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Aluminium alloy castings — Radiography testing

Pièces moulées en alliages d'aluminium — Contrôle par radiographie



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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 9915 was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Sub-Committee SC 7, *Aluminium and cast aluminium alloys*.

Annexes A and B form an integral part of this International Standard. Annexes C and D are for information only.

Aluminium alloy castings — Radiography testing

1 Scope

This International Standard specifies general rules for appropriate implementation of radiographic inspection and stresses the technical specifications to be defined for agreement on discontinuity acceptance criteria by this technique.

It applies to aluminium castings.

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 1027:1983, *Radiographic image quality indicators for non-destructive testing — Principles and identification*.

ISO 3522:1984, *Cast aluminium alloys — Chemical composition and mechanical properties*.

ISO 5579:1985, *Non-destructive testing — Radiographic examination of metallic materials by X- and gamma rays — Basic rules*.

ASTM E 155-85, *Standard reference radiographs for inspection of aluminium and magnesium castings*.

ASTM E 505-75, *Standard reference radiographs for inspection of aluminium and magnesium die castings*.

3 Radiographic inspection practice

3.1 General

Radiography, of which the basic rules are given in ISO 5579, is a very commonly used technique in aluminium alloy casting industries for testing highly stressed castings or for the final development of sophisticated manufactures. This International Standard has been finalized with a view to obtaining satisfactory radiographs, and to facilitate the interpretation of results with reference to ASTM E 155 and ASTM E 505. Special requirements have to be specified by the customers in accordance with the provisions given in clause 4.

NOTE 1 Casting quality is not assessed using radiography only, but also by other methods of non-destructive testing, and no one method can be automatically retained as a single criterion.

3.2 Principle of the method — Limitation

3.2.1 Radiography consists in recording on a film the image of the inspected casting and of the discontinuities contained therein. For this purpose advantage is taken of the property of materials to be penetrated by electromagnetic radiations with short wavelengths and to absorb part of the radiation. The image will be lighter or darker as a function of X-ray absorption, which in turn depends on the material thickness and nature and on the wavelength used. Radiography will therefore detect differences in specific gravity (due to porosity or holes) and the presence of inclusions according to the nature of discontinuities present in the casting.

3.2.2 However, some discontinuities are not easily detected by radiographic inspection. For complex castings, detection and interpretation of discontinuities are often made difficult by the orientation of the casting and by thickness differences within the

X-ray beam. Discontinuity visibility is mainly dependent on their thickness in the direction of radiation. Very thin discontinuities such as cracks will be hardly visible unless incidence is extremely favourable. In such difficult cases other methods shall be used (ultrasonic testing, penetrant testing, etc.).

3.3 Safety practices

X-ray use shall be associated with special precautions defined according to the regulation in force in each country.

3.4 Qualification of personnel

Radiographic inspection shall be performed by qualified personnel. Such qualification may, if required, be the subject of special certification.

3.5 Execution of radiography

3.5.1 Preparation of castings

Special preparation of the casting surface is not always needed. However, it is desirable to remove pronounced irregularities. Radiographic interpretation shall not be disturbed by the surface finish but shall be carried out taking this factor into account.

3.5.2 Identification

All castings or parts of castings to be radiographed shall be systematically identified. They shall be marked with a serial number permitting unambiguous correlation with the corresponding radiographs. It is thus possible to locate the discontinuities revealed by radiography accurately on the castings.

Markers shall permit identification

- of the casting;
- of areas of special interest on the casting.

Location markers are lead letters or numbers which are placed on the part being examined on the radiation source side, in such a way that defect inspection is not disturbed. This can be achieved, for example, by placing markers on a block (or shim) having approximately the same thickness as the casting being examined. If several radiographs are necessary for covering one casting or an area of a

casting, films shall be arranged so as to overlap and markers shall provide evidence that overlap is evident.

3.5.3 Image quality indicators (IQI) (or penetrameters)

3.5.3.1 Image quality indicators are used to assess the radiographic quality of radiographs. They are used to obtain evidence that the conditions for exposure and processing have been adequately chosen and fulfilled.

They are not intended for use in judging the size of discontinuities nor for the establishment of acceptance limits for castings being radiographed.

3.5.3.2 Considering the conventional nature of the indicator use, it is not absolutely necessary that the absorption coefficients of the materials used for the IQI's and the radiographed castings are the same; however, they are usually equivalent.

3.5.3.3 The indicators used are those defined by ISO 1027:

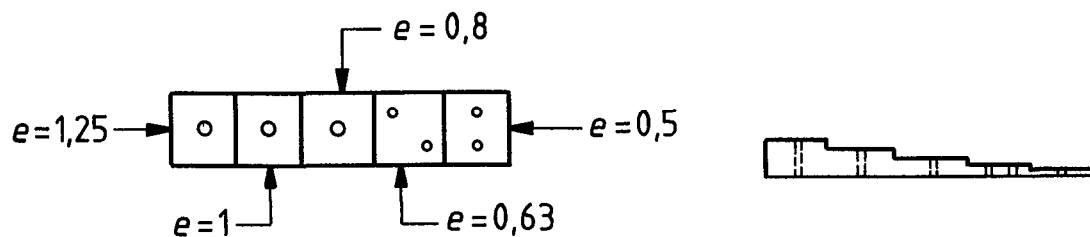
- a) IQI's composed of steps including one or several holes whose diameters are equal to the step thickness;
- b) IQI's composed of seven wires of different diameters; these are most common for radiographic inspection of aluminium alloys.

The two types of IQI's are described hereafter and given as examples in figures 1 and 2. (See also example of commercial design of wire indicators, annex D).

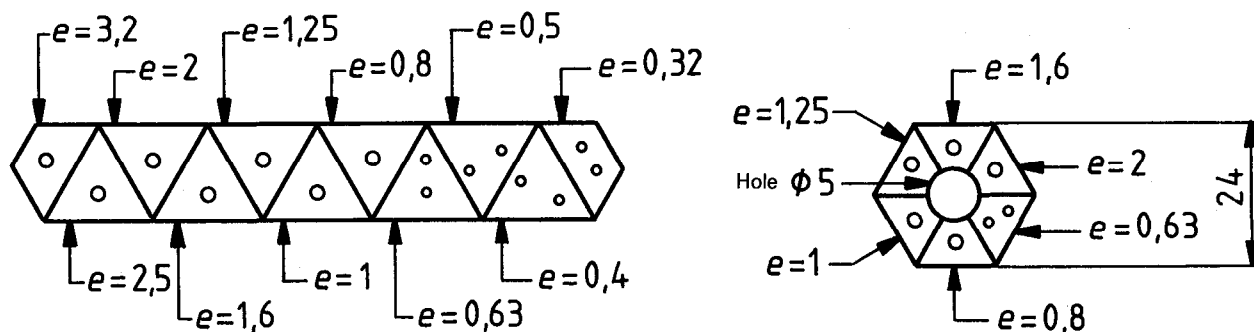
3.5.3.4 The IQI shall be placed on the radiation source side of the casting being examined. Its position shall be such that it does not mask the discontinuities being inspected. If it is located in an area of the casting where thickness is less than the thickness of the area being radiographed, it shall be placed on a block compensating for thickness difference. The block shall be of the same material as the casting, or of material presenting the same absorption.

The hole-type IQI shall be placed as close as possible and normal to the beam axis. The wire-type IQI may have various positions and incidences without losing much of its sensitivity.

Dimensions in millimetres; e = thickness of steps



NOTE — As alternatives to the step arrangement shown above, the steps may be arranged as indicated below.



NOTE — In each step, holes should be drilled in accordance with the requirements of ISO 1027 : 1983, subclause 5.2.

Figure 1 — Examples of step and hole type image quality indicators (ISO 1027)

Dimensions in millimetres; d = wire diameter

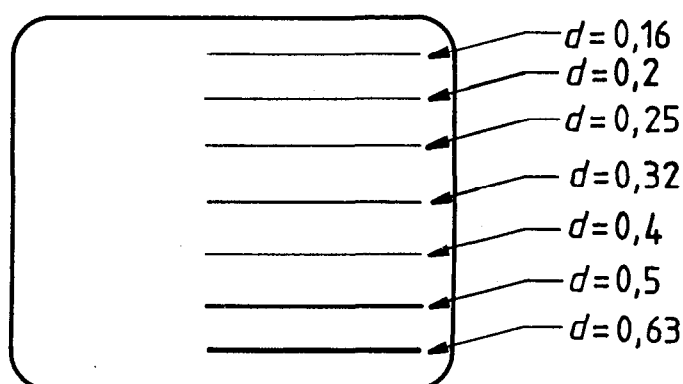


Figure 2 — Example of design of wire-type image quality indicator (ISO 1027)

3.5.4 Defect detection sensitivity and image quality

3.5.4.1 Defect detection sensitivity

Detection sensitivity is defined as the size of the smallest discernable detail measured on a radiograph in the direction of the primary radiation beam.

3.5.4.2 Image quality

The image quality is generally expressed by determining the number of holes or the diameter of the smallest wire visible on the radiograph. This control shall be performed in the same conditions as the reading of the whole radiograph. Steps including two holes must be simultaneously visible for the reading corresponding to a given step to be valid.

NOTE 2 Table 1 gives the diameter of the smallest hole or wire visible under appropriately chosen operating conditions, as a function of the thicknesses to be penetrated. These values are only to be considered for guidance for the correct implementation of radiographic techniques.

Table 1 — Diameters of smallest visible wire or hole
Dimensions in millimetres

Thickness	Diameter of smallest visible wire	Diameter of smallest visible hole
6 to ≤ 8	0,125	0,25
8 to ≤ 10	0,16	0,32
10 to ≤ 16	0,20	0,40
16 to ≤ 25	0,25	0,50
25 to ≤ 32	0,32	0,63
32 to ≤ 40	0,4	0,8
40 to ≤ 60	0,5	1

3.5.5 Conditions of exposure

The factors which optimize the exposure conditions are as follows.

3.5.5.1 Apparatus

In the case of aluminium alloys, the physical and electrical characteristics of the apparatus play an important part in the quality of radiographs. It is recommended to use generators delivering constant voltage and intended for operation at low voltage with a high current intensity. The tube shall have low level internal filtration and shall be fitted with a beryllium window.

3.5.5.2 Exposure time

The exposure time shall be determined so that film density and image quality are satisfactory.

It is calculated from an exposure chart which is developed for each X-ray tube. For each combination

of film density, source-film distance, film type and alloy, the exposure, expressed in milliamperes minutes, is chosen with the voltage to be applied.

3.5.5.3 Intensity

The intensity shall be set to the maximum value achievable with the available X-ray tube, so as to minimize exposure time, according to the voltage chosen (see 3.5.5.4).

3.5.5.4 Voltage

The voltage applied shall be the smallest possible (provided selected film densities) so as to increase pre-film contrast while remaining compatible with a reasonable exposure time. This is especially valid for castings with small thickness variations. In the contrary case, a voltage increase leads to wider thickness latitude.

3.5.5.5 Focus-to-film distance

Any increase in focus-to-film distance results in smaller geometric unsharpness but in extended exposure times. Compromise shall then be achieved. In practice, this distance shall be approximately 0,7 m to 1 m, 0,7 m being considered as a minimum with an optical focus of 1,5 mm × 1,5 mm.

3.5.5.6 Geometric unsharpness

Geometric unsharpness is due to the fact that the X-ray source is not spotlike and that the image of a discontinuity on a film always presents areas of umbra and penumbra. The maximum geometric unsharpness is given by the formula

$$f = \frac{d \cdot a}{F - a}$$

where

d is the useful size, in millimetres, of the focal spot;

a is the distance, in millimetres, from the radiation incidence surface to film;

F is the focus-to-film distance, in millimetres.

It is observed that the greater F is, the smaller the geometric unsharpness is. In practice, it will be ensured that f is less than 0,2 mm.

3.5.6 Scattered radiation

3.5.6.1 Back-scattered radiation

It is indispensable to place a lead layer of adequate thickness behind the film or the film cassette, to absorb back-scattered radiation. A thickness of 3 mm