SLOVENSKI STANDARD
SIST EN 584-1:2006

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Neporušitveno preskušanje - Film za industrijsko radiografijo - 1. del: Klasifikacija sistemov filmov za industrijsko radiografijo

Non-destructive testing - Industrial radiographic film - Part 1: Classification of film systems for industrial radiography

Zerstörungsfreie Prüfung - Industrielle Filme für die Durchstrahlungsprüfung - Teil 1: Klassifizierung von Filmsystemen für die industrielle Durchstrahlungsprüfung

Essais non destructifs - Film pour radiographie industrielle - Partie 1: Classification des systemes films pour radiographie industrielle

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ICS:

19.100	Neporušitveno preskušanje	Non-destructive testing
37.040.25	Radiografski filmi	Radiographic films

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English Version

Non-destructive testing - Industrial radiographic film - Part 1: Classification of film systems for industrial radiography

Essais non destructifs - Film pour radiographie industrielle - Partie 1: Classification des systèmes films pour radiographie industrielle

Zerstörungsfreie Prüfung - Industrielle Filme für die Durchstrahlungsprüfung - Teil 1: Klassifizierung von Filmsystemen für die industrielle Durchstrahlungsprüfung

This European Standard was approved by CEN on 9 March 2006.

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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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Foreword

This document (EN 584-1:2006) 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 2006, and conflicting national standards shall be withdrawn at the latest by October 2006.

This document supersedes EN 584-1:1994.

EN 584 comprises a series of European Standards for industrial radiographic films which is made up of the following:

EN 584-1 Non-destructive testing — Industrial radiographic film — Part 1: Classification of film systems for industrial radiography

EN 584-2 Non-destructive testing — Industrial radiographic film — Part 2: Control of film processing by means of reference values

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

1 Scope

The purpose of this standard is to fix the performance of film systems.

This standard is applicable for the classification of film systems in combination with specified lead screens for industrial radiography (non-destructive testing). This standard is intended to assure that the image quality of radiographs – as far as this is influenced by the film system – is in conformity with the requirements of European Standards such as EN 444, EN 1435 and EN 12681. This European Standard does not apply to the classification of films used with fluorescent intensifying screens. The measurement of film systems in this standard is restricted to a selected radiation quality to simplify the procedure. The properties of films will change with radiation energy but not the ranking of film system quality.

Additional methods for evaluating the photographic process are described in EN 584-2 by which the performance of film systems can be controlled under the conditions given in industry.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 584-2, *Non-destructive testing — Industrial radiographic film — Part 2: Control of film processing by means of reference values.*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005)*

3 Terms and Definitions

For the purposes of this standard, the following terms and definitions apply:

3.1
film system
combination of film and film processing which is carried out in accordance with the instructions of the film manufacturer and/or the manufacturer of the processing chemicals.

3.2
film gradient
G
slope of the characteristic curve of a film at a specified optical density D

3.3
granularity
σ_D
stochastic density fluctuations in the radiograph, superimposed on the image of the object

NOTE The limiting values given in this standard are related to fixed radiation energies and specified screens.

3.4
characteristic curve
curve showing the relationship between the common logarithm of exposure $\log K$, and the optical density D

3.5
specular density
quantitative measure of film blackening (optical density) when light passing the optics of a microdensitometer transmits the film.

3.6
diffuse density
quantitative measure of film blackening (optical density) as determined by a densitometer. It is the sum of all transmitted and scattered light into the half sphere behind the film.

3.7
signal/noise ratio
in industrial radiography the ratio of a local film density to the granularity σ_D at this density level. It is correlated to the gradient/noise ratio

3.8
CEN speed
S
reciprocal value of the dose K_S measured in Gray which results in a specified diffuse optical transmission density D of the processed film:

$$S = \frac{1}{K_S} \tag{1}$$

3.9
film system class
classification taking into account of limiting values given in Table 1.

3.10
gradient/noise ratio
ratio of the gradient G and the granularity σ_D. It relates directly to the signal/noise ratio. All further parameters determining the signal, such as the modulation transfer function or the energy of the radiation, are considered to be constant.

4 Sampling and storage

For product specification it is important that the samples evaluated yield the average results obtained by users. This will require the evaluation of several different batches periodically under conditions specified in this standard. Prior to evaluation, the samples shall be stored according to the manufacturers' recommendations for a length of time to simulate the average age at which the product is normally used. The basic objective in selecting and storing samples as described above is to ensure the film characteristics are representative of those obtained by a consumer at the time of use.

5 Test method

5.1 Preparation

The film samples shall be exposed to X-rays from tungsten target tubes. Inherent filtration of the tube, plus an additional copper filter located as close to the X-ray tube target as possible shall provide filtration equivalent to (8,00 ± 0,05) mm of copper. The potential across the X-ray tube shall be adjusted until the half-value-absorption is obtained with (3,5 ± 0,2) mm of copper. A potential of approximately 220 kV generally meets this requirement.

The film system shall include a front and a back screen of 0,02 to 0,04 mm lead. If single coated films are used, the emulsion coated surface shall face the X-ray tube. Good film screen contact shall be ensured.

Exercise care to ensure that the film specimen does not contain density variations arising from the exposing equipment (such as non-uniform beam filters or damaged, or defective lead screens) or processing system. During and after exposure, prior to processing, maintain the film specimen at the temperature of 23°C ± 5°C and relative humidity of 50 ± 20%. The film processing chemicals and procedures shall be the same for determining gradient and granularity, and they shall be used and described completely as specified.

Use manufacturer certified film test strips according to EN 584-2 to test the specified developer system with the specified immersion time and developer temperature. The speed index S_x shall be within ± 5% of the manufacturer's certificate. The developer temperature may differ by ± 1°C from the certified value to adjust S_X within ± 5% of the manufacturer certificate value. The obtained S_X and used developer temperature shall be documented in the test report. This test shall be done, on a daily basis, before and after the development of the exposed films for classification with the same developer temperature and immersion time.

If a manufacturer certificate is not available, film test strips shall be manufactured and calibrated according to EN 584-2 by the user.

5.2 Measurement of gradient G

Gradient G relates to a D versus $\log_{10} K$ curve. Within the scope of this standard G is calculated

from the slope $\frac{\mathrm{d}D}{\mathrm{d}K}$ of a D versus K curve at density $(D - D_0)$, i. e.

$$G = \frac{\mathrm{d}D}{\mathrm{d}\log_{10} K} = \frac{K}{\log_{10} e} \cdot \frac{\mathrm{d}D}{\mathrm{d}K} \qquad (2)$$

where

K is the measured dose, in Gray, required for density $(D - D_0)$;

D_0 is the measured optical density of an unexposed and processed film including base (fog and base density).

The D versus K curve is approximated by a polynomial of third order. To obtain a reliable curve, a series of exposures are made with the same film sample to obtain at least 12 uniformly distributed measuring points covering at least density 1,0 and 4,5 above D_0. The polynomial approximation shall include all measured values between 1,0 and 4,5. For the numerical approximation (fit procedure) no zero value shall be included. At least six gradient measurements shall be made on different film samples to determine the mean gradient value G. The densitometer used shall be calibrated regularly up to a diffuse density of $D \geq 4{,}8$. For the calibration, a certified film step tablet shall be used. This shall be generated from double sided X-ray film of C3 class or higher (C1 or C2).

NOTE Densitometers may have limited accuracy for measurements at $D > 4$ and need careful calibration correction in the full range. Small deviations of the density values at D > 4 have considerable influence to the accuracy of the G at $D - D_0 = 4$ - value due to the properties of the polynomial approximation procedure.

The mean gradient values shall be determined with a maximum uncertainty of ± 5 % for G2 and ± 7 % for G4 at a confidence level of 95 %.

Measurement laboratories, which certify film systems, shall participate in a proficiency test on a periodical basis. A new film, exposed in accordance with this standard, shall be used in all participating labs and for each periodical test.

5.3 Measurement of granularity σ_D

The granularity is measured by linear or circular scanning of a film of constant diffuse optical density with a microdensitometer. Both emulsion layers shall be recorded; this means that the depth of focus of the microdensitometer has to include both layers.

The granularity value shall be determined in terms of diffuse density.

If the optical density is measured as specular density, it shall be converted into diffuse optical density, using the plot of the curve of diffuse density versus specular density at the mean density value of the granularity film specimen. The diffuse density of each step shall be measured with the calibrated densitometer.

Determine this curve using a film having a stepped series of densities, which is prepared using the same type of film, exposure, and processing techniques as used for the granularity film specimen. The specimen film shall be scanned using identical microdensitometer settings. A limited range of densities can typically be measured for a given microdensitometer gain setting. The stepped series of densities shall lie within that range.

The calibration shall be made from the diffuse vs specular density plot with at least 5 values between diffuse density 1,5 and 2,8 (including fog and base). The conversion can be performed on basis of a linear regression analysis of the log(diffuse density) vs log(specular density) plot. The determined coefficients shall be used for the conversion of the specular density into diffuse density values.

The conversion shall be performed before the numerical determination of the standard deviation σ_D, which is a measure of the granularity. σ_D is calculated by

$$\sigma_D = \sqrt{\frac{1}{N-1} \cdot \sum_{i=1}^{N} (D_i - \bar{D})^2} \tag{3}$$

The diffuse optical density of the measured film shall be $\bar{D} = 2{,}00 \pm 0{,}05$ above fog and base. The determined σ_D-value shall be corrected on the basis of the diffuse mean density $\bar{D}$ above fog and base of this film. The corrected σ_D-value is calculated by

$$\sigma_{D-corr} = \sigma_D \cdot \sqrt{(2 / \bar{D})} \tag{4}$$

As an alternative, three or more samples of the film specimen at different density levels, within the range from 1,80 to 2,20, may be measured, and the granularity value at a diffuse density of 2,00, above base plus fog, shall be taken from a linear regression analysis of the plot of granularity as a function of the square root of diffuse density above fog and base.

The scanning length on the radiographic film shall be at least 116 mm. The diameter of a circular measuring aperture of the microdensitometer shall be (100 ± 5) µm. A square aperture of 88,6 µm × 88,6 µm has the same area as a circular one of 100 µm diameter and is concerning the measured granularity equivalent to a circular one with 100 µm diameter.

The determined $\sigma_{D\text{-}corr}$-value shall be corrected on the basis of the real (measured) aperture diameter A_d (in µm) of a circular aperture. The corrected σ_D-value is calculated by

$$\sigma_{D-corr\text{-}a} = \sigma_{D-corr} \cdot (A_d / 100) \tag{5a}$$

If a square aperture of the microdensitometer is used, the corrected σ_D-value is calculated by

$$\sigma_{D-corr\text{-}b} = \sigma_{D-corr} \cdot \sqrt{(4 \cdot A_a / (\pi \cdot 10000))} \tag{5b}$$