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Postal services — Automatic identification of items — Two dimensional bar code symbol print quality specification for machine readable Digital Postage Marks

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National foreword

This Published Document is the UK implementation of CEN/TS 14826:2022. It supersedes DD CEN/TS 14826:2004, which is withdrawn.

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The UK participation in its preparation was entrusted to Technical Committee SVS/4, Postal services.

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

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English Version

Postal services - Automatic identification of items - Two dimensional bar code symbol print quality specification for machine readable Digital Postage Marks

Services postaux - Identification automatique des envois postaux - Mesure de la qualité d'impression des Marques d'Affranchissement Digitales sous la forme de symboles de codes à barres bidimensionnels lisibles par une machine

Postalische Dienstleistungen - Automatische Identifizierung von Sendungen - Druckqualität von zwei-dimensionalen Strichcodes für Digitale Freimachungsvermerke

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European foreword

This document (CEN/TS 14826:2022) has been prepared by Technical Committee CEN/TC 331 "Postal Services", the secretariat of which is held by NEN.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes CEN/TS 14826:2004.

Organisations contributing to the development of the document include:

— Universal Postal Union;

— ISO/IEC JTC 1/SC 28 "Office equipment";

— ISO/IEC JTC 1/SC 31 "Automatic identification and data capture techniques";

It is intended that this document is adopted by ISO/IEC JTC 1/SC 28, in the work programme of which the project has been assigned project number ISO/IEC NP 18050.

For compatibility between CEN and UPU versions of this document, the term 'document' is used. In a CEN context, this is interpreted as being equivalent to the deliverable mentioned on the title page of this document. In a UPU context, this is interpreted as being equivalent to 'standard'.

In comparison with the previous edition, the following technical modifications have been made:

— EN 14615 has been added as a normative reference.

— Clauses 5, 7.4.2 and A.3 have been modified to take into account the latest edition of ISO/IEC 15415.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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Introduction

Digital Postage Marks (or franking marks), sometimes abbreviated to DPM, are used to evidence the payment of postage and/or other fees related to services requested by mailers. Digital Postage Marks are represented by symbols imprinted on the envelope, the label or the insert. Digital Postage Marks produced by different vendors' systems are generated with a variety of symbols and graphical images. The symbologies used for these images are primarily two-dimensional bar codes of both multi-row (PDF417) and matrix types (e.g. Data Matrix), as specified in UPU standard S28. However, postal operators can also use other symbologies, e.g. OCR or 4-state codes for these purposes. The two-dimensional bar code symbologies offer advantages for the machine-readable representation of data strings of the order of 80 or more bytes in length, due to their high information density characteristics.

Public postal operators and private carriers in Europe have a high interest in automatically reading and validating these marks, preferably at high speed. It is essential that these symbols are read reliably by postal processing equipment. The highest practicable read rate is desired by users of such equipment in order to ensure efficient automation of this process, and any shortfall in the read rate can have as its consequence a loss of revenue to the operator.

This document has been designed to customise the generic method of measuring the print quality of two-dimensional bar code symbols to the needs of the postal application and to recommend appropriate print quality levels that should contribute to the achievement of the read rates desired by the authorities responsible for validation of the Digital Postage Marks and by postal operators; it is also intended to provide guidelines for printing machine readable Digital Postage Marks on mail items. The Technical Specification will provide mailers, postal operators and their suppliers with a practical, quantitative, and objective way to measure and communicate to each other basic print quality parameters of machine-readable Digital Postage Marks. Since all attributes do not contribute uniformly to the readability of a Digital Postage Mark, the Technical Specification identifies five levels of criticality for an attribute (graded 0 to 4, in ascending order of quality), and a grading scheme that assesses the overall symbol quality based on averaging the results of multiple scans.

The document can be used in the following ways:

— it allows an estimate to be made of the readability of a Digital Postage Mark without actually submitting it to any postal validation and the qualification of said symbol as acceptable or not acceptable for readability purposes;

— it allows an estimate to be made of the quality levels potentially achievable by a printing system with particular substrates;

— it provides a tool for process control in the operation of Digital Postage Mark printing systems.

The document applies the measurement methodology defined in ISO/IEC 15415 for print quality attributes that tend to influence the readability of two-dimensional bar codes. This methodology is derived from a view of the current state-of-the-art in two-dimensional bar code scanning technologies.

Yet, such a state-of-the-art is not a perfectly defined concept. First, it is likely to evolve with time towards improved recognition capabilities. Second, an automatic identification and data capture system is always the result of a compromise between recognition power and cost. This is why the Technical Specification is expressed in the form of guidelines rather than prescriptions. However, it is not technically possible to define guidelines concerning solely the printing of Digital Postage Marks without taking into account the manufacturing of the mail item as a whole. The readability of the Digital Postage Mark is a function not only of the inherent quality of printing, i.e. the interaction of the ink, substrate and printing mechanism together with the effects of the shape of the mail-piece and its transport through the printing system on the production of the mark, but also of the effects of environmental and handling factors in transit between the production point and the point at which it is to be read. For example, the symbol contrast of

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Digital Postage Marks is not only that provided by the printer/paper combination under defined illumination conditions. It also results from a variety of other factors among which the covering of the mail item or the material of the transparent window through which the Digital Postage Mark can be seen. As a consequence, the guidelines described in this document apply to the Digital Postage Mark blocks of fully assembled mail items. It is the responsibility of the users of the Technical Specification to achieve compliance with the guidelines by controlling the effects of the physical elements resulting in the relevant attributes.

The guidelines are primarily a tool for predicting the level of Digital Postage Mark readability with respect to current scanning technologies, and compliance with them should result in a high level of Digital Postage Mark readability. The guidelines are aimed at facilitating the relations between postal operators and customers, vendors of mail generation and printing equipment and suppliers of mail reading and sorting equipment. In particular, equipment vendors need firm and precise guidance in designing print systems and formats for machine readability. Therefore, a quantitative specification of print quality is critical to the development of products that meet the needs of mailers and postal operators.

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1 Scope

This document:

— specifies a methodology for the measurement of defined print quality attributes of Digital Postage Marks in the form of two-dimensional bar code symbols on mail-pieces;

— defines methods for grading the results of these measurements and deriving an overall symbol quality grade as a guide to estimating the readability of the Digital Postage Marks;

— provides guidelines for printing and gives information on possible causes of deviation from high grades to assist users in taking appropriate corrective action;

— defines a test procedure for the assessment of printing systems for the production of Digital Postage Marks.

These provisions apply to the Digital Postage Mark blocks as they appear on fully produced mail items when remitted to postal operators, including the characteristics resulting from operations other than printing per se that affect their appearance to a mail processing system (covering, inserts into transparent window envelopes, affixed Digital Postage Mark labels).

This document does not define the qualification tests or sampling requirements necessary to determine the practical feasibility of any specific read rate.

Although this document is not intended for barcodes (other than Digital Postal Marks) which can be printed on mail pieces for item identification or additional services, a similar methodology can be applied.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1556, *Bar coding - Terminology*

ISO/IEC 15415, *Information technology — Automatic identification and data capture techniques — Bar code symbol print quality test specification — Two-dimensional symbols*

ISO/IEC 15416, *Automatic identification and data capture techniques — Bar code print quality test specification — Linear symbols*

ISO/IEC 15419, *Information technology — Automatic identification and data capture techniques — Bar code digital imaging and printing performance testing*

ISO/IEC 15426-2, *Information technology — Automatic identification and data capture techniques — Bar code verifier conformance specification — Part 2: Two-dimensional symbols*

UPU standard S28[1], *Communication of Postal Information using Two-dimensional Symbols*

UPU standard S44-1[1], *Colour and Durability Attributes of Franking Marks*

[1] UPU documents are available from the Universal Postal Union International Bureau.

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in in ISO/IEC 15415, ISO/IEC 15416, EN 1556 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

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3.1
broad-band
descriptive of illumination in which the spectral distribution of the light is wide, with a bandwidth in excess of 200 nm at the 50% power level

3.2
mail format
form taken by a finished mail-piece or other carrier of a Digital Postage Mark, e.g. envelope with or without contents, or flat sheet of paper

3.3
narrow-band
descriptive of illumination in which the spectral power distribution is concentrated in a narrow band of wavelengths, with a bandwidth of less than 200 nm at the 50% power level

3.4
overall symbol grade
measure of symbol quality calculated as arithmetic mean of scan grades from a number of individual scans of the symbol

3.5
read rate
percentage representing the number of items carrying digital postage marks that have been successfully read, out of all such items attempted to be read in a given period

3.6
scan grade
result of the assessment of a single scan of a symbol, derived by taking the lowest grade achieved for any measured parameter in that scan

3.7
spectral response characteristic
integral response of the reading system, a function of wavelength across the spectral region of interest and calculated for each wavelength as the product of the intensity of light emitted, the transmission characteristic of any filters or coatings used, and the response of the sensor element at that wavelength

3.8
validation
technical process by which the authenticity, data integrity and uniqueness of a Digital Postage Mark are confirmed or denied

3.9
verification
technical process by which a bar code symbol is measured to determine its conformance with the specification for that symbol

3.10
verifier
device used to measure and analyse quality attributes of a bar code symbol such as element and quiet zone dimensions, reflectances, and other aspects against a standard to which the bar code symbol conforms

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4 Symbols and abbreviations

For the purposes of this document, the following symbols apply:

dpi	dots per inch (25,4 mm);
dpmm	dots per millimetre;
°K	degrees Kelvin;
UEC	Unused Error Correction;
X	nominal width of a narrow element (bar code) or of a module (matrix code);
Y	nominal height of an element (bar code).

5 Requirements

The print quality requirement for a Digital Postage Mark, when measured in accordance with ISO/IEC 15415 and the following clauses, is expressed in the form:

grade/aperture/light/angle, where:

— "*grade*" is the overall symbol grade, i.e. the arithmetic mean to one decimal place of the scan reflectance profile or scan grades;

NOTE 1 Where the value is followed by an asterisk, it indicates that there are extremes of reflectance in the symbol surroundings which can potentially interfere with reading.

— "*aperture*" is the aperture reference number (from ISO/IEC 15416 for linear scanning techniques, or the diameter in thousandths of an inch (to the nearest thousandth) of the synthetic aperture defined in ISO/IEC 15415);

— "*light*" defines the illumination: a numeric value indicates the peak light wavelength in nanometres (for narrow- band illumination); the alphabetic character W indicates that the symbol has been measured with broad-band illumination (sometimes referred to as "white light" although the terms are not directly equivalent) the spectral response characteristics of which shall imperatively be defined or have their source specification clearly referenced;

— "*angle*" is an additional parameter defining the angle of incidence (relative to the plane of the symbol) of the illumination. It shall be included in the reporting of the overall symbol grade when the angle of incidence is other than 45°. Its absence indicates that the angle of incidence is 45°.

In view of the close correlation between print quality and reading performance, where maximum reading performance is critical, a Digital Postage Mark represented by a two-dimensional bar code symbol shall achieve a minimum overall symbol grade of 2,8[2] under the following measurement conditions:

— aperture diameter 0,25 mm (reference number 10), in the case of a Digital Postage Mark in the form of a two- dimensional multi-row bar code symbol; or

— aperture diameter from 0,25 to 0,40 mm (reference number 10 to 16) in the case of a Digital Postage Mark in the form of a two- dimensional matrix symbol;

and

— peak wavelength of 660 nm in the case of a Digital Postage Mark intended to be read under narrow-band illumination; or

— light reference W, together with the specification of the spectral response characteristics used or a reference to a source of this specification, in the case of a Digital Postage Mark intended to be read under broad-band illumination.

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NOTE 2 The aperture reference number represents the nominal diameter, in thousandths of an inch, of the measuring aperture. For multi-row symbologies, ISO/IEC 15415 specifies that its diameter is to be determined by the application specification; see 7.4.1. For matrix symbols, the measuring aperture diameter is a function of the symbol X dimension; see 7.4.2.

In either case the angle of incidence of the light shall be 45°. These would be expressed as, for example, 2,8/16/W (with the spectral response specification, or an appropriate reference) for a Digital Postage Mark in the form of a two-dimensional matrix symbol intended for reading in broad-band light, or 2,8/10/660 for a Digital Postage Mark in the form of a multi-row bar code symbol intended to be read in narrow- band (visible red) light with a peak wavelength of 660 nm.

The illumination conditions used for verification shall imperatively be specified or clearly referenced with the verification results.

In order to allow for the effect of less easily controllable substrates, where a somewhat lower read rate can result (for example with Digital Postage Mark symbols printed on relatively low-reflectance substrates that are unable to meet the preferred symbol contrast requirements), the overall symbol grade requirement may be reduced to 1,8[3] provided that all measured parameters except Symbol Contrast are consistent with the requirements of the higher grade of 2,8. A minimum overall symbol grade of 1,8 governed by any of the measured parameters would probably lead to a further reduction in read rate performance. See Clause 8 for details, and Annex C for a description of the measurement parameters.

While the above grades are recommended as the minima to ensure an adequate read rate, postal operators may determine their minimum recommended grades corresponding to the particular reading requirements of their environment or to the read rate which they require.

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[2] An overall symbol grade of 2,8 can only be obtained as the arithmetic mean of scan grades from a number of individual scans, for instance four scans with grade 3 (B) and one with grade 2 (C). Since it is no longer required to measure a symbol at different orientations, such result could be achieved after five successive measurements of the same symbol, or on a batch of five identical symbols produced in the same conditions (cf. Annex A).
[3] Similarly, an overall symbol grade of 1,8 can only be obtained as the arithmetic mean of scan grades from a number of individual scans, for instance four scans with grade 2 (C) and one with grade 1 (D).

6 Basic measurement methodology

Digital Postage Marks shall be measured according to the methodology defined in ISO/IEC 15415 for the type of symbology concerned, either two-dimensional multi-row symbologies (e.g. PDF417 as defined in ISO/IEC 15438) or two-dimensional matrix symbologies (e.g. DataMatrix as defined in ISO/IEC 16022). The print quality requirements specified in ISO/IEC 15438 and ISO/IEC 16022, and in similar symbology standards, which were published prior to the development of the generic methodologies defined in ISO/IEC 15415 shall not be applied to the evaluation of Digital Postage Marks.

NOTE For two-dimensional multi-row symbols, ISO/IEC 15415 adapts (and supplements) the methodology for the print quality assessment of linear bar code symbols defined in ISO/IEC 15416. For matrix symbols, the methodology of ISO/IEC 15415 requires the capture of a two-dimensional grey-scale image of the symbol to be verified, under defined and controlled illumination conditions, and the processing of the image to analyse its specified parameters. ISO/IEC 15415 defines the reference optical arrangement to be used for measurement, and the symbol attributes to be measured (see Annex C for a list of the measured parameters for each type of symbol). ISO/IEC 15415 requires to be read in conjunction with the International Standard or other equivalent formal specification of the symbology concerned and in particular makes use of the reference decode algorithm defined in that specification as a common, standard basis for evaluation. It assigns grades on a five-step scale to each of the parameters; there are four passing grades, from 4 to 1 in descending order of quality, and one failing grade of 0. It provides for multiple scans of the symbol in different positions in order to derive an average assessment of the symbol, and defines an overall grading scheme that takes account of the individual parameters and the results from individual scans. It provides for applications to determine the minimum grade for acceptability for that application. It also allows for applications to establish additional parameters. In the case of Digital Postage Marks, the quiet zone is an additional graded parameter (see Clause 9), and the spectral response characteristics of the system by which the Digital Postage Mark is intended to be read need to be specified.

In each scan of the symbol a number of parameters is measured and graded, and the scan is given a scan grade, which is equal to the lowest grade obtained for any parameter in that scan; the overall symbol grade in accordance with ISO/IEC 15415 is the arithmetic mean, to one decimal place, of the scan grades. However, for the purposes of this document, if any scan grade is 0, the overall symbol grade shall also be regarded as 0. In this event it can be appropriate to perform the verification process a second time to eliminate the possibility of a random or transient incident having affected one of the scans.

The overall symbol grades are only meaningful when reported in conjunction with additional parameters defined in the application specification: the measuring aperture size, the illumination (peak wavelength or spectral response characteristic), and the angle of incidence of the illumination.

7 Verification requirements for Digital Postage Marks

7.1 Verification equipment

Instruments to be used for the verification of Digital Postage Marks shall comply with the requirements of ISO/IEC 15426-2. These devices provide a standardized means of measurement of two-dimensional bar code symbols to enable consistent and repeatable measurements of symbol quality to be made. Their basic configuration is intended to replicate a bar code reading device that uses image capture and processing techniques, as is likely to be the case with mail processing equipment. ISO/IEC 15415 defines a reference optical arrangement for reflectance measurements, with the results of which the reflectance measurements obtained by a verifier should correlate. There is however no requirement that its construction should follow the reference arrangement. The specification of certain components of the device, described in the following subclauses, shall be matched to the defined requirements of the application in which the bar code symbols are intended to be used. The instrument shall be calibrated before use in accordance with the manufacturer's instructions.

For the verification of Digital Postage Mark symbols, the image capture component of the equipment should preferably be a camera, and associated illumination, of the same type and spectral response characteristics as the equipment expected to be used for operational reading of the mail-piece(s) to be

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verified, with a mechanism, of a similar nature to that expected to be used, to transport the mail-pieces past the measurement window. However, if such mechanism is not available, or differs from the intended equipment in a manner that can affect scan grading significantly, measuring on standstill test samples may be preferred.

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If equipment precisely matching the spectral response characteristics of the mail processing equipment expected to be used is not available, a device complying with the general requirements of ISO/IEC 15415 and ISO/IEC 15426-2 shall be used with a light source covering the spectral band indicated for the ink colour in question in UPU S44-1. It should be noted that in this case the reflectance measurements (of ink and paper) recorded may differ from those perceived by the operational mail processing equipment and the results should be taken as indicative rather than predictive of the symbol contrast perceived by the specific mail processor.

7.2 Optical geometry

ISO/IEC 15415 defines a default geometry for print quality assessment of two-dimensional symbols. This consists of two elements. The first element is an annular light source, or a set of individual light sources arranged in a circle, giving flood incident illumination which is uniform across the sample area. The light source(s) shall be concentric with the sample area and shall lie in a plane parallel to that of the sample area, at a height which will allow incident light to fall on the centre of the sample area at an angle of 45° to its plane. The second component is a light collection device, the optical axis of which is perpendicular to the sample area and passes through its centre, and which focuses an image of the test symbol on a light-sensitive array. This arrangement is appropriate for the measurement of the diffusely reflected light from the surface of a mail-piece and shall be used for the verification of Digital Postage Marks; another arrangement may be used if its results can be correlated with those obtained by the use of the default geometry.

7.3 Light source

The apparent reflectance of a sample area to a scanner or verifier is primarily a function of:

- response of the ink and substrate to the illumination (its absorption or reflection of incident light at different wavelengths); and
- spectral response characteristics of the reading system, which in turn depend on:
  - spectral distribution of the illumination (the intensity of light of different wavelengths emitted across the spectrum);
  - spectral characteristics of any filters in the optical path (the transmittance of light of different wavelengths);
  - spectral response of the photosensitive elements of the image capture device (their sensitivity at different wavelengths).

When the light is not monochromatic, the apparent reflectance is the integrated response across the image capture device's spectral band.

The illumination conditions used by mail processing systems generally require broad-band light (of various colour temperatures, and the spectral response characteristics of the specific equipment may, therefore, differ) to capture not only the image of the Digital Postage Mark but also the images of the address block and other information which are not covered by this document. Hand-held reading equipment for Digital Postage Marks may have a narrow-band red light source.

Ink specifications for the Digital Postage Mark are defined in UPU standard S44-1. For a given ink, its reflectance will vary widely with different light sources. The ink reflectance will also depend on the ink coverage, which is determined principally by the print mechanism. UPU standard S44-1 indicates the reference spectral bands and the desirable contrast levels within these for the various ink colours on a range of backgrounds. It also describes the use of a default set of spectral characteristics for the assessment of reflectances, which may be correlated with those of a specific type of reading equipment by the use of an appropriate correction factor. Individual postal operators may define the colours permitted in their territory.

The substrates used may be of a variety of materials and colours, and their reflectances will also vary widely with the light source.

It is therefore essential, in order to maximize the correlation between reflectance values as measured by a verifier and their appearance to reading and mail processing equipment, that the spectral response characteristics of the two types of equipment should match as closely as practicable. The print quality of a Digital Postage Mark should be measured under the same spectral response conditions as are used in the mail processing equipment expected to be used. Because the spectral response characteristics of different equipment specified by postal operators may vary, the verifier shall either have the capability to change the light source or image capture component, or have its particular set of spectral response characteristics clearly identified.

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Annex B describes the spectral response characteristics of a number of common types of light source used for the reading of Digital Postage Marks.

7.4 Measuring aperture

7.4.1 General

The shape and dimensions of the measuring aperture shall be specified.

NOTE This is necessary in order that defects in the symbol are not given exaggeratedly high or unjustifiably low importance, and secondly in order to maximize the measured contrast between dark and light elements. Defects include voids in low reflectance areas and extraneous specks in high reflectance areas, which will tend to decrease the modulation of the area by bringing the reflectance of the area closer to the Global Threshold (the midpoint between the highest and lowest reflectances in the symbol, used to binarize the image into dark and light areas). These goals are achieved by specifying a circular aperture whose diameter is slightly smaller than the width of the smallest element specified for the application.

The measuring aperture may be either a real physical aperture in the optical path of the verifier or a virtual one achieved by applying a mathematical process to integrate the reflectance values from a number of adjoining pixels in the image capture device.

7.4.2 Measuring aperture for two-dimensional multi-row symbologies

For Digital Postage Mark symbols in the form of a two-dimensional multi-row symbol, complying with UPU standard S28, with a minimum X dimension of 0,38 mm, the measuring aperture shall be a circular aperture of diameter 0,250 mm (aperture reference number 10, as defined in ISO/IEC 15416).

ISO/IEC 15416 indicates that this aperture is appropriate for symbols with X dimensions up to 0,63 mm, but it also states that the aperture to be used for verification shall be the aperture appropriate for the smallest X dimension permitted by the application.

7.4.3 Measuring aperture for two-dimensional matrix symbologies

ISO/IEC 15415 defines the measuring aperture for these symbols as a circular aperture, synthesized from the individual image pixels, from 0,5X to 0,8X in diameter (based on the smallest X dimension specified for the application), and specifies that the resolution of the verifier shall be sufficient to ensure that the parameter grading results are consistent irrespective of the rotation of the symbol. For Digital Postage Mark symbols in the form of a two- dimensional matrix symbol, complying with UPU standard S28, which specifies an X dimension of 0,508 mm or more, an aperture from 0,25 to 0,40 mm diameter (reference number 10 to 16) is appropriate in accordance with ISO/IEC 15415.

NOTE Experience has shown that the imaging system used for verification can require an effective linear resolution of 6 to 8 pixels per module (corresponding to 11,8 to 15,7 pixels per mm for an X dimension of 0,508 mm), or 30 to 60 pixels per module on an area basis, to provide the required consistency of results. Annex D, D.2, indicates that current mail processing systems typically use a resolution of approximately 8 to 10 pixels per mm for reading.

7.5 Mail format

The form in which the Digital Postage Mark is verified depends on the purpose for which it is being measured and the point in the entire mailing process at which it is measured. As a general principle, the capabilities of the production system dictate the highest quality that can be achieved, and the introduction of other factors (substrate materials, filling of envelopes, window envelopes or overwraps, handling in transit, etc.) will tend to reduce symbol quality, and allowance shall be made for this when setting quality levels.

For testing the performance of printing equipment, it will normally be sufficient to test symbols printed on to a flat substrate, in order to minimize the effect of external variables.

For process control of symbol production, it is appropriate to verify the symbol on the mail-piece in the form in which it emerges from the printing system.

For predicting whether the readability of the Digital Postage Mark is likely to reach an acceptable level it is appropriate to verify the symbol on the finished mail-piece in the form in which it is presented to the postal service, or received at the mail processing point.

In the cases of process control and the prediction of readability of a complete mail piece, it can be desirable to allow for the influence of factors such as the geometrical distortions caused by contents of the mail-piece, the optical effects of window materials or film wraps through which the Digital Postage Mark has to be read, and the effects of environmental conditions and handling while it is in transit.

These factors lead to the recommendation that the symbol quality at the point of production should, wherever possible, be higher than the minimum required for acceptable readability at the point of reading, to allow for possible degradation by these factors.

Annex D discusses a number of factors related to the printing and scanning process that can have an impact on symbol quality.

8 Grading implications for individual symbol attributes

The minimum overall symbol grades specified in Clause 5 are based on averaging the profile (or scan) grades of multiple scans of a symbol, which are in turn based on the lowest grade for any parameter in each scan. It is not possible, therefore, to define a set of threshold values which have to be exceeded for all parameters in every scan. However, it is possible to suggest, for guidance, that the average value of each individual parameter for all scans should be within a limiting value which is derived from the minimum overall symbol grade.

Tests have indicated that an overall symbol grade of 2,8 should result in a read rate in the region of 99,5 %. If the overall symbol grade is reduced to 1,8, the resulting read rate can be in the region of 95 %. If, however, the values of all parameters except Symbol Contrast are consistent with an overall grade of 2,8 and those of the Symbol Contrast parameter with a grade of 1,8, the resulting read rate can be in the region of 97 %. There is, however, no direct linkage between a particular quality grade and a particular read rate, since read rates achieved in practice can be governed by a number of factors additional to print quality that cannot be assessed simply by verifying the symbol.

Certain parameters (e.g. Decode) are graded only on a pass/fail basis, i.e. they can only have the grade 4 or 0; if graded 0 the scan grade shall also be 0 and the overall symbol grade will also be 0, in accordance with the requirement in Clause 6. In consequence they shall pass the relevant test in every scan and the limiting value is therefore an absolute one rather than a mean.

Tables 1 and 2 indicate the limiting mean values for two-dimensional multi-row and matrix symbols respectively, corresponding to the grades and read rates indicated above.

Table 1 — Indicative limiting mean parameter values for two-dimensional multi-row symbols

Approx. desired read rate	**99,5 %**	**97 %**	**95 %**
Parameter	**Limiting mean value**		
Decode*	Pass*	Pass*	Pass*
Minimum reflectance*	≥ 0,5R_{max}*	≥ 0,5R_{max}*	≥ 0,5R_{max}*
Min. edge contrast*	≥ 0,15*	≥ 0,15*	≥ 0,15*
Symbol contrast	≥ 0,52	≥ 0,36	≥ 0,36
Modulation	≥ 0,58	≥ 0,58	≥ 0,48
Defects	≤ 0,21	≤ 0,21	≤ 0,26
Decodability	≥ 0,475	≥ 0,475	≥ 0,35
Codeword yield	≥ 0,63	≥ 0,63	≥ 0,56
Unused error correction	≥ 0,48	≥ 0,48	≥ 0,36
Quiet zone*	3X*	3X*	3X*
NOTE Parameters indicated with an asterisk are pass/fail parameters, and the values indicated are absolute values which shall be met in every scan of the symbol.			

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Table 2 — Indicative limiting mean parameter values for two-dimensional matrix symbols

Approx. desired read rate	**99,5 %**	**97 %**	**95 %**
Parameter	**Limiting mean value**		
Decode*	Pass*	Pass*	Pass*
Symbol contrast	≥ 0,52	≥ 0,36	≥ 0,36
Fixed pattern damage	grade 2,8	grade 2,8	grade1,8
Modulation	≥ 0,38	≥ 0,38	≥ 0,28
Axial non-uniformity	≤ 0,084	≤ 0,084	≤ 0,104
Grid non-uniformity	≤ 0,52	≤ 0,52	≤ 0,64
Unused error correction	≥ 0,48	≥ 0,48	≥ 0,35
Quiet zone*	3X*	3X*	3X*
NOTE Parameters indicated with an asterisk are pass/fail parameters, and the values indicated are absolute values which shall be met in every scan of the symbol.			

ISO/IEC 15415 gives general guidance on possible causes of low grades for individual parameters. Annex E gives additional guidance on the possible causes of low grades that are more specifically related to the production and reading environments for Digital Postage Marks.

NOTE The measurement of print growth, while important for process control, is not taken into account in grading the symbol and no limiting value can therefore be defined for this parameter. Its effect is, to some extent, reflected in the modulation parameter.

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9 Additional grading parameters - Quiet zone

ISO/IEC 15415 provides that specifications may define additional grading parameters. This document requires that the symbol shall be analysed to ensure that the minimum quiet zones required by the symbology specification are respected. This parameter shall be graded on a pass/fail basis in each scan profile: if the width of the quiet zone on all sides of the symbol is equal to or greater than 3X, the grade for this parameter shall be 4; otherwise it shall be 0.

NOTE ISO/IEC 16022 defines the minimum quiet zone width for Data Matrix symbols as 1X for general applications; ISO/IEC 15438 defines the minimum quiet zone width for PDF417 symbols as 2X; UPU standard S28 defines the minimum quiet zone for all two-dimensional symbols used for the representation of postal information as 2X. However, the value of 3X is specified for the Digital Postage Mark application by this document in order to facilitate the achievement of the high reading speeds required.

10 Qualification of printing systems for Digital Postage Marks

ISO/IEC 15419 defines general requirements for the performance testing of bar code digital imaging and printing systems, designed to confirm that the bar code symbol is correctly formatted in accordance with the relevant symbology specification by the software and hardware combination used, and to measure certain parameters of the system performance on a standardized basis. These provisions apply equally to systems for the production of Digital Postage Marks. The mail processing application has additional needs and characteristics which shall also be tested. In particular, the variety of substrates, mail-piece formats (labels, filled envelopes, etc.), inks and illumination conditions for image capture needs to be tested in combinations that are appropriate for the system under test.

ISO/IEC 15419 tests, *inter alia*, the following performance characteristics of the system (but does not set minimum requirements):

— Encoding of data in accordance with the symbology specification, including optional characteristics of the symbology;

— Control of variables (X dimension, Y dimension, element width ratios, etc.) by software;

— Accuracy of dimensional instructions output by software (measured in terms of decodability, as defined in ISO/IEC 15416);

— Comparison of actual dimensions (X and Y dimensions) achieved with those intended;

— Range of X and Y dimensions supported;

— Smallest X dimension at which at least grade 1,5 symbols are achievable;

— Highest printing speed at which grade 1,5 symbols of the smallest X dimension are achievable.

Printing systems for Digital Postage Marks shall be tested in accordance with ISO/IEC 15419 and additionally in accordance with the test procedure specified in Annex A, for those combinations of substrate, mail-piece format and inks which they are intended to handle.

Annex A
(normative)

Test procedure for printing systems for Digital Postage Marks

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A.1 Environmental conditions for test

The conditions under which the test samples are printed, and verification of the resulting test symbols is performed, shall be as follows, and materials to be used (paper, ink) shall have been stored under these conditions for at least 24 h prior to the test in order to allow them to stabilize:

Table A.1 — Environmental conditions for testing of printing systems

Ambient Temperature:	18 °C to 28°C
Humidity:	40 % to 60 % RH
Max. air flow speed (ink-jet printing only):	< 0,2 m/s

A.2 Test materials

The test shall be performed on a range of closed and sealed envelopes typical of those encountered in the jurisdiction of the postal authority concerned, with inserts, together with the equipment manufacturer's recommended label stock, if applicable. Twenty envelopes or labels of each material shall be tested on each sample of the printing system under test; these shall be the first 10 and the last 10 envelopes or labels produced in a continuous run of the system.

The envelope materials shall have the following characteristics:

Dimensions: The envelopes may be of any dimensions capable of being handled by the printing system under test. All envelopes of one type shall be of identical material and size.

Paper weight: Between 80 g/m² minimum and 120 g/m² maximum.

Reflectance values: These shall be measured with the spectral response characteristics appropriate for the postal operator concerned, and details of these characteristics shall be recorded with the test results; they shall be measured on the filled and sealed envelope.

Table A.2 — Test envelope materials

Sample reference	Description	Reflectance
1	White label	≥ 70 %
2	Standard white envelope	≥ 80 %
3	White recycled paper	≥ 75 %
4	Grey recycled paper	≥ 65 %
5	Brown Kraft	≥ 50 %

Insert: One sheet White Offset Paper, 80 g/m², folded twice in a z form to yield 3 layers.

A.3 Test procedure

For the purpose of testing the design of printing systems, in order to be more representative of the batch of equipment, the test shall be performed once with each of three units of the equipment under test, selected at random from a batch of the equipment, giving a total of (10 + 10) × 5 × 3 = 300 envelopes or labels to be verified. For other purposes, it may be sufficient to test a single unit, and if appropriate this shall be selected at random from a batch of machines.

The equipment shall be set up in accordance with the manufacturer's instructions. For each batch of envelopes, it shall be run for 10 min continuously, and it shall be allowed to cool down between batches.

Each batch of envelopes, and the batch of labels, shall be imprinted with a Digital Postage Mark as specified by the postal operator concerned, using ink supplied by the manufacturer that conforms with the requirements of UPU standard S44-1 and otherwise in respect of toxicity, optical density/reflectance and other attributes specified. The first 10 and the last 10 envelopes from each batch shall be taken for testing, keeping each set separate.

All sample envelopes and labels shall be clearly identified with the envelope material reference and whether they are from the first or second set of samples for each machine tested.

The sample envelopes shall be verified using a verifier conforming with the requirements set out in Clause 7, except for the fact that images are captured from static (standstill) samples. A mechanism may optionally be used to transport the mail-pieces past the measurement window, provided that it doesn't affect barcode grading significantly. The individual and mean results and the standard deviations of the results for all measured parameters for each subset of samples shall be recorded and analysed.

As the measuring equipment returns an integer number, an overall symbol grade of 2,8 can only be obtained as the arithmetic mean of scan grades from a number of individual scans, for instance four scans with grade 3 (B) and one with grade 2 (C). Additionally, since it is no longer required by ISO/IEC 15415 to measure a symbol at different orientations, such result could be achieved after five successive measurements of the same symbol, or on a batch of five identical symbols produced in the same conditions. Generally speaking, the overall symbol grade will be the arithmetic mean of scan grades from the individual scans of the 20 envelopes of labels to be tested.

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Annex B
(informative)

Light sources and spectral response characteristics for verification of Digital Postage Marks

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B.1 General

The spectral response characteristics to be used for the verification of Digital Postage Marks should match as closely as possible those to be used for the reading of the marks with mail processing systems. The latter should also be suited to the reflectance characteristics of the mail-piece materials and Digital Postage Marks to be processed. Spectral response characteristics should be consistent with the requirements defined in UPU S44-1 for Digital Postage Marks produced using inks of the colours permitted by that standard and by the postal operator intending to read them.

B.2 Narrow-band illumination

Monochromatic or narrow-band illumination has a power distribution peaking strongly at a defined wavelength and with a low bandwidth. The most frequently encountered narrow-band illumination is in the red region of the spectrum and is suited to the reading of Digital Postage Marks printed in a wide range of colours, with the exception of red, and on a range of substrate colours, with the exception of blue and green materials. Hand-held bar code readers for multi-row bar code symbols, which use a rastering beam to scan the symbol, normally operate in this area of the spectrum. The most common light source for these devices is a solid-state laser diode emitting coherent monochromatic light with a peak wavelength of 660 nm or 670 nm. Hand-held bar code readers for multi- row symbols using a linear CCD typically use light emitting diodes with a peak wavelength in the range of 650 nm to 680 nm. and a bandwidth of approx. 50 nm at the 50 % points.

Other narrow-band illuminations can also be specified, but are uncommon in generally available bar code reading hardware.

For example, USPS Publication 25 specifies two narrow-band spectral responses, one red peaking at 650 nm, with a 160 nm bandwidth at the 50 % points of the response curve, and one green peaking at 540 nm, with a 90 nm bandwidth at the 50 % points of the response curve. Symbols satisfying the requirements of USPS Publication 25 are required by that document to exhibit sufficient contrast under both red and green illuminations.

NOTE In practice this means that red inks, and some blue inks, would fail to yield a sufficiently low reflectance under one or other illumination, and would also restrict the choice of substrate colours.

The monochromatic or narrow-band nature of the light makes it unnecessary to specify closely the characteristics of the sensor, provided that it has adequate sensitivity at these wavelengths and that the verifier is calibrated by the use of materials with known reflectances at the wavelength concerned.

It is desirable to protect the sensor from ambient illumination and incident light at other than the desired wavelength by including a narrow-pass filter with peak transmission close to the specified peak wavelength in the optical path, and this is normally a standard component of the hardware.

B.3 Broad-band illumination (white light)

B.3.1 General

There is a wide choice of broad-band light sources, the spectral characteristics of which can be related to their apparent colour temperature. Broad-band light sources, by definition, emit light over a band of wavelengths without a concentration of power close to a single clearly defined narrow peak. Many of these sources are described loosely as “white light” sources. Nonetheless, the intensity of light emitted at different wavelengths will vary and there can be one or more peaks in the spectral distribution. For example, light with a colour temperature in the region of 3000°K is described as “warm” light and the spectral distribution of this light shows higher intensity of emission towards the red (and infrared) region of the spectrum, whereas light with a higher colour temperature in the region of 6500°K is described as “cool” light and its spectral distribution is biased to the blue-violet region of the spectrum, extending into the ultraviolet.

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“Warm” light sources will tend to yield lower reflectance values (i.e. increased contrast) for blue inks than “cool” light sources do, and are therefore preferable when blue inks are specified for the printing of Digital Postage Marks. “Cool” light sources will tend to yield lower reflectance values (increased contrast) for red inks, and for dye-based black inks, than “warm” light sources do, and are therefore preferable when red, or dye-based black, inks are specified for the printing of Digital Postage Marks. In the case of pigment-based black inks, reflectance values tend to vary less significantly with the illumination characteristics, and either type of light source is therefore acceptable for reading purposes. This does not, however, obviate the need to match verification and reading spectral characteristics.

The spectral characteristics of a light source can be modified by the use of filters, e.g. to cut off the extremities of the spectrum (e.g. the infrared and/or ultraviolet components), to restrict the spectral band covered, or to modify the colour temperature.

The following subsections describe some of the different types of lamp commonly used for mail processing, but the descriptions do not necessarily replicate the specification of an actual device. If it is not possible to verify symbols under spectral conditions matching those expected to be used in practice, the values for Rmax and Rmin, and therefore Symbol Contrast, should be obtained by the use of a light source, the spectral characteristics of which can be related to the spectral band for the ink in question, as defined in UPU standard S44-1.

UPU standard S44-1 also discusses the correlation between colour measurements obtained with the use of a standard spectrodensitometer and the reflectance values obtained with the use of reading equipment with other spectral response characteristics.

Manufacturers of mail processing equipment can define sets of coefficients to be applied to colour reflectance measurements (e.g. RGB values) obtained by the use of such instruments, to predict the reflectance values that would be perceived by their equipment. These coefficients will vary with the spectral factors of the reading equipment.

B.3.2 Halogen lamps

These are also known as tungsten halogen lamps. The spectral distribution of these lamps is normally a smooth curve with emission increasing from a relatively low value in the blue/green area of the spectrum to a maximum in the near infrared, around 1000 nm. A typical source is a halogen lamp of colour temperature 3050°K used in conjunction with an infrared absorbing filter to give a spectral range extending from 425 nm to 700 nm, with peak emission at 680 nm.

NOTE This type of lighting will normally give lower reflectance values (increased contrast) for blue and black inks than for red inks. Dye-based black inks (the absorption of which decreases rapidly at near infrared wavelengths) will have a higher apparent reflectance (and therefore lower contrast) than pigment-based black inks under this illumination.

B.3.3 Light emitting diode

An example of this type of illumination is a white LED of colour temperature 7000°K, with peak emission at 460 nm, and a secondary peak (60 % of the main peak) at 580 nm.

NOTE This type of lighting will normally give lower reflectance values (increased contrast) for black (both dye- and pigment-based) and red inks than for blue inks. However, when used in conjunction with a long pass filter, it is possible to reduce the reflectance, and therefore improve the contrast, of blue inks.

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B.3.4 Gas discharge lamp

The spectral distribution of these sources is characterized by several sharp (individually, virtually monochromatic) peaks with relatively low emission between these peaks. These characteristics are so dissimilar to those of a black body radiator that assigning a colour temperature to describe the light is practically meaningless. An example source of this type is a sodium lamp with peak emission at 580 nm and secondary peaks at 430 nm, 525 nm and 660 nm, used in conjunction with infrared and ultraviolet absorbing filters to give a spectral range extending from 425 nm to 670 nm. However, other gases are also used, e.g. mercury vapour which has a peak emission in the green/blue area of the visible spectrum.

NOTE Sodium lighting will normally give lower reflectance values (increased contrast) for blue and black inks than for red inks, though the light from mercury vapour lamps will give lower reflectance values (increased contrast) for red and black than for blue.

B.3.5 Fluorescent lamps

Similar to gas discharge lamps, these also show a multi-peak spectral distribution, but with a somewhat smoother curve (i.e. greater emission between peaks) enabling a colour temperature value to be more accurately assigned. Depending on the specific compounds used to coat the tube, a range of colour temperatures from 3000°K to 6000°K or more can be obtained. A typical fluorescent source (with three bands in its spectrum) is a 5000°K lamp, with peak emission at 434 nm, 546 nm and 610 nm.

Annex C
(informative)

Symbol parameters measured in accordance with ISO/IEC 15415

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C.1 General

The parameters required to be measured under ISO/IEC 15415 differ according to whether the symbology is a two-dimensional multi-row symbology, e.g. PDF417, or a two-dimensional matrix symbology. For a full definition of each parameter, its measurement and grading, it is recommended to refer to ISO/IEC 15415 and additionally, in the case of two-dimensional multi-row symbols, to ISO/IEC 15416.

For both types of symbology, the measurement of all parameters is based on the application of the symbology reference decode algorithm to either the scan reflectance profiles or the captured images.

The methodology is based on the measurement of diffuse reflectance from the symbol. Reflectances are expressed as the percentage of incident light diffusely reflected by the sample, taking the reflectance of a reference material (normally barium sulphate) as 100 %. The reflectance response of a verifier is calibrated to such a reference material before taking measurements, to ensure consistency.

C.2 Parameters for two-dimensional multi-row symbols

The following parameters (identified with an asterisk) are the same as those measured for linear bar code symbols in accordance with ISO/IEC 15416. Some of them are only measured and graded on the start and stop (or equivalent) patterns of the two-dimensional symbol, others only in the data area, and the "decode" parameter is assessed over the whole symbol.

— Symbol contrast (graded)*: the difference in percentage reflectance between the lightest and darkest points in the scan;

— Minimum reflectance (pass/fail)*: at least one bar shall be less than half the reflectance of the lightest point in the scan;

— Minimum edge contrast (pass/fail)*: every bar and space transition shall separate points with a reflectance difference of at least 15 percentage points;

— Modulation (graded)*: the ratio of minimum edge contrast to Symbol Contrast, a measure of variations in contrast within the symbol;

— Defects (graded)*: the ratio of the depth of the greatest irregularity in the scan reflectance profile (caused by specks and voids) to Symbol Contrast;

— Decode (pass/fail)*: the symbol characters tested shall pass the symbology reference decode algorithm;

— Decodability (graded)*: the lowest margin between any measurement used in the reference decode algorithm and the applicable reference threshold.

Additional parameters are also defined to allow for the special characteristics of two-dimensional multi-row symbologies, and are measured in the data area of the symbol, or the quiet zone:

— Codeword Yield (graded): the percentage of the number of codewords that could potentially be decoded (i.e. the number of rows scanned multiplied by the number of codewords per row) that was actually decoded;

— Unused error correction (graded): the fraction of the error correction capacity of the symbol not required to correct for errors or erasures;

— Codeword quality (graded): codewords in the data area are graded for defects, modulation and decodability and these gradings are then modified to allow for the effect of error correction in compensating for errors and erasures (refer to ISO/IEC 15415 for details);

— Quiet zone (pass/fail)*: the existence or otherwise of a quiet zone which is compliant with the specification;

— Print growth (ungraded): a measure of bar width gain or loss as a process control tool, not entering into grading calculations.

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C.3 Parameters for two-dimensional matrix symbologies

— Decode (pass/fail): the symbol tested shall pass the symbology reference decode algorithm.

— Symbol contrast (graded): the reflectance difference between the lightest and darkest modules, based on the reflectances of circular sample areas centred on the grid intersections of the symbol.

— Fixed pattern damage (graded): derived from the number of modules incorrectly seen as dark or light in the fixed patterns of the symbol, or in the quiet zone, as a percentage of the total number of modules in the feature; the features assessed carry different weightings. The fixed patterns and the grade threshold values vary from symbology to symbology and are specified in ISO/IEC 15415 or the symbology specification.

— Modulation (graded): the lowest reflectance difference between the lightest dark module or the darkest light module and the Global Threshold, relative to Symbol Contrast; a measure of variations in reflectance.

NOTE The calculation of this parameter is modified to compensate for the effects of error correction. See ISO/IEC 15415 for details of the calculation.

— Axial non-uniformity (graded): the relative scaling of the axes of the symbol.

— Grid non-uniformity (graded): the largest vector deviation of any grid intersection determined by the reference decode algorithm from its position in a theoretical ideal symbol, as a fraction of the X dimension.

— Unused error correction (graded): the fraction of the error correction capacity of the symbol not required to correct for errors.

— Quiet zone (pass/fail): the existence or otherwise of a quiet zone which is compliant with the specification.

— Print growth (ungraded): the highest difference between the dimension of a defined measurement (module or group of modules) and its nominal dimension, as a fraction of the X dimension; print growth is measured separately in each axis as a process control tool, and does not enter into grading calculations.

Annex D
(informative)

Characteristics of Digital Postage Mark printing and reading environments that affect print quality

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D.1 Introduction

Digital Postage Marks are an application of bar code technology with specialized printing and reading environments that have characteristics that complicate the print quality picture.

D.2 Printing of Digital Postage Marks

D.2.1 General

The four principal techniques for the production of Digital Postage Marks are:

— Ink-jet printing (on special franking machines or on PC-controlled office printers);

— Laser printing (on PC-controlled office printers);

— Thermal transfer printing (on PC-controlled office printers, special label printers or franking machines);

— Direct thermal printing (on PC-controlled office printers, special label printers or franking machines).

D.2.2 Ink-jet printing

Special franking machines using this process are generally dedicated machines, the design of which has been optimized to achieve the highest quality Digital Postage Marks consistent with the throughput speeds required by users. These devices can typically have a nominal resolution (dot centre pitch) in the range of 160 to 600 dpi, though the actual dot centre pitch in the direction of transport is influenced by variations in the envelope transport speed and by variations in the print-head to surface distance (which affects the droplet travel time), typically caused by variations in the thickness of the contents. The actual resolution of these printers can also be varied by controlling the paper or printhead movement in smaller increments than the nominal resolution.

Ink-jet office printers are controlled by special Digital Postage Mark software resident in a personal computer. They can have a nominal resolution in the range of 300 dpi to 1200 dpi, though other values are also encountered; variations in dot position can be caused by uneven print-head movement (across the direction of feed) or uneven feeding of the envelope (in the feed direction). They have the capability of printing in black or colour. Where it is required to produce Digital Postage Marks in colours other than black, and particularly when the colour is composed of dots of different primary colours, the acceptability of the resulting symbols should be tested under the appropriate illumination conditions.

The dot shape is nominally circular with a diameter slightly in excess of the nominal dot centre pitch to ensure overlap of adjacent dots; the dot size can also be affected by ink spread due to the absorbency of the substrate. Other effects such as satelliting, where ink droplets or spray fall on the areas intended to remain unprinted, can, if severe, lead to a poor 'defects' grade or even a reduction in the apparent reflectance of light areas.

D.2.3 Laser printing

These systems are based on standard general-purpose office printers, driven by personal computers running specialized software to generate the Digital Postage Marks. Laser printers will typically have a print resolution in the range of 300 dpi to 1200 dpi. The image is normally produced with black toner, although other colours are possible.

D.2.4 Thermal transfer printing

The thermal transfer technique is primarily used in label printers, either driven by a separate personal computer or stand-alone units possessing internal intelligence for encoding data into the bar code symbology, label formats, etc.

It is also used in a number of franking machines. The image is formed by selectively heating elements in the print head, causing ink carried on a special ribbon to melt and transfer to the substrate to be printed. Thermal transfer printers will typically have a resolution in the range of 8 dpmm to 16 dpmm. Thermal transfer ribbons can be produced in a variety of colours, although black is most usual.

D.2.5 Direct thermal printing

This technique uses precisely the same print engine as thermal transfer printing, as described in D.2.4, except that the thermal transfer ribbon and plain paper substrate are replaced by a substrate with a heat-sensitive coating which darkens in areas to which heat is applied by the elements in the print head. It should be noted, when using this technique, that certain coatings produce dark images that have a high reflectance in the infrared spectrum and are therefore better suited to reading with equipment with a low response in the infrared part of the spectrum.

D.2.6 Matching X dimension to printer resolution

In order to obtain maximum print quality, software for the generation of bar code symbols should match the X dimension of the output to the resolution of the printer so that each module is made up of an integer number of dots, and this is a requirement of UPU standard S28. In general printers with higher resolution will be capable of better matching target X dimensions. Actual dark element widths will be affected by dot gain (and light element widths will be reduced by an equal amount). If the effect of dot gain or ink spread is significant it can also be necessary to change one or more dots from dark to light at each dark-to-light transition to compensate.

UPU standard S28 contains recommendations for the X dimensions that can be obtained matching the resolution of a range of printing devices. ISO/IEC 15419 contains detailed advice and examples of the process, including compensation for ink spread, as applied to linear symbols, that can be adapted by programmers for the production of two-dimensional symbols.

The following Table summarizes values given in UPU standard S28, based on the minimum X dimensions specified for DataMatrix symbols (0,5 mm) and PDF417 symbols (0,38 mm), for a number of commonly encountered printer resolutions. The values quoted assume that effects of print growth (dot gain or ink spread) are negligible, but if these are significant (i.e. greater than approx. 0,5 dot per element), an adjustment as outlined above can be required.

EN 14615 recommends a minimal resolution of 300 dpi for the printing of Digital Postage Marks. Indeed, most mail processing equipment will require at least 4 dots per module to achieve the read rates referred in Clause 8.

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Table D.1 — Number of printer dots to match minimum target X dimensions for Data Matrix and PDF417 symbols

	Values for symbols with target X = 0,5 mm		**Values for symbols with target X = 0,38 mm**	
Printer Resolution (dots/inch)	**X (dots)**	**X (approx. mm)**	**X (dots)**	**X (approx. mm)**
150	3	0,51	2	0,34
200	4	0,51	3	0,38
300	6	0,51	5	0,42
360	8	0,56	6	0,42
600	12	0,51	9	0,38
720	15	0,53	11	0,39
NOTE Precise matching of the achieved module dimension to the specified X dimension is less critical for successful reading than achieving the highest possible symbol quality grade.				

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D.3 Reading environment

There are two principal situations in which a Digital Postage Mark can be read. The first, and less critical, is by the use of a hand-held reader, where the operator will normally be able to position the field of view of the reader so that the Digital Postage Mark symbol is approximately centred in it, and he has the opportunity of making several read attempts if the first ones are unsuccessful. This situation can tolerate a lower overall symbol grade, although since the application is primarily designed for automated reading, the minimum quality requirements defined in Clause 5 should be met. In many cases the equipment used has a narrow-band red light source, in which case symbols printed using red inks are not likely to provide adequate contrast.

The second situation is the environment for which Digital Postage Marks are designed to be read, namely by high- speed, automated mail processing equipment. In these the mail-pieces are transported at speeds up to 4 m per second and 40 000 items per hour past a scanning head. The mail-piece can be constrained to lie in a defined plane relative to the scanning head and can be oriented so that one of its axes is parallel to the direction of movement. These do not guarantee, however, that the Digital Postage Mark will necessarily lie in the same plane or be oriented exactly parallel or perpendicular to the direction of movement. The majority of these installations use broad-band light sources of various characteristics (see Annex B). At the date of publication of this document, the typical resolution of mail processing systems lies in the range of 200 to 256 pixels per inch (approx. 8 to 10 pixels per mm).

The symbol can be deformed as a result of the thickness of the contents of the mail-piece. A label carrying the Digital Postage Mark might have been affixed to the mail-piece out of square. Where the image capture is by means of a linear sensor array which is scanned at very short intervals, to build up a two-dimensional image from multiple, successive one-dimensional slices, any unevenness in the transport speed - either as a result of slippage of the mail-piece or because of mechanical variations - will have the effect of distorting the image along the axis of movement.

The response of the symbol to the different light sources can require verification to be carried out using more than one light source.

Annex E
(informative)

Possible causes of low parameter grades in the Digital Postage Mark environment

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E.1 Multi-row symbologies

E.1.1 Symbol Contrast

E.1.1.1 General

The causes of low symbol contrast are either a low background or space reflectance under the illumination conditions used for verification, or a high reflectance of the bars, or a combination of both.

E.1.1.2 Low background/space reflectance

In the postal environment, where the postal operators have relatively little control over the materials from which the mail-pieces are manufactured, mail processing systems have to contend with a wide variety of envelope and similar materials. Many of these appear to the reading system to be of relatively low reflectance, e.g. visually dark materials under broad-band light, blue papers when a red light source is used. Glossy window materials with a high degree of specular reflection can also prevent adequate diffuse reflection from the underlying symbol. Showthrough from a dark insert, where the opacity of the substrate is low, can also contribute. Extreme amounts of satelliting with ink-jet printers can contribute to a reduction in the reflectance of light modules.

E.1.1.3 High bar reflectance

The most likely reason for this is the choice of an unsuitable ink formulation/colour for the franking marks, one which exhibits low absorption of the incident light under the specified illumination conditions.

Failure to deposit sufficient ink on the substrate will also have the same result.

A further reason can be the effect of window material which, if of insufficient clarity or excessively glossy, will reflect a proportion of the incident light before it can be absorbed by the dark areas of the symbol.

E.1.2 Minimum reflectance

Failure for this parameter indicates that every bar in the symbol has a reflectance greater than half of the maximum reflectance (R_{max}) of the symbol. The probable causes are as described in E.1.1.3.

E.1.3 Minimum edge contrast

Failure under this heading indicates that an adjacent bar and space pair differ in reflectance by less than 15 %. The most probable reasons are excessive print growth or loss or the use of too large a measuring aperture.

E.1.4 Modulation

Most frequently, print growth or loss is the underlying reason for low modulation values. However, the use of a measuring aperture that is larger than that specified for the symbol X dimension will also reduce the measured edge contrast of narrow elements more than that of wide elements, and hence reduce the modulation value of the symbol. Irregular reflectance of the substrate (e.g. the effect of material fibres in a synthetic or recycled material, or of a printed background), uneven ink deposition (e.g. caused by a blocked ink jet nozzle) or showthrough of the contents of the mail-piece can also affect this parameter.

E.1.5 Decode

Failure of the reference decode algorithm can be a consequence of many factors, many of which are detailed elsewhere in this subsection. Incorrect encoding of the symbol as a result of software errors in the printing system is an additional reason.

E.1.6 Defects

A low defects grade indicates the presence of spots of extraneous ink or other low-reflectance marks in nominally light areas of the symbol or of voids in nominally dark areas. Causes of the former can be satelliting with ink jet printers (when extraneous ink droplets fall in the spaces or quiet zone), specks of dark material in the substrate, contamination with dirt in transport, etc. The latter can be caused by blocked ink jet nozzles, faulty print head elements, abrasion in transport, etc.

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E.1.7 Decodability

In symbologies which can be decoded using only edge to similar edge decoding techniques, such as PDF417, systematic print growth or loss affecting element widths has no effect on decodability as measurements of the width of individual single elements are not used by the reference decode algorithm. Low decodability values therefore indicate a local distortion. Possible causes include dot errors in symbol printing, slippage of the mail-piece in the axis perpendicular to the height of the bars in transport through the printer, missing dots in ink-jet or thermal printing, and deformation of the mail-piece by its contents.

E.1.8 Codeword yield

This parameter is affected partly by excessive tilt of the scan line relative to the symbol row, resulting in an excessive number of row crossings, but more usually by print growth in the y-axis, which has the effect of reducing the scannable height of the row to a band through the middle of the row; reducing the Y dimension to less than the recommended minimum multiple of the X dimension (3X in the case of PDF417 symbols) will also cause a low codeword yield value. Adjustment of printer settings, or increasing row height, is usually required.

E.1.9 Unused error correction (UEC)

Anything that reduces the ability of the symbol characters to be correctly identified will reduce the UEC grade. Most typically:

— Physical damage to the symbol (scuffing, tearing, obliteration);

— Defects (spots or voids) causing bit errors;

— Excessive print growth or loss (in X and/or y-axis);

— Local deformations (caused by e.g. mail-piece contents);

— Excessive tilt of scan line relative to symbol row.

E.1.10 Quiet zone

Intrusion of extraneous print or other dark markings into the 3X quiet zones of the symbol, or the placement of the symbol too close to the edge of the mail-piece so that the minimum quiet zone requirement cannot be met are the usual causes of failure for this parameter.

E.1.11 Print growth

Print growth can be either positive or negative (print loss). The detailed causes of this are dependent on the print technology used and on the substrate. With ink-jet printing, the ink can be absorbed into the substrate and the image will spread; this can be progressive over some time (minutes or even hours after printing). The droplet size can be excessive. If too many satellites are generated they can increase the apparent size of a feature. With ink-jet and laser printing, dot gain can be a contributory factor. With thermal transfer printing, the most usual cause is incorrect print head temperature, resulting in the transfer of too much or too little pigment from the ribbon. Slippage of the mail-piece in transport past the print head can cause dragging and smearing of the image in one axis. While print growth or loss is not graded in itself it can have an adverse effect on other parameters, e.g. modulation, or codeword yield (if in the y-axis), and a measurement of the growth is helpful for process control purposes.

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E.1.12 Codeword quality

Since the scan reflectance profiles of multi-row symbols are only fully evaluated for the start and stop patterns of multi-row symbols, ISO/IEC 15415 makes provision for the assessment and grading of Decodability, Defects and Modulation in the data area of the symbol. Since a number of codewords can be rendered undecodable (erasures) or misdecoded (errors) as a result of problems with these attributes, within the error correction capacity of the symbol, and without affecting its readability, the calculation of the gradings for these parameters makes allowance for this, it is recommended to refer to ISO/IEC 15415 for details.

E.2 Matrix symbologies

E.2.1 Symbol Contrast

The causes of low symbol contrast are identical with those described in E.1.1.

E.2.2 Fixed pattern damage

This can be caused either during printing of the Digital Postage Mark symbol, e.g. as a result of blocked nozzles (ink-jet printing) or missing dots (thermal transfer printing) in the print head, or as physical damage to the symbol, e.g. scuffing, tearing in transit.

E.2.3 Modulation

Although modulation shows itself in the form of apparent local variations in contrast it is also an effect of print growth or loss. Potential causes are therefore:

— misplaced modules;

— voids within dark modules (e.g. non-overlapping or missing printer dots) or spots within light modules;

— variation in ink pigmentation or background reflectance (e.g. halftone printed background colour, fibres in paper);

— print growth or loss;

— incorrect measuring aperture size;

— showthrough of the contents of the mail-piece.

Since error correction will mask the effect of a number of bit errors caused by apparently erroneous modules, the grading calculation makes allowance for this. It is recommended to refer to ISO/IEC 15415 for details.

E.2.4 Axial non-uniformity

The most likely cause of non-uniform scaling of the symbol in different axes is a mismatch between the speed of transport of the mail-piece past a print head and the height of the symbol.

E.2.5 Grid non-uniformity

Deformation of the symbol grid can arise from a number of causes, including:

— Transport errors during printing or reading (acceleration, deceleration, vibration, slippage);

— Variations in print-head to substrate distance due to mail-piece contents;

— Verifier or scanner axis not perpendicular to symbol surface.

E.2.6 Unused error correction

The factors causing reduction of the UEC grade are identical with those described in E.1.9 (with the omission of scan line tilt).

E.2.7 Quiet zone

The factors causing failure for this parameter are identical with those described in E.1.10.

E.2.8 Print growth

Print growth can be either positive or negative (print loss). The detailed causes of this are dependent on the print technology used and on the substrate. With ink-jet printing, the ink can be absorbed into the substrate and the image will spread; this can be progressive over some time (minutes or even hours after printing). The droplet size can be excessive or insufficient. The ink formulation can be unsuited to the type of substrate. If too many satellites are generated they can increase the apparent size of a feature. With thermal transfer printing, the most usual cause is incorrect print head temperature, resulting in the transfer of too much or too little pigment from the ribbon. Slippage of the mail-piece in transport past the print head can cause dragging and smearing of the image in one axis. Measurement of print growth is useful for process control purposes.

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