

BRITISH STANDARD : AEROSPACE SERIES

METHOD FOR THE

ETCH INSPECTION OF METALLIC MATERIALS

AND COMPONENTS

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FOREWORD

This British Standard, prepared under the authority of the Aerospace Industry Standards Committee, is one of a series on the non-destructive testing and inspection of aerospace materials, components and structures. Other standards in this series will cover radiographic, ultrasonic, magnetic particle and penetrant methods.

The standard is intended to provide a method for carrying out etch inspection of metallic materials and components used in the aerospace industry. Consideration may subsequently be given to the preparation of further standards describing specific applications of etch inspection techniques.

This standard makes reference to the following:

British Standards:

BS 1134. Centre-line-average height method for the assessment of surface texture.

BS 4000. Sizes of papers and boards.

*Ministry of Defence Specifications:

DEF 151. Anodizing of aluminium and aluminium alloys.

DEF 162. The treatment and protection of very high tensile steels.

DEF 2331. Protective PX-1 dyed and undyed.

*Ministry of Technology:

DTD 901. Process specification—cleaning and preparation of metal surfaces.

*Obtainable from H.M.S.O.

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METHOD

1. GENERAL

1.1 SCOPE

1.1.1 This British Standard describes a method for carrying out etch inspection of metallic materials and components and describes some of the widely accepted etching solutions currently in use.

1.1.2 The materials covered by the standard are grouped as follows:

Ferrous metals

- (1) Plain carbon, medium and low alloy steels.
- (2) High alloy (corrosion and heat-resisting) steels.

Non-ferrous metals

- (3) Copper alloys.
- (4) Aluminium alloys.
- (5) Magnesium alloys.
- (6) Titanium alloys.
- (7) Nickel and cobalt base alloys.

1.2 PURPOSE OF ETCH INSPECTION

1.2.1 Etch inspection is employed to examine the surface conditions (see 1.2.2) of metallic materials to reveal or accentuate any variations of these conditions using either differential chemical or electrolytic attack. It may be applied at one or more stages in the manufacturing processes of a part or assembly and also subsequently in service.

1.2.2 Etching may be used to inspect for the following principal surface conditions:

- (1) Variations in grain size and flow.
- (2) Segregation.
- (3) Grinding abuse.
- (4) Faulty heat treatment.
- (5) Inclusions.
- (6) Cracks and folds.

1.3 GENERAL CONSIDERATIONS

1.3.1 The initial surface texture of the material or component should be commensurate with obtaining satisfactory results from the process used and the degree of inspection required. For components, the surface texture should generally be better than 6.3 μm (250 micro-inches) CLA. For materials, the surface finish should not exceed 12.5 μm (500 micro-inches) CLA*.

1.3.2 Consideration should be given to the following effects caused by etching:

- (1) Change of overall dimensions.
- (2) Change of surface finish.
- (3) Modification of fatigue properties.
- (4) Production of hydrogen embrittlement of surface layers.

1.3.3 The actual etching process (listed in 2.2.2 Op. 10) may be carried out by:

- (1) Chemical etching, i.e. immersion in a solution, or application of a solution to localized areas.
- (2) Electrochemical etching, i.e. immersion in an electrolyte and the passage of direct current.

*As defined in BS 1134, 'Centre-line-average height method for assessment of surface texture'.

Because of the greater degree of control which is necessary when etching electrochemically, the process is confined generally to the less reactive metals, and also to workpieces where greater dimensional changes or an electro-polishing action can be tolerated.

NOTE. Agitation of the solution in both (1) and (2) is desirable.

1.4 APPROVALS

1.4.1 The preparation of all solutions, the installation of the equipment and the entire procedure shall be under the control of a responsible person functioning by agreement between the contracting parties.

1.4.2 It is strongly emphasized that etch inspection shall not be carried out except as part of an accepted inspection schedule prepared under the control of the responsible person acting with the approval of the Design Authority.

2. PROCEDURE

2.1 INTRODUCTION

2.1.1 The particular etchant composition and etching time to be used shall be chosen having due regard to:

- (1) The material to be inspected (see 1.1.2).
- (2) The surface condition to be investigated (see 1.2.2).
- (3) The extent of attack that can be tolerated (see 1.3.2).

2.1.2 The procedure consists of pretreatment, the etching process, inspection, and post-treatment. It shall be continuous, with a minimum of delay between each of the operations listed in 2.2.1 to 2.2.4. (See also Appendix A and Fig. 1.)

2.1.3 If delays are anticipated, the process should not be started. However, if unforeseen delays arise after commencement of the process, the material or component should be hot-rinsed and dried off, the process then being restarted when the line is fully operative. It may be necessary to apply a temporary corrosion preventative in accordance with DEF 2331.

2.2 OPERATIONS

2.2.1 Pretreatment. The preparation of the workpiece for etching shall comply with the relevant stress-relieving and cleaning requirements of DTD 901, using one or a combination of the following operations:

Op.1. De-scale to remove heavy surface contamination. This may be carried out by mechanical or chemical means.

Op. 2. Dry or wet-blast to remove surface oxides. The size of media and time of blasting shall be minimal and selected to suit the hardness of the surface and also to avoid the peening effect in masking the flaws.

Op. 3. Stress-relieve where necessary.

Op. 4. De-grease.

Op. 5. Mask all areas not requiring etching with a suitable material that is not affected by the solution, such as PVC adhesive tape or film.

Op. 6. Rinse in cold running water.

Op. 7. Electro-polish to produce a chemically clean and smooth surface when a high degree of finish is required.

Op. 8. Chemically clean using an alkaline cleaner.

Op. 9. Rinse in cold running water.

2.2.2 The etching process. The etching operation shall continue as follows:

Op. 10. Etching in accordance with the relevant sections of the table in Appendix B.

Op. 11. Rinse in cold running water.

Op. 12. De-smut, if specified in Appendix B, to remove chemical residues remaining from the etching operation by immersing in the chemical solution specified in the relevant process instruction.

Op. 13. Rinse in cold running water.

Op. 14. Neutralize, where necessary, to eliminate further surface reactions by the application of suitable chemical solutions.

Op. 15. Rinse in cold running water.

Op. 16. Immerse in hot water and dry off.

Op. 17. Remove all traces of masking.

Op. 18. Hydrogen de-embrittle, when specified in the relevant process instruction for the material concerned.

2.2.3 Inspection

Op. 19. Inspect to the requirements of the acceptance standard.

2.2.4 Post-treatment. The workpiece shall be treated using one or both of the following stages:

Op. 20. Remove the etch structure by mechanical means to prevent possible detrimental effect of the etch process on the mechanical properties.

Op. 21. Apply a corrosion preventative in accordance with DEF 2331.

3. EQUIPMENT AND SPECIAL CONSIDERATIONS

3.1 PROCESSING EQUIPMENT

3.1.1 Chemical etchant tanks. The size of the tanks containing the etchant shall be such that they will contain the workpiece; the tanks shall be constructed of materials that are non-reactive to the solution employed, and, if necessary, shall be capable of maintaining the specified process temperatures. Agitation of the solution shall be possible. Where size permits, covers to the tanks shall be used to protect the solution between periods of use.

3.1.2 Electrolytic etchant tanks. The size of the tanks containing the etchant shall be such that they will contain the workpiece; the tanks shall be constructed of materials that are non-reactive to the solution employed. Temperature control and agitation of the electrolyte shall be provided. The cathode may be the tank and/or individual plates carried from the cathode bars. It shall be possible to maintain uniform current density especially when treating hollow and complex shapes, e.g. by the use of auxiliary cathodes or work shrouds. Adequate electrical supply with current and voltage control, and instrumentation shall be provided. A high standard of cleanliness should be maintained in respect of clamps, busbars, etc.

3.1.3 Rinse tanks. Tanks containing the rinse water shall be capable of containing the workpiece and be constructed of corrosion resistant materials. The rinse tank shall be supplied with an adequate supply of cold running water. The location of entry and exit (preferably over a weir) should be such as to produce the fullest possible circulation and/or agitation within the tank. The hot rinse tank shall have a supply of water and shall be capable of maintaining the contents at the required elevated temperature.

3.1.4 Control and maintenance of solutions. The solutions in the tanks shall be maintained at a constant level. The efficiency of the solution shall be regularly maintained in accordance with the instructions stated in Appendix B.

The frequency of analysis of the solutions is dependent upon the work load. Mechanical aids, e.g. floating glass or plastics capsules, should be used, where applicable, to prevent unduly high evaporation rates.

3.1.5 Extraction and ventilation. Adequate fume extraction shall be provided in accordance with the relevant Home Office requirements. To comply with local byelaws it may be necessary to clean the extracted air before it is discharged into the atmosphere.

Extractor ducts should be regularly cleaned to remove all deposits, in order to maintain the efficiency of the system.

Adequate ventilation with clean warm air should be provided to replace that removed by the extraction equipment.

3.2 VIEWING AIDS

Viewing aids such as low power magnifiers and binoculars shall be of good optical quality, free from serious distortion and chromatic aberration.

3.3 IN-SITU APPLICATIONS

Use of the etch method for the in-situ examination of a component contained within an assembly or structure is not generally recommended for routine inspection.

However, if this method is used, special consideration shall be given to the following:

- (1) Adequate masking.
- (2) Confinement of the chemicals.
- (3) Possible proximity of dissimilar materials.
- (4) The application of pretreatment and post-treatment.

4. PERSONNEL

4.1 EYESIGHT

The eyesight of all personnel engaged in etch inspection shall be regularly checked.

4.2 FATIGUE

4.2.1. Personnel who work steadily at the inspection of etched components will become fatigued due to the sustained concentration that is required. The length of time before an inspector becomes fatigued will depend on numerous factors, the principal ones being listed below:

- (1) Physical condition of the inspector (i.e. tired or fresh).
- (2) Environmental conditions such as temperature, humidity, freshness of air, noise level and location.
- (3) Viewing conditions. (As the magnification increases so does the rate of fatigue.)
- (4) Surface appearance of etched components. (Bright etches generally increase the rate of fatigue.)
- (5) The surface condition being inspected for. (The greater the concentration required, the more rapid the fatigue.)

4.2.2 It is difficult to lay down a standard procedure, due to the number of variables which can influence fatigue, but experience has shown that continuous viewing should be limited to: