Document	:	Coating specifications
Project	:	Solar Energy System
PO no.	:	
TSS Reference	:	TSS-PRJ-D013

Rev	Date	Description	Prepared	Checked
R00	20181008	Painting specifications	JWL	JVV
R01	20190313	Document name changed into Coating specifications	JvV	JWL
R02	20220214	Duplex coating explained and lifetime of conserved metal updated	JvV	JWL

Contents

1. Scope

This document describes the technical requirements for powder coating as per TSS4U sub-vendor's standards.

2. General

The purpose of corrosion treatment is to provide a durable protection.

This is applicable for following TSS products:

- PV module support structure or control equipment racks, made of hot dip galvanized (HDG) steel or stainless steel.
- Battery boxes, made of stainless steel material.
- Explosion proof electrical enclosures (ATEX/IECEx) made of stainless steel or aluminium alloy.

Steel material will be hot dip galvanized according European standard EN-ISO 1461 or American standard ASTM A123.

Aluminium alloy, HDG steel and stainless steel material will be powder coated according standard ISO 12944, divided in:

- Corrosive category C4 high. Industrial areas and coastal areas with moderate salinity.
- Corrosive category C5-M very high (marine). Coastal and offshore areas with high salinity.

Finishing of surfaces should be visually checked and total layer thickness should be measured after completion of galvanizing and after completion of coating.

An inspection report for both surface treatments (as applicable) will be provided by supplier.

Bird spikes and mounting materials are made of stainless steel material. The bird spike assembly set is uncoated because of the limited surface area and the shape of spikes and base profile. The quality of the adhesion on these parts would be insufficient.

3. The duplex coating system explained

When HDG steel is painted or powder coated, the duplex coating provides a more sophisticated manner of corrosion protection known as the synergistic effect. The exterior layer of paint or powder coating acts as an additional barrier and slows down the rate at which the zinc is consumed; greatly extending the life of the galvanized steel. In return, the underlying galvanized coating acts as a noble primer eliminating the pinhole corrosion and peeling effect often seen on bare steel.

Once the exterior layer has been weathered down or damaged, the zinc beneath is still available to provide cathodic and barrier protection. As a result of this synergistic effect, the substrate steel is afforded corrosion protection for 1.5 to 2.3 times the sum of the expected life of each system alone.

For example, if a galvanized coating alone on blank steel would provide 60 years of maintenance-free protection and a paint coating would not require any maintenance for 10 years, the combination duplex system would provide maintenance-free protection for 90 to 150 years in the same environment, if you allow both coatings to wear out completely.

This is not to suggest the original paint or powder coating will last more than a century. Rather this lifetime assumes no maintenance will be performed and the paint or powder coating would naturally

wear way, and then the galvanizing would provide corrosion protection for the remainder of the life. However, the owner will likely want to maintain the paint/powder system for aesthetics. So in practice, the synergistic effect is realized in the delayed maintenance cycle (touch-up, maintenance paint, and full repaint) of the paint/powder coating of the duplex system. The maintenance cycle paint/powder on galvanized steel is 1.5 to 2 times the cycle for paint/powder on bare steel.

4. Coating of non-metal enclosures/boxes

Enclosures for electronic equipment (controller, circuit breakers, fuses) are standard made of Glass Reinforced Polyester (GRP) and not coated. Standard colour is RAL 7035 (Light grey).

Battery boxes made of Glass Reinforced Polyester (GRP) are considered durable and suitable for outdoor environments without additional coating. However coating on the outside is recommended, it avoids pollution on the surface, standard colour is RAL 9010 (Pure white).

5. Coating materials

All coating material shall be supplied and stored in the manufacturer's original containers, durable and legibly marked with a description of contents. The description shall include at least colour code reference number, area of use / application, batch number, date of production, shelf-life expiry date, environmental limits during use and manufacturer's name or recognized trade mark.

Different brands or types of paint or coating shall not be mixed. Storage and preparation of paint or other coating materials shall be done according manufacturer's instructions.

Samples which follow the same coating process at the same time for testing of adhesion to base material have to be provided.

6. Painting contractor

The painting contractor shall be responsible for:

- The quality of workmanship and all other relevant documents such as safety rules, referred standards, codes and practices.
- Performing appropriate inspections and tests as per applicable standards.
- The protection of all equipment, materials to be coated, structures and other areas against mechanical damage, environmental damage, damage caused by abrasives during blast cleaning, paint droppings or paint spray.
- Providing the technical and safety characteristics of paints and coatings as obtained from the paint manufacturer. The characteristics shall be obtained via provision of technical datasheets and health and safety data sheets.
- Provision of all painting, cleaning materials, tools and competent supervision necessary for a satisfactory completion of the work.
- Controlled environmental friendly disposal of waste resulting from painting and coating activities.
- Maintaining workshop facilities, tools and equipment in a proper way.
- Spray guns, brushes, rollers and paint pots etc. shall be regularly cleaned or disposed of and shall be suitable for their purpose.

7. Standard applicable colour codes

Painting and coating will be provided following the RAL colour code system.

RAL colour code (*):	Applicable for:
Light grey (RAL 7035)	
	Solar module support structure (HDG steel or stainless steel)
	Battery boxes (Stainless steel) (safe area or ATEX/IECEx)
	Control rack frame (HDG steel or stainless steel)(ATEX/IECEx)
Signal white (RAL 9003)	
	Solar module support structure (HDG steel or stainless steel)
	Battery boxes (Stainless steel)(safe area or ATEX/IECEx)
	Control rack frame (HDG steel or stainless steel)(ATEX/IECEx)
White aluminium (RAL 9006)	
	Solar module support structure (HDG steel or stainless steel)
	Battery boxes (Stainless steel)(safe area or ATEX/IECEx)
	Control rack frame (HDG steel or stainless steel)(ATEX/IECEx)
	Control equipment enclosures (Stainless steel or aluminium)(ATEX/IECEx)
Pure white (RAL 9010)	
	Battery boxes Glass Reinforced Polyester (GRP)

(*) Note: It's up to the client to decide which RAL colour to be used which can have a cost impact.

8. Hot Dip Galvanizing and coating procedure overview

The following procedures describe HDG and painting processes for various types of equipment and materials including the duplex coating system that is applied.

Hot Dip Galvanized steel structure		
Meets standards:	EN ISO 1461 / ASTM A123	EN ISO 1461 / ASTM A123 ISO 12944
Corrosion class:	C4	
Protection:	HDG	Duplex powder coating **standard**(1)
Pre-treatment:	HDG (layer thickness is depending on the material thickness)	HDG and Acid pickling (spraying) / grit blasting
Primer:		Epoxy powder coating 60-80µm
1 layer:		Polyester powder coating 60-80µm
Minimum coating thickness	-	112µm
Average coating thickness	-	140µm
Expected lifetime:	16 – 33 yr. (≥ 3 - < 6mm).	HDG + coating: 55 < 84 yr.
Applicable for:	Support structure	

Note 1: Standard offered for coated support structures.

The applied primer is Interpon 100 (AL072F) or Jotun Primax Protect

The applied topcoat is Interpon D2525 or Jotun Corro-Coat PE

Hot Dip Galvanized steel PV module support structure		
Meets standards:	EN ISO 1461 / ASTM A123	EN ISO 1461 / ASTM A123 ISO 12944
Corrosion class:	C5-M (marine)	
Protection:	HDG	Duplex powder coating **high-end**
Pre-treatment:	HDG (layer thickness is depending on the material thickness)	Acid pickling (spraying)/ grit blasting
Primer:		Epoxy powder coating 60-80µm
1st layer:		Epoxy powder coating 60-80µm
2nd layer:		Polyester powder coating 60-80µm
Minimum coating thickness	-	144µm
Average coating thickness	-	190µm
Expected lifetime:	8 – 10 yr (≥ 3 - < 6mm)	HDG + coating: 35 < 37 yr.
Applicable for:	Support structure Control equipment rack (ATEX/IECEx)	

Stainless steel PV module support structure / control rack / battery box		
Meets standard:	ISO 12944	
Corrosion class:	C4	C5-M
Protection:	Duplex powder coating **standard**(1)	Duplex powder coating **high-end**
Pre-treatment:	Acid pickling (spraying) / grit blasting	Acid pickling (spraying) / grit blasting
Primer:	Epoxy powder coating 60-80µm	Epoxy powder coating 60-80µm
1st layer:	Polyester powder coating 60-80µm	Epoxy powder coating 60-80µm
2nd layer:		Polyester powder coating 60-80µm
Minimum coating thickness	112µm	144µm
Average coating thickness	140µm	190µm
Expected lifetime:	> 15 yr.	> 15 yr.
Applicable for:	Support structure Battery box safe area	Support structure Control equipment rack (ATEX/IECEx) Ex e Battery box (ATEX/IECEx) Salty environments (offshore)

Note 1: Standard offered for coated support structures and coated safe area battery boxes

The applied primer is Interpon 100 (AL072F) or Jotun Primax Protect

The applied topcoat is Interpon D2525 or Jotun Corro-Coat PE

Bartec Ex d enclosure Aluminium or Stainless steel	
Protection:	Duplex powder coating
Pre-treatment:	Phosphor-degreasing and washing with demineralized water
Process:	Paint is applied with automatic or manual guns with negative terminal (60/80KV)
Top layer:	Polyester powder coating
Post treatment	Afterwards the enclosure is heated in a stove to a temperature between 160°C-190°C
Minimum coating thickness	80µm
Average coating thickness	140µm
Maximum coating thickness	200µm
Applicable for:	Ex d enclosures (ATEX/IECEx) Salty environments (offshore)

8.1 Hot dip galvanizing procedure

PV module support structure materials will first be hot dip galvanized according European standard EN-ISO 1461 or American standard ASTM A123. A chemical surface treatment (pickling in acid) is carried out in order to clean the surface of the steel and to roughen the surface for a correct adhesion prior to galvanizing process.

8.2 Time limits before coating

To reduce the risk of deterioration of prepared surface the coating shall be applied immediately after completion of the preparation activity or before any visible deterioration of the surface.

8.3 Standard coating procedure

As per vendors standard an organic coating suitable for industrial applications is applied on HDG or stainless steel.

This is a duplex-system C4 according standard ISO 12944.

The painting process comprises of two layers. The first layer is an epoxy powder coating (primer) and the second layer is a polyester powder coating.

The process comprises

of three steps:

- Surface pre-treatment (HDG or stainless steel)
- First layer coating (standard or high-end)
- Top layer coating (standard or high-end)

Surface pre-treatment for HDG steel:

The following surface preparation treatments are performed:

- Touching up bare spots, removal of sharp edges
- Dust and grease removal
- Pickling in acid (spraying)
- Spraying with zirconium

As an alternative surface pre-treatment grit blasting can be used.

Surface pre-treatment for stainless steel:

The following surface preparation treatments are performed:

- Acid etching
- Scratching up manually (raising)

As an alternative surface pre-treatment grit blasting can be used.

8.3 High-end (marine) coating procedure

As per vendors standard an organic coating suitable for offshore applications is applied on hot dipped galvanized or stainless steel.

This is a duplex-system C5-M in accordance with standard ISO 12944.

The painting process comprises of three layers. The first two layers are an epoxy powder coating (primer) and the third layer is a polyester powder coating.

The process comprises of four steps:

- Surface pre-treatment
- First layer coating
- Second layer coating
- Top layer coating

Surface pre-treatment HDG and stainless steel:

As described in the Standard coating description.

8.4 Alternative surface treatment by grit blasting

Some TSS sub-suppliers are using grit blasting for surface pre-treatment. The fundamental principle of the grit blasting process is the removal of rust, mill scale or other surface contaminants stream of relatively small abrasive particles at high velocity impact of abrasive particles. In preparing steel surface for painting by blast cleaning, rust, mill scale and old paint are removed along with some of the base metal.

The blasting of the HDG steel surface is carried out with sharp edged cast iron / garnet mineral blasting material.

The tolerances of the blasted steel surface need to correspond to the comparison sample of standard G 2001 lower - 3 medium.

The cleanliness and roughness of the blasted surface needs to correspond to ISO 8503-1 and 8503-2:

Cleanliness: Minimum SA 2.5

Profile: RZ 50-70 (maximum Rmax 100 µm and peak amount Pc 10µm of 20 measured with perthometer (Mahr)

The required surface roughness of substrate prior to the first primer application is measured using surface roughness measuring equipment (e.g. a comparator) or by actually measuring the roughness (EN ISO 3274 and EN ISO 5436-1 and 2).

After grit blasting the materials need to be cleaned.

9. Inspection and testing

The following coating inspection and testing shall be performed:

- Surface contamination
- Dry film thickness
- Adhesion

9.1 Surface contamination

Tests indicating the extent of substrate contamination as a result of iron, chlorides and dust are specified respectively in ISO 8502-1, ISO 8502-2 and ISO 8502-3.

9.2 Dry film thickness (DFT)

Standard ISO 2808, Method No.6, describes the test techniques suitable for measurement of the coating of dry film thickness.

Dry film thickness of individual layers and of the total coating system shall be measured at 5 random locations in areas representative for the coated component. There shall be at least one measurement on each horizontal, vertical and curved surface.

9.3 Adhesion

For a coating of dry film thickness ≤ 150µm a cross cut adhesion test according standard ISO 2409 shall be used.

Acceptable maximum number of defects will be 0 (zero).

Adhesion tests will be performed on test plates prepared and painted at the same time as components. They will be identified and marked in such manner that it is traceable to the corresponding production batch.

9.4 Inspection and test reports

The client shall have the right to inspect the ongoing painting activities during all stages of the process.

As a minimum the reports shall include:

- Name of the contractor / responsible person
- PO number
- Date of coating
- Ambient conditions
- List of used materials
- Type and quantity of quality checks performed and test results, such as measured values and conclusions.
- Quantity of threated materials.

10. Final colour and corrosion treatment (project dependent)

Item	In scope	HDG	Coating standard (140µm)	Coating high end (190µm)	Coating Ex d enclosures (140µm)	RAL 7035	RAL 9003	RAL 9006	RAL 9010
Support structure					X				
Control rack					X				
Control box									
Battery box									
Battery box Ex e					X				

Note: tick "√" in the box which is applicable