

Understanding 2D Verification

**Comparing Quality Parameters for
Data Matrix Symbol Verification**

MICROSCAN®

Understanding 2D Verification Using a Comparison of Quality Parameters

This white paper outlines variations in 2D symbols and tracks symbol readability for three parameters of quality standards. The purpose of Data Matrix symbol verification is to ensure reliability and consistency of symbols based on the strict criteria outlined in quality standards such as:

- ISO/IEC 15415
- AS9132
- AIM DPM

Microscan Systems, Inc.

ISO/IEC 15415 Evaluation Parameters

The ISO/IEC 15415 standard specifies the methodologies for measuring, evaluating, and grading 2D symbol characteristics in order to indicate the quality of the mark. In addition, the standard identifies possible causes for symbol degradation. Users with less than optimal symbols due to problems with marking methods or substrate inconsistencies can use this information to correct and improve their marks and achieve better symbol quality.

AS9132 Evaluation Parameters

The AS9132 standard specifies uniform quality and technical requirements for Data Matrix direct part mark (DPM) symbols on metal substrates such as metal, PCB, or plastic. Direct part marking methods addressed in the AS9132 standard include: dot peen, laser etch, and electrochemical etch. Manufacturers of aerospace components are directly affected by the AS9132 standard. The standard mandates that generally the maker of the part determines the location of the symbol. To determine ideal symbol location, manufacturers should position the symbol so that it can be illuminated evenly from all angles.

AIM DPM Quality Guideline

The AIM DPM Quality Guideline was developed to assess the symbol quality of direct part marks. It defines modifications to the measurement and grading of certain symbol quality parameters.

Parameter Comparisons

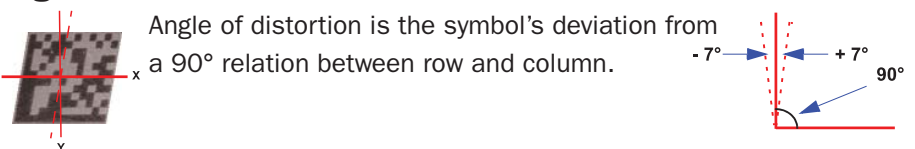










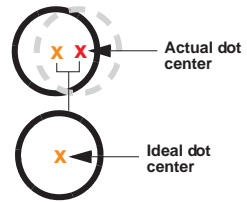

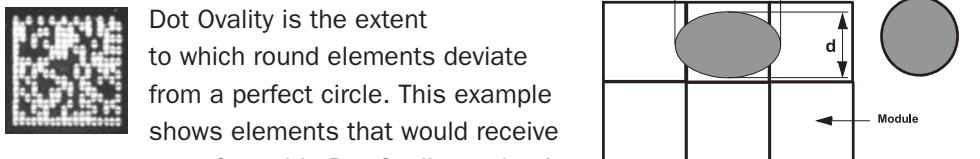

	ISO/IEC 15415	AS9132	AIM DPM
Angle of Distortion		✓	
Axial Non-Uniformity	✓		✓
Cell Contrast			✓
Cell Fill		✓	
Cell Modulation			✓
Dot Center Offset		✓	
Dot Ovality		✓	
Fixed Pattern Damage	✓		✓
Grid Non-Uniformity	✓		✓
Modulation	✓		
Pixels Per Element	✓	✓	✓
Print Growth	✓		✓
Quiet Zone		✓	
Symbol Contrast	✓	✓	
Unused Error Correction	✓		✓

Parameter Comparisons

ISO/IEC 15415

AS9132

AIM DPM

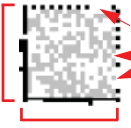



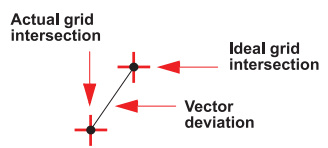
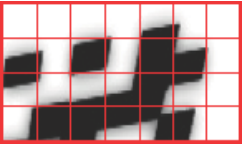




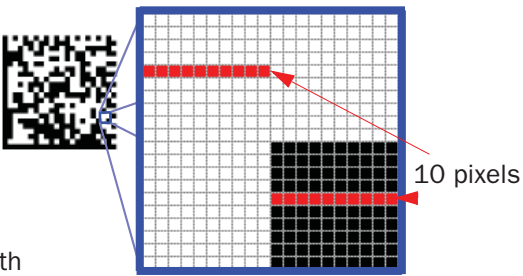






<p>Angle of Distortion</p>  <p>Angle of distortion is the symbol's deviation from a 90° relation between row and column.</p> <p>Acceptable angle deviation is $\pm 7^\circ$.</p>			
<p>Axial Non-Uniformity</p>  <p>Axial Non-Uniformity is the amount of deviation along the symbol's major axes. In this example, the symbol's Y-axis dimension is clearly greater than its X-axis dimension. This indicates that the marking process is resulting in the Y-dimensions of individual modules being greater than their X-dimensions. This inconsistency of X- and Y-dimensions typically indicates movement of the object as it is being marked.</p>			
<p>Cell Contrast</p>  <p>Cell Contrast is the value difference between light and dark symbol elements, and between the quiet zone and perimeter elements. This example shows a low-contrast direct part mark symbol. The light and dark elements are too close in value, which undermines readability.</p>			
<p>Cell Fill</p>  <p>Cell Fill is the percentage of the ideal cell size that the module or element fills. The example at left shows dot peen elements that overflow the ideal cell size. The elements of the dots exceed the cell boundaries.</p>			
<p>Cell Modulation</p>  <p>Modulation refers to the reflectance uniformity of a symbol's light and dark elements. In this example of a dot peen mark, notice that the light/dark values of some of the elements are inconsistent.</p>			
<p>Dot Center Offset</p>  <p>A symbol's Dot Center Offset value indicates the deviation of actual dot centers from theoretical or "ideal" dot centers.</p>			
<p>Dot Ovality</p>  <p>Dot Ovality is the extent to which round elements deviate from a perfect circle. This example shows elements that would receive an unfavorable Dot Ovality evaluation.</p> <p>If $D - d > 20\%$ of nominal module size, then dot ovality is out of spec with AS9132 requirements.</p>			

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ISO/IEC 15415

AS9132

AIM DPM




<p>Fixed Pattern Damage</p>  <p>Fixed Pattern Damage refers to finder pattern and clock pattern damage. Notice the missing elements in the clock pattern and the damaged L-pattern in the example symbol.</p>			
<p>Grid Non-Uniformity</p>  <p>Grid Non-Uniformity refers to a symbol's cell deviation from the ideal grid of a theoretical "perfect symbol". The Data Matrix reference decode algorithm is applied to a binarized image of the symbol, comparing its actual grid intersections to ideal grid intersections. The greatest distance from an actual to a theoretical grid intersection determines the Grid Non-Uniformity grade.</p>  <p>The reference decode algorithm plots the symbol's grid intersections and compares them to an ideal grid.</p>  <p>The largest vector deviation on the grid determines the Grid Non-Uniformity grade.</p>			
<p>Modulation</p>  <p>Modulation refers to the reflectance uniformity of a symbol's light and dark elements. In this example, notice that the light/dark values of some elements are inconsistent.</p>			
<p>Pixels Per Element</p>  <p>Pixels Per Element refers to the number of pixels in each individual symbol element. The magnified symbol detail at right contains 4 elements, each with a width of 10 pixels.</p>			
<p>Print Growth</p>  <p>Print Growth refers to the deviation (larger or smaller) of actual element size from intended element size due to printing problems. When a symbol is printed, the ink may "bleed" when it comes in contact with the substrate, causing an Overprint. If there is not enough ink, or if there is some other problem with printing equipment, the result may be an Underprint.</p>			

Parameter Comparisons

ISO/IEC 15415

AS9132

AIM DPM

	ISO/IEC 15415	AS9132	AIM DPM
<p>Quiet Zone</p>  <p>The Quiet Zone is an unmarked space of at least one element in width surrounding the symbol, required for symbol readability. The red box in the example represents the outer perimeter of the minimum Quiet Zone requirement. The Quiet Zone can be any amount greater than one element in width, but any Quiet Zone width less than one element will make the symbol difficult or impossible to read.</p>		✓	
<p>Symbol Contrast</p>  <p>Symbol Contrast is the value difference between light and dark symbol elements, and between the Quiet Zone and perimeter elements. This example shows a low-contrast symbol. The dark elements (etched) and the light elements (the substrate's surface) are too close in value, which undermines readability.</p>	✓	✓	
<p>Unused Error Correction</p>  <p>Unused Error Correction indicates the amount of available Error Correction in a symbol. Error Correction is a method of reconstructing or replacing data that is lost through symbol damage. 100% Unused Error Correction is ideal, as shown in this example.</p>	✓		✓

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