and grit and the hot spraying particles when metallizing.

6.1 The adherence of electric arc sprayed coatings to the base depends upon mechanical interlocking of the first layer to the interstices of the roughened surface. For attaining a high degree of adhesion, careful attention should be paid to the surface preparation.

**6.2 Cleaning Prior to Abrasive Blasting –**

Grease, paint and other foreign matter should be removed from the area to be sprayed as well as the adjoining areas. If these are not removed from the surface prior to grit blasting, they may contaminate the grit. On recirculation of the grit, the surface may be re-contaminated, and this will prevent attainment of the required standard of surface cleanliness.

6.3 A chemical solvent such as Petroleum Hydrocarbon Solvent to Low Aromatic Grade 145/205 to IS: 1745-1978, Acetone or MDC or any other suitable solvent or a combination of solvent cleaning and heating should be employed to remove oil or grease and cleaning the metal surfaces prior to blasting.

6.4 Blasting with abrasive material shall be adopted for removing all existing corrosion and foreign material.

**6.5 Abrasives for Blasting**

**6.5.1** Crushed steel grit / Copper slag is most commonly used where the abrasive may be reclaimed. Round steel shot or rounded grit should never be used. Aluminum oxide is also used where it may be reclaimed. All abrasives should be clean, dry and free from oil or other contamination.

**6.5.2 Sizes:**

- a. Chilled iron grit- Grit Grade G-C 100 to G-C 42 as per IS: 4683 shall be used.
- b. Aluminum oxide – The grain size should be between 300 microns and 850 microns; a minimum of 40% should be retained on a 425microns IS Sieve.

**6.6 Blasting Method:-**

**6.6.1** Common blasting methods in use for metal spraying are pressures blasting and centrifugal blasting (airless blasting). Blasting method shall be in accordance with IS: 6586.

While pressure blasting is suitable for manual or mechanized operation, centrifugal blasting is used only as a mechanized system. After blasting it shall have a uniform metallic colour and correspond in appearance to prints designate Sa 2½ in IS: 9954 - 1981 i.e. near white metallic surface. The standard of cleanliness and surface roughness as prescribed in IS: 5905-1989 should be maintained. Pictorial comparison may also be referred with ISO 8501.

6.7 The final surface roughness achieved shall be comparable to roughness with a reference surface produced in accordance with Annex A of IS: 5905 and shall provide an adequate key for subsequently sprayed metal

## **7. ZINC METALLIZATION:**

- 7.1 The layer of the coating must be applied within 4 hours of blasting and the surface must be finished to the specified thickness within 8 hours of blasting.
- 7.2 Uniform thermal spray with Zn-Al (85%-15%) alloy wire of suitable dia. to ISO 14919 purity 84% to 86% (Zinc) and 14% to 16% (Aluminium) is given with a spray gun. Zinc alloy wire is fed into Electric arc just inside the nozzle of the spraying gun. Compressed air is admitted into the nozzle to atomize the metal and to force it against the surface to be coated. The advantage of coating metal by this method is that thickness of the sprayed film can be controlled. The nominal thickness of the coating shall be 150 microns. The minimum local thickness at any point shall not be less than 75% of the specified nominal thickness. On this basis the minimum local thickness stipulated is as 115 microns. Further, minimum local thickness should not be less than the nominal thickness in all but one of the measurement point of the test location (i.e. 1 out of 6 points mentioned as in Annexure A).
- 7.3 The operating conditions, such as wire speed, voltage, electric power etc. as recommended by the manufacturer of the thermal spray equipment should be strictly adhered to. The practice of increasing spraying rates over those recommended, by increasing currents, should be avoided as this may lead to poor results.
- 7.4 The specified thickness of coating shall be applied to build 85%Zn-15%Al coating thickness as per specifications. The surface after spraying shall be free from uncoated parts or lumps of loosely spattered metal. If upon later inspection and prior to sealer application, 85%Zn-15%Al coating thickness is less than the specified thickness, the operator shall apply additional 85%Zn-15%Al coating to meet the requirement

## **7.5 SPRAYING:**

The metal spraying should be carried out without delay after the surface has been prepared by suitable grit blasting, but in any case within such period that the metal is sprayed on to a surface which is still completely clean, dry and without visible oxidation. If deterioration in the surface to be coated is observed by comparison with a freshly prepared metal surface of similar quality, which has undergone the same preparation, the preparation treatment shall be repeated on surface to be coated. Further, after blasting, dust and small shot particles may adhere to the steel surface shall be removed before metallization with compressed air if required.

- 7.6 **Purity of Zinc Aluminium Alloy:** The purity of the Zinc-Aluminium alloy must conform to ASTM B 833 or ISO 14919: 2015. Chemical composition test shall be conducted for supply of each lot received by manufacturer or whenever purchaser/inspecting agency considers it necessary.
- 7.7 **Spraying Procedure:** Procedure followed should be strictly in accordance to as specified in IS 6586-1972. All the safety precautions shall be observed.
- 7.8 **Adhesion:** The sprayed metal coating shall be subjected to an adhesion test as given in clause 10.2.2 below.

## **8 SEALER COAT OVER METALLISED STEEL SURFACE:**

After metalizing, steel surfaces shall be sealed with a sealer coat as per ISO 2063-2 as follows:

- 8.1 Immediately but not later than 4 to 6 hours of zinc alloy (Zn 85%- Al 15%) metallization, Sealer coat shall be applied uniformly over metallised surface by automated spraying. Sealer material is intended to seal any porosity/ capillary action to impart a smooth uniform surface over metallization. Though it possesses corrosion inhibiting properties, it does not work as a permanent protective coating by itself. Sealer should be applied evenly until no more is absorbed. Thickness of the sealer coating shall be about 5-10 microns but not less than 5 microns.

- 8.2 A suitable sealer with low viscosity such as phenolic resin or a vinyl formulation can be applied. Sealer should be applied evenly until no more is absorbed. The thickness of the sealer coat should be about 5 -10 microns but not less than 5 microns. Sealants based on alkyd resins should not be applied to zinc and zinc alloys. The application of sealer should be followed as per the Supplier manual. Sealer coat material manufacturers shall provide certification that their sealer is compatible with the Thermal Spray Coating and service environment.
- 8.3 It should be ensured that the sealer coat must properly dry up before moving the fabricated steel as any physical movement can damage sealer coat layer.
- 8.4 The total dry film thickness of all coats is about 155-160 microns (150 micron for coating and 5-10 microns for sealer coat).

## **9 Repair of damaged coating**

### **9.1 Localized damage**

Localized damage occurred during loading, unloading, handling and erection shall be repaired with a fresh coat. All the removal of previously applied coating around the damaged portions shall be as per Clause 12.8

**10 Tests and Documentation:** Record of all the tests will be maintained as per Annexure B.

### **10.1 Qualifying Criteria test:**

**10.1.1 Salt Spray Test:** Salt spray test shall be conducted as per ASTM B117 on the final product i.e. after Zn-AL alloy metallisation and sealer application. After 30 days exposure it should not show any brown rust on the finished surface. Test may be conducted at any National Test House (NTH)/ accredited test laboratories. If there is any major change/modification in process or use of Zn-Al alloy or sealer of a different make material or whenever purchaser considers it necessary on the basis of the results of the acceptance tests stipulated in this specification, the test will be conducted again.

### **10.2 Acceptance test**

**10.2.1 Determination of thickness:** Thickness shall be measured by the commercially available Elcometer. The method adopted shall be in accordance to IS: 3203- 1982.

#### **10.2.2 Adhesion test:**

The Zn 85%-Al 15% coating layer tensile bond (Pull of strength) shall be measured according to ASTM D4541 using a self-aligning adhesion tester or approved equivalent. Minimum Tensile Bond (Pull of strength) Requirements

(According to ASTM D 4541 using self-aligning adhesion tester)

Feedstock	MPa
85/15 Zn/Al	4.83

**10.2.3 Visual Inspection/Appearance:** The surface of the sprayed coating should be of uniform texture and free from lumps, coarse area and loosely adhered particles. The surface coating should not be flaked or delaminated.

### **10.3 Documentation:**

Documentation shall be provided by the manufacturer. It shall also contain the test results. Furthermore, designations of the parts, tracing back of the operation steps and quality assurance documents (e.g. work instructions, test instructions and reports, technical data sheets of the blasting grit, the spray material, other coating materials) are to be kept. Reports of maintenance and repair works shall be also documented.

## 11. RETREATMENT OF DEFECTIVE AREAS:

Any defective area shall be cleaned of all sprayed metal by blasting and re-prepared to confirm the requirement the clause 6, surface preparation. Where the defect has been solely due to, too thin coating, sprayed metal of same quality may be added, provided that the surface has been kept dry and is free from visible contamination.

## 12. SAFETY PRECAUTIONS

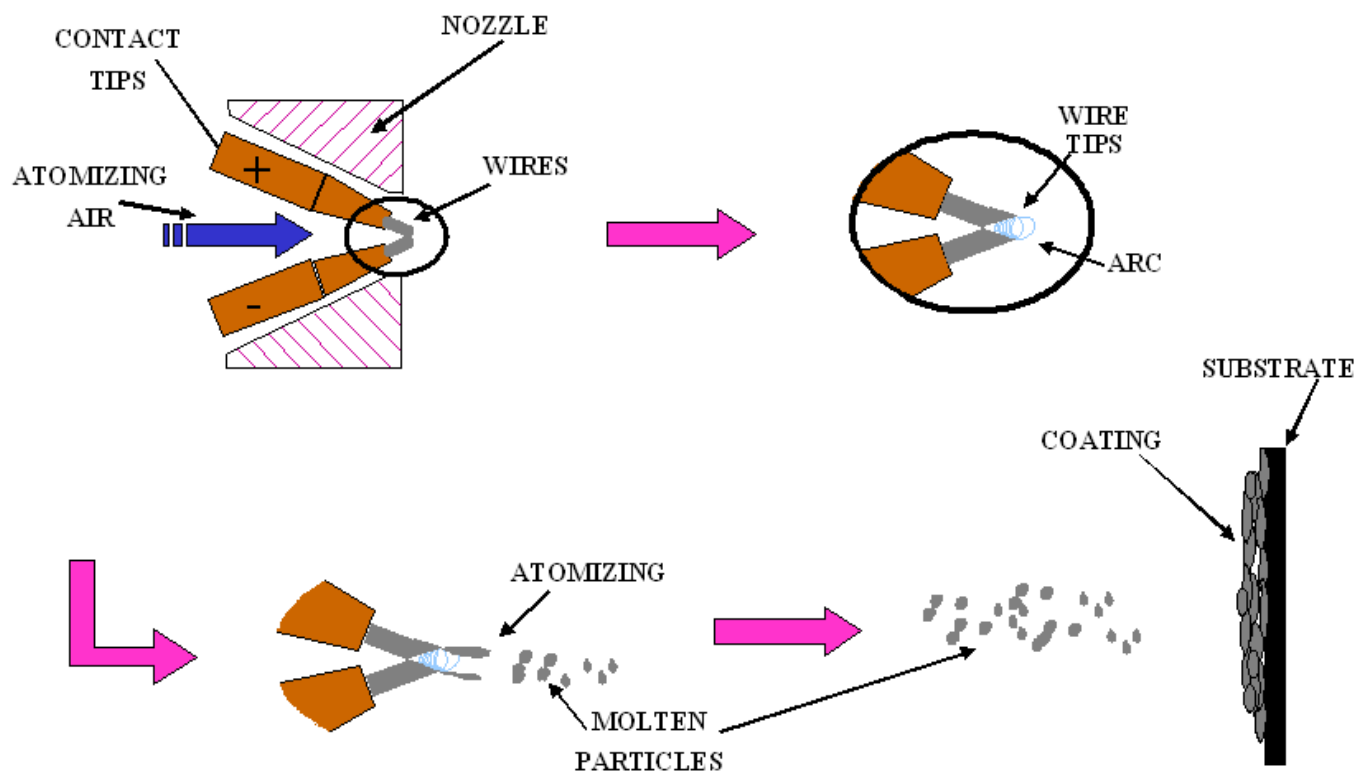
- 12.1 The normal precautions against fumes and dust hazards, such as wearing of mask and proper ventilation should be observed.
- 12.2 Any warning printed on containers by the sealer material manufacturers should be observed and the user should consult him in all cases of doubt regarding health and fire hazards arising from the product. Safety precautions specified by equipment manufacturers is strictly adhered to.
- 12.3 Blast cleaning, METALLIZING and sealer operation should be carried out in dry weather conditions, sealing should not be done during damp and rainy weather without prior approval of Engineer in charge of work
- 12.4 Spray coating should be applied without any undue delay and contamination of sprayed surfaces with oil, grease, dirt should be removed before application of sealer coat.
- 12.5 Sealers have to be used to fill coating pores so that the metallic coating and steel substrate can be protected from corrosive reagents or damaging environment such as sea water, steam, dilute acids, corrosive gases etc.
- 12.6 Adequate precaution should be taken for operators' safety, particularly during grit blasting and Zinc Aluminium alloy (Zinc 85%-Al 15%) spraying.
- 12.7 The normal precautions against fumes and dust hazards, such as wearing of mask and proper ventilation should be observed. No special danger arises during the Zinc Aluminium alloy (Zinc 85%-Al 15%) spraying (If wearing proper PPE). Indian standard IS 9623 may also be referred for selection, use and maintenance of respiratory protective devices.

## WELDING PROCEDURE OF ZINC- ALUMINIUM COATED STEEL

- 1. **Coating removal:** Coating removal is essential for sound welds. The coating removal for welding of Zn – Al coated steel is considered moderate. Coating needs to be physically removed via abrasion (40 Grit) abrasives.
  - 1.1 **Suitable tools:**
    - 1.1.1 40 Grit Flap disc fitted to an angle grinder.
    - 1.1.2 40 Grit Sanding belt fitted to a suitable tool (useful for under foot areas).
  - 1.2 Coating must be removed for a minimum of 150mm each end of rails before welding (AT welding). Avoid coating entrapment in weld – weakens weld.
  - 1.3 **For depot/mobile flash butt welding** - Coating removal is not required from electrode and clamp contact areas (foot/web) as Good electrical contact is retained. Coating does not lead to slippage of clamps.
  - 1.4 **Coating removal test:** To verify spread - spray copper sulphate solution (blue) onto cleaned area. Copper colour indicates effective coating removal.
  - 1.5 Black indicates incomplete removal - Repeat cleaning and re-test.
  - 1.6 After testing all copper colour must be removed (Abrasion), prior to welding.
- 2. **Portable Coating equipment:** After welding, the coating shall be done on complete removed coated length i.e. 150mm on each end and welding length by Flame Arc coating machine or spray bottle or brush.

- 3. Precautions during welding:** During coating removal the following PPE should be worn by operators in the vicinity of coating removal operations:
- 3.1 Dust mask to IS 9623 or EN149: FFP2S or FFP3S
  - 3.2 Eye protection (goggles)
  - 3.3 Gloves (suitable for hand tool being used)
  - 3.4 Hearing protection (if applicable for hand tool usage)

FIGURE 1: Electric arc spraying equipment



**List of codes referred:**

S. No.	Code No./Specification	Subject
1.	IS 4683:1968	Specification for Chilled Iron Shot and Grit for Use in foundries
2.	IS 5905-1989	Sprayed Aluminium and Zinc Coatings on Iron and Steel-Specification
3.	IS 9954-1981	Pictorial Surface Preparation Standards for Painting of Steel Surfaces
4.	ISO 2063-1:2019	Thermal spraying -- Zinc, aluminium and their alloys -- Part 1: Design considerations and quality requirements for corrosion protection systems
5.	ISO 2063-2	Thermal spraying -- Zinc, aluminium and their alloys -- Part 2: Execution of corrosion protection systems
6.	Technical requirements for hot dip galvanizing of low carbon steel metal liner to IS:2062	Technical requirements for hot dip galvanizing of low carbon steel metal liner to IS:2062 issued by RDSO vide letter no. CT/FD/2 dated 22.01.2009
7.	IS 3203-1982	Method for Testing Local Thickness of Electroplated coatings
8.	ISO 14919-2015	Specification for Thermal spraying Wires, rods and cords for flame and arc spraying - Classification - Technical supply conditions
9.	ASTM B 833	Standard Specification for Zinc and Zinc Alloy Wire for Thermal Spraying (Metallizing) for the Corrosion Protection of Steel.
10.	IS 6586-1989	Metal spraying for protection of iron and steel-recommended practice.
11.	ASTM D 4541	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
12.	NaceNo.12/AWSC2.23M/SSPC-CS 23.00	Specification for the application of thermal spray coatings (metallizing) of aluminum, zinc and their alloys and composites for the corrosion protection of steel.
13.	ISO 8501	Corrosion protection of Steel Structures by Painting
14.	ASTM B 117	Standard practice for Operating Salt Spray(Fog) Apparatus

## Annexure-A

## Metallization work

### Inspection and test results

Shift No.

Date.

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