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Non-destructive testing — Qualification of radiographic film digitisation systems —

Part 2: Minimum requirements

Essais non destructifs — Qualification des systèmes de numérisation des films radiographiques —

Partie 2: Exigences minimales

Reference number
ISO 14096-2:2005(E)

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 14096-2 was prepared by the European Committee for Standardization (CEN) (as EN 14096-2:2003) and was adopted, under a special “fast-track procedure”, by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 5, *Radiation methods*, in parallel with its approval by the ISO member bodies.

ISO 14096 consists of the following parts, under the general title *Non-destructive testing — Qualification of radiographic film digitisation systems*:

— *Part 1: Definitions, quantitative measurements of image quality parameters, standard reference film and qualitative control*

— *Part 2: Minimum requirements*

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Foreword

This document (EN 14096-2:2003) has been prepared by Technical Committee CEN/TC 138, "Non-destructive testing", the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by October 2003, and conflicting national standards shall be withdrawn at the latest by October 2003.

EN 14096 comprises a series of European Standards for radiographic film digitisation systems which is made up of the following:

EN 14096-1, *Non-destructive testing – Qualification of radiographic film digitisation systems – Part 1: Definitions, quantitative measurements of image quality parameters, standard reference film and qualitative control*

EN 14096-2, *Non-destructive testing – Qualification of radiographic film digitisation systems – Part 2: Minimum requirements*

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, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Radiographic film systems are used for industrial inspection by X- and gamma rays. To apply modern means of computer support for analysis, transmission and storage the information stored in the radiographic film should be converted into digital data (digitisation). This European Standard defines minimum requirements to ensure that the relevant information for evaluation of the digital data is preserved during the film digitisation process.

1 Scope

This European Standard specifies three film-digitisation quality classes for the requirements of non-destructive testing. The selected class depends on the radiation energy, penetrated material thickness and the quality level of the original radiographic film. This European Standard does not address signal processing, display and storage of the digitised data.

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

EN 1435, *Non-destructive examination of welds — Radiographic examination of welded joints.*

EN 12681, *Founding — Radiographic examination.*

EN 14096-1, *Non-destructive testing — Qualification of radiographic film digitisation systems — Part 1: Definitions, quantitative measurements of image quality parameters, standard reference film and qualitative control.*

ISO 5579, *Non-destructive testing — Radiographic examination of metallic materials by X- and gamma rays — Basic rules.*

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply.

3.1
radiographic film digitisation system
digitiser
sequential application of the two functions below:

a) detection of the diffuse transmittance of a small unit area of the film (pixel, picture element) by means of an optical detector, giving an electric output signal (geometrical digitisation);

b) conversion of the above electrical signal into a numerical value (densitometrical digitisation)

3.2
pixel size
P
geometrical centre-to-centre distance between adjacent pixels in a row (horizontal pitch) or column (vertical pitch) of the scanned image

3.3
optical density
D
logarithmic value to the base 10 of the diffuse light intensity ratio in front of (I_0) and behind (I_D) the radiographic film according to equation (1):

$$D = \lg \frac{I_0}{I_D} \quad (1)$$

3.4
spatial frequency
f
described by a sinusoidal intensity variation along a geometrical axis

The period of this function is measured in number of line pairs per millimetre (lp/mm).

3.5
modulation transfer function
MTF
normalised magnitude of the Fourier-transform (FT) of the differentiated spatial optical density edge spread function (ESF) (see EN 14096-1:2003, Figure 1)

It describes the unsharpness function of the digitiser (contrast transmission as a function of the object size).

NOTE This MTF calculation is based on optical densities, which correspond to the X-ray dose.

3.6
digital resolution in bit
number of bits provided by the analogue-to-digital converter of the digitiser used for densitometrical digitisation

NOTE A digital resolution of N bits corresponds to 2^N digital values.

3.7
density contrast sensitivity
ΔD_{CS}
minimum density variation of the film, which is resolved by the digitiser

This is mostly determined by the digitisation noise of the digitise (quantum noise of the light detector).

NOTE The determination of this value is described in EN 14096-1:2003, 4.1.5.

3.8
density range
D_R
range of maximum and minimum optical densities, which can be measured by the digitiser

Depending on the construction of the digitiser, this density range can be split into several working ranges (e.g. by a different illumination power and/or a different detector integration time).

3.9
working range
D_{WR}
range of optical densities, where the digitiser guarantees a minimum density contrast sensitivity in one single acquisition

Only in this working range the digitised data can be used for evaluation. Depending on the digitiser construction there can be more than one working range, e.g. for brighter or darker films.

4 Digitisation quality classes

All radiographic film digitisation systems are subdivided into 3 quality classes DS, DB and DA :

DS - the enhanced technique which performs the digitisation with an insignificant reduction of signal-to-noise-ratio and spatial resolution.
Application field: digital archiving of films (digital storage).

DB - the enhanced technique, which permits some reduction of image quality.
Application field: digital analysis of films, original radiographic films have to be archived.

DA - the basic technique, which permits some reduction of image quality and further reduced spatial resolution.
Application field: digital analysis of films, original radiographic films have to be archived.

Each radiographic film digitisation system for NDT applications shall be identified with all working ranges of optical densities. It shall be classified by the quality class corresponding to Table 1 and the maximum MTF 20 % value, corresponding to EN 14096-1, which can be performed by this system.

EXAMPLE A digitisation system of class DS 4,2 (scanner class DS (see Table 1), maximum MTF 20 % = 4,2 lp/mm (see Table 2)) can be applied for archiving of radiographs taken with X-rays above 200 keV or γ-rays and can be applied for all class DB and DA digitisation tasks.

5 Minimum requirements for film digitisation quality classes

5.1 Density range and working ranges of the film digitisation system

Table 1 defines the minimum density range of the radiographic digitisation system. In this density range the digitiser shall provide a density contrast sensitivity ΔD_{CS} with $\Delta D_{CS} \leq 0{,}02$. Depending on the construction of the digitiser, this density range can be split into several working ranges.

The minimum digital resolution is given for devices converting the digital value proportional to the optical density. If the digital value is converted proportional to the light intensity, the digital resolution has to be increased at least by 2 additional bits.

Table 1 — Minimum density range of the radiographic digitisation system with a minimum density contrast sensitivity

Parameter	Class DS	Class DB	Class DA
Density range[a] D_R	0,5 to 4,5	0,5 to 4,0	0,5 to 3,5
Digital resolution in bit	≥ 12	≥ 10	≥ 10
Density contrast sensitivity ΔD_{CS} within D_R	≤ 0,02	≤ 0,02	≤ 0,02
[a] This density range may be splitted into separated working ranges.			

5.2 Minimum spatial resolution of film digitisation systems

Due to the energy dependence of the inherent unsharpness of industrial X-ray film systems the following parameters (see Table 2) shall be observed:

Table 2 — Minimum spatial resolution of film digitisation systems

Energy	Class DS		Class DB		Class DA	
keV	Pixel size μm	MTF 20 % lp/mm	Pixel size μm	MTF 20 % lp/mm	Pixel size μm	MTF 20 % lp/mm
≤ 100	15	16,7	50	5	70	3,6
> 100 to 200	30	8,3	70	3,6	85	3
> 200 to 450, Se-75, Yb-169	60	4,2	85	3	100	2,5
Ir-192	100	2,5	125	2	150	1,7
Co-60, > 1 MeV	200	1,25	250	1	250	1

NOTE 1 For the normal check corresponding to EN 14096-1, the MTF 20 % value can be determined by the converging spatial resolution targets.

NOTE 2 Due to possible aliasing, the converging spatial resolution targets can give less accurate values than MTF measurements.

NOTE 3 For energies lower than 70 keV the spatial resolution of the radiographic film can be better than the scanner resolution required by the class DS 16,7. In this case the spatial resolution of the scanner should be adapted to the film resolution, or the original radiographic film should be archived.

5.3 Digitisation class depending on the radiographic testing class

The standards ISO 5579, EN 444, EN 1435 or EN 12681 define two radiographic testing classes A and B. Radiographs taken according to these standards shall be digitised corresponding to Table 3.

Table 3 — Minimum digitisation class depending on the radiographic testing classes A and B, if radiographs are taken on the basis of ISO 5579, EN 444, EN 1435 or EN 12681

wall thickness [mm] steel	Class DS	Class DB	Class DA
< 5	B	A	—
≥ 5	B	B	A

NOTE For the detection of cracks and fine imperfections Class DB or better should be used.

After digitisation process all required image quality indicators shall be visible in the digital image as on the original radiographic film.

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