INTERNATIONAL STANDARD

ISO 4987

Second edition
2010-03-15

Steel castings — Liquid penetrant inspection

Pièces moulées en acier — Contrôle par ressuage

Reference number
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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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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 4987 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 11, *Steel castings*.

This second edition cancels and replaces the first edition (ISO 4987:1992), which has been technically revised.

Introduction

This International Standard complements the general principles of liquid penetrant inspection described in ISO 3452-1 for the additional requirements of the foundry industry.

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

Steel castings — Liquid penetrant inspection

1 Scope

This International Standard specifies a method for the liquid penetrant inspection of steel castings, whatever their grade and the casting procedure used to produce them.

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.

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

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

ISO 4990, *Steel castings — General technical delivery requirements*

ISO 9712, *Non-destructive testing — Qualification and certification of personnel*

3 Ordering information

Subject to agreement between the manufacturer and the purchaser, enquiries and purchase orders for castings requiring liquid penetrant inspection should include the following information:

— the qualification or certification of the operators who will carry out the inspection;

— the area of the casting to be inspected;

— the required surface finish of the areas to be inspected;

— a mention that inspection is to be carried out in accordance with ISO 3452-1;

— the type of discontinuity;

— the severity level;

— the frequency/number of castings to be inspected;

— the qualification level of the inspector carrying out the inspection.

The sensitivity can differ depending on the method of liquid penetrant inspection selected. Therefore, the severity levels required shall be selected as a function of the liquid penetrants used and the method agreed between the manufacturer and the purchaser.

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

4 Method of inspection

4.1 Operating mode

Inspection shall be carried out as specified in ISO 3452-1. 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

Inspection shall be performed by personnel qualified in accordance with ISO 9712 or by a certification scheme which is considered to be equivalent. The qualification level of the personnel shall be agreed between the manufacturer and purchaser by the time of the acceptance of the order.

4.3 Surface preparation

The surface to be inspected shall be clean and free from oil, grease, moulding and coating residues, or any other contaminant which could interfere with the correct implementation and interpretation of the penetrant-inspection test results. For small indications, it may be necessary to improve the surface. Some guidance for the surface is given in Annex A.

Surface treatment or cleaning techniques which may seal or close indications are to be avoided. Chemical etching may be used to ensure that the smallest relevant indication required can be evaluated.

The surface finish of the casting in the area to be tested shall have sufficient brightness and contrast of colour and an adequate shape for determining the required severity level.

Liquid penetrant inspection shall be performed on castings in the as-delivered condition. If sand blasting or shot blasting[1)] is required, 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.

4.4 Conditions of inspection

The inspection shall be carried out with the naked eye or at a maximum magnification of 3× and under viewing conditions in accordance with ISO 3059.

5 Acceptance criteria

5.1 Definition of liquid penetrant indications

5.1.1 General

The discontinuity indications revealed by the liquid penetrant inspection can have different shapes and sizes. The distinction between the discontinuity indications is made depending on the ratio of the length L of the indication to its width W, in the manner described in 5.1.2 and 5.1.3.

5.1.2 Non-linear indications (SP)

The indications are considered to be non-linear when the length L is smaller than three times the width W. Indications are considered to be aligned when the distance between non-linear indications is less than 2 mm and

1) Shot blasting is not recommended prior to liquid penetrant testing.

at least three indications are aligned. An alignment of indications is considered to be a unique indication and its length is equal to the overall length L of the alignment.

5.1.3 Linear indication (LP)

5.1.3.1 The indications are considered to be linear when the length L is greater than or equal to three times the width W.

The symbol for linear indications is LP (L for linear and P for liquid penetrant).

The lengths of the linear indications greater than the minimum length shall be added together and the result shall be compared to the “cumulative” length specified in Table 2.

5.1.3.2 Indications are considered to be linear when the distance between two indications is smaller than the length L of the longest indication. An alignment of indications is considered to be a unique indication and its length is equal to the overall length L of the alignment.

5.2 Severity levels

5.2.1 General

The severity levels are designed as a reference scale and are defined depending on the types of indications.

5.2.2 Non-linear indications

For the non-linear indications, the severity levels (see Table 1) are defined by

— the length (largest dimension) L_1 of the smallest indication to be taken into account, and

— the maximum length L_2 of the indications.

5.2.3 Linear indications

5.2.3.1 General

For the linear indications, the severity levels (see Table 2) are defined by

— the length (largest dimension) L_1 of the smallest indication to be taken into account, and

— the maximum length L_2 of the linear indications;

— the sum of the lengths of the linear indications exceeding the length L_1 in the frame measuring 105 mm $\times$ 148 mm.

5.2.3.2 Section thickness type

Three section thickness types are specified (see Table 2):

— a: $t \leqslant$ 16 mm;

— b: 16 mm $< t \leqslant$ 50 mm;

— c: $t >$ 50 mm;

where t is the section thickness.

5.2.4 Selection of the severity level

The severity levels shall be selected from Tables 1 and/or 2 in conjunction with, if necessary, the reference figures given in Annexes B and C. The reference figures are drawn to a scale of 1:1 and are given as examples. The largest non-relevant indication is shown in a 26 mm × 37 mm frame corresponding to the ISO format A10.

Table 1 and Annex B correspond to non-linear (SP) indications (isolated).

Table 2 and Annex C correspond to linear (LP) indications[2)].

The severity levels cannot be considered in the same progression from Table 1 to Table 2. They should not be considered equivalent as regards inspection severity. The severity criteria and the severity levels can differ from one part of a casting to another.

5.2.5 Designation of severity levels

The requirements in the order or in the specifications shall conform to the terminology used in this International Standard.

Examples of correct terminology are given below:

— non-linear indications, level 2:SP 2 (see 5.2.2);

— linear indications, level 5:LP 5_c (see 5.2.3).

6 Classification of the indications and interpretation of results

6.1 Classification of the indications using Tables 1 and 2

6.1.1 General

In order to classify a discontinuity indication, it is necessary to place a 105 mm × 148 mm frame in the most unfavourable location, i.e. showing the greatest severity for discontinuities.

6.1.2 Non-linear indications

Only those indications with a length greater than L_1 shall be taken into account (see Table 1).

The length of these indications shall be measured.

The level of the SP indications shall be established using Table 1.

6.1.3 Linear indications

The length L of the isolated indications greater than the minimum length taken into account, defined by the required severity level, shall be measured. The sum of the indications included in the 105 mm × 148 mm frame shall be calculated.

The section thickness t at the inspection location shall be measured.

The level of the LP indications shall be established using Table 2.

2) It should be noted that several equivalent severity levels defined in Table 2 are represented by the same reference figure. In certain cases, the equivalence of the figure is only approximate because of slight differences in the parameters in Table 2.

The lengths of the linear indications greater than the minimum length shall be summated and the result shall be compared to the “cumulative” length specified in Table 2.

6.2 Interpretation of results

The casting shall be considered to conform with this International Standard when the observed severity level is equal to or better than that specified in the order. The qualification level of the personnel shall be agreed between the manufacturer and purchaser by the time of acceptance of the order. If, for any indication type, the observed severity level is worse than that specified in the order, the casting shall be considered not to conform with this International Standard.

NOTE Non-linear as well as linear indications can appear simultaneously on the same part of the casting.

7 Retesting

Retesting shall be in accordance ISO 3452-1.

8 Post-examination cleaning procedures

Post-examination cleaning procedures shall be in accordance with ISO 3452-1.

9 Inspection documentation

When an inspection document is specified in the enquiry and the order, it shall contain at least the following information:

— information on the manufacturer;

— information on the purchaser (including the order number);

— the casting designation;

— the date and place of inspection;

— the traceability identification;

and also, as applicable, any of the following:

— a reference to this International Standard for the acceptance criteria;

— the position of the inspection stage in the manufacturing process;

— the surface finish;

— the inspection method;

— the equipment used;

— the testing materials used;

— the criteria required in accordance with this International Standard;

— the reference to the specification;

— the results (description and location);

— the cartography of the significant indications;

— the decision taken after the interpretation of results;

— the elements required in ISO 4990 [type of document, signature(s) of the authorized persons according to the type of document];

— the name and the signature of the non-destructive testing operator and his certification or qualification.

A model of a bilingual inspection document is shown in Annex D.

Table 1 — Severity levels for liquid penetrant inspection — Non-linear (SP) indications (isolated)

Characteristic	Severity levels						
	SP 001	SP 01	SP 1	SP 2	SP 3	SP 4	SP 5
Inspection means	magnifying glass or eye		eye				
Magnification for observation of penetrant indication	$\leqslant 3$		1				
Length L_1 of the smallest indication to be considered, in millimetres	0,3	0,5	1,5	2	3	5	5
Maximum number of non-linear indications allowed	5	6	8	8	12	20	32
Maximum individual length L_2 allowed, in millimetres	1	2	3[a]	6[a]	9[a]	14[a]	21[a]

[a] A maximum number of two indications of the designated dimension are permitted.

Table 2 — Severity levels for liquid penetrant inspection — Linear (LP) indications

Characteristic		Severity levels											
		LP 001	LP 01	LP 1		LP 2		LP 3		LP 4		LP 5	
Inspection means		magnifying glass or eye		eye									
Magnification for observation of penetrant indication		$\leqslant 3$		1									
Length L_1 of smallest indication to be considered, in millimetres		0,3		1,5		2		3		5		5	
Acceptable indications[a] Individual (I) or total (T) length		I or T		I	T	I	T	I	T	I	T	I	T
Maximum length L_2 of linear (LP) indications allowed depending on the section thickness t, in millimetres[b]	section thickness type a $t \leqslant 16$ mm	0	1	2	4	4	6	6	10	10	18	18	25
	section thickness type b 16 mm $< t \leqslant$ 50 mm	0	1	3	6	6	12	9	18	18	27	27	40
	section thickness type c $t >$ 50 mm	0	2	5	10	10	20	15	30	30	45	45	70

[a] A maximum number of two indications of the designated maximum dimension are permitted.

[b] No functional relationship exists between each type of section thickness and maximum crack length, relative to a fracture-mechanics study. However, this table is a useful guide where no relevant fracture-mechanics parameters currently exist.

Annex A
(informative)

Recommended surface finish for liquid penetrant inspection

Table A.1 — Recommended surface finish for liquid penetrant inspection

Dimension of smallest indication mm	Visual/tactile comparators[a]	
	BNIF[b]	**SCRATA**[b]
0,3	2/0S1 - 1/0S1 1 S2 - 2 S2	—
1,5	1 S1 - 2 S1 3 S2 - 4 S2	A 1 H 1
2	2 S1 - 3 S1 4 S2 - 5 S2	A 2 H 2
$\geqslant$ 3	unspecified (rough surface)	A 3 - A 4 H 3

[a] Two visual/tactile comparators are currently used (see ISO 11971):

— *SCRATA comparators for the definition of surface quality of steel castings*, available from Castings Technology International, Advanced Manufacturing Park, Brunel Way, Rotherham, S60 5WG, United Kingdom;

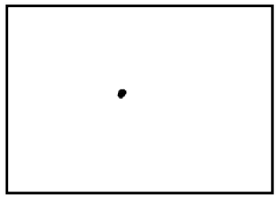
— *BNIF 359, Recommandation technique du Bureau de Normalisation des Industries de la Fonderie. Caractérisation d'états de surface des pièces moulées — Utilisation des échantillons types de 110 mm $\times$ 160 mm*, available from Éditions Techniques des Industries de la Fonderie, 44 avenue de la Division Leclerc, 92310 Sèvres, France.

[b] See Annex B.

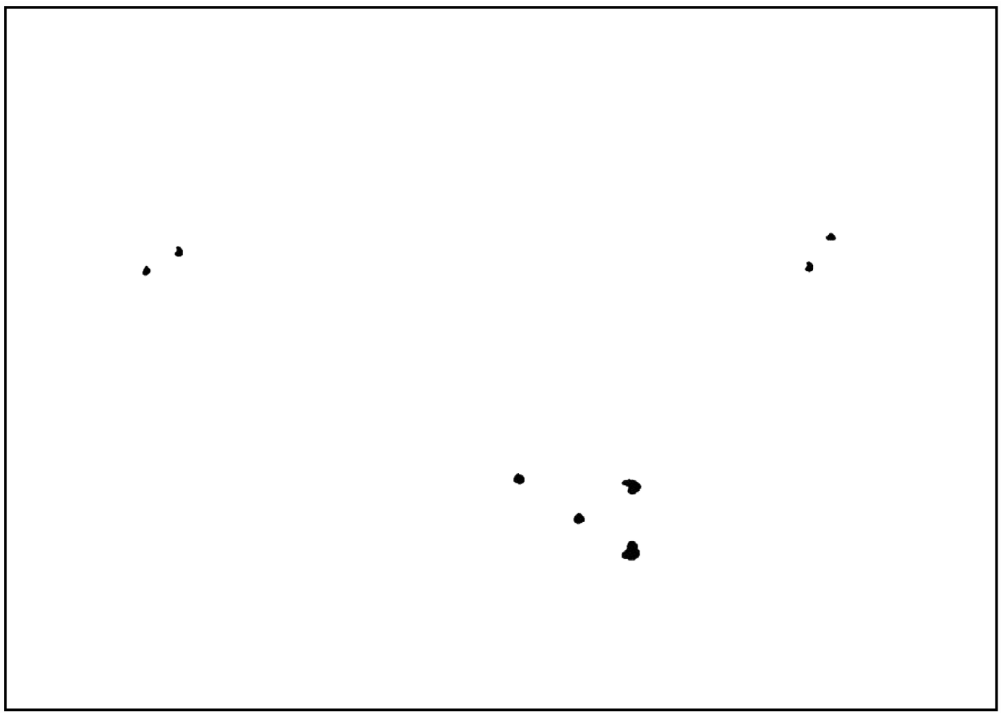
Annex B
(informative)

Reference figures — Non-linear isolated indications (SP)

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

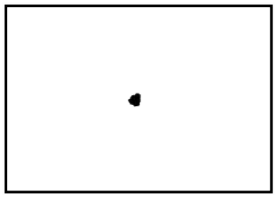


a) Maximum size allowed for a non-relevant indication for severity level SP 1

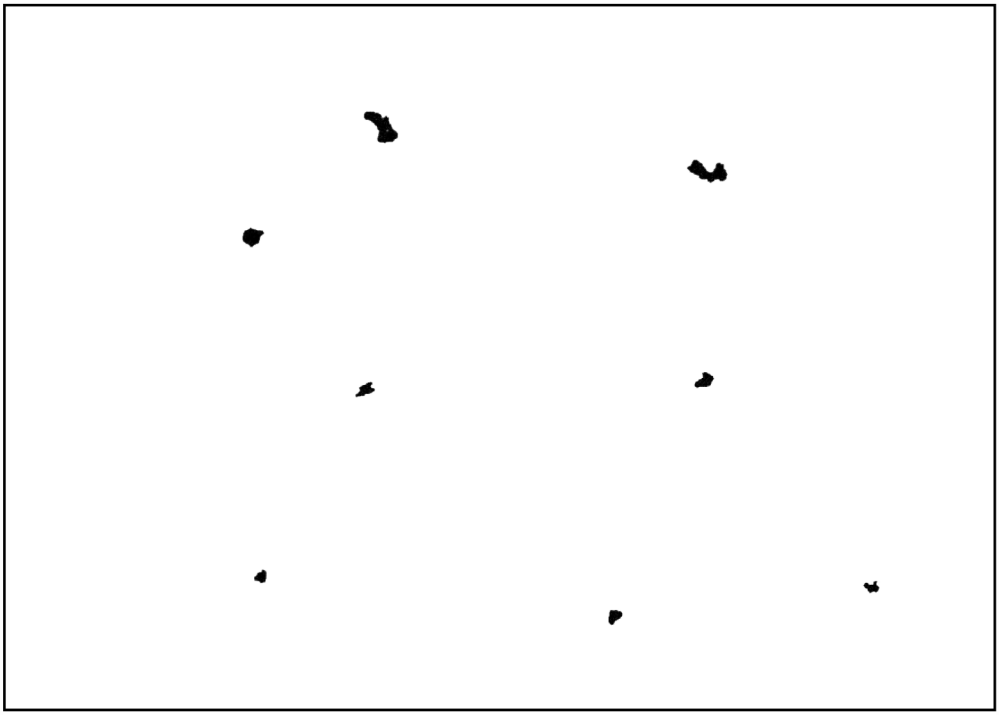


b) Severity level SP 1

Figure B.1 — Severity level SP 1

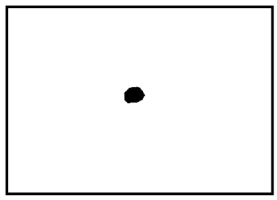


a) Maximum size allowed for a non-relevant indication for severity level SP 2

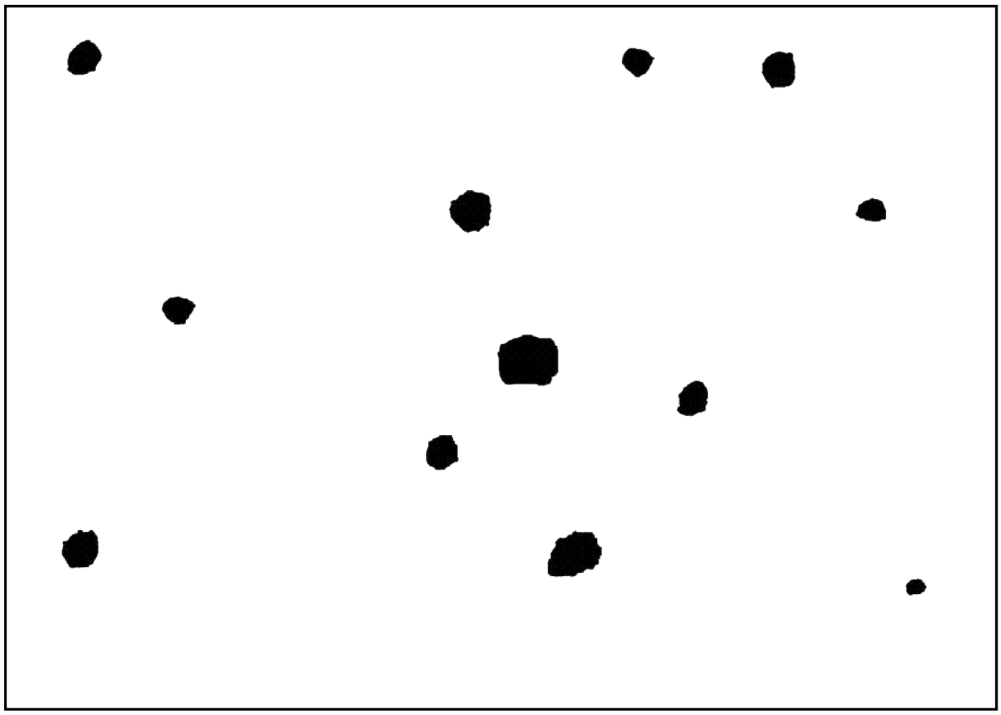


b) Severity level SP 2

Figure B.2 — Severity level SP 2

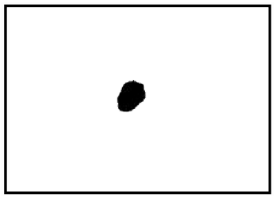


a) Maximum size allowed for a non-relevant indication for severity level SP 3

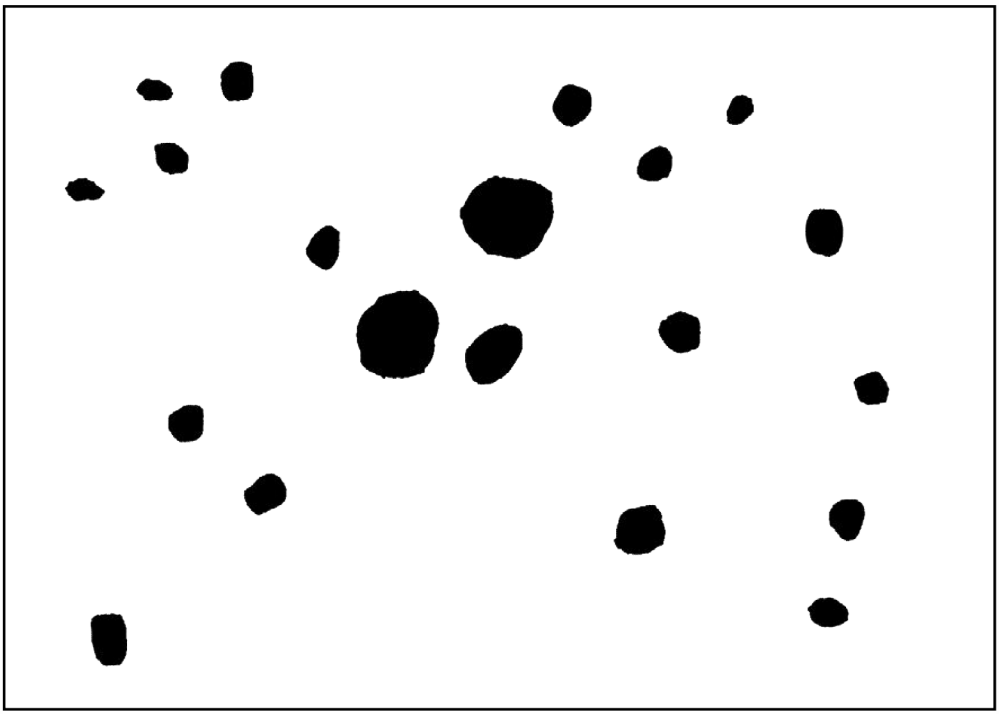


b) Severity level SP 3

Figure B.3 — Severity level SP 3

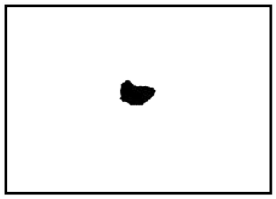


a) Maximum size allowed for a non-relevant indication for severity level SP 4

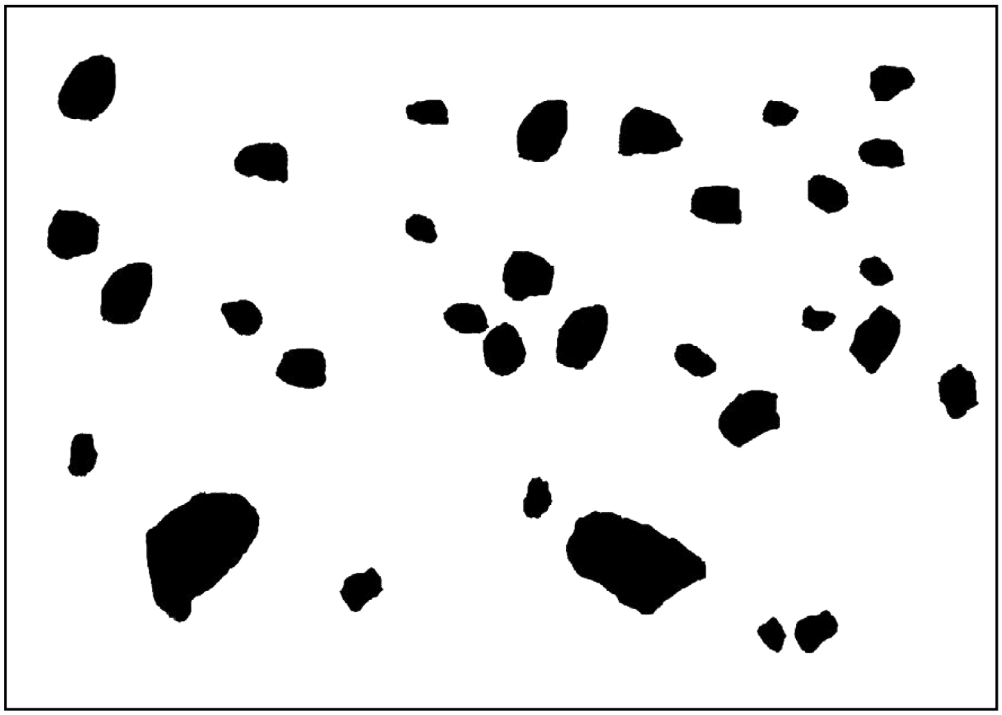


b) Severity level SP 4

Figure B.4 — Severity level SP 4



a) Maximum size allowed for a non-relevant indication for severity level SP 5



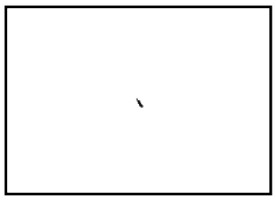
b) Severity level SP 5

Figure B.5 — Severity level SP 5

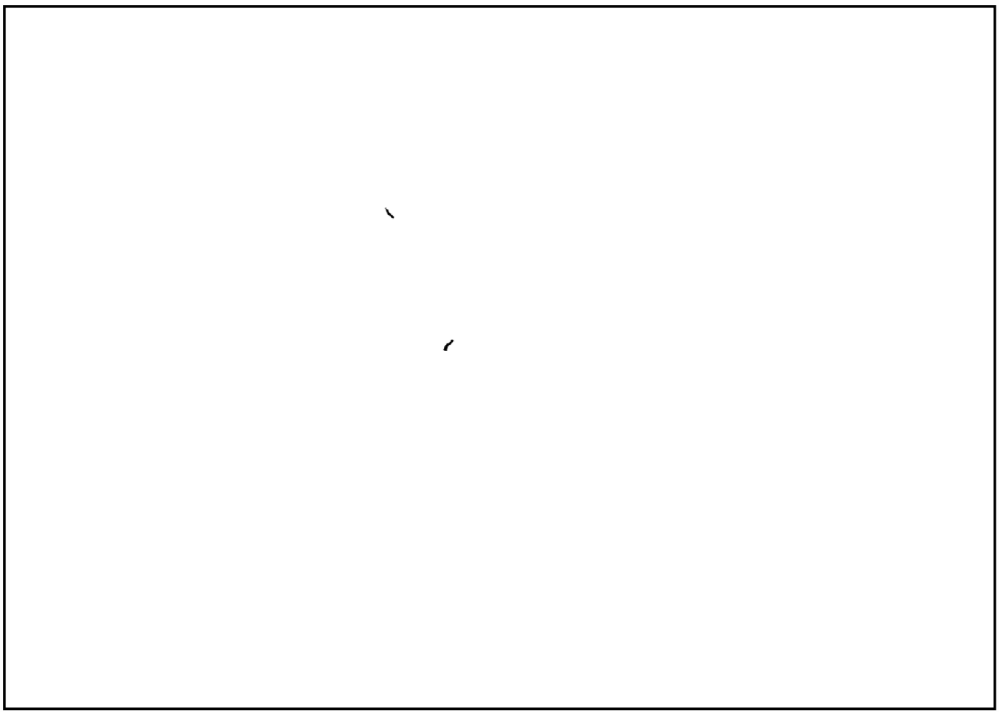
Annex C
(informative)

Reference figures — Linear indications (LP)

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

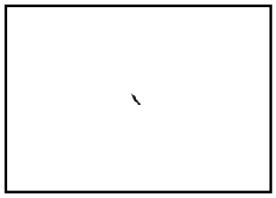


a) Maximum size allowed for a non-relevant indication for severity level LP 1a

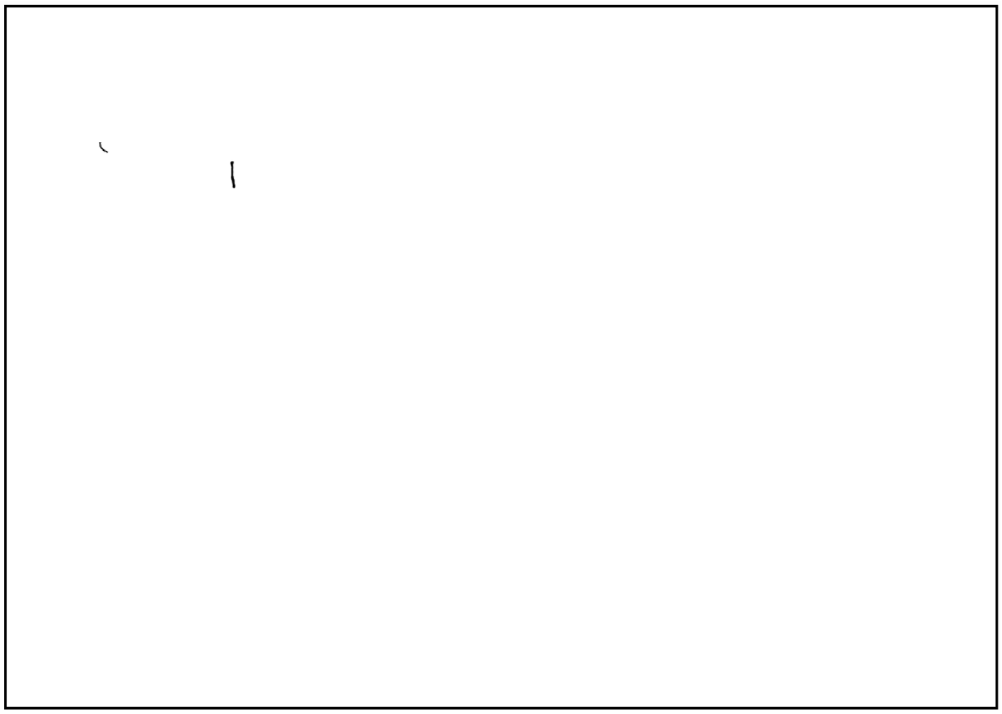


b) Severity level LP 1a

Figure C.1 — Severity level LP 1a

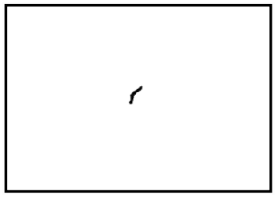


a) Maximum size allowed for a non-relevant indication for severity level LP2a

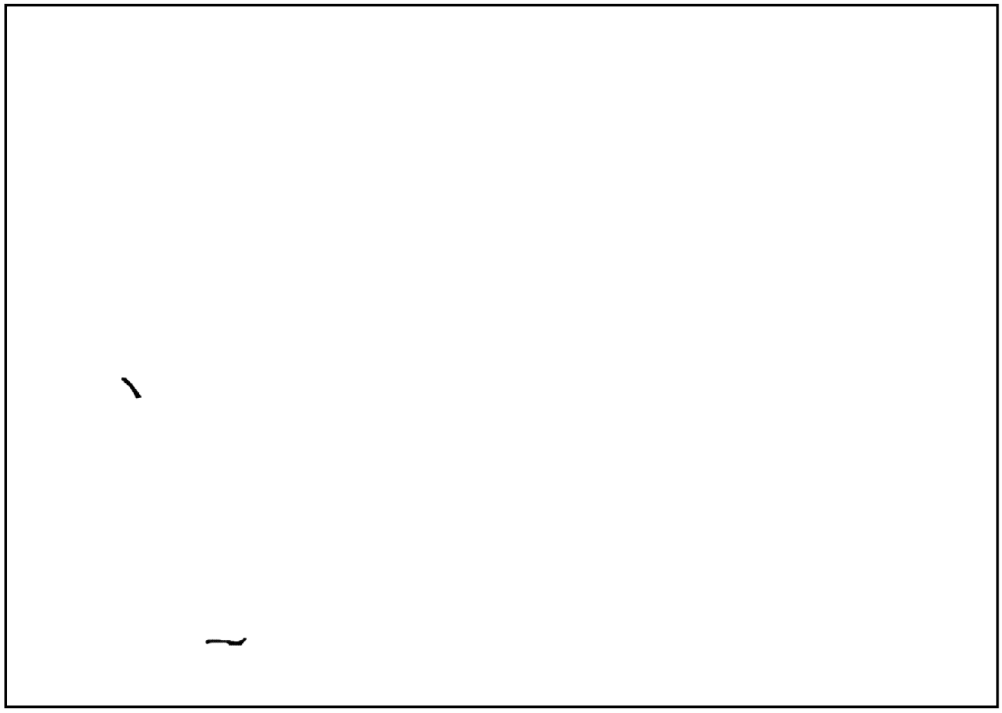


b) Severity level LP 2a

Figure C.2 — Severity level LP 2a

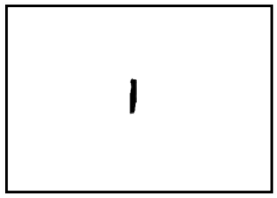


a) Maximum size allowed for a non-relevant indication for severity level LP 3a

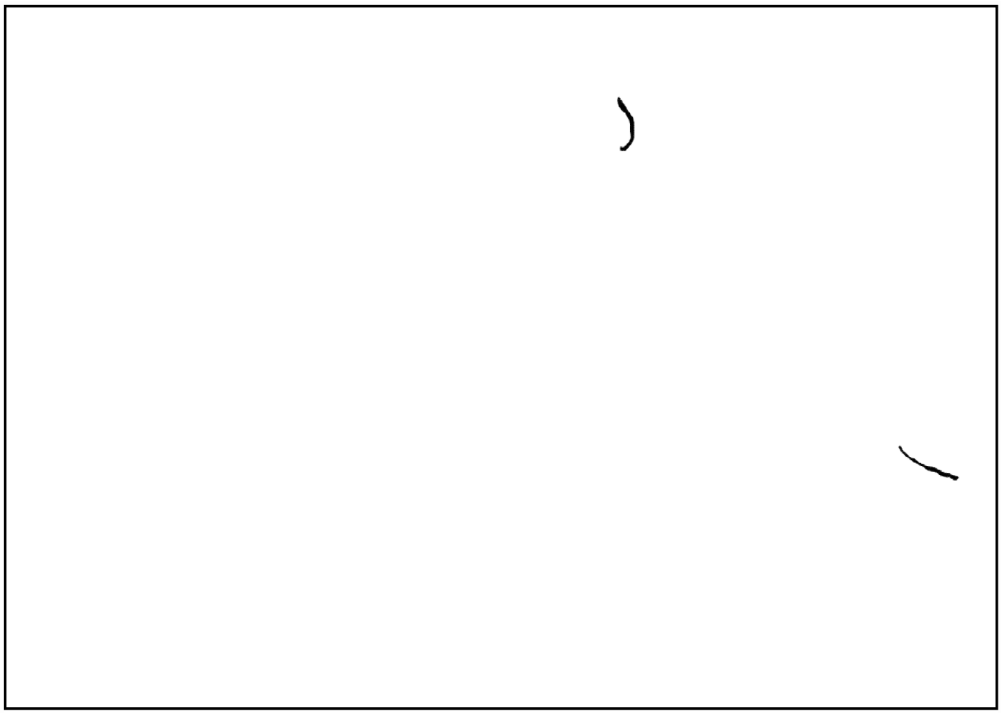


b) Severity level LP 3a

Figure C.3 — Severity level LP 3a

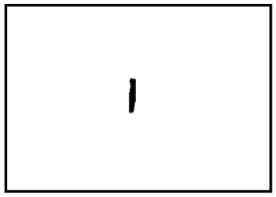


a) Maximum size allowed for a non-relevant indication for severity level LP 4a

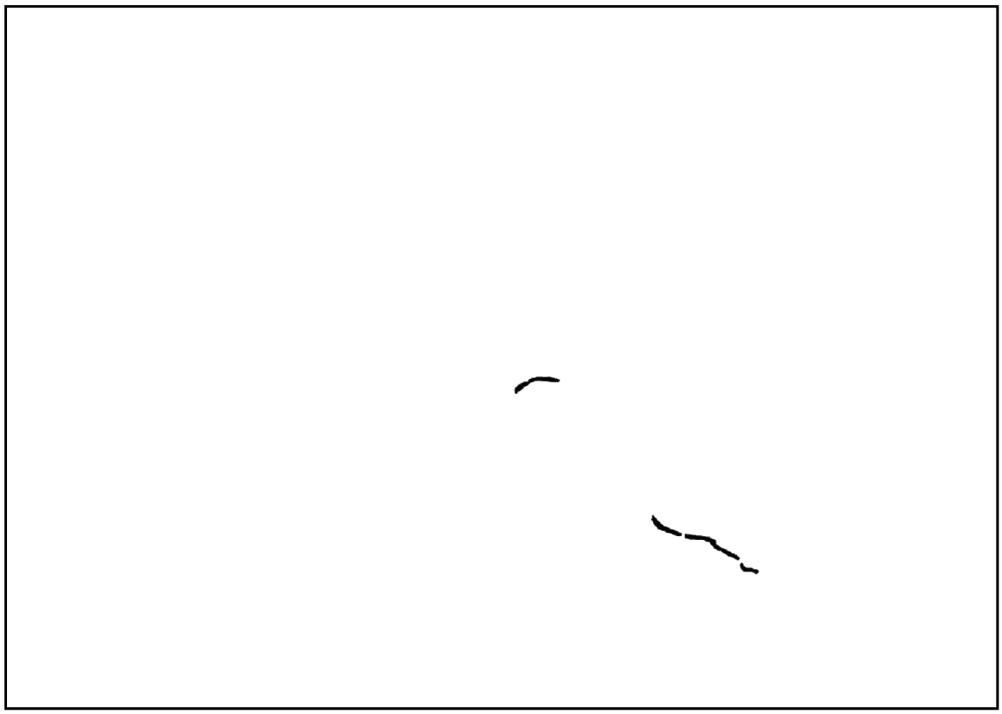


b) Severity level LP 4a

Figure C.4 — Severity level LP 4a

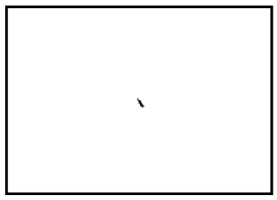


a) Maximum size allowed for a non-relevant indication for severity level LP 5a

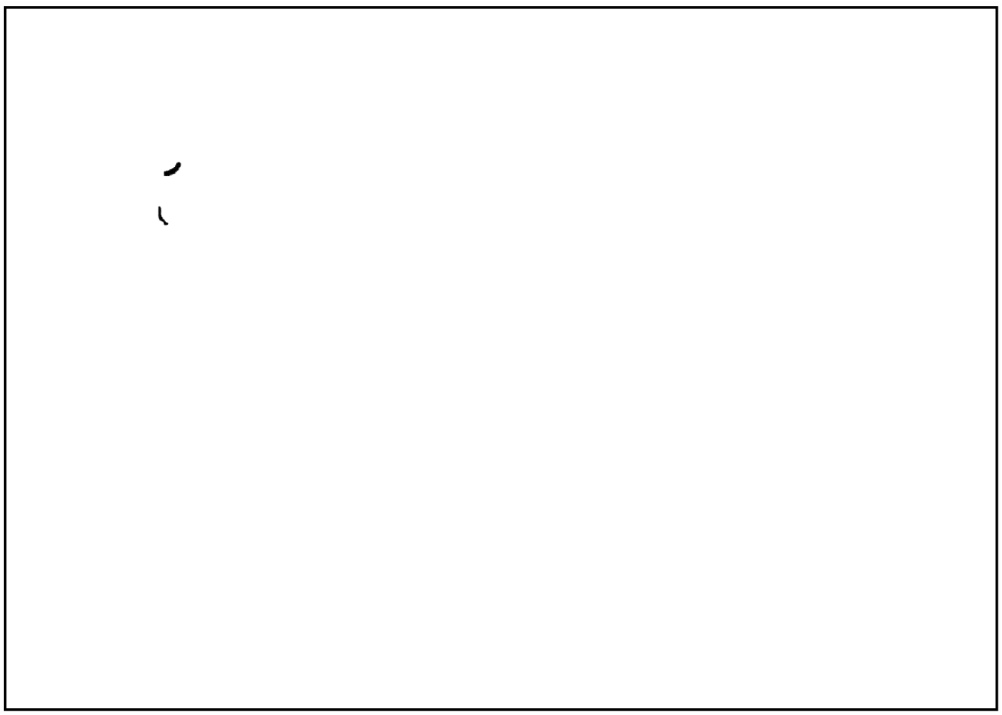


b) Severity level LP 5a

Figure C.5 — Severity level LP 5a

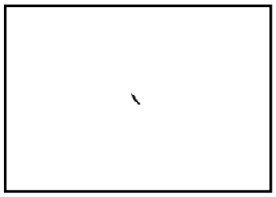


a) Maximum size allowed for a non-relevant indication for severity level LP 1b

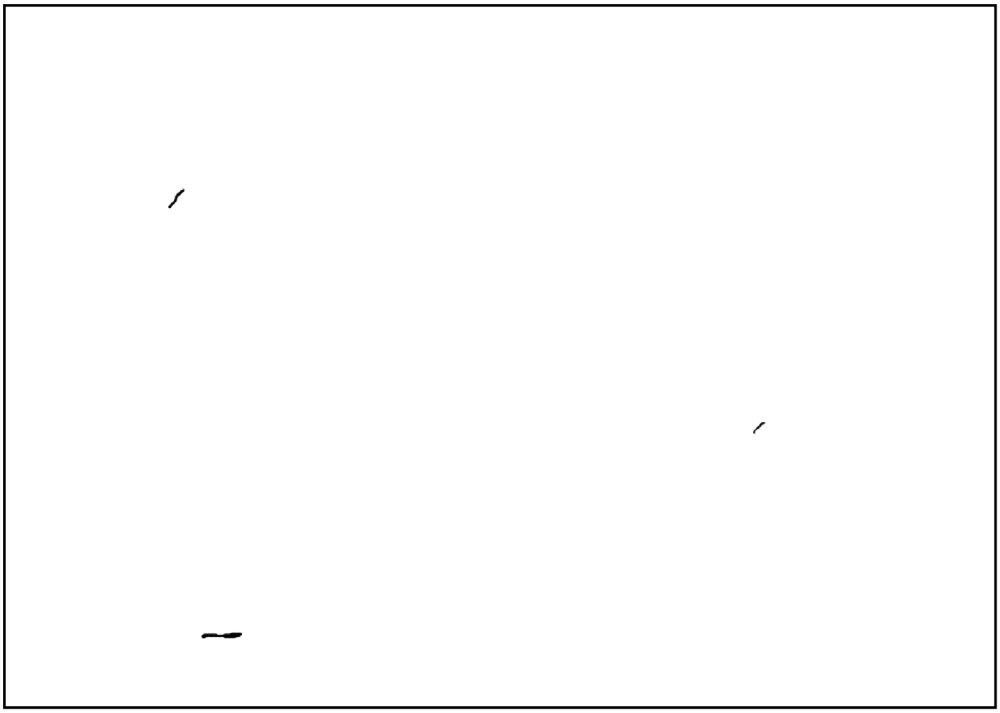


b) Severity level LP 1b

Figure C.6 — Severity level LP 1b



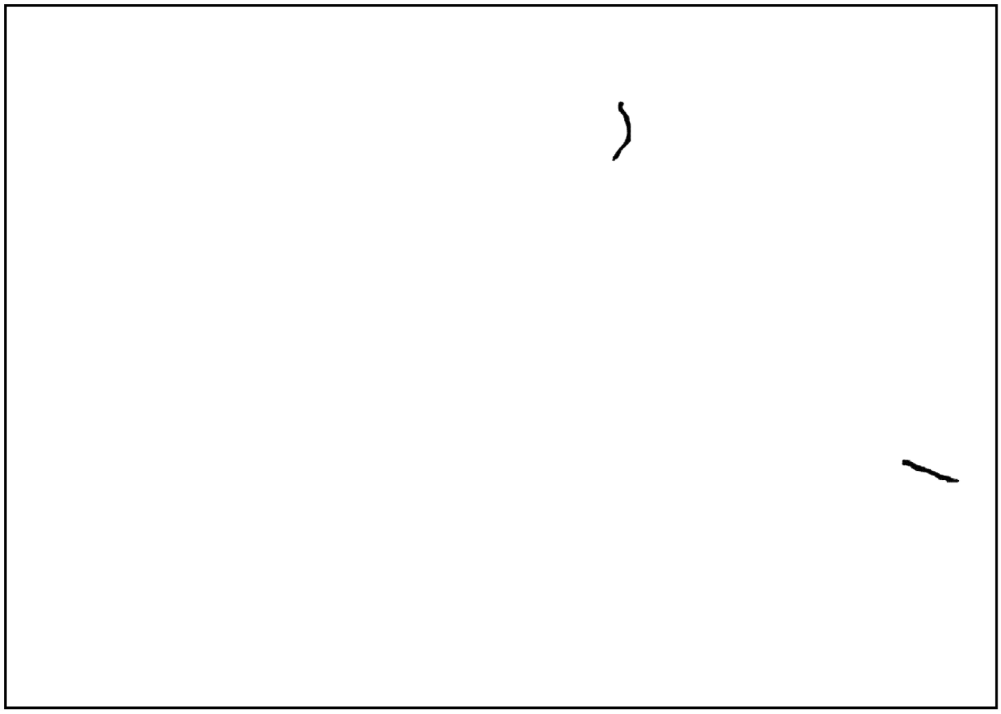
a) Maximum size allowed for a non-relevant indication for severity level LP 2b



b) Severity level LP 2b

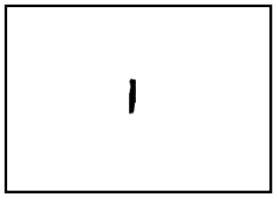
Figure C.7 — Severity level LP 2b

a) Maximum size allowed for a non-relevant indication for severity level LP 3b

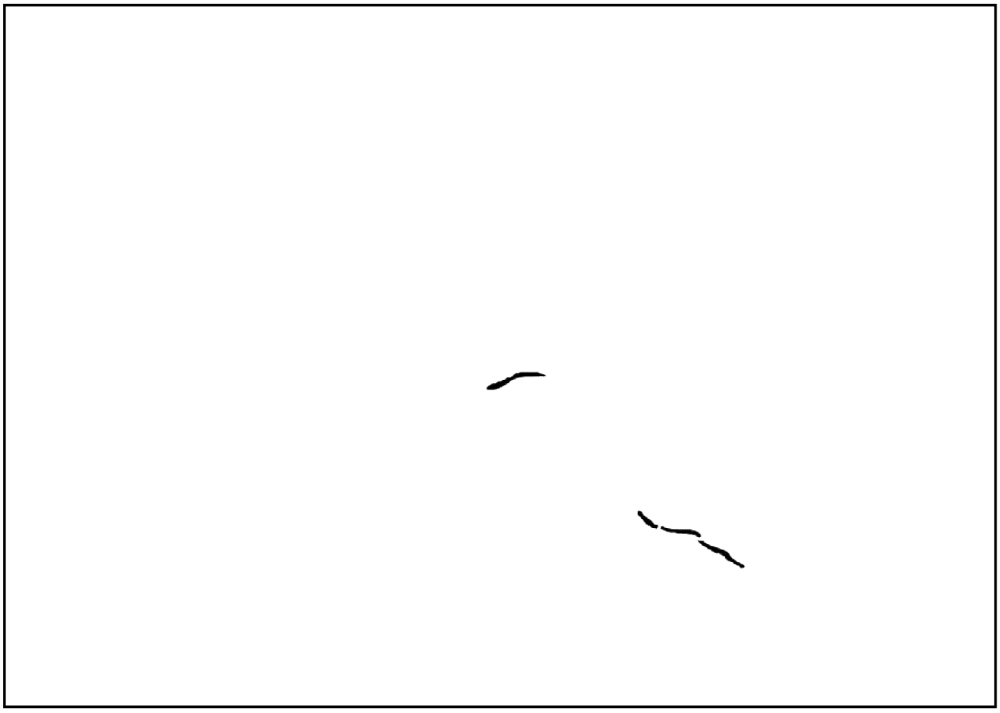


b) Severity level LP 3b

Figure C.8 — Severity level LP 3b

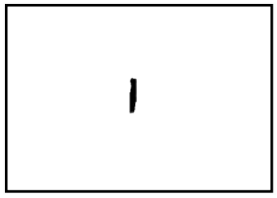


a) Maximum size allowed for a non-relevant indication for severity level LP 4b

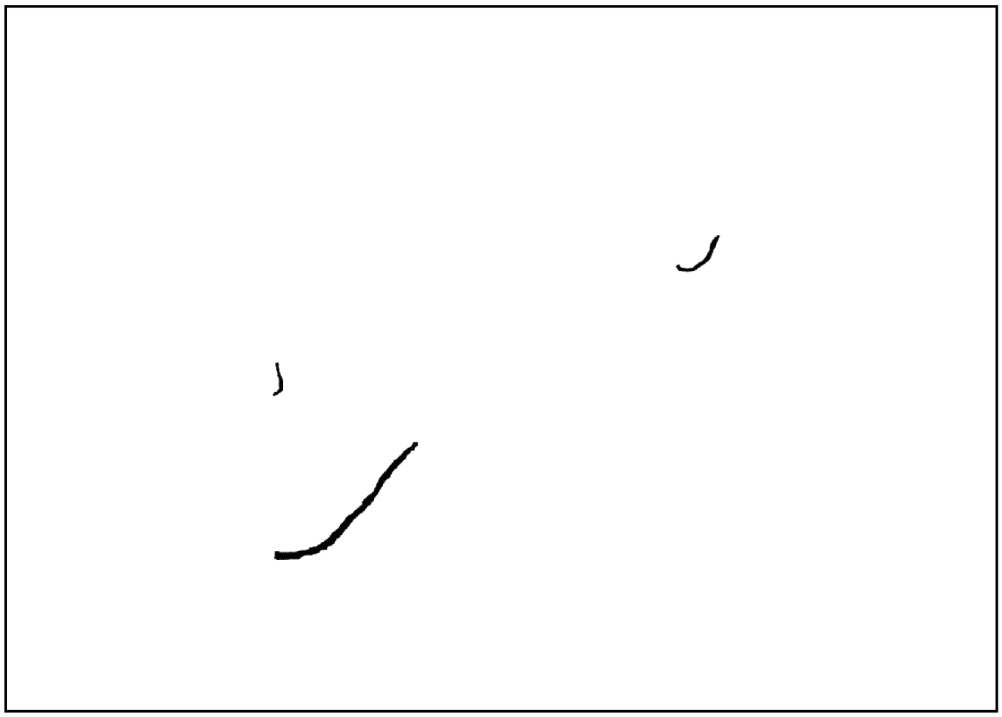


b) Severity level LP 4b

Figure C.9 — Severity level LP 4b

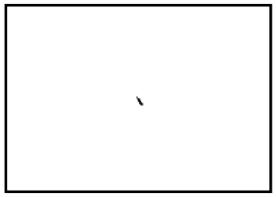


a) Maximum size allowed for a non-relevant indication for severity level LP 5b

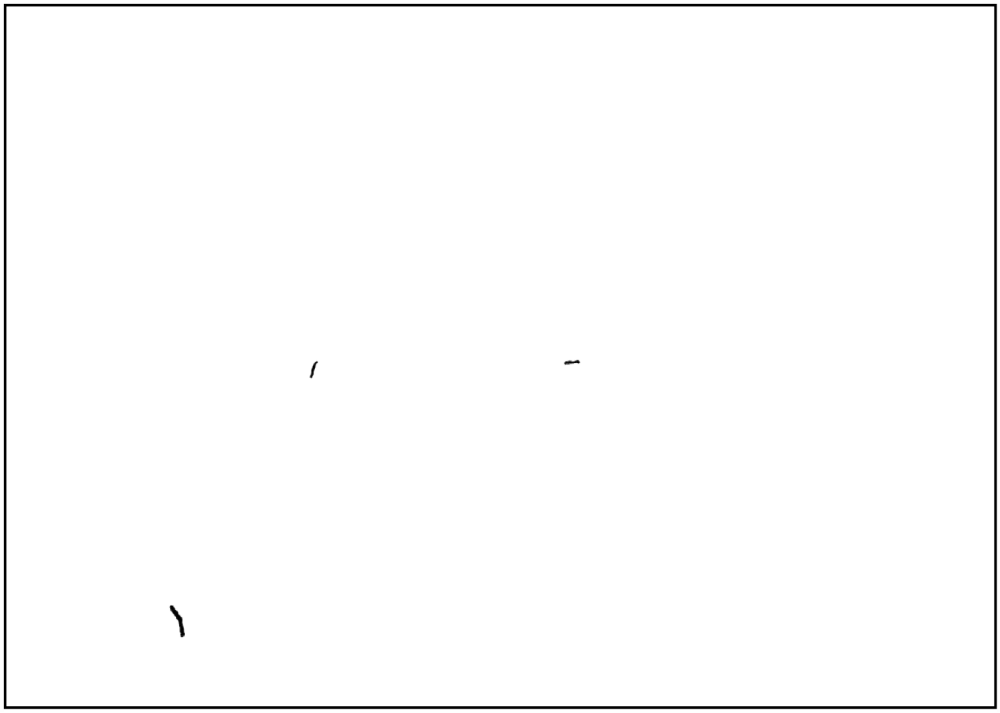


b) Severity level LP 5b

Figure C.10 — Severity level LP 5b

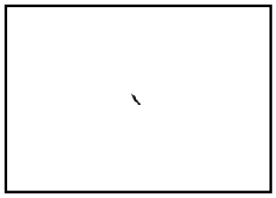


a) Maximum size allowed for a non-relevant indication for severity level LP 1c

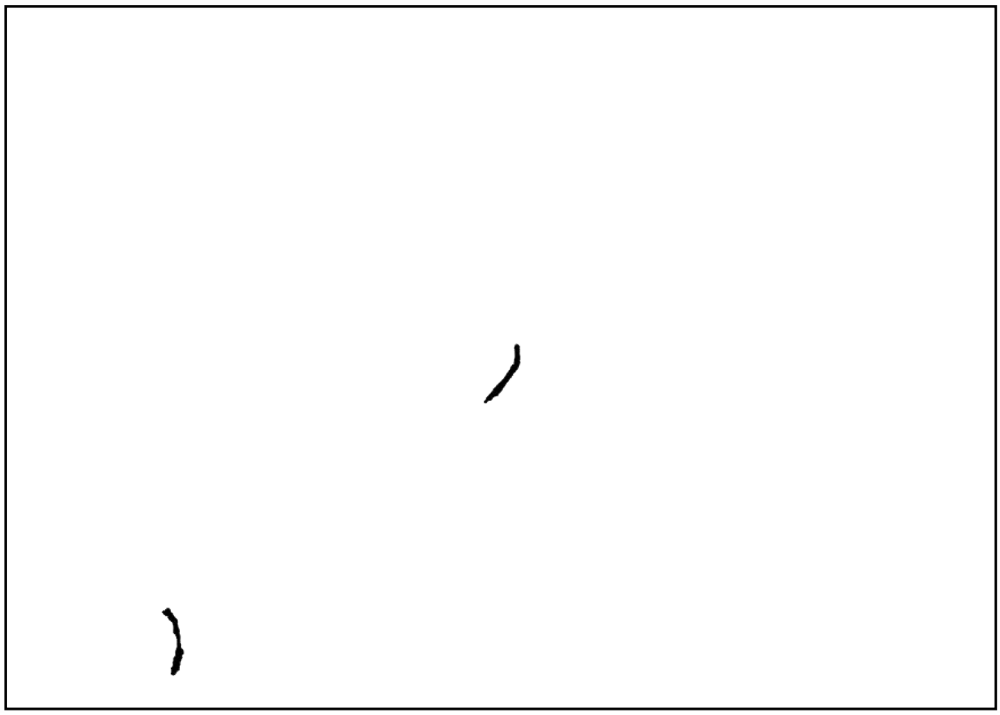


b) Severity level LP 1c

Figure C.11 — Severity level LP 1c



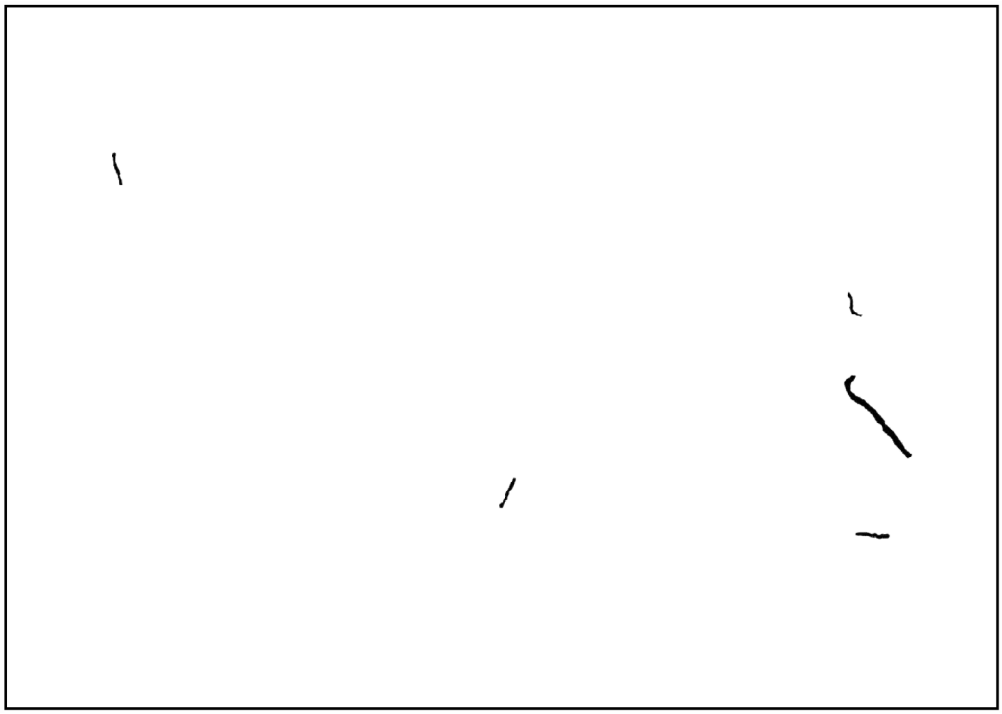
a) Maximum size allowed for a non-relevant indication for severity level LP 2c



b) Severity level LP 2c

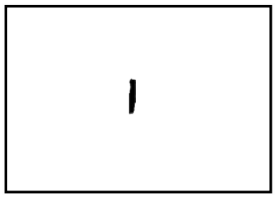
Figure C.12 — Severity level LP 2c

a) Maximum size allowed for a non-relevant indication for severity level LP 3c

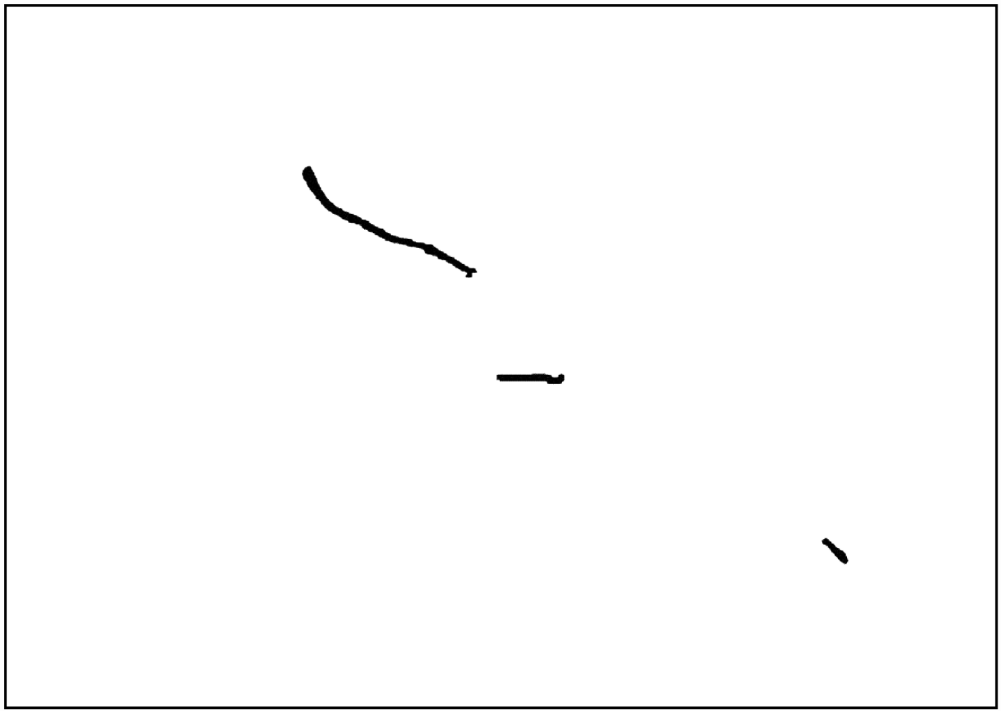


b) Severity level LP 3c

Figure C.13 — Severity level LP 3c

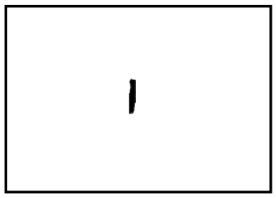


a) Maximum size allowed for a non-relevant indication for severity level LP 4c

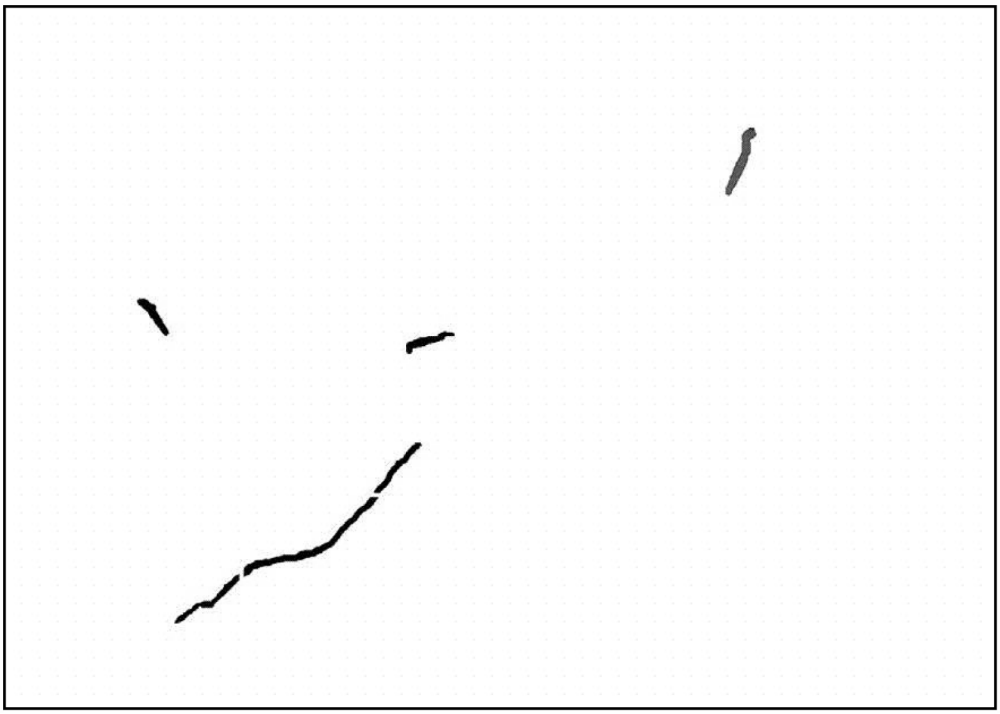


b) Severity level LP 4c

Figure C.14 — Severity level LP 4c



a) Maximum size allowed for a non-relevant indication for severity level LP 5c



b) Severity level LP 5c

Figure C.15 — Severity level LP 5c

Annex D
(informative)

Model of a liquid penetrant inspection document

<table>
<tr><td rowspan="3">Company
Société</td><td colspan="3" rowspan="3">Liquid penetrant inspection document
Document de contrôle</td><td colspan="2">No.
N°</td></tr>
<tr><td colspan="2">Sheet
Page</td></tr>
<tr><td colspan="2">According to
Conforme à</td></tr>
<tr><td colspan="3">Customer
Client</td><td colspan="3">Order No.
Commande n°</td></tr>
<tr><td colspan="3">Specification
Spécification</td><td>Material
Nuance</td><td colspan="2">Heat No.
Coulée n°</td></tr>
<tr><td>Identification
Marquage</td><td>Quantity
Quantité</td><td>Casting designation
Désignation des pièces</td><td>Lot No.
N° du lot</td><td colspan="2">Drawing No.
Plan n°</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
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<tr><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="6">Area examined – Zone contrôlée
100 %
testing scheme – plan de contrôle
cavity root – fonds affouillements</td></tr>
<tr><td colspan="6">Stage – Stade
after heat treatment – après traitement thermique
before stress relieving – avant détensionnement</td></tr>
<tr><td colspan="6">Dye penetrant – Pénétrant
Trademark – Marque</td></tr>
<tr><td colspan="6">Dye penetrant remover – Produit de nettoyage</td></tr>
<tr><td colspan="6">Developer – Révélateur
Trademark – Marque</td></tr>
<tr><td colspan="6">Testing conditions – Conditions d'examen</td></tr>
<tr><td colspan="6">Surface condition – État de surface
shot-blasted – grenaillé
ground – meulé
machined – usiné</td></tr>
<tr><td colspan="6">Casting temperature – Température de la pièce moulée
5 °C up to/jusqu'à 14 °C
15 °C up to/jusqu'à 35 °C
36 °C up to/jusqu'à 55 °C
..... °C</td></tr>
</table>

Test material – *Produit indicateur* dry – *sec* wet – *humide* fluorescent – *fluorescent*
Test results – *Résultats de l'examen*
According to – *Conforme à* ....
Accepted – *Accepté* yes – *oui* no – *non*
Non-conformance note – *Fiche d'anomalie* ....
Continuation sheet – *Annexe* yes – *oui* no – *non*
Inspection authority – *Organisme de contrôle* ....
Quality assurance section – *Service assurance qualité* ....
Date/place – *Date/lieu* .....
Signature of inspector/operator – *Signature de l'inspecteur/opérateur* .....

If applicable, tick the relevant box.

Suivant le cas, cocher la case correspondante.

Bibliography

[1] ISO 11971, *Steel and iron castings — Visual examination of surface quality*

ICS 77.040.20; 77.140.80

Price based on 31 pages