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ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 1106

RECOMMENDED PRACTICE FOR RADIOGRAPHIC INSPECTION OF FUSION WELDED BUTT JOINTS FOR STEEL PLATES UP TO 50 mm (2 in) THICK

1st EDITION

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BRIEF HISTORY

The ISO Recommendation R 1106, *Recommended practice for radiographic inspection of fusion welded butt joints for steel plates up to 50 mm (2 in) thick,* was drawn up by Technical Committee ISO/TC 44, *Welding,* the Secretariat of which is held by the Association Française de Normalisation (AFNOR).

Work on this question led to the adoption of a Draft ISO Recommendation.

In April 1967, this Draft ISO Recommendation (No. 1166) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia	Ireland	South Africa, Rep. of
Austria	Israel	Spain
Belgium	Japan	Sweden
Canada	Korea, Rep. of	Switzerland
Czechoslovakia	Netherlands	Turkey
Denmark	New Zealand	United Kingdom
Finland	Norway	U.S.A.
France	Poland	U.S.S.R.
Greece	Portugal	Yugoslavia
India	Romania	

One Member Body opposed the approval of the Draft :

Germany

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in September 1969, to accept it as an ISO RECOMMENDATION.

ISO Recommendation | R 1106 | September 1969

RECOMMENDED PRACTICE FOR RADIOGRAPHIC INSPECTION OF FUSION WELDED BUTT JOINTS FOR STEEL PLATES UP TO 50 mm (2 in) THICK

INTRODUCTION

The increasing use of X-rays and gamma-rays for the examination of welded joints has made it desirable to issue ISO Recommendations of a general character giving guidance on the application of these methods in order to attain satisfactory sensitivity in the test itself.

In the present state of knowledge of radiographic inspection of welds, it is undesirable to impose strict rules to be followed in order to obtain the best results; the final result depends upon many variables, for example the characteristics of the X-ray equipment or radioactive source, the characteristics of films and screens, and the characteristics and accessibility of welds.

However, it is possible, within certain limits, to access the radiographic quality by means of such devices as image quality indicators (I.Q.I), which are specified in ISO Recommendation R 1027, *Radiographic image quality indicators – Principles and identification.*

1. SCOPE

This ISO Recommendation provides general guidance on the techniques of radiography 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 ISO Recommendation relates to the examination of fusion welded butt joints in steel plate up to 50 mm (2 in) in thickness.

It should not be regarded as giving acceptance standards for joints and is concerned only with radiography as such.

3. DEFINITIONS

Definitions of the principal terms concerning radiographic techniques used in this ISO Recommendation are indicated in an Appendix published separately under the title *Explanations on the significance of the principal radiographic terms used in ISO Recommendations concerning welding.*

4. CLASSIFICATION OF RADIOGRAPHIC TECHNIQUES

The examination techniques are divided into the following three classes :

- Class A, general technique for X-ray examination;
- Class B, more sensitive X-ray technique;
- Class C, general technique for gamma-ray examination.

4.1 Class A

Most cases, in particular where mild or low alloy steel is concerned, are covered by the correct use of the technique given for Class A.

4.2 Class B

Class B (high-sensitivity X-ray examination) is intended only for more important and difficult cases or where the Class A technique is unlikely to reveal the imperfections sought. It is a technique in which only fine-grain films and lead screens are used; it therefore requires longer exposure times and, on occasions, the use of equipment capable of giving higher voltages than those required for Class A.

4.3 Class C

With regard to Class C (gamma-ray examination), it is to be noted that the detectability of imperfections obtainable even with the best gamma-ray technique is always inferior to that obtainable with the Class A technique. The use of gamma-rays should, therefore, be limited as far as possible to cases in which the shape, the thickness or the accessibility of the weld renders X-ray inspection impossible. It should be mentioned in the recording of technical data that gamma-rays have been used and full details of the source should be given (see section 7).

5. GENERAL

5.1 Protection

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

Safety precautions to be taken against X-rays and gamma-rays are those in force in each country.*

5.2 Surface preparation

In order to obtain the best flaw sensitivity, it is always advisable to remove surface imperfections before taking radiographs.

In general, surface preparation may not be necessary for radiography, but where surface irregularities might cause difficulty in detecting internal imperfections, the surface should be ground smooth.

5.3 Location of the weld in the radiograph

Markers, usually in the form of lead arrows or other symbols, should be placed alongside the weld on each side of it, so that the position of the weld can be identified on the radiograph. This may not be necessary if the reinforcement is retained.

5.4 Identification of radiographs

Lead letters or symbols should be affixed to each section of the weld being radiographed. The images of these letters should appear in the radiograph to ensure unequivocal identification of the section.

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* In default of such regulations, reference should be made to the latest Recommendations of the International Commission on Radiological Protection.

5.5 Marking

In general, permanent markings on the work piece will provide reference points for the accurate re-location of the position of each radiograph. Where the nature of the material and its service conditions render stamping impossible, other suitable means for re-locating the radiographs should be sought. This may be done by paint marks, or by accurate sketches.

5.6 Overlap of films

In radiographing a continuous length of weld, the separate radiographs should overlap sufficiently to ensure that no portion of this length remains unexamined.

5.7 Image quality indicators

An image quality indicator (I.Q.I) of mild steel, of a type specified in ISO Recommendation R 1027 and agreed between the contracting parties, should be placed at one or each end of every section to be radiographed. It should be placed on the surface facing the source of radiation, and in such a manner that the thinnest part or smallest diameter of the indicator is placed where the thickness penetrated by the radiation is greatest and, depending upon its type, adjacent to or across the weld. Only where this surface is inaccessible should the I.Q.I. be placed on the film side. If this has to be done, it should be mentioned in the recording of technical data, as the I.Q.I. indication has not the same meaning when the I.Q.I. is placed in this position. For details of the recommended type of I.Q.I., see ISO Recommendation R 1027.

The sensitivity values required from I.Q.I. should be agreed between the contracting parties. These values merely provide a guide to the quality of the technique used and do not necessarily bear any direct relation to sensitivity as regards the detection of faults in welds.

6. RECOMMENDED TECHNIQUE FOR MAKING RADIOGRAPHS

6.1 Films and screens*

The following types of films and screens should be used :

6.1.1 *Class A.* According to circumstances, non-screen films may be used without screens or with lead screens. The thickness of these screens should lie within the range 0.02 to 0.15 mm (0.001 to 0.006 in).

The use of salt screens is not recommended, but if, because of unavoidable circumstances, they are used, they should be of the high-definition type, and this should be mentioned in the recording of technical data, as this technique causes loss of definition.

6.1.2 *Class B.* Fine-grain, high-contrast films should be used in combination with lead screens. The thickness of these screens should lie within the range 0.02 to 0.15 mm (0.001 to 0.006 in).

6.1.3 *Class C.* Fine-grain, high-contrast films should be used in combination with lead screens. The thickness of the front screens should lie within the range 0.02 to 0.15 mm (0.001 to 0.006 in). The back screens may be of greater thickness.

6.2 Cassettes

Films and screens (if used) should be contained in cassettes. Rigid cassettes are recommended, but flexible cassettes may be used. In either case, adequate precautions should be taken to ensure a good film-to-screen contact.

6.3 Alignment of beam

The axis of the radiation beam should be directed at the middle of the section under examination and should be normal to the plate surface at that point, except in special examination for certain imperfections which it is known can best be revealed by a different alignment of the beam, for example imperfections at a fusion face where the exposure should be made with the beam directed along the fusion face.

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* The definitions of the types of recommended films (non-screen and screen type, fine-grain, high-contrast, etc.) correspond to the conventional descriptions of sensitive material. The same applies to high-definition and high-speed salt screens. The figures for thickness of lead screens are intended only for guidance.

6.4 Interception of unwanted and scattered radiation

The film should be shielded from all back scattered radiation by an adequate thickness of lead, 1.5 mm (0.05 in) at least, placed behind the film-screen combination. On account of the back radiation originated by the lead itself it is suggested that a tin sheet about 1 mm (0.04 in) thick or, better, a tin and a copper sheet, each 1 mm (0.04 in) thick, should be inserted between the lead plate and the film-screen combination.

Moreover, in order to reduce the effect of internal scattered radiation, adequate masking should be provided so as to limit the area irradiated to the section under examination.

6.5 Target (source) -to-film distance

The distance between the film and the adjacent weld surface should be as small as possible.

The minimum target (source) -to-film distance $f_{min.}$ depends on the effective dimension d* of the focal spot or source of radiation and on the distance b between the film and the surface of the specimen facing the X-ray tube or gamma-ray source.

The resulting geometric unsharpness or penumbra, u, can be calculated from the following formula :

$$u = \frac{bd}{f_{min.} - b}$$

It should not exceed the following values :

Class A	Class B	Class C
0.4 mm (0.015 in)	0.2 mm (0.008 in)	0.4 mm (0.015 in)

6.6 Size of the area examined

The 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 incident at that point, does not exceed the actual thickness at that point by more than the following values :

Class A	Class B	Class C
10 %	6 %	10 %

A larger target (source) -to-film distance will, therefore, generally allow the use of larger film size.

6.7 Density of radiograph

Exposure conditions should be such that the density of the radiograph of the sound weld metal in the area under examination, including fog density, lies within the following ranges :

Class A	Class B	Class C
1.7 to 3.0 for non-screen type films 1.3 to 2.3 for screen type films for the exceptional case where this type of film is used	2.0 to 3.0	2.0 to 3.0

Higher densities may be used with advantage where the viewing light is sufficiently bright to permit adequate interpretation. Precautions should be taken to avoid glare.

• The *effective focal spot dimension* is the maximum dimension of the projected focal spot in a line at right angles to the tube axis which passes through the target. To verify the effective dimension of the focal spot, see document 183-65 of the International Institute of Welding, *Recommendation for the determination of focal spot size of X-ray tubes.*

For Classes B and C, if prior agreement has been given by the inspecting authority, who in some cases will be the purchaser himself and in other cases an authority in whom consulting and inspection rights have been vested by the purchaser, the density may be reduced to 1.7.

In order to avoid unduly high fog densities arising from film ageing, development, or temperature, the fog density should be checked from time to time on a non-exposed sample taken from the films being used, and handled and processed under the same conditions as the actual radiographs. The fog density should not exceed 0.2.

6.8 Tube voltage or type of source

In order to increase the contrast, the tube voltage should be as low as practicable. As a basis, the voltage should be chosen so as to give an appropriate density with an exposure of not less than 8 mA minute for Class A, and not less than 15 mA minute for Class B, for a target (source) -to-film distance of about 760 mm (30 in); the time should in no case be less than 1 minute.

Gamma-ray sources give the best results above the following thicknesses :

^{192}Ir	10 mm ($\frac{3}{8}$ in)
^{137}Cs	25 mm (1 in)
^{60}Co	38 mm (1 $\frac{1}{2}$ in)

6.9 Processing

Film should be processed in accordance with the recommendations of the film manufacturer. Particular attention should be paid to temperature and developing time. The radiographs should be free from imperfections, due to processing or other causes, which would interfere with interpretation.

6.10 Viewing

The radiographs should be examined in a darkened room on an illuminated diffusing screen and the illuminated area should be masked to the minimum required for viewing the radiographic image. The brightness of the viewing screen should preferably be adjustable so as to allow satisfactory reading of the radiographs.

7. RECORDING OF TECHNICAL DATA

For each radiograph, or set of radiographs, information should be available on the radiographic technique used, and on any other special circumstances which would allow a better understanding of the results.

In particular, the following should be stated :

(*a*) type of X-ray equipment, tube voltage and current;

(*b*) characteristics of the radioactive source (nature, size, nuclear activity, etc);

(*c*) time of exposure, type of film and screen and target (source) -to-film distance;

(*d*) system of marking used.

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