TECHNICAL REPORT

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Information technology — Automatic identification and data capture techniques — Direct Part Mark (DPM) Quality Guideline

Technologies de l'information — Techniques automatiques d'identification et de capture de données — Ligne directrice de qualité du marquage direct sur pièce (DPM)

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Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example) it may decide to publish a Technical Report. A Technical Report is entirely informative in nature and shall be subject to review every five years in the same manner as an International Standard.

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

ISO/IEC TR 29158 was prepared jointly by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

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, ink jet, 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.

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. 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 applicator to define the appropriate parameters of this guideline for use in conjunction with a particular application.

Information technology — Automatic identification and data capture techniques — Direct Part Mark (DPM) Quality Guideline

1 Scope

This Technical Report is an engineering document intended for verifier manufacturers and application specification developers.

This Technical Report describes modifications which are to be considered in conjunction with the symbol quality methodology defined in ISO/IEC 15415 and a symbology specification. It defines alternative illumination conditions, some new terms and parameters, modifications to the measurement and grading of certain parameters, and the reporting of the grading results.

This Technical Report 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 may also be applied to symbols produced by other methods. This is appropriate when direct part marked (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.

2 Normative references

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

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

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

ISO/IEC 19762-1, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC*

ISO/IEC 19762-2, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 2: Optically readable media (ORM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 15415, ISO/IEC 15416, ISO/IEC 19762-1, ISO/IEC 19762-2 and the following apply.

3.1
MLcal
mean of the light lobe from a histogram of the calibrated standard

3.2
MLtarget
mean of the light lobe from the final grid-point histogram of the symbol under test

3.3
reference symbol
high-contrast printed calibration card

EXAMPLE The GS1 Data Matrix calibrated conformance standard test card.

3.4
Rcal
reported reflectance value, Rmax, from a calibration standard

3.5
Rtarget
measured percent reflectance of the light elements of the symbol under test relative to the calibrated standard

3.6
SRcal
system response parameters (such as exposure and/or gain) used to create an image of the calibration standard

3.7
SRtarget
system response parameters (such as exposure and/or gain) used to create an image of the symbol under test

3.8
stick
line segment comprised of image pixels that is used to connect areas of the same colour that are near to each other

3.9
T1
threshold created using a histogram of the defined grey-scale pixel values in a circular area twenty times the aperture size in diameter, centred on the image centre using the algorithm defined in Annex A

3.10
T2
threshold created using the histogram of the reference grey-scale image pixel values at each intersection point of the grid using the method defined in Annex A

4 Abbreviated terms

CM Cell Modulation

CC Cell Contrast

FPD Fixed pattern damage

LED Light emitting diode

MD MeanDark

5 Overview of methodology

5.1 Process differences from 15415

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

- A different method for setting the image contrast.

- A different method for creating the binary image.

- A new method for choosing the aperture size.

- An image pre-process methodology for joining disconnected modules in a symbol.

- A different process for determining the Modulation and Reflectance Margin parameter renamed Cell Modulation.

- A different process for determining the Symbol Contrast parameter which has been renamed Cell Contrast.

- A difference process for computing Fixed Pattern Damage

- A new parameter called Minimum Reflectance.

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

5.2 Lighting

This guideline recommends three specific lighting environments consisting of two forms of diffuse lighting (non-directional):

- diffuse on-axis illumination uses a diffuse light source illuminating the symbol nominally perpendicular to its surface (nominally parallel to the optical axis of the camera).

- diffuse off-axis illumination uses light from an array of LEDs reflected from the inside of a diffusely reflecting surface of a hemisphere, with the symbol at its centre, to provide even incident illumination from all directions.

- Directional illumination is oriented at a low angle (approximately 30 degrees) to the mark surface.

6 Obtaining the image

6.1 Orientation of the symbol to the camera

6.1.1 Camera position

The camera is positioned such that the plane of the image sensor is parallel to the plane of the symbol area.

6.1.2 Orienting the symbol

The part is placed such that the symbol is in the centre of the field of view and oriented so that the horizontal lines in the symbol are parallel with a line formed by the edge of the image sensor to within +/- 5 degrees.

6.2 Lighting

Two lighting environments each with sub-options are defined in this document. The defined lighting environments are denoted in the reported grade using the format defined in ISO/IEC 15415 using the angle specifier with a combination of numbers and letters as defined below.

Note: This does not limit the prerogative of an Application Specification to choose different lighting environments based on application requirements. Alternate lighting environments should include specifiers consistent with the format of those below which can be used for communicating quality requirements and quality grades.

6.2.1 Diffuse perpendicular (on-axis/bright field) (90)

A flat diffusing material is oriented such that the plane of the material is parallel to the plane of the symbol area. The symbol is uniformly illuminated with diffuse light incident at 90 +/- 15 degrees relative to the optical axis to the plane of the symbol. The angle specifier shall be 90 to denote this lighting environment.

6.2.2 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.

6.2.3 Low angle, four direction (30Q)

Light is aimed at the part at an angle of 30 +/- 3 degrees from the plane of the surface of the symbol from four sides such that the lines describing the centre of the beams from opposing pairs of lights are co-planar and the planes at right angles to each other. One lighting plane is aligned to be parallel to the line formed by a horizontal edge of the image sensor to within +/- 5 degrees. The lighting shall illuminate the entire symbol area with uniform energy. The angle specifier shall be 30Q.

6.2.4 Low angle, two direction (30T)

Light is aimed at the part at an angle of 30 +/- 3 degrees from two sides. The light may be incident from either of the two possible orientations with respect to the symbol. The lighting plane is aligned to be parallel to the line formed by one edge of the image sensor to within +/- 5 degrees. The lighting shall illuminate the entire symbol area with uniform energy. The angle specifier shall be 30T.

6.2.5 Low angle, one direction (30S)

Light is aimed at the part at an angle of 30 +/- 3 degrees from one side. The light may be incident from any of the four possible orientations with respect to the symbol. The plane perpendicular to the symbol surface containing the centre of the beam is aligned to be parallel to the line formed by one edge of the image sensor to within +/- 5 degrees. The lighting shall illuminate the entire symbol area with uniform energy. The angle specifier shall be 30S.

6.3 Image focus

The camera is adjusted such that the symbol is in best focus.

6.4 Reflectance calibration

Using a high-contrast, nationally traceable printed calibration card (such as the GS1 Data Matrix calibrated conformance standard test card) calibrated using a known aperture, take an image of the calibration card. Using the known aperture size, sample the centre of every element in the image, not including the outer spaces, and pick the highest reflectance of the target.

Set the system response so that the mean of the light elements is in the range of 70% to 86% of the maximum grey scale (MLcal) and the black level (no light) is nominally equal to zero. The system response is the linear relationship between the reflectivity of the target and the pixel intensity values in the image as a result of several factors (e.g. shutter speed, imager sensitivity, f-stop, gain, illumination intensity.) This procedure requires the ability to adjust at least one of these factors in order to adjust the system response.

Record the system response as the Reference System Response (SRcal) and record MLcal.

6.5 Initial image reflectance level of the symbol under test

6.5.1 Initialize aperture size

Set the aperture to 0.8 of the minimum X-dimension of the application, and apply it to the original image to create a reference greyscale image.

6.5.2 Create initial histogram of symbol under test

Create a histogram of the reference grey-scale pixel values in a circular area 20 times the aperture size in diameter, centred on the image centre, and find the Threshold, T1, using the algorithm defined in Annex A.

The threshold divides the histogram into two portions: a portion less than the threshold which contains dark pixels and a portion greater than the threshold which contains light pixels (called the “light lobe”).

6.5.3 Compute mean

Compute the mean of the light lobe.

6.5.4 Optimize image

Adjust the system response by taking new images and repeating steps 6.5.1 and 6.5.2 until the mean of the light elements is in the range of 70% to 86% of the maximum grey scale.

7 Obtaining the test image

The referenced matrix symbologies all require the locating of continuous modules in their reference decode algorithms. Some marking technologies are not capable of producing symbols with smooth, continuous lines when viewed by an imager. For example, dot peened symbols often produce unconnected dots. This section includes a method of pre-processing the image that will connect disconnected modules so that the standard reference decode algorithms can operate successfully.

Once the grid of the symbol is determined, the location information is transferred to the evaluation of the reference greyscale image and subsequent processing occurs using the reference greyscale image.

7.1 Binarize image

Compute a reference greyscale image using the current aperture size. Using T1, binarize the entire image.

7.2 Apply Reference Decode Algorithm

Attempt to find and process the symbol using the symbology Reference Decode Algorithm and the current aperture size. If the attempt fails, go to 7.3. If successful go to 7.4.

Note: where a symbology has a reference decode algorithm that operates successfully on nominally disconnected modules (e.g. “dot” codes) the process of connecting modules is inappropriate. With these symbologies, if the application of the Reference Decode Algorithm fails then go to 7.3.4 (not 7.3).