INTERNATIONAL STANDARD ISO 2405

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Recommended practice for radiographic inspection of fusion welded butt joints for steel plates 50 to 200 mm thick

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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 2405 was drawn up by Technical Committee ISO/TC 44, *Welding.*

It was approved in January 1972 by the Member Bodies of the following countries :

Austria	India	Sweden
Belgium	Ireland	Thailand
Canada	Israel	Turkey
Czechoslovakia	Italy	United Kingdom
Egypt, Arab Rep. of	Norway	U.S.S.R.
Finland	Romania	
France	South Africa, Rep. of	

The Member Bodies of the following countries expressed disapproval of the document on technical grounds :

Germany
Japan
Switzerland

Printed in Switzerland

Recommended practice for radiographic inspection of fusion welded butt joints for steel plates 50 to 200 mm thick

0 INTRODUCTION

The radiographic techniques suitable for examination of fusion butt welds in steel plates up to 50 mm thick are described in ISO/R 1106. This new document is arranged on similar lines, to cover welds in plate thicknesses up to 200 mm.

It is hoped that these documents will have the effect of ensuring more unified practice and so simplify interpretation of results. This document does not lay down standards of acceptance for the welds.

There is only a limited number of types of equipment suitable for this work (for example there are no commercial X-ray sets operating between 400 and 1 000 kV). The available equipment has been arranged into a number of groups and techniques have been detailed which are suitable for the production of satisfactory radiographs, from the equipment in each group. Many clauses in the recommended practice are common to all the techniques.

The steel thickness for which each type of equipment is considered to be suitable is given in Table 1; it is possible to use betatrons and linear accelerators for greater thicknesses.

The Figure indicates the relative performance of the various types of equipment in terms of I.Q.I. sensitivity, using the techniques described. These values of sensitivity are not mandatory, but are given as a guide for choosing a technique for a particular weld thickness.

Explanatory notes are included, as necessary.

1 SCOPE

This International Standard 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 International Standard relates to the examination of fusion welded joints for steel plates 50 to 200 mm thick.

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

3 REFERENCES

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

ISO/R 1106, *Recommended practice for radiographic inspection of fusion welded butt joints for steel plates up to 50 mm (2 in) thick.*

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

4 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 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* .

TABLE 1 – **Type of equipment and thickness of steel**

Group	Description of equipment	Useful thickness mm
A	X-rays : up to 400 kV	50 to 85
B (I)	X-rays : 1 and 2 MV, focus > 6 mm	50 to 125[1]
B (II)	X-rays : 1 and 2 MV, focus < 1 mm	50 to 125[1]
C	X-rays : linear accelerators 3 to 8 MV	70[2] to 200
D	X-rays : betatrons and linear accelerators, 8 to 35 MV	70[2] to 200
E	Gamma-rays, Cobalt 60	50 to 150[3]
F	Gamma-rays, Iridium 192	50 to 110[3]

1) For the 2 MV equipments, the maximum thickness can be extended to 200 mm.

2) This thickness may be reduced to 60 mm if very fine-grain films are used and a density of 3 is reached.

3) The upper end of the thickness range can only be achieved with either very high strength sources or very long exposure times.

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

5 EQUIPMENT

Table 1 shows the types of equipment which are at present known to be commercially available and indicates the steel thicknesses (within the range covered by this document) for which the equipment is considered to be suitable for butt weld inspection.

6 SURFACE PREPARATION

In general, surface preparation may not be necessary for radiography, but where surface irregularities might cause difficulty in detecting internal defects, the surface should be ground smooth. It is always advisable to remove surface defects before taking radiographs.

7 LOCATION OF WELD IN RADIOGRAPH

Markers designating the weld limits, usually in the form of lead arrows or other symbols, should be placed alongside the weld on each side of it, in such a way that they are visible on the radiograph. This may not be necessary if the reinforcement is retained.

8 IDENTIFICATION OF RADIOGRAPHS

Lead letters 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.

9 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 undesirable, other suitable means for re-locating the radiographs should be sought. This may be done by paint marks or by accurate sketches.

10 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. The overlap of films should not exceed 20 mm.

11 IMAGE QUALITY INDICATORS

An image quality indicator (I.Q.I.) of mild steel, of a type specified in ISO/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 use of recommended I.Q.I.s, see ISO 2504.

The sensitivity values required from I.Q.I.s 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.

12 TYPE OF FILM

12.1 With equipment in groups A, B, E and F, the film used should be one of the types known as medium-speed, fine-grain or very fine-grain X-ray film. These films are usually described as "direct type", for use with metal intensifying screens, or as "non-screen" film.

12.2 With equipment in groups C and D, the film should be of the fine-grain or very fine-grain, direct type. Medium-speed film is not normally necessary.

13 INTENSIFYING SCREENS

The film should be used in a type of X-ray cassette which ensures very good contact between the intensifying screens (or screen) and the film emulsion.

NOTE – With thick screens, conventional cassettes are not always satisfactory from this point of view and vacuum-type cassettes can be used with advantage.

The screen thicknesses and materials should be as follows :

Group A :

Lead foil screens : front 0.02 to 0.1 mm;
: back 0.02 to 0.1 mm.

Group B :

Lead foil screens : front 0.2 to 1.0 mm;
: back 0.5 to 1.6 mm.

Group C :

Copper or lead screens : front 1.0 to 1.6 mm;
: back 1.0 to 1.6 mm.

Group D :

Tantalum, tungsten or lead screens : front 1.0 to 1.6 mm;
: back none.

NOTE – Screens of tantalum or tungsten give better sensitivity.

Group E :

Copper or lead screens : front 0.2 to 1.0 mm;
: back 0.1 to 0.5 mm.

NOTE – In place of copper or copper base alloy screens, it is possible to use screens of other materials of low atomic number and high specific density (Ni, Zn and their alloys).

Group F :

Lead foil screens : front 0.05 to 0.2 mm;
back 0.05 to 0.2 mm.

14 FILTERS

When gamma-ray sources are used, i.e. equipment in groups E and F, a filter may be placed between the specimen and cassette. This filter should be of lead 1.0 mm thick with Iridium 192 sources and 2.0 mm thick with Cobalt 60 sources.

15 ALIGNMENT OF BEAM

The beam of radiation should be directed to the middle of the section of the weld being examined and should be normal to the plate surface at that point, except in special examinations for certain defects, for example, lack of side-wall fusion, when it is known that these can best be detected by a different alignment of the beam.

16 INTERCEPTION OF SCATTERED RADIATION

The film cassette should be shielded as thoroughly as possible from all back-scattered radiation by an adequate thickness of lead placed in or behind the cassette.

With equipment in groups A, B, E and F, the minimum desirable thickness of lead is about 2.5 mm.

In order to minimize the unwanted effect of the scattered radiation from the workpiece and from its surroundings, masking should be used whenever possible to limit the size of the film and edge blocking should also be used if the end of the weld, or any large section-change, is within the radiation field.

17 FOCUS-FILM DISTANCE/SOURCE-FILM DISTANCE (f.f.d./s.f.d.)

Two separate considerations arise. With equipment in Groups A, B, E and F, the f.f.d. (or s.f.d.) is determined from the focal spot or source size, in terms of unsharpness and an economical exposure-time.

With equipment in Groups C and D, the radiation field is usually restricted in size and the f.f.d. is chosen in terms of a useful field size (length of weld covered per exposure).

Table 2 shows minimum values of f.f.d. or s.f.d. based on these criteria, for a number of specimen thicknesses. Intermediate values can be interpolated for other specimen thicknesses but the exact value of f.f.d. is not critical to this extent.

1) See ISO 2504.

TABLE 2 – **Minimum source-film distances (focus-film distances)**

Equipment group	Minimum source-film distance (or f.f.d.) in mm					See Notes
	Specimen thickness, mm					
	50	75	100	150	200	
A	1 000	1 250	–	–	–	1
B (I)	1 500	1 800	2 000	3 000	3 800	
B (II)	1 000	1 000	1 000	1 250	1 500	
C	–	1 000	1 500	1 500	1 500	2 and 3
D	–	–	–	–	–	4
E	500	650	750	900	–	5
F	750	900	1 000	–	–	5

NOTES

1 These values are based on a focus size of 5 mm; if the focus is of a different size, the f.f.d. should be adjusted in direct proportion.

2 These values are based on a focus size of 2 mm or less.

3 If a large field coverage is required, these values may have to be increased, irrespective of the focus size, dependent on the amount of beam-flattening which the equipment utilises.

4 The s.f.d. to be used should be chosen with regard to the length of the weld to be radiographed in one exposure and the beam-flattening of the equipment.

5 These values are based on a source diameter of 4 mm; for other sizes they should be adjusted in direct proportion, with a minimum value of 250 mm s.f.d.

18 SPECIMEN-FILM DISTANCE

Some equipment in Groups B (II) and D can have focus sizes less than 0.5 mm. With such equipment projective magnification techniques are practicable and the cassette may then be placed away from the specimen. This will result in improved sensitivity, but the length of weld covered on each radiograph will be smaller. Typical values of projective magnification are between 2 : 1 and 3 : 1. Such techniques should only be necessary for special applications.

With all other equipment, the film cassette should be placed near to the specimen. If there are considerable sudden changes of thickness in the weld, a small distance of about 10 mm between film and specimen can be recommended in order to eliminate to a certain extent the disadvantageous inhomogeneities of scattered radiation. If it is necessary for the cassette to be a greater distance from the specimen, the minimum f.f.d. values given in section 17 should be increased.

19 FILM DENSITY

In the image of the weld under examination, the film density corresponding to sound metal should not be less than 2.0 and not greater than 3.0; these values are inclusive of the fog density which should not be greater than 0.3.

There is no objection to having film densities higher than 3.0 if satisfactory film viewing conditions can be provided[1].

20 FILM PROCESSING

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

21 SENSITIVITY AND FILM VIEWING

The radiographs should be examined and the I.Q.I. sensitivity calculated in accordance with ISO 2504. The following should be noted in particular :

The I.Q.I. sensitivity required should be mutually agreed between the contracting parties but the Figure gives an indication of the values which should be expected. These values are not intended to be mandatory, but if the values obtained are not similar to these values, it is an indication that the technique is not being correctly applied.

The radiograph should be examined on an illuminated diffusing screen (viewing box) in a darkened room and the illuminated area should be masked to the minimum required for viewing the radiographic image. The brightness of the screen should be adjustable so as to allow satisfactory reading of the radiographs[1].

22 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) the type of equipment and for X-rays the tube voltage and current;

b) the time of exposure, type of film and screen, type of I.Q.I., source-film distance;

c) system of marking used.

1) See ISO 2504.