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Non-destructive testing — Penetrant testing —

Part 1: General principles

Essais non destructifs — Examen par ressuage —

Partie 1: Principes généraux

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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 (see 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 (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 3452-1:2013) which has been technically revised.

The main changes compared to the previous edition are as follows:

— clarification of understanding of product family;

— addition of the new procedure “no developer”;

— technical revision according to the state of the art.

A list of all parts in the ISO 3452 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Non-destructive testing — Penetrant testing —

Part 1: General principles

1 Scope

This document 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 using white light or UV-A (365 nm) radiation. 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 document also includes requirements for process and control testing, but is not intended to be used for acceptance criteria. It 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 document in the sense that no evaluation concerning acceptability or non-acceptability is included.

NOTE 3 CEN/TR 16638 addresses penetrant testing using actinic blue light.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. 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.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Safety precautions

As penetrant inspection techniques often require the use of harmful, flammable and/or volatile materials, safety regulations (e.g. optical radiation legislation) shall be taken into account.

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, taking into account all applicable safety regulations.

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

UV-A sources shall always be maintained in a good condition.

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 to 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. Penetrant testing operations, unless otherwise agreed, shall be authorized by a competent 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 clean and dry. Suitable penetrant is then applied to the test area and enter 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 non-destructive testing (NDT) be required, it is preferable that the penetrant inspection be performed first, so as not to introduce contaminants into open discontinuities. If penetrant inspection is used following another NDT technique or method, the surface shall be cleaned carefully to remove contaminants before application.

5.3 Process sequence

The penetrant process shall be continuous with no undue delays between the stages. If process parameters are not met, surfaces shall be cleaned and reprocessed.

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) postcleaning and corrosion protection (see 8.8).

The process shall be as given in Annex A.

5.4 Equipment

The equipment used for carrying out penetrant testing depends on the number, size, weight 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;

f) viewing conditions.

Control checks shall be carried out to demonstrate that the correct testing parameters are used in accordance with Annex B.

6 Products, sensitivity and designation

6.1 Product family

Various test systems exist in penetrant testing. The penetrant system and the product family shall be selected according to the application. Various factors have an impact on the effectiveness and sensitivity of the process, e.g. the surface roughness and condition, size and shape of the parts to be tested and the sensitivity level of the product family. For example, using a high sensitivity penetrant on a rough surface may result in a less sensitive test than using a lower sensitive penetrant.

A product family is understood as a combination of the following penetrant testing materials: penetrant, excess penetrant remover (except method A) and developer. A product family may be defined by the manufacturer, user or inspection authority and the testing materials do not necessarily have to be from the same manufacturer, but shall be type tested in accordance with ISO 3452-2.

6.2 Testing products

The products used for testing are given in Table 1.

6.3 Sensitivity

Sensitivity levels shall be determined according to ISO 3452-2. By using specific product families, different sensitivity levels may be achieved. ISO 3452-2 describes penetrant baseline sensitivity and product family sensitivity.

6.4 Designation

The 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 according to ISO 3452-2.

EXAMPLE A product family comprising a fluorescent penetrant (I), water as the excess penetrant remover (A), and a dry-powder developer (a), and having 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/procedures

Penetrant		Excess penetrant remover		Developer	
Type	**Denomination**	**Method**	**Denomination**	**Form**	**Denomination**
I	Fluorescent	A	Water	a	Dry
II	Colour contrast	B	Lipophilic emulsifier	b	Water-soluble
III	Dual purpose (fluorescent and colour contrast)	C	Solvent	c	Water-suspendable
		D	Hydrophilic emulsifier	d	Solvent-based (non-aqueous for type I)
		E[a]	Water and solvent	e	Solvent-based (non-aqueous for Types II and III)
				f	Special application
				g[b]	No developer (type I only)

NOTE 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] Method E relates to the use of two products, both water and solvent. Penetrant materials qualified for method A are also considered qualified for method E.

[b] For form g, development time is required, see 8.6.1.

7 Compatibility

7.1 General

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

7.2 Compatibility of penetrant testing products

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

7.3 Compatibility of penetrant testing products and the material to be tested

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

7.3.2 The wettability of the test surface using the selected penetrant testing product shall be established before testing. When parts are not visible during penetrant application (e.g. automated systems), the wettability of the penetrant on the test surface shall be visually checked before testing on a representative sample.

7.3.3 The chemical or physical properties of some non-metallic materials can be adversely affected by the penetrant testing products; their compatibility shall be established before inspecting parts manufactured from, and assemblies that include, such materials.

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

7.3.5 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 products shall be given special consideration.

8 Test procedure

8.1 Written test procedure

All testing shall be performed in accordance with an approved written documentation, either specifically prepared or included in the relevant product standard. The written test procedure shall also include all relevant parameters for testing, e.g. temperatures, times, pressures. When generating test procedures, the product manufacturer's recommendations shall be taken into account.

8.2 Precleaning

8.2.1 General

Contaminants such as scale, rust, oil, grease, paint and water 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 blasting (water or ice pellets). 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. Therefore, chemical agents shall be removed from the surface under examination, after the cleaning process, using suitable cleaning methods.

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 on the test surface and in the discontinuities.

8.3 Temperature

The testing materials, 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 from 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 defined in the written test procedure.

8.5 Excess penetrant removal

8.5.1 General

The excess penetrant removal shall be such that penetrant remains in the discontinuities.

8.5.2 Water

When water is used for removal it shall be applied by wiping, immersion or spray. Care shall be exercised to avoid overwashing for example by the use of high-pressure spray, excessive time or excessive mechanical action. When wiping is used, excess penetrant shall be removed first by using a suitable clean lint-free cloth or absorbent paper and subsequently by cleaning with a clean lint-free cloth lightly moistened with water.

8.5.3 Solvents

Excess penetrant shall be removed first by using a suitable clean lint-free cloth or absorbent paper and subsequently by using 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 the 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 shall 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 determined by the user through pre-tests. 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.