

DEP SPECIFICATION

THERMAL SPRAY COATINGS OF ALUMINUM

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for thermal sprayed aluminium coatings for the purpose of corrosion control for both atmospheric conditions and beneath insulation or fireproofing as applied to onshore and offshore structures, equipment and piping, etc.

TSA coatings are used when the period to first coating maintenance is 15 years or more, or where protection against corrosion under insulation (CUI) is required.

Additional requirements for Deep Water Projects are specified in (Appendix 3).

The following aspects of the thermal sprayed aluminium coating system are covered:

- surface preparation;
- thermal spraying;
- coating materials;
- prequalification;
- quality assurance and control, and;
- repair procedures.

This DEP may also be applied when thermal spray coatings are specified for corrosion control on immersed and buried surfaces, equipment and structures.

The TSA coating may be applied either in the shop or in the field (on-site). The particular coating application system and procedures require approval by the Principal and, if applicable, the Contractor, prior to production coating operations.

Thermal spray coatings use high heat, and aluminium dust can ignite and explode under certain conditions. Rigorous safety precautions are required when thermal spray coatings are applied, particularly automated thermal spray aluminium coatings. See (2.3).

This is a revision of the DEP of the same number dated February 2012; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The **Applicator (Vendor)** is the party that applies the thermal spray coating.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
AFC Drawing	Approved for Construction Drawing
Arc spray	A form of thermal spraying where two consumable metal wires are fed independently into the spray gun. These wires are charged and an arc is generated between them. The heat from this arc melts the incoming wire, which is then entrained in air jet from the gun and deposited onto a substrate.
Bend test	180° bending of a sample on a mandrel.
Companion coupon	Rectangular steel coupon, prepared for qualification of thermal spray coating materials and coated concurrently with the workpiece for quality control and inspection.
Dew point	The temperature of a given air/water-vapour mixture at which, under atmospheric pressure, condensation starts.
DFT	dry-film thickness
Flame spray	A form of thermal spraying where the wire spray material is melted in a gaseous oxygen-fuel flame and deposited onto a substrate.
Feather	Smooth tapered transition between thermal spray coating and the adjacent non-coated surface.
Holding period	Time between the completion of the final surface blasting and completion of the thermal spraying.
ITP	Inspection Test Plan
Overspray	The portion of the thermal spray deposit that is not deposited on the desired area of the workpiece.
Rust bloom	Discoloration indicating the beginning of rusting, bleeding through the interconnecting pores of the thermal spray coating.
Sealer	A thin paint coating, about 40 µm thick, that is absorbed into the pores of the thermal spray coating and seals the coating surface.
Shift	Production run of which the beginning and end coincide with a change in personnel.
Soluble salt contaminants	Water-soluble salts, such as chlorides and sulphates, which contaminate the steel surface and cause rust bloom and premature coating failure.
Thermal spray	Application of metallic coating by means of arc- or flamespray equipment.

Topcoat Paint coat applied over a sealed thermal spray coating.

TSA Thermally Sprayed Aluminium

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (10).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a minor revision of the DEP of the same number dated February 2012. The following are the main, non-editorial changes.

Section/Clause	Change
1.1 para 2	changed number from 25 to 15 years or more
1.1 para 3	added reference to (Appendix 3)
2.1 para 1	changed number from 25 to 15 years or more
3.2	added requirement for wire and wrapping
4.1 new para	added NDE requirement
4.1 para 2	added requirements of ISO 8501-3, preparation Grade P3
4.3.2	added requirements of the relevant parts of ISO 11124 and ISO 11126
4.3.2 Table 1	removed coal slag
6.1 (three new para)	added TSA application process
6.1 para 4	added NACE CIP level 3 certification (or similar) for Principal's representative
6.2 para 4 item ii	test coupons number changed from 150 mm x 150 mm to 150 mm x 50 mm,
6.3 para 3	inactive sprayer needs to be re-qualified.
6.4.5 para 3	added requirement for metallographic digital image
7.4.4 para 2	bend test number 6 in x 6 in, changed to 6 in x 2 in,
7.4.5 para 2	added "and only for carbon steel substrates."
10	added reference ISO 8501-3
Appendix 3	added new appendix "Additional requirements for Deep Water projects"

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (Other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

2. GENERAL REQUIREMENTS

2.1 GENERAL

TSA shall be used when the period to first coating maintenance is 15 years or more, or where protection against corrosion under insulation (CUI) is required.

Thermal spray coatings specified in this DEP shall be applied by either arc or flame spraying, using a solid metal wire. Powder consumables, high velocity oxy-fuel (HVOF) and plasma techniques shall not be used.

Thermal spray aluminium coating shall not be sealed when applied:

- i) to immersed components;
- ii) under insulation (to protect against CUI); or
- iii) to buried components (e.g. buried piping).

When TSA is used for immersed conditions, additional cathodic protection by means of sacrificial anodes may be required.

When TSA is used under fireproofing or insulation material, the materials used for fireproofing or insulation shall be selected such that, when exposed to water, the environment that the TSA coating is exposed to remains within a pH range of 4 to 8. However, it is acceptable to use TSA under perlite insulation which, in the presence of water, can develop a pH of approximately 10.

For new construction of equipment, consideration should be given during the design such that the surface which requires TSA should be accessible for grit blasting and TSA application. NACE SP0178 and/or ISO 12944-3 should be taken as a guideline for this. Examples where design for TSA access should be considered in the equipment design are (1) the clearance between insulation support rings and shell should be twice the thickness of the ring to enable grit blasting and TSA coating application of shell section behind the rings and (2) the name plate bracket design should be such that shell can be grit blasted and TSA coated behind bracket.

Finished prefab piping shop welds may be TSA coated in shop prior to (field) hydrotesting as permitted under clause 3.3.1 of DEP 74.00.10.10-Gen.

2.2 DOCUMENT HIERARCHY

In the event of conflicts between contract documents, As For Construction (AFC) drawings, specifications and other referenced standards, the following document hierarchy shall apply:

- Contract or agreement (including any approved exceptions);
- AFC drawings – latest revisions;
- Principal's specifications (including project specific information);
- Industry Standards (e.g. ISO, NACE).

2.3 SAFETY

2.3.1 General

Thermal spray coatings may involve the use of hazardous materials, operations, and equipment. This DEP does not address all of the potential safety concerns associated with their use.

TSA coating application should be considered as hot work and associated safety precautions should be taken.

It is the responsibility of the Contractor and/or Applicator to establish appropriate safety and health requirements, and determine any regulatory requirements or limitations prior to use.

Health, Safety and Environment concerns should be identified and included in the detailed coating procedure and pre-job discussions. All surface preparation and coating application systems shall undergo a complete safety inspection and checkout prior to use.

Adequate exhaust/ventilation equipment shall be used, as required, for removal of any air contaminated products to achieve acceptable air quality standards and to protect personnel.

When personnel are working in confined spaces, adequate ventilation and spark proof lighting shall be provided.

All personnel shall be provided with approved personal protection, e.g. protective clothing, safety glasses, safety shoes, hard hats, goggles, respirators, earplugs, fresh air fed hood and any other necessary safety equipment. All safety equipment shall be maintained in good working condition.

Adequate warning signs shall be prominently displayed at all access points to areas where abrasive blasting and thermal spraying is in progress.

Thermal spraying is a safe process when performed by an Applicator who follows the recommended precautionary measures, has a proper understanding of thermal spraying practices, has knowledge and skill, and exercises care in using thermal spray equipment.

Thermal spray equipment should have safety devices that stop the spray process as well as the wire feeding when the safety handle is released. For re-starting the process, a two hand operation is required.

Coating work pieces shall be electrically grounded (earthed) as required to eliminate static charges associated with surface preparation and coating operations.

2.3.2 Hazardous components

Potential thermal spray hazards include exposure to flame, heat, vapours, (metal) dust, fumes, gases (CO exposure), noise, (from the spray gun) and arc ultraviolet (UV) radiation. Additionally, improperly used thermal spray equipment can create potential fire and explosion hazards from the fuel and carrier gases and a potential electrical shock hazard from the electrical and electronic equipment and charged wire spools. To minimize hazards, safety precautions should be followed. Thermal sprayers shall comply with the procedures in the safety regulations, the Manufacturer/Supplier's technical manuals, and the material safety data sheets.

2.3.3 Safety measures

Source of risk factors, consequences, and recommended safety measures for thermal spray coatings are listed below and should include the following barriers:

Source	Risk	Safety measures
Heat from spray gun Flame from spray gun	Burn injuries Fire CO exposure	Wear non-flammable, heat-resistant clothing, in compliance with ISO 11611 for arc spray and ISO 11612 for flame spray. Wear respirator equipment
Noise from spray gun	Ear damage	Wear suitable ear protectors
UV-exposure from arc spray	Irritation / damage of eyes	Wear dark (welder's) glasses, face shield or helmet

Metal (spray) dust	Irritation of airways / lungs Fire Dust explosions	Wear hood with forced air supply when using arc spray, particulate respirator when using flame spray. Water shall not be used; Use dry sand, or Class D fire-extinguisher. Regular cleaning of floor and equipment to remove metal spray dust (good housekeeping).
Heavy weight of gun	Overstraining muscles	Regular job rotation during spraying.
Heat from life equipment	Heat stresses	Regular job rotation during spraying.

2.4 COMPANY ACCESS

The Principal's representative, including independent inspectors or consultants as may be engaged by the Principal, shall be permitted access to the coating application site at any time to conduct performance analyses, including quality control tests of the materials being used.

The Principal's representative has the right to reject any or all work or equipment that in his/her opinion does not conform to these requirements. Any work that in the opinion of the Principal's representative does not comply with these requirements shall be rectified at the Contractor's expense.

The Principal's representative has the right to request quality control tests at any time in addition to those completed at pre determined intervals.

2.5 PRE-JOB MEETING

The Applicator shall schedule a pre-job meeting to ensure that job requirements are fully understood.

The personnel present at the meeting shall include, but not be limited to, the Principal's representative, and the Applicator's representatives for coating supervision, quality control and safety. If required a technical representative of the Manufacturer/Supplier shall be present.

Roles and responsibilities shall be clarified at the pre-job meeting, such as when the Principal deals with the Applicator, who are the focal points and how administration procedures are executed. Technical aspects, such as: qualification of vendors/sprayers, application procedures, equipment, Inspection Test Plan (ITP) shall be discussed. It shall be confirmed that all parties have the latest version of the Contract, technical specifications, AFC drawings and ITP.

3. MATERIALS

3.1 BACKGROUND

Aluminium and its alloys provide both barrier and cathodic protection to a steel substrate. Thermal spray aluminium coatings may be specified as protective coatings for atmospheric exposure, under thermal insulation, hot surface and (sea) water immersion applications.

The recommended service temperature of aluminium for non-immersion services is 45 °C to 595 °C (–50 °F to 1,100 °F).

3.2 THERMAL SPRAY COATING

For application of thermal spray coating in accordance with this DEP, the chemical composition of the metallic wire material used shall meet the following requirements:

- Aluminium in accordance with ISO 209 Grade 1100.

Alternative Grade 1350 aluminium shall only be used with specific approval of the Principal.

The wire shall be furnished in a protective wrapping, which clearly identifies the type of material, batch number and supplier. The wrapping shall be capable of protecting the surface finish and cleanliness of the wire prior to use. The wire shall be stored under cover, and shall be protected from sources of contamination.

3.3 SEALER

Sealers are designed to fill the porosity of the thermal spray coating, and not to build film thickness.

The sealer shall have sufficiently low viscosity to penetrate into the pores and seal the surface of the thermal spray coating. The dry-film thickness (DFT) of the sealer shall not exceed 40 µm (1.5 mils).

TSA coating shall not be sealed when applied:

- To components that are to be immersed (e.g., in sea water);
- Under insulation (to protect against CUI);
- To components (e.g. piping) that are to be buried.

TSA coatings may be sealed when used under atmospheric conditions, e.g., to prevent fouling of the surface, or when a particular decorative finish, or safety colours are required.

The following sealer materials shall be used:

- Epoxy: to a maximum temperature of 120 °C (248 °F);
- Silicone: to a maximum temperature of 450 °C (840 °F).

3.4 TOP COAT

Topcoats applied on thermal spray coating shall be chemically compatible with the sealer and shall be applied according to the instructions of the paint Manufacturer/Supplier.

TSA coatings may be topcoated when used under atmospheric conditions, and when a finishing colour is required, e.g. for safety markings, visual appearance, etc. The following coating system shall be used:

- Epoxy sealer, maximum DFT 40 µm (1.5 mils);
- Aliphatic polyurethane topcoat, maximum DFT 40 µm (1.5 mils).

4. SURFACE PREPARATION

4.1 GENERAL

All non-destructive evaluation (NDE) of welds, as required, shall be completed and accepted prior to any surface preparation activities for thermal spray coating.

All edges to be coated shall be rounded off by grinding to a radius of 2 mm (1/8 in) minimum. Flame cut areas and weld spatter shall be ground flush with the requirements of ISO 8501-3, preparation Grade P3.

Cleaning of surfaces shall be done by dry blast cleaning, in accordance with ISO 8504-2.

Fabrication should be complete before surface preparation begins.