BS EN 1371-2:2015

BSI Standards Publication

Founding — Liquid penetrant testing

Part 2: Investment castings

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National foreword

This British Standard is the UK implementation of EN 1371-2:2015. It supersedes BS EN 1371-2:1998 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/111, Steel Castings and Forgings.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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Fonderie - Contrôle par ressuage - Partie 2 : Pièces en moulage de précision (cire perdue)

Gießereiwesen - Eindringprüfung - Teil 2: Feingussstücke

This European Standard was approved by CEN on 12 December 2014.

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COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 1371-2:2015) has been prepared by Technical Committee CEN/TC 190 “Foundry technology”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by July 2015, and conflicting national standards shall be withdrawn at the latest by July 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1371-2:1998.

Within its programme of work, Technical Committee CEN/TC 190 requested CEN/TC 190/WG 11 "Surface inspection" to revise the following standard:

— EN 1371-2:1998, *Founding — Liquid penetrant inspection — Part 2: Investment castings*

This is one of two European Standards for liquid penetrant testing for castings.

The other standard is:

— EN 1371-1, *Founding — Liquid penetrant testing — Part 1: Sand, gravity die and low pressure die castings*.

Annex F provides details of significant technical changes between this European Standard and the previous edition.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard complements the general principles of liquid penetrant testing given in EN ISO 3452-1 for the additional requirements for investment castings.

The structure of this European Standard is similar to that of EN 1371-1:2011, *Founding — Liquid penetrant testing — Part 1: Sand, gravity die and low pressure die castings* [1].

It has been written to take account of the difference of dimension of the reference area and the difference of nature of discontinuities with regard to other casting processes for which EN 1371-1 is applicable.

Liquid penetrant testing as well as any other non-destructive examination method is part of a general or specific assessment of the quality of a casting to be agreed between the manufacturer and the purchaser at the time of acceptance of the order.

1 Scope

This European Standard specifies a liquid penetrant testing method for castings produced by investment casting for general purposes.

NOTE Investment casting is sometimes referred to as lost-wax casting.

This European Standard applies to all cast metals, except copper-tin and/or copper-tin-lead alloy castings, where copper is the major constituent (see EN 1982 [3]).

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.

EN 1370, *Founding — Examination of surface condition*

EN 4179, *Aerospace series — Qualification and approval of personnel for non-destructive testing*

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

EN ISO 3452-1, *Non-destructive testing — Penetrant testing — Part 1: General principles (ISO 3452-1)*

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

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

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

EN ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel (ISO 9712)*

3 Conditions for liquid penetrant testing

The manufacturing stage(s) when liquid penetrant testing is to be performed shall be clearly defined by agreement between the manufacturer and the purchaser by the time of ordering.

The methods detailed in this standard shall only apply to the agreed surfaces of castings and the percentage or number of castings to be checked.

For each agreed area of the casting to be inspected, the following shall be indicated:

— type of discontinuity;

— severity level.

This information enables the manufacturer to assess the additional testing and operations involved.

Sensitivity can differ depending on the method of liquid penetrant testing selected and surface conditions, the application of the casting (e.g. increased wear, safety related component) and its manufacture stage. Therefore the liquid penetrants used and the method agreed shall fit to detect the minimum required severity level.

The type of discontinuity and the severity level can vary depending on the area of the casting inspected (see Table 1 and Table 2).

The conversion from the severity levels specified in EN 1371-2:1998, Table 3 [2], to the severity levels specified in Table 2 of the present edition is given in Table A.1.

4 Method of testing

4.1 Operating mode

Testing shall be carried out as described in EN ISO 3452-1, EN ISO 3452-2, EN ISO 3452-5 and EN ISO 3452-6. The characteristics of the penetrant materials shall be checked in accordance with specifications to be agreed between the manufacturer and the purchaser.

4.2 Qualification of the operators

Testing shall be performed by qualified personnel. The level of qualification shall be agreed between the contracting parties (e.g. EN ISO 9712, or EN 4179, or a similar certification scheme).

4.3 Surface preparation

The surface to be inspected shall be clean, free from rust, scale, moulding residues, oil, grease, paint or any other contaminant which can interfere with a correct testing. The surface to inspect shall be cleaned by using mechanical or chemical methods, or a combination of these.

Shot blasting is not recommended prior to liquid penetrant testing. If shot blasting is necessary, it shall be as light as possible, in order to avoid sealing or closing up possible discontinuities. If the risk of sealing or closing up possible discontinuities is unacceptable then blasting shall be followed by chemical etching in order to enable detection of discontinuities. The chemical composition of the etching bath and other parameters such as concentration, temperature, immersion time neutralizing and rinsing, if applicable, shall be recorded.

To detect the smallest indication to be considered, the surface finish shall be in accordance with Table 3, unless otherwise specified at the time of ordering.

The assessment of surface finish should be carried out using a visual cast-surface roughness comparator; see EN 1370.

4.4 Viewing conditions

The examination of the indications shall be carried out with the naked eye or at a minimum magnification of 3 and viewing conditions in conformity with EN ISO 3059.

5 Acceptance criteria

5.1 Indications of discontinuities

5.1.1 General

The indication of discontinuities can be non-linear (isolated or clustered), aligned or linear. Although liquid penetrant testing cannot generally be used to determine the size of detected discontinuities, it allows discontinuities to be assessed by measurement of the length L of the indication. In the following clauses:

— L indicates length;

— W indicates width;

— P indicates liquid penetrant;

— SP indicates non-linear isolated indication;

— CP indicates non-linear clustered indication;

— AP indicates aligned indication;

— LP indicates linear indication.

NOTE Based on the principle of the test method, the operator evaluates the size of the indications, not the real size of discontinuities.

5.1.2 Criteria

The physical discontinuities shall give either a non-linear, linear or aligned liquid penetrant testing indication.

The various types of penetrant indication can correspond to the discontinuities (A, B, C, etc.) shown in Annex B.

5.2 Definition of liquid penetrant indications

a) Linear indication (LP). An indication with a largest dimension three or more times its smallest dimension (i.e. $L \geq 3\ W$);

b) Non-linear indication. An indication with a largest dimension less than three times its smallest dimension (i.e. $L < 3\ W$):

   1) isolated (SP);

   2) clustered (CP): area of multiple indications, the distance between the indications cannot be measured (they seem to form only one indication);

c) Aligned indication (AP). Indication that is either:

   1) linear: the distance between two indications is smaller than the length of the longest discontinuity in the alignment; or

   2) non-linear: the distance between two indications is less than 2 mm and at least three indications are noted.

5.3 Severity levels

5.3.1 General

Several severity levels are recognized in accordance with Table 1 and Table 2. It is necessary to carry out the test on a surface corresponding to a given degree of finish (see Table 3) depending on the severity level desired.

The liquid penetrant testing for each type of indication and its severity levels shall be specified at the time of ordering, by the purchaser, depending on the use of the castings. The manufacturer shall give his agreement.

The penetrant indications to be taken into account shall have dimensions in accordance with the severity level.

5.3.2 Criteria

Table 1 and Table 2 show the largest dimensions of the smallest indications to be considered in the severity level concerned.

5.3.3 Tables

Table 1 corresponds to non-linear isolated or non-linear clustered indications.

Table 2 corresponds to linear or aligned indications.

Table 1 and Table 2 are independent (different severity levels may be selected from these tables).

Reference figures corresponding to non-linear, aligned and clustered indications in accordance with Table 1 and Table 2 are represented in Annexes C and D for guidance only.

6 Classification of the indications and interpretation of results

In order to classify an indication of discontinuity, a frame measuring 25 mm × 25 mm shall be placed in the most unfavourable location. The observed indications shall be in relation to the reference severity levels as described in this standard and compared to the equivalent or immediately better severity level.

If the casting dimensions in total are smaller than 25 mm × 25 mm, then the indicating criteria shall be in proportion to the surface area.

Indications shall be considered to be equivalent when the same number of non-linear spots and/or the same length of linear indications of similar appearance are detected. Maximum permissible discontinuities may appear simultaneously on the area of 25 mm × 25 mm.

If, for any indication type, the observed severity level is worse than that specified in the order, the casting shall be considered to be in non-conformance with this standard. It shall be considered as conforming to this standard when the observed severity level is equal to or better than that specified in the order.

Classification of severity levels shall be made to the values in Table 1 and Table 2. Only values expressed in these tables are valid. Reference figures are for information only (see Annexes C and D).

The requirements detailed in the order or in the specifications shall be written in conformance to the terminology used in this standard.

Examples of how the requirements shall be specified are as follows:

— non-linear indications level 2 (abbreviated as "SP 2");

— linear and aligned indications level 5 (abbreviated as "LP 5" and "AP 5").

NOTE 1 Severity level references are arbitrary. They cannot be considered in the same progression from one table to the other, nor from one kind of indication to another.

NOTE 2 Provided that on the casting surface no tested area contains discontinuities which exceed the agreed severity level, there is no limit to the acceptability of discontinuities.

7 Retesting

Retesting shall be carried out in accordance with EN ISO 3452-1.

8 Post cleaning and protection

Unless otherwise specified in the order, post cleaning shall be carried out in accordance with EN ISO 3452-1. If required, a suitable corrosion protection shall be applied.

9 Test report

The test report shall be in accordance with EN ISO 3452-1. A model of a trilingual liquid penetrant test report is shown in Annex E.

Table 1 — Severity levels for liquid penetrant testing — Non-linear indications — Isolated (SP) or clustered (CP)

Characteristic		Severity level							
		SP 1 CP 1	SP 2 CP 2	SP 3 CP 3	SP 4 CP 4	SP 5 CP 5	SP 6 CP 6	SP 7[a] CP 7[a]	SP 8[a] CP 8[a]
Diameter of the smallest indication [b] to take into account, in mm.		0,3	0,3	0,5	1	1,5	2	3	5
Maximum number of non-linear indications [c].		0	2	2	2	2	2	2	1
Maximum dimensions of indication A, B, C, F and N, in mm.	SP	0,3	1	1,5	2	3	5	7	10
	CP	0,3	2	3	4	6	8	11	15
Reference figures		see Figure C.1							
The penetrant indications can grow over a period of time and this should be taken into account.									

a Informative for specific dimensions (e.g. large sized castings outside the usual range).

b "SP" or "CP".

c "SP" + "CP".

Table 2 — Severity levels for liquid penetrant testing – Linear (LP) and aligned (AP) indications

Characteristics	Severity levels															
	LP 01 AP 01		LP 1 AP 1		LP 2 AP 2		LP 3 AP 3		LP 4 AP 4		LP 5 AP 5		LP 6 AP 6		LP 7[a] AP 7[a]		LP 8[a] AP 8[a]	
Testing means	Magnifying glass								Eyes									
Magnification for observation of penetrant indication	≥ 3								1									
Length of smallest indication to be considered (mm)	none		0,3		0,3		0,5		1		1,5		2		2,5		3	
Arrangement of indications[b], isolated (I) or cumulative (C)	I or C		I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C
Maximum length of linear (LP) and aligned (AP) indication allowed (mm)	none		0,3		0,5	1	1	2	1,5	3	2	4	3	6	4	8	6	12
Reference figures	see Figure D.1																	

The severity levels "01" and "1" are difficult to achieve and should be specified with caution.

The penetrant indications can grow over a period of time and this should be taken into account.

NOTE The sensitivity can differ, depending on the method of penetrant testing selected.

[a] Informative for specific dimensions (e.g. large sized castings outside the usual range).

[b] The length L of an aligned indication is the distance between the starting point of the first discontinuity and the opposite end of the last discontinuity ($L \geq 3\ W$).

Table 3 — Recommended surface finish for liquid penetrant testing

Dimension of smallest indication mm	Visual tactile comparators[a]	
	BNIF [4]	SCRATA [5]
0,3	2/0S1 – 1/0S1 1 S2 – 2 S2	—[b]
1	1 S1 – 2 S1 3 S2 – 4 S2	A 1 – A 2 —[b]
2	2 S1 – 3 S1 4 S2 – 5 S2	A 2 – A 3 H 1[c]
≥ 3	not specified (rough surface)	A 3 – A 4 H 3 – H 4 – H 5

[a] See EN 1370.

[b] No corresponding comparator available.

[c] Corresponds to "5 S2".

Annex A
(informative)

Indicative conversion of severity levels of linear (LP) and aligned (AP) indications

Table A.1 gives an indicative conversion from the severity levels specified in EN 1371-2:1998, Table 3 to severity levels specified in Table 2 of the present edition.

Table A.1 only applies to drawings and specifications based on EN 1371-2:1998. Table A.1 is prepared as a tool for adaptation of specifications and/or drawings based on EN 1371-2:1998.

Table A.1 — Indicative conversion between the severity levels

Severity levels of the present edition	**Severity levels of EN 1371-2:1998**		
	Section thickness $t \leq 16$ mm	Section thickness 16 mm $< t \leq 50$ mm	Section thickness $t > 50$ mm
LP 01 AP 01	—	—	—
LP 1 AP 1	1	1	1
LP 2 AP 2	2	—	—
LP 3 AP 3	3	2	—
LP 4 AP 4	4	—	2
LP 5 AP 5	5	3	—
LP 6 AP 6	6	4	3
LP 7 AP 7	—	5	—
LP 8 AP 8	—	6	4
> LP 8 > AP 8	—	—	5
	—	—	6

Annex B
(informative)

Nature of discontinuities and types of corresponding liquid penetrant indications

Table B.1 — Nature of discontinuities and types of corresponding liquid penetrant indications

Nature of discontinuities	Symbol	Types of liquid penetrant indications			
		non-linear		linear	aligned
		isolated SP	clustered CP	LP	AP
Gas porosity	A	X	X	–	X
Sand and/or slag inclusions (other than alumina)	B	X	X	–	X
Shrinkage	C	X	X	X	X
Cracks	D	–	–	X	X
Hot tears	E	–	–	X	X
Inserts	F	X	–	X	X
Laps and cold shuts	H	–	–	X	X
Presence of aluminium oxides (alumina) or magnesium oxides[a]	J	–	–	X	X
Other inclusions (shell)	N	X	X	–	X

[a] For aluminium alloy or magnesium alloy castings only.

Annex C
(informative)

Reference figures – Non-linear clustered indications designated CP

All reference figures shown in this annex are for guidance only and should be used at a scale of 1:1.

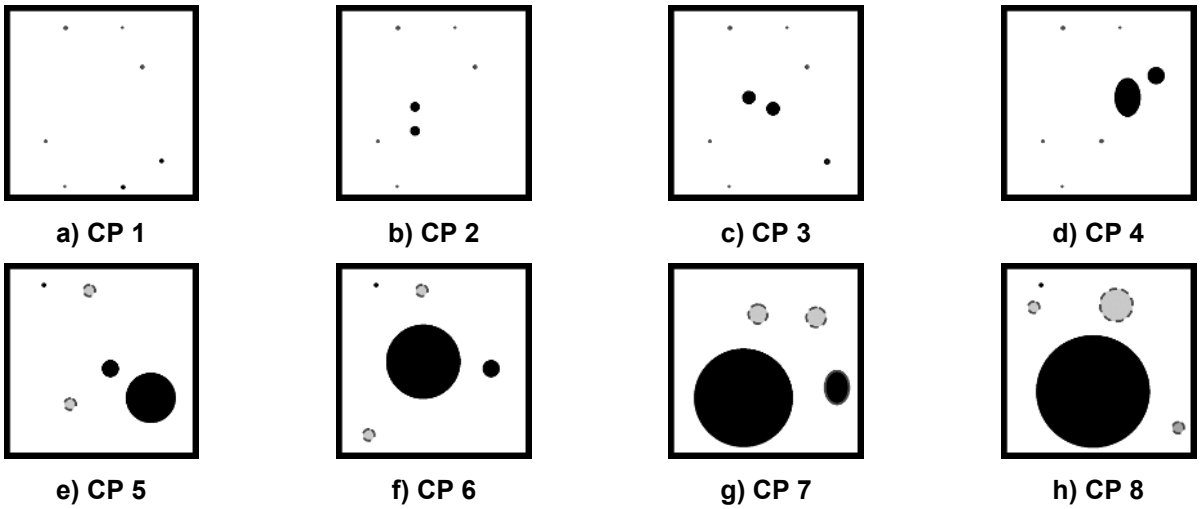

Figure C.1 — Non-linear clustered indications designated CP

Annex D
(informative)

Reference figures – Linear and aligned indications designated LP and AP

All reference figures shown in this annex are for guidance only and should be used at a scale of 1:1.

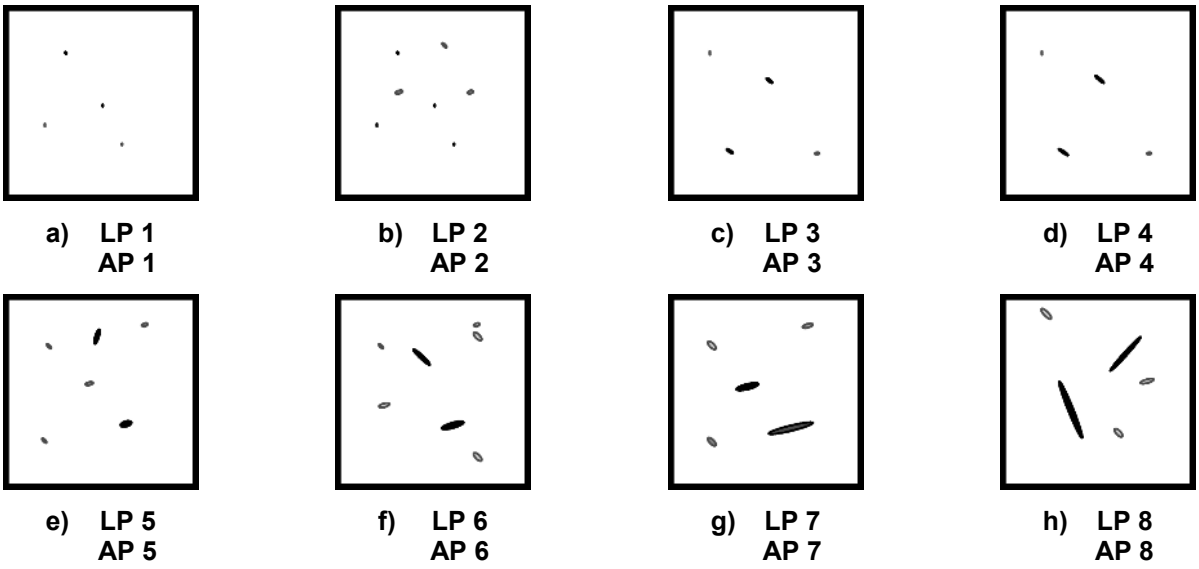

Figure D.1 — Linear and aligned indications designated LP and AP

Annex E
(informative)

Model of a liquid penetrant test report

<table>
<tr><td>Company
Société
Firma</td><td colspan="3">Liquid-penetrant test report
Contrôle par ressuage - Rapport d'essais
Prüfbericht zur Eindringprüfung</td><td>No.
n°
Nr.</td></tr>
<tr><td rowspan="2"></td><td colspan="3" rowspan="2"></td><td>Sheet
Page
Blatt</td></tr>
<tr><td>According to
Conforme à
Entsprechend</td></tr>
<tr><td colspan="2">Customer
Client
Kunde</td><td colspan="3">Order No.
Commande n°
Bestell-Nr.</td></tr>
<tr><td colspan="2">Specification
Spécification
Vorschrift</td><td colspan="2">Material
Nuance
Werkstoff</td><td>Heat No.
Coulée n°
Schmelze Nr.</td></tr>
<tr><td>Identification
Marquage
Kennzeichnung</td><td>Quantity
Quantité
Menge</td><td>Casting designation
Désignation des pièces
Gussstückbezeichnung</td><td>Lot No.
n° du lot
Los Nr.</td><td>Drawing No.
Plan n°
Zeichnung Nr.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Area examined – Zone contrôlée – Prüfbereich
□ 100 %
□ testing scheme – plan de contrôle – Prüfplan
□ cavity root – fonds affouillements – Ausmuldung für Schweißung</td></tr>
<tr><td colspan="5">Stage – Stade – Zustand
□ after heat treatment – après traitement thermique – nach Wärmebehandlung
□ before stress relieving – avant détensionnement – vor Spannungsarmglühen</td></tr>
<tr><td colspan="5">Penetrant – Pénétrant – Eindringmittel ……
Trademark – Marque – Handelsmarke ……</td></tr>
<tr><td colspan="5">Excess penetrant remover – Produit de nettoyage – Spülmittel ……
Trademark – Marque – Handelsmarke ……</td></tr>
<tr><td colspan="5">Developer – Révélateur – Entwickler ……
Trademark – Marque – Handelsmarke ……</td></tr>
</table>

(continued)

Model *(continued)*

Testing conditions – Conditions d'examen – Prüfbedingungen
Surface condition – Etat de surface – Oberflächenzustand □ shot blasted – grenaillé – gestrahlt □ ground – meulé – geschliffen □ machined – usiné – mechanisch bearbeitet
Casting temperature – Température de la pièce moulée – Gussstücktemperatur □ 5 °C up to / jusqu'à / bis 14 °C □ 15 °C up to / jusqu'à / bis 35 °C □ 36 °C up to / jusqu'à / bis 55 °C □ ……..……..…….. °C
Pre-cleaning – Nettoyage préalable – Vorreinigung □ yes – oui – ja □ no – non – nein
Penetrant application – Application du pénétrant – Auftragen des Prüfmittels □ brush – pinceau – Pinsel □ spray – pulvérisation – sprühen □ dip – immersion – tauchen Penetration time – Temps d'imprégnation – Eindringdauer ……..…… min
Penetration removal – Elimination du pénétrant – Entfernen des Eindringmittels □ cleaning with water – lavage à l'eau – Abspülen mit Wasser □ solvent – solvant – Lösemittel Drying time – durée de séchage – Trocknungsdauer …… min Drying temperature – Température de séchage – Trocknungstemperatur ……..…… °C
Developer application – Application du révélateur – Anwendung des Entwicklers □ brush – pinceau – Pinsel □ spray – pulvérisation – sprühen □ wet – humide – nass □ dry – sec – trocken Developing time – Temps de révélation – Entwicklungsdauer ……..…… min
Illumination – Eclairage – Beleuchtung □ natural – naturel – Tageslicht □ artificial – artificiel – künstlich □ ultraviolet – ultraviolet – ultraviolet

Model *(continued)*

Testing results – Résultats de l'examen – Prüfergebnisse
According to – Conforme à – entsprechend …… ……
Accepted – Accepté – abgenommen □ yes – oui – ja □ no – non – nein
Non-conformance note – Fiche d'anomalie – Beanstandung …… ……
Continuation sheet – Annexe – Fortsetzungsblatt □ yes – oui – ja □ no – non – nein
Inspection authority – Organisme de contrôle – Abnahmegesellschaft ……
Quality assurance section – Service assurance qualité – Abteilung Qualitätssicherung ……
Date – Date – Datum ……
Signature of inspector / operator – Signature de l'inspecteur / contrôleur – Unterschrift des Leiters der Prüfstelle / Prüfers ……

If applicable, tick the relevant box.

Suivant le cas, cocher la case correspondante.

Falls zutreffend, Entsprechendes ankreuzen.

Annex F
(informative)

Significant technical changes between this European Standard and the previous edition

Table F.1 — Significant technical changes between this European Standard and the previous edition

Clause/Paragraph/Annex/Table/ Figure	Changes
General	Structure and wording in conformity with EN 1371-1.
5.3.2	Deletion of section thickness ranges for linear and aligned indications.
Table 1	Was Table 2.
Table 1	Maximum dimension of indication for severity levels CP 5, CP 6 and CP 7 are increased.
Table 2	Was Table 3 with modifications (deletion of section thickness ranges and two new severity levels added).
Table 3	Was Table 4.
Annex A	New annex giving the conversion from the severity levels specified in EN 1371-2:1998, Table 3 to severity levels given in Table 2 of the present edition.
Annex B	Was Table 1.
Annex C	New annex giving reference figures for non-linear indications.
Annex D	New annex giving reference figures for linear and aligned indications.
Annex E	New model of a liquid penetrant test report.
NOTE The referred technical changes include the significant technical changes from the revised EN, but is not an exhaustive list of all modifications from the previous version.	

Bibliography

[1] EN 1371-1:2011, *Founding — Liquid penetrant testing— Part 1: Sand, gravity die and low pressure die castings*

[2] EN 1371-2:1998, *Founding — Liquid penetrant inspection — Part 2: Investment castings*

[3] EN 1982, *Copper and copper alloys — Ingots and castings*

[4] BNIF 359 - Recommandation technique du Bureau de Normalisation des Industries de la Fonderie. Caractérisation d'états de surface des pièces moulées - Utilisation des échantillons types de 110 × 160 mm", available from Editions Techniques des Industries de la Fonderie, 44 avenue de la Division Leclerc, 92310 Sèvres, France.[1)]

[5] "SCRATA surface comparators for the definition of surface quality of steel and iron castings", ASTM A 802 shorter set, available from Castings Technology International, Advanced Manufacturing Park, Brunel Way, Rotherham, S60 5WG, South Yorkshire, United Kingdom

1) "BNIF 359 Technical Recommendation issued by Bureau de Normalisation des Industries de la Fonderie - Characterization of surface condition of castings - Use of 110 x 160 mm standard specimens"

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