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Automatic identification and data capture techniques — Bar code symbol quality test specification — Direct part mark (DPM)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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This document was prepared by Joint Technical Committee ISO/JTC 1, *Information Technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This second edition cancels and replaces the first edition (ISO/IEC 29158:2020), which has been technically revised.

The main changes are as follows:

— the definition of continuous grading has been deleted (it is now defined in ISO/IEC 15415);

— the rounding method has been revised to always round down.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

Direct part marking (DPM) is a technology whereby, generally, an item is physically altered to produce two different surface conditions. This alteration can be accomplished by various means including, but not limited to, dot peen, laser mark, ink jetting and electro-chemical etch. The area of the alteration is called "the mark." The area that includes the mark and background as a whole, when containing a pattern defined by a bar code symbology specification, is called "a symbol."

When light illuminates a symbol, it reflects differently depending on whether it impinges on the background of the part or on the physical alteration. In most non-DPM bar code scanning environments, light is reflected off a smooth surface that has been coloured to produce two different diffuse reflected states. The DPM environment generally does not fit this model because the two different reflected states depend on at least one of the states having material oriented to the lighting such that the angle of incidence is equal to the angle of reflection. Sometimes, the material so oriented produces a specular (mirror like) reflectance that results in a signal that is orders of magnitude greater than the signal from diffuse reflectance.

In addition, from the scanner point-of-view, some marking and printing methods generate dots and are not capable of producing smooth lines. This is important for symbologies such as Data Matrix, which is specified to contain smooth continuous lines, but can be marked with disconnected dots in DPM applications.

Current specifications for matrix symbologies and two-dimensional print quality are not exactly suited to reading situations that have either specular reflection or unconnected dots or both. Additionally, symbologies specified to consist of smooth continuous lines may appear with unconnected dots. This is intended to act as a bridge between the existing specifications and the DPM environment in order to provide a standardized image-based measurement method for DPM that is predictive of scanner performance.

As with all symbology and quality standards, it is the responsibility of the application to define the appropriate parameters of this document for use in conjunction with a particular application.

This document was developed to assess the symbol quality of direct marked parts, where the mark is applied directly to the surface of the item and the reading device is a two-dimensional imager.

When application specifications allow, this method is also potentially applicable to symbols produced by other methods. This is appropriate when DPM symbols and non-DPM symbols are being scanned in the same scanning environment. The symbol grade is reported as a DPM grade rather than as an ISO/IEC 15415 grade.

Automatic identification and data capture techniques — Bar code symbol quality test specification — Direct part mark (DPM)

1 Scope

This document describes the modifications to the symbol quality methodology defined in ISO/IEC 15415 and provides a symbology specification.

This document establishes alternative illumination conditions, some new terms and parameters, modifications to the measurement and subsequent grading of certain parameters, and the reporting of the grading results.

This document is intended for verifier manufacturers and application specification developers.

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.

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

ISO/IEC 19762, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 15415, ISO/IEC 19762 and the following apply.

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

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

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

3.1
reference symbol
high-contrast printed calibration card for which results are traceable back to national or international standards and for which the supplier supplies a calibration certificate

3.2
stick
line segment comprised of image pixels that is used to connect areas of the same colour that are near to each other

4 Symbols and abbreviated terms

4.1 Symbols

C_C	value of cell contrast
C_{MOD}	value of cell module modulation
f_x	remaining distance fraction of the x position
f_y	remaining distance fraction of the y position
g	current threshold of the grid-centre point histogram in the calculation of the optimal threshold according to Annex A
M_D	mean of the grid-centre point histogram of the dark elements
M_L	mean of the grid-centre point histogram of the light elements
M_{Lcal}	mean of the light lobe from a histogram of the calibrated standard
$M_{Ltarget}$	mean of the light lobe from the final grid-centre point histogram of the symbol under test
R	measured reflectance of the cell
R_{cal}	reported reflectance value, R_{max}, from a calibration standard
R_{target}	measured percent reflectance of the light elements of the symbol under test relative to the calibrated standard NOTE R_{target} is graded and reported as the parameter named "minimum reflectance".
S_{Rcal}	system response parameters (such as exposure and/or gain) used to create an image of the calibration standard
$S_{Rtarget}$	system response parameters (such as exposure and/or gain) used to create an image of the symbol under test
T_1	threshold created using a histogram of the defined grey scale pixel values in a circular area 20 times the aperture size in diameter, centred on the image centre using the algorithm given in Annex A
T_2	threshold created using the histogram of the reference grey scale image pixel values at each intersection point of the grid using the method given in Annex A
T_{min}	current minimum threshold in the calculation of the optimal threshold according to Annex A
T_{max}	current maximum threshold in the calculation of the optimal threshold according to Annex A
V	current sum of two variances according to Annex A
V_D	current variance of the grid-centre point histogram of the dark elements according to Annex A
V_L	current variance of the grid-centre point histogram of the light elements according to Annex A
V_{min}	current minimum variance in the calculation of the optimal threshold according to Annex A
x	x position on the camera image plane
x'	x position on the virtual camera plane
x_p	x position of image pixel on the camera image plane

y y position on the camera image plane

y' y position on the virtual camera plane

y_{p} y position of image pixel on the camera image plane

4.2 Abbreviated terms

CM cell modulation

CC cell contrast

CMOD cell module modulation

DFPD distributed fixed pattern damage

DPM direct part marking

FPD fixed pattern damage

TCL tilted coaxial lighting and camera position

5 Overview of methodology

5.1 Process differences from ISO/IEC 15415

All parameters in the symbology and print quality specifications apply except for:

— multi-row bar code symbols are not supported by the method described in this document;

— a different method for setting the image contrast;

— a new method for choosing the aperture size;

— an image pre-process methodology for joining disconnected modules in a symbol (where applicable);

— a different process for determining the modulation parameter which has been renamed cell modulation (CM);

— a different process for determining the symbol contrast parameter which has been renamed cell contrast (CC);

— a different process for computing FPD;

— a new parameter called minimum reflectance (R_{target});

— print growth is not graded and not included in the final grade.

This document explains how to both specify and report quality grades in a manner complementary to, yet distinct from, the method in ISO/IEC 15415.

NOTE Annex E gives a cross reference comparison of this document to ISO/IEC 15415.

5.2 Lighting

Lighting environments shall be reported in accordance with 6.2 and 10.2. The lighting environment(s) shall be selected by the application specification in consideration of the properties of the mark and the requirements of the reading equipment and environment of the application.

5.3 Tilted coaxial lighting and camera position

Tilted coaxial lighting and camera position (TCL) is useful for DPM applications that use a geometrical mark which is peened, drilled or carved into a surface. Reading camera and unidirectional illumination are located at a coaxial position with a known fixed tilt angle and object rotation angle and position.

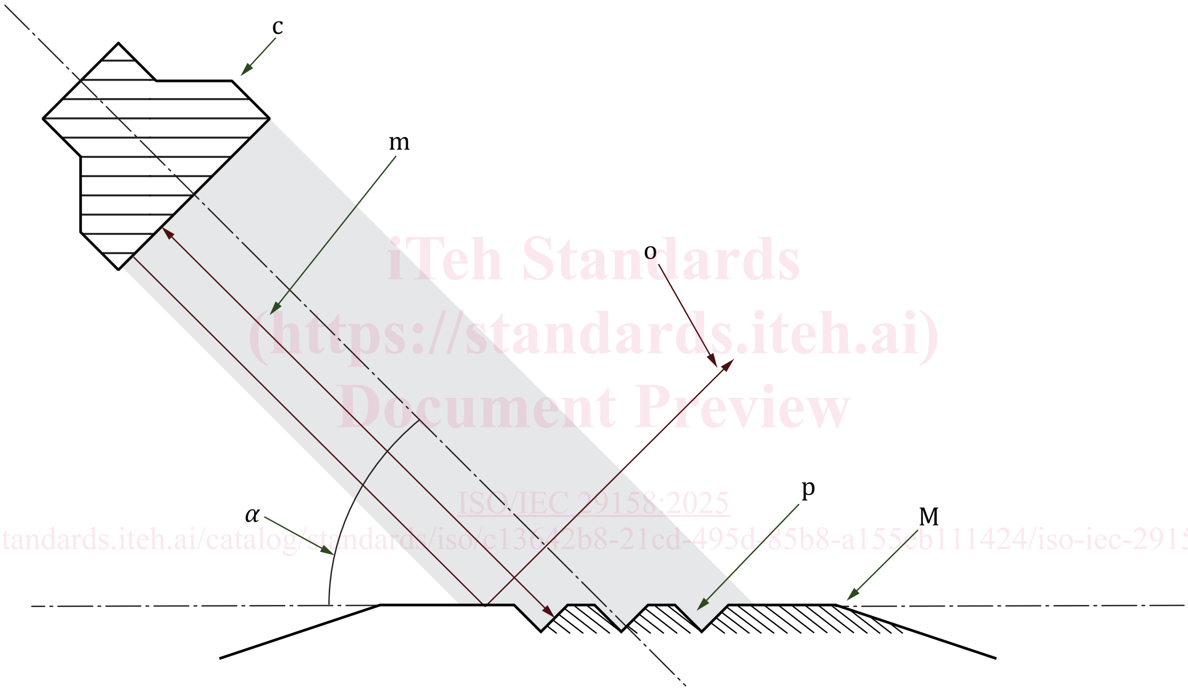
To read dot-peened codes, there are multiple reading setups possible. This document defines several camera and lighting setups in order to address various dot peen geometries.

This specific TCL environment is focussing on the system response of the mark (e.g. the image a camera sees). SAE Standard AS9132[2] takes a different approach to specify the mark geometry.

Figure 1 illustrates the setup. The essential parameter is the camera reading angle. Typical camera reading angles include 30°, 45° or 60° in relation to the plane of the mark.

NOTE 1 The camera angle is defined in a compatible way to the lighting angle of ISO/IEC 15415:2024, Figure 1.

NOTE 2 Within the dot peen industry, it is common to specify the stylus angle which is twice the camera angle given in Figure 1.



Key

c camera and coaxial lighting

m light beam in mark is reflected to camera

o light beam outside mark is reflected away

α camera reading angle

p peened mark

M marked object

Figure 1 — Tilted coaxial lighting and camera setup

This setup is referenced by the abbreviation "TCL" in the following text.

It is not feasible to grade this setup with a camera angle of 90°. The result will not be significant for this application, as other features of the marked object are measured.

Recognise that a general-purpose verifier device does not always cover this application, as it requires a special construction.

6 Obtaining the image

6.1 Camera position and symbol orientation

6.1.1 Symbol placement

Camera to object position is described in this subclause. By default, the horizontal and vertical axis of the symbol are parallel to a line formed by the edge of the image sensor within ±3° (i.e. nominally no rotation). This symbol orientation should be maintained unless an application specification requires or allows a different orientation. An application specification may specify a different symbol rotation. Since the symbol rotation is determined after decoding, the actual rotation angle should be reported so that the setup can be reproduced easily. In applications in which the rotation angle is specified, the rotation angle shall be reported to confirm conformance to specified requirements.

The part is placed such that the symbol is in the centre of the field of view.

NOTE Placing the symbol in the centre of the field of view results in the intended angle and position of illumination and camera and tends to achieve the most accurate results.

6.1.2 Camera position in a 90° camera angle set up

The camera is positioned such that the plane of the image sensor is parallel to the plane of the symbol area. This is identical to a 90° camera angle.

6.1.3 TCL setup

Within the TCL setup, camera and symbol position differs in the following points.

— The camera is positioned in the camera angle defined by the application.

— The raw image is geometrically transformed to correspond to a test image with a virtual camera position with a 90° camera angle, as described in Annex B.

— The symbol rotation angle needs to be specified by the application and shall be respected by ±5°.

6.2 Lighting environments

6.2.1 General

The lighting environment is specified by the application. This shall include a direction specifier or an angle or both. The format is an extension of the angle specifier used in ISO/IEC 15415. Several examples are given in the following subclauses.

6.2.2 Perpendicular coaxial (“90”)

The symbol is illuminated with diffuse light such that the specular reflection from the entire field of view is nominally uniform.

6.2.3 Diffuse off-axis (“D”)

A diffusely reflecting dome is illuminated from below so that the reflected light falls non-directionally on the part and does not cast defined shadows. This is commonly used for reading curved parts. The angle specifier shall be “D”.

This lighting is also called dome lighting.