SLOVENSKI STANDARD
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Neporušitveno preskušanje – Kvalificiranje sistemov za digitaliziranje radiogramov – 1. del: Definicije, kvantitativne meritve parametrov kakovosti radiografske slike, standardni referenčni radiogram in kvalitativna kontrola

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

Zerstörungsfreie Prüfung - Qualifizierung von Röntgenfilm-Digitalisierungssystemen - Teil 1: Definitionen, quantitative Messung von Bildqualitätsparametern, Standard-Referenzfilm und Qualitätssicherung

Essais non destructifs - Qualification des systemes de numérisation des films radiographiques - Partie 1: Définitions, mesures quantitatives des parametres de qualité d'image, film de référence normalisé et contrôle qualitatif

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This European Standard was approved by CEN on 11 March 2003.

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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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Contents

Foreword

This document (EN 14096-1:2003) 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of an identical text or by endorsement, at the latest by October 2003, and conflicting national standards shall be withdrawn at the latest by October 2003.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 procedures for the evaluation of basic performance parameters of the radiographic film digitisation process such as spatial resolution and spatial linearity, density range, density contrast sensitivity and characteristic transfer curve. They can be integrated into the system software and together with a standard reference film (as described in clause 5) used for quality control of the digitisation process. This reference film provides a series of test targets for performance evaluation. The test targets are suitable for evaluating a digitisation system with a spatial resolution down to 25 µm, a density contrast sensitivity down to 0,02 optical density, a density range of 0,5 to 4,5 and a film size capacity of (350 x 430) mm². This standard does not address signal processing and display 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 584-1, *Non-destructive testing — Industrial radiographic film — Part 1: Classification of film systems for industrial radiography.*

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

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
scanning aperture
S_A
spatial extension (area) on the radiographic film through which the digitiser performs the scanning of one pixel for geometrical digitisation

The size of the scanning aperture corresponds:

— in the case of rectangular aperture: to the longer side,

— in the case of circular aperture: to the diameter.

The scanning aperture limits the spatial resolution of the digitiser.

3.3
pixel size
P
geometrical centre-to-centre distance between adjacent pixels in a row (horizontal pitch) or column (vertical pitch) of the scanned image

3.4
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):

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

3.5
edge spread function
ESF
resulting profile across a step function after digitisation

NOTE This function can be either as light intensity or optical density.

3.6
digitiser unsharpness
U_D

blurring of sharp edges by the scanning aperture, scattered light, flare or electronic bandwidth

It is determined from the geometrical distance of the 10% and 90% point of the Edge Spread Function (ESF) from a light intensity step function.

3.7
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).

3.8
spatial frequency maximum value
f_c
in theory, this value, in number of line pairs per millimetre, is given by the Nyquist sampling theorem, see equation (2):

$$f_c = 1 / (2 * P) \quad (2)$$

Practically, the scanning aperture, the mechanics and the electronics of the digitiser reduce this theoretical value.

3.9
modulation transfer function
MTF
normalised magnitude of the Fourier-transform (FT) of the differentiated spatial optical density edge spread function (ESF) (see 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.

3.10
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).

3.11
characteristic transfer curve
CTC
relationship between the optical density of the film and the digitised data

3.12
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.

3.13
density sampling pitch
ΔD_{SP}
optical density variation corresponding to an increase of 1 in the digitised value

NOTE This density variation depends on the characteristic transfer curve of the digitiser. The density sampling pitch can be a function of the density.

3.14
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 digitiser (quantum noise of the light detector).

3.15
working range
D_{WR}
range of optical densities, where the digitiser guarantees a minimum density contrast sensitivity in one single acquisition

Only in this density 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.

3.16
single acquisition
digitisation of one radiographic film performed with one single scan

The result of which is a collection of data not subject to any type of further processing. A unique set of parameters of the digitisation system is used for this acquisition.

3.17
standard reference film
photographic image on an industrial radiographic film containing all of the reference targets described in this document

3.18
targets
physical patterns on the standard reference film which are used to evaluate the digitiser

4 Evaluation procedures

4.1 Evaluation of the characteristic transfer curve, density range, pixel size and density contrast sensitivity

4.1.1 Stepped density target

For the measurement of the characteristic transfer curve, the density range and the density contrast sensitivity of the digitiser a stepped density target on a reference radiograph (standard reference film) is required with the following requirements:

— to cover the optical density interval between D = 0,5 and D = 4,5;

— the optical density spacing between 2 adjacent steps is not greater than ΔD = 0,5;

— the area of each step is at least 100 mm²;

— a fine grain type film (system class C1 in EN 584-1) with light exposure shall be used to achieve a fine granularity resulting into a film noise less than ΔD = 0,01 (at 88,6 µm pixel size).

4.1.2 Characteristic transfer curve (CTC)

For a unique set of digitiser parameters, an acquisition of the stepped density target on the reference film is performed. For each density step D_i the arithmetic mean value $\overline{gl}_i$ of the digitised data values $gl_{j,i}$ for an area of (15 x 15) pixel shall be determined according to equation (3):

$$\overline{gl}_i = \frac{1}{225} \times \sum_{j=1}^{225} gl_{j,i} \qquad (3)$$

The characteristic transfer curve of the digitiser is constructed from the table of D_i versus $\overline{gl}_i$.

Missing density values between the measured density steps can be interpolated in compliance with the following conditions:

— for linear systems (digital data proportional to light intensity) the curve shall be logarithmic,

— for logarithmic systems (digital data proportional to optical film density, provided by electronic log-amplifiers or digital LUT) the curve shall be linear.

The digital data provided by the digitiser and the corresponding optical density values shall be reported in a table and/or a diagram.

The discrete density values expressed by the digital data shall be named $D(gl)$.

Depending on the construction of the digitiser, the CTC can be different for the stepped density target in scanning direction and perpendicular to it.

4.1.3 Density range (D_R)

The density range of the digitiser is determined by the characteristic transfer curve. It is the difference between the minimum and maximum optical density, which can be resolved by the digitiser. The minimum and maximum optical density for a given parameter set of the digitiser can be found from the corresponding characteristic transfer curve. But there can be digitiser parameters which select a different CTC. Then the density range is calculated from the maximum and minimum optical density values of all possible CTC's.