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Radiographic inspection of resistance spot welds for aluminium and its alloys — Recommended practice

Examen aux rayons X des soudures par résistance par points sur l'aluminium et ses alliages — Pratiques recommandées

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3777 was drawn up by Technical Committee ISO/TC 44, *Welding*, and was circulated to the Member Bodies in May 1975.

It has been approved by the Member Bodies of the following countries :

Austria	Ireland	Sweden
Belgium	Israel	Switzerland
Bulgaria	Italy	Turkey
Canada	Netherlands	United Kingdom
Czechoslovakia	New Zealand	U.S.A.
France	Romania	U.S.S.R.
Germany	South Africa, Rep. of	Yugoslavia
India	Spain	

No Member Body expressed disapproval of the document.

Radiographic inspection of resistance spot welds for aluminium and its alloys — Recommended practice

0 INTRODUCTION

As it appeared desirable to publish documents for the radiographic examination of fusion welded joints on steel and on aluminium (ISO/R 947, ISO/R 1106, and ISO 2437), it has also been thought worth-while to prepare similar documents for the examination of resistance welds on aluminium and its alloys.

In fact, on comparing these joints with fusion welded butt joints, the following differences will be observed :

- absence of reinforcement;
- the surface of the joint runs parallel to the surfaces of the welded members;
- particular shape of the weld metal zone;
- defects which may be different from those found in fusion welds;
- small total thickness (in general under 6 mm).

Moreover, it is to be observed that resistance spot welding is, under excellent conditions, applicable to heat-treatable alloys, notably those alloyed with copper, on which fusion butt welded joints are inadvisable.

The recommendations in question should not be considered as acceptance standards for welds; they are concerned only with the radiographic technique to be used.

1 SCOPE

This International Standard establishes general principles for radiographic techniques with the object of enabling satisfactory results to be obtained and it enunciates some rules which are based on generally accepted practice and the fundamental theory of the subject.

2 FIELD OF APPLICATION

This International Standard applies to lap joints made on aluminium and its alloys. It is based upon radiographic techniques, which were or are successfully applied in industry for the inspection of resistance spot welds on light alloys of small total thicknesses.

3 REFERENCES

ISO/R 1027, *Radiographic image quality indicators — Principles and identification.*

ISO 2504, *Radiography of welds and viewing conditions for film — Utilization of recommended patterns of image quality indicators (I.Q.I.).*

4 GENERAL

4.1 Protection

Exposure of any part of the human body to X-rays can be highly injurious. It is therefore essential that, wherever X-ray equipment is in use, adequate precautions should be taken to protect the radiographer and any other person in the vicinity.

Safety precautions against X and gamma radiations are specified in the Recommendations of the International Commission on Radiological Protection. In most countries official recommendations exist. These are in the main based on the recommendations of the International Commission.

4.2 Surface preparation

Generally speaking, surface preparation is not necessary when radiographs of spot welds are to be taken.

4.3 Location of the weld on the radiograph

Markers, usually in the form of lead arrows or other symbols, should be placed along both sides of the weld so that its position can be identified on the radiograph.

4.4 Identification of radiographs

Lead letters should be affixed to each section of the weld being radiographed. The images of those letters should appear on the radiograph to ensure unequivocal identification of the section.

4.5 Marking of the work-pieces

As the nature of the material and its service conditions often forbid stamping the work-pieces, other means of localisation, such as paint marks and accurate sketches, should be used.

4.6 Overlap of films

In radiographing a continuous length of spot welds the separate radiographs should overlap sufficiently to ensure that no portion of this length remains unexamined[1].

4.7 Image quality indicators (I.Q.I.)[2]

An image quality indicator of a type agreed between the contracting parties should be placed at one or both ends of every section radiographed. It should be placed on the surface facing the source of radiation. Only where this surface is inaccessible should the Image Quality Indicator be placed on the film side; in that case its position should be mentioned in the report, as the I.Q.I. indication does not then have the same meaning (for details concerning I.Q.I.s, see clause 6).

The minimum sensitivity values required from the I.Q.I. should be agreed between the contracting parties. These values merely provide a guide to the quality of the technique used.

5 RECOMMENDED TECHNIQUE FOR MARKING RADIOGRAPHS

5.1 Relative positions of the film and source of radiation

Depending on the circumstances and the accessibility of the work pieces, the following methods should be used :

5.1.1 *Flat work-pieces*

There is no difficulty in this case; both sides of the work-piece being always accessible, the method illustrated in figure 1 can be used.

5.1.2 *Cylindrical work-pieces : a) longitudinal and b) transverse welds* (figure 2)

5.1.2.1 FILM INSIDE, SOURCE OUTSIDE (figure 3)

The X-ray source is placed outside, the axis of the beam being perpendicular to the plane tangential to the circumference at the point where the axis strikes the work-piece.

The film is placed inside against the wall, its centre corresponding with the axis of the radiation beam.

Where continuous lengths of welds are concerned, this technique can only be used for hollow bodies sufficiently large to allow the film being placed correctly and only where the conditions laid down in 5.7 can be observed.

5.1.2.2 FILM OUTSIDE, SOURCE INSIDE (figure 4)

The X-ray source is placed inside and, in the case of a continuous length of transverse welds (b), preferably with the focus situated in the centre of the hollow body. The film is outside, its centre corresponding with the axis of the X-ray beam.

This technique, when applicable, gives the best results for circular welds on hollow cylindrical bodies, because the different parts of the film are situated at the same distance from the source, thus enabling uniform density to be obtained. However, for this technique, it is necessary either to use special equipment (a tube with a rod anode) or to have a work-piece of sufficient diameter to enable the source to be placed inside it.

5.1.2.3 FILM AND SOURCE OUTSIDE (figure 5)

The source is placed outside and, for transverse welds, the axis of the beam is inclined with respect to the surface containing the weld. Depending on the source-film distance chosen and the dimensions of the hollow body, it is possible to obtain with this technique, used for circular welds, either two images (source S) or a single image (source S′ or S″).

The film shall always be placed on the surface opposite to that facing the source of radiation.

This method should only be used for hollow bodies, the interior of which is inaccessible. Generally the positions S′ and S″ are used, position S (Double Wall Double Image) is seldom used and only for surfaces sufficiently close to each other to avoid the need for too great a source-to-film distance for obtaining the required geometrical unsharpness (see 5.4).

NOTE — Difficulty may arise due to the fact that radiation can penetrate either three or four times the nominal thickness of the parent metal.

5.2 Films and screens[3]

The use of salt screens is not permitted and the films should be of the direct, fine or ultra-fine grain type.

The X-ray generator voltages being generally lower than 100 kV, the intensifying role of the lead screens is negligible and the front screen, if its thickness is more than 0,02 mm, stops a great part of the radiation transmitted through the work piece, but has a filtering action on non-coherent scattered radiation.

Under these conditions, operators are recommended to use a lead back screen (thickness greater or equal to 0,2 mm) to reduce the effects of radiation diffused by objects situated behind the cassette.

NOTE — In certain cases a lead front screen of 0,02 to 0,05 mm for films being exposed to voltages between 50 and 100 kV could improve the image quality by filtering non-coherent scattered radiation. For voltages lower than 50 kV, the front screen is not of much practical importance, on the one hand because its filtering role becomes negligible because the scattered radiation is particularly coherent and, on the other hand, because of the over-long exposure times required.

In the absence of international standards, by "fine grain film" is meant a film having sufficient definition to reveal very small flaws.

1) For this purpose the last identifying letter placed at the end of a film shall appear also at the beginning of the next film.

2) The term "penetrameter" is commonly used in certain countries in this sense, but the expression "Image Quality Indicator" is now the internationally accepted term.

3) The definitions of the type of recommended films (non-screen and screen type, at least fine grain, high contrast, etc.) are related to the conventional descriptions of sensitive material. The figures for the thickness of lead screens are only intended for guidance.

5.3 Cassettes

As resistance spot welding on light alloys is only applicable to relatively small thicknesses and the walls of metallic cassettes offer the risk of being too absorbent, the film should, generally, be used in its paper envelope or, preferably, in an envelope which will not give a parasitic image.

However, when lead screens are used (relatively thick work-pieces and high voltages in the region of 100 kV or greater) rigid cassettes can be used to ensure a satisfactory film-screen contact.

With curved surfaces, in view of the general difficulty of procuring rigid cassettes with the desired curvature, it is preferable systematically to use flexible cassettes.

When appropriate and agreed between the contracting parties, long lengths of film in commercial packs, with integral metal intensifying screens, may be used.

5.4 Focus-film distance

The focus-film distance (f) depends on the dimensions (d) of the focal spot, the film to work-piece distance (b)[1] and the acceptable geometric unsharpness (U).

These three factors are related by the expression :[2]

$$f = \frac{b\,d}{U}$$

The film to work-piece distance (b) should be as small as possible, the film being maintained in close contact with the wall. In these conditions, the distance (b) is practically identical with the thickness of the weld being inspected.

However, in the case of the source-work-piece position shown in figure 5 and described in 5.1.2.3, which leads to the formation of two images, the distance (b) in the formula should be the exterior diameter of the tube and not the wall thickness, if it is intended to use two images.

The minimum focus-to film distance (f min.) should be determined on the basis of a value of 0,25 mm for the geometric unsharpness (U).

Under these conditions, a focus of $2 \times 2\ \text{mm}^2$ seems, in general, amply sufficient.

5.5 Alignment of the beam

As a general rule, the axis of the beam of radiation should be directed to the middle of the section under examination and should be normal to the surface at that point.

When using the double-wall and double-image technique, the inclination of the beam (figure 5) should be just sufficient to prevent a superimposition of the two images.

The inclination of the axis of the beam depends on the diameter and thickness of the cylindrical body and on the diameter of the spot welds.

5.6 Shielding from scattered radiation

Films should be shielded from scattered radiation by an adequate thickness of lead, at least 1,5 mm, placed behind the film-screen combination.

In addition, in order to reduce the effect of radiation scattered by the work-piece, adequate masking should be provided so as to limit the area irradiated to the section under examination.

5.7 Size of the area examined

The maximum area to be taken into consideration at each exposure should be such that the thickness of the material at the extremities of the exposed area, measured in the direction of the beam, does not lead to density values, on the film, outside the admissible limits laid down in 5.8.

5.8 Density of the radiograph

Exposure conditions should be such that the density of the radiograph in the area under examination, taking account of fog density, should be in excess of 2. A maximum value has not been fixed as this depends on the power of the viewer used.

To avoid unduly high fog densities, arising from ageing of the film, development time or temperature, the fog density should be checked from time to time on an unexposed sample taken from the films used and handled and processed under the same conditions as the actual radiographs. The maximum fog density should not exceed 0,2.

5.9 Tube voltage

To increase the contrast, the tube voltage should be as low as possible.

As a basis, the voltage should be chosen so as to give an appropriate density with an exposure of not less than 15 mA min for a target-to-film distance of about 760 mm.

As the choice of tube voltage is the determining factor, preference should be given to generators with continuously variable voltage. However, generators with voltage variable by steps are acceptable, provided the voltage variations between consecutive steps are lower than 10 % of the desired voltage.

1) By film-to-work-piece distance is meant the distance between the surface directly exposed to radiation and the film.

2) This is an approximation for the correct formula : $f = \frac{b\,(d + U)}{U}$