

BRITISH STANDARD: AEROSPACE SERIES

METHOD FOR

PENETRANT INSPECTION OF AEROSPACE 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 cover radiographic, ultrasonic, magnetic particle and etch inspection methods.

The standard is intended to provide general guidance on the procedures for carrying out penetrant inspection of materials and components used in the aerospace industry. The standard is not intended to be used as a level of acceptance or rejection as both of these aspects should be covered in an appropriate application standard or be agreed between the interested parties.

It is emphasized that non-destructive testing methods, being complementary to one another, should always be considered in relationship to testing as a whole. When non-destructive testing methods are specified, the most suitable method and amount of inspection compatible with the ultimate application for the product should be employed.

This standard makes reference to the following:
British Standards:

BS M.37. Method for the etch inspection of metallic material and components.

BS 580. Trichloroethylene.

BS 3683. Glossary of terms used in non-destructive testing. Part 1. Penetrant flaw detection.

BS 4000. Sizes of paper and board.

BS 4489. Method for assessing black light used in non-destructive testing.

**Ministry of Defence Specifications:*

Defence Standard 03-2/1. Cleaning and preparation of metal surfaces.

DEF. 2331. Protective PX-1 dyed and undyed.

**Air Registration Board Circulars:*

ARB-BL/10-9. Basic testing of materials of chemical solutions. Performance testing of penetrant materials.

Attention is also drawn to DTD.929*. Process specification. Penetrant methods of flaw detection.

*Obtainable from H.M.S.O.

Confirmed
December 2009

METHOD

1. SCOPE

This British Standard gives requirements and procedures for detecting surface flaws in aerospace materials and components, during both the manufacturing stage and in service, by penetrant inspection techniques.

2. TERMS AND DEFINITIONS

For the purposes of this British Standard, the terms and definitions given in BS 3683, Part 1 apply.

3. INTRODUCTION

3.1 General

3.1.1 Penetrant inspection techniques are capable of locating discontinuities such as laps, folds, cracks and porosity which are open to the surface of a material or component. Penetrant techniques can be used on materials independent of their physical properties provided the surface is normally non-absorbent and compatible with the penetrant process.

3.1.2 The efficiency of the process is dependent upon the ability to carry out each separate operation correctly. Inability to accomplish any single operation properly can seriously affect the validity of the inspection.

3.1.3 The effectiveness of penetrant inspection rests on the technical competence of the personnel employed on the work and their ability to interpret indications given by the techniques. In interpreting results, it is necessary to distinguish between relevant indications from flaws and spurious indications arising from other causes.

3.1.4 The manufacturers of penetrant materials provide comprehensive technical services and it is recommended that these services be used when selecting a process for a particular inspection task. Intermixing of materials from different manufacturers for an individual process is strongly deprecated.

3.2 Principle of inspection. Penetrant inspection consists essentially of the following sequence of operations, see also Appendix A:

(1) The surfaces of components to be inspected are prepared by pre-cleaning and degreasing.

(2) Penetrant is applied to the prepared surfaces and a period of time is allowed for it to enter any discontinuity open to the surfaces.

(3) The excess penetrant is removed in such a manner that will ensure retention of penetrant in any discontinuities.

(4) A developer agent is applied in order to draw the penetrant liquid from the discontinuities out to the surface and thereby give an enhanced

indication of the discontinuities.

(5) The discontinuities are then visually examined and assessed under appropriate viewing conditions.

(6) The part is then cleaned and, as necessary, a corrosion preventative is applied.

4. COMPATIBILITY OF MATERIALS

4.1 All penetrant inspection materials shall be non-corrosive and compatible with the material to be tested.

4.2 The chemical or physical properties of some non-metallic materials may be adversely affected by penetrant inspection materials. Therefore, their compatibility shall be established before testing components manufactured from such materials.

4.3 Special consideration shall be given to guided weapon and rocket components, as it is essential that the penetrant inspection material be compatible with explosives, propellants or similar materials which may come into contact with the components after testing.

4.4 In situations where contamination might occur, care shall be taken to ensure that the penetrant inspection materials do not have a deleterious effect on fuels, lubricants, hydraulic fluids, etc.

4.5 Unless a component has been thoroughly cleaned, a surface which has been treated with a dye penetrant shall not subsequently be processed using a fluorescent penetrant, since residual dye penetrant may react with the fluorescent penetrant resulting in complete or partial quenching of fluorescence.

5. CLASSIFICATION AND GROUPING

5.1 Penetrants. For the purposes of this standard, penetrants are classified as either:

A. fluorescent penetrants, or

B. dye penetrants,

according to whether the inspection of the surface under test is to be carried out under black light or ordinary light. However, some penetrants may qualify for inclusion in both classes.

5.2 Penetrant removers. Penetrant removal operations fall into five main classes i.e. those involving the use of:

A. Solvent in liquid form.

B. Solvent in vapour form.

C. Water only.

D. Water before, and usually after, a proprietary penetrant remover solution which is usually water-soluble.

E. Emulsifier which is usually oil-soluble, followed by water.

5.3 Developers. Developers may consist of:

- A. Dry powder.
- B. Suspension of powder in a volatile liquid carrier.

C. Suspension of powder in a comparatively involatile liquid carrier, often water-based.

5.4 Summary table. It is recommended that both manufacturers and users of penetrant materials classify their systems in accordance with the following:

Penetrant	Penetrant remover	Developer
A. Fluorescent B. Dye	A. Solvent (liquid) B. Solvent (vapour) C. Water D. Water (optional) Penetrant remover solution Water E. Emulsifier Water	A. Dry powder B. Suspension in volatile carrier C. Suspension in comparatively involatile carrier

5.5 Grouping. Penetrant processes may, if required be grouped in terms of the above classification. Thus a sequence involving the use of a fluorescent penetrant, a water-wash and a dry powder developer can be placed in a group designated ACA. It should not be inferred, however, that all proprietary penetrant flaw detection processes belonging to one group are of necessity fully interchangeable or are of comparable sensitivity.

6. SAFETY PRECAUTIONS

6.1 As penetrant inspection techniques may require the use of toxic, flammable and volatile materials, certain precautions have to be considered. Working areas shall be well-ventilated and situated well away from heat, open fires and flames.

6.2 Care shall be taken to ensure that under no circumstances can unfiltered radiation from a black light source be directed at the eyes. The filter used with a black light source, either as an integral part of the lamp or as a separate component, shall always be maintained in good condition.

6.3 Penetrant inspection materials and equipment shall be used with caution and always in accordance with the manufacturer's instructions.

7. SELECTION OF PROCESS

7.1 General. Some of the technical factors affecting the choice of a penetrant process are:

- (1) The surface conditions of the component,
- (2) The geometry of the component,
- (3) The contrast required and sensitivity i.e. the ability of a penetrant process to reveal a particular type of discontinuity in a given component.
- (4) Accessibility of component to be inspected.

7.2 'In situ' applications. Penetrant processes shall only be applied 'in situ' when the conditions allow a satisfactory test to be carried out. Normally, the 'in situ' application should be considered inferior to any controlled production line application as, of necessity, the complete sequence of operations often has to be applied manually under inferior lighting conditions and with possibly restricted access. The items which require careful consideration in respect of an 'in situ' inspection procedure are as follows:

7.2.1 Preparation of surface.

(1) It may be advantageous to carry out masking for confinement of penetrant flaw detection materials.

(2) For the removal of protective finishes e.g. paint, an approved method should be used.

(3) As the discontinuities being sought are usually of crack formation, it may be advantageous to apply a force which would tend to open any flaw. Such action shall not be taken, however, without consulting the Design Authority.

(4) When degreasing a component, considerable care is needed as any defect present might become filled with contaminant. In some instances, experience may show that it is impossible to clean defects adequately and resource to some other method of inspection may be necessary.

7.2.2 Penetrant. The penetrant is applied by spray, brush, or in some cases, a reservoir can be constructed over the area requiring inspection. Contact times will often be longer than the controlled production line application.

7.2.3 Remover. In general, a process involving a solvent remover should be employed because of the obvious difficulties of using water and the associated drying process on large 'in situ' components or structures. The remover should preferably be applied with a lint-free cloth because if a spray is used the surface might be flooded to the

extent that the remover could enter the defect and dilute the penetrant. Because of its toxic effects, there is a health hazard associated with spraying a solvent remover in confined spaces.

7.2.4 Developer. Better control of application can be obtained if a wet developer applied by spraying is used, particularly where access is restricted or the area being inspected is in a confined space. Care is needed to ensure that application of developer is not excessive as thick layers can mask small indications.

8. EQUIPMENT

8.1 Field inspection kits. Field inspection kits for 'in situ' applications comprise a complete set of processing materials, together with brushes, swabs, cleaning rags etc, and, if the fluorescent process is to be used, a black light lamp of suitable intensity (see 12.1).

8.2 Equipment. This equipment comprises a series of individual units placed in a line sequence, enabling parts to be introduced at one end of the line and passed out at the other end. The units may be semi-automated or fully automated and, as appropriate, the installation shall consist of the following in sequence:

8.2.1 Degrease/cool station. A trichloroethylene vapour tank, manufactured from suitable material, together with an area for cooling components prior to application of penetrant, shall be provided. Both shall be of adequate size to handle the flow of components.

8.2.2 Penetrant application station. The penetrant tank shall be of suitable materials and of such a size that components can be satisfactorily covered with penetrant either by immersion or by a brushing or flow-on technique. The tank shall be equipped with a cover when not in use, and suitable drains shall be provided for removal of both uncontaminated and contaminated penetrant.

8.2.3 Penetrant drain station. The penetrant drain station shall consist of a sloping shallow tray arranged so that the penetrant is collected in a separate container.

8.2.4 Spray wash station. The spray wash station shall consist of a tank similar in size to the penetrant tank with an open drain in its base and with splash guards fitted to prevent water entering adjacent tanks. For fluorescent penetrant inspection, the area should preferably contain a black light lamp for use under darkened conditions in order to facilitate obtaining the correct degree of washing. For washing purposes, an air-accelerated water spray in which the air-to-water ratio can be adjusted to produce a fine to medium spray is required.

8.2.5 Emulsifier station. The emulsifier tank shall

be of suitable material and size to enable the components to be completely immersed.

8.2.6 Agitated water wash station. The tank shall be of suitable material and size to enable total immersion of the components to be effected immediately it is required. The unit shall be fitted with a weir to enable water which is contaminated with penetrant to be removed. The water shall be continuously replenished and agitated. Agitation may be achieved by air flow through drilled pipes arranged in the bottom of the tank or by mechanical means.

8.2.7 Hot wash station. The tank shall be of suitable material and size to enable total immersion of the component to be effected immediately it is required. The unit shall be fitted with a weir to enable water which is contaminated by penetrant to be renewed. Means shall be provided to control the temperature of the water within the range 65°C to 85°C.

8.2.8 Drying stage. A supply of dry clean filtered air at a maximum pressure of 2 bar* (30 lbf/in²) shall be available for the removal of excess water prior to drying. For drying purposes, a hot air circulating oven controlled in the temperature range of 60°C to 85°C is recommended.

8.2.9 Developing station.

(1) *Powder developer.* Application is best achieved by using a dust storm cabinet, followed by extraction of excess powder from the cabinet, both sequences being in operation for a pre-determined time. The cabinet shall be of sufficient dimensions to accommodate the work in its entirety either as single components or multiples placed in wire mesh baskets. It shall have a sealed hinged lid and preferably be fitted with heaters to prevent contamination of the powder by moisture. The use of electrostatic spray or flock gun spray methods is not precluded.

(2) *Wet spray developer.* The developer shall be applied using a suitable spray actuated with dry clean filtered air. The operation should be carried out in a cabinet which allows unrestricted spraying of the components to take place. An extraction system is required to remove excess spray.

(3) *Wet-dip developer.* The developer shall be contained in a tank of suitable material and size to allow for complete immersion of the work piece and subsequent draining of excess developer from its surfaces. Mechanical means shall be provided to agitate the developer.

8.2.10 Inspection station

(1) *Fluorescent penetrant.* The inspection station may consist of a booth or area with the level of ambient lighting reduced by suitable means. Sufficient space should be provided for the

* 1 bar = 10⁵ N/m².