AEROSPACE MATERIAL SPECIFICATION

AMS03-4

Issued 2015-04

The Pre-Treatment and Protection of Steel Items of Specified Maximum Tensile Strength Exceeding 1450 MPa

RATIONALE

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FOREWORD

REVISION NOTE

This Defence Standard was raised to Issue 6 to update its content and incorporate the latest MoD/DStan policy in place at the time.

HISTORICAL RECORD

This standard supersedes the following:

Def Stan 03-4 / Issue 1 dated 23 November 1971

Def Stan 03-4 / Issue 2 dated 31 March 1977

Def Stan 03-4 / Issue 3 dated 1 February 1991

Def Stan 03-4 / Issue 4 dated 2 January 1998

Def Stan 03-4 / Issue 5 dated 13 October 2006

INTRODUCTION

This Standard sets out the special treatments and precautions that are to be observed when protective and other surface treatments are applied to items, including springs, made from steel of specified maximum tensile strength exceeding 1450 MPa. The requirements of this Standard qualify those in process specifications and override the latter where there is conflict. The Standard also gives advice on design, manufacture, and preparation of items prior to cleaning and protection.

Though this Standard refers to the use of cadmium, it should be noted that in accordance with MOD Policy and UK Environmental (Control of Hazardous Substances) No.2 Regulation1993, cadmium is only to be used where specific agreement has been given by the MOD. Every effort must be made to define alternative coatings (see Def Stan 03-36) and cadmium is only to be used where its use is permitted by regulation and no other acceptable alternative is available.

Similarly there is increasing concern regarding the use of hexavalent chromium chemicals with more and more legislation being introduced to limit its use. Although this standard refers to the use of chromium electroplating, for instance, users should make every effort to identify alternatives (see Def Stan 03-38).

NOTE: In the case of hexavalent chromium it is the coating process itself where the hazard exists not the end product; i.e., chromium electroplate is non-toxic. This is contrary to cadmium for instance where potential hazards exist during processing, use and disposal.

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1. SCOPE

This SAE Standard specifies the special treatments and precautions that are to be observed when protective and other surface treatments are applied to items, including springs, made from steel of specified maximum tensile strength exceeding 1450 MPa. The requirements of this Standard qualify those in process specifications and override the latter where there is conflict. The Standard also gives advice on design, manufacture, and preparation of items prior to cleaning and protection.

2. WARNING

This section which appeared in DEF STAN 03-4 Issue 6 has been deliberately deleted.

3. NORMATIVE REFERENCES

3.1 The publications shown below are referred to in the text of this standard. Publications are grouped and listed in alpha-numeric order.

BS EN ISO 2063	Thermal Spraying. Metallic and Other Inorganic Coatings. Zinc, Aluminium and their Alloys
BS EN ISO 4527	Metallic Coatings. Autocatalytic (Electroless) Nickel-Phosphorous Alloy Coatings
BS EN ISO 6507-1	Metallic Materials: Vickers Hardness Test: Test Method
BS EN 2828	Adhesion Tests for Metallic Coatings by Burnishing
BS EN 2829	Adhesion Tests for Metallic Coatings by Shot Peening
BS EN 2830	Adhesion Tests for Metallic Coatings by Shearing Action
BS EN 2831	Hydrogen Embrittlement of Steels: Test by Slow Bending
BS EN 2832	Hydrogen Embrittlement of Steels: Notched Specimen Test
BS 1872	Specification for Electroplated Coatings of Tin
BS 4921	Specification for Sherardized Coatings on Iron and Steel
BS 7195	Guide for the Prevention of Corrosion of Metals Caused by Vapours from Organic Coatings
BS M37	Method for the Etch Inspection of Metallic Materials and Components
BS 2X33	Specification for Two Component Epoxy Primer for Aerospace Purposes
BS 2X34	Specification for Air Drying, Two Component, Polyurethane Finish for Aerospace Purposes
Def Stan 00-970	Design and Airworthiness Requirements for Service Aircraft
Def Stan 03-2	Cleaning and Preparation of Metal Surfaces
AMS03-2	Cleaning and Preparation of Metal Surfaces
Def Stan 03-9	Electro-Deposition of Silver
AMS03-9	Electro-Deposition of Silver
Def Stan 03-11	Phosphate Treatment of Iron and Steel
AMS03-11	Phosphate Treatment of Iron and Steel

Def Stan 03-14	Electro-Deposition of Chromium for Engineering Purposes
AMS03-14	Electro-Deposition of Chromium for Engineering Purposes
Def Stan 03-17	Electro-Deposition of Gold
AMS03-17	Electro-Deposition of Gold
Def Stan 03-19	Electro-Deposition of Cadmium
AMS03-19	Electro-Deposition of Cadmium
Def Stan 03-20	Electro-Deposition of Zinc
AMS03-20	Electro-Deposition of Zinc
Def Stan 03-21	Mechanical Methods for the Inducement of Compressive Surface Residual Stresses
Def Stan 03-27	Electro-Deposition of Nickel for Engineering Purposes
AMS03-27	Electro-Deposition of Nickel for Engineering Purposes
Def Stan 03-28	Physical Vapour Deposition of Metals
AMS03-28	Physical Vapor Deposition of Metals
Def Stan 03-30	Treatments for the Protection of Metal Parts of Service Stores and Equipment against Corrosion
Def Stan 03-31	A Guide to the use of Chromium Plating for Engineering Purposes
Def Stan 03-36	Guidance to the Use of Cadmium Alternatives in the Protective Coating of Defence Equipment
Def Stan 03-38	Guidance to the Use of Alternatives to Hard Chromium Plating and Chromium Conversion Coatings for the Protective Coating of Defence Equipment
Def Stan 80-54	Paint, Finishing, General Service, Fuel Resistant, Gloss
Def Stan 80-161	Paint, Finishing, Spraying, Epoxy, Multi Pack
Def Stan 80-206	Paint, Priming, Zinc Phosphate, Non-Aircraft Use, Low VOC, Single or Multi Pack
Def Stan 80-207	Paint, Priming, Zinc Chromate, Non-Aircraft Use, Low VOC, Single or Multi Pack
Def Stab 80-208	Paint, Finishing, Polyurethane Multi Pack, Matt IRR, Chemical Agent Resistant, Non-Aircraft Use, Low VOC
Def Stan 91-70	Cutting Fluid, Soluble, Biostable. Joint Service Designation
ASTM F519	Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

3.2 This section which appeared in DEF STAN 03-4 Issue 6 has been deliberately deleted.

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4. DEFINITIONS

4.1 For the purpose of this Standard the following definitions apply:

4.2 BAKING

A low temperature heat treatment given after processing to reduce or eliminate the danger of hydrogen embrittlement by expelling absorbed hydrogen and/or diffusing it throughout the item.

4.3 CATEGORIZATION OF STEELS

4.3.1 Throughout this Standard the tensile strength figures refer to specified maximum tensile strength. Steels shall be categorized according to specified maximum tensile strength in accordance with Table 1. Where the steel specification specifies only the minimum tensile strength the equivalent maximum tensile strength category shall be determined from Table 1.

Table 1 - Tensile strength criteria

Specified Minimum Tensile Strength MPa	Specified Maximum Tensile Strength MPa
* up to 1000	* up to 1100
* from 1001 to 1400	* from 1101 to 1450
from 1401 to 1800	from 1401 to 1800
1801 and greater	1801 and greater

* Included for comparison purposes.

4.3.2 If no maximum or minimum tensile strength figure is specified for the steel, hardness values of 425HV, 440HV and 560HV (as determined in accordance with BS EN ISO 6507-1) shall be regarded as equivalent to 1400, 1450, and 1800 MPa respectively. Steels which have been wholly or partly surface hardened shall be considered as being in the category appropriate to the hardness of the surface layer.

4.4 DESIGN AUTHORITY

The approved firm, establishment or branch responsible for the detailed design of materiel to approved specifications and authorized to sign a certificate of design or to certify sealed drawings.

4.5 HEAT TREATMENT TIMES

The appropriate heat treatment time commences when the items have reached the specified temperature.

4.6 HYDROGEN EMBRITTLEMENT

A loss of ductility, load carrying ability or cracking (usually initiating as sub-microscopic cracks) of a metal or alloy due to the presence of hydrogen in or on the material. The hydrogen can be introduced during fabrication, cleaning, pickling, phosphating, electro-plating, and auto-catalytic processes.

4.7 PROCESS CONTROL SCHEDULE

The document which specifies/defines:

a. The sequence of manufacturing operations and processes.

b. The control parameters and their tolerances for each individual process within the total sequence.

4.8 PHYSICAL PREPARATION

Physical preparation is concerned with the reduction of deleterious internal and surface stresses and/or the introduction by mechanical means of beneficial compressive stresses in the surface.

4.9 STRESS RELIEF

A low temperature heat treatment given before processing to reduce stresses in the surface of the item, not necessarily causing the relief of deeper internal stresses.

5. INFORMATION TO BE SUPPLIED BY THE PURCHASER

The following information shall be given on the drawing, contract or order:

a. The specification and category of the steel (see 4.3), or other information from which the category can be established.

b. Instructions concerning stress relief (see 8.1). These instructions shall take into account the highest temperature to which the part may be heated and the prior physical preparation.

c. The number of this AMS Material Specification or its superseded Defence Standard and the section(s) applicable.

6. PROCESS CONTROL

6.1 A Process Control Schedule suitable of achieving the requirements of this Standard shall be prepared by the processing contractor(s) prior to the commencement of production.

6.2 Details of the coating process, including all preparatory treatments and after treatments, processing, the pH range, operating temperature, chemical composition, method of agitation, any galvanic or electrolytic initiation, pre and post-plating heat treatments, tests and all other processes and treatments shall be included in the Process Control Schedule.

6.3 All stages in the complete Schedule shall follow each other without delay.

7. RECOMMENDATIONS FOR DESIGN AND MANUFACTURE

7.1 Design Considerations

7.1.1 Choice of Steel

7.1.1.1 Designers should avoid selecting steels of unnecessarily high strength. The susceptibility of high strength steels to hydrogen embrittlement is affected by the type of steel and the steelmaking process, therefore, advice should be sought.

7.1.1.2 In order that effective stress relief and de-embrittlement by baking can be given to the item, steels which give the required strength with a tempering temperature greater than 300 °C should be chosen in preference to those requiring tempering at a lower temperature.

7.1.1.3 Designers should seek authoritative advice and recommendations concerning the implementation of the applicable parts of this Standard, particularly when steels of tensile strength 1800 MPa and greater are selected.

7.1.2 Avoidance of Stress Concentrations

7.1.2.1 Notches, sharp radii and sudden changes of section should be avoided as they lead to the development of stress concentrations which promote failure both under sustained load and by fatigue.

7.1.2.2 Stresses produced by press and shrink fits and tapers, or otherwise introduced during assembly, should be kept to a minimum.

7.1.3 Protective Treatment

The choice of protective treatment is normally made by the designer from Def Stan 03-30 or from the appropriate master design manual for the item in question, e.g., the design requirements laid down for aircraft (Def Stan 00-970), etc. Hydrogen embrittlement can be avoided by using non-electrolytic processes, e.g., wide tolerance items may be metal sprayed with Aluminum or Zinc (BS EN ISO 2063) and close tolerance items may be coated with cadmium by ion vapor deposition (AMS03-28 Part 2/Def Stan 03-28 Part 2). Whenever possible processes known either not to embrittle or to produce the lowest hydrogen absorption shall be used.

7.2 Type Testing

7.2.1 Methods whereby aqueous protective treatments can be applied without some risk of harmful effects, e.g., embrittlement or poor adhesion, are not yet established with certainty. Much laboratory work remains in progress, and of necessity this Standard contains a high proportion of descriptive and advisory matter. Many of the special requirements and recommendations are directed to the avoidance of hydrogen embrittlement and of the harmful effect on the surface treatments and heat treatments on fatigue properties.

7.2.2 The behavior of standard laboratory test specimens is not always a reliable guide to the behavior of actual items, and it is strongly recommended that production items should be type tested on the protected condition under the type of stress and in the kind of environment the items will meet in service.

7.2.3 For the detection of hydrogen embrittlement, sustained load tests, e.g., BS EN 2832 or ASTM F519, or slow bend tests, e.g., BS EN 2831 are recommended.

7.2.4 For the assessment of adhesion, testing by burnishing (e.g., BS EN 2828), shot peening (e.g., BS EN 2829), or shearing (e.g., BS EN 2830) may be used.

7.3 Manufacture

7.3.1 Machining and Grinding

7.3.1.1 The final mechanical shaping of fully heat-treated items should be carried out in a way designed to avoid introducing tensile stresses or thermal abuse into the surface. Tool and work-piece should be held rigid and machining or grinding should be light with copious cooling of the work-piece. An appropriate grade of abrasive wheel shall be selected for use and the wheel regularly dressed to prevent its use in a glazed condition.

7.3.1.2 Cutting oils and coolants can introduce hydrogen into the steel. The risk is least with mineral oils with the next in order of preference being water-oil-emulsions. If soluble oils are used, they should be of the non-activated type such as ZX-9 (Def Stan 91-70) and should be used with an oil content of not less than 15%. Sulfurized oils and fully activated oils should be avoided, but if their use is essential the time of contact of the item with the oil should be kept to a minimum and should not be longer than 30 minutes at room temperature. Any type of emulsion (water-in-oil, or oil-in-water) used should be removed as soon as possible after machining and replaced by a temporary protective.

7.3.1.3 All components of a critical nature shall be thoroughly inspected after all grinding operations by a suitable etch inspection method, e.g., BS M37, which will identify grinding damage. Such inspection techniques must be defined in the Process Control Schedule.

NOTE: Etch inspection which makes use of acid solutions may introduce hydrogen into the surface. It must, therefore, precede any scheduled de-embrittling treatment and in any case be followed by de-embrittlement.

7.3.2 Chemical Machining

Chemical contouring and electro-chemical machining offer attractive ways of shaping very strong steel items but may only be used subject to agreement by the Design Authority. Methods known to be non-embrittling are available.

7.3.3 Cold Forming

Heat-treated items, other than springs, shall not be cold formed or straightened without the concurrence of the Design Authority.

7.3.4 Surface Rolling

Threads and other areas containing unavoidable sharp radii should, after final heat-treatment, be subject to surface rolling or other treatment likely to impart compressive surface stresses (see Section 8). Stress relief (see Section 8) before rolling is an advantage.

7.3.5 Protection during Manufacture

Up to the time at which the final protective coating is applied, items shall be protected with a temporary protective or a non-aggressive oil.

7.3.6 Etch Inspection

If items are given an etching treatment in an acid solution, e.g., nital etching, to reveal damage to the surface caused by abusive grinding or machining, then this treatment shall be given at this stage, i.e., prior to stress relief; any hydrogen embrittlement caused by the etching treatment will be eliminated by the stress relieving providing it is carried out immediately after etching.

8. PHYSICAL PREPARATION

8.1 Stress Relief

8.1.1 General

The relief of internal and deleterious surface stresses, by a suitable heat treatment, aids resistance to sustained load and fatigue failure. As a rule, internal stresses developed during quenching are relieved at temperatures of 400 °C and above, and surface stresses developed during mechanical finishing operations can be reduced by heating at temperatures of 200 °C and above. The relief of beneficial surface compressive stresses introduced during production should, however, be avoided (see 8.1.3). Stress relief shall be applied before cleaning according to Section 9, although items may, if necessary, be degreased before heating. Items, e.g., springs manufactured to certain British Standard Aircraft Series specifications, which have been stress relieved as a mandatory requirement for the manufacturing specification do not require further stress relief before cleaning. The stress relief treatment can be omitted for maraging steels which have been aged after final machining.

8.1.2 Standard Procedure

The standard stress relief consists of heating the items to the highest temperature possible within the limit imposed by the tempering or ageing temperature or by any susceptibility of the steel to temper brittleness. The period at temperature shall be as follows:

- for category 1451 to 1800 MPa, not be less than 18 hours at 200 to 230 °C
- for category 1801 MPa and over, not be less than 24 hours at 200 to 230 °C

followed by cooling in still air.

NOTE 1 Suitable combinations of a shorter time at appropriate higher temperatures may be used if they have been shown not to be detrimental.

NOTE 2 At the discretion of the Design Authority, case hardened items which are not to be electroplated on the hardened area may, however, be stress relieved at only 130 °C for 6 hours, as a higher temperature may unacceptably reduce the hardness of the case.

NOTE 3 If the tempering temperature of the steel is less than 50 °C above the temperature ranges stated above, the heat treatment may be undertaken at a temperature that is at least 50 °C below the tempering temperature.

8.1.3 Stress Relief of Items

The application of stress relief should be considered in relation to the methods of mechanical preparation of items, described in 8.2.

8.1.3.1 Items not given a Treatment to Introduce Beneficial Compressive Stresses into the Surface

The standard treatment (see 8.1.2) shall be applied to all items.

8.1.3.2 Items given a Treatment to Introduce Beneficial Compressive Stresses into the Surface

Standard stress relief prior to these mechanical treatments is recommended and if given shall not be repeated after the mechanical treatment. If no prior stress relief is given, then items given one of the mechanical treatments all over shall not be stress relieved after treatment and items given one of the mechanical treatments over only part of the surface shall be stress relieved after treatment by the standard procedure (8.1.2).

8.1.3.3 Springs

Notwithstanding the above, shot peened or dry blasted springs may be stress relieved at a temperature recommended by the manufacturer but not exceeding 230 °C.

8.2 Mechanical Preparation

The introduction of compressive stresses into the surface is strongly recommended, either all over or upon selected areas. These stresses will be balanced by tensile stresses of varying intensity elsewhere in the item, and design and mechanical preparation should be such that these tensile stresses can do no harm.

8.2.1 The following treatments introduce compressive stresses into surfaces:

8.2.1.1 Shot Peening

The advantage of this process is that it can be controlled and that the beneficial effects persist after the surface has been ground smooth under controlled conditions. The intensity of peening shall produce on an Almen A test specimen an arc height of not less than 0.3 mm when measured by the method described in Def Stan 03-21. If necessary the peened surface of the item may be ground smooth by the removal of the minimum possible amount of metal from the surface, and in any case not more than 0.1 mm, measurement being made from the asperities of the peened surface.

8.2.1.2 Surface Rolling

This may be carried out after heat treatment, e.g., of bolts.

8.2.1.3 Abrasive Blasting

Methods D1 and D2 of AMS03-2/Def Stan 03-2 may be of value in some instances (grit blasting which is used for descaling and other purposes is also used prior to metal spraying as metal spraying processes can reduce fatigue properties).

9. CLEANING

9.1 Prior to protective treatment, items shall be cleaned by one or more of the following methods. The steps selected in the cleaning sequence shall follow one another without interruption other than any necessary washing, and be followed immediately by the protective treatment. The Method numbers refer to the particular methods in Annex J of AMS03-2/Def Stan 03-2 to be used to produce a chemically clean surface receptive to subsequent processing, e.g., for maraging steels the final preparation for plating shall be dry grit blasting with virgin aluminum oxide. Special cleaning procedures may also be required for steels, other than maraging steels, prior to particular processes, e.g., as in 10.5.1.2 prior to chromium electrodeposition etc.

9.2 Category 1451 – 1800 MPa Steels

9.2.1 Degreasing in an organic solvent (Method A1 or A2).

9.2.2 Degreasing in an aqueous alkaline solution (Method B1) with applied anodic direct current if desired. Neither cathodic nor alternating current treatments shall be used.

9.2.3 Alkaline de-rusting (Method K1).

9.2.4 Abrasive cleaning (Process D). This Process, especially grit blasting (Method D1) leaves the surface very susceptible to corrosion, and further processing shall be given without delay.

9.2.5 Anodic pickling in sulphuric acid solution (Process H) must be carefully controlled. Additionally, parts shall be connected and the current switched on before the parts are immersed in the solution, and after treatment the items shall be withdrawn rapidly before the current is finally switched off, and washed immediately. The sulphuric acid used to make up the solution shall at no time contain more than 11 ppm oxidizable material calculated as sulphur dioxide, determined by the method described in Annex A (this precaution is necessary because reduced sulphur, phosphorus, and arsenic compounds in the acid promote hydrogen absorption during washing).

9.2.6 Where electrolytic de-rusting to AMS03-2/Def Stan 03-2 (Process K) is required, an alkaline electrolyte and anodic current shall be used. A sea-water electrolyte and cathodic current or alternating current shall not be used (unlikely because heavily rusted very strong steel items would normally be rejected for poor surface condition and poor fatigue properties).

9.3 Category 1801 MPa and Greater Steels

9.3.1 Degreasing in an organic solvent as in 9.2.1.

9.3.2 Alkaline treatments as in 9.2.2, 9.2.3, or 9.2.6.

9.3.3 Abrasive cleaning as in 9.2.4.

10. PROTECTIVE TREATMENTS

10.1 Precautions Applicable to all Treatments

10.1.1 Protective treatment shall follow without delay the last stage of cleaning. Surfaces shall be clean, free from rust and cleaning products.

10.1.2 Items other than close-coiled springs shall not be mechanically stressed during treatment, e.g., by jigs, clips, etc. Close-coiled springs should be extended only sufficiently to allow adequate coverage of the springs and the constraint should be removed immediately after post treatment washing. Electrodeposited or phosphated springs shall not be unnecessarily flexed before baking for the removal of hydrogen embrittlement.

10.1.3 Wherever practicable treatment shall start as soon as the item enters the treatment solution. Treatment baths shall be at full operating temperature and large items should be warmed before treatment, e.g., by immersion in hot water if it is not appropriate to heat them in the processing solution.

10.1.4 Baking treatments shall be started as soon as possible and preferably within 3 hours of the completion of the electroplating or phosphate treatment.

NOTE: In certain applications the Design Authority may require baking to commence within 1 hour on completion of processing.

10.1.5 If after baking a protective process has been applied to only part of the surface, the untreated surface shall then be coated with a temporary protective.

10.2 Cadmium Electrodeposition (AMS03-19/Def Stan 03-19)

10.2.1 Preparation

Items shall be prepared and cleaned as described earlier in Sections 7, 8, and 9. Subject to 10.2.2 and 10.2.3, the requirements of AMS03-19/Def Stan 03-19 shall be followed.

10.2.2 Choice of Electrolyte

The electrolyte shall not contain brightening agents. The proportions of the constituents of a normal cyanide electrolyte may influence hydrogen embrittlement. Acid electrolytes may cause less embrittlement than standard cyanide electrolytes, but may have rather poor throwing power. Proprietary cyanide electrolytes containing oxidizing agents such as nitrate and pertitanate also cause less embrittlement but need careful control. Electrolytes maintained in a high state of purity may cause less embrittlement. A cadmium strike at a high current density (100 A/m²) may be beneficial in reducing the risk of embrittlement.

10.2.2.1 The Design Authority may require non-embrittling characteristics of the process to be demonstrated prior to production use and monitored thereafter. A suitable hydrogen embrittlement test is the sustained load notched tensile test, described in ASTM F519 or BS EN 2832 or the slow bend test described in BS EN 2831.

10.2.3 Baking

Electrodeposited items shall be baked according to the requirements of Table 2 prior to passivation.

10.2.4 Protection Against Vapor Corrosion

For protection of unpainted cadmium against corrosion by organic vapors (see BS 7195) a tin flash may be applied over fully baked, unpassivated, cadmium electroplate. Further baking is neither required nor, because of the melting point of cadmium-tin alloy (176 °C), is it permitted. The process is unsuitable for items subject to temperatures exceeding 160ºC in service.

10.3 Physical Vapor Deposition of Aluminum, Cadmium and Titanium Nitride (AMS03-28 parts 1, 2, and 3/Def Stan 03-28 parts 1, 2, and 3)

This process does not cause hydrogen embrittlement and is the preferred method of coating cadmium. Items shall be treated in accordance with the relevant part of AMS03-28/Def Stan 03-28.

10.4 Zinc Electrodeposition (AMS03-20/Def Stan 03-20)

During zinc electrodeposition the problems of hydrogen absorption from a cyanide solution are broadly the same as those from cadmium electroplating, and similar advice and requirements apply (see 10.2.1, 10.2.2, and 10.2.3).

10.5 Hard Chromium Electrodeposition (AMS03-14/Def Stan 03-14)

This process is applied to working items many of which are subject to fatigue as well as to sustained load. It has, however, a very deleterious effect on fatigue properties unless special measures are taken. Mechanical preparation of shot–peening which improves fatigue properties also improves sustained load properties. Designers should consult Def Stan 03-31 before using this process.

10.5.1 Preparation

Items shall be prepared and cleaned as described in Sections 7, 8, and 9. It is strongly recommended that items made in steel subject to fatigue in service shall be prepared by shot-peening in accordance with 8.2.

10.5.1.1 Items shall be further cleaned as specified in AMS03-14/Def Stan 03-14. Although anodic pickling is not generally allowed by 9.3 for category 1800 MPa and greater steels, it may be used on both categories when followed by chromium electroplating and baking.

10.5.1.2 Any prior nickel electrodeposition, e.g., such as a nickel strike, shall be carried out in accordance with 10.6 and 10.7, and preparation for subsequent chromium electroplating shall be in accordance with AMS03-14/Def Stan 03-14.

10.5.2 Baking

Electrodeposited items shall be baked according to the requirements of Table 2.

10.5.3 Post-Electrodeposition Grinding

A fluorescent penetrant inspection method which is capable of identifying cracks caused by abusive grinding shall be used.

10.6 Nickel Electrodeposition for Engineering Purposes (AMS03-27/Def Stan 03-27)

The general requirements of AMS03-27/Def Stan 03-27 apply but copper undercoats are not permitted. Items shall be prepared and cleaned as described in Sections 7, 8, and 9. Steels may be anodically pickled as in 9.2.5. Heavy electroplating has a deleterious effect on fatigue properties and it is strongly recommended that items subject to fatigue in service shall be prepared as in 10.5.1 and electrodeposited by the low stress sulfamate process. Electrodeposited items shall be baked according to the requirements of Table 2.

10.7 Electroless Nickel Coating of Metals (BS EN ISO 4527)

Items shall be treated in accordance with the requirements of 10.6. The process also has a deleterious effect on fatigue properties.

NOTE: The hardness of the electoless-nickel deposit will depend significantly on the post-deposition, heat treatment temperature and the phosphorus content.

10.8 Silver Electrodeposition (AMS03-9/Def Stan 03-9)

Items shall be prepared and cleaned as described in Sections 7, 8, and 9. The general requirements of AMS03-9/Def Stan 03-9 shall apply except that copper or brass undercoats are not permitted. Electrodeposited items shall be baked according to the requirements of Table 2.

10.9 Gold Electrodeposition (AMS03-17/Def Stan 03-17)

The items shall first be electroplated with nickel and/or silver according to 10.6 and 10.8 including the appropriate baking treatment. Copper electrodeposition is not permitted. The items shall be prepared and cleaned as described in Sections 7, 8, and 9. Any electrolytic cleaning shall be anodic. The items after gold electroplating shall be baked according to the requirements of Table 2.

10.10 Sprayed Coatings of Aluminum and Zinc (BS EN ISO 2063)

Providing tolerances and thicknesses allow and the requirements of BS EN ISO 2063, particularly those relating to adhesion, are met, the steel may be metal sprayed. For improved corrosion protection metal spraying should be followed by a full paint scheme; over zinc, an etch primer shall be used but over aluminum, an etch primer is optional. No baking is required for hydrogen de-embrittlement after metal spraying.

10.11 Phosphate Treatment (AMS03-11/Def Stan 03-11)

The general requirements of AMS03-11/Def Stan 03-11 shall apply. In order to reduce hydrogen absorption, the phosphate treatment process shall be of the accelerated, but copper-free, type working at a pointage not exceeding 30. Items shall be prepared and cleaned as described in Sections 7, 8, and 9. Phosphate items shall be baked according to the requirements of Table 2.