

# INTERNATIONAL STANDARD

**ISO**  
**9916**

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## **Aluminium alloy and magnesium alloy castings — Liquid penetrant inspection**

*Pièces moulées en alliages d'aluminium et de magnésium — Contrôle  
par ressuage*

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Reference number  
ISO 9916:1991(E)

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 9916 was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*.

Annex A of this International Standard is for information only.

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# Aluminium alloy and magnesium alloy castings — Liquid penetrant inspection

## 1 Scope

This International Standard specifies a method for liquid penetrant inspection of discontinuities rising to the surface of aluminium alloy and magnesium alloy products and castings. It also defines severity levels as a function of the nature and number of discontinuities present.

This International Standard applies to all aluminium alloy and magnesium alloy castings, whatever their grade and the casting procedure used to produce them.

## 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 for liquid penetrant inspection

The manufacturing stage(s) where liquid penetrant inspection is to be performed shall be clearly defined by agreement between the purchaser and the supplier.

Inspection only applies to those parts of castings and the percentage of castings to be inspected. These details shall be clearly indicated in the enquiry, the request for prices and, more particularly, in the order sent to the supplier and accepted by him, so that he can access the costs of manufacturing to achieve the required severity level, the costs of additional inspections and operations, and the manufacturing risks involved.

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

- the type of discontinuity;
- the severity level.

It should be noted that sensitivity may differ depending on the method of liquid penetrant inspection selected. Hence required severity levels shall be selected as a function of the penetrants and the method agreed upon by the purchaser and the supplier.

The type of discontinuity and the severity level may vary depending on the area of the casting inspected (see table 2, table 3 and table 4).

Inspection shall be considered satisfactory if the discontinuities found correspond to a severity level lower than, or equal to, that agreed upon by contract.

If this is not the case, the casting shall be either rejected or brought into conformity with the specification agreed upon by contract, by a method acceptable to the purchaser.

In general, there is no limit to the extent of the acceptability of discontinuities in a casting provided that, in the casting as a whole, no single area of 105 mm × 148 mm<sup>\*)</sup> contains discontinuities which exceed the severity level in question.

\*) A6 Format. If the dimensions of a casting do not correspond to this format, severity levels corresponding to a new format will have to be agreed upon by the purchaser and the supplier.

## 4 Method of inspection

### 4.1 Procedure

The general principles shall be as described in ISO 3452: 1984, clause 7. The characteristics of the penetrants shall be checked in accordance with the requirements of ISO 3453.

### 4.2 Competence of operators

Liquid penetrant inspection shall be performed by technically competent operators.

Their competence shall be demonstrated by certification procedures.

### 4.3 Surface preparation

The surface to be inspected shall be clean and free from oil, grease, moulding residues or any other contaminant which could interfere with the correct interpretation of the penetrant inspection test results.

The surface shall be prepared taking into account the dimensions of the smallest discontinuity present. The surface finish shall be selected from table 1, unless otherwise specified at the time of ordering.

It is recommended that the assessment of surface finish be carried out using a visual cast-surface roughness gauge.

Liquid penetrant inspection shall be performed on castings in the as-delivered condition. If sand-blasting or shot-blasting is required, it shall be as light as possible, in order to avoid sealing or closing up possible defects.

If this risk cannot be accepted (e.g. in the case of lost-wax castings), blasting may be followed by chemical etching in order to make detection of defects easier. The bath composition and application (concentration, temperature, immersion time, etc.) shall be defined for each case.

**Table 1 — Recommended surface finish for liquid penetrant inspection of aluminium alloy and magnesium alloy castings**

Size of smallest indication considered	$R_a$ <sup>1)</sup>
mm	$\mu\text{m}$
0,3	$\leq 6,3$
1,5	$\leq 12,5$
2	$\leq 25$
3	$> 25$

1) For guidance in the selection of a visual cast-surface roughness gauge. By agreement, one of the following specimens may be used:

- LCA No. 3 (obtainable from: Forges du Vulcain, 26, rue du Bailly, 93200 St Denis, France, or Lefèvre Précision, Z.I. des Richardets, 14-16, rue du Ballon, 93160 Noisy Le Grand, France,
- CSC (Cast Surface Comparator) (obtainable from: The Aluminium Association, 818 Connecticut avenue, Washington, DC 2006, USA).

### 4.4 Conditions of examination

The inspection shall be carried out with the naked eye or at a maximum magnification of  $\times 3$ .

## 5 Acceptance test

### 5.1 Discontinuity indications

The images of discontinuities or so-called discontinuity indications may be non-linear (isolated or clustered), aligned or linear. Although liquid penetrant inspection cannot generally be used to determine the size of detected discontinuities, it allows linear discontinuities to be assessed by measurement of the length  $L$  of the discontinuity indication. The various types of penetrant indication can correspond to the discontinuities shown in table 2.

Table 2 — Nature of discontinuities and types of corresponding indication

Nature of discontinuity	Designation	Type of indication			
		Non-linear		Aligned	Linear
		isolated	clustered		
SR	AMR	AR	LR		
Blowholes, pinholes	A	X	X	X	
Inclusions (other than alumina)	B	X	X	X	
Shrinkage	C	X	X	X	X
Cracks	D			X	X
Cold shuts, cold sets	H	X		X	X
Alumina	J			X	X

The physical discontinuities designated A, B, C, D, H, J in table 2 can give different types of penetrant indication:

a) non-linear, such that  $L < 3b$ :

- isolated SR,
- clustered AMR: area of multiple indications, the distance between which cannot be measured, so that they seem to form only one indication;

b) aligned AR:

- non-linear, the distance between indications is less than 2 mm and at least three indications are noted,
- linear, the distance between two indications is smaller than the length of the longest discontinuity in the alignment;

c) linear LR: such that  $L \geq 3b$ ;

where

$L$  is the length of the indication;

$b$  is the width of the indication.

## 5.2 Severity levels

Different severity levels may be selected from table 3 and table 4.

Table 3 corresponds to linear indications "SR" or clustered "AMR" indications.

Table 4 corresponds to linear indications "LR" or aligned indications "AR".

The maximum permissible length for linear indications may vary depending on the casting thickness. The corresponding severity level shall be selected accordingly and specified in the order by agreement between the purchaser and the supplier.

Table 3 and table 4 are independent. The severity level for each type of indication shall be specified at the time of ordering.

The penetrant indications to be taken into account shall have dimensions varying according to the severity level.

**Table 3 — Severity levels for penetrant inspection — Non-linear Indications (isolated “SR” or clustered “AMR”)**

This table specifies the maximum permissible number of indications in an area of 105 mm × 148 mm.

Severity levels are designated SR 01-AMR 01 to SR 3-AMR 3.

Severity levels	SR 01 AMR 01	SR 02 AMR 02	SR 03 AMR 03	SR 1 AMR 1	SR 2 AMR 2	SR 3 AMR 3
Means of observing penetrant indications	Magnifying glass or eye	Eye				
Magnification for observation	≤ 3	× 1				
Diameter <i>D</i> of smallest indication considered	0,3 mm	0,5 mm	1 mm	1,5 mm	2 mm	
Maximum number of non-linear indications <sup>1)</sup>	5	6	7	8	8	12
Maximum size of discontinuity indications A, B, C, H: — isolated indications SR — clustered indications AMR (with a maximum of two per area)	1 mm 3 mm	1 mm 4 mm	1,5 mm 6 mm	3 mm 10 mm	5 mm 16 mm	8 mm 25 mm
Minimum distance between neighbouring clusters or isolated indications	Twice the longest indication					
1) Such that $L < 3b$ , where $L$ is the length and $b$ the width of the indication.						

**Table 4 — Severity levels for liquid penetrant inspection — Aligned “AR” and linear “LR” indications**

This table specifies the permissible lengths, in millimetres, in an area of 105 mm × 148 mm.

Severity levels are designated AR 001-LR 001 to AR 5-LR 5.

Severity levels	AR 001 LR 001	AR 1 LR 1	AR 2 LR 2	AR 3 LR 3	AR 4 LR 4	AR 5 LR 5					
Means of observing penetrant indications	Magnifying glass or eye	Eye									
Magnification for observation	≤ 3	× 1									
Length of smallest indication considered	0,3 mm	1,5 mm	2 mm			3 mm					
Arrangement of indications	Isolated or cumulative	Isolated	Cumulative	Isolated	Cumulative	Isolated	Cumulative	Isolated	Cumulative	Isolated	Cumulative
Maximum length of aligned AR <sup>1)</sup> and linear LR indications	0 mm	2 mm	4 mm	4 mm	6 mm	6 mm	10 mm	16 mm	25 mm	40 mm	63 mm
1) The length <i>L</i> of an aligned indication is the distance between the starting point of the first discontinuity and the opposite end of the last discontinuity.											

## 6 Interpretation of results

In order to classify a discontinuity indication as obtained by liquid penetrant inspection of a casting, it is necessary to place a frame measuring 105 mm × 148 mm in the most unfavourable location. For the type of discontinuity concerned, the observed indications shall be related to the reference severity levels as specified in this International Standard and ascribed to the equivalent or immediately higher severity level.

Indications are equivalent when the same number of non-linear spots and/or the same length of linear indications of similar appearance can be detected, it being understood that maximum permissible discontinuities may appear simultaneously on the area of 105 mm × 148 mm.

If, for any indication type, the observed severity level is higher than the severity level specified in the order, the casting shall be considered as not conforming with this International Standard. In the contrary case, it shall be considered as conforming with this International Standard.

Classification by severity levels is made by comparison with reference indication types for classes 1, 2, 3, 4 and 5. For classes 001, 01, 02 and 03, and in the event of dispute in the interpretation of the following classes, reference shall be made to the values in table 3 and table 4. Reference indication

types corresponding to non-linear, linear, aligned and clustered indications in accordance with table 3 and table 4 are represented in annex A for guidance only, taking the form of diagrams drawn to scale 1.

The requirements in the order or in the specifications shall be in conformity with the terminology used in this document.

The requirements shall, for example, be as follows:

- non-linear indications: level 2;
- linear and aligned indications: level 1.

It should be noted that severity level references are purely arbitrary and are only relevant to the individual table.

## 7 Further inspection

Refer to ISO 3452: 1984, clause 10.

## 8 Cleaning after examination

Refer to ISO 3452: 1984, clause 11.

## 9 Test report

Refer to ISO 3452: 1984, clause 13.

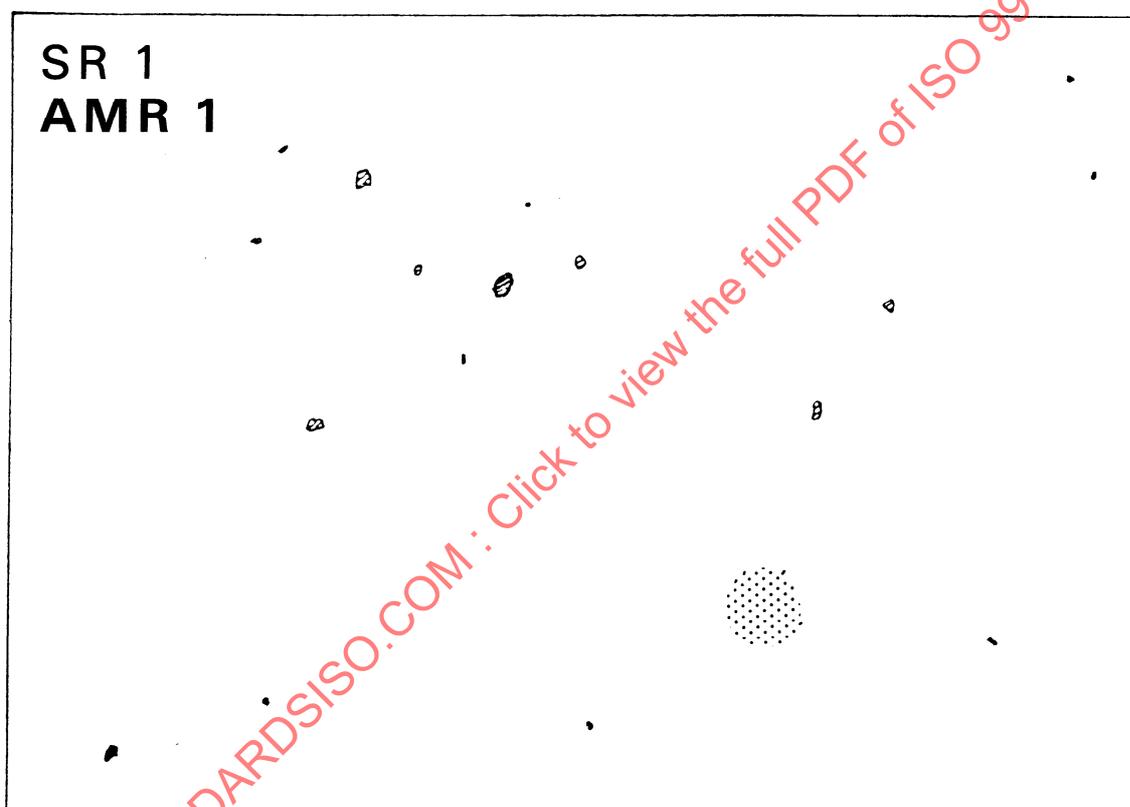
**Annex A**  
(informative)

**Indication types**

**A.1 Severity levels — Non-linear indications (types A, B, C and H) designated SR-AMR**

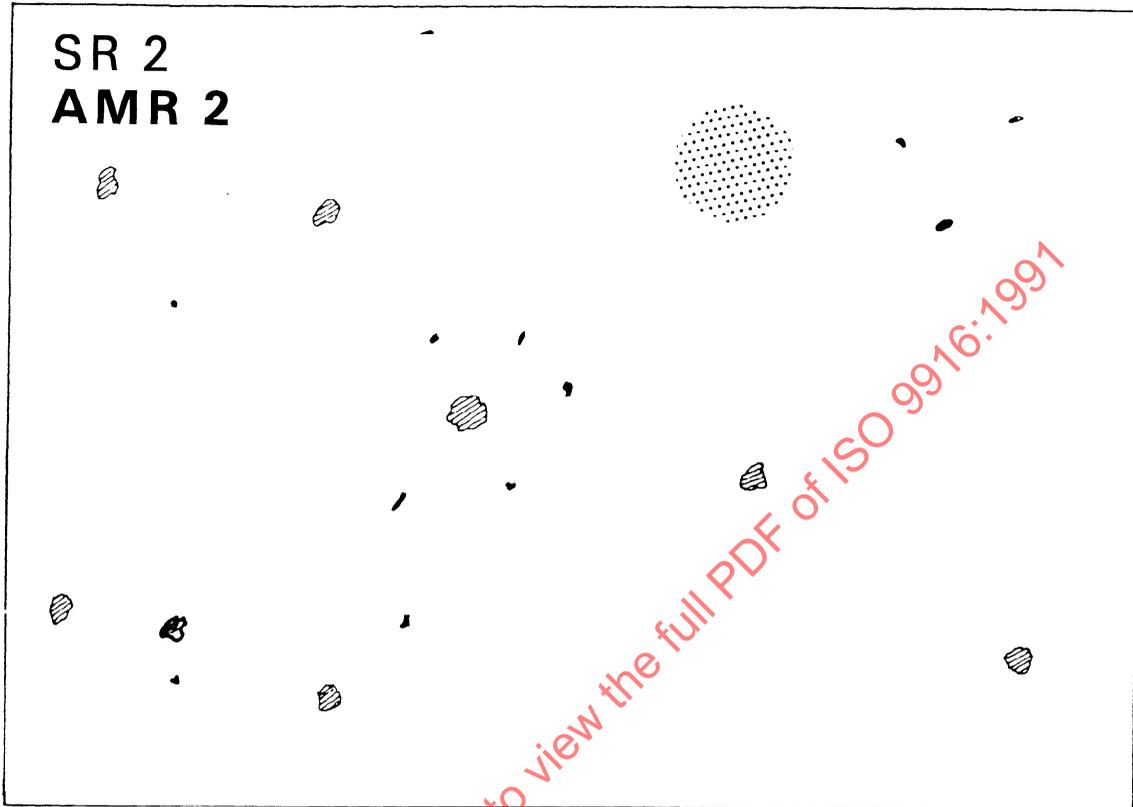
**A.1.1 Severity level SR 1 — AMR 1**

Maximum eight non-linear indications,  $1,5 \text{ mm} \leq D \leq 3 \text{ mm}$ , forming a cluster with a diameter less than 10 mm.



**A.1.2 Severity level SR 2 — AMR 2**

Maximum eight non-linear indications,  $2 \text{ mm} < D < 5 \text{ mm}$ , forming a cluster with a diameter less than 16 mm.



**A.1.3 Severity level SR 3 — AMR 3**

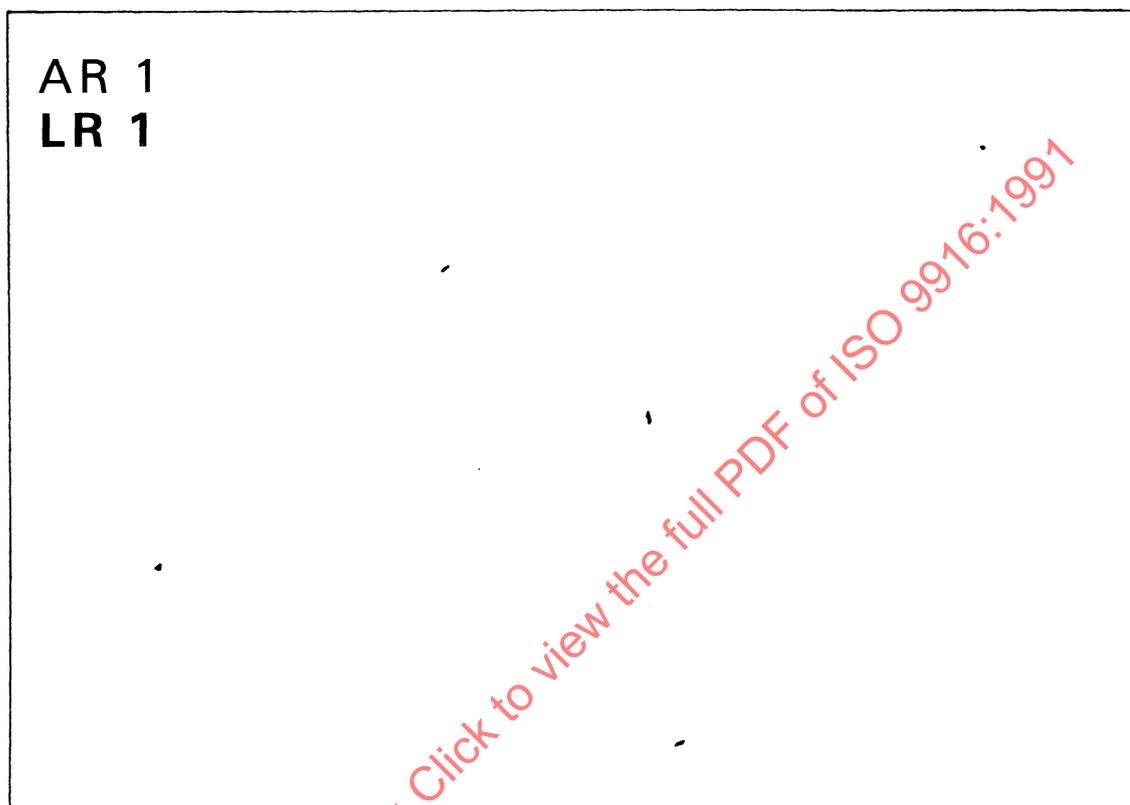
Maximum twelve non-linear indications,  $2 \text{ mm} \leq D \leq 8 \text{ mm}$ , forming a cluster with a diameter less than 25 mm.



**A.2 Severity levels — Aligned and linear indications (types A, B, C, D, H, and J) designated AR-LR**

**A.2.1 Severity level AR 1 — LR 1**

1,5 mm < isolated length ≤ 2 mm. Cumulative length ≤ 4 mm.



**A.2.2 Severity level AR 2 — LR 2**

2 mm < isolated length ≤ 4 mm. Cumulative length ≤ 6 mm.

