PHENOLIC MODIFIED EPOXY FOR IMMERSION SERVICE ON THERMALLY INSULATED EQUIPMENT - YELLOW TOPCOAT

Rev	Reason of Change	Date	Made By	Reviewed By	Approved By	Status
0	Initial release	28-08-2017	MN	AS	KKD	Released

Summary:
This specification defines the requirements for the application of a two coat paint system using a phenolic modified epoxy coating system for immersion service where the equipment is thermally insulated.

NOTE: USE ON EQUIPMENT WITH ADEQUATE CATHODIC PROTECTION

1.0 SCOPE

This specification defines the requirements for the application of a two coat paint system using a phenolic modified epoxy coating system for immersion service where the equipment is thermally insulated. This coating system should be used with adequate cathodic protection. This coating system is for use on equipment with internal temperatures up to 350 °F (177 °C). The system consists of Sigma Phenguard 930/7409 (white, formerly Phenguard primer) as the base coat and Sigma SigmaLine 780/7580 (yellow, formerly Sigmarite Subsea) top coat.

2.0 Abbreviations

The following abbreviations are used throughout this procedure.

Abbreviation	Description
ASTM	ASTM International (formerly American Society for Testing and Materials)
CRA	corrosion resistant alloy
DBI	data base information, synonymous with part report
DFT	dry film thickness
HSE	health, safety, and environmental
ISO	International Organization for Standardization
MSDS	material safety data sheet
N/A	not applicable
NACE	NACE International (formerly National Association of Corrosion Engineers)
PDS	product data sheet
PPE	personal protection equipment
QN	quality notification
SDS	safety data sheet
SSPC	The Society for Protective Coatings
WFT	wet film thickness

3.0 REFERENCED APPLICABLE CODES AND STANDARDS

List of referenced documents; The latest revision shall apply for each of the documents listed unless otherwise stated.

Organization	Doc Number	Description
ASTM - American Society for Testing and Materials	D3359	Standard Method for Measuring Adhesion by Tape Test
	D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
	D4417	Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
	D4541	Standard Test Method for Pull-Off Strength of Coating Using Portable Adhesion Testers
ISO - International Organization for Standardization	2409	Paints and varnishes -- Cross-cut test
	4624	Paints and varnishes - Pull-off test for adhesion
	8501 - 1	Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings
	8501 - 3	Preparation grades of welds, edges and other areas with surface
	8503	Surface roughness characteristics of blast-cleaned steel substrates
	8504-3	Preparation of steel substrates before application of paints and related products -
	11126	Preparation of steel substrates before application of paints and related products -
	12944-4	Types of surface and surface preparation
	19840	Measurement of, and acceptance criteria for, the thickness of dry film on rough surfaces
	29601	Assessment of porosity in a dry film
NACE International	SP0188	Discontinuity (Holiday) Testing of New Protective Coating on Conductive Substrates
SSPC - The Society for Protective Coatings	AB 1	Mineral and Slag Abrasives
	AB 3	Ferrous Metallic Abrasive
	SP COM	Surface Preparation Specifications
	SP 1	Solvent Cleaning
	SP 2	Hand Tool Cleaning
	SP 3	Power Tool Cleaning
	SP 5	White Metal Blast Cleaning
	SP 10	Near-White Metal Blast Cleaning
	SP 11	Power Tool Cleaning to Bare Metal
	PA 2	Measurement of Dry Paint Thickness with Magnetic Gages
	VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive
	VIS 3	Guide and Reference Photographs for Steel Surfaces Prepared by Power- and

4.0 GENERAL REQUIREMENTS

1. All coatings shall be applied in accordance with the part report (DBI), this document and the manufacturer's PDS. Precedence shall be in the order provided above with the part report (DBI) holding the ultimate requirements.
2. The Applicator is responsible for applying markings / stenciling on the finished part to maintain traceability of the part as required in the part report (DBI) and drawing.
3. A test coupon measuring at least 75 x 125 x 6 mm (3" x 5" x 0.25") of the same base metal type as the part(s) shall accompany each part or batch of parts throughout the entire coating process. This coupon shall be traceable to the part(s) and the purchase order that it corresponds to and shall be used for inspection purposes.

5.0 SURFACE PREPARATION REQUIREMENTS

5.1 REMOVAL OF MACHINING AND WELDING DEFECTS

1. Prior to surface cleaning, all cutting, machining, welding and heat treating operations shall be completed and the surface shall be free from all visible defects. Excessive flux, spatter, slag or other laminations left from welding shall be chipped or ground off in accordance with the welding fabrication requirements of the component / assembly. ISO 8501-3 grade P3 / AWS D1.1 code acceptance criteria shall be used as a standard unless otherwise specified. Rough welds and other sharp projections shall be ground smooth.

2. All sharp edges, including those resulting from fillets / welds, shall be rounded to a minimum edge radius of 2 mm (0.08"). Any hand or power tools used on carbon / low alloy steels shall not be used on stainless steel / CRA materials.

5.2 CHEMICAL CLEANING

Each part to be coated shall be cleaned to remove visible hydrocarbon contamination in order to avoid poor adhesion of the coating to the substrate. Cleaning shall be in accordance with ISO 12944-4 / SSPC SP 1 but must not impair machined surfaces or affect plastic /elastomeric components (such as seals). After cleaning, either a fresh water rinse shall be performed to remove chlorides or soluble salt testing shall be performed to determine the level of chloride presence. When performed soluble salt testing shall be per ion detection or conductometric methods (such as per ISO 8502-5 or 8502-6 and 8502-9 respectively) a minimum of once per part or batch of parts. Should the chloride concentration be above 20 mg/m^2 (2 µg/cm^2)) or if a degreaser/ emulsifier was used to remove visible hydrocarbon contamination, then a fresh water rinse shall be performed. During rinsing the appearance of beading of water indicates the presence of remaining oil / grease contamination which shall be removed.

Note: Many solvents are hazardous and care must be taken when using these substances for solvent cleaning. Special safety precautions must be followed with regard to ventilation, smoking, static electricity, respirators, eye protection and skin contact. Used solvents should always be recycled or disposed of according to applicable environmental regulations. Reference SSPC SP COM "Surface Preparation Specifications" for OSHA solvent threshold limit values along with other precautionary information.

5.3 ABRASIVE BLAST CLEANING

1. After chemical cleaning, dry abrasive blast cleaning shall be performed unless stated otherwise on the part report (DBI) or drawings. All seal surfaces and surfaces with 32 RMS finish or below (as defined by the part drawings) shall NOT be blasted unless otherwise specified on the part report (DBI) or drawings.

2. Surfaces not to be coated shall be masked with a suitable material prior to blast cleaning. These surfaces include: non-ferrous and austenitic stainless steel materials, seal areas and surfaces, ring grooves, valve bores, bleeder ports, grease ports, nameplates, valve stems, rotating equipment, blind stud holes of 40 mm (1.5 inch) diameter or less, fasteners (i.e., bolts, studs and nuts required to be fastened prior to blasting) and previously coated areas unless specified otherwise by the part report (DBI).

3. Abrasive blast media shall be grit type only and shall be kept dry and free from contaminants. For blast cleaning of stainless steels / CRAs, media shall be only aluminum oxide, garnet or staurolite material in accordance with ISO 11126 / SSPC AB1. For carbon / low alloy steel substrates, coal slag per ISO 11126-4 / SSPC AB1 and chilled iron / steel grit per ISO 11124 / SSPC AB3 are acceptable in addition to the media identified for stainless steels / CRAs. Blast media used shall comply with local environmental regulations. Silica sand shall not be used for abrasive blast operations. For assemblies that feature dissimilar metal construction, only those media approved for stainless steels / CRAs shall be used. Recycling of blast media shall only be allowed when used on carbon and low alloy steels. Cleanliness of recycled blast media shall be confirmed in accordance with a written procedure or industry standard.

4. Equipment air supply lines used shall be equipped with after-coolers, knockout pots or traps to remove moisture and oil. Absence of water and oil from air supply shall be verified in accordance with ASTM D4285 prior to blast cleaning and rechecked at a minimum of once per shift.

5. Blast cleaning shall not be performed in the immediate area where coating or curing of coated surfaces is in progress. Blasting hose shall be equipped with "deadman" handle / switch to reduce risk of injury.

6. Blast cleaning shall not take place if the relative humidity is greater than 85% or the substrate temperature is less than 3 °C (5 °F) above the dew point. The environmental conditions shall be measured prior to the start of work and at least an additional two times throughout the shift. Environmental conditions shall be recorded on the inspection report for verification that these conditions were met.

7. Surface preparation standard for subsea pressure containing equipment (valve blocks, flow loops, manifold piping, jumpers, risers, etc.) shall be white metal blast cleaning per ISO 8501-1 SA 3 / SSPC SP 5. Surface preparation standard for topside, structural and all other components (Sleds, Plets, Frames, etc.) shall be near-white metal blast cleaning per ISO 8501-1 SA 2.5 / SSPC SP 10 or better. Visual standards (ISO 8501-1 supplement or SSPC Vis 1) shall be used as reference.

8. Anchor profile (average maximum peak to valley distance) shall be a minimum of 50 microns (2 mils) and up to 25 percent of the total dry film thickness (DFT). However, anchor profile shall not exceed 100 microns (4 mils). Verification of surface anchor profile achieved shall be performed using replica tape, visual comparator or profile depth gauge in accordance with ISO 8503 / ASTM D4417. If replica tape is used, the actual test tapes shall be attached to the coating inspection report. The verification of surface anchor profile shall be performed at least once per part or once per batch of parts.

9. All blast media and dust shall be blown or vacuumed from the surface before coating. Blow / vacuum all blast media from unmasked holes, making sure that it is dislodged. The air supply shall be of the same source as that used for blasting or alternatively ASTM D4285 test shall be performed on new source to verify that no water / oil contamination is present.

10. Parts shall be protected between blasting and coating processes from exposure to any foreign contaminants. The surface preparation standard shall be maintained on the substrate immediately prior to coating. A guideline is that the primer coat shall be applied within 4 hours of initial blast cleaning. Environmental conditions, substrate type and any residual salt presence will affect the time before flash rusting appears, however. Should flash rusting or contamination appear prior to coating,

the surface shall be re-blasted.

6.0 COATING MATERIAL MIXING REQUIREMENTS

1. Mixing of coating materials shall not take place unless the atmospheric conditions are in accordance with those specified in the respective manufacturer's PDS. If none are provided, the ambient temperature conditions listed in section 7.0 of this document shall apply for mixing operations.

2. Coating materials shall be mixed in accordance with the manufacturer's PDS until they are smooth and free of lumps and then strained through a 30-mesh (595 micron) or finer screen. The mixed materials shall be agitated to keep the solids in suspension during application. Zinc rich coating materials shall be mechanically agitated at all times. Any induction ("sweat-in") times shall be adhered to if indicated by the manufacturer's PDS prior to coating.

3. The pot life shall be monitored in accordance with the manufacturer's PDS and any mixed coating that exceeds the pot life shall be discarded.

7.0 COATING APPLICATION REQUIREMENTS

1. Coating application shall not be performed if the relative humidity is greater than 85% or the substrate temperature is less than 3 °C (5 °F) above the dew point. Ambient and substrate temperatures during coating application shall be in accordance with the manufacturer's PDS but shall not be allowed to be 0 °C (32°F) or below or exceed 43 °C (110 °F). The environmental conditions shall be measured prior to the start of coating work and at least an additional two times throughout the shift. Environmental conditions shall be recorded on the inspection report for verification that these conditions were met.

2. Heating, air-conditioning or dehumidification equipment may be required to meet this specification as well as the manufacturer's defined cure schedule. Direct fuel fired heating devices (such as propane or kerosene fueled heaters) shall not be used as they produce hydrocarbons which can be detrimental to the cure and adhesion of the coating system.

3. Prior to coating, visually inspect all parts for removal of all abrasive material, especially from seal areas, bleeder ports, grease ports, ring grooves and any internally threaded holes. Inspect masking material for damage prior to coating. If masking is damaged, the area shall be inspected for damage to the substrate. Damaged masking shall be replaced prior to the start of coating.

4. Coating shall be applied using clean equipment of the correct type in accordance with the respective manufacturer's PDS. Brushes and rollers shall be compatible with the coating material. Roller application of the primer coat is not acceptable. ASTM D4285 blotter test shall be performed on all compressed air sources for coating application prior to coating and rechecked at a minimum of once per shift. No visible water / oil contamination shall be present.

5. In order to achieve required DFT, a stripe coat shall be applied by brush to all welds, bolts, corners, sharp edges and any other areas where spray application may not provide necessary film thickness or where spray application in those areas would result in excessive film thickness on adjacent areas. The stripe coat shall be applied using the second coat material. For two coat systems, the stripe coat shall be applied before application of the second (top) coat. Inorganic zinc coatings shall not be applied by brush.

6. The edges of existing coatings (if present) shall be feathered toward the substrate prior to overcoating.

7. The minimum curing time between coats shall conform to the respective coating manufacturer's

PDS. Parts shall be protected from contamination between coats during curing.

8. The number of hours between coats shall not exceed the coating manufacturer's PDS. If the time between applications of coats does exceed the coating manufacturer's recommended interval, the previously applied coat shall be prepared for the next coat per coating manufacturer's recommended practices and procedures including cleaning of the surface to remove any oil, grease or other foreign contaminants. If no procedures are available, the coating shall be removed and reapplied in accordance with the original requirements.

9. Inorganic zinc coatings shall not be applied in more than one application. Intermediate coats and top coats may be applied in more than one coat to achieve required thickness.

8.0 INSPECTION REQUIREMENTS

8.1 VISUAL INSPECTION

1. All coated surfaces shall be 100% visually inspected without magnification throughout the coating process for defects or damage and to ensure that surfaces are coated according to requirements. Coating defects may include but are not limited to skips, runs, pinholes, dirt inclusions, blistering, cissing (fish eyes), cracking, dry spray, overspray, orange peel and delamination. DuPont™ "Paint Defects Solution Guide" or "Whitford "Solving Common Coating Problems" chart may be used as reference for defect definitions and identification.

2. Coating quality imperfections including skips, pinholes, dirt inclusions, blistering, cissing (fish eyes), cracking, dry spray, delamination, inadequate cure and rusting of the substrate shall be repaired by removing the affected coating and reapplying per section 9.1.

3. Runs, orange peel and overspray that do not exceed 2% of the total coating area for pressure containing equipment (valve blocks, flow loops, manifold piping, jumpers, risers, etc.) or 5% of the total coating area for structural equipment (sleds, plets, frames, etc.) are acceptable. Defects covering larger percentage surface areas shall be repaired per section 9.2.

8.2 THICKNESS TESTING

1. Prior to measuring DFTs, the coating shall meet minimum time to "hard dry" or "dry to handle" as identified by manufacturer's PDS.

2. The coating DFT of each part shall be measured per ISO 19840 / SSPC PA2 (including number of measurements) for conformance to the coating spec. The device used shall be of a non-destructive type rated for the substrate type tested (ferrous vs non-ferrous). Thickness gauges such as magnetic pull-off type (i.e., banana gauge) or constant pressure probe type (i.e. electronic gauge) are acceptable.

3. The DFT of each coat shall be determined and shall meet the requirements prior to the application of subsequent coats.

4. If the average DFT of an individual coating layer is above the maximum allowance layer, that layer shall be sanded down until the thickness complies or the entire affected coating area shall be removed and reapplied in accordance with the part report (DBI), coating specification and this document. If the average applied DFT of an individual layer exceeds the maximum allowance of the manufacturer's PDS, the affected coating area shall be completely removed and reapplied. Top coats shall receive a light spray coat after any sanding in order to maintain aesthetic appearance.

5. If the average DFT of an individual coating layer is determined to be below the minimum coating specification allowance, additional coats may be applied to achieve the required thickness with the

exception of inorganic zinc coatings and any coatings products in which the manufacturer's PDS does not allow overcoating (in which case the affected coating area shall be removed and reapplied). For systems containing multiple coating types, additional thickness of one coating type is not acceptable to make up for insufficient DFT of a different coating type.

8.3 ADHESION TESTING

1. Prior to performing adhesion testing, the coating shall meet minimum time to "full cure" as identified by manufacturer's PDS.

2. Either of the following adhesion test methods shall be performed on the test coupon prepared along with each part or batch of parts as identified in section 4.

   - ISO 4624 / ASTM D4541 "dolly" pull off testing - Coating shall be scored around the dolly down to base metal before testing. The minimum acceptable value for adhesion strength shall be 5 MPa (725 psi) or 3 MPa (435 psi) on systems with zinc-rich primers. A minimum of three dollies shall pass the acceptance criteria.
   - Cross or X-cut testing - One of the following shall be performed based on the measured coating system DFT:
     - DFT ≤ 125 microns (5 mils) - ISO 2409 / ASTM D3359 Method B Cross Cut Test. Rating shall be a "1" or less for ISO 2409 and a 4B or higher for ASTM D3359 Method B in order to be considered acceptable. A rating of "2" for ISO 2409 and 3B for ASTM D3359 Method B shall be allowed systems with zinc rich coating layers.
     - DFT > 125 microns (5 mils) - ASTM D3359 Method A X-Cut Test. Minimum acceptable rating shall be 3A for systems with zinc rich coating layers and 4A for all other systems.

9.0 COATING REPAIR REQUIREMENTS

1. It is not mandatory that repair work be performed by the original Applicator, but the work shall be performed by a qualified Applicator. Coating product(s) used for repair shall be the same as that used for the original coating unless allowed by 9.2. Thus, in the case of someone other than the original Applicator performing rework, the original coating report must be reviewed to determine the correct coating product.

2. Alternate coating products may be used for repair only if applied after the minimum "full cure" / "cure to immersion" time of the original coating and must be a product that is acceptable.

3. The requirements identified in all sections of this document apply for repairs unless specified otherwise within section 9. A test coupon is not required for the repair coating, however, all inspection tests identified in this document that are performed on the part are to be completed for the repair area. All coating rework information is to be recorded on an inspection report form.

9.1 EXPOSED SUBSTRATE

1. Prior to surface preparation of the repair area, any loose coating shall be removed and then the area solvent cleaned in accordance with ISO 12944-4 / SSPC SP1.

2. When the substrate is exposed and the repair area is greater than 0.1 m^2 (1 ft^2), the surface preparation shall consist of spot blasting the affected area to ISO 8501-1 SA 2.5 / SSPC SP 10 and the original required surface profile. A Monti Bristle Blaster® tool may be used as an alternative to spot blasting provided that ISO 8501-1 SA 2.5 / SSPC SP 10 surface cleanliness and the original required surface profile are achieved.

3. When the substrate is exposed and the repair area is equal to or less than 0.1 m^2 (1 ft^2), the surface preparation shall be per section 9.1.2 or per SSPC SP11 "Power Tool Cleaning to Bare Metal", which requires a minimum 25 micron (1 mil) surface profile.

4. When the substrate is exposed and the repair area is equal to or less than 0.01 m^2 (0.1 ft^2) the surface preparation shall be per section 9.1.2, 9.1.3 or per ISO 8504-3 / SSPC SP2 / SSPC SP3 for hand / power tool cleaning.

5. Surface preparation of repairs on welds shall be performed per section 9.1.2 or 9.1.3 regardless of the repair area size.

6. Any hand or power tools used on carbon / low alloy steels shall not be used on stainless steel / CRA materials.

7. Around each repair area, the existing coating shall be abraded so that a minimum of 12 mm (0.5 inch) of each coating layer is exposed and feathered to provide smooth transitions between layers. For systems consisting of a single coating layer, a minimum of 25 mm (1 inch) shall be required. Abrading shall be performed by either lightly blast cleaning or by ISO 8504-3 / SSPC SP2 / SSPC SP3 hand / power tool cleaning.

8. Each layer of the original coating system shall then be applied in accordance with the original requirements. However, when the repair area is equal to or less than 0.1 m^2 (1 ft^2) and all coats of the system are of the same type, the repair may consist of fewer coats than the original system as long as the overall DFT of the original system is met and no individual coat exceeds the allowance of the manufacturer's PDS. Inorganic zinc coatings shall be repaired with organic zinc coatings only.

9.2 UNEXPOSED SUBSTRATE

1. Damage to the coating that does not expose bare metal substrate shall be repaired by removing any loose coating and then solvent cleaning the area in accordance with ISO 12944-4 / SSPC SP1. The entire damaged area shall then be abraded per ISO 8504-3 / SSPC SP2 / SSPC SP3 hand / power tool cleaning without exposing the substrate.

2. Each layer of the coating system exposed shall be applied per the original requirements in the repair areas. However, when all exposed coats of the system are of the same type, the repair may consist of fewer coats than the original system as long as the overall DFT of the original system is met and no individual coat exceeds the allowance of the manufacturer's PDS. Inorganic zinc coatings shall be repaired with organic zinc coatings only.

9.3 ANODE TAB COATING REQUIREMENTS

Anode tabs that are welded on after the subsea component has been coated are to be mechanically cleaned with wire brush or grit paper per ISO 8504-3 / SSPC SP 2, solvent cleaned per ISO 12944-4 / SSPC SP 1 and then spray / brush coated with the specified top coat only using the same coating product as the adjacent component coating unless specified otherwise on the part report (DBI). Minor coverage of the adjacent anode surface or the existing coated surface is permissible but must be no more than 12 mm (0.5 inch) onto the anode. Coating present beyond this limit on an anode must be removed.

10.0 THICKNESS

3.1 The optimal total thickness of the coating is 10-14 mils (250-350 microns) DFT.

3.2 Coating: 5-7 mils (125-175 microns) DFT Phenguard 930/7409 base coat and 5-7 mils (125-175 microns) DFT SigmaLine 780/7580 top coat.

Note: Up to 16 mils (400 microns) total DFT with both coats is acceptable; however, proper spraying parameters should allow thickness control in the 5 to 7 mils (125-175 microns) range.

11.0 DRYING TIMES

Substrate Temperature	10°C/50°F	15°C/59°F	20°C/68°F	25°C/75°F	30°C/86°F	40°C/104°F
Under Coat Minimum Interval Before Top Coat Application	60 hours	48 hours	36 hours	30 hours	24 hours	16 hours
Under Coat Maximum Interval Before Top Coat Application	28 days	25 days	21 days	17 days	14 days	7 days
Top Coat Minimum Curing Before Seawater Immersion	14 days	14 days	10 days	9 days	7 days	5 days
Dry to Handle or Begin Insulation	18 hours	12 hours	8 hours	6 hours	3 hours	2 hours

*Based on 15 mil (375 micron) thick coating.

12.0 ACCEPTABLE COATING SYSTEMS

PAINT SUPPLIER	UNDER COAT	TOP COAT
Sigma	Phenguard 930/7409 (White)	SigmaLine 780/7580 (Yellow - either RAL 1018 or RAL 1004 is acceptable unless indicated otherwise by the part report [DBI] or drawing)

13.0 RECORD KEEPING REQUIREMENTS

1. For each part or batch of parts, the Applicator shall complete an inspection report, recording information from the coating process. The report shall be generated either from the form found at the end of this document or an alternate form (only if all of the information as identified in the provided form is included). Any areas of the inspection report form used that do not apply shall be marked as "N/A". The inspection report shall be signed by a representative of the Applicator. By signing, the Applicator is indicating that the information on the report is correct and that all requirements of the part report (DBI), this document and the manufacturer's PDS were met.

2. The completed form shall be retained by the Applicator for a period of at least 5 years at the facility and archived thereafter for a period not longer than contractually agreed.

3. Coating coupons shall be retained by the Applicator and be traceable to the respective order.