INTERNATIONAL STANDARD

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Non-destructive testing — Penetrant testing —

Part 1: General principles

Essais non destructifs — Examen par ressuage —

Partie 1: Principes généraux

Reference number
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Foreword

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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

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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*

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[a]: — Class 1, halogenated — Class 2, non-halogenated — Class 3, special application	c	Water-suspendable
		D	Post-emulsifiable, hydrophilic	d	Solvent-based (non-aqueous for Type I)
		E	Water- and solvent-removable	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.

[a] 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^2 (100 µW/cm^2) 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.