INTERNATIONAL

Designation: B850 − 98 (Reapproved 2022)

Standard Guide for Post-Coating Treatments of Steel for Reducing the Risk of Hydrogen Embrittlement[1]

This standard is issued under the fixed designation B850; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

When atomic hydrogen enters steel, it can cause a loss of ductility, load carrying ability, or cracking (usually as submicroscopic cracks), as well as catastrophic brittle failures at applied stresses well below the yield strength or even the normal design strength for the alloys. This phenomenon often occurs in alloys that show no significant loss in ductility, when measured by conventional tensile tests, and is referred to frequently as hydrogen-induced delayed brittle failure, hydrogen stress cracking, or hydrogen embrittlement. The hydrogen can be introduced during cleaning, pickling, phosphating, electroplating, autocatalytic processes, porcelain enameling, and in the service environment as a result of cathodic protection reactions or corrosion reactions. Hydrogen can also be introduced during fabrication, for example, during roll forming, machining, and drilling, due to the breakdown of unsuitable lubricants, as well as during welding or brazing operations.

1. Scope

1.1 This guide covers procedures for reducing the susceptibility in some steels to hydrogen embrittlement or degradation that may arise in the finishing processes.

1.2 The heat treatment procedures established herein may be effective for reducing susceptibility to hydrogen embrittlement. This heat-treatment procedure shall be used after plating operations but prior to any secondary conversion coating operation.

1.3 This guide has been coordinated with ISO/DIS 9588 and is technically equivalent.

NOTE 1—The heat treatment does not guarantee complete freedom from the adverse effects of hydrogen degradation.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A919 Terminology Relating to Heat Treatment of Metals (Withdrawn 1999)[3]

B374 Terminology Relating to Electroplating

B851 Specification for Automated Controlled Shot Peening of Metallic Articles Prior to Nickel, Autocatalytic Nickel, or Chromium Plating, or as Final Finish

2.2 *ISO Standards:*[4]

ISO 2080 Electroplating and Related Processes—Vocabulary

ISO DIS 9588 Post-Coating Treatments of Iron or Steel for Reducing the Risk of Hydrogen Embrittlement

[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.02 on Pre Treatment.

Current edition approved May 1, 2022. Published June 2022. Originally approved in 1994. Last previous edition approved in 2015 as B850–98(2015). DOI: 10.1520/B0850-98R22.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

2.3 *Federal Standard:*[5]
QQ-C-320 Chromium Plating (Electrodeposited)

3. Terminology

3.1 *Definitions*—Many of the terms used in this guide can be found in Terminology B374, A919, or ISO 2080.

4. Requirements

4.1 Heat treatment may be performed on coated metals to reduce the risk of hydrogen embrittlement. The duration of heat treatment in all cases shall commence from the time at which the whole of each part attains the specified temperature.

4.2 Parts made from steel with actual tensile strengths ≥1000 MPa (with corresponding hardness values of 300 HV_{10kgf}, 303 HB, or 31 HR_C) and surface-hardened parts may require heat treatment unless Class ER-0 is specified. Preparation involving cathodic treatments in alkaline or acid solutions shall be avoided. Additionally, the selection of electroplating solutions with high cathodic efficiencies is recommended for steel components with tensile strengths above 1400 MPa (with corresponding hardness values of 425 HV_{10kgf}, 401 HB, or 43 HR_C).

4.3 Table 1 provides a list of embrittlement-relief heat-treatment classes from which the purchaser may specify the treatment required to the electroplater, supplier, or processor on the part drawing or purchase order.

NOTE 2—The treatment class selected is based on experience with the part, or similar parts, and the specific alloy used or with empirical test data. Because of factors such as alloy composition and structure, type of coating, coating thickness, size, mass, or design parameters, some parts may perform satisfactorily with no embrittlement-relief treatment. Class ER-0 treatment is therefore provided for parts that the purchaser wishes to exempt from treatment.

NOTE 3—The use of inhibitors in acid pickling baths may not minimize hydrogen embrittlement.

4.4 The electroplater, supplier, or processor is not normally in possession of the necessary information, such as design considerations, operating stresses, etc., that must be considered when selecting the correct embrittlement relief treatment. It is in the purchaser's interest that his or her part designer, manufacturing engineer, or other technically qualified individual specify the treatment class on the part drawing or purchase order.

[5] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098

TABLE 1 Classes of Embrittlement-Relief Heat Treatment (See Sections 4 – 6 for details on the Use of Table 1)

Hydrogen Embrittlement-Relief Treatment Classes for High-Strength Steels			
Class	Steels of Tensile Strength (R_m), MPa	Temperature, °C	Time, h
ER-0	not applicable		
ER-1	1701 to 1800	190–220	min 22
ER-2	1601 to 1700	190–220	min 20
ER-3	1501 to 1600	190–220	min 18
ER-4	1401 to 1500	190–220	min 16
ER-5	1301 to 1400	190–220	min 14
ER-6	1201 to 1300	190–220	min 12
ER-7[A]	1525 or greater	177–205	min 12
ER-8	1101 to 1200	190–220	min 10
ER-9	1000 to 1100	190–220	min 8
ER-10[A]	1250 to 1525	177–205	min 8
ER-11[A]	1450 to 1800	190–220	min 6
ER-12[A]	1000 to 1500	177–205	min 4
ER-13	1000 to 1800 unpeened items and for engineering chromium plated items	440–480	min 1
ER-14[A]	surface-hardened parts <1401	130–160	min 8
ER-15[A]	surface-hardened parts 1401 to 1800 plated with cadmium, tin, zinc, or their alloys	130–160	min 8
ER-16	surface-hardened parts <1401 plated with cadmium, tin, zinc, or their alloys	130–160	min 16

[A] Classes ER-7, ER-10, ER-11, ER-12, ER-14, and ER-15 are traditional treatments used in Federal Standard QQ-C-320. They do not apply to any other standard.

5. Embrittlement Relief Treatment Classes

5.1 With the exception of surface-hardened parts and parts that have been shot peened in accordance with Specification B851, heat treatment conditions may be selected on the basis of actual tensile strength. When only the minimum tensile strength is specified, or if the tensile strength is not known, the heat treatment condition may be selected by relating known or measured hardness values to equivalent tensile strengths. It is recommended that the tensile strength be supplied by the purchaser.

5.2 Steels that have been wholly or partly surface hardened may be considered as being in the category appropriate to the hardness of the surface-hardened layer.

5.3 If the purchaser requires any tests to be performed in order to verify adequate embrittlement relief treatment, the test method and the sampling plan to be used shall be specified.

6. Heat Treatment After Processing

6.1 The heat treatment shall commence as soon as possible, preferably within 1 h but not later than 3 h after plating and before commencement of any grinding or other mechanical operation. For cadmium, tin, zinc, their alloys, or any other coating receiving a chromate treatment, heat treatment shall be conducted before chromate treatment.

NOTE 4—Chromate coatings undergo change at temperatures above 66 °C. The coating changes from an amorphous structure to a crystalline structure and no longer exhibits self-healing properties. While the crystallized chromate coating will provide satisfactory corrosion protection under most natural environments, the chromate coating will no longer pass accelerated corrosion tests.

NOTE 5—The time period referred to is the length of time between the end of the plating operation and loading of the item concerned into the heat treatment processor.

6.2 For high-strength steels, the conditions given in Table 1 may be applied. For steels of actual tensile strength below 1000 MPa, heat treatment after plating is not essential.

6.3 Electroplated steel items having surface-hardened areas and through hardened or bearing steels, which would suffer an unacceptable reduction in hardness by treatment in accordance with Table 1 shall be heat treated at a lower temperature, but not below 130 °C.

6.4 Treatment at 440 to 480 °C will reduce the hardness of chromium deposits. It shall not be applied to steels that may be