

Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites



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ERRATA

The following corrections are for errors found in ANSI/AWS C2.18-93, *Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites*.

- 1) Page 4, Table 3B: Certain values in Table 3B are an order of magnitude small. Use the table below in place of Table 3B in the document.

Table 3B				
Nominal Feedstock Required Per ft²/0.001-in. (U.S. Customary Units)				
(Deposit Efficiency on a Flat Plate)				
Feedstock Material	Flame Spray		Arc Spray	
	Deposit Efficiency (%)	Material Required (lbs/ft ² /0.001 in.)	Deposit Efficiency (%)	Material Required (lbs/ft ² /0.001 in.)
Aluminum Wire	80-85	0.014	70-75	0.017
Aluminum Powder	85-90	0.014	NA	NA
Zinc Wire	65-70	0.050	60-65	0.054
Zinc Powder	85-90	0.039	NA	NA
85/15 Wire	85-90	0.036	70-75	0.049
90/10 MMC Wire	80-85	0.014	70-75	0.017

- 2) Page 17, "SAFETY PRECAUTION" box, last line: The reference to *OSHA Safety and Health Standards* should be **29 CFR 1910** and not **10 CFR 1910**.

Keywords — Aluminum, Aluminum Metal Matrix Composite, Arc Spray, Flame Spray, Steel Protection, Thermal Spray Coating, Zinc, Zinc/Aluminum Alloy

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Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and Their Alloys and Composites

Prepared by
AWS Committee on Thermal Spraying

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This guide presents an industrial process for the application of thermal spray coatings (TSC) on steel. It covers safety, job/contract description, background and requirements, selection of TSCs, TSC operator qualification, materials and equipment, application-process method with quality-control check points, Job Control Record, maintenance and repair of TSCs, records, debris containment and control, and warranty.



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Foreword

(This Foreword is not a part of ANSI/AWS C2.18-93, *Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and Their Alloys and Composites*, but is included for information purposes only.)

Thermal spray coatings (TSCs) are used extensively for the corrosion protection of steel and iron in a wide range of environments. The corrosion tests carried out by the American Welding Society¹ and the 34-year marine-atmosphere performance report of the LaQue Center for Corrosion Technology² confirm the effectiveness of flame sprayed aluminum and zinc coatings over long periods of time in a wide range of hostile environments. The British Standards Institution code of practice for the corrosion protection of steel³ specifies that only TSCs give protection greater than 20 years to first maintenance for the 19 industrial and marine environments considered and that only sealed, sprayed aluminum or zinc gives such protection in sea water immersion or splash zones.

The selection of a TSC depends on the desired service life, environmental envelope, operating duty and substrate-inspection cycle, and the maintenance and repair support provided during the life-cycle. This AWS guide summarizes the major elements to select, plan, and quality control (QC) the application of TSCs for the protection of steel. The information in this guide is formatted as an industrial process instruction (with fill-in blanks) to permit purchasers to analyze and specify their TSC requirements and process envelope and for Thermal Spray Coating Contractors (TSCCs) to add and subtract as necessary to match their production and quality capabilities and their customer requirements.

This document has been coordinated with the Zinc Metallizers Association.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Managing Director, Technical Services Division, American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

Official interpretations of any of the technical requirements of this standard may be obtained by sending a request, in writing, to the Managing Director, Technical Services Division, American Welding Society. A formal reply will be issued after it has been reviewed by the appropriate personnel following established procedures.

1. *Corrosion Tests of Flame-Sprayed Coated Steel, 19-Year Report*, American Welding Society C2.14-74. AWS publications available from American Welding Society, P.O. Box 351040, Miami, FL 33135.

2. R.M. Kain and E.A. Baker, *Marine Atmospheric Corrosion Museum Report on the Performance of Thermal Spray Coatings on Steel*, ASTM STP 947. ASTM publications available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

3. *Code of Practice for Protective Coatings of Iron and Steel Structures Against Corrosion*, British Standards Institution B.S. 5493: 1977. Available from American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

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Acronyms and Conversion Factors Used in This Publication

AWWA	American Water Works Association
Al	aluminum
ANSI	American National Standards Institute
AW	arc wire
AWS	American Welding Society
DFT	dry film thickness
FP	flame powder
JCR	Job Control Record
m	meter = 39.4 inches
M&R	maintenance and repair
MMC	metal matrix composite
NACE	National Association of Corrosion Engineers
QC	quality control
SSPC	Steel Structures Painting Council
TSB	thermal spray boundary
TSC	thermal spray coating
TSCC	thermal spray coating contractor
WFT	wet film thickness
Zn	zinc
85/15	alloy of 85 weight% zinc and 15 weight% aluminum
90/10	metal matrix composite of 90 vol% Al and 10 vol% alumina
μm	micron or micrometer = 10^{-6} meter

Length

1 in.	= 25.4 mm
0.001 in.	= 25.4 microns (μm) $\approx 25 \mu\text{m}$
1/16 in.	= 0.0625 in. = 1.5875 mm ≈ 1.6 mm
3/32 in.	= 0.09375 in. = 2.38125 mm ≈ 2.4 mm
1/8 in.	= 0.125 in. = 3.175 mm ≈ 3.2 mm
3/16 in.	= 0.1875 in. = 4.7625 mm ≈ 4.7 mm
1 μm	= 10^{-6} meter = 0.0394×10^{-3} in.
1 mm	= 0.0394 in. = 39.4×10^{-3} in.

Thermal Spraying

Parameter	To Convert From	To	Multiply By
Spray Rate	lb/hr	kg/hr	0.454
	kg/hr	lb/hr	2.20
Area Coverage	$\text{ft}^2/\text{hr}/0.001 \text{ in.}$	$\text{m}^2/\text{hr}/100\mu\text{m}$	0.236
	$\text{m}^2/\text{hr}/100\mu\text{m}$	$\text{ft}^2/\text{hr}/0.001 \text{ in.}$	4.24

Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and Their Alloys and Composites

1. General

1.1 Scope. This guide covers the application of thermal spray coatings (TSC) for the protection of steel with aluminum, zinc and their alloys, mixtures, and composites. This scope of this guide includes the major elements of an industrial process instruction covering job description, safety, consumable materials, surface-preparation and thermal spray equipment, quality control (QC) equipment, TSC operator training and qualification, a step-by-step surface preparation and thermal spraying application method with quality control checkpoints, maintenance and repair of thermal spray coatings, and a job control record. Nominal TSC feedstock spray rates and coverage information for a common planning base are presented for purchasers and contractors. A TSC selection guide for various service environments and the operator qualification requirements are presented in appendices. This guide is modelled on the thermal spray method of MIL-STD-2138A(SH), *Metal Sprayed Coating Systems for Corrosion Protection Aboard Naval Ships*.¹

1.2 Definitions. The following define abrasive blast cleaning methods for various surface finishes.

Abrasive Blast Cleaning:

NACE No. 1: White-Metal Blast-Cleaned Surface Finish. Defined as a grey-white (uniform metallic) color, slightly roughened to form a suitable pattern for coatings. This surface is free of all oil, grease, dirt, mill scale,

rust, corrosion products, oxides, paint, and other foreign matter. (NACE No. 1 is comparable to SSPC-SP 5, *White Metal Blast Cleaning*.)²

SSPC-SP 5: White-Metal Blast Cleaning. These blast-cleaned surfaces must have a uniform, grey-white metallic color and must be free of all oil, grease, dirt, mill scale, rust, corrosion products, oxides, old paint, stains, streaks, or any other foreign matter.³

NACE No. 2: Near-White Blast Finish. This is defined as a surface from which all oil, grease, dirt, rust scale, and foreign matter have been completely removed except for slight shadows, streaks, or discolorations (of oxides bonded with metal). At least 95% of any given surface area has the appearance of NACE No. 1, and the remainder of the area is limited to slight discolorations. (NACE No. 2 is comparable to SSPC-SP 10 *Near-White-Metal Blast Cleaning*.)

SSPC-SP 10: Near-White-Metal Blast Cleaning. A near-white metal blast-cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except for staining as noted. Staining shall be limited to no more than 5% of each square inch of surface area and may consist of light

1. Military specifications are available from Standardization Order Desk, 700 Robbins Avenue, Building #4, Section D, Philadelphia, PA 19111-5094.

2. *Visual Standard for Surfaces of New Steel Centrifugally Blast Cleaned with Steel Grit and Shot*, TM0175-75. Available from National Association of Corrosion Engineers, 1440 South Creek Drive, P.O. Box 218340, Houston, TX 77084.

3. *Steel Structures Painting Manual*, Volume 2. Available from Steel Structures Painting Council (SSPC), 4400 Fifth Avenue, Pittsburgh, PA 15213-2683.

shadows, slight streaks, or minor discolorations caused by stains of mill scale or stains of previously applied paint.

2. Safety

2.1 General. The basic precautions for thermal spraying are essentially the same as for welding and cutting. Consult Chapter 11 (Safety), AWS *Thermal Spraying: Practice, Theory, and Application*⁴; ANSI/ASC Z49.1, *Safety in Welding and Cutting*⁴, and NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*.⁵ Read and follow safety precautions in the manufacturer's *Material Safety Data Sheet* for specific feedstock materials used.

Airborne metal dusts, finely divided solids, or accumulations should be treated as explosives. Adequate ventilation in the thermal spray work area and collection of the overspray should be made to minimize the danger of dust explosions and fires. In shop environments, wet-bag, and filter-cartridge collectors may be used to collect the fine overspray particles, thus minimizing the explosion and fire hazard and release of controlled and hazardous materials. Bag- and filter-cartridge-collector units should be at least 15 m (50 ft) removed from the spraying area to preclude ignition from the flame or heat of thermal spray guns.

Field work may require partial or complete containment of the work site for surface preparation and thermal spraying and the collection and safe disposal of the used blasting media and thermal spray overspray. Follow the industrial safety and environmental compliance requirements cited in 3.1 and section 13. Consult local community (city, county, and state) and Federal air quality and hazardous materials control agencies for amplifying information as required.

The extremely hot conditions of thermal spray operations require additional precautions such as not pointing the thermal spray gun at any person or at any combustible or explosive material. Paper, wood, oily rags, cleaning solvents, sealers, and paints should be stored away from the thermal spraying area.

Good housekeeping in the shop and field work areas should always be maintained to avoid accumulation of metal dusts, with particular attention given to inspecting for dust on beams, rafters, tops of booths, and in floor cracks.

4. Available from American Welding Society, 550 N.W. LeJeune Rd., P.O. Box 351040, Miami, FL 33135.

5. Available from National Fire Protection Association (NFPA), Batterymarch Park, Quincy, MA 02269.

2.2 Thermal Spray Powder. The following are basic safety principles for handling aluminum and zinc powders:

(1) Read and follow the manufacturer's instructions on the Materials Safety Data Sheet.

(2) Avoid any condition that will suspend or float particles in the air creating a dust cloud.

(3) Avoid actions that generate static electricity, create sparks or otherwise result in reaching the ignition energy or temperature. This includes NO SMOKING.

(4) Take actions to minimize and dissipate the generation of static electricity, such as bonding and grounding, to avoid spark discharge.

(5) Take steps to limit the size of a fire or explosion and to hold any resulting damage to the very minimum, i.e., store aluminum and zinc powder containers separately and away from flammable materials and oxidizing agents such as sulphur and nitrates. Zinc dust forms an explosive mixture with dry and moist air.

(6) Do not use water to extinguish aluminum or zinc fires. Use dry sand or a Class D extinguisher.

SAFETY PRECAUTION: *Uncontrolled aluminum and zinc powder are a combustion and explosion hazard (from suspended fine aluminum or zinc dust). Thermal spray aluminum and zinc powders, nominally 40–110 μm (0.0016–0.0044 in.) diameter, are not a combustion or explosive hazard when handled and used in accordance with powder manufacturer's instructions.*

Note: Safety and Procedure Precautions are cited in double-lined boxes. QC Check Points are cited in single-lined boxes.

Recommendations for Storage and Handling of Aluminum Powder and Paste gives the Aluminum Association's recommendations for the storage and handling of aluminum powder.⁶

3. Job and Contract Description

3.1 General. Describe the overall job and cite all the major thermal spray job or contract requirements referencing the sections and paragraphs in the body of the job or contract as applicable. Cite job-site access, job permits, industrial safety and environmental compliance requirements as appropriate.

3.2 Thermal Spray Boundary (TSB). The perimeter of the area of the workpiece or structure to be thermal

6. *Recommendations for Storage and Handling of Aluminum Powder and Paste*, TR-2, SGE/5M/12-86/4A. Available from the Aluminum Association, Inc., 818 Connecticut Avenue NW, Washington, DC 20006.