



# **Non-destructive testing – Penetrant testing**

## **Part 1: General principles**



AS ISO 3452.1:2020

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- Australian Institute for Non-Destructive Testing
- Australian Nuclear Science and Technology Organisation
- Austroroads
- Engineers Australia
- Institute of Electrical Inspectors
- National Aerospace Non-Destructive Testing Board of Australia
- Weld Australia

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## **Part 1: General principles**

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## Preface

This Standard was prepared by the Australian members of Joint Standards Australia/Standards New Zealand Committee MT-007, Non-Destructive Testing of Metals and Materials, to supersede AS 2062—1997, *Non-destructive testing — Penetrant testing of products and components*.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this Standard is to specify a method of penetrant testing used to detect discontinuities, e.g. cracks, laps, folds, porosity and lack of fusion, which are open to the surface of the material to be tested. It is mainly applied to metallic materials, but can also be performed on other materials, provided that they are inert to the test media and not excessively porous (castings, forgings, welds, ceramics, etc.)

This Standard also includes requirements for process and control testing, but is not intended to be used for acceptance criteria and gives neither information relating to the suitability of individual test systems for specific applications nor requirements for test equipment.

This Standard is identical with, and has been reproduced from, ISO 3452-1:2013, *Non-destructive testing — Penetrant testing — Part 1: General principles*.

As this document has been reproduced from an International Standard, the following applies:

- (a) In the source text “this part of ISO 3452” should read “this Australian Standard”.
- (b) A full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. [www.iso.org/directives](http://www.iso.org/directives)

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received. [www.iso.org/patents](http://www.iso.org/patents)

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC ISO 3452-1 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 138, *Non-destructive testing*, in collaboration with ISO Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 2, *Surface methods*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 3452-1:2008) which has been technically revised. Changes from the first edition include a table referring to the testing products.

This corrected version of ISO 3452:2013 incorporates the following corrections: a footnote has been added to Table 1; the flowchart of [Annex A](#) has been modified.

ISO 3452 consists of the following parts, under the general title *Non-destructive testing — Penetrant testing*:

- *Part 1: General principles*
- *Part 2: Testing of penetrant materials*
- *Part 3: Reference test blocks*
- *Part 4: Equipment*
- *Part 5: Penetrant testing at temperatures higher than 50 °C*
- *Part 6: Penetrant testing at temperatures lower than 10 °C*

## NOTES

# Australian Standard®

## Non-destructive testing – Penetrant testing

### Part 1: General principles

#### 1 Scope

This part of ISO 3452 specifies a method of penetrant testing used to detect discontinuities, e.g. cracks, laps, folds, porosity and lack of fusion, which are open to the surface of the material to be tested. It is mainly applied to metallic materials, but can also be performed on other materials, provided that they are inert to the test media and not excessively porous (castings, forgings, welds, ceramics, etc.)

It also includes requirements for process and control testing, but is not intended to be used for acceptance criteria and gives neither information relating to the suitability of individual test systems for specific applications nor requirements for test equipment.

NOTE 1 Methods for determining and monitoring the essential properties of penetrant testing products to be used are specified in ISO 3452-2 and ISO 3452-3.

NOTE 2 The term *discontinuity* is used in this part of ISO 3452 in the sense that no evaluation concerning acceptability or non-acceptability is included.

#### 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3059, *Non-destructive testing — Penetrant testing and magnetic particle testing - Viewing conditions*

ISO 3452-2, *Non-destructive testing — Penetrant testing — Part 2: Testing of penetrant materials*

ISO 3452-3, *Non-destructive testing — Penetrant testing — Part 3: Reference test blocks*

ISO 3452-4, *Non-destructive testing — Penetrant testing — Part 4: Equipment*

ISO 3452-5, *Non-destructive testing — Penetrant testing — Part 5: Penetrant testing at temperatures higher than 50 degrees C*

ISO 3452-6, *Non-destructive testing — Penetrant testing — Part 6: Penetrant testing at temperatures lower than 10 degrees C*

ISO 12706, *Non-destructive testing — Penetrant testing — Vocabulary*

#### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12706 apply.

#### 4 Safety precautions

As penetrant inspection techniques often require the use of harmful, flammable and/or volatile materials, certain precautions shall be taken.

Prolonged or repeated contact of these materials with the skin or any mucous membrane should be avoided. Working areas shall be adequately ventilated and sited away from sources of heat, sparks or naked flames in accordance with local regulations.

The penetrant testing products and equipment shall be used with care and always in compliance with the instructions supplied by the manufacturer.

When using filtered UV-A sources, care shall be taken to ensure that unfiltered radiation from the UV-A source does not directly reach the eyes of the operators. Whether it forms an integral part of the lamp or is a separate component, the UV-A filter shall always be maintained in good condition.

In addition to the need to follow legislation (e.g. Directive 2006/25/EC), care shall be taken to ensure the safe implementation of the method.

## **5 General principles**

### **5.1 Personnel**

Testing shall be carried out by proficient, suitably trained and qualified personnel and, where applicable, shall be supervised by competent personnel nominated by the employer or, by delegation of the employer, the inspection company in charge of testing. To demonstrate appropriate qualification it is recommended that personnel be certified according to ISO 9712 or an equivalent formalized system. Operating authorization for qualified persons shall be issued by the employer in accordance with a written procedure. Non-destructive testing (NDT) operations, unless otherwise agreed, shall be authorized by a competent and qualified NDT supervisory individual (Level 3 or equivalent) approved by the employer.

### **5.2 Description of the method**

Prior to penetrant testing the surface to be inspected shall be cleaned and dried. Suitable penetrants are then applied to the test area and enter into discontinuities open to the surface. After the appropriate penetration time has elapsed the excess penetrant is removed from the surface and the developer applied. The developer absorbs the penetrant that has entered and remains in the discontinuities and may give a clearly visible enhanced indication of the discontinuity.

Should complementary NDT be required, the penetrant inspection shall be performed first, unless otherwise agreed upon between the contracting parties, so as not to introduce contaminants into open discontinuities. If penetrant inspection is used following another NDT technique, the surface shall be cleaned carefully to remove contaminants before application.

### **5.3 Process sequence**

Testing generally proceeds through the following stages:

- a) preparation and precleaning (see [8.2](#));
- b) application of penetrant (see [8.4](#));
- c) excess penetrant removal (see [8.5](#));
- d) application of developer (see [8.6](#));
- e) inspection (see [8.7](#));
- f) recording (see [8.7.4](#));
- g) postcleaning (see [8.8.1](#)).

See [Annex A](#).

## 5.4 Equipment

The equipment used for carrying out penetrant testing depends on the number, size and shape of the parts to be tested. The equipment shall be as specified in ISO 3452-4.

## 5.5 Effectiveness

The effectiveness of the penetrant testing depends upon many factors, including

- a) types of penetrant materials and testing equipment,
- b) surface preparation and condition;
- c) material under examination and expected discontinuities,
- d) temperature of the test surface,
- e) penetration and development time, and
- f) viewing conditions.

Control checks shall be carried out to demonstrate that the correct parameters are used. See [Annex B](#).

## 6 Products, sensitivity and designation

### 6.1 Product family

Various test systems exist in penetrant testing.

A product family is understood as a combination of the following penetrant testing materials: penetrant, excess penetrant remover (except method A) and developer. When tested in accordance with ISO 3452-2 the penetrant and excess penetrant remover shall be from a single manufacturer. Only approved product families shall be used.

### 6.2 Testing products

The products used for testing are given in [Table 1](#).

### 6.3 Sensitivity

The sensitivity level of a product family shall be determined using reference block 1 in accordance with ISO 3452-3. The assessed level always refers to the method used for type testing of the approved product family.

### 6.4 Designation

The approved product family to be used for penetrant testing is given a designation comprising the type, the method and the form for the testing products, and a figure which indicates the sensitivity level achieved by testing with the reference block 1 according to ISO 3452-3.

**EXAMPLE** An approved product family comprising fluorescent penetrant (I), water as the excess penetrant remover (A), a dry-powder developer (a), and a system sensitivity of level 2 gives the following penetrant testing system designation when using ISO 3452-1 and ISO 3452-2: product family ISO 3452-2, IAa Level 2.

**Table 1 — Testing products**

Penetrant		Excess penetrant remover		Developer	
Type	Denomination	Method	Denomination	Form	Denomination
I	Fluorescent penetrant	A	Water-washable	a	Dry powder
II	Colour contrast	B	Post-emulsifiable, lipophilic	b	Water-soluble
III	Penetrant Dual-purpose (fluorescent colour contrast penetrant)	C	Solvent-removable <sup>a</sup> : — Class 1, halogenated — Class 2, non-halogenated — Class 3, special application	c	Water-suspendable
				d	Solvent-based (non- aqueous for Type I)
				e	Solvent-based (non- aqueous for Types II and III)
		f	Special application		

For specific cases, it is necessary to use penetrant testing products complying with particular requirements with regards to flammability, sulfur, halogen and sodium content and other contaminants. See ISO 3452-2.

<sup>a</sup> The class of Method C is not part of the designation.

## 7 Compatibility of testing materials with the part(s) to be tested

### 7.1 General

The penetrant testing products shall be compatible with the material to be tested and the use for which the part or parts is designed.

### 7.2 Compatibility of penetrant testing products

The penetrant testing materials shall be compatible with each other.

Drag-out losses shall be replaced with the same materials, which may be from a different batch.

The products shall be from the same manufacturer.

### 7.3 Compatibility of penetrant testing materials with parts under examination

**7.3.1** In most cases the compatibility of products can be assessed prior to use by means of the corrosion test detailed in ISO 3452-2.

**7.3.2** The chemical or physical properties of some non-metallics can be adversely affected by penetrant testing materials; their compatibility has to be established before inspecting parts manufactured from, and assemblies that include such materials.

**7.3.3** In situations where contamination might occur, it is essential to ensure that the penetrant testing materials do not have a deleterious effect on fuels, lubricants, hydraulic fluids, etc.

**7.3.4** For parts associated with peroxide rocket fuel, explosive stores (these include all items containing explosive propellant, initiating or pyrotechnic materials), oxygen equipment or nuclear applications the compatibility of penetrant testing materials shall be given special consideration.

## **8 Test procedure**

### **8.1 Written test procedure**

All testing shall be performed in accordance with an approved written procedure, which may be specific to or included in the relevant product standard.

### **8.2 Precleaning**

#### **8.2.1 General**

Contaminants such as scale, rust, oil, grease or paint shall be removed — if necessary using mechanical or chemical methods, or a combination of these. Precleaning shall ensure that the test surface is free from residues and that it allows the penetrant to enter any discontinuity. The cleaned area shall be large enough to prevent interference from areas adjacent to the actual test surface.

#### **8.2.2 Mechanical precleaning**

Scale, slag, rust, etc., shall be removed using suitable methods such as brushing, rubbing, abrasion, blasting or high-pressure water blasting. These methods remove contaminants from the surface and generally are incapable of removing contaminants from within surface discontinuities. In all cases care shall be taken to ensure that the discontinuities are not masked by plastic deformation or clogging from abrasive materials. If necessary to ensure that discontinuities are open to the surface, subsequent etching treatment shall be carried out, followed by adequate rinsing and drying.

#### **8.2.3 Chemical precleaning**

Chemical precleaning shall be carried out, using suitable chemical cleaning agents, to remove residues such as grease, oil, paint or etching materials.

Residues from chemical precleaning processes can react with a penetrant and greatly reduce its sensitivity. Acids and chromates in particular can greatly reduce the fluorescence of fluorescent penetrants and the colour of the colour contrast penetrant. Therefore, chemical agents shall be removed from the surface under examination, after the cleaning process, using suitable cleaning methods, which may include water rinsing.

#### **8.2.4 Drying**

As the final stage of precleaning, the parts to be tested shall be thoroughly dried, so that neither water nor solvent remains in the discontinuities.

### **8.3 Temperature**

The testing material, the test surface and the ambient temperature shall be within the range from 10 °C to 50 °C, except for the drying process (8.2.4). Rapid temperature changes can cause condensation, which may interfere with the process and should be avoided.

For temperatures outside the range 10 °C to 50 °C, inspection shall be carried out in accordance with ISO 3452-5 or ISO 3452-6, as applicable.

### **8.4 Application of penetrant**

#### **8.4.1 Methods of application**

Penetrant can be applied to the part to be tested by spraying, brushing, flooding, dipping or immersion.

Penetrant shall remain on the test surface throughout the entire penetration time.

### 8.4.2 Penetration time

The appropriate penetration time depends on the properties of the penetrant, the application temperature, the material of the part to be tested and the discontinuities to be detected.

The penetration time shall be between 5 min and 60 min and shall not be less than the manufacturer's recommended time for the required sensitivity. The penetration time shall be recorded in the written test procedure.

## 8.5 Excess penetrant removal

### 8.5.1 General

The application of the remover medium shall be such that penetrant remains in the discontinuities.

### 8.5.2 Water

The excess penetrant shall be removed by washing (rinsing), immersion or wiping using water. Care shall be taken to minimize the effect of mechanical action caused by the rinsing method.

### 8.5.3 Solvents

Excess penetrant shall be removed, first, by using a clean lint-free cloth and, subsequently, by cleaning with a clean lint-free cloth lightly moistened with solvent. Any other removal technique shall be technically approved for adequacy and agreed by the contracting parties, particularly when solvent remover is sprayed directly onto the part to be tested.

### 8.5.4 Emulsifier

#### 8.5.4.1 Hydrophilic (water-dilutable)

To allow the post-emulsifiable penetrant to be removed from the test surface, it shall be rendered water-rinsable by application of an emulsifier. Before the application of the emulsifier, a water wash should be performed in order to remove the bulk of the excess penetrant from the test surface and facilitate a uniform action of the hydrophilic emulsifier that will be applied subsequently.

The emulsifier shall be applied by immersion or by foam equipment. The concentration and the contact time of the emulsifier shall be evaluated by the user through pre-tests according to the manufacturer's instructions. The predetermined emulsifier contact time shall not be exceeded. After emulsification, a final wash shall be carried out in accordance with [8.5.2](#).

#### 8.5.4.2 Lipophilic (oil-based)

To allow the post-emulsifiable penetrant to be removed from the test surface, it shall be rendered water-rinsable by application of an emulsifier. This can only be done by immersion. The emulsifier contact time shall be evaluated by the user through pre-tests according to the manufacturer's instructions.

This time shall be sufficient to allow only the excess penetrant to be removed from the test surface during the subsequent water wash. The emulsifying time shall not be exceeded. Immediately after emulsification, a water wash shall be carried out in accordance with [8.5.2](#).

### 8.5.5 Water and solvent

First, the excess water-washable penetrant shall be removed using water (see [8.5.2](#)). Subsequent cleaning with a clean lint-free cloth, lightly moistened with solvent, shall be then carried out.

### 8.5.6 Excess penetrant removal check

During excess penetrant removal the test surface shall be checked for penetrant residues. For fluorescent penetrants, this shall be carried out under a UV-A source. The minimum UV-A irradiance at the test surface shall not be less than 1 W/m<sup>2</sup> (100 µW/cm<sup>2</sup>) and the visible light not more than 100 lx.

For colour contrast penetrants the white light illuminance on the test surface shall be more than 350 lx.

Excessive background shall normally necessitate reprocessing unless otherwise authorized by a suitably qualified person.

### 8.5.7 Drying

In order to facilitate rapid drying of excess water, any droplets and puddles of water shall be removed from the part.

Except when using water-based developer the test surface shall be dried as quickly as possible after excess penetrant removal, using one of the following methods:

- a) wiping with a clean, dry, lint-free cloth;
- b) evaporation at ambient temperature after hot water dip;
- c) evaporation at elevated temperature;
- d) forced air circulation;
- e) a combination of methods a) to d).

If compressed air is used, particular care shall be taken to ensure that it is water- and oil-free and that impinging pressure on the surface of the part is kept as low as possible.

If a low-pressure, forced-air drying system (e.g. oven) is used for drying the air temperature shall not exceed 70 °C. The drying time shall not lead to a surface temperature higher than 50 °C.

The method of drying the part to be tested shall be carried out such that the penetrant entrapped in the discontinuities does not dry.

The surface temperature shall not exceed 50 °C during drying, unless otherwise approved.

## 8.6 Application of developer

### 8.6.1 General

The developer shall be maintained in a uniform condition during use and shall be evenly applied to the test surface.

The application of the developer shall be carried out as soon as possible after the removal of excess penetrant.

Care shall be exercised when using water-based developers with water-washable penetrants to avoid removing further penetrant from the discontinuities.

### 8.6.2 Dry powder

Dry powder may only be used with fluorescent penetrants. The developer shall be uniformly applied to the test surface by one of the following techniques: dust storm, electrostatic spraying, flock gun, fluidized bed or storm cabinet. The test surface shall be thinly covered; local agglomerations are not permitted.

Excess developer shall be gently removed after the development time and before inspection using a method that will not disturb indications.

### **8.6.3 Water-suspendable developer**

A thin, uniform application of the developer shall be carried out by immersion in agitated suspension or by spraying with suitable equipment in accordance with the approved procedure. The immersion time and temperature of the developer shall be evaluated by the user through pre-tests according to the manufacturer's instructions. The immersion time shall be as short as possible to ensure optimum results.

The part shall be dried by evaporation and/or by the use of a forced-air circulation oven.

### **8.6.4 Solvent-based developer**

The developer shall be applied by spraying uniformly. The spray shall be such that the developer arrives slightly wet on the surface, giving a thin, uniform layer.

### **8.6.5 Water-soluble developer**

A thin, uniform application of the developer shall be carried out by immersion or by spraying with suitable equipment in accordance with the approved procedure. The immersion time and temperature of the developer shall be evaluated by the user through pre-tests according to the manufacturer's instructions. The immersion time should be as short as possible to ensure an optimum result.

The part shall be dried by evaporation and/or by the use of a forced-air circulation oven.

### **8.6.6 Water- or solvent-based for special application (e.g. peelable developer)**

When an indication that needs to be recorded is shown with the penetrant inspection process the following procedure should be used.

- Wipe off the developer with a clean, dry, lint-free cloth.
- Apply the same penetrant by any convenient means, then follow exactly the same process as initially used, up to application of the developer.
- After excess penetrant removal and drying of the part, apply the peelable developer as recommended by the manufacturer.
- When the recommended development time has elapsed, carefully peel off the developer coating. Indication(s) appear(s) on the face of the coating in direct contact with the part.

### **8.6.7 Development time**

The development time should be between 10 min and 30 min; longer times may be agreed between the contracting parties.

The development time begins

- immediately after application, when dry developer is applied, or
- immediately after drying, when wet developer is applied.

## 8.7 Inspection

### 8.7.1 Viewing conditions

#### 8.7.1.1 General

Viewing conditions shall conform to ISO 3059.

#### 8.7.1.2 Fluorescent techniques

Sufficient time shall be allowed for the operator's eyes to become dark-adapted in the inspection area, at least 1 min.

In some cases it may be advantageous to provide UV-A background lighting. The UV-A irradiance at the surface inspected shall be  $10 \text{ W/m}^2$  ( $1\,000 \text{ }\mu\text{W/cm}^2$ ) or greater with a low level of visible light (maximum total of ambient and from UV-A source  $20 \text{ lx}$ ).

#### 8.7.1.3 Colour contrast techniques

For inspection, the illuminance at the test surface shall be  $500 \text{ lx}$  or greater.

### 8.7.2 General

Indications produced by the penetrant method may provide limited information on shape and dimension of discontinuities. In some cases it may be advantageous to carry out the first examination just after the application of the developer or as soon as the developer is dry. This facilitates a better interpretation of indications.

Final inspection shall be carried out when the development time has elapsed.

Inspection aids such as magnification instruments can be used.

Assessment by the wipe-off technique (see 8.7.3) may further assist evaluation.

### 8.7.3 Wipe-off technique

This procedure is used to assist in assessment of the nature of a discontinuity causing an indication and consists of removal of the initial indication followed by a further development process. It shall not be used to remedy general inspection process irregularities such as inadequate removal. The exact procedure may be the subject of specific agreement between the contracting parties or included within relevant acceptance criteria. Unless otherwise agreed, repeating the procedure is not permitted. Where no indication redevelops this shall not be the sole evidence for assessing an indication as spurious or non-relevant but can be used to demonstrate that initial interpretation is correct (e.g. water mark or surface contamination) or to allow the inspector to obtain additional beneficial information by witnessing the growth of the indication during the redevelopment time.

Procedure:

- a) using a small, clean, lint-free swab, wipe across the surface where the indication is present to remove the penetrant materials (one pass only);
- b) view the area under inspection conditions to ensure the penetrant materials have been completely removed;
- c) apply further developer — use a light coating of wet non-aqueous developer, applied from a distance where the material dries almost immediately on contact, unless otherwise agreed;
- d) inspect the area immediately after application of the developer;
- e) inspect again at intervals and at the final development time of 10 min.

#### 8.7.4 Recording

Recording may be done by any adequate method, e.g. written description, sketch or photograph.

### 8.8 Postcleaning and protection

#### 8.8.1 Postcleaning

After final inspection, postcleaning of the part is necessary only in those cases where the penetrant testing products could interfere with subsequent processing or service requirements.

#### 8.8.2 Protection

If required, a suitable corrosion protection shall be applied.

#### 8.9 Retesting

If retesting is necessary, e.g. because no unambiguous evaluation of indications is possible, the entire test procedure, starting with the precleaning, shall be repeated.

If necessary, more favourable test conditions shall be chosen for this procedure. The use of a different type of penetrant or a penetrant of the same type from a different supplier is not allowed unless thorough cleaning has been carried out to remove penetrant residues remaining in the discontinuities.

## 9 Test report

The test report shall contain the following information, in reference to this part of ISO 3452:

- a) information on the part tested:
  - 1) designation;
  - 2) dimensions;
  - 3) material;
  - 4) surface condition;
  - 5) production stage;
- b) purpose of testing;
- c) designation of the penetrant system used, as specified in 6.4, giving the manufacturer's name and product designation as well as the batch number;
- d) test instructions;
- e) deviations (if any) from the test instructions;
- f) test results (description of discontinuities detected);
- g) test location, date of testing, name of the operator;
- h) name, qualification status and signature of the test supervisor.

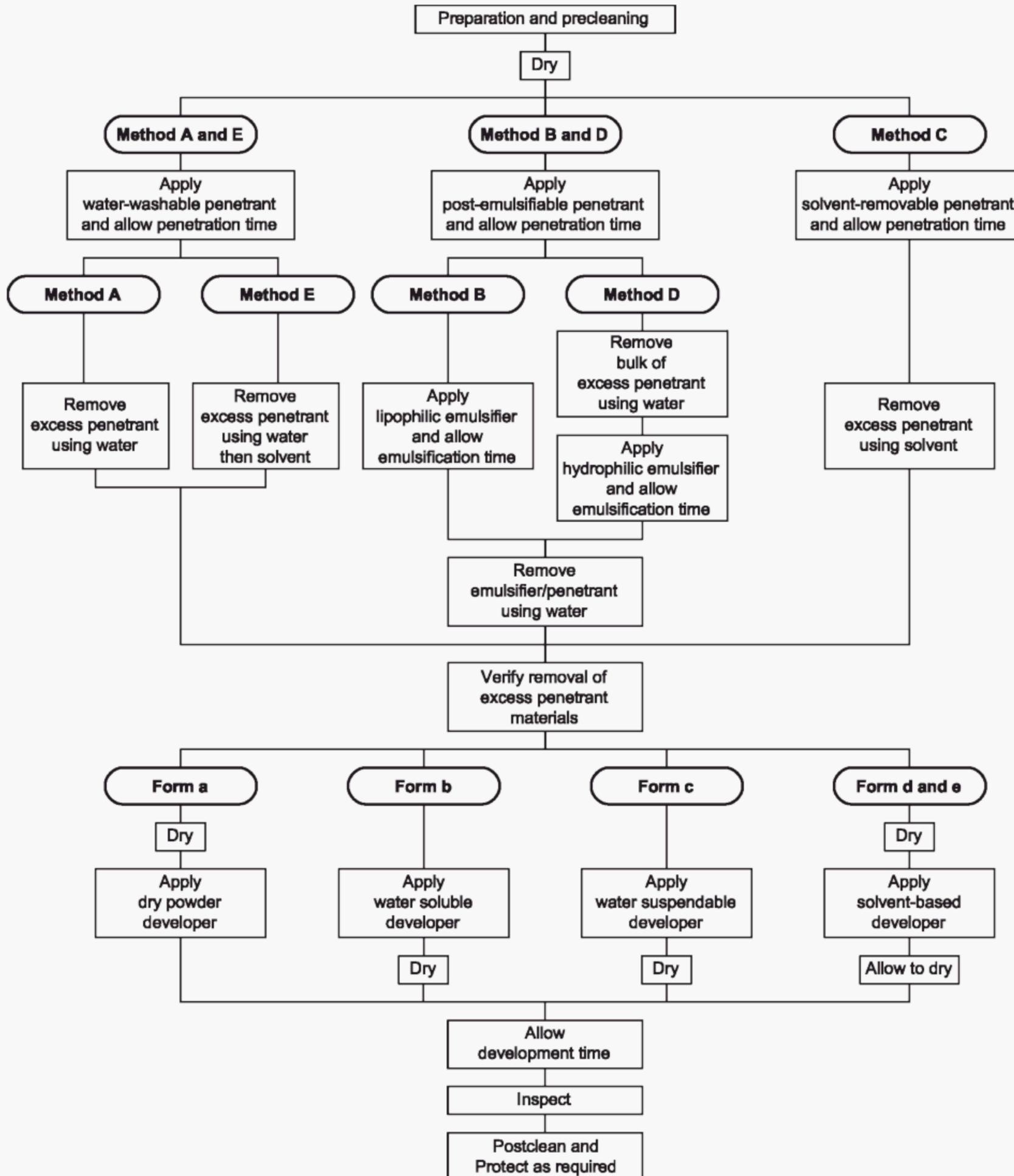
The layout of a form that can be used for the test report is given in [Annex C](#). It shall include all the details relating to the method which are important for the evaluation of the test results, as well as additional information relating to the parts to be tested, although this data should be modified, as appropriate, depending on the type of part. If another form is used it shall contain all the information detailed in items a) to h).

The test report may be omitted if a test procedure fulfilling the requirements of 8.1 is submitted, containing the information mentioned in Clause 9 from a) to d) and if the information under e) to h) is documented in an appropriate manner.

## Annex A (normative)

### Main stages of penetrant examination

The sequence of operations to be followed is illustrated for the general case by this flow chart.



## **Annex B** **(normative)**

### **Process and control tests**

#### **B.1 General**

[Annex B](#) describes process and control tests used to monitor the implementation of the method.

In order to maintain the integrity of a penetrant process, the process as a whole and the individual components of the system shall be regularly checked to ensure that they meet the required standards. This requirement is applicable to process lines where materials are reused. For products supplied in aerosols or thixotropic penetrants, only used for a single inspection, reduced or no testing may be required as determined by a suitably qualified person, e.g. ISO 9712, Level 3.

[Table B.1](#) details the process and control tests to be carried out and their frequency. It is the responsibility of a suitably qualified person, e.g. ISO 9712, Level 3, to decide which tests are applicable to a particular process line. The tests may be carried out at more frequent intervals or additional tests carried out if necessary to ensure correct processing conditions.

The test shall be carried out and the results recorded in accordance with [Table B.1](#) by a suitably qualified person, e.g. ISO 9712, Level 2.

#### **B.2 Records**

A separate record of the process and control test results for each penetrant plant shall be maintained. Any deviations found shall be reported to the responsible person and the appropriate corrective action taken.

The following information shall be included in the records:

- a) company and site;
- b) process line identity;
- c) date;
- d) shift;
- e) name and qualification;
- f) signature.

#### **B.3 Control tests**

##### **B.3.1 Materials levels (including refillable spray systems)**

The level of material in all process systems shall be visually examined to ensure that there is sufficient material to allow complete coverage of the components to be processed. If insufficient material is in the system, extra material shall be added and mixed before any other tests are carried out.

### **B.3.2 System performance**

This test shall be carried out using a type 2 reference test block in accordance with ISO 3452-3. Alternative known defect standards may be used where authorized by a suitably qualified person, e.g. ISO 9712, Level 3. It may be advantageous to also use a component with known discontinuities typical of those normally expected.

A record in the form of a permanent replica, photograph or other suitable means, showing the discontinuities, including the level of background, shall be prepared using new, unused materials of the same family and processed using the same parameters normally in use and retained for reference. This record shall be used as a comparison for the practical results obtained using the same test for the daily system performance check. Indications from peelable developers are not the same as those obtained using standard developers. The indications on the chrome-plated side of the type 2 reference test block or on the component with known discontinuities shall show the same number of indications and pattern as those of the record prepared using the same materials and process sequence. Similarly, the level of background shall be the same as that shown on the record.

Permanent replica shall be scaled approximately 1:1, and the indications shall be easy to compare with test results.

Separate reference pieces shall be allocated to each individual penetrant; for this purpose an individual penetrant shall be only one product as designated by the manufacturer.

#### **B.3.2.1 Reference test parts cleaning**

The test panel or known defect standard used for the performance test shall be maintained in such condition that it detects changes in process parameters. In particular, it is necessary to remove penetrant materials remaining from previous tests. It may be beneficial between uses to store the panel in solvent or other remover.

No method used shall physically modify the discontinuities.

### **B.3.3 Penetrant appearance**

Check for any abnormal aspects of the penetrant (e.g. milky appearance, visible contamination, deposits of water at the bottom or top of the penetrant).

### **B.3.4 Rinse water appearance**

When using recycled water, check for opacity, fluorescence, foam or coloration of the rinse water, the presence of any of which can suggest that the treatment system is not functioning effectively.

### **B.3.5 Rinse water temperature**

Check that the rinse water temperature is within the specified limits.

Table B.1 — Process and control tests

Control tests	Subclause	Frequency				Recording	
		Start of each work period	Weekly	Monthly	Yearly	Numerical value	Visual assessment
<b>System review</b>							
Materials levels	B.3.1	X					X
System performance	B.3.2	X					X
<b>General review</b>							
Penetrant appearance	B.3.3	X					X
Rinse-water appearance	B.3.4	X					X
Rinse-water temperature	B.3.5	X				X	
Oven temperature	B.3.6	X				X	
Working area	B.3.7	X					X
Compressed-air filter(s)	B.3.8		X				X
UV-A lamps	B.3.9	X					X
UV-A irradiance	B.3.10			X		X	
Visible light intensity in inspection booth (fluorescent systems)	B.3.11			X		X	
Visible light intensity (colour contrast systems)	B.3.12			X		X	
<b>Penetrants</b>							
Fluorescent brightness <sup>a</sup>	B.3.13			X			X
Colour contrast intensity <sup>a</sup>	B.3.14			X			X
Supplier's overcheck	B.3.15				X		X
<b>Emulsifiers</b>							
Concentration of hydrophilic remover	B.3.16			X		X	
<b>Developers</b>							
Appearance of dry powder	B.3.17.1	X					X
Fluorescence of dry powder	B.3.17.2	X				X	

Table B.1 — (continued)

Control tests	Subclause	Frequency				Recording	
		Start of each work period	Weekly	Monthly	Yearly	Numerical value	Visual assessment
Water-soluble developer							
a) Concentration	B.3.17.3.1	X				X	
b) Wetting test	B.3.17.3.2	X				X	
c) Temperature	B.3.17.3.3	X				X	
d) Fluorescence of solution	B.3.17.3.4	X					X
Water-suspendable developer							
a) Concentration	B.3.17.4.1	X				X	
b) Temperature	B.3.17.4.2	X				X	
c) Fluorescence of suspension	B.3.17.4.3	X					X
<b>Calibration</b>							
Ultraviolet radiometers	B.3.18				X		X
Luxmeters	B.3.19				X		X
Thermometers	B.3.20				X		X
Pressure gauges	B.3.21				X	X	
Test blocks	B.3.22				X	X	X
a	Not intended for aerosols.						

### **B.3.6 Oven temperature**

Check that the oven temperature is within the specified limits in the area of the work pieces (see [8.5.7](#)).

### **B.3.7 Working area**

Ensure that the working area is clean and tidy. When inspecting components processed with a fluorescent penetrant system, there shall be no reflective surface, e.g. white paper, on the inspection bench or in the immediate vicinity of the inspection area. In addition, there shall be no stray white light sources near to the inspection area.

### **B.3.8 Compressed-air filter(s)**

Ensure that the trap(s) are free of contaminants.

### **B.3.9 UV-A lamps**

Ensure that lamps are functioning correctly, are in good condition and that UV-A filters, where fitted, are intact.

### **B.3.10 UV-A irradiance**

Measure UV-A irradiance in accordance with ISO 3059.

### **B.3.11 Visible light intensity in inspection booth (fluorescent systems)**

Measure, in accordance with ISO 3059, the maximum visible light intensity in the booth.

### **B.3.12 Visible light intensity (colour contrast systems)**

Measure the minimum visible light intensity at the working area in accordance with ISO 3059. Where light levels can vary, e.g. when daylight is involved, the frequency of the test shall be increased.

### **B.3.13 Fluorescent brightness**

Measure the fluorescent brightness in accordance with ISO 3452-2.

**Requirement:** the fluorescent brightness shall be within the range 90 % to 110 % of the reference.

### **B.3.14 Colour contrast intensity**

**B.3.14.1** Use standard reference samples of the colour contrast penetrant at 1 %, 0,9 %, 0,8 % and 0,7 % in high-flash kerosene or any other suitable non-volatile solvent.

To prepare the reference samples, it is recommended that dilutions of 10 %, 9 %, 8 % and 7 % are first prepared and then further diluted at 1 to 10.

These reference samples shall be stored in light-proof sealed containers.

**B.3.14.2** Prepare a 1 % solution of the penetrant under test in the same solvent as specified in [B.3.14.1](#).

**B.3.14.3** Using test tubes, under evenly distributed visible light, compare the colour intensity of the penetrant under test against the reference samples.

Record the level at which the colour intensities are similar.

**Requirement:** the colour intensity shall be greater than 80 % of reference.

### **B.3.15 Supplier's overcheck**

A representative sample of the in-use penetrant shall be taken at least once a year and sent to the supplier's or other suitable laboratory for analysis. Otherwise, the penetrant shall be discarded and replaced.

The overchecking laboratory shall issue a report stating that the physical-chemical parameters of the penetrant under test are all within acceptable limits when compared with the nominal values for a new penetrant. It is recommended that the report shows actual values and not only a statement.

It is the responsibility of the supplier to choose which parameters are to be checked.

### **B.3.16 Concentration of hydrophilic remover**

The test is applicable for freshly prepared solutions and regular tests, which shall be carried out using a refractometer.

The test refractometer shall be calibrated using accurately prepared solutions of the new hydrophilic emulsifier. At least five solutions shall be used. One shall be the nominal concentration, two shall be above and two below the nominal concentration. The values shall be plotted graphically.

To estimate the concentration of the hydrophilic remover, read the value given by a sample of the freshly prepared product and determine its concentration from the graph.

All parts of the test shall be carried out at ambient temperature.

**Requirement:** Adjust concentration to required value. Mix well before rechecking.

Any change in visual appearance shall require further tests to be carried out.

### **B.3.17 Developers**

#### **B.3.17.1 Appearance of dry powder**

Ensure that the powder is free flowing, fluffy and not caked.

#### **B.3.17.2 Fluorescence of dry powder**

Examine a sample of the powder under ultraviolet light to ensure that it is free from fluorescence that could affect the process.

As a guide it is not expected that more than 10 specks per 10 000 mm<sup>2</sup> (e.g. eight specks on a 100 mm diameter disk) will be visible when applied by the production method.

#### **B.3.17.3 Water-soluble developer**

##### **B.3.17.3.1 Concentration**

This test uses a graph of concentration against density produced by the manufacturer to determine the concentration of the developer.

- a) Check the level of the tank and bring it back to its original level by the addition of water and mix thoroughly.
- b) Take a sample of the contents of the tank and adjust the temperature to 20 °C or to the temperature at which the hydrometer has been calibrated.
- c) Measure the density of the sample using a hydrometer.

The density will enable the concentration of the developer to be determined from the graph.

### **B.3.17.3.2 Wetting test**

Ensure that the whole surface of the reference test block type 2 used for the system performance check has been evenly coated with developer.

### **B.3.17.3.3 Temperature**

Ensure that the developer temperature is within specified limits.

### **B.3.17.3.4 Fluorescence of solution**

Examine a sample of the solution under ultraviolet light to ensure that it is free from fluorescence.

## **B.3.17.4 Water-suspendable developer**

### **B.3.17.4.1 Concentration**

This test uses a graph of concentration against density produced by the manufacturer to determine the concentration of the developer.

- a) Check the level of the tank and, if necessary, add water to bring it back to its original level and mix thoroughly to ensure a full and uniform suspension.
- b) Take a sample from the tank and adjust the temperature to 20 °C or to the temperature at which the hydrometer has been calibrated.
- c) Measure the density of the sample using a hydrometer.

The density will enable the concentration of the developer to be determined from the graph.

### **B.3.17.4.2 Temperature**

Check that the developer temperature is within specified limits.

### **B.3.17.4.3 Fluorescence of suspension**

Thoroughly agitate the bath of developer to ensure that the powder is in suspension. Examine a sample of the developer suspension under ultraviolet light to ensure that it is free from fluorescence.

## **B.3.18 Ultraviolet radiometer calibration**

The in-use ultraviolet radiometer shall have valid calibration stickers or identification referring to ISO 3059.

Before using the radiometer, the operator shall check the stickers for the “valid to” or “calibrate before” dates. The unit shall be calibrated at least once every 12 months.

## **B.3.19 Luxmeter calibration**

The luxmeter shall have valid calibration stickers or identification referring to ISO 3059.

Before using the luxmeter, the operator shall check the stickers for the “valid to” or “calibrate before” dates. The unit shall be calibrated at least once every 12 months.

## **B.3.20 Thermometer calibration**

Thermometers shall be calibrated with an accuracy of  $\pm 1$  °C or better.

**B.3.21 Pressure gauge calibration**

Check that all gauges are set within the nominal values stated by the applicable process procedure. Check that they have valid calibration identification.

**B.3.22 Test block calibration**

Changes in the discontinuities contained in the test block will affect results. Therefore, each block shall be retested to demonstrate stability. This may be done by comparison of the results achieved when tested using new, unused materials with the retained replica or photograph (see [B.3.2](#)). Any changes shall be assessed by a suitably qualified person, e.g. ISO 9712, Level 3 and appropriate action taken.

## Annex C (informative)

### Example test report

Test report			
Company name:	Reference no.:		
Departments:	Subreference no.:		
<b>Penetrant testing</b>			
Project:	Test report no.:	Sheet _____ of _____ sheets	Parts:
Commissioned by:	Manufacturing no.:		
Commission order no.:	Drawing no.:		
Part to be tested:	Further details, e.g.:		
Dimensions:	Weld plan no.:	Test follow-up plan no.:	
Material:	Weld no.:	Sheet no.:	
Surface condition:	Unit no.:	Part no.:	
Heat treatment condition:	Cast no.:	Model no.:	
Pre-treatment:			
Test instruction:	(e.g. specification, test direction, delivery condition)		
Scope of testing:			
<b>Penetrant system</b>			
Designation:	(further details, e.g. free from corrosive constituents, in accordance with ISO 3452-2)		
<b>Manufacturer:</b>			
<b>Product designation</b>			
Penetrant:	Batch no.:		
Excess penetrant remover:	Batch no.:		
Developer:	Batch no.:		
<b>Procedure</b>			
Test temperature:	Excess penetrant removal (further details, e.g. anticorrosive agents):		
Precleaning:	Emulsifying time:		
Drying:	Drying:		
Penetration time:	Development time:		
Deviations from test instructions:	Postcleaning/protection:		
Deviations from ISO 3452-1:			
Test results:	(e.g. for discontinuities: details of location, types, distributions, sizes and number; sketch)		
Test location:	Test date:	Operator's name:	
Evaluation (in accordance with test instructions):	Acceptable:	Unacceptable:	
Remarks:			
Test supervisor:	Qualification status:	Date:	Signature:
<i>or</i>			
Commissioner/expert:		Date:	Signature:
<i>or</i>			
Test house:		Date:	Signature:

## **Bibliography**

- [1] ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*
- [2] Artificial Optical Radiation Directive (AORD) (2006/25/EC)

### **Standards Australia**

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