TC 135

International Standard ISO 5579

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Non-destructive testing — Radiographic examination of metallic materials by X- and gamma rays — Basic rules

Essais non destructifs — Contrôle des matériaux métalliques au moyen de rayons X et γ — Règles de base

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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.

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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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Contents

Non-destructive testing — Radiographic examination of metallic materials by X- and gamma rays — Basic rules

Radiation protection — Health warning

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

Limits for the safe levels of X- and gamma radiation as well as the recommended practice for radiation protection are those valid in the different countries. If there are no official regulations or recommendations in a country, the latest Recommendations of the International Commission on Radiological Protection should be applied.

0 Introduction

NOTE — Throughout this International Standard the terms "flaw", "flaw detection", "flaw sensitivity" are used without the term "flaw" having any implication of unacceptability or acceptability.

For an item submitted to radiographic flaw detection by means of X- or gamma rays, the detectability of flaws depends on the details of the radiographic technique. Since the quality of the radiograph cannot be completely ensured by the use of an image quality indicator (I.Q.I.), this International Standard explains the basic rules and technical procedures to obtain comparable radiographs from different origins.

Standards relating to specific applications should conform with these basic rules.

1 Scope and field of application

This International Standard gives the basic rules for industrial X- and gamma radiography for flaw detection purposes, using film techniques, applicable to metallic products and materials.

2 References

ISO 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.).*

ISO 5576, *Industrial radiology — Non-destructive testing — Vocabulary.* [1)]

3 Definitions

Definitions of terms concerning radiographic techniques used in this International Standard are indicated in ISO 5576.

4 Classification of radiographic techniques

Radiographic techniques are divided into the following two classes:

— Class A: a general technique;

— Class B: a more sensitive technique intended for use where the usual method may give unsatisfactory results or is unlikely to reveal the anomalies sought.

Many applications are covered by the correct use of the rules given for class A.

Class B is intended for cases which require a greater degree of sensitivity. It generally requires longer exposure times.

In addition to having an adequate flaw sensitivity, some applications of radiography require the radiographs to cover a range of specimen thicknesses. Several modifications of either class A or B will produce an increase in thickness latitude; details are given in 8.5.

The class required for a particular application shall be agreed in advance between the customer and the supplier, taking into account the flaw sensitivity required, the thickness latitude necessary, the equipment available, cost, accessibility, etc.

1) At present at the stage of draft.

5 Test arrangement

The test arrangement consists of the radiation source, test object and the film or film-screen combination in a cassette. It depends on the size and shape of the object and the accessibility of the area to be tested. Generally, one of the arrangements illustrated in figures 1 to 7 should be used, figure 1 being the most usual case.

The beam of radiation shall be directed at the middle of the section under examination and shall be normal to the surface at that point except when it is known that certain flaws are better revealed by a different alignment of the beam.

When radiographs are taken in a direction other than normal to the surface, this shall be indicated in the test report.

Double-wall techniques shall only be used if single-wall techniques are technically not practical.

6 Surface conditions

Visible surface irregularities which could adversely affect evaluation of the radiograph shall be removed before radiography is carried out. In special cases it may be advantageous to remove excessive surface roughness before the test.

7 Identification and marking

Letters or symbols shall be affixed to each section of a test object being radiographed. The image of these markers shall appear in the radiograph to ensure unequivocal identification of the section. The use of a film imprinter or other means prior to development is also permitted.

In general, permanent markers on the test object 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 shall be sought. This may be done by paint marks or by accurate sketches.

If the position of the area to be examined cannot be recognized from the shape of the workpiece, markers shall be placed so that the position of the area can be identified on the radiograph.

8 Technique

8.1 Principles

The ability to detect flaws on a radiograph depends on the viewing conditions and on the photographic density difference (contrast) between the image and the background, when the film is placed on an illuminated viewing screen. Overall radiographic sensitivity depends on the following factors:

- radiation source and energy (see 8.4);
- scattered radiation (see 8.6);
- type of film and screens (see 8.2);
- film characteristics (see 8.2 and clause 10);
- geometric conditions (see 8.3);
- material and thickness of specimen.

8.2 Choice of film and intensifying screens

8.2.1 Film classes

Until the publication of another specific International Standard on this subject, the approximate classification given in table 1 may be used.

Those types of films which are used in combination with special screens, for example, fluorescent screens, are not included in table 1.

Table 1 — Classification of X- and gamma ray films

Film classes	Grain	Speed
G I	Very fine-grained film	Very slow
G II	Fine-grained film	Slow
G III	Film with medium grain size	Medium speed
G IV	Film with larger grain size	High speed

8.2.2 Film type

For class A, G III or finer-grained film shall be used.

For class B, G II or finer-grained film shall be used.

8.2.3 Intensifying screens

Screens of metal foil of thicknesses given in table 2 shall be used. These screens shall be clean, smooth and free from mechanical defects which could affect the interpretation. They shall be held in close contact with the film emulsion.

In the double-film technique, the use of an intermediate screen is recommended.

8.3 Geometric conditions

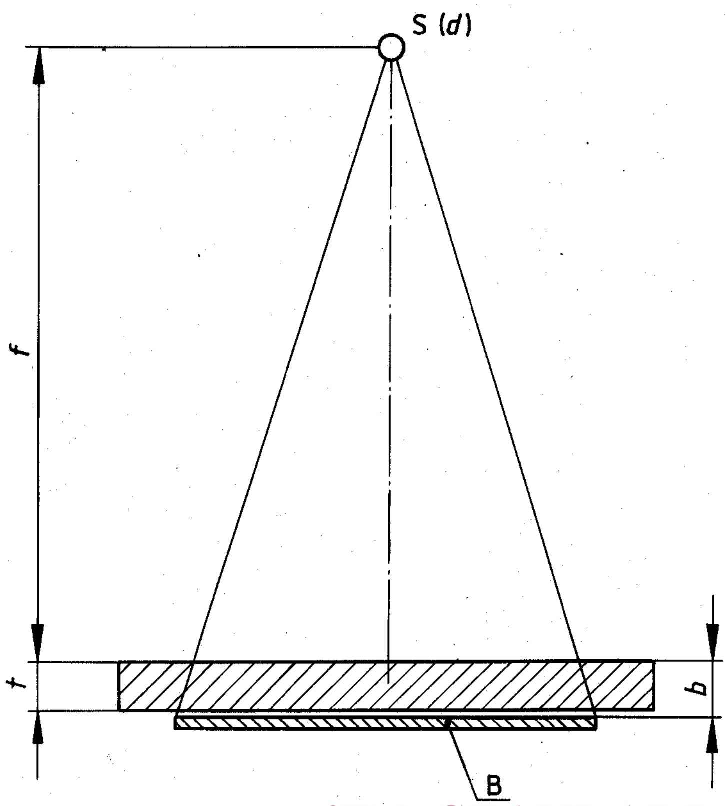
In order to avoid an unreasonable total unsharpness, the requirements given in 8.3.1 and 8.3.2 shall be fulfilled.

When using a magnification technique, it is necessary to increase the object-to-film distance (dimension b in figure 1). In this case sub-clauses 8.3.1, 8.3.2 and 8.3.3 would not be applicable.

In the case of curved specimens, the source shall be positioned to avoid any geometrical distortion.

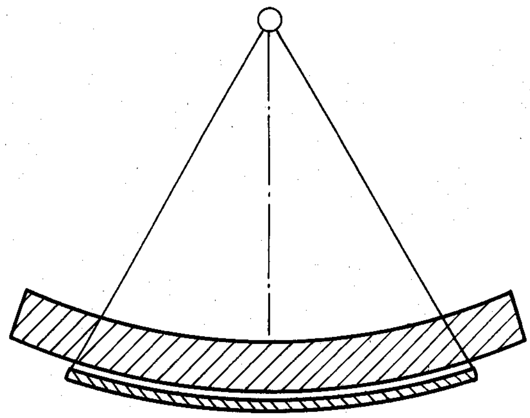
8.3.1 Source-to-object distance

The minimum distance f between the radiation source and the nearest surface of the specimen is given in figure 8, in terms of the specimen thickness t and the effective optical focus size d



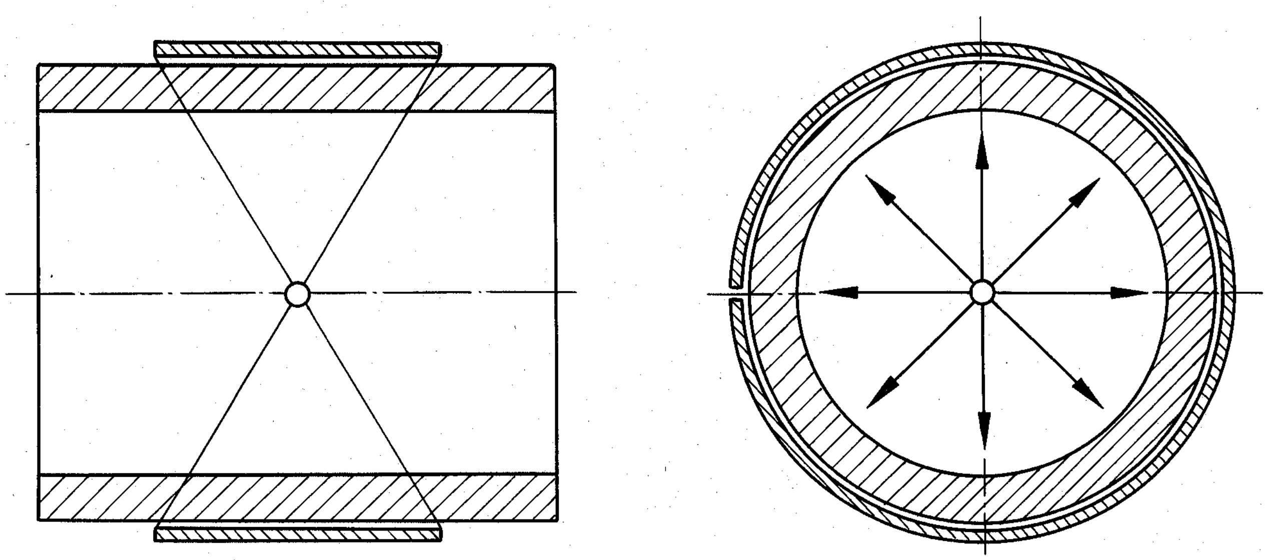
S Radiation source with an effective optical focus size d [1)]
B Film
f Source-to-object distance
t Material thickness
b Distance between the film and the surface of the object nearest the source.

Figure 1 — Arrangement 1 :
— single-wall penetration
— objects with plane walls



NOTE — This arrangement is preferred to arrangement 4 (see figure 4).

Figure 2 — Arrangement 2 :
— single-wall penetration
— object with curved walls
— source off-centre on concave side, film on convex side



NOTE — One advantage of this technique is that the whole circumference may be radiographed in one exposure. This arrangement is preferred to arrangements 2 (see figure 2), 4 (see figure 4) or 5 (see figure 5).

Figure 3 — Arrangement 3 :
— single-wall penetration
— object with curved walls
— source located centrally

1) International Standard in preparation; see also annex A.

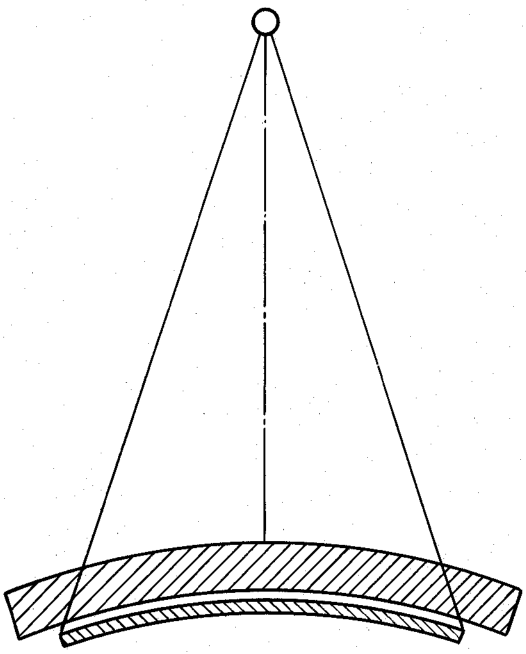
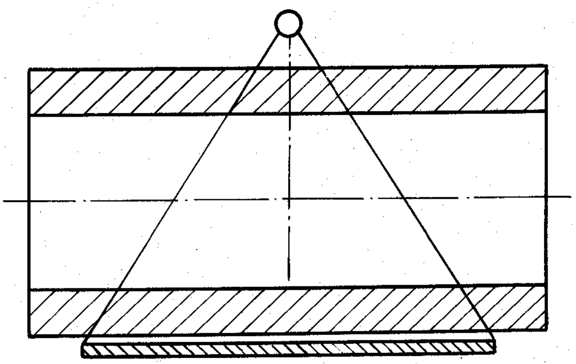
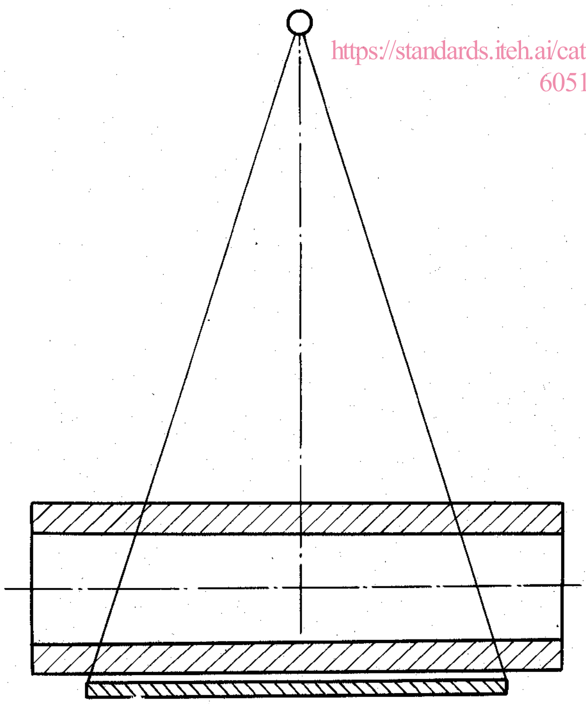


Figure 4 — Arrangement 4 :
— single-wall penetration
— object with curved walls
— source on convex side, film on concave side



NOTE — Because the source is close to the upper wall, flaws in this wall should not be evaluated.

Figure 5 — Arrangement 5 :
— double-wall penetration
— single-wall evaluation
— source and film outside



NOTE — Flaws in the upper wall may be evaluated. For some applications the radiation beam might be used at a different angle (i.e. not perpendicular to the centre of the film).

Figure 6 — Arrangement 6 :
— double-wall penetration
— double-wall evaluation
— source and film outside

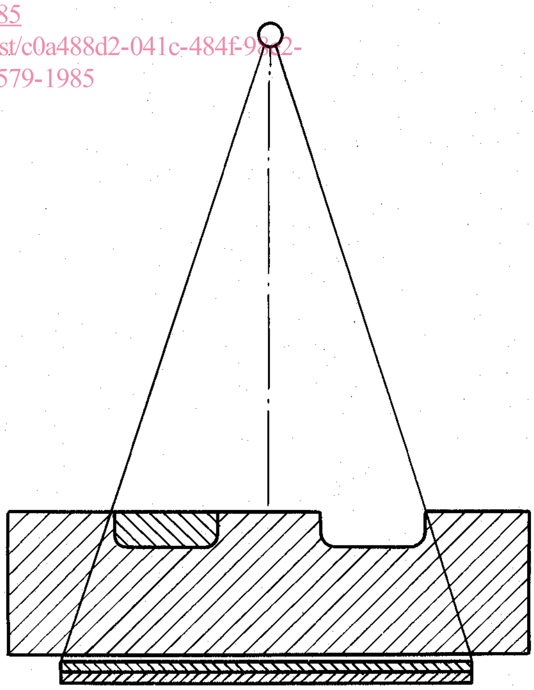


Figure 7 — Arrangement 7 :
— single-wall penetration
— objects with plane or curved walls of different thicknesses or materials
— two films with the same or different speeds

Table 2 — Choice of intensifying screens

X-ray potentials or gamma-source	Class A	Class B
≤ 400 kV	0,02 to 0,25 mm front and back screens of lead[1]	
^{192}Ir	0,05 to 0,25 mm front and back screens of lead	
^{60}Co	0,1 to 0,5 mm front and back screens of lead, steel[2] or copper[3]	0,4 to 0,7 mm front and back screens of steel[2] or copper[3]
1 to 2 MV	0,1 to 1,0 mm lead front and back screens	
2 to 6 MV	1,0 to 1,5 mm front and back screens of copper[3] or steel[2]	
6 to 12 MV	1,0 to 1,5 mm front screen < 1,5 mm back screen }	of copper[3], steel[2] or tantalum
> 12 MV	1,0 to 1,5 mm front screen of tantalum or tungsten No back screen	

1) For X-ray potentials below 100 kV no front screen is necessary, although a thin lead screen is sometimes useful to reduce scattered radiation.

2) Alloyed or unalloyed.

3) See also table 3.

in accordance with annex A for the two test classes. For direct determination of source-to-object distance, see the nomogram in annex B.

The corresponding geometric unsharpness U_g is given by the formula

$$U_g = \frac{d}{f} t$$

where

d is the effective optical focus size in accordance with annex A, in millimetres;

f is the source-to-object distance, in millimetres;

t is the material thickness, in millimetres.

For specimen thicknesses in the range of 40 to 100 mm, the source-to-object distance is usually a compromise between the technically desirable distance and a reasonably short exposure time. In this thickness range an increase in f will generally produce an improvement in flaw sensitivity.

8.3.2 Object-to-film distance

The cassette shall be in close contact with the surface of the test object whenever possible. When this is not possible and when the distance b is large compared with the thickness t, t shall be replaced by b on the abscissa of figure 8.

8.3.3 Special rules for objects with curved test areas

When objects with curved test areas are to be tested, the distance f in accordance with figure 8 and annex B may be reduced to half the value — but not less than the relevant radius of the test object — if placing the radiation source inside the test objects (for example, a pipe or pressure vessel, arrangement 2 or 3) leads to a more suitable direction of radiation than do arrangements 4, 5 or 6.

8.4 Radiation source

As stated in 8.1, an image on a radiograph on a viewing screen is discerned because of the photographic density difference between the image and the background (the image contrast).

Amongst other things, this image contrast depends on the radiation energy taken in relation to the material and thickness of the object (see 8.4.1).

The amount of scattered radiation reaching the film also affects this image contrast and steps need to be taken to minimize this scattered radiation (see clause 9).

8.4.1 Choice of radiation energy

The choice of radiation energy is dependent on the specimen thickness and its material, and sometimes on the accessibility for suitable radiographic equipment.

As a general rule, the radiation contrast increases as the radiation energy is decreased, so that, unless other reasons prevail, the lowest radiation energy compatible with an acceptable exposure time shall be used; for X-rays up to 450 kV, see figure 9; for X-rays above 1 MV and for gamma rays, see table 3.

With megavoltage X-rays, different considerations apply.

There are only a few gamma ray radio-isotopes with characteristics suitable for industrial radiography and only two of these, Iridium-192 and Cobalt-60, are widely used. Caesium-134 and -137, Tantalum-182, Ytterbium-169 and Thulium-170 are used in special cases.