INTERNATIONAL STANDARD

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Steel castings — Penetrant inspection

Pièces moulées en acier — Contrôle par ressuage

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Foreword

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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.

International Standard ISO 4987 was prepared by Technical Committee ISO/TC 17, *Steel*, Sub-Committee SC 11, *Steel castings*.

Annexes A, B, C and D of this International Standard are for information only.

International Organization for Standardization
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Steel castings — Penetrant inspection

1 Scope

This International Standard specifies a test method for determining the acceptance limits of surface discontinuities detected by liquid penetrant inspection, when such an inspection procedure has been contractually agreed upon at the request of the purchaser. It applies to all steel castings, whatever casting process is used.

NOTE 1 It should be remembered that liquid penetrant inspection, like all methods of non-destructive inspection, forms part of an overall or special assessment which is defined in the contract.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3452:1984, *Non-destructive testing — Penetrant inspection — General principles.*

ISO 3453:1984, *Non-destructive testing — Liquid penetrant inspection — Means of verification.*

3 Conditions of liquid penetrant inspection

This International Standard only applies to the parts of castings and the percentage of castings to be inspected. The conditions shall be clearly indicated on the enquiry, in the request for prices and, more particularly, in the order sent to the supplier and accepted by him.

The manufacturing stage(s) at which the inspection is to be carried out shall be clearly defined by agreement between the parties concerned.

For each part of the castings to be inspected, the following shall be indicated:

— the severity level (see table 1);

— the type of discontinuity indication (linear or non-linear) (see annex A).

For each part of the casting, the severity level should be separately specified for each discontinuity type. (For surface condition, see 4.3.)

Unless otherwise specified, the severity level applies both to linear or aligned indications and to non-linear indications (clusters).

The test is considered to be satisfactory if the discontinuity indications obtained are of levels below or equal to those selected from table 1 and in accordance with clause 6.

If not, it shall be the responsibility of the founder to bring the casting into conformity with the specification defined above, by a method approved by the purchaser.

In general, there is no limit to the extent of discontinuities acceptable in a casting, provided that in the casting as a whole no area of 105 mm × 148 mm[1)] contains discontinuities which exceed the severity level specified.

1) Format ISO A6.

Table 1 — Severity levels for liquid penetrant inspection

This table fixes the number and/or the maximum permissible dimension, diameter or length, in millimetres, within the frame ISO A6 — 105 mm × 148 mm.

Severity levels		001	01	1		2		3		4		5	
Means of observing indications		Magnifying glass or eye[1]		Eye		Eye		Eye		Eye		Eye	
Magnification		⩽ 3		1		1		1		1		1	
Diameter (D) or length (L) of the smallest image considered (mm)		0,3		1,5		2		3		5		10	
Non-linear indications (SR)[2]	Number of indications	— 5 —	— 5 —	— 8 —		— 8 —		— 12 —		— 20 —		— 32 —	
	Dimensions (mm)	⩽ 1	⩽ 1	⩽ 3		⩽ 6		⩽ 9		⩽ 14		⩽ 21	
Linear indications (LR)[3] or aligned (AR)[4]	Indication type	Isolated or cumulative	Isolated or cumulative	Isolated	Cumulative	Isolated	Cumulative	Isolated	Cumulative	Isolated	Cumulative	Isolated	Cumulative
	Wall thickness $\delta \leqslant 16$ mm	0	1	2	4	4	6	6	10	10	18	18	25
	Wall thickness 16 mm $< \delta \leqslant 50$ mm	0	1	3	6	6	12	9	18	18	27	27	40
	Wall thickness $\delta > 50$ mm	0	2	5	10	10	20	15	30	30	45	45	70
Examples of castings or parts of castings concerned		Fabrication for aircraft or space craft: — lost wax casting — special applications		Other mechanical engineering castings according to surface finish and application									

1) The use of a magnifying instrument with a measuring graticule is permitted.

2) Non-linear indications (SR): $L < 3b$ where L is the length and b the larger indication.

3) Linear indications (LR): $L > 3b$

4) Aligned indications (AR): linear, or non-linear, separated by a maximum of 2 mm and comprising at least three indications.

4 Method of inspection

4.1 Operating mode

The general principles and the means of verification of penetrant inspection are described in ISO 3452 and ISO 3453 respectively.

They are supplemented by the specific requirements which appear in annex B.

4.2 Qualification of the operators

The tests shall be carried out and interpreted by technically competent operators whose qualifications shall be agreed upon at the time of the enquiry or order.

4.3 Surface condition

The surface to be examined shall be clean, free from oil, grease, sand or scale or any other condition which could interfere with the correct interpretation of penetrant indications. It shall be sand or shot blasted (round or angular shot), ground or machined in line with the severity level demanded (see 5.2).

The required surface finish of the areas of the casting to be inspected shall be subject to agreement at the time of enquiry or order.

4.4 Conditions of examination

The inspections shall be carried out with the naked eye or at a maximum magnification of 3 × (see table 1).

5 Acceptance test

5.1 Discontinuity indications

Penetrant inspection is a means of non-destructive inspection which is used solely to reveal the presence or absence of discontinuities open to the surface. Penetrant inspection does not enable the nature, shape and the dimensions of the discontinuities revealed to be determined. The discontinuity indications are linear[2] or aligned[3], or non-linear.

The dimensions of the discontinuity indications do not directly represent the actual dimensions of the discontinuity. The different types of penetrant indications are listed in annex A.

5.2 Severity levels

Seven severity levels are recognized in accordance with table 1. Depending on the severity level required, it is necessary to carry out the test on a surface corresponding to a given degree of finish (see annex C):

— precision;

— smooth;

— rough.

The maximum permissible length for linear or aligned indications varies with the casting section thickness δ. Three thickness categories are specified:

— $\delta \leqslant 16$ mm

— 16 mm $< \delta \leqslant 50$ mm

— $\delta > 50$ mm

Table 1 shows the minimum length below which the indications are not to be taken into consideration in the respective category.

Examples of non-linear indications, given to a scale of 1, are shown in annex D. These have been established in accordance with table 1.

6 Interpretation of results

In order to classify discontinuity indications obtained by liquid penetrant inspection of the casting, it is necessary to place a frame measuring 105 mm × 148 mm positioned in the most unfavourable location relative to the indications being evaluated. The test is considered satisfactory if the indications being evaluated are less severe or equal to those specified in the order.

Indications are equivalent when they show the same clusters of non-linear indications or the same length of linear indications of similar appearance.

The types of indications are given only as a guide and the classification by severity level is based on the length of the discontinuities, in accordance with table 1.

2) The largest dimension L (length) is at least three times the smallest b (width) ($L \geqslant 3b$). (See table 1.)

3) See note 4 of table 1.

Aligned and non-aligned indications shall be taken into account for the calculation of the cumulative length.

7 Order

The enquiry and/or order shall specify the following points:

a) the parts of castings and percentage of castings to be inspected (see clause 3);

b) the manufacturing stage(s) at which the inspection is to be carried out, as agreed between the parties concerned (see clause 3);

c) the surface condition for the areas to be inspected (see 4.3);

d) the type of discontinuity indication and the severity level for each part of casting to be inspected (see clause 3 and 5.2);

e) the qualification of the operators carrying out the inspection (see 4.2).

8 Additional test for cleaning after inspection

The requirements given in ISO 3452 are also appropriate to this International Standard.

Annex A
(informative)

Nature of discontinuities — Types of indication

Nature of discontinuities	Nomenclature	Indications	Type	Definition
Blowholes Pinholes	A	Non-linear Aligned	SR AR	$L < 3b$ $d < 2$
Sand spots Inclusions	B	Non-linear Aligned	SR AR	$L < 3b$ $d < 2$
Shrinkage	C	Linear Non-linear Aligned	LR SR AR	$L \geqslant 3b$ $L < 3b$ $d < 2$
Tears	D	Linear Aligned	LR AR	$L \geqslant 3b$ $d < 2$
Cracks	E	Linear Aligned	LR AR	$L \geqslant 3b$ $d < 2$
Remains of core support	F	Linear Non-linear Aligned	LR SR AR	$L \geqslant 3b$ $L < 3b$ $d < 2$
Remains of internal chills	G	Linear Non-linear Aligned	LR SR AR	$L \geqslant 3b$ $L < 3b$ $d < 2$
Cold shuts	H	Linear Aligned	LR AR	$L \geqslant 3b$ $d < 2$

L = length of indication
b = width of indication
d = distance, in millimetres, between two indications, edge-to-edge

Annex B
(informative)

Liquid penetrant examination test method — Specific requirements for cast steels

a) The halogens and sulfur content of the products employed shall be less than 1 %.

b) The impregnation time shall be not less than that recommended by the penetrant manufacturer.

c) The temperature of application shall be between 10 °C and 50 °C.

d) Rinsing with water shall be performed at pressures below 200 kPa (2 bars) and the water temperature shall be less than 40 °C.

e) Drying shall be carried out with clean and "dry" air at pressures below 200 kPa (2 bars) and at a temperature below 70 °C.

f) The development time is generally between 15 min and 30 min.

Annex C
(informative)

Equivalence of surface conditions (as a guide)

Surface condition	Precision						Smooth				Rough	
Roughness R_a (µm) [1]	1,6		3,2		6,3		12,5		25		> 25	
Surface preparation	Very smooth grinding Smooth precision	Very smooth shot blasting	Very smooth grinding Very smooth machining Precision	Smooth shot blasting Investment cast	Smooth grinding	Smooth shot blasting Precision cast (ceramic)	Grinding Smooth machining	Smooth shot blasting Precision cast (shell moulded, ceramic)	Grinding Rough machining	Medium shot blasting Careful moulding	Rough preparation	Sand cast
BNIF 341-02	—	—	—	—	1S2	—	2S2 3S2	1S1	4S2 5S2	2S1 3S1	1S3 2S3 5S3 6S3	4S1 5S1 6S1
ACI	—	—	—	—	—	SIS1	—	SIS3	—	SIS4	—	—
CSC (Cast Surface Comparator)	—	—	—	C30		C40	—	C70	—	C90	—	—
SCRATA		—	—	—	—	—	—	A1	H1 H2	A2 A3	G2 G3	A4 C3 D3
LCA 2 Grinding	15	—	16	—	17	—	18	—	19	—	—	—
LCA 3 Shot blasting	—	N7 (15)	—	N8 (16)	—	N9 (17)	—	N10 (18)	—	N11 (19)	—	—

1) The roughness values R_a indicated in this table are those given by the manufacturers of small plates.

S1: As cast or shot blasted

S2: Ground

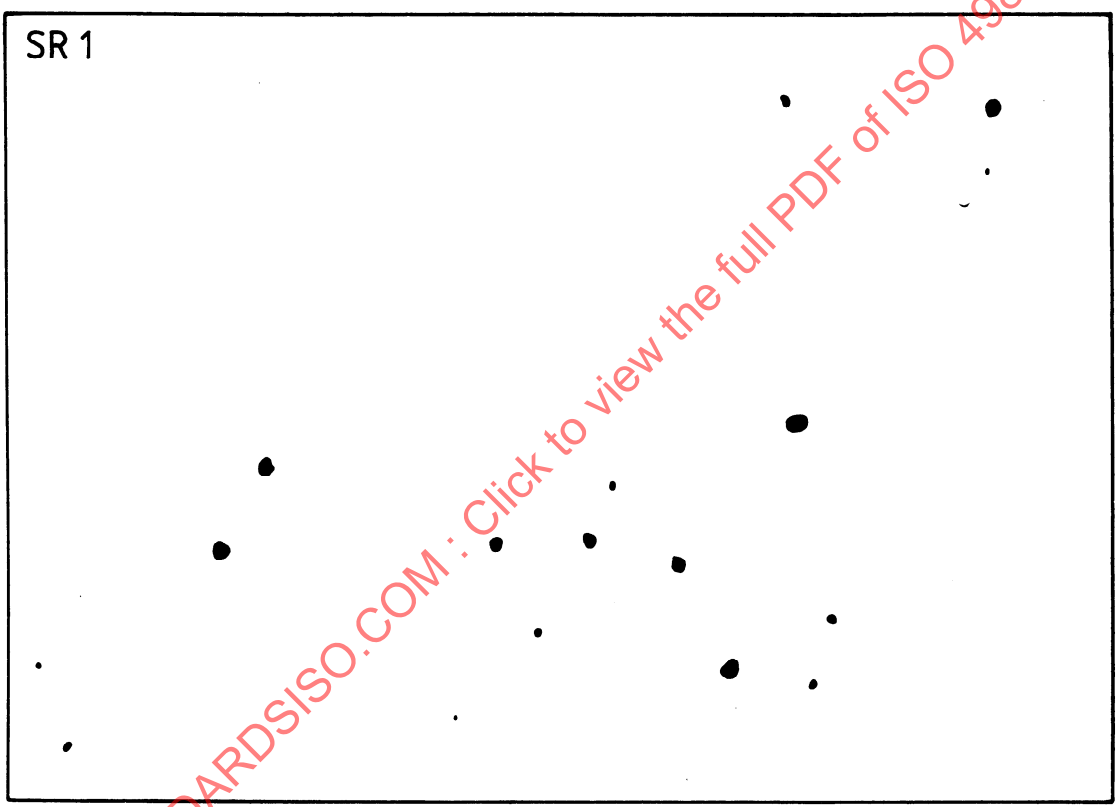
Annex D
(informative)

Examples of severity levels

Sketches of non-linear indications (SR 1 to SR 5) are given in D.1 to D.5.

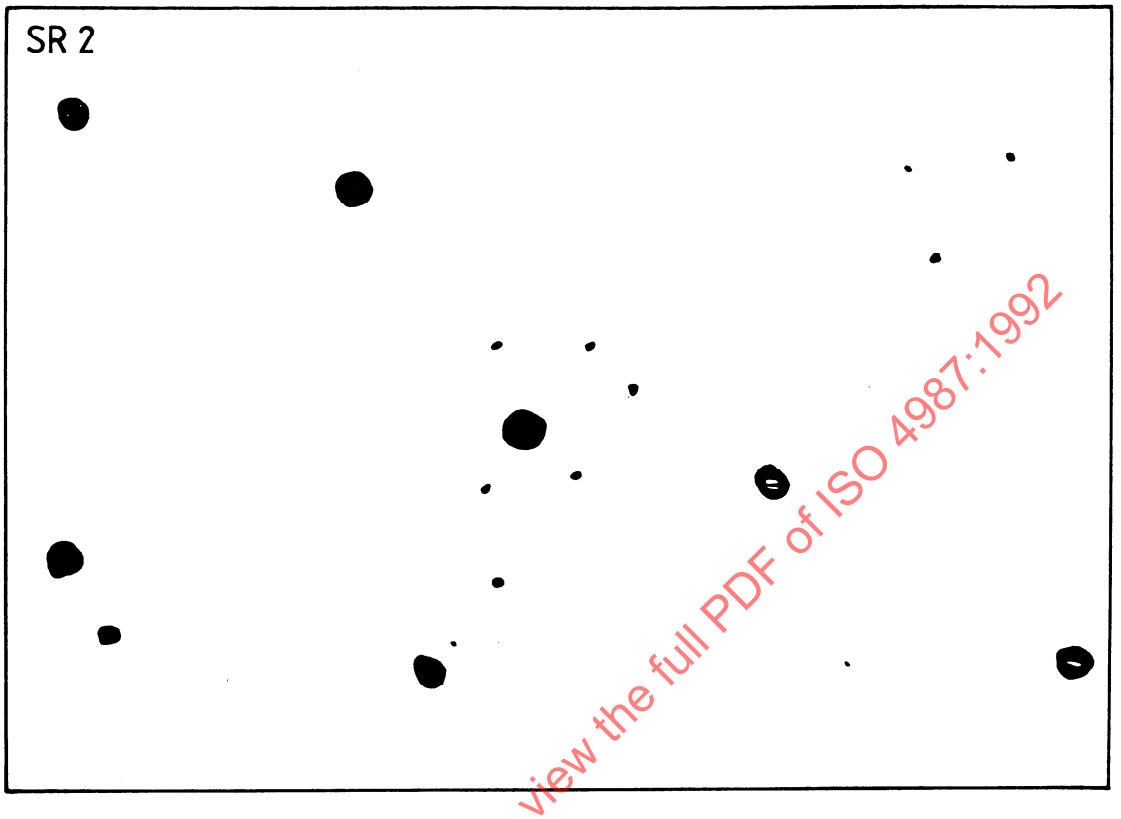
D.1 Severity level SR 1

Eight non-linear indications, 1,5 mm $\leqslant D \leqslant$ 3 mm.



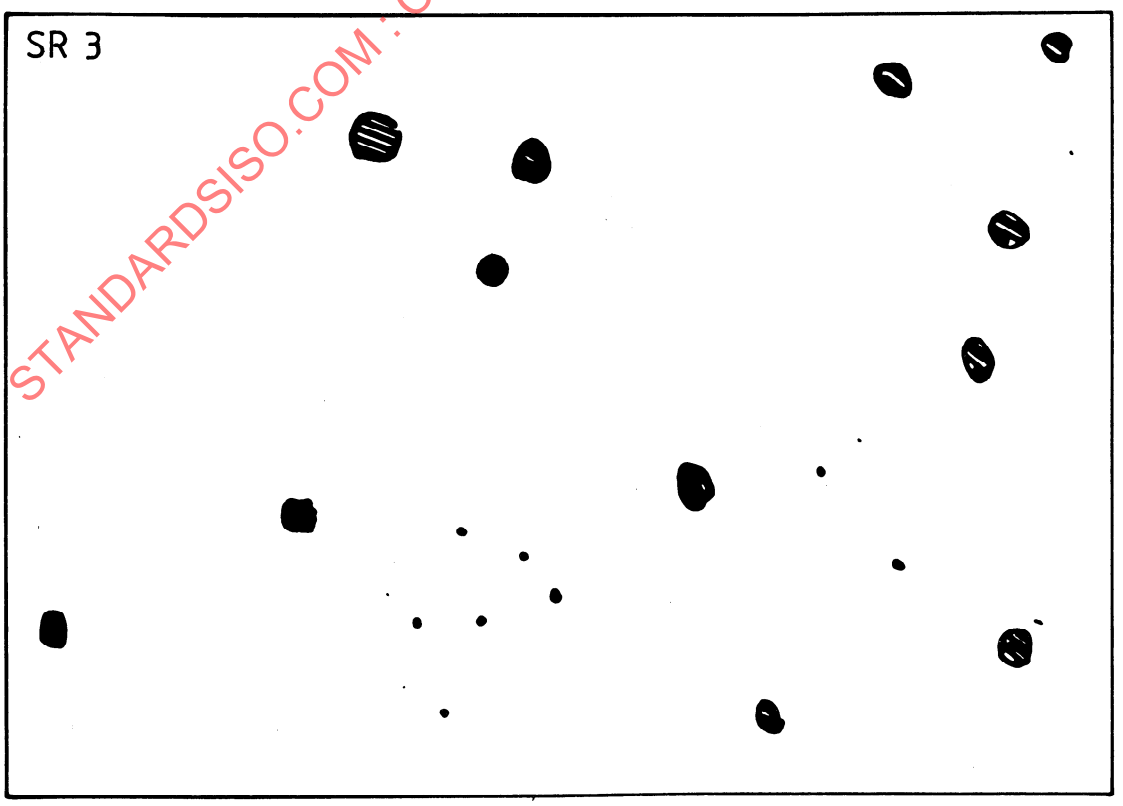
D.2 Severity level SR 2

Eight non-linear indications, $D > 2$ mm.



D.3 Severity level SR 3

12 non-linear indications, $D > 3$ mm.



D.4 Severity level SR 4

20 non-linear indications, $D > 5$ mm.