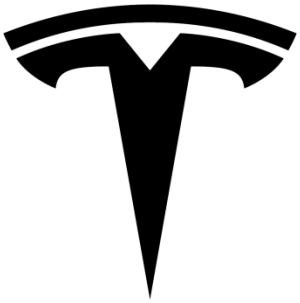

TM-0009F-M Electrodeposited Zinc-Based Anti-Corrosion Coatings

Fasteners, Sheet, Plate

Proprietary and Confidential

Prepared by Alec Pezeshkian
Approved by Benjamin Zabik

1 Scope

This specification establishes standards of quality, performance and delivery condition for zinc and zinc-alloy anti-corrosion coatings applied to vehicle components by electrodeposition. Coated components may also possess any of a number of secondary surface treatments intended to confer lubrication, alter tribological characteristics, seal the basecoat or provide color. This specification encompasses a variety of zinc or zinc-alloy basecoat chemistries, delineated as grades below.

The materials specified herein are suitable for interior and exterior applications, per the guidelines below. Common substrates include internally- or externally-threaded ferrous fasteners and non-threaded ferrous parts requiring protection in corrosive environments. Zinc- or zinc-alloy-plated parts should not be used in conjunction with polyamide (nylon) 6 or 6,6. Coatings specified herein are not recommended for components of tensile strength greater than 1000 MPa.

Based on application, each specified coating must meet the affiliated criteria agreed upon by Tesla Motors and its suppliers. Deviations from the requirements cited herein must be agreed upon by Tesla Motors and the appropriate supplier.

2 References

ASTM B117
ASTM D543
ASTM D610
ISO 554
ISO 1463
ISO 2177
ISO 2178
ISO 2819
ISO 3497
ISO 4042
ISO 9227
ISO 10683
ISO 16047
ISO 17025
SAE J2334

3 Requirements

General Guidelines. Several coating grades are specified by this standard, sorted by chemistry and corrosion resistance. Alloying element concentrations must not exceed the limits noted in Table 1.

TABLE 1.

	CHEMISTRY	COMPOSITION	CORROSION RESISTANCE	
GRADE		% ALLOY ELEMENT	MINIMUM HOURS TO	
			RED CORROSION	WHITE CORROSION
01	Zn (unalloyed)	---	96	48
02	Zn (unalloyed)		240	72
03	Zn (unalloyed)		480	120
10	Zn + Ni	10 – 15	1000	240
11	Zn + Ni		720	240
12	Zn + Ni		480	---
13	Zn + Ni		240	---
14	Zn + Ni		850	240
20	Zn + Fe	0.4 – 0.7	96	---

All coating systems specified per this document must be free of hexavalent chromium.

Unless otherwise noted, coatings meeting this specification must maintain functional integrity between –50 C and +180 C.

All samples to be tested must be conditioned for at least 24 hours at +23±2 C and 50±5% RH prior to testing per ISO 554.

Default values of temperature and humidity are taken to be +23±2 C and 50±5% RH. If not specified otherwise, such conditions may be assumed.

All prescribed values of temperature and humidity are target values; variations within ±2 C and ±5% RH of these values are permissible, unless otherwise noted.

Exposure time periods carry a tolerance of ±5 minutes. If a specimen must be transferred from one test environment to another within a given cycle, this lapse may not last longer than one minute.

A minimum of three specimens must meet the requirements of each test criterion for this specification to be considered met.

3.1 Pre-treatment. Alkaline degreasing and/or shot-blasting are recommended methods of surface preparation. Shot-blasting is not recommended for components with captive washers or internally-threaded parts. If acidic cleaning methods must be used, only acids with suitable inhibitors are allowed; exposure time to the acid solution, as well as time between exposure and final coating, shall be kept to a minimum. Acidic cleaning must be followed by heat treatment for hydrogen effusion.

Weld seams shall be removed of slag and silicate residues that may hinder uniform coating.

3.2 Post-treatment. A number of surface treatments may be incorporated into a component "topcoat", as specified by the part drawing. The topcoat must completely cover the electrodeposited basecoat without irregularities in appearance. Exterior components with electrodeposited basecoats require aftertreatment.

PASSIVATION. May be colored or uncolored. Must not contain Cr(VI).

SEALANTS. Increase corrosion resistance. May incorporate lubricants. Maximum 2 µm thickness. Must not affect coating functional properties.

ORGANIC FINISHES/PAINTS. Increase corrosion resistance. May provide color. Must not fill recesses.

3.3 Appearance. Substrates to be plated must be visually smooth and defect-free, without scratches, cracks, porosity, traces of rust or scale. The coated specimen must be free of scratches, cracks, pores, flakes, or blisters and shall not be slippery or tacky to the touch. Coating thickness shall be uniform, with no undercoated or overcoated surfaces such that part performance is compromised. The coating shall be free of foreign contaminants and shall leave no visible residue upon manipulation. Color requirements may be indicated on the part drawing.

3.4 Thickness. Unless otherwise specified, total coating thickness may be no less than 8 µm. Refer to ISO 4042. Coating thickness must be verified by any of the following test methods: ISO 1463, ISO 2177, ISO 2178, ISO 3497. Thickness measurements are taken over flat faces. Thickness values encompass basecoat and topcoat. For measurement in bulk processes, coating thickness may be correlated to part weight. The coating thickness on bearing surfaces shall not exceed 25 µm. The coating thickness applied to threads is limited by the basic thread size per ISO 4042 (tolerance h or H). After coating, parts must gauge with a referee nut or fastener.

3.5 Corrosion Performance. Minimum corrosion performance requirements are to be verified by neutral salt spray testing per ISO 9227 or ASTM B117 as specified in Table 1. Coatings shall meet the minimum exposure requirements specified without the appearance of "white corrosion" (oxidation of the coating material) or "red corrosion" (oxidation of the base metal). In the former case, a slightly pale, white appearance (or "blush") must not necessarily be construed as evidence of white corrosion.

In series production, such testing shall be conducted regularly to maintain statistical process control.

3.6 Torque-Tension Characteristics (Fasteners M6 and larger). Coated M10 x 1.5 surrogate test bolts, processed alongside production parts, shall be subject to torque-tension testing per ISO 16047. The tightening speed shall be 30±3 RPM and the tension load shall be 28.3 kN. The test shall be conducted with uncoated test nuts and test washers. The three-sigma torque range shall lie within 40 – 56 N-m.

3.7 Coating Durability. Coatings must tolerate normal handling, storage, and installation conditions (including bending, compression and tension) without loss of adhesion, chipping or flaking. When processing, the use of soft-handling equipment is recommended.

3.8 Hydrogen Embrittlement. Components hardened to a surface rating of HRC 35 or core rating of HRC 32, or those of strength > 1000 N/mm^2, that are exposed to elevated hydrogen concentrations or treated through hydrogen-generating processes must be handled per ISO 4042 Annex A.

INITIAL SOURCE APPROVAL REQUIREMENTS (FOR COATING QUALIFICATION ONLY).

3.9 Temperature Resistance. The coated specimen must withstand continuous heating at 180 C for 3 hours without evidence of white or red corrosion. The coated specimen must also withstand continuous exposure to 260 C for 30 minutes followed by rapid water quenching to room temperature without evidence of blistering or peeling of the coating per ISO 2819.

3.10 Accelerated Corrosion Resistance. Testing shall be conducted per SAE J2334 with no evidence of red corrosion (ASTM D610 grade 8 or better) according to the following schedule:

I. GRADE 10: 75 CYCLES.

II. GRADE 11: 50 CYCLES.

III. GRADE 12: 30 CYCLES.

3.11 Cathodic Protection. The cathodic protection capacity of coatings shall be assessed by neutral salt spray testing per ISO 9227 or ASTM B117. Specimens shall be scribed to the base metal (with scratch no wider than 0.5 mm) with no evidence of red corrosion following 96 hours of exposure.

3.12 Adhesion. Coatings shall not exhibit peeling, flaking or blistering after 96 hours of exposure to 95% RH at +40 C. Within 30 minutes of removal from the environmental chamber, a tape adhesion test per ISO 10683 (7.5) shall be conducted; there must be no significant coating transfer to the tape surface. Coating transfer may indicate inadequate cure.

3.13 Chemical Resistance. The coated specimen must withstand exposure to the following chemicals per ASTM D543 Practice B, conducted at room temperature. There must be no discoloration or visible evidence of property loss.

I. WINDSHIELD WASHER FLUID (50% METHANOL SOLUTION)

II. BRAKE FLUID (DOT 3)

III. ENGINE COOLANT (50% ETHYLENE GLYCOL SOLUTION)

IV. SOAP SOLUTION 2.5% WITH ECE TEST SOAP 77 BY HENKEL

V. AMMONIA (GLASS CLEANER) SOLUTION 5%

VI. UNIVERSAL CLEANER WITH VINEGAR

3.14 Frictional Properties. Coated fasteners shall have a friction coefficient of coefficient within the range 0.10 – 0.16 when tested per ISO 16047 with tightening speed 30±3 RPM against uncoated and degreased type HH test bearing plates or washers. Tests nuts and bolts shall be similarly uncoated and degreased. After tightening, there must be a minimum of two full threads outside of the nut and one full thread from the maximum grip gauging length.

3.15 Bearing Surface Properties. Coated M10 class 10.9 heavy hex bolts shall be subject to torque-tension testing per ISO 16047. The tightening speed shall be 30±3 RPM and the tension load shall be 24 kN. The test shall be conducted with zinc-finished test nuts, unhardened e-coated test washers and aluminum 6061 test washers. The measured friction coefficient values may vary between 0.10 – 0.16 for samples tested with both e-coated and aluminum bearing surfaces.

3.16 Torque Chatter. Coated M10 class 10.9 heavy hex bolts shall be subject to torque-tension testing per ISO 16047. The tightening speed shall be 100±10 RPM and the tension load shall be 48 kN. The test shall be conducted with zinc-finished test nuts and unhardened e-coated test washers. A plot of torque versus time or angle will reveal evidence of torque incapability; a fastener meeting this specification must produce a smooth torque curve.

4 Conditions & Regulations

4.1 **Laws.** This specification shall never supersede applicable laws and regulations. All materials must meet legal requirements valid in the country of usage.

4.2 **Language.** Only the English language version of this text shall be binding.

4.3 **Process Accreditation.** All materials testing must be conducted by a laboratory or facility accredited to ISO 17025 by an established third-party auditor.

4.4 **Standard Obsolescence.** It is the responsibility of the supplier to ensure that the most current versions of all cited standards are employed.

4.5 **Materials Equivalency.** Materials or parts approved and purchased to this specification must be equivalent in every respect to the initial samples verified and approved by the appropriate Tesla engineering department.

4.6 **Initial Source Approval.** Delivery of production goods shall not be accepted until representative initial production samples have been verified for compliance to this specification by the appropriate Tesla engineering department.

4.7 **Change Reporting.** The supplier is exclusively responsible for reporting all product changes, including (but not limited to) material formulation or performance, manufacturing methodology, and production facility to the appropriate Tesla engineering department. Materials must be retested as if for initial release unless agreed otherwise.

4.8 **Quality Control.** Test frequency and sample size for process control and product continuous compliance monitoring must meet the agreed quantities and frequencies defined in the Control Plan, DFMEA, PFMEA and PPAP packages submitted and approved by Tesla SQA or Tesla suppliers that use and deliver parts covered by this specification.

4.9 **Product Appearance.** All materials, components and assemblies deemed as "appearance items" must match the corresponding master sample for all colors, gloss and texture as indicated on the applicable released engineering information as approved by the Tesla Design Office and must follow the AAR (Appearance Approval Report) procedure published by Quality Perception Engineering. No final PPAP approval shall be granted to these items unless prior AAR approval has been obtained.

4.10 **IMDS Submission.** All materials, components and processes used to produce parts under this specification and delivered to Tesla Motors, or to be part of products delivered to Tesla Motors as part of the assembled vehicle, must be registered to the International Material Data System prior to being supplied for production usage.

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5 Revision History

VERSION	REVISOR	DATE	DESCRIPTION OF CHANGE
01			
02	Alec Pezeshkian	08/01/2012	Addition of Grade 03.