



BSI Standards Publication

Founding — Liquid penetrant testing

Part 1: Sand, gravity die and low pressure die castings

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National foreword

This British Standard is the UK implementation of EN 1371-1:2011. It supersedes BS EN 1371-1:1997 which is withdrawn.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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Amendments issued since publication

Date	Text affected
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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1371-1

November 2011

ICS 77.140.80; 77.150.99

Supersedes EN 1371-1:1997

English Version

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

Fonderie - Contrôle par ressage - Partie 1: Pièces
moulées en sable, en coquille, par gravité et basse
pression

Gießereiwesen - Eindringprüfung - Teil 1: Sand-,
Schwerkraftkokillen- und Niederdruckkokillengussstücke

This European Standard was approved by CEN on 15 October 2011.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Foreword

This document (EN 1371-1:2011) 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 May 2012, and conflicting national standards shall be withdrawn at the latest by May 2012.

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 1371-1:1997.

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

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

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

The other standard is:

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

Annex G 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, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This European Standard complements the general principles of liquid penetrant testing given in EN 571-1 for the additional requirements for castings.

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 in conventional sand moulds, by gravity and low-pressure die casting, except for investment castings and high-pressure die castings.

This European Standard applies to all cast metals, except copper-tin and/or copper-tin-lead alloy castings, where copper is the major constituent.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 473, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

EN 571-1, *Non destructive testing — Penetrant testing — Part 1: General principles*

EN ISO 3059, *Non-destructive testing — Penetrant testing and magnetic particle testing — Viewing conditions (ISO 3059:2001)*

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 condition. 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 1371-1:1997, Table 3 [1], 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 571-1. 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

Unless otherwise agreed, testing shall be performed by personnel, qualified in accordance with EN 473 or by a certification scheme which is considered to be equivalent.

4.3 Surface preparation

The surface to be inspected shall be clean, free from rust, sand, scale, moulding and mould coating residues, oil, grease, paint or any other contaminant which can interfere with a correct testing.

Shot blasting is not recommended prior to liquid penetrant testing, except for sand moulded castings. 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.

NOTE It is recommended that the assessment of surface finish is carried out using a visual cast-surface roughness comparator, see EN 1370.

4.4 Conditions of testing

The testing shall be carried out with the naked eye or at a maximum 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 (informative).

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. $L < 3 W$):
 - isolated (SP);
 - 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). Indications that are either:
 - linear: the distance between two indications is smaller than the length of the longest discontinuity in the alignment; or
 - 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, D and E for guidance only.

6 Classification of the indications and interpretation of results

In order to classify an indication of discontinuity, a frame measuring 105 mm × 148 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.

NOTE 1 105 mm × 148 mm corresponds to ISO format A6. If the casting dimensions in total are smaller than 105 mm × 148 mm, then the indicating criteria should 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 105 mm × 148 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.

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 2 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 3 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 571-1.

8 Post-examination cleaning procedures

Unless otherwise specified in the order, post-examination cleaning procedures shall be carried out in accordance with EN 571-1.

9 Test report

The test report shall be in accordance with EN 571-1. A model of a trilingual liquid penetrant test report is shown in Annex F.

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

Characteristic	Severity levels							
	SP 01 ^a CP 01 ^a	SP 02 CP 02	SP 03 CP 03	SP 1 CP 1	SP 2 CP 2	SP 3 CP 3	SP 4	SP 5
Direct visual testing	Magnifying glass or eyes	Eyes						
Magnification for observation of penetrant indication	≤ 3	1						
Length of smallest indication to be considered in mm	0,3	0,5	1	1,5	2	3	5	5
Maximum number of non-linear indications allowed	5	6	7	8	8	12	20	32
Maximum size of discontinuity indication A, B, C and F allowed in mm								
— isolated indications SP	1	1	1,5	3	6	9	14	21
See Annex C - Figure				C.1	C.2	C.3	C.4	C.5
— clustered indications CP (for aluminium alloys only, with a maximum of 2 per area)	3	4	6	10	16	25	—	—
See Annex D - Figure				D.1	D.2	D.3		
NOTE 1	Only values expressed in this table are valid. Reference figures are for information only (see Annexes C and D).							
NOTE 2	The sensitivity can differ, depending on the method of penetrant testing selected.							
NOTE 3	The penetrant indications may grow over a period of time and this should be taken into account.							
^a	Severity level to be reserved for particular uses.							

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

Characteristics	Severity levels															
	LP 001 AP 001	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 AP 7							
Testing means	Magnifying glass or eyes	Eyes														
Magnification for observation of penetrant indication	≤ 3	1														
Length of smallest indication to be considered (mm)	No indication allowed	0,3	1,5	2	3	5	5	5	5	5						
Arrangement of indications ^a , isolated (I) or cumulative (C)	I or C	I	C	I	C	I	C	I	C	I	C					
Maximum length of linear (LP) and aligned (AP) indication allowed (mm)	No indication allowed	1	2	4	4	6	6	10	10	18	18	25	25	45	45	70
See Annex E - Figure		E.1	E.2	E.3	E.4	E.5	E.6	E.7								
NOTE 1	Only values expressed in this table are valid. Reference figures are for information only (see Annex E).															
NOTE 2	The severity levels 001, 01 and 1 are difficult to achieve and should be specified with caution.															
NOTE 3	The sensitivity can differ, depending on the method of penetrant testing selected.															
NOTE 4	The penetrant indications may grow over a period of time and this should be taken into account.															
^a	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 [3]	SCRATA [4]
0,3	2/0S1 – 1/0S1 1 S2 – 2 S2	–
1,5	1 S1 - 2 S1 3 S2 – 4 S2	A 1 - A 2 -
2	2 S1 – 3 S1 4 S2 – 5 S2	A 2 - A 3 H 1 ^b
≥ 3	non specified (rough surface)	A 3 – A 4 H 3 - H4 - H5

^a See EN 1370 [2].
^b Corresponds to 5 S2.

Annex A
(normative)

Conversion of severity levels of linear (LP) and aligned (AP) indications

The Table A.1 gives the conversion from the severity levels specified in EN 1371-1:1997, Table 3 [1] to severity levels specified in Table 2 of the present edition.

This Table A.1 only applies to drawings and specifications based on EN 1371-1:1997. This Table A.1 is prepared as a tool for adaptation of specifications and/or drawings based on the EN 1371-1:1997.

Table A.1 — Conversion between the severity levels

Severity levels of the present edition	Severity levels of EN 1371-1:1997		
	Section thickness type a $t \leq 16 \text{ mm}$	Section thickness type b $16 \text{ mm} < t \leq 50 \text{ mm}$	Section thickness type c $t > 50 \text{ mm}$
LP 001 AP 001	LP 001 AP 001	LP 001 AP 001	LP 001 AP 001
LP 01 AP 01	LP 01 AP 01	LP 01 AP 01	LP 01 AP 01
LP 1 AP 1	LP 1 AP 1		
LP 2 AP 2	LP 2 AP 2	LP 1 AP 1	
LP 3 AP 3	LP 3 AP 3	LP 2 AP 2	LP 1 AP 1
LP 4 AP 4	LP 4 AP 4	LP 3 AP 3	LP 2 AP 2
LP 5 AP 5	LP 5 AP 5	LP 4 AP 4	LP 3 AP 3
LP 6 AP 6		LP 5 AP 5	LP 4 AP 4
LP 7 AP 7			LP 5 AP 5
NOTE	t indicates section thickness.		

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 isolated SP	clustered CP	linear LP	aligned 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 alumina ^a	J	—	—	X	X
Graphite flotation ^b	K	No image, but "background" indications			

^a For non-ferrous alloys only.

^b For cast iron only.

Annex C
(informative)

Reference figures – Non-linear isolated indications designated SP

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

These reference figures are valid for all cast alloys, except cast aluminium and magnesium alloys.

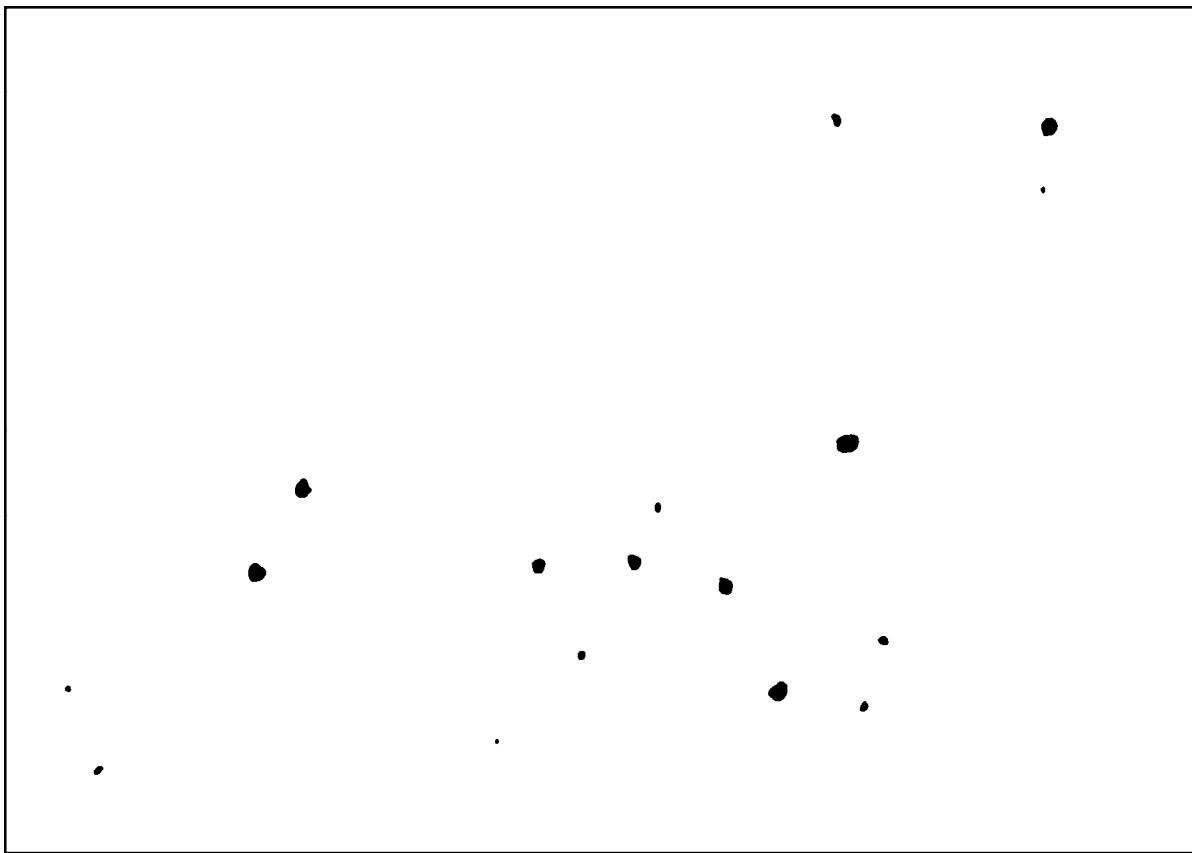


Figure C.1 — Severity level SP 1

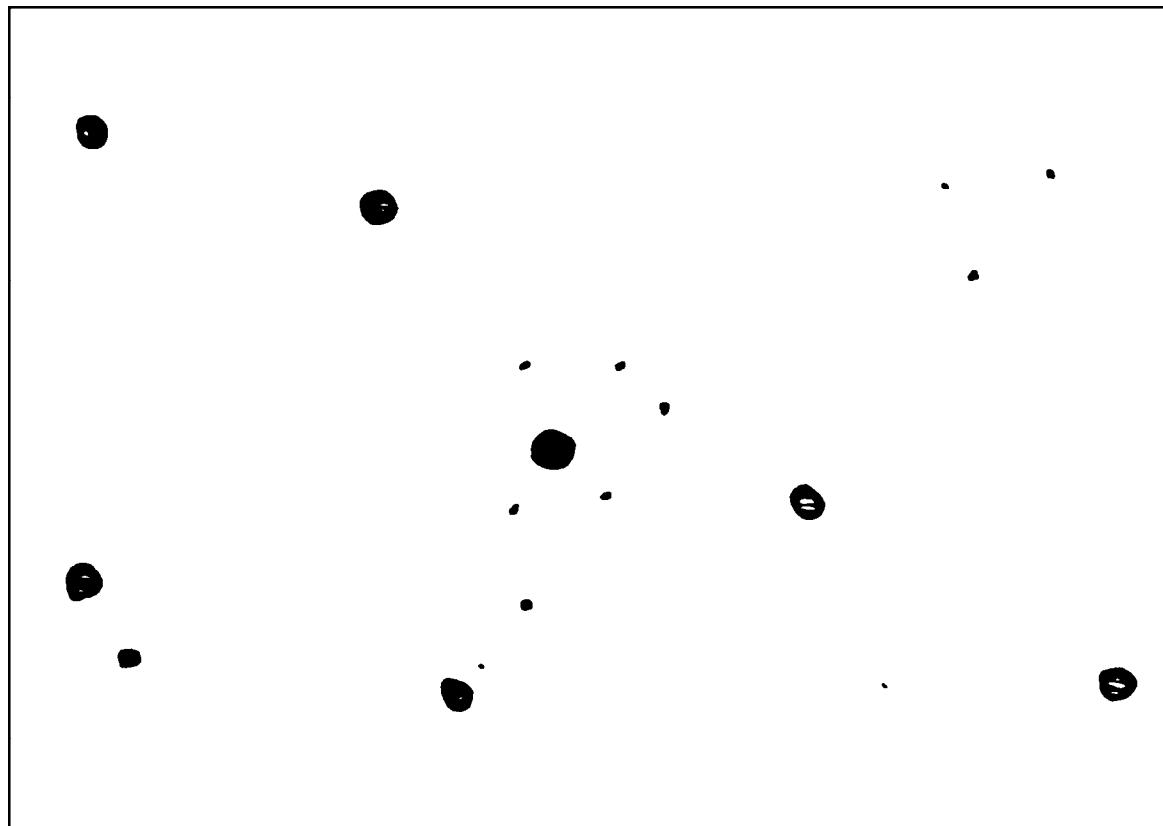


Figure C.2 — Severity level SP 2

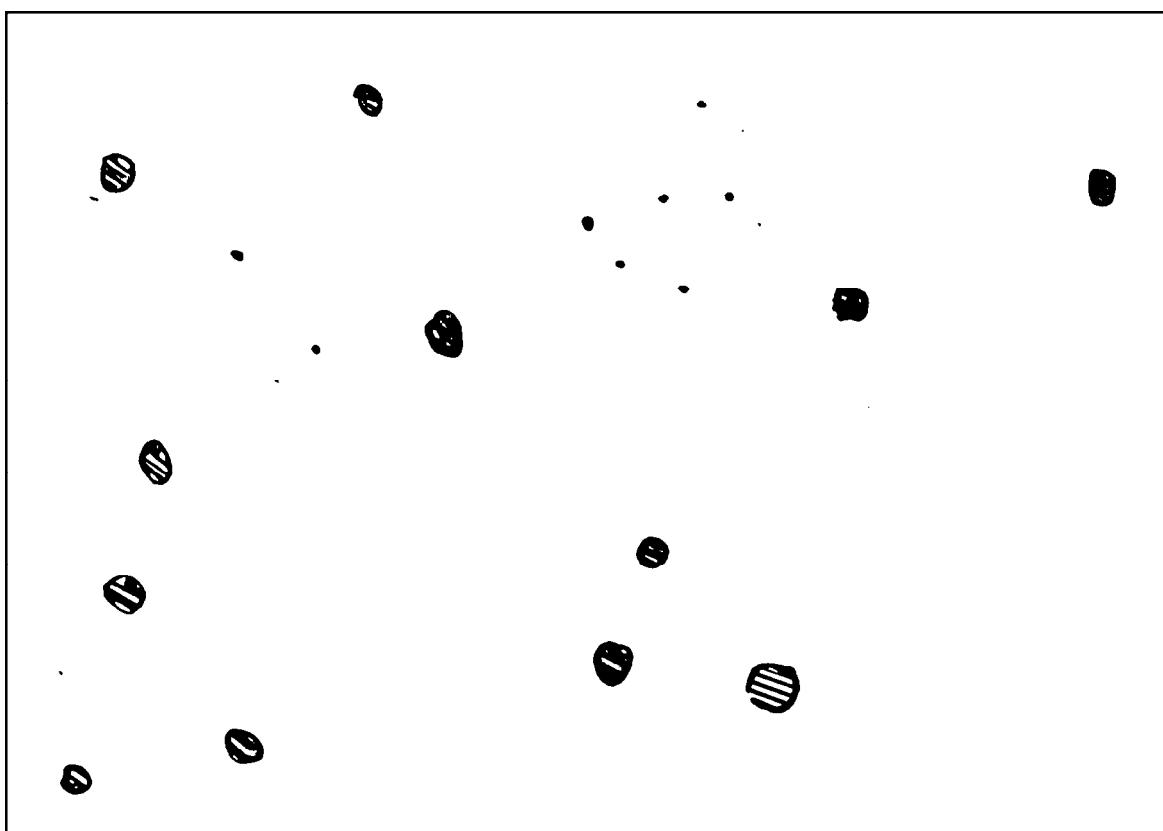


Figure C.3 — Severity level SP 3

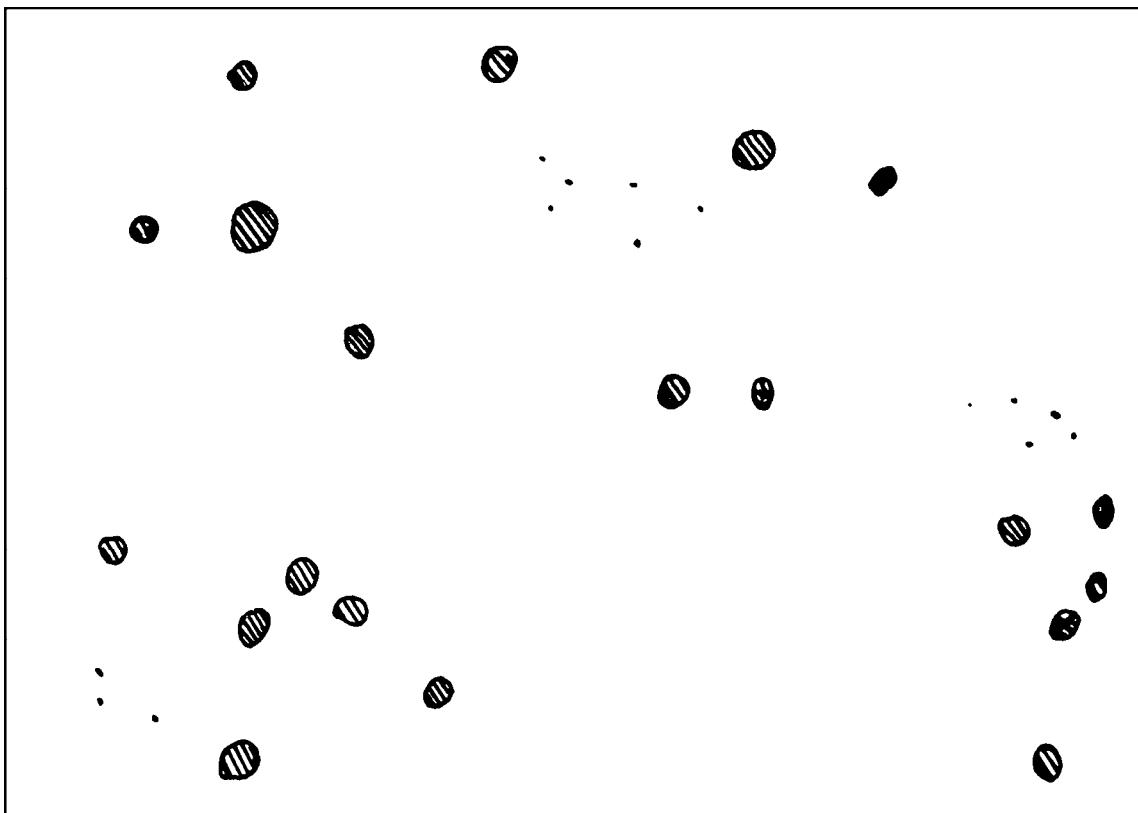


Figure C.4 — Severity level SP 4

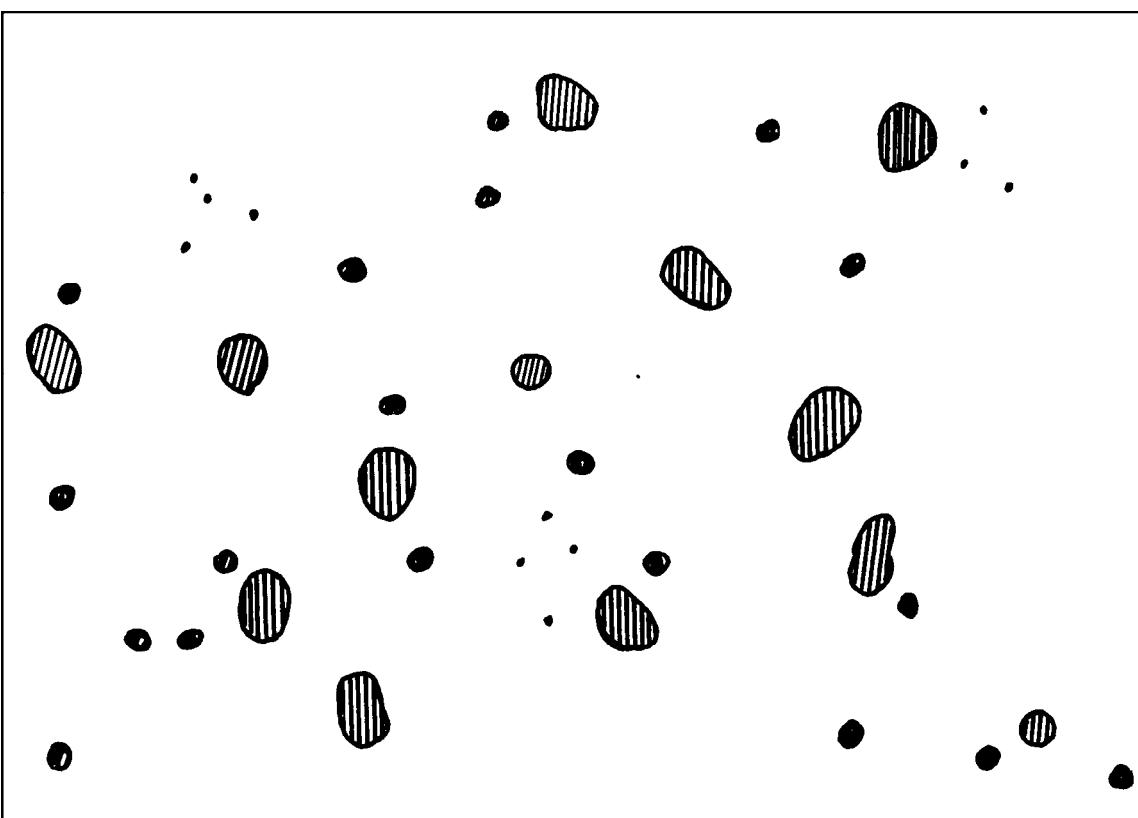


Figure C.5 — Severity level SP 5

Annex D
(informative)

Reference figures – Non-linear indications designated SP and CP

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

These reference figures are valid for aluminium and magnesium cast alloys.

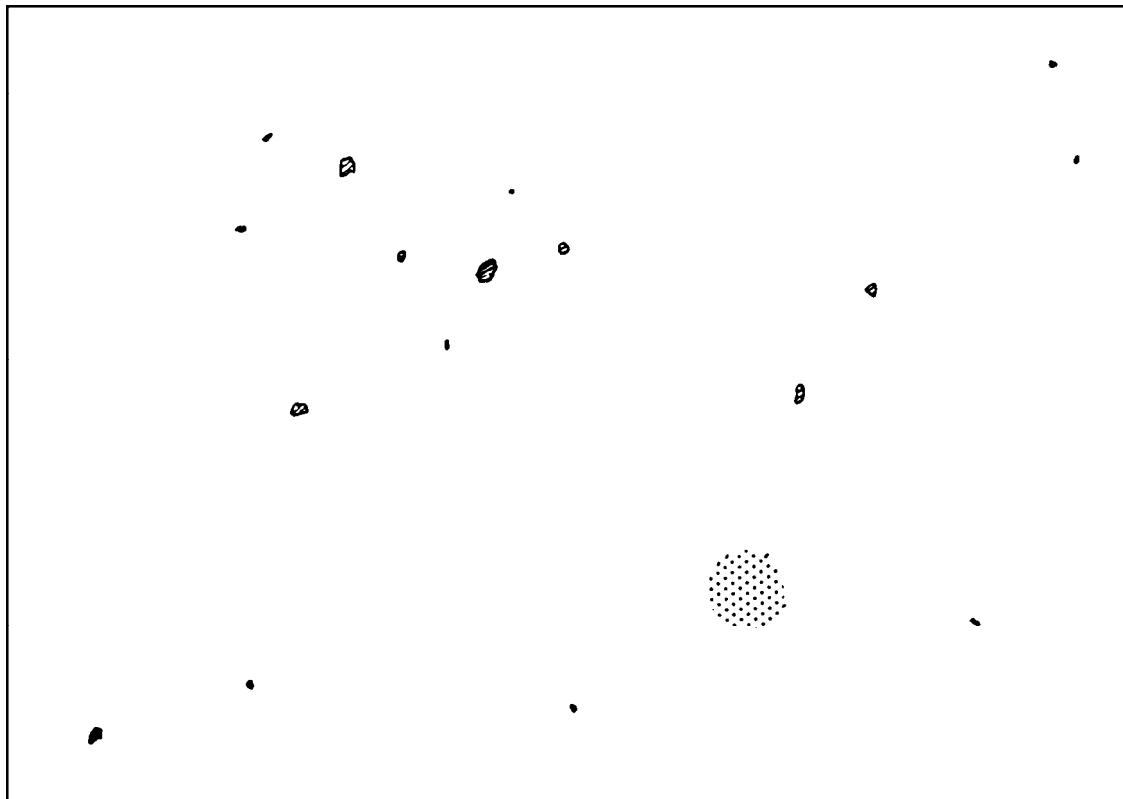


Figure D.1 — Severity level SP 1 – CP 1

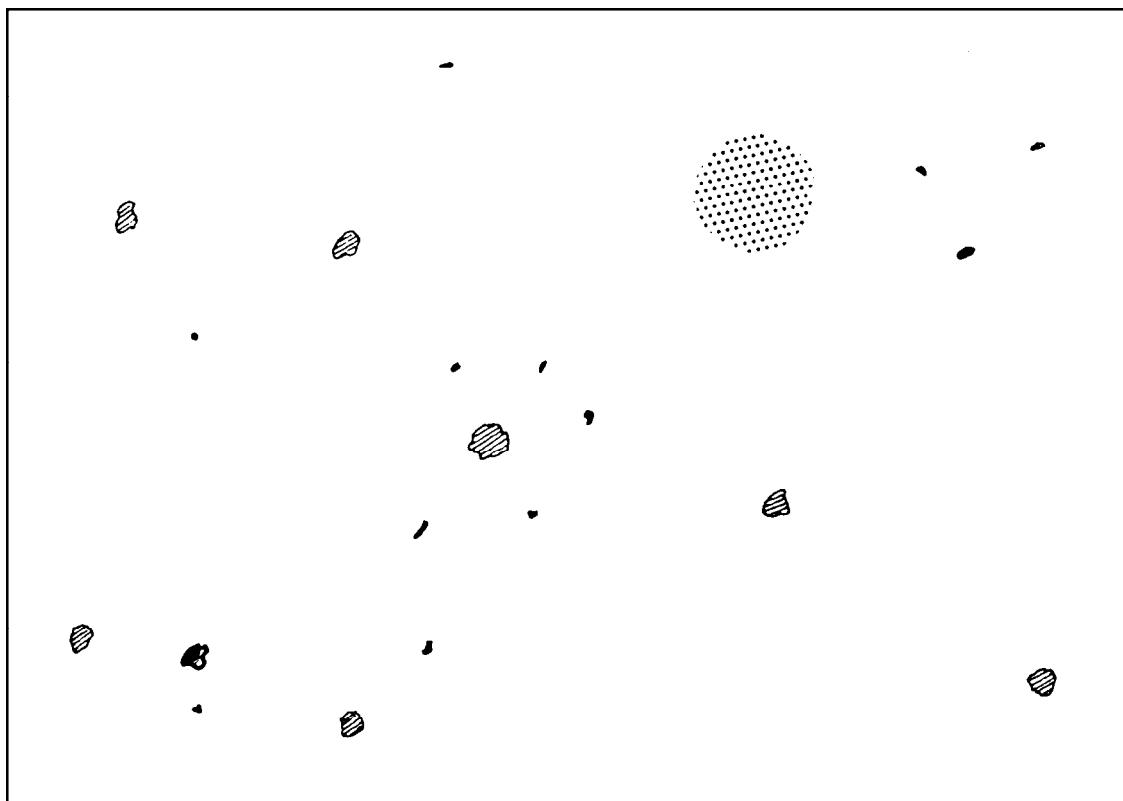


Figure D.2 — Severity level SP 2 – CP 2

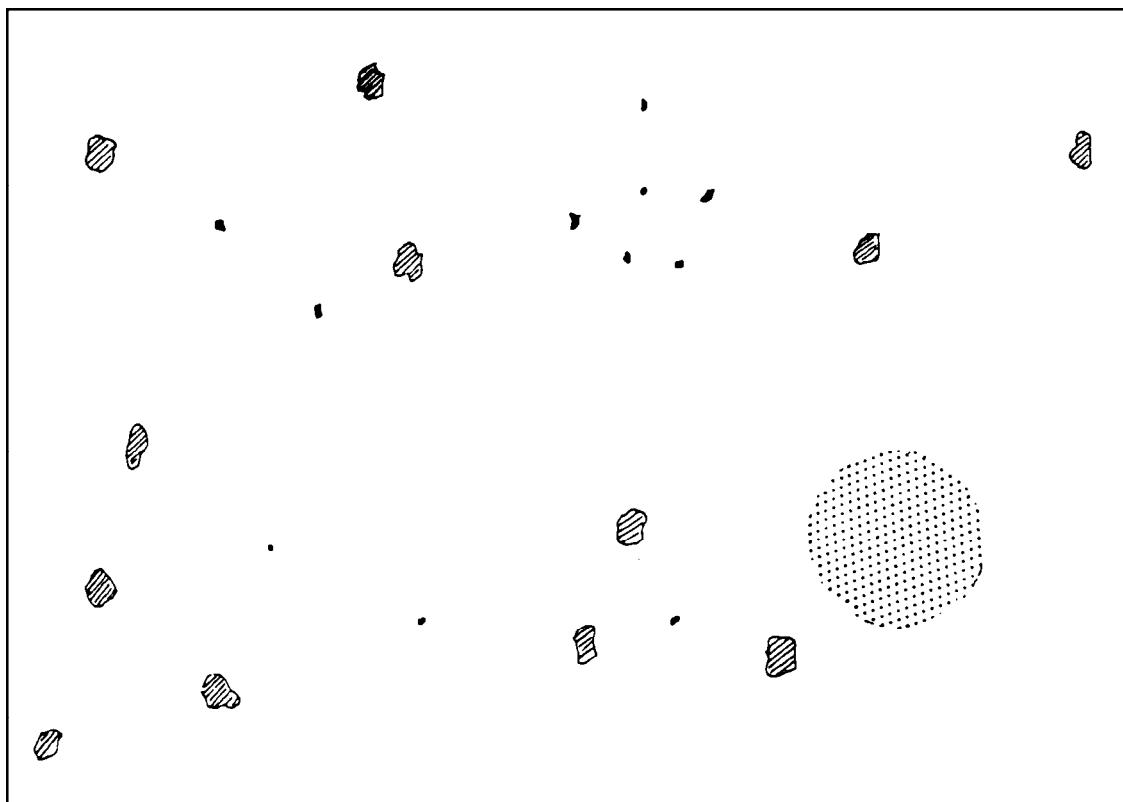


Figure D.3 — Severity level SP 3 – CP 3

Annex E
(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.

These reference figures are valid for all cast alloys.



Figure E.1 — Severity level LP 1 – AP 1



Figure E.2 — Severity level LP 2 – AP 2

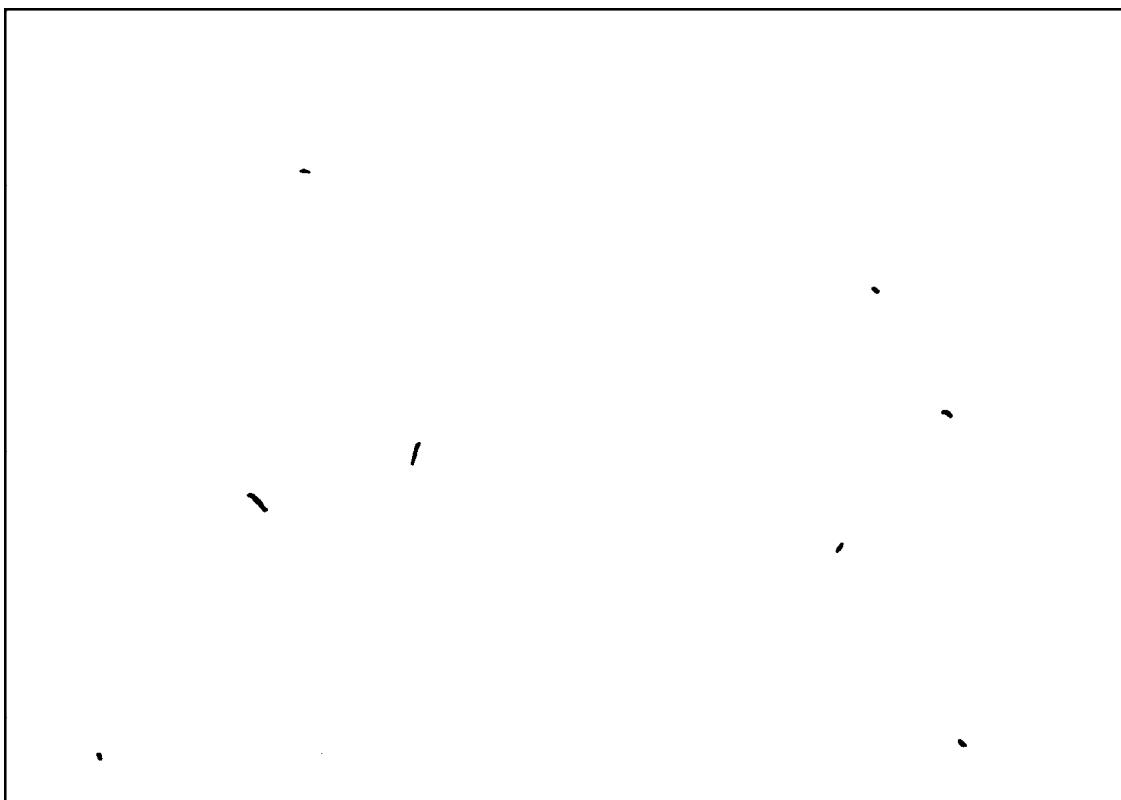


Figure E.3 — Severity level LP 3 – AP3



Figure E.4 — Severity level LP 4 – AP 4

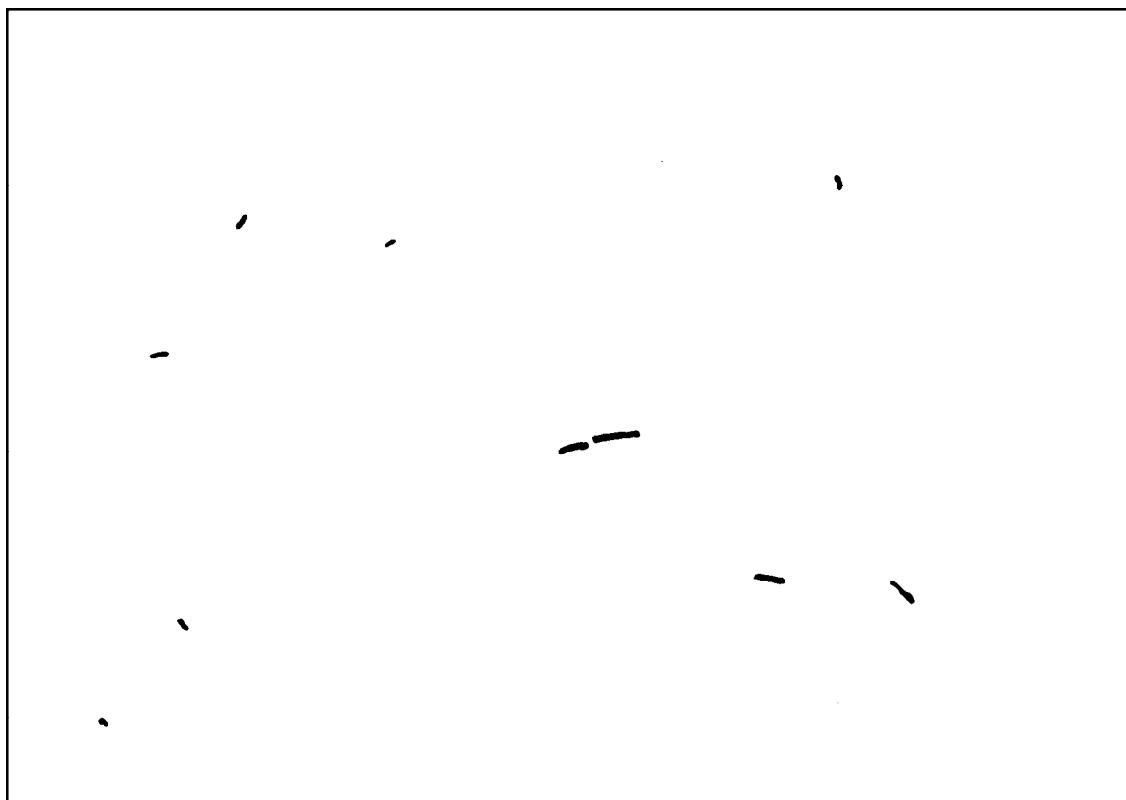


Figure E.5 — Severity level LP 5 – AP 5



Figure E.6 — Severity level LP 6 – AP 6



Figure E.7 — Severity level LP 7 – AP 7

Annex F (informative)

Model of a liquid penetrant test report

Model (continued)

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

(continued)

Model (concluded)

Non-conformance note – Fiche d'anomalie – Beanstandung

.....

.....

Continuation sheet – Annexe – Fortsetzungsblatt

yes – oui – ja

no – non – nein

Inspection authority – Organisme de contrôle – Abnahmegergesellschaft

.....

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 G (informative)

Significant technical changes between this European Standard and the previous edition

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

Clause/Paragraph/Table/Figure	Changes
5.3.2	Deletion of section thickness types (also in the figures of Annex E)
6	Deletion of Note 2
Table 1	Was Table 2
Table 2	Was Table 3 with modifications (two new severity levels added)
Table 3	Was Table 4
Annex A	New Annex giving the conversion from the severity levels specified in EN 1371-1:1997, Table 3 [1] to severity levels given in Table 2 of the present edition
Annex B	Was Table 1

NOTE The technical changes referred include the significant technical changes from the EN revised but this is not an exhaustive list of all modifications from the previous version.

Bibliography

- [1] EN 1371-1:1997, *Founding — Liquid penetrant inspection — Part 1: Sand, gravity die and low pressure die castings*
- [2] EN 1370, *Founding — Examination of surface condition*
- [3] 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 x 160 mm", available from Editions Techniques des Industries de la Fonderie, 44 avenue de la Division Leclerc, 92310 Sèvres, France.¹⁾
- [4] "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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