INTERNATIONAL STANDARD

ISO 3452-1

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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

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 3452-1 was prepared by the European Committee for Standardization (as EN 571-1:1997) and was adopted, under a special "fast-track" procedure, by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 2, *Surface methods*, in parallel with its approval by the ISO member bodies.

ISO 3452-1 cancels and replaces ISO 3452:1984 which has been technically revised.

Throughout the text of this document, read "this European Standard" and "this standard" to mean "this International Standard".

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*

Annex ZZ provides a list of corresponding International and European Standards for which equivalents are not given in the text.

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 138, Non-destructive testing, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 1997, and conflicting national standards shall be withdrawn at the latest by July 1997.

In the framework of its scope, Technical Committee CEN/TC 138 entrusted CEN/TC 138/WG 4, Liquid penetrant testing, to prepare this European Standard.

EN 571 comprises a series of European Standards on penetrant testing which is made of the following:

EN 571-1	*Non-destructive testing — Penetrant testing — Part 1: General principles*
EN 571-2	*Non-destructive testing — Penetrant testing — Part 2: Testing of penetrant materials*
EN 571-3	*Non-destructive testing — Penetrant testing — Part 3: Reference test blocks*

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

1 Scope

This standard defines 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 they are not excessively porous, examples of which are castings, forgings, welds, ceramics, etc.

This standard is not intended to be used for acceptance criteria and gives no information relating to the suitability of individual test systems for specific applications nor requirements for test equipment.

The term ‘discontinuity’ is used here in the sense that no evaluation concerning acceptability or non-acceptability is included.

Methods for determining and monitoring the essential properties of penetrant testing products to be used are specified in EN 571-2 and EN 571-3.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 473	*Qualification and certification of NDT personnel — General principles*
prEN 571-2	*Non-destructive testing — Penetrant testing — Part 2: Testing of penetrant materials*[1]
prEN 571-3	*Non-destructive testing — Penetrant testing — Part 3: Reference test blocks*[1]
prEN 956	*Non-destructive testing — Penetrant testing — Equipment*
prEN 1330-6	*Non-destructive testing — Terminology — Part 6: Terms used in penetrant systems* [1]
prEN1956	*Non-destructive testing — Penetrant testing and magnetic particle testing — Viewing conditions*[1]

3 Definitions

For the purposes of this standard the definitions of prEN 1330-6 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 and 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 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.

There is legislation and regulations regarding health, safety, pollution and storage, etc.

5 General principles

5.1 Personnel

The examination shall be carried out or supervised by competent personnel and, if required, qualified and certified according to EN 473 or to a system agreed upon by the contracting parties.

5.2 Description of the method

Prior to penetrant testing the surface to be inspected shall be cleaned and dried. Then suitable penetrants are 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. This 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 be required, the penetrant inspection shall be performed first unless agreed upon between the contracting parties so as not to introduce contaminants into open discontinuities. If penetrant inspection is used following another non-destructive testing technique, the surface shall be cleaned carefully to remove contaminants before application.

[1] In preparation.

Table 1. Testing products

Penetrant		Excess penetrant remover		Developer	
Type	**Designation**	**Method**	**Designation**	**Form**	**Designation**
I	Fluorescent penetrant	A	Water	a	Dry
II	Colour contrast penetrant	B	Lipophilic emulsifier 1 Oil-based emulsifier 2 Rinsing with running water	b	Water soluble
III	Dual purpose (fluorescent colour contrast penetrant)	C	Solvent (liquid)	c	Water suspendable
		D	Hydrophilic emulsifier 1 Optional prerinse (water) 2 Emulsifier (water-diluted) 3 Final rinse (water)	d	Solvent-based (non-aqueous wet)
		E	Water and solvent	e	Water or solvent based for special application (e.g. peelable developer)

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 prEN 571-2.

5.3 Process sequence

The sequence of operations is illustrated for the general case in annex A.

Testing generally proceeds through the following stages:

a) preparation and precleaning (see **8.2**);

b) application of penetrant (see **8.3**);

c) excess penetrant removal (see **8.4**);

d) application of developer (see **8.5**);

e) inspection (see **8.6**);

f) recording (see **8.7**);

g) postcleaning (see **8.8**).

5.4 Equipment

The equipment for carrying out penetrant testing depends on the number, size and shape of the parts to be tested. For the requirements of equipment, see EN 956.

5.5 Effectiveness

The effectiveness of the penetrant testing depends upon many factors such as:

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, etc.

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 and developer. When tested in accordance with prEN 571-2 the penetrant and excess penetrant remover shall be from one manufacturer. Only approved product families shall be used.

6.2 Testing products

The testing products are given in table 1.

6.3 Sensitivity

The sensitivity level of a product family shall be determined using reference block 1 as described in prEN 5713. 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 as described in prEN 571-3.

Example

Designation of an approved product family comprising fluorescent penetrant (I), water as excess penetrant remover (A) and a dry powder developer (a), and a system sensitivity of level 2 is the following penetrant testing system when using prEN 571-1 and prEN 572-2 giving the example: product family EN 571-IAa-2.

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 is designed.

7.2 Compatibility of penetrant testing products

The penetrant testing materials shall be compatible with each other.

Penetrant materials from different manufacturers shall not be mixed during the initial filling of the facility. Dragout losses shall not be replaced using penetrant materials from different manufacturers.

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 prEN 571-2.

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 require special consideration.

7.3.5 If, after postcleaning, penetrant testing materials remain on the parts there is a possibility of corrosion, e.g. of stress corrosion or of corrosion fatigue.

8 Test procedure

8.1 Written test procedure

When contractually required a written test procedure shall be prepared and approved prior to the examination.

8.2 Preparation and precleaning

Contaminants, e.g. scale, rust, oil, grease or paint shall be removed, if necessary using mechanical or chemical methods or a combination of these methods. 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.

8.2.1 *Mechanical precleaning*

Scale, slag, rust, etc., shall be removed using suitable methods such as brushing, rubbing, abrasion, blasting, high pressure water blasting, etc. These methods remove contaminants from the surface and generally are incapable of removing contaminants from within surface discontinuities. In all cases and in particular in the case of shot blasting, 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.

8.2.2 *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 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.

8.2.3 *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 Application of penetrant

8.3.1 *Methods of application*

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

Care shall be taken to ensure that the test surface remains completely wetted throughout the entire penetration time.

8.3.2 *Temperature*

In order to minimize moisture entering discontinuities, the temperature of the test surface shall generally be within the range from 10 °C to 50 °C. In special cases temperatures as low as 5 °C may be used.

For temperatures below 10 °C or above 50 °C only penetrant product families and procedures approved in accordance with prEN 571-2 for this purpose shall be used.

NOTE. Especially in the low temperature range there is a danger of water condensing in the discontinuities and on the surfaces, and this water will prevent the penetrant from entering the discontinuities.

8.3.3 *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 can vary from 5 min to 60 min. The penetration time should be at least as long as the time used for the determination of sensitivity (see **6.3**). If not, the actual penetration time shall be recorded in the written test procedure. In no case shall the penetrant be allowed to dry during the penetration time.

8.4 Excess penetrant removal

8.4.1 *General*

The application of the remover medium shall be such that no penetrant is removed from the discontinuities.

8.4.2 *Water*

The excess penetrant shall be removed using a suitable rinsing technique. Examples: spray rinsing or wiping with a damp cloth. Care shall be taken to minimize the effect of mechanical action caused by the rinsing method. The temperature of the water shall not exceed 50 °C.

8.4.3 *Solvents*

Generally, the excess penetrant shall be removed first by using a clean lint-free cloth. Subsequent cleaning with a clean lint-free cloth lightly moistened with solvent shall then be carried out. Any other removal technique shall be approved by the contracting parties, particularly when solvent remover is sprayed directly on to the part to be tested.

8.4.4 *Emulsifier*

8.4.4.1 *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 to facilitate a uniform action of the hydrophilic emulsifier which 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 as described in **8.4.2**.

8.4.4.2 *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 as described in **8.4.2**.

8.4.5 *Water and solvent*

First the excess water-washable penetrant shall be removed with water (see **8.4.2**). Subsequent cleaning with a clean lint-free cloth, lightly moistened with solvent, shall be then carried out.

8.4.6 *Excess penetrant removal check*

During excess penetrant removal the test surface shall be visually 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 3 W/m^2 (300 μW/cm^2).

When faced with excessive background on parts after excess penetrant removal has been carried out, the decision on future action shall be taken by a suitably qualified person.

8.4.7 *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 the methods listed under a) to d).

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

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

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

8.5 Application of developer

8.5.1 *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.

8.5.2 ***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.

8.5.3 ***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. 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.

8.5.4 ***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.

8.5.5 ***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. Immersion time and temperature of the developer shall be evaluated by the user through pretests according to the manufacturer's instruction. 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.

8.5.6 ***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 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 which was in direct contact with the part.

8.5.7 ***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;

– immediately after drying when wet developer is applied.

8.6 Inspection

8.6.1 ***General***

Generally, it is advisable 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.

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

Aids for visual examination, such as magnification instruments or contrast spectacles, can be used.

NOTE. The diameter, width or intensity of the indication provide limited information.

8.6.2 ***Viewing conditions***

8.6.2.1 *Fluorescent penetrants*

Photochromatic spectacles shall not be worn.

Sufficient time shall be allowed for the operator's eyes to become dark-adapted in the inspection booth, usually at least 5 min.

UV radiation shall not be directed in the operator's eyes. All surfaces which can be viewed by the operators shall not fluoresce.

No paper or cloth which fluoresces under UV light shall be in sight of the operator.

A UV-A background lighting may be provided, if necessary, to allow the operator to move freely inside the booth.

The test surface shall be viewed under a UV-A radiation source, in accordance with prEN 1956. The UV-A irradiance at the surface inspected shall not be less than 10 W/m^2 (1000 μW/cm^2).

The statements above shall apply to inspections in darkened rooms where the visible light is limited to a maximum of 20 lx.

8.6.2.2 *Colour contrast penetrants*

The test surface shall be inspected under daylight or under artificial white light with an illuminance of not less than 500 lx on the surface of the tested part. The viewing conditions shall be such that glare and reflections are avoided.