

# TECH SHEET

## PEM® REF/ MATERIALS AND MANUFACTURE



### **SUBJECT: MATERIALS AND MANUFACTURING**

- 6.1 The coatings shall be non-alloyed zinc produced by electrodeposition.
- 6.2 Defects in the surface of the basis metal, such as scratches, porosity, pits, inclusions, cracks, roll marks, and die marks, may adversely affect the appearance and performance of coatings applied thereto despite the observance of the best electroplating practices. Accordingly, the electroplater's responsibility for defects in the coating resulting from such conditions shall be waived, except when he is the prime contractor supplying electroplated parts. In this event, the basis metal shall be subjected to such polishing or buffing operations as are necessary to yield deposits with the desired final luster and appearance. To minimize problems of this sort, the specifications covering the basis material on the item to be electroplated shall contain appropriate limitations to such basis metal conditions.
- 6.3 Cleaning of Basis Metal – Proper preparatory procedures and thorough cleaning of the basis metal are essential to ensure satisfactory adhesion and corrosion resistance performance of the coating. It is recommended that the following appropriate recommended practices and guides be used: B 183, B 242, B 254, B 320, and B 322.
- 6.4 Pretreatment of Iron or Steel for the Purpose of Reducing the Risk of Hydrogen Embrittlement – All steel parts having an ultimate tensile strength greater than 1000 MPa (31 HRC) and that have been machined, ground, cold formed, or cold straightened, shall be heat treated for stress relief to reduce the risk of hydrogen embrittlement in the part before clean and electroplate processes. If these heat treatments are not required, the purchaser shall specify in the ordering information their exception, (5.2.5). If the purchaser does not specify an exception to heat treatment, then the plater shall use Table 1 in B 849 to determine the appropriate heat treatment for the steel based on its tensile strength.
- 6.5 Post Coating Treatments of Iron and Steel for the Purpose of Reducing the Risk of Hydrogen Embrittlement – All electroplated steel parts having a tensile strength greater than 1000 MPa (31 HRC) as well as surface hardened parts, shall be baked to reduce the risk of hydrogen embrittlement. If these heat treatments are not required, the purchaser shall specify in the ordering information their exception (5.2.5). If the purchaser does not specify an exception to heat treatment, then the plater shall use Table 1 in B 850 to determine the appropriate heat treatment for the steel based on its tensile strength. The baking treatment shall be done before the application of the supplementary treatments and within 4 h of removal from the last process. Electroplated springs and other parts subject to flexure shall not be flexed before the hydrogen embrittlement relief treatment. Baked parts shall not crack or fail by fracture when tested in accordance with 10.4.
- 6.6 Reactivation Treatment – Electroplated surfaces passivated as a result of the baking operation shall be reactivated before receiving a supplementary treatment.

NOTE 1 – Surfaces should be activated as soon as possible following baking and handled carefully to avoid contamination and maintain an active surface for post processing. Proprietary methods are available to prepare the surface or a 2% v/v sulfuric acid in deionized water or a 7-10 g/l solution of sulfamic acid in deionized water can be used.

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6.7 Supplementary Treatments - The supplementary film treatment for Types II, III, V, and VI shall be in accordance with Practice B 201 (see Notes 2 and 3). The treatment required for conversion to Type IV shall be in accordance with Guide D 2092.

NOTE 2 - The zinc surface is attacked by supplementary treatments, thereby diminishing the amount of metallic zinc present. With Classes Fe/Zn25 and Fe/Zn13, this reduction is insignificant; but it is significant with Fe/Zn8 and Fe/Zn5. Therefore, it is recommended that supplementary treatments not be applied to zinc coatings having a nominal thickness less than 5  $\mu\text{m}$ .

NOTE 3 - Although Types V and VI are technically not "chromate" films and they do not contain leachable hexavalent chromium ions, they are supplemental coatings that render the active zinc surface passive and provide added protection to the steel part.

**END**

### 6. Requirements

6.1 Coating Requirements - The electrodeposited coating as ordered shall cover all surfaces and shall meet the following requirements:

6.1.1 The coating metal deposit shall be bright or semi-bright unless otherwise specified by the purchaser, smooth, fine grained, adherent and uniform in appearance.

6.1.2 The coating shall be free of blisters, pits, nodules, roughness, cracks, unplated areas, and other defects that will affect the function of the coating.

6.1.3 The coating shall not be stained, discolored or exhibit any evidence of white or red corrosion products.

6.1.3.1 Slight discoloration that results from baking, drying, or electrode contact during rack-plating, or all of these, as well as slight staining that results from rinsing shall not be cause for rejection.

6.2 Corrosion Resistance - Coated fasteners, when tested by continuous exposure to neutral salt spray in accordance with 9.3, shall show neither corrosion products of coatings (white corrosion) nor basis metal corrosion products (red rust) at the end of the test period. The appearance of corrosion products visible to the unaided eye at normal reading distance shall be cause for rejection, except when present at the edges of the tested fasteners. Refer to Annex A1 for neutral salt spray performance requirements for zinc, zinc alloy and cadmium coatings.

6.3 Thickness - The coating thickness shall comply with requirements of Table 2 when measured in accordance with 9.1.

6.3.1 Restrictions on Coating Thickness - This specification imposes minimum local thickness requirements at significant surfaces in accordance with Table 2. Thick or thin local thickness in a location other than a significant surface shall not be a cause for rejection. However the following restrictions apply:

6.3.1.1 Minimum coating thickness at low current density areas, such as the center of a bolt or recesses, must be sufficient to provide for adequate chromate adhesion.

6.3.1.2 External Threads - Maximum coating thickness at high current density threaded tips must provide for class 3A GO thread gauge acceptance.

6.3.1.3 Internal Threads - Maximum coating thickness of internal threads must provide for class 1B, 2B, or 3B GO thread gauge acceptance.

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- 6.3.1.4 Surfaces such as threads, holes, deep recesses, bases of angles, and similar areas on which the specified thickness of deposit cannot readily be controlled, are exempted from minimum thickness requirements unless they are specially designated as not being exempted. When such areas are subject to minimum thickness requirements, the purchaser and the manufacturer shall recognize the necessity for either thicker deposits on other areas or special racking.
- 6.3.2 Applicability to Unified Inch Screw Threads:
- 6.3.2.1 The applicability of the required coating to unified inch screw threads is limited by the basic deviation of the threads, and hence limited by the pitch diameter, allowance and tolerance positions. Refer to Appendix X3 as a guideline for the tolerances of the various thread sizes and classes and the coating thickness they will accommodate.
- 6.3.2.2 Because of the inherent variability in coating thickness by the barrel-plating process, the application of a minimum coating thickness of 0.0005 in. is not recommended for a standard screw thread by this method due to the fact that dimensional allowance of most threaded fasteners normally does not permit it. If the size of the fastener is large enough to economically use the rack-plating process, then the latter shall be used to obtain this thickness requirement. If heavier coatings are required allowance for the deposit buildup must be made during the manufacture of fasteners.
- 6.3.3 Applicability to Wood Screws and Thread Forming Screws - Any classification code in Table 2 may be applied to screws that cut or form their own threads.
- 6.4 Hydrogen Embrittlement Relief:
- 6.4.1 Requirement for Baking - Coated fasteners made from steel heat treated to a specified hardness of 40 HRC or above, case-hardened steel fasteners, and fasteners with captive washers made from hardened steel shall be baked to minimize the risk of hydrogen embrittlement. Unless otherwise specified by the purchaser, baking is not mandatory for fasteners with specified maximum hardness below 40 HRC.
- NOTE 2 - With proper care many steel fasteners can be plated without baking by correlating process condition to the susceptibility of the fastener material to hydrogen embrittlement, and by applying adequate process control procedures, such as those outlined in Appendix X4.2. Test Method F 1940 is a recognized verification method for process control to minimize the risk of hydrogen embrittlement. Upon agreement between the supplier and the purchaser, this test method can be used as a basis for determining if baking should be mandated in a controlled process environment.
- 6.4.2 Baking Conditions - At the time of publication of this specification it was not considered possible to give an exact baking duration. Eight hours is considered a typical example of baking duration. However, upon agreement between the purchaser and the manufacturer, baking times between 2 and 245 h at temperatures of 350 to 450°F are suitable depending on the type and size of the fastener, geometry, mechanical properties, cleaning process and cathodic efficiency of the electroplating process used. The baking conditions shall be selected based on the results of recognized embrittlement test procedures such as Test Methods F 606, F 1624, F 1940, or NASM-1312-5.
- 6.4.2.1 Bake time and temperatures may require lowering to minimize the risk of solid or liquid metal embrittlement resulting from alloy compositions such as those containing lead or from the lower melting point of cadmium (610°F) in comparison to zinc (786°F).

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6.4.2.2 Fasteners must be baked within 4 h, preferably 1 h after electroplating. Baking to relieve hydrogen embrittlement must be performed prior to the application of the chromate finish because temperatures above 150°F damage the chromate film thereby negating its performance.

6.4.3 Hydrogen Embrittlement Testing - Hydrogen embrittlement testing is mandatory for fasteners with a specified hardness of 40 HRC or above unless the electroplating process has been qualified in accordance with Test Method F 1940 (that is, the process has been shown not to cause embrittlement for a given product or class of product). This specification does not require mandatory testing of fasteners having a specified hardness below 40 HRC, unless otherwise specified by the purchaser.

6.5 Trivalent Chromite Finish - The use of hexavalent chromium is prohibited when processing coated fasteners to the requirement of 4.3.1. Coated fasteners shall be free of hexavalent chromium when tested in accordance with the test method defined in 9.4.

### FROM GM PAGE 1 ----3 REQUIREMENTS - 3.1 APPEARANCE

3.1 Appearance. The as-received appearance and color hue shall be as agreed upon between the purchaser and supplier using approved color and hue engineering standards when available. In the case of zinc plus passivation coating listed herein, a clean, commercial finish is required; range of color, iridescence, opaqueness, and sheen are normally not critical unless otherwise specified by the purchaser. In the case of bright zinc plus clear finishes listed herein, a clear bright appearance (also referred to as colorless, blue-bright and clear silver-white) is required. Specified colors shall be uniform, tightly adherent, hard and dry.

### From ASTM PAGES

#### 6. Coating Requirements

6.1 Appearance:

6.1.1 The coating on the significant surfaces of the product shall be smooth and free of visual defects such as blisters, pits, roughness, cracks, flaking, burned deposits, and uncoated areas. Visual defects are defined as those visible, unmagnified, to the unaided eye, 20/20 vision, or vision corrected to 20/20. The boundaries of electroplating that cover only a portion of the surface shall, after finishing as indicated in the drawing, be free of beads, nodules, jagged edges, and other detrimental irregularities. Imperfections and variations in appearance in the coating that arise from surface conditions of the basis metal (scratches, pores, roll marks, inclusions, etc.) and that persist in the finish despite the observance of good metal finishing practices shall not be cause for rejection (Note 7).

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Note 7 - Applied finishes generally perform better in service when the substrate over which they are applied is smooth and free of torn metal, inclusions, pores, and other defects. It is recommended that the specification covering the unfinished product provide limits from these defects. A metal finisher can often remove defects through special treatments, such as grinding, polishing, abrasive blasting, chemical treatments, and electropolishing. However, these are not normal in the treatment steps preceding the application of the finish. When they are desired they must be stated in the purchase order (see 5.1.7).

6.8 Workmanship - Adding to (spotting-in) or double electroplating, unless evidence of a satisfactory bond is established, shall be cause for rejection (see 7.3). Parts having a hardness greater than 35 HRC (equivalent to a tensile strength of 1200 MPa or greater) that have been acid-stripped for recoating shall be rebaked for embrittlement relief (see 6.2) before electroplating. Stress relieving after stripping is not necessary if the stripping is done anodically in an alkaline solution. Within the areas designed as significant surfaces there shall be no uncoated (or bare) areas (see 4.1). Contact marks shall be minimized in size and frequency. When contacts must be located on significant areas, they shall be placed in areas of minimum exposure to service or environmental conditions as designated by the purchaser. Superficial staining resulting from rinsing, or slight discoloration resulting from baking operations to relieve embrittlement shall not be cause for rejection unless specified to the contrary by the purchaser. (See 5.1.9.). Electrodeposited nickel that is to be finished by machining may have slight surface blemishes in the as-electroplated condition provided that these can be eliminated by the machining operation.