BRITISH STANDARD

BS EN
12681:2003

Founding — Radiographic examination

The European Standard EN 12681:2003 has the status of a British Standard

ICS 77.040.20

National foreword

This British Standard is the official English language version of EN 12681:2003.

The UK participation in its preparation was entrusted to Technical Committee ISE/NFE/9, Foundry technology, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Founding - Radiographic examination

Fonderie - Contrôle par radiographie

Gießereiwesen - Durchstrahlungsprüfung

This European Standard was approved by CEN on 21 November 2002.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

This document (EN 12681:2003) has been prepared by Technical Committee CEN/TC 190 "Foundry Technology", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2003, and conflicting national standards shall be withdrawn at the latest by July 2003.

Within its programme of work, Technical Committee CEN/TC 190 requested CEN/TC 190/WG 4.10 "Inner defects" to prepare the following standard:

EN 12681, *Founding — Radiographic examination.*

Annex A is informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Radiography can be used to detect internal discontinuities in a casting. The discontinuities can be gas cavities, non-metallic inclusions, shrinkage, cracks, chaplets or chills or inclusions that have lower or higher densities than the parent metal.

1 Scope

This European Standard gives specific procedures for industrial X-radiation and gamma radiography for discontinuity detection purposes, using film techniques. These procedures are applicable to castings produced by any casting process, especially for steel, cast iron, magnesium, zinc, copper, nickel, aluminium, titanium and any alloys of them.

This European Standard does not apply to:

— the testing of welded joints;

— acceptance criteria;

— radioscopy (real time inspection).

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 444:1994, *Non-destructive testing — General principles for radiographic examination of metallic materials by X- and gamma-rays.*

EN 462-1, *Non-destructive testing — Image quality of radiographs — Part 1: Image quality indicators (wire type) — Determination of image quality value.*

EN 462-2, *Non-destructive testing — Image quality of radiographs — Part 2: Image quality indicators (step/hole type) — Determination of image quality value.*

EN 462-3, *Non-destructive testing — Image quality of radiographs — Part 3: Image quality classes for ferrous metals.*

EN 462-4, *Non-destructive testing — Image quality of radiographs — Part 4: Experimental evaluation of image quality values and image quality tables.*

EN 25580, *Non-destructive testing — Industrial radiographic illuminators — Minimum requirements (ISO 5580 : 1985).*

NOTE Informative references to documents used in the preparation of this standard, and cited at the appropriate places in the text, are listed in the bibliography.

3 Terms and definitions

For the purposes of this European Standard the terms and definitions given in EN 444:1994 apply.

4 General

4.1 Protection against ionizing radiations

Local, national or international safety precautions shall be strictly applied, when using ionizing radiation.

WARNING: Exposure of any part of the human body to X-rays or gamma-rays can be highly injurious to health.

4.2 General requirements

This European Standard shall be used in combination with EN 444.

Examination reports shall be made according to EN 444.

4.3 Agreements

Castings with a complex geometry can include areas which cannot be radiographically inspected or can only be partly inspected. Such areas shall be identified before starting the radiographic examination. Areas which cannot be radiographicly inspected shall be noted by all contracting parties and be marked on the film position plan.

The following items shall be agreed:

a) manufacturing stage;

b) extent of examination;

c) examination areas;

d) surface condition;

e) test class according to EN 444[1)];

f) information about the film position plan;

g) marking of examination areas on the casting;

h) image quality value according to EN 462-3 and EN 462-4;

i) marking of the films;

j) acceptance criteria.

Any additional items shall be agreed between the contracting parties.

Radiographs shall be evaluated by comparison to reference radiographs.

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1) It is recommended to perform the examination according to EN 444 test class A, if not otherwise specified. For alloys having a density of less than 5 kg/dm^3, test class B is recommended.

NOTE A selection of corresponding reference radiographs for materials and thickness ranges is given in annex A.

4.4 Personnel qualification

It is assumed that radiographic examination is performed by qualified and capable personnel. In order to prove this qualification, it is recommended to certify personnel in accordance with EN 473.

5 Examination arrangements

5.1 General

The examination arrangements to be used shall be in accordance with:

— Figures 1 to 6 for test areas of simple section;

— Figure 7 for double wall radiography;

— Figures 8 to 12 for test areas of complex section.

If these arrangements are not applicable, other arrangements may be used.

5.2 Single wall radiography of plane areas

The examination arrangement for single wall radiography of plane areas shall be in accordance with Figure 1.

5.3 Single wall radiography of curved areas

The test arrangement for single wall radiography of curved areas shall be in accordance with either Figures 2, 3 or 4.

NOTE If possible, the source of radiation should be placed in accordance with the arrangements shown in Figures 3 and 4 to achieve a more suitable direction of examination. The reduction in minimum source-to-object distance should not be greater than 40 % provided that the image quality requirements are met. EN 444:1994, 6.6 should be taken into account.

When the source is located centrally inside the object and the film outside (technique shown in Figure 4) and provided that the IQI requirements are met, this percentage can be increased. However, it is recommended that the reduction in minimum source-to-object distance is not greater than 50 %. Rigid cassettes can be used if the corresponding increase of b is considered for the calculation of the distance f between the source and source side of the test object.

5.4 Double wall radiography of plane and curved areas

The examination arrangement for double wall radiography of plane and curved areas shall be in accordance with either Figure 5, 6 or 7.

Double wall radiography shall be used, as an overview technique according to Figure 7, if the geometrical conditions make other examination arrangements difficult to apply or if there is a better sensitivity for detecting discontinuities by using this technique. It shall be assured that unacceptable discontinuities are detected with sufficient certainty. The required image quality shall be met.

In the case of examination arrangements according to Figures 6 and 7, the discontinuities shall be classified with reference to the single wall thickness. In the case of different wall thicknesses the reference shall be the smaller one.

In the case of examination arrangements according to Figure 5, the distance of the source from the surface of the area under examination shall be minimized provided that the requirements of IQI are met.

5.5 Choice of examination arrangements for complex geometries

Unless otherwise agreed, the examination arrangements for complex geometry areas shall be in accordance with Figures 8 to 12 (as appropriate).

5.6 Acceptable examination area dimensions

In addition to the requirements given in EN 444, the angle of incident radiation shall not exceed 30°.

NOTE This value can be larger, if special orientations of discontinuities can be detected in this way or if it is the only way to test areas otherwise impossible to test.

5.7 Explanation of symbols used in the figures

In Figure 1, the following symbols apply:

Q is the source of radiation;

t is the nominal thickness of the material in the region under examination;

b is the distance between the radiation side of the test object side and the film surface measured along the central axis of the radiation beam;

B is the radiographic film;

f is the distance between the source of radiation and the source side of the test object measured along the central axis of the radiation beam;

w is the thickness of material in the direction of the radiation beam calculated on the basis of the nominal thickness (see clause 6). If the actual thickness of the material deviates from the nominal one by more than 10 %, the actual wall thickness shall be used (see *t* and *W*).

In Figures 2 to 12, the symbols given in Figure 1 apply accordingly.

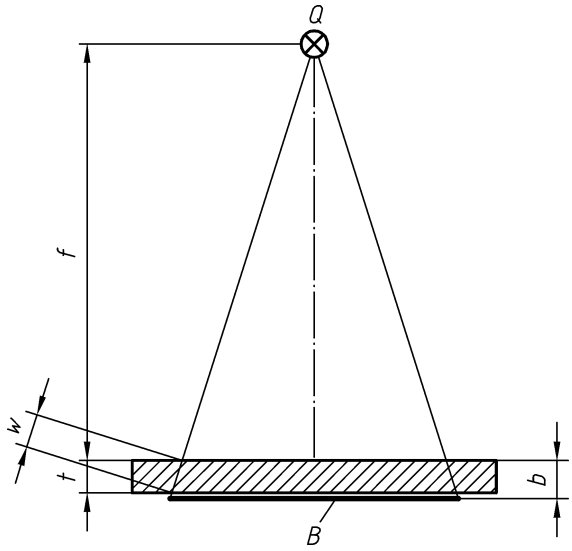


Figure 1 — Examination arrangement for single wall radiography of plane areas

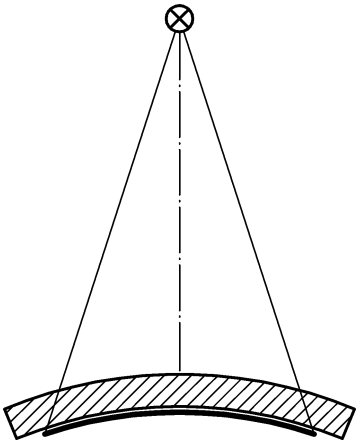


Figure 2 — Examination arrangement for single wall radiography of curved areas with the source on the convex side and the film on the concave side of the area under examination

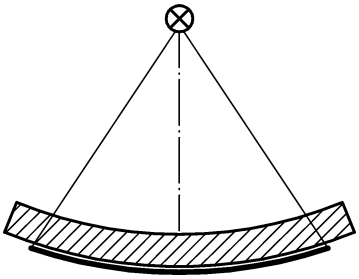


Figure 3 — Examination arrangement for single wall radiography of curved areas with eccentric positioning of the source on the concave side and the film on the convex side of the area under examination

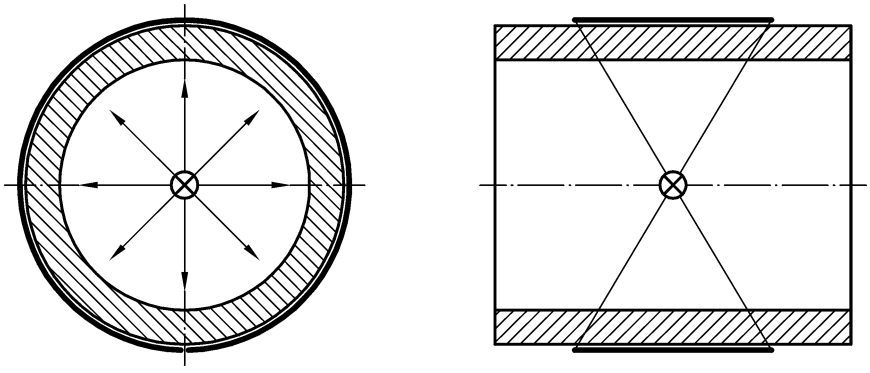


Figure 4 — Examination arrangement for single wall radiography of curved areas with central positioning of the source on the concave side and the film on the convex side of the area under examination

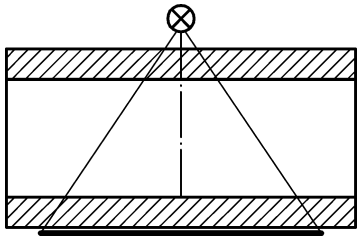


Figure 5 — Examination arrangement for double wall radiography of plane or curved areas under examination; source and film outside the test area, only the film side wall imaged for interpretation

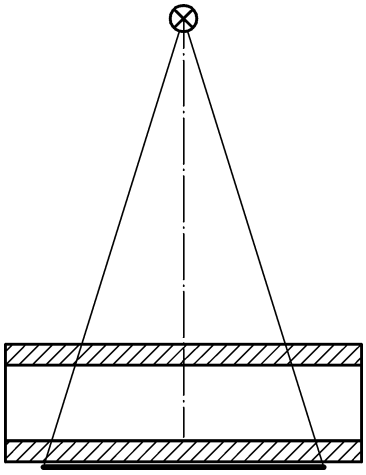


Figure 6 — Examination arrangement for double wall radiography of plane or curved areas under examination; several exposures; source and film outside of the test area; both walls imaged for interpretation

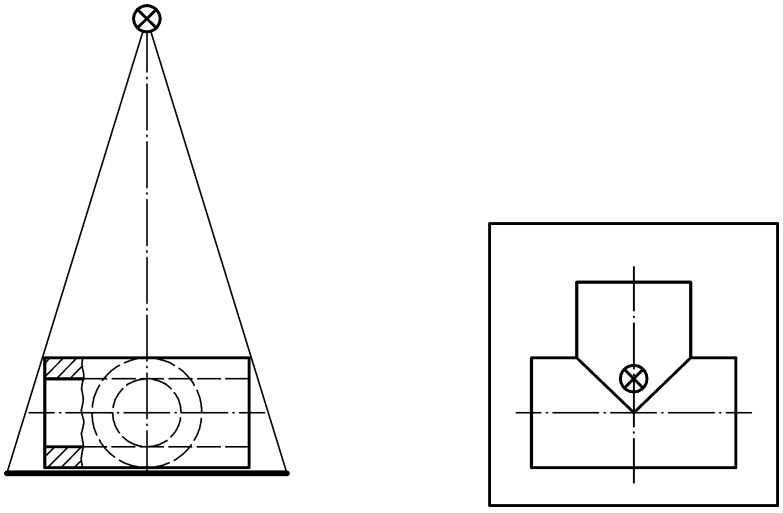
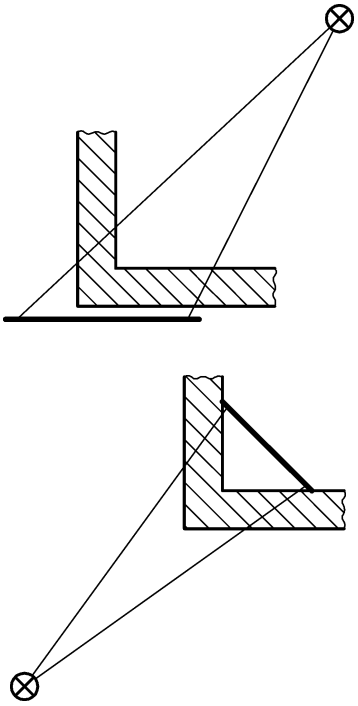


Figure 7 — Examination arrangement for double wall radiography of plane or curved areas under examination; overview exposure; source and film outside of the test area; both walls imaged for interpretation

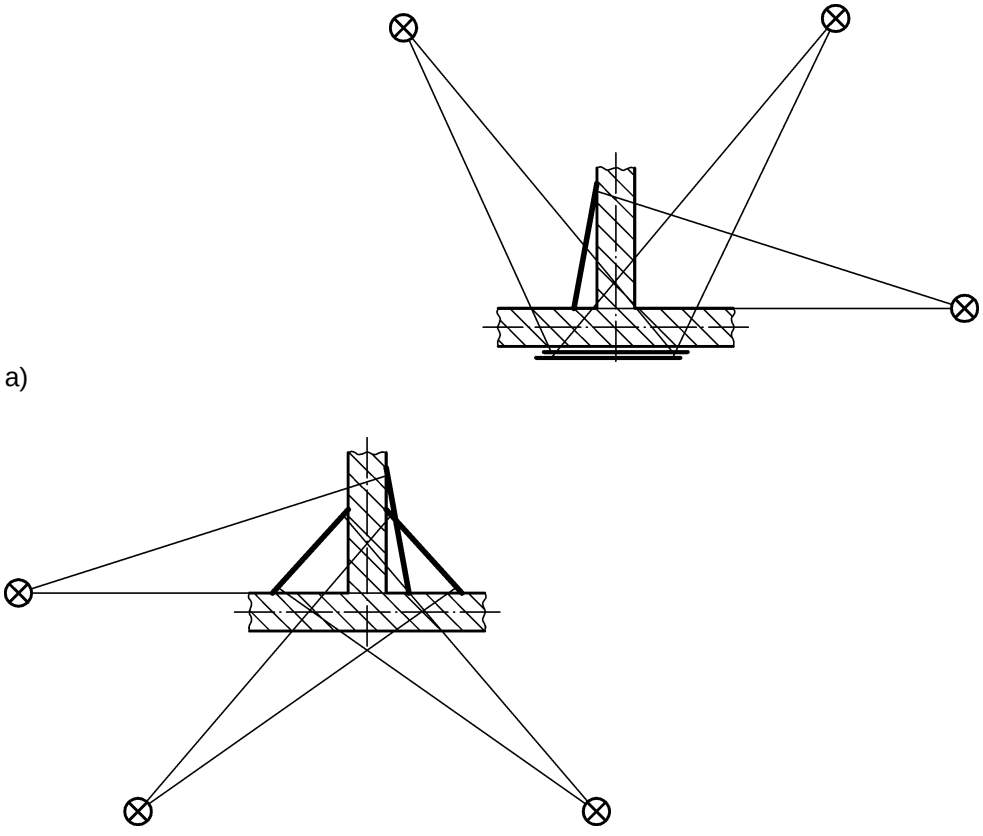
a)



b) should only be used, if a) is not possible.

Figure 8 — Examples for edges and flanges

a)



b) should only be used, if a) is not possible.

Figure 9 — Examples for ribs

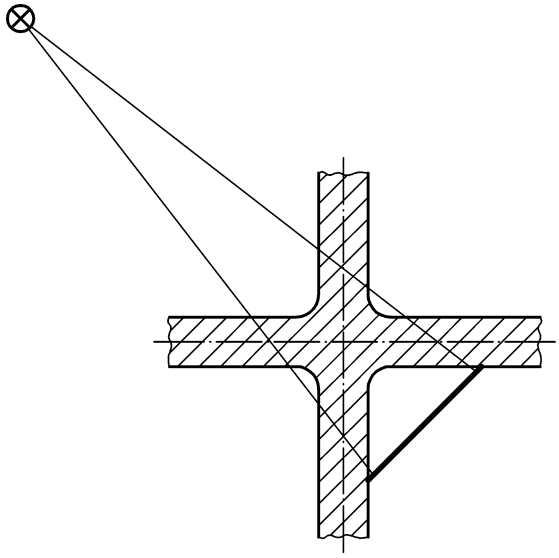


Figure 10 — Example for crosslike geometries

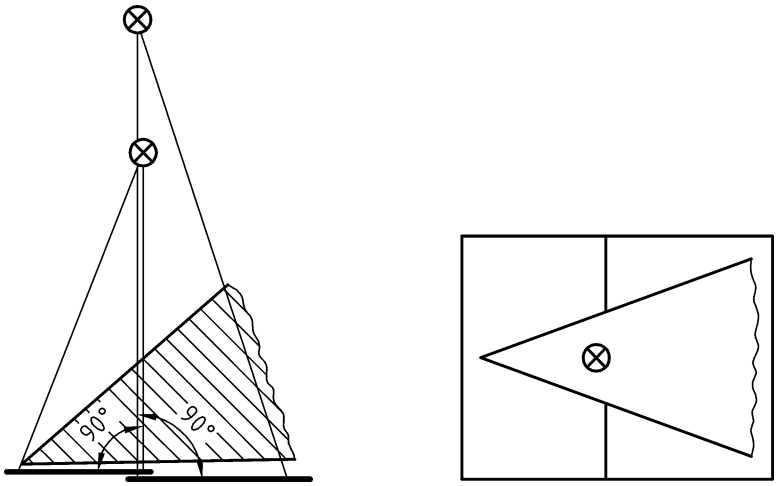
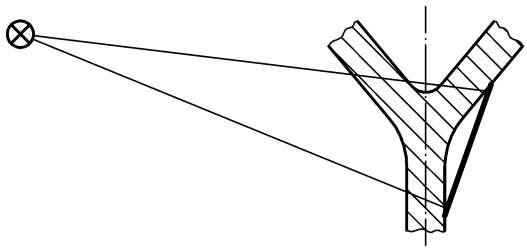
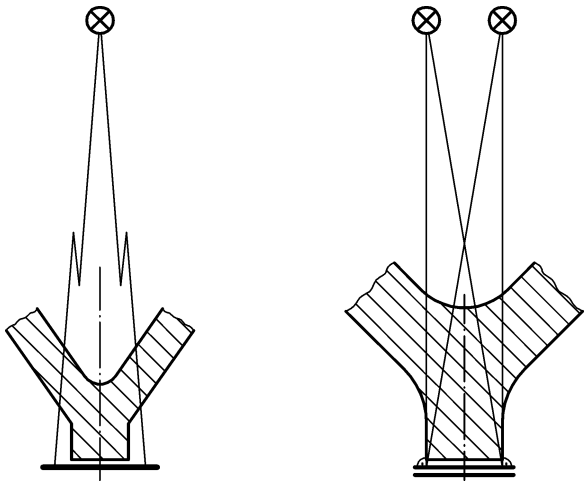


Figure 11 — Example for wedge geometries



a)



b)

Figure 12 — Example for ribs and supports

6 Choice of radiation source

The choice of the radiation source is a function of the penetrated thickness w of the test object (see EN 444), the test class, the examination arrangement and the material. For non perpendicular incident radiation, w is the penetrated thickness in the direction of the central beam. For double wall radiography, w is the sum of the penetrated thicknesses of the test object. If there are different thicknesses imaged with one exposure, an averaged value of these thicknesses can be used.

Instead of EN 444:1994 (Table 1), the thickness range for cobalt 60 (Co-60) in test class A is limited to:

— Test class A, Co-60: 40 mm < $w \leq$ 170 mm.

NOTE In addition to EN 444, the γ-source Se-75 can be used for the examination. In this case the wall thickness range for steel castings should be for class A: 10 mm ≤ $w \leq$ 40 mm, and for class B: 14 mm ≤ $w \leq$ 40 mm.

By agreement between the contracting parties, the minimum wall thickness of steel castings for Se-75 can be further reduced to 5 mm.

The wall thickness range for aluminium and aluminium alloys shall be for class A: 35 mm ≤ $w \leq$ 120 mm.

7 Specific film system classes

When using a selenium source for the radiography of steel, copper and copper alloys, and nickel and nickel alloys for class A, at least film system class C5 and for test class B, at least film system class C4 shall be used. Front- and back lead screens with a thickness of 0,1 mm to 0,2 mm shall be used.

When using a selenium source for the radiography of aluminium and titanium and their alloys for test class A, at least film system class C5 shall be used. Back lead screens with a thickness of 0,1 mm to 0,2 mm and front lead screens with a thickness of 0,2 mm shall be used.

8 Techniques for increasing the covered thickness range

8.1 General

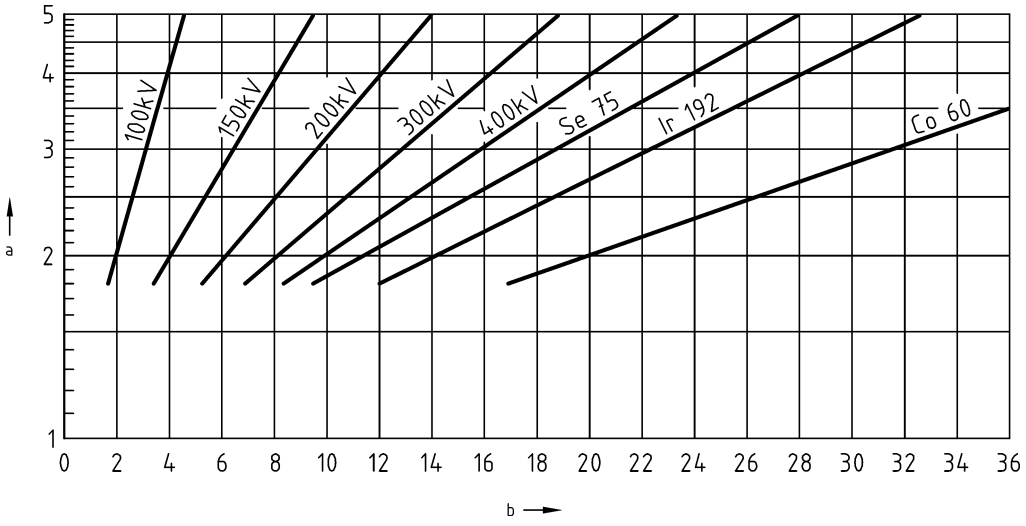
In many applications it is useful to image a larger thickness range within the given limits of the optical density with one exposure. This can be done by one of the following techniques:

— multiple film technique;

— contrast decreasing by higher radiation energy or beam hardening;

— thickness equalization.

NOTE The possible covered thickness range within a certain range of density can be estimated according to Figure 13 for different X-ray tube voltages and gamma sources.

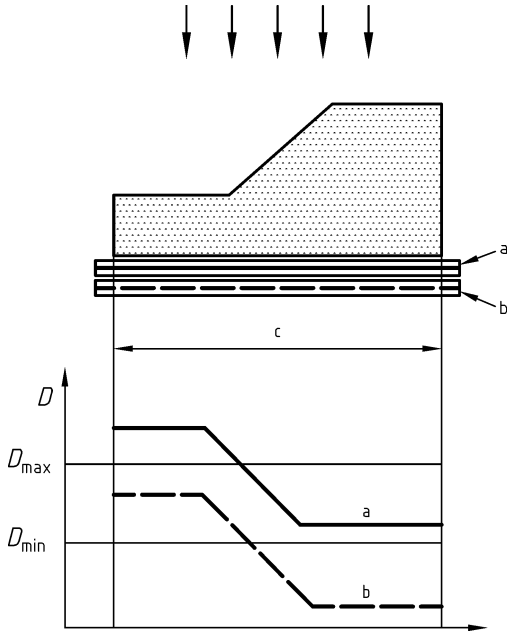


Key
a Optimal quotient of density $D_{max.}/D_{min.}$
b Thickness range in millimetres

Figure 13 — Estimation of possible covered thickness range for different radiation energy levels for steel

8.2 Multiple film technique

For multiple film technique two or more films are exposed at the same time (see Figure 14) and viewed singly or together.



Key

D Density

a Film system with higher sensitivity
b Film system with lower sensitivity
c Lateral dimension

Figure 14 — Film arrangement for multiple film technique

These shall be at least one screen between each of the films. When paper backed lead screens are used two screens shall be inserted with the metal layer to the film side. Films and front and back screens shall be chosen in accordance with Tables 2 and 3 of EN 444:1994.

The film areas with low density shall be masked to avoid dazzle whilst viewing.

Viewing identification marks (at least 2) shall be imaged to ensure the exact positioning of multiple films on top of each other. The geometrical features of the casting and of their images on the films shall correspond.

The density of a single film (see clause 11) shall not be less than 1,3, if double film viewing is used.

8.3 Contrast decreasing by higher radiation energy

A contrast decreasing by higher radiation energy is only permissible in test class A.

For X-ray sources up to 500 keV, the maximum permissible tube voltage according to EN 444:1994, Figure 1 may be exceeded by max. 30 %. For increasing the covered thickness range, X-ray sources may be replaced by γ-sources or linear accelerators.

The image quality requirement(s) given in EN 462-3 or EN 462-4 shall be met.

8.4 Beam hardening

Beam hardening for contrast decreasing is only permissible for class A.

The image quality requirement(s) given in EN 462-3 or EN 462-4 shall be met.

8.5 Thickness equalization

In class A, imaging different wall thicknesses with one exposure on one film is possible by covering the area of thinner wall thickness — which is imaged on the film with higher density — with material equalizing the differences in wall thickness, so that the requirements of density according to clause 11 are met for the whole thickness range.

The equalizing material shall be free from discontinuities and from coarse structure and shall not cause image disturbance that could harm a good analysis of the examined area.

9 Radiographs

9.1 Identification of radiograph, examined area, film position plan

There shall be a clear identification of the examined area and of the corresponding radiograph.

For castings which require a large number of radiographs a film position or photo documentation shall be prepared. The position of each film and the corresponding examined areas shall have a clearly defined co-ordination.

In cases where the arrangement figure according to this European Standard does not define the position of the radio source, either a special plan of the radiation sources shall be prepared or the radiation source shall be noted in the film position plan or to the photo documentation.

9.2 Marking of the test areas

The position of the examined areas shall be shown by markers when it is expected that the radiograph will not show it. These markers shall consist of a more absorbing material than the casting to show-up the examined area on the radiograph. The position of the markers shall also be recorded on the surface of the casting.

9.3 Overlap of films

When radiographing an area with two or more separate films, the films shall overlap sufficiently to ensure that all the examined area is radiographed. This shall be verified by a high density marker placed on the surface of the object which will appear on each film.

10 Verification of image quality

Unless otherwise agreed, the image quality shall be verified by the use of image quality indicators (IQI) in accordance with EN 462-1, EN 462-2, EN 462-3 or EN 462-4. If the IQIs cannot be placed on the casting in accordance with these standards, the image quality shall be verified by one representative test object with an IQI on it on the same film. If a high number of radiographs has to be taken under the same conditions with one exposure, the image quality shall be verified by at least one IQI on each film. When an area with different wall thickness has to be radiographed, the IQI shall be positioned at the examined area with the largest wall thickness.

For exposures of circular objects with diameters of 200 mm and above with the source centrally located at least three IQIs shall be placed equally spaced at the circumference.

The wall thickness in the area of the location of the IQI and the IQI type shall be recorded, in order to make a verification of the image quality.

11 Radiograph density requirements

Exposure conditions shall be such that the radiograph density in the examined area is at least equal to that required in EN 444.

By agreement of the contracting parties, the radiograph density may be reduced to 1,5 for class A and to 2,0 for class B provided that the IQI requirements are met.

When multiple film technique is chosen, the lower limit of the radiograph density may be reduced to 1,5 for class A and 2,0 for class B provided that the IQI requirements are met.

The upper limit of the radiograph density is influenced by the screen luminance of the film viewer according to EN 25580. The minimum transmitted screen luminance on the inspector's side of the film shall conform to EN 25580.

The tolerance for all radiograph density measurements is ± 0,1.

12 Influence of crystalline structure

Diffraction and absorption in crystalline structures can result in diffraction mottle in a radiograph. Diffraction mottle can be confirmed by changing the exposure technique, e.g. by choosing a higher radiation energy or by increasing the distance between the surface of the test object on the radiation side and the film (see Figure 1).

When diffraction mottle makes film interpretation impossible, other parameters than those given in this standard may be used by agreement between the contracting parties.

NOTE Diffraction mottle can occur in some light alloys, copper alloys, cobalt and nickel alloys and austenitic steels.

Annex A
(informative)

Possible discontinuities in castings — Reference radiographs and designation

In Table A.1 reference radiographs existing in ASTM standards are given for the different materials, radiation sources and wall thicknesses.

Furthermore the discontinuity categories and their classification into quality classes are listed.

For cast iron, reference radiographs are under development. A collection of reference radiographs mainly for grey cast iron is published in DGZfP-D5 [1]. A collection of reference radiographs for spheroidal graphite cast iron is going to be published as VDG-Merkblatt P-541 [2]. In the meantime reference radiographs for steel castings should be used. Until these reference radiographs are introduced into practice, the reference radiographs for steel castings should be used.

Tables A.2 and A.3 give a list of the nature of possible discontinuities and their designation as either code number or code symbol for the different materials in Table A.1.

Table A.1 — References for evaluation of radiographs

Material[a]		Radiation source	ASTM		Thickness range[c] mm	Discontinuity code (see Tables A.2 and A.3)	Severity level
Aluminium and magnesium castings	Aluminium	X-ray[b]	E 155		≤ 12,7 over 12,7 to 51	3.2.2 (more or less dense); 3.2.3; 3.2.4; 3.2.10	1 to 8
					all thicknesses	3.2.9	
	Magnesium				≤ 12,7 over 12,7 to 51	3.2.2 (more or less dense); 3.2.3; 3.2.5; 3.2.6	
					all thicknesses	3.2.7; 3.2.8	
Aluminium and magnesium die castings	Aluminium and magnesium	X-ray[b]	E 505		≤ 3	A, B	1 to 4
					over 3 to 25	A, C	
					≤ 25	D	
Copper castings	High strength copper-base and nickel-copper alloys	X-ray[b] Co-60 (2 MeV)	E 272		≤ 51	A, Ba, Bb, Cd	1 to 5
					over 51 to 152	A, Ba, Bb, Ca, Cd	
	Copper-tin alloys	X-ray[b] Ir 192	E 310		≤ 51	A, B, Ca, Cd, Da, Eb	
Iron castings	Grey cast iron	X-ray[b] Ir 192 Co-60	E 802		≤ 114	C	
	Spheroidal graphite cast iron	X-ray[b] Ir 192 (1 MeV) Co-60 (2 MeV) 4-30 MeV	E 689	E 446 E 186	≤ 51, over 51 to 114	A, B, CA, CB, CC, CD, D, E, F, G	
				E 280	over 114 to 305	A, B, C1, C2, C3, D, E, F	

Table A.1 (*continued*)

Material[a]		Radiation source	ASTM	Thickness range[c] mm	Discontinuity code (see Tables A.2 and A.3)	Severity level
Steel castings[d]	Steel	Ir 192 (1 MeV) Co-60 (2 MeV) 4-30 MeV	E 186	over 51 to 114	A, B, C1, C2, C3 D, E, F	1 to 5
		Co-60 (2 MeV) 4-30 MeV	E 280	over 114 to 305		
		X-ray[b] Ir 192 (1 MeV) Co-60 (2-4 MeV)	E 446	≤ 51	A, B, CA, CB, CC, CD D, E, F, G	
Investment steel castings	Steel	X-ray[b]	E 192	≤ 6,4 over 6,4 to 12,7 over 12,7 to 25,4	3.2.1.1; 3.2.2.2; 3.2.2.3; 3.2.3.1	1 to 8
				all thicknesses	3.2.2.1; 3.2.2.4	
Titanium castings	Titanium	X-ray[b]	E 1320	≤ 9,5 over 9,5 to 16 over 16 to 25,4	4.1.1.2; 4.1.1.3; 4.1.2.1; 4.1.2.2; 4.1.3; 4.1.4	1 to 8
				over 6,35 to 25,4	4.1.2.3	
				over 25,4 to 38,1 over 38,1 to 51	4.1.1.3; 4.1.2.3; 4.1.2.2	

[a] At the time of the preparation of this standard reference radiographs do not exist for nickel and zinc alloy castings.

[b] X-ray: ≤ 0,5 MeV

[c] Groupings for specific reference radiograph sets.

[d] For conducting radiographic and ultrasonic tests in combination, see 4.3.3 of EN 12680-1:2002 and EN 12680-2:2002, Figure 4, and 7.3.3.1 of EN 1559-2:2000.

Table A.2 — Discontinuity code number

Discontinuity code (number)	Aluminium and aluminium alloy and magnesium and magnesium alloy castings (according to ASTM E 155)	Investment steel castings (according to ASTM E 192)	Discontinuity code (number)	Titanium and titanium alloy castings (according to ASTM E 1320)
3.2.1	—	Gas	4.1.1	Gas
.1	—	gas holes	.1	gas holes
3.2.2	Foreign materials	Shrinkage	.2	clustered gas holes
.1	—	shrinkage cavity	.3	scattered gas holes
.2	—	shrinkage, sponge	4.1.2	Shrinkage
.3	—	shrinkage, dentritic	.1	scattered shrinkage
.4	—	shrinkage, filamentary	.2	centreline shrinkage
3.2.3	Gas holes	Heterogeneities	.3	shrinkage cavity
.1	—	foreign materials — less dense	4.1.3	Inclusions less dense
.2	—	foreign materials — more dense	4.1.4	Inclusions more dense
3.2.4	Gas porosity	Discrete discontinuities		
3.2.5	Microshrinkage (feathery type)	Defective mould		
3.2.6	Microshrinkage (sponge type)	Diffraction pattern		
3.2.7	Reacted sand inclusions	—		
3.2.8	Segregations	—		
3.2.9	Shrinkage cavity	—		
3.2.10	Shrinkage porosity or sponge	—		

Table A.3 — Discontinuity code symbol

Discontinuity code symbol	Steel and cast iron castings (according to ASTM E 186, E 280 or E 446 as appropriate)	Copper and copper alloy castings (according to ASTM E 272 or E 310 as appropriate)	Aluminium and aluminium alloy castings and magnesium and magnesium alloy die castings (according to ASTM E 505)
A	Gas porosity	Gas porosity	Porosity
B	Sand and slag inclusions	—	Cold fill
Ba	—	sand inclusions	—
Bb	—	dross	—
C	Shrinkage	Shrinkage	Shrinkage
C1, CA, Ca	shrinkage	linear shrinkage	—
C2, CB	shrinkage	—	—
C3, CC	shrinkage	—	—
CD, Cd	shrinkage	feathery, spongy[a]	—
D	Crack	—	Foreign materials
Da	—	hot tear[a]	—
E	Hot tear	—	—
Eb	—	insert, chaplet[a]	—
F	Insert	—	—
G	Mottling	—	—

[a] Copper-tin alloys.

Bibliography

In the preparation of this European Standard, use was made of a number of documents for reference purposes. These informative references are cited at the appropriate places in the text and the publications are listed hereafter.

EN 473, *Non destructive testing - Qualification and certification of NDT personnel - General principles.*

EN 1559-2:2000, *Founding — Technical conditions of delivery — Part 2: Additional requirements for steel castings.*

EN 12680-1:2003, *Founding — Ultrasonic examination — Part 1: Steel castings for general purposes.*

EN 12680-2:2003*, Founding – Ultrasonic examination – Part 2: Steel castings for highly stressed components.*

ASTM E 155:1995, *Reference Radiographs for Inspection of Aluminium and Magnesium Castings.*

ASTM E 186:1993, *Reference Radiographs for Heavy-Walled (2 to 4½-in.) (51 to 114-mm) Steel Castings.*

ASTM E 192:1995, *Reference Radiographs of Investment Steel Castings of Aerospace Applications.*

ASTM E 272:1995, *Reference Radiographs for High-Strength Copper-Base and Nickel-Copper Alloy Castings.*

ASTM E 280:1993, *Reference Radiographs for Heavy-Walled (4½ to 12-in.) (114 to 305-mm) Steel Castings.*

ASTM E 310:1995, *Reference Radiographs for Tin Bronze Castings.*

ASTM E 446:1993, *Reference Radiographs for Steel Castings up to 2 in. (51 mm) in Thickness.*

ASTM E 505:1996, *Reference Radiographs for Inspection of Aluminium and Magnesium Die Castings.*

ASTM E 689:1995, *Reference Radiographs for Ductile Iron Castings.*

ASTM E 802:1995, *Reference Radiographs for Gray Iron Castings up to 4 ½ in. (114 mm) in Thickness.*

ASTM E 1320:1995, *Reference Radiographs for Titanium Castings.*

[1] DGZfP-D5[2)], *Reference radiographs for grey iron castings and ductile iron castings.*

[2] VDG-Merkblatt P 541[3)], (under preparation: Reference radiographs for spheroidal graphite cast iron)

2) Available from: Deutsche Gesellschaft für Zerstörungsfreie Prüfung (DGZfP) e. V., Max-Planck-Str. 6, 12489 Berlin.

3) Available from: Verein Deutscher Gießereifachleute e. V., Postfach 10 51 44, 40042 Düsseldorf.

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