

Radiographic examination of fusion welded butt joints in steel —

**Part 1: Methods for steel 2 mm up to and
including 50 mm thick**

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Foreword

This Part of BS 2600 has been prepared under the direction of the Welding Standards Committee. It is a revision of BS 2600-1:1973, which is withdrawn. It is essential to quote the technique number in addition to the BS number whenever this standard is used.

The standard is divided into two Parts, not only to align with the thickness division adopted in the ISO recommendations, but also to allow more definite requirements to be given in BS 2600-2 for the greater thicknesses.

The same number of techniques has been maintained, the methods being suitable for all types of application, but no mandatory direction is given of when a particular technique should be used. As so many factors affect the exposure time, minimum values have not been made mandatory but are merely included as guidance. The extent of radiographic examination that should be applied and standards of acceptance are not specified as both of these aspects should be covered in the appropriate application standard or be agreed between the contracting parties.

The explanatory information in appendix A has been retained to amplify and, in some instances, to give the reasons underlying what is stated in this standard.

This edition introduces Ytterbium 169 and Thulium 170 for the first time as gamma-ray sources, thus reducing the lower limit of the thickness range covered by the standard to 2 mm for both X-rays and gamma-rays.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of this British Standard describes methods for the radiographic examination of fusion welded butt joints in steel 2 mm up to and including 50 mm thick.

The techniques have many features in common and the major differences lie in:

- a) whether X-rays or gamma-rays are used,
- b) the type of film used.

Because several techniques with differing sensitivities are detailed, it is necessary to specify for each particular application which technique is required to be used. It is insufficient merely to state that BS 2600-1 be followed without specifying the technique number (see Table 1).

No attempt is made to define which technique should be used for any particular application because this is a matter for agreement between the contracting parties.

NOTE 1 BS 2910 details the radiographic examination of butt welds in steel pipes.

NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Techniques

The techniques to be used shall be one of those given in Table 1, fuller details of which are given in clause 19 and appendix A.

3 Gamma-ray sources

The gamma-ray source to be used shall be one of those given in Table 2 according to the thickness of steel to be penetrated.

4 Protection

Exposure of any part of the human body to X-rays or gamma-rays can be injurious. It is essential that whenever X-ray equipment or radioactive sources are in use, adequate precautions shall be taken to protect the radiographer and others in the vicinity.

NOTE It should be noted that the use of X-ray equipment and gamma radiography in factories, on sites and in certain other premises and works coming within the scope of the Factories Act 1961 is currently controlled by the Ionising Radiations (Sealed Sources) Regulations 1969 and Radioactive Substances Act, 1960.

In the near future, the 1969 Regulations will be replaced by Ionising Radiations Regulations which will control all uses of X-rays and gamma rays for radiographic purposes. In addition there may be local regulations and requirements which need to be taken into consideration.

Some radiographic equipment recommendations are specified in BS 5650.

Advice on radiation safety may be obtained from the National Radiological Protection Board, Harwell, Didcot, Oxon, OX11 0RQ.

Table 1 — Individual techniques

Radiation	Technique number ^a	Type of film	Film density of weld area under examination
X-rays	1	Ultra-fine-grain high-contrast direct-type	2.0 to 3.0
	2	Fine-grain high-contrast direct-type	
	3	Medium-speed direct-type	
Gamma-rays	6	Ultra-fine-grain high-contrast direct-type	
	7	Fine-grain high-contrast direct-type	

NOTE 1 The type of film used with lead screens is known both as "non-screen" and as "direct-type" film.

NOTE 2 BS 5230 explains how industrial film speed and contrast are measured. Until measurements based on that standard are available the type of film should be agreed between the contracting parties.

NOTE 3 A density higher than 3.0 can be used, provided the film is examined on a high intensity illuminator.

^a There are fewer techniques than in earlier editions, but established technique numbers have been retained.

Table 2 — Minimum thicknesses for gamma-ray sources

Gamma-ray source	Minimum thickness of steel	Maximum thickness of steel
	mm	mm
Iridium 192	10	above 50
Caesium 137	25	above 50
Ytterbium 169	2	10
Thulium 170 ^a	2	10

NOTE It is emphasized that the minimum thicknesses on which gamma rays may be used, as given in Table 2, should not be interpreted as implying that on these thicknesses the flaw sensitivity with gamma-rays is equivalent to the flaw sensitivity with X-rays. Gamma-rays should be used only on the understanding that apart from geometric considerations the flaw sensitivity will be inferior to that of a good X-ray technique.

^a Thulium gives inferior results to ytterbium and the latter should be used when available.

5 Surface condition

In order to obtain maximum flaw sensitivity, the part of the work to be examined shall be smooth and free from irregularities such as weld ripples and grinding or chipping marks. The contour of the weld surface shall be smooth and any change in section shall be gradual.

Temporary backing shall be removed prior to radiography.

NOTE If the above conditions cannot be met the expedients described in A.2 may be used by agreement between the contracting parties.
NOTE By agreement between the contracting parties, the weld may be examined in the as-welded condition.

6 Weld image location

Markers, usually in the form of lead arrows or other symbols, shall be placed alongside, but clear of, the outer edges of the weld to identify its position.

7 Identification of radiographs

Each section of weld radiographed shall have suitable symbols affixed uniquely to identify:

- a) the job or workpiece;
- b) the joint;
- c) the section of the joint.

The symbols, usually consisting of lead letters or numerals, shall be positioned so that their images appear in the radiograph to ensure unequivocal identification of the section.

Radiographs of weld repairs shall be appropriately identified.

A written record detailing the identification of the radiograph shall be made.

8 Marking

In general, permanent marking of the workpiece shall be used to 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 of marking shall be used.

9 Density of radiograph

In the image of the length of weld under examination, the film density corresponding to the sound weld metal shall be not less than 2.0 and not greater than 3.0, unless special arrangements are made for the adequate viewing of higher density film.

NOTE These values are inclusive of the fog density¹⁾ of not greater than 0.3 (see also A.3).

¹⁾ Density of a processed unexposed film.

10 Image quality indicators

In order to provide a guide to the quality of the radiographic technique used, an Image Quality Indicator (IQI), otherwise known as a penetrameter, of one of the types recommended in BS 3971 shall be used, with dimensions appropriate to the thickness of the weld.

The method of assessing the radiographic sensitivity shall be that described in BS 3971 (see also A.4).

11 Intensifying screens

Intensifying screens shall be used in all the techniques except where otherwise indicated. The material of which they are to be made and their thickness ranges shall be in accordance with the details given in Table 3 (see also A.5).

Table 3 — Intensifying screens

Radiation	Screen material	Front screen thickness	Back screen thickness
		mm	mm
X-rays: below 120 kV	Lead	None	0.1 min.
X-rays: 120-250 kV	Lead	0.01 to 0.125	0.1 min.
X-rays: 250-400 kV	Lead	0.05 to 0.16	0.1 min.
Gamma-rays: ¹⁹² Ir, ¹³⁷ Cs	Lead	0.05 to 0.16	0.16 min.
Gamma-rays: ¹⁶⁹ Yb, ¹⁷⁰ Tm	Lead	0.05 to 0.16 ^a	0.1 ^a min.

^a Below 5 mm weld thickness image quality is improved at the expense of exposure times by the omission of the lead screens.

12 Cassettes

In all cases precautions shall be taken to ensure good film-screen contact irrespective of whether rigid cassettes, which are recommended, or flexible cassettes are used.

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

13 Object-film distance

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