

Code of practice for

Cleaning and preparation of metal surfaces

UDC 621.7.02 : 669.056

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Code Drafting Panel 423

Mr D W Smith (*Chairman*)

Mr D W Smith }
Mr H G Cole }
Mr S W Baier }
Mr V F Henley }
Mr J E Martin }
Mr A W Murdoch }
Mr C M Prosser }
Mr A T S Rudram }
Mr H Silman }
Mr V Wakelin }
Mr R Mills }

Representing:

Ministry of Defence (Procurement Executive)

Personal capacity

Secretary, BSI

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Code of Practice for

Cleaning and preparation of metal surfaces

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British Standards Institution · 2 Park Street · London W1A 2BS

Telephone: 071-629 9000

Telex: 266933



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Foreword

This Code of Practice was prepared in conjunction with the Ministry of Defence to make available to industry at large the main provisions of Defence Standard DEF STAN 03-2/1, 'Cleaning and preparation of metal surfaces'.

The Code is divided into three sections. Section 1 gives recommended practice for cleaning a variety of metals and alloys when no subsequent coating is required and Section 2 deals with cleaning and preparation prior to the application of a comprehensive range of coatings. Full details of those methods recommended in Sections 1 and 2 are given in Section 3 at the end of the Code. The designation of the methods conform alphabetically with those given in DEF STAN 03-2/1. It is noteworthy, however, that this code includes a number of processes not referred to in DEF STAN 03-2/1 as they are not generally used in the defence field.

The cleaning and preparation of iron and steel prior to painting is not dealt with in this Code as the more important aspects of this subject are already covered by CP 231 'Painting of Buildings', CP 2008 'Protection of iron and steel structures from corrosion', PD 420 'Methods of protection against corrosion for light gauge steel used in building', and BS 4232 'Surface finish of blast-cleaned steel for painting'.

It should be emphasized that the methods given for the treatment of metals are indicative of those most commonly used in practice. There are, in addition, numerous proprietary processes and solution formulations available which, when operated in accordance with the supplier's instructions, are frequently more convenient to use and can in some cases give superior results.

British Standard Code of Practice for Cleaning and preparation of metal surfaces

0. Scope

Section 1 of this Code of Practice refers to processes for the cleaning of the metal surfaces to remove any extraneous or undesirable materials or deposits at any stage of manufacture, storage or service. Such cleaning processes are also suitable for cleaning prior to adhesive bonding, brazing and non-destructive testing. Appropriate stress relieving treatments are also included.

NOTE. While some of the methods given in this section might be applicable to the preparation of surfaces before welding, the recommendations regarding stress relief in Appendix A do not apply to parts which are to be welded.

Section 2 of this Code of Practice refers to the processes which are necessary for preparing metals prior to the application of the following surface coatings:

- (1) Electrodeposited metal coatings.
- (2) Electroless metal coatings.
- (3) Conversion coatings.
- (4) Anodic oxidation coatings.
- (5) Hot dipped coatings.
- (6) Sprayed metal coatings.
- (7) Diffusion coatings.
- (8) Vitreous and porcelain enamel coatings.
- (9) Paint coatings on non-ferrous metals.

Section 3 of this Code describes methods for the following treatments:

- (1) Cleaning.
- (2) Descaling.
- (3) Pickling.
- (4) Acid dipping.
- (5) Etching.
- (6) De-rusting.
- (7) Chemical smoothing.
- (8) Removal of corrosion products.
- (9) Preparation for electroplating.
- (10) Chemical polishing.
- (11) Electrobrightening.
- (12) Electropolishing.
- (13) Fluoride anodizing process for cleaning magnesium alloys.

NOTE. The titles of the BSI publications referred to in this Code of Practice are listed on the inside back cover.

1. General cleaning where no subsequent coatings are to be applied

1.1 Scope

This section of the Code of Practice refers to processes for the cleaning of metal surfaces to remove any extraneous or undesirable materials or deposits at any stage of manufacture, storage or service. Such cleaning processes are also suitable for cleaning prior to adhesive bonding, brazing and non-destructive testing. Appropriate stress relieving treatments are also included.

NOTE. While some of the methods given in this section might be applicable to the preparation of surfaces before welding, the recommendations regarding stress relief in Appendix A do not apply to parts which are to be welded.

1.2 Information required by the processor

The following information should be given on the drawing or order, when appropriate:

- (1) The specification and metallurgical condition of the material of the part.
- (2) Details of any particularly difficult surface condition or coating requiring to be removed.
- (3) The minimum specified tensile strength (or hardness) of the material of the part.
- (4) Instructions concerning any stress relieving heat treatment required before processing including the limits of temperature and time to be employed.
- (5) When necessary, the cleaning method or methods given in this Code which are to be used.
- (6) Instructions concerning any post-cleaning de-embrittlement which may be required.

1.3 General requirements

1.3.1 Avoidance of mercury. Mercury or mercury compounds should not be present in any of the materials used.

1.3.2 Rinsing. Rinsing is essential after each treatment in an aqueous solution. Rinsing is frequently carried out with hot water followed by cold. Contamination and staining problems can be avoided by the use of demineralized water, especially for the final dip.

To avoid repetition, however, these rinsing operations are not mentioned in the methods described in this code, except where special sequences are required.

1.3.3 Drying. Parts to be given further treatment by a dry process and parts which are not to be subjected to further processing, should be thoroughly dried.

If an air draught is used for this purpose it should be free from oil or other contaminants.

1.3.4 Cleaning treatments. Parts will often require more than one cleaning treatment.

1.3.5 Condition of basis metal after cleaning. After final cleaning the following conditions should apply:

- (1) The surface should be free from foreign matter.
- (2) The mechanical properties should not be significantly impaired except insofar as they may be recovered by subsequent baking.
- (3) The dimensions and surface finish should be to an acceptable standard.

1.4 Standard cleaning methods

1.4.1 Throughout this Code of Practice the methods given after references to cleaning treatments are to be found in Section 3.

1.4.2 The efficiency of many of the methods may be increased by the application of ultrasonic agitation but care should be taken to avoid damage to delicate parts and assemblies.

1.4.3 When composite components are being processed, the treatments chosen should be suitable for each constituent material and combination of materials.

1.5 Cast irons

1.5.1 Selection of method of cleaning. It should be borne in mind that treatment of cast iron in acid solutions is liable to set up preferential etching around the graphite grains which may become detached leaving holes which may entrap treatment solution and give rise to subsequent staining or corrosion. Cast irons containing flake graphite are particularly liable to give this effect.

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1.5.2 Cleaning methods. The parts should be cleaned as in 3.2 to 3.12 by one or more of Methods A to L as appropriate.

1.6 Steels, non-corrosion-resisting

1.6.1 Selection of method of cleaning. The choice of cleaning methods for medium and high strength steels is restricted by the requirements of 1.6.3 in order to avoid embrittlement by hydrogen absorption during cathodic or acid treatments.

1.6.2 Stress-relieving heat treatment. Appropriate stress relieving heat treatments are given in Appendix A.

1.6.3 Cleaning methods

1.6.3.1 Steels of minimum specified tensile strength less than 1000 N/mm²*. The parts should be cleaned as in 3.2 to 3.12 by one or more of Methods A to L as appropriate.

1.6.3.2 Steels of minimum specified tensile strength from 1000 N/mm² to 1400 N/mm²*. No form of cathodic cleaning treatment of these steels should be carried out. The parts should be cleaned as in 3.2, 3.3, 3.5, 3.9 or 3.11 by one or more of (Methods A, B, D, H or K) of which 3.5.2 and 3.11.1 (Methods D.2 and K.1) are preferable.

1.6.3.3 Steels of minimum specified tensile strength in the range 1400 N/mm² to 1800 N/mm²*. The parts should be cleaned by one or more of the following methods:

- (1) Degreasing in an organic solvent, see 3.2.1 or 3.2.2 (Method A.1 or A.2).
- (2) Degreasing in an aqueous alkaline solution, see 3.3.1 (Method B.1), with applied anodic direct current if desired. Neither cathodic nor alternating current treatments should be used.
- (3) Alkaline de-rusting, see 3.11.1 (Method K.1).
- (4) Abrasive cleaning, see 3.5 (Method D). This method, especially grit blasting, see 3.5.1 (Method D.1), leaves the surface very readily corrodible, and further processing should be given without any delay.
- (5) Anodic etching in a sulphuric acid solution, see 3.9 (Method H), subject to close control. Additionally, parts should be connected and the current switched on before the parts are immersed in the solution, and after treatment the parts should be withdrawn rapidly before the current is finally switched off, and washed immediately. The sulphuric acid should at no time contain more than 11 p.p.m. oxidizable material calculated as sulphur dioxide, determined by the method described in Appendix B. (This precaution is necessary because reduced sulphur, phosphorus and arsenic compounds in the acid promote hydrogen absorption during washing.)
- (6) Acid pickling in an inhibited acid solution, see 3.7 (Method F.1) followed, if desired and subject to agreement, by a dip in plain acid, see 3.8 (Method G) and then by baking prior to further treatment, at not less than 190 °C for not less than four hours.
- (7) Electrolytic de-rusting using an alkaline electrolyte and anodic current.

1.6.3.4 Steels of tensile strength greater than 1800 N/mm²*. Parts should be cleaned by one or more of the following treatments:

- (1) Degreasing in an organic solvent, see 3.2.1 or 3.2.2 (Method A.1 or A.2).
- (2) Alkaline treatments, namely items (2), (3) and (7) of 1.6.3.3.
- (3) Abrasive cleaning as in item (4) of 1.6.3.3.

1.7 Steels, stainless†

1.7.1 General cleaning. Parts should be cleaned by one or more of the methods given in 1.6.3 appropriate to the tensile strength of the steel. After cleaning, parts not subject to further processing may be given a 'passivating' treatment, see 3.13 (Method M), or may be electropolished; such treatment may be essential if iron or iron oxide remains embedded in the surface, e.g. from abrasive blasting or from pick-up from forming tools.

High density solutions are used for electropolishing (electro-chemical brightening) martensitic, ferritic and austenitic stainless steels. The exact working conditions are critical.

* 10 N/mm² = 1 hbar ≈ 0.65 tonf/in²

† Stainless steel is the name given to a group of corrosion-resistant steels containing a minimum of 9 % chromium. Further information may be obtained from the Stainless Steel Development Association and the Stainless Steel Fabricators' Association.

Electropolishing generates an ideally clean and passive condition by anodic electrolytic action in strong mineral acid solutions: it is generally regarded as a final process which includes passivation treatment.

For electropolishing, the stainless steel (martensitic, ferritic or austenitic) parts are made anodic in one of the following typical processes:

- (1) Phosphoric acid ($d = 1.70$) 500 ml/l
Sulphuric acid ($d = 1.84$) 450 ml/l
Temperature: 70 °C to 90 °C
Current density: 2000 A/m² to 3000 A/m² (with the parts anodic)
- (2) Phosphoric acid ($d = 1.70$) 600 ml/l
Chromic acid (CrO₃) 150 g/l
Temperature: 30 °C to 80 °C
Current density: 1000 A/m² to 10 000 A/m² (with the parts anodic)

NOTE. Parts should be well rinsed after treatment. Although the acid residues do not harm stainless steel they may nevertheless be unsightly.

1.8 Aluminium and its alloys

1.8.1 General cleaning

1.8.1.1 Parts should be cleaned by one or more of the following methods as appropriate:

- (1) As in 3.2 (Method A), 3.3.2 (Method B.2) and 3.5 (Method D).
- (2) Etching in chromic acid/sulphuric acid solution, see 3.15 (Method O).
- (3) Pickling, see 3.14 (Method N).
- (4) An agreed chemical polishing treatment, see 3.31 (Method AV), or electrolytic polishing treatment, see 3.30 (Method AW).

1.8.1.2 Certain heat treatable aluminium alloys may suffer some alteration in mechanical properties as a result of prolonged treatment at or near 100 °C.

1.8.2 Cleaning of corroded parts. Where corrosion products are to be removed, immersion in chromic acid/phosphoric acid solution as in 3.21 (Method U) is the method recommended as it results in least attack on underlying metal. Light corrosion products and soil may be removed as in 3.15 by Method O, by a phosphoric acid solution containing kaolin, see 3.16.1 (Method P.1), or by fine abrasive blasting, see 3.5.2 (Method D.2).

1.8.3 Preparation for adhesive bonding of unanodized parts. Parts should be prepared for bonding by cleaning and etching, see 3.15 (Method O) or by abrasive blasting, see 3.5.2 (Method D 2).

1.9 Copper and its alloys

1.9.1 Avoidance of stress corrosion cracking. It is recommended that alloys in a condition susceptible to stress corrosion cracking should be cleaned only in organic solvents, see 3.2 (Method A) prior to stress relief. After stress relief, these alloys may be cleaned by any of the methods given in 1.9.2.

1.9.2 General cleaning

1.9.2.1 Parts should be cleaned by one or more of the following methods as appropriate:

- (1) Degreasing in an organic solvent, see 3.2 (Method A).
- (2) Degreasing in an aqueous alkaline solution, see 3.3 (Method B).
- (3) Coarse abrasive blasting, see 3.5.1 (Method D.1) (for castings), fine abrasive blasting, see 3.5.2 (Method D.2) or scouring, see 3.5.3 (Method D.3).
- (4) Cleaning etch treatment, see 3.17 (Method Q).
- (5) Etching or brightening by an agreed chemical treatment as in 3.18 (Methods R.2 and R.3) or electrolytic treatment, see 3.31 (Method AV).

1.10 Nickel and its alloys

1.10.1 General cleaning. The parts should be cleaned by one or more of the following methods as appropriate:

- (1) Degreasing in an organic solvent, see 3.2 (Method A).
- (2) Degreasing in an aqueous alkaline solution, see 3.3 (Method B).

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- (3) Abrasive cleaning, see 3.5 (Method D).
- (4) Molten caustic alkali descaling, see 3.6 (Method E).
- (5) Pickling in an acid solution.

NOTE. The supplier should always be consulted concerning the pickling of nickel alloys. The choice of solution depends on the type of alloy concerned and this should be agreed between the parties.

Solutions are usually of an aggressive nature and are generally based on nitric/hydrofluoric acids, with or without the addition of ferric sulphate.

- (6) An agreed chemical polishing process, see 3.33 (Method AT), or electropolishing process, see 3.34 (Method AS).

1.11 Titanium and its alloys

1.11.1 General cleaning. Parts should be cleaned by one or more of the following methods as appropriate. Care should be taken to ensure that the particular process will not cause any significant hydrogen embrittlement or stress corrosion.

1.11.1.1 Degreasing in an organic solvent, see 3.2 (Method A). Chlorinated hydrocarbon solvents may cause stress corrosion cracking of some titanium alloys and the following precautions should be observed when these solvents are used:

- (1) Parts of Ti-5Al-2½Sn alloy made by cold forming or welding should not be exposed to hot chlorinated hydrocarbon solvents prior to stress relief.
- (2) The solvents should be maintained clean and the accumulation of free acid should be prevented in accordance with the supplier's operating instructions.
- (3) The time of immersion in hot trichloroethylene liquid and/or vapour should not exceed 30 minutes for any one degreasing operation.
- (4) Care should be taken to remove all traces of solvent from the part immediately after cleaning and before any further operation is performed.

1.11.1.2 Degreasing in an aqueous alkaline solution, see 3.3 (Method B). Cathodic cleaning should not be used.

1.11.1.3 Abrasive cleaning by wet methods only, see 3.5 (Method D).

1.11.1.4 Descaling by a process, e.g. that in 3.6 (Method E), acceptable to the purchaser.

1.11.1.5 Pickling in nitric acid/hydrofluoric acid solution, see 3.19 (Method S).

1.12 Magnesium alloys

1.12.1 General cleaning. Cleaning of magnesium alloys, including specific methods to ensure a decontaminated surface, forms part of a complete protective scheme which should be agreed between the parties. Degreasing may be carried out as in 3.2 or 3.3 by one of the methods A or B as appropriate.

1.13 Zinc and its alloys

1.13.1 General cleaning. Unless otherwise required, degreasing should be carried out as in 3.2.1, 3.2.2 or 3.3.2 by Methods A.1, A.2 and/or B.2. Die-cast components may contain sub-surface porosity and any process such as acid etching which might penetrate the non-porous surface skin, will reveal this porosity with consequent entrapment of corrosive residues. Such processes should therefore be avoided during all stages of manufacture.

1.13.2 Cleaning of corroded parts. A suitable method of removing corrosion products is by immersion in a solution containing about 100 g/l of chromic acid at 90 °C. Corrosion of pressure die-cast zinc alloys during storage or service may reveal sub-surface porosity. As described in 1.13.1, any cleaning process leaving corrosive residues should be avoided.

2. Preparation prior to the application of surface coatings

2.1 Scope

This Section 2 of the Code of Practice refers to the processes which are necessary for preparing metals prior to the application of the following surface coatings:

- (1) Electrodeposited metal coatings.
- (2) Electroless metal coatings.
- (3) Conversion coatings.
- (4) Anodic oxidation coatings.
- (5) Hot dipped coatings.
- (6) Sprayed metal coatings.
- (7) Diffusion coatings.
- (8) Vitreous and porcelain enamel coatings.
- (9) Paint coatings on non-ferrous metals.

2.2 Information required by the processor

The following information should be given on the drawing or order, when appropriate:

- (1) The specification and metallurgical condition of the material of the part.
- (2) Details of any particularly difficult surface condition or coating requiring to be removed.
- (3) The minimum specified tensile strength (or hardness) of the material of the part.
- (4) Instructions concerning any stress relieving heat treatment required before processing including the limits of temperature and time to be employed.
- (5) When necessary, the cleaning and preparation methods given in this Code which are to be used.
- (6) The surface coating which is to be subsequently applied.
- (7) Instructions concerning any de-embrittlement which may be required.

2.3 General requirements

2.3.1 Avoidance of mercury. Mercury or mercury compounds should not be present in any of the materials used.

2.3.2 Rinsing. Rinsing is essential after each treatment in an aqueous solution. Rinsing is frequently carried out with hot water followed by cold. Contamination problems can be avoided by the use of demineralized water, especially for the final dip. To avoid repetition however, these rinsing operations are not mentioned in the methods described in this Code, except where special sequences are required.

After the final rinsing or preparatory treatment, parts to be given a treatment in aqueous solutions should be transferred immediately without drying to the treatment bath.

2.3.3 Cleaning treatments. Parts will often require more than one cleaning treatment.

2.3.4 Condition of basis metal after cleaning. After final cleaning:

- (1) The surfaces should be in a suitable condition to receive any subsequent specified treatment(s) which should be applied without delay.
- (2) The mechanical properties should not be significantly impaired except insofar as they may be recovered by subsequent baking.
- (3) The dimensions and surface finish should be such as to enable the finished (e.g. plated) parts to be within the required drawing or specification limits.

2.4 Standard cleaning methods

2.4.1 Throughout this Code of Practice the methods given after references to cleaning treatments are to be found in Section 3.

2.4.2 The efficiency of many of the methods may be increased by the application of ultrasonic agitation but care should be taken to avoid damage to delicate parts and assemblies.

2.4.3 When composite components are being processed the treatments chosen should be suitable for each constituent material and combination of materials.

2.5 Cast irons

2.5.1 Selection of method of cleaning. It should be borne in mind that treatment of cast iron in acid solutions is liable to set up preferential etching around the graphite grains which may entrap treatment solution and give rise to subsequent staining or corrosion. Cast irons containing flake graphite are particularly liable to give this effect.

2.5.2 Cleaning prior to electroplating. The parts should be cleaned as in 3.2 to 3.12 by one or more of Methods A to L as appropriate.

2.5.3 Cleaning prior to electroless nickel plating. The following procedure should be carried out:

- (1) Clean as in 3.2 and 3.7 by one or more of Methods A and F as appropriate.
- (2) Acid dip in 50 % by volume hydrochloric acid ($d = 1.16$).
- (3) Electroless nickel plate.

NOTE. A warm rinse may be found desirable immediately before stage (3) to preheat large components but care must be taken to ensure that the parts do not dry off before being immersed in the electroless nickel solution.

2.5.4 Cleaning prior to phosphating and the application of other conversion coatings. Clean as in 3.2 to 3.12 using one or more of the methods A to L as appropriate. If inhibited solutions are used for acid pickling, see 3.7 (Method F), or de-rusting, see 3.10 (Method J), it may be necessary to remove absorbed inhibitor before rinsing and phosphating or the application of other conversion coatings.

2.5.5 Cleaning and preparation for hot tinning*. Some special methods described in 2.5.5.1 to 2.5.5.3 below have been developed for preparing cast irons for hot tinning since they may possess hard siliceous casting skins and their surfaces are often rich in graphite which interferes with the tinning process.

2.5.5.1 T.R.I. 'Direct chloride process'. The procedure for this process is as follows:

(1) Mechanical preparation is carried out by grinding, machining, or coarse abrasive blasting, see 3.5.1 (Method D.1). Cutting oils or coolants should not be used during machining. When abrasive blasting is used, metallic shot or grit is preferred.

(2) Degrease, see 3.2.1 (Method A.1).

(3) Thoroughly grit-blast with fine angular chilled iron grit which will pass a BS 410 test sieve of 212 μm nominal aperture size. Alternatively, fine abrasive liquid blasting using alumina may be used.

NOTE. Operation (3) may be omitted if the mechanical preparation given in operation (1) consists of fine grinding.

(4) Immerse in an aqueous flux solution of the following composition:

Zinc chloride	400 g/l
Ammonium chloride	25 g/l
Hydrochloric acid ($d = 1.16$)	100 ml/l (max.)

(5) Tinning should be carried out using an ebullient flux cover on the first tinning bath, consisting of zinc chloride 73 %, sodium chloride 18 % and ammonium chloride 9 %. The initial thickness of the flux cover should be about 10 mm but before use it is thoroughly activated by copious spray-application of water, when it becomes frothy and its thickness may rise to 50 mm to 75 mm.

The pre-fluxed castings are lowered slowly through the ebullient flux cover into the tin.

2.5.5.2 Proprietary fused salt processes. There are proprietary processes available which prepare cast iron for tinning by oxidizing graphite exposed at the surface. They are normally used electrolytically.

2.5.5.3 Electroplating with a readily tinnable metal. The difficulty of tinning over a graphite-contaminated surface may be avoided by electroplating the cast iron with a readily tinnable metal such as iron, copper or nickel, iron plating being preferred.

Iron plating may be carried out as follows:

(1) Tumble parts with a suitable fine abrasive, see 3.5.4 (Method D.4) or shot blast with fine abrasive, see 3.5.2 (Method D.2).

(2) Degrease in trichloroethylene vapour, see 3.2.1 (Method A.1).

(3) Pickle for approximately two minutes in hydrochloric acid, see 3.7.2 (Method F.2).

(4) Electroplate with iron until the casting is completely covered. A suitable electrolyte consists of a solution of 300 g/l ferrous ammonium sulphate operated at room temperature at a current density of 100 A/m² to 150 A/m².

(5) After rinsing, the plated castings should be fluxed and tinned immediately.

* The information given in this clause has been abstracted from the booklet 'Hot-tinning' by C. J. Thwaites (published by the Tin Research Institute) which should be consulted for further information.

2.5.6 Cleaning and preparation for hot dip galvanizing. Preparation should be carried out using one of the following procedures:

(1) Abrasive blasting with chilled iron or steel grit, see 3.5.1 (Method D.1) to remove moulding sand and iron scale. After blasting, methods 3.7.1 or 3.7.2 (Methods F.1 or F.2) may be used and where necessary a flux coating should be applied.

(2) Hydrofluoric acid (30 % HF) diluted to 2 % to 10 % by volume aqueous solution may be used, followed by hosing with water to remove any gelatinous products. After hosing, 3.7.2 (Method F.2) is used and if necessary a flux should be applied.

2.5.7 Cleaning prior to metal spraying (for protection against corrosion and high temperature oxidation)*. The surface should be degreased, see 3.2 to 3.4 (Methods A to C, as appropriate) and then roughened by compressed air or centrifugal blasting with a suitable abrasive grit, see 3.5.1 (Method D.1). Immediately before spraying it should be free from grease, scale, rust, moisture or other foreign matter. It should be comparable in roughness with a reference surface produced in accordance with Appendix A of BS 2659 and should provide an adequate key for the subsequent sprayed metal coating.

2.5.8 Cleaning prior to the application of diffusion coatings. One or more of 3.2 to 3.12 (Methods A to L) as appropriate.

2.5.9 Cleaning and preparation for vitreous enamelling. The surface of the casting should be cleaned by blasting, see 3.5.1 (Method D.1) usually with steel shot or chilled angular grit. The correct grade of blasting media will depend upon the degree of cleaning required, but generally a mixture of Grade G14 and G15 to BS 2451 is found to be satisfactory.

Unless the castings can be used fresh from the foundry, a 'burn-off' process is desirable. This is usually carried out at around 800 °C for an appropriate time depending upon the thickness and weight of the casting.

NOTE. An 'annealing' ground coat may be used in certain cases so that only one fusing will be necessary in place of two. Much will depend upon the quality of the casting.

Clean castings which have stood for some time will require heat treatment before use.

2.6 Steels, non-corrosion-resisting

2.6.1 Selection of method of cleaning. The choice of cleaning methods for medium and high strength steels is restricted by the requirements of 2.6.3 in order to avoid embrittlement by hydrogen absorption during cathodic or acid treatments.

2.6.2 Stress relieving heat treatment. Appropriate stress relieving heat treatments are given in Appendix A.

2.6.3 General

2.6.3.1 Steels of minimum specified tensile strength less than 1000 N/mm²†. The parts should be cleaned as in 3.2 to 3.12 by one or more of Methods A to L, as appropriate.

2.6.3.2 Steels of minimum specified tensile strength from 1000 N/mm² to 1400 N/mm²†. No form of cathodic cleaning treatment of these steels should be carried out. The parts should be cleaned as in 3.2, 3.3, 3.5, 3.9 or 3.11 by one or more of Methods A, B, D, H or K of which 3.5.2 and 3.11.1 (Methods D.2 and K.1) are preferable.

2.6.3.3 Steels of minimum specified tensile strength from 1400 N/mm² to 1800 N/mm²†. The parts should be cleaned by one or more of the following methods. The steps selected in the cleaning sequence should follow one another without interruption other than any necessary washing and be followed immediately by the protective treatment.

(1) Degreasing in an organic solvent, see 3.2.1 or 3.2.2 (Method A.1 or A.2).

(2) Degreasing in an aqueous alkaline solution, see 3.3.1 (Method B.1) with applied anodic direct current if desired. Neither cathodic nor alternating current treatments should be used.

(3) Alkaline de-rusting, see 3.11.1 (Method K.1).

(4) Abrasive cleaning, see 3.5 (Method D). This method, especially grit blasting, see 3.5.1 (Method D.1), leaves the surface very readily corrodible, and further processing should be given without any delay.

(5) Anodic etching in a sulphuric acid solution, see 3.9 (Method H) subject to close control. Additionally, parts should be connected and the current switched on before the parts are immersed in the solution, and

* For further information see BS 2569.

† 10 N/mm² = 1 hbar ≈ 0.65 tonf/in².

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after treatment the parts should be withdrawn rapidly before the current is finally switched off, and they should be washed immediately. The sulphuric acid should at no time contain more than 11 p.p.m. oxidizable material calculated as sulphur dioxide, determined by the method described in Appendix B. (This precaution is necessary because reduced sulphur, phosphorus and arsenic compounds in the acid promote hydrogen absorption during washing.)

(6) Acid pickling in an inhibited acid solution, see 3.7.1 (Method F.1) followed, if desired and subject to agreement, by a dip in plain acid, see 3.8 (Method G) and then by baking prior to further treatment, at not less than 190 °C for not less than four hours.

(7) Electrolytic de-rusting using an alkaline electrolyte and anodic current.

2.6.3.4 Steels of tensile strength greater than 1800 N/mm². Parts should be cleaned by one or more of the following treatments:

- (1) Degreasing in an organic solvent, see 3.2.1 or 3.2.2 (Methods A.1 or A.2).
- (2) Alkaline treatments, namely items (2), (3) and (7) of 2.6.3.3.
- (3) Abrasive cleaning as in 2.6.3.3. (4).

2.6.4 Cleaning prior to electroplating. The parts should be cleaned by one or more of the methods in 2.6.3 appropriate to the tensile strength of the steel. If inhibited solutions are used for acid pickling, see 3.7 (Method F) or de-rusting, see 3.10 (Method J), it may be necessary to remove absorbed inhibitor from the surface, e.g. by acid dipping, see 3.8 (Method G), or suitable alkaline treatment before chemical smoothing, see 3.12 (Method L), and/or electroplating.

2.6.5 Preparation for electroless nickel plating

2.6.5.1 Steels of a minimum specified tensile strength of less than 1000 N/mm². The following procedure should be carried out:

- (1) Clean as in 3.2 to 3.7 by one or more of the Methods A to F, as appropriate.
- (2) Acid dip in 50 % by volume hydrochloric acid ($d = 1.16$).
- (3) Electroless nickel plate.

NOTE 1. An alkaline periodic reverse current cleaner (10 seconds each way finishing anodically) can be used as an alternative to the activating treatment for stage (2). Cathodic treatments alone may cause hydrogen embrittlement and prolonged anodic treatments are undesirable because of the risk of passivating the surface.

NOTE 2. A warm rinse may be found desirable immediately before stage (3) to preheat large components but care should be taken to ensure that the parts do not dry off before being immersed in the electroless nickel solution.

2.6.5.2 Steels of a minimum specified tensile strength in the range 1000 N/mm² to 1400 N/mm². The following procedure should be carried out:

- (1) Clean as in 3.2 to 3.7 by one or more of the methods A to F, as appropriate.
- (2) Anodically etch, see 3.9 (Method H), for 1 minute to 3 minutes.
- (3) Rinse very thoroughly to remove all viscous sulphate solution from the surface.
- (4) Electroless nickel plate.

2.6.6 Cleaning prior to phosphating and the application of other conversion coatings. One or more methods listed in 2.6.3 appropriate to the phosphating or other process and to the tensile strength of the steel should be used. If inhibited solutions are used for acid pickling, see 3.7 (Method F) or de-rusting, see 3.10 (Method J), it may be necessary to remove absorbed inhibitor before rinsing and phosphating or the application of other conversion coatings. Abrasive cleaning, see 3.5 (Method D) is preferred for high tensile steels and some alloy steels.

2.6.7 Cleaning and preparation for hot tinning*

2.6.7.1 Normal mild steels. 3.2.1 (Method A.1) or 3.3.1 (Method B.1), followed by either 3.7.1 (Method F.1) or 3.7.2 (Method F.2) should be used.

2.6.7.2 'Difficult' mild steels. Certain batches of mild steel sheet and strip are more difficult to tin than others, coatings tending to de-wet even when the usual methods of cleaning and pickling are thoroughly carried out. Such steels are called 'difficult' steels. They possess a non-reactive surface skin formed by the polymerization of certain rolling lubricants present on the surface during low temperature bright annealing, or during such operations as pressing and spinning.

* The information given in this clause has been abstracted from the booklet 'Hot-tinning' by C. J. Thwaites (published by the Tin Research Institute) which should be consulted for further information.