BRITISH STANDARD

BS EN ISO
21227-1:2003
Incorporating
Corrigendum No. 1

Paints and varnishes — Evaluation of defects on coated surfaces using optical imaging —

Part 1: General guidance

The European Standard EN ISO 21227-1:2003 has the status of a British Standard

ICS 87.040

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National foreword

This British Standard is the official English language version of EN ISO 21227-1:2003. It is identical with ISO 21227-1:2003.

The UK participation in its preparation was entrusted to Technical Committee STI/10, Test methods for paints, which has the responsibility to:

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Summary of pages

This document comprises a front cover, an inside front cover, the EN ISO title page, the EN ISO foreword page, the ISO title page, pages ii to v, a blank page, pages 1 to 11 and a back cover.

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Amendments issued since publication

Amd. No.	Date	Comments
14767 Corrigendum No. 1	23 October 2003	Incorporating corrected EN ISO foreword page

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 20 August 2003

ISBN 0 580 42487 1

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 21227-1

August 2003

ICS 87.040

English version

Paints and varnishes - Evaluation of defects on coated surfaces using optical imaging - Part 1: General guidance (ISO 21227-1:2003)

Peintures et vernis - Evaluation par imagerie optique des défauts des surfaces revêtues - Partie 1: Lignes directrices générales (ISO 21227-1:2003)

Beschichtungsstoffe - Beurteilung von Beschichtungsschäden mittels digitaler Bildverarbeitung - Teil 1: Allgemeine Anleitung (ISO 21227-1:2003)

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Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN ISO 21227-1:2003 E

CORRECTED 2003-09-24

Foreword

This document (EN ISO 21227-1:2003) has been prepared by Technical Committee ISO/TC 35 "Paints and varnishes" in collaboration with Technical Committee CEN/TC 139 "Paints and varnishes", 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of an identical text or by endorsement, at the latest by February 2004, and conflicting national standards shall be withdrawn at the latest by February 2004.

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.

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INTERNATIONAL STANDARD

ISO 21227-1

First edition
2003-08-01

Paints and varnishes — Evaluation of defects on coated surfaces using optical imaging —

Part 1: General guidance

Peintures et vernis — Évaluation par imagerie optique des défauts des surfaces revêtues —

Partie 1: Lignes directrices générales

Reference number
ISO 21227-1:2003(E)

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Foreword

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ISO 21227-1 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

ISO 21227 consists of the following parts, under the general title *Paints and varnishes — Evaluation of defects on coated surfaces using optical imaging*:

— *Part 1: General guidance*

— *Part 2: Evaluation procedure for results of multi-impact stone-chipping test*

— *Part 3: Evaluation procedure for delamination and corrosion around a scribe*

At the time of publication of this part of ISO 21227, Parts 2 and 3 were in preparation.

Introduction

Conventional ISO test methods used for evaluating surface defects and appearance changes often utilize pictorial standards which depict particular types of surface deterioration and require human visual evaluation. The technology described in the various parts of this International Standard can yield more objective, accurate, quantitative and reproducible results when compared to the human visual evaluation techniques.

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Paints and varnishes — Evaluation of defects on coated surfaces using optical imaging —

Part 1: General guidance

1 Scope

This part of ISO 21227 gives definitions for and provides guidance in the use of optical imaging systems for the quantitative characterization of defects on coated surfaces that occur after exposure in various test methods, e.g. stone chipping, weathering or cross-cut testing. One aim of ISO 21227 is to use optical imaging to reproduce the results of already existing methods for visual assessment. Additionally, optical imaging provides further information which can be used for a more detailed evaluation of coating defects.

This part of ISO 21227 contains a general introduction in optical-imaging methods and definitions. The performance of individual test methods and requirements for precision are described in other parts of the standard.

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.

CIE Publication No. 17.4:1987, *International lighting vocabulary*/IEC 60050-845:1987, *International Electrotechnical Vocabulary — Lighting*

3 Terms and definitions

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

3.1
optical imaging
method for acquiring, digitizing, processing and analysing images using optical components and computer systems

3.2
illumination
application of light to a scene, objects or their surroundings so that they may be seen

[CIE 17.4:1987/IEC 60050-845:1987]

3.2.1
reflection illumination
illumination whereby light source and optical sensor are both arranged on the same side of the object

3.2.2
transmission illumination
illumination whereby light source and optical sensor are arranged on opposite sides of the object

3.2.3
bright-field illumination
method of image acquisition in which light reflected by the object and light scattered by the object are detected by the optical sensor

3.2.4
dark-field illumination
method of image acquisition in which only light scattered by the object is detected by the optical sensor

3.2.5
directional lighting
lighting in which the light on the working plane or on an object is incident predominantly from a particular direction

[CIE 17.4:1987/IEC 60050-845:1987]

3.2.6
diffused lighting
lighting in which the light on the working plane or on an object is not incident predominantly from a particular direction

[CIE 17.4:1987/IEC 60050-845:1987]

3.3 Terms relating to the optical sensor

3.3.1
field of vision
area on the object surface which is acquired by the optical sensor

3.3.2
region of interest
that part of the original image which is used for image processing and image analysis

3.3.3
objective
optical system, usually consisting of one or more lenses, which is used to acquire an image of the field of vision

3.3.4
object distance
distance between the first lens of the objective and an object which gives a sharp image

3.3.5
depth of focus
difference between the minimum and maximum object distance

3.4
image acquisition
image capture
process of creating a two-dimensional original image of an object

3.4.1
original image
digitized image taken by the image-acquisition system, without having carried out any image processing

3.4.2
charge-coupled device
CCD
device that uses a semi-conductive material as an optical sensor

NOTE The CCD chip is subdivided into very fine elements, each of which corresponds to a pixel of the digitized image. The CCDs can be arranged as an array (digital camera) or in a row (line scanner).

3.4.3
scanner
device for image acquisition which uses a one-dimensional optical sensor in which CCDs are lined up in a row

NOTE The image is built up by line scanning of the surface of an object.

3.4.4
digitization
process of converting an analogue image into a digital image

NOTE The image is divided into pixels by a grid and each pixel is assigned to one grey level.

3.4.5
pixel
smallest image-forming element to which a grey level is assigned

3.4.6
resolution
number of pixels per unit length on the surface of an object

NOTE If the resolution in the X- and Y-directions is different, both values have to be reported.

3.4.7
grey level
shade of grey assigned to a pixel

NOTE The shades are usually positive integer values taken from the grey scale.

3.4.8
grey scale
series of grey levels between white and black

EXAMPLE The 8-bit grey scale has 2^8 (= 256) grey levels. Grey level 0 corresponds to black, grey level 255 (the 256th level) to white.

3.4.9
gamma
γ
exponent used in the function $Y = X^{\gamma}$

where

X is the input signal;

Y is the output signal;

X and Y range from 0 to 1 (0 corresponding to black, 1 to white)

3.4.10
frame grabber
device for converting an analogue video signal into an digital original image

3.5
image processing
software manipulation of the original image in order to prepare for subsequent image analysis

NOTE For example, image processing can be used to eliminate mistakes generated during image acquisition or to reduce image information to the essential.

3.5.1
binary image
image in which each pixel is either 0 (black) or 1 (white)

3.5.2
gamma correction
modification of the value of gamma, which can be carried out using software or hardware

3.5.3
brightness
average grey level of a specified part of the image

3.5.4
contrast
difference between the grey levels of two specified parts of the image

3.5.5
shading correction
software method for correcting non-uniformity of the illumination of the object

3.5.6
thresholding
reduction of the number of different grey levels of an image, preferably resulting in a binary image

NOTE In order to produce a binary image, each pixel in the grey-scale image is assigned a grey level of 0 or 1, depending whether this pixel has a grey level greater than or less than or equal to a given constant (the threshold).

3.5.7
delineation
edge detection
method of isolating and locating an optical edge in a given digital image

3.6
image analysis
reduction of the image information to a set of values which are specific to the application

3.6.1
reference panel
specified panel which has already been assessed and therefore has a known rating

NOTE It is used to check the reproducibility and repeatability of the parameter settings.

3.7
image evaluation
process of relating the set of values resulting from image analysis to one or more characteristic values via a classification or rating scheme

4 Principle

Perception and evaluation of visual information is an outstanding ability of the human mind. ISO 21227 is intended to imitate and in some cases to exceed this ability by use of digital optical imaging.

Before defects on a coated surface can be analysed using optical imaging, an image has to be acquired and transformed into a digital format. An image is acquired via an image sensor such as a charge-coupled device. In a second step, the subsequent spatial image information is digitized and processed by manipulating the grey levels. Using image analysis, the image information is reduced to a set of values which are specific to the application.

In the paint industry, coated panels are generally used for testing. These are exposed in accordance with a standard test method. In order to obtain results which are comparable with these existing methods of visual assessment, the parameters of image acquisition as well as image processing and image analysis have to be adapted to the specific application (given in subsequent parts of this International Standard). In paint testing, the following typical defects can be distinguished:

— individual coating defects less than 5 mm in size, e.g. craters, blisters, inclusions;

— larger individual coating defects, e.g. delamination, flaking and cross-cuts;

— multiple coating defects spread over a large area, e.g. defects due to stone chipping, multiple blisters;

— imperfections which extend over a large area, e.g. loss in gloss, brush marks.

5 Requirements

5.1 Illumination

5.1.1 Kinds of illumination

Different materials and surface conditions and different types of defect will require different optics and illumination to show adequately the features in an image that are to be analysed. Therefore the optimum combination of optics and illumination for the specific application has to be used. Generally, the following kinds of illumination are used:

a) directional lighting;

b) diffuse lighting;

c) mixture of directional and diffuse lighting;

d) bright-field illumination;

e) dark-field illumination.

All the above kinds of illumination can be either reflection or transmission illumination.

5.1.2 Uniformity and constancy

Generally, the illuminance can be adjusted.

An appropriate combination of light source and optical devices shall be used to ensure that the illumination at the surface of the panel being evaluated is uniform. The illuminance measured at the point on the panel surface which receives the highest illuminance shall not be more than 10 % greater than the illuminance at the

point on the surface receiving the lowest illuminance. Improvements can be made using software. This requirement is not valid for an inclined-illumination geometry.

The illuminance and spectral-power distribution shall be kept constant during the whole measurement period.

5.2 Panel positioning and focussing

Panels shall be flat and positioned in the plane of two mutually perpendicular axes X and Y. The third axis (Z) shall be the optical axis of the image-acquisition system. In most cases, the Z-axis is perpendicular to the X-Y plane and its point of intersection with the panel surface defines the point of focus. The distance between the front-end image-acquisition optics and the panel surface shall be constant, independent of the thickness of the panels, so that focussing and magnification are not adversely affected.

5.3 Image acquisition

The optical and illumination system is typically comprised of a CCD (e.g. digital camera or scanner), focussing optics, light sources, a lighting-geometry adjustment system, a panel support and a light-tight enclosure. The resolution of the optical system shall be higher than the resolution of the image-aquisition sensor. The minimum requirement for a digitized image is 512×512 pixels and a range of 256 grey levels (8-bit). The image information is digitized directly within the sensor unit or using a frame grabber. The characteristic line of the image-acquisition system, i.e. the correlation between the brightness of a pixel and its grey level, is the determining influence on the result of the image analysis and shall therefore be reported. The image-acquisition sensor shall not use automatic gamma correction.

The components of the image-acquisition system shall be adjustable. Once set up for a particular measurement or series of measurements, the system shall be protected against unintentional interference. The system shall also be protected against interference by external illumination.

In order to ensure the repeatability and reproducibility of the optical-imaging procedure, calibration shall be performed at regular intervals. This can be done using reference panels, for example.

5.4 Image processing

The image is processed and analysed using a computer equipped with software containing mathematical algorithms. The digitized images are then stored. If a compressed file format is used, this shall be free from losses.

For different types of defect, a variety of sequential image-processing procedures could be carried out. The image processing covers numerous features such as brightness, contrast, edge detection, shading correction, and inversion.

Different softwares may employ different mathematical algorithms for similar operations, and the processed images produced by different image-processing algorithms will not be identical. A calibration process, e.g. using reference panels, shall therefore be used to ensure that results are comparable.

In order to ensure reproducibility within a series of measurements related to the same calibration, all images shall be processed in identical fashion.

5.5 Image analysis

Essentially, two different methods are used for image analysis: binary (black/white) analysis and grey-level analysis. To obtain a binary image from a grey-level image, the thresholding procedure is used.

As in image processing, automatic image analysis requires a number of sequential steps for the analysis of different types of surface defect. Algorithms shall be selected carefully for each specific application. Advanced image-analysis systems use software that can be adapted to different applications.

5.6 Image evaluation

The result of image analysis is a set of values which are specific to a particular application. This set of values is transformed into one or more characteristic values via a classification or rating scheme. In order to ensure comparability with conventional methods using visual assessment, it is important that image processing and analysis produces characteristic values similar to those obtained using the existing classification scales.

NOTE This ensures that the data which has been obtained by conventional methods is comparable with the results of optical imaging. Nevertheless, the user is free to obtain additional characteristic values from optical-imaging methods for a more detailed evaluation.

5.7 Documentation

All relevant illumination, image-acquisition, image-processing and image-analysis parameters shall be documented. These comprise:

a) for the illumination: the light source used and the lighting geometry;

b) for the image acquisition: the original image and details of the image-acquisition system (optical components, resolution), the image size, the range of grey levels and the value of gamma;

c) for the image processing and image analysis: the procedures used (including details of filters) and details of the software used (trade name and manufacturer).

NOTE Management of test data, such as storage, transfer and database manipulation, can be automated utilizing digital-format files. In addition, inter-laboratory test data including image data can be easily transferred using various data transfer protocols.

Annex A
(informative)

Standards for visual assessment of coating defects

ISO 2409, *Paints and varnishes — Cross-cut test*

ISO 4623-1, *Paints and varnishes — Determination of resistance to filiform corrosion — Part 1: Steel substrates*

ISO 4623-2, *Paints and varnishes — Determination of resistance to filiform corrosion — Part 2: Aluminium substrates*

ISO 4624, *Paints and varnishes — Pull-off test for adhesion*

ISO 4628-1, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 1: General introduction and designation system*

ISO 4628-2, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 2: Assessment of degree of blistering*

ISO 4628-3, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 3: Assessment of degree of rusting*

ISO 4628-4, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 4: Assessment of degree of cracking*

ISO 4628-5, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 5: Assessment of degree of flaking*

ISO 4628-6, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 6: Assessment of degree of chalking by tape method*

ISO 4628-7, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 7: Assessment of degree of chalking by velvet method*

ISO 4628-8, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 8: Assessment of degree of delamination and corrosion around a scribe*

ISO 4628-10, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 10: Assessment of degree of filiform corrosion*

ISO 7253, *Paints and varnishes — Determination of resistance to neutral salt spray (fog)*

ISO 12944-6, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 6: Laboratory performance test methods*

ISO 20567-1, *Paints and varnishes — Determination of stone chip resistance of coatings — Part 1: Multi-impact test*

ISO 20567-2, *Paints and varnishes — Determination of stone chip resistance of coatings — Part 2: Single-impact test using a guided indenter*

EN 3665, *Aerospace series — Test methods for paints and varnishes — Filiform corrosion resistance test on aluminium alloys*

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