Understanding 2D Verification

The purpose of symbol verification is to ensure reliability and consistency of symbols based on the strict criteria outlined in the AS9132A and ISO/IEC 15415 standards.

The **Quadrus Verifier** is designed to evaluate marks based on these two sets of parameters.

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 to achieve better symbol quality.

AS9132A Evaluation Parameters

The AS9132A standard specifies uniform quality and technical requirements for Data Matrix direct part marking symbols on metal substrates.

Direct part marking methods addressed in the AS9132A standard include: dot peen, laser etch, and electrochemical etch.

Manufacturers of aerospace components are directly affected by the AS9132A 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.

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ISO/IEC 15415 Verification Parameters

Symbol Contrast

Symbol Contrast is the difference in reflectance between the light and dark regions of the symbol, including the 1x quiet zone.

This example shows a low-contrast symbol. The closer the light and dark elements are in value, the more difficult it is for a reader to determine which elements are dark and which elements are light.

Fixed Pattern Damage

Fixed Pattern Damage refers to quiet zone, finder pattern, and clock pattern damage.

Fixed patterns are used for locating, orienting, and mapping the symbol. Missing elements or distortions to these patters can severely inhibit readability.

**Missing elements in clock pattern**
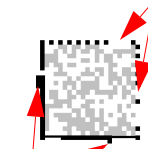
Distortions in finder pattern

Axial Non-Uniformity

**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 indi-

cates 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.

X

Y
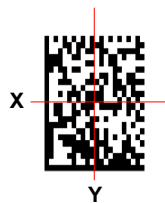
Grid Non-Uniformity

Grid Non-Uniformity refers to the cell deviation from the theoretical or "ideal" grid intersections to those that are determined by the reference decode algorithm.

Imagine an ideal grid overlaying the symbol shown in this

example. Grid Non-Uniformity measures the maximum vector deviation from that ideal grid to the one mapped using the reference decode algorithm.

X

Y
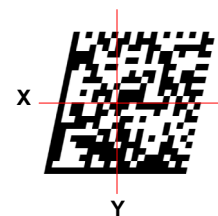
Modulation

Modulation measures the ability to discriminate between light and dark elements.

In this example, notice that the dark values of some elements are inconsistent. This can result in a reader's inability to properly determine whether a light element is light or a dark element is dark.

Unused Error Correction Capacity

Unused Error Correction Capacity indicates the amount of error correcting capability remaining after applying the error correcting algorithms to reconstruct a damaged or poorly modulated symbol.
100% Unused Error Correction Capacity is ideal and would indicate that there is no damage to the symbol.

Print Growth (Ungraded)

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**.


Overprint

Underprint

Pixels Per Element

For consistent and reliable verification, a symbol must have a minimum of 10 **Pixels Per Element** (PPE). Pixels Per Element refers to the number of pixels in the width of each individual symbol element. Microscan's Quadrus Verifier appends a Pixels Per Element value to both ISO/IEC 15415 and AS9132A verification reports. The magnified symbol detail below contains **4** elements, each with a width of **10** pixels.


10 pixels
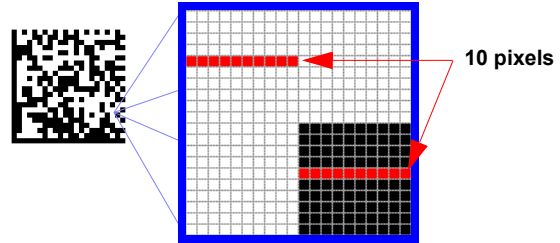
AS9132A Verification Parameters

Dot Center Offset

A symbol's **Dot Center Offset** value indicates the deviation of actual dot centers from theoretical or "ideal" dot centers.

X — Ideal dot center

The difference between the ideal and actual dot centers is the **Dot Center Offset** value.
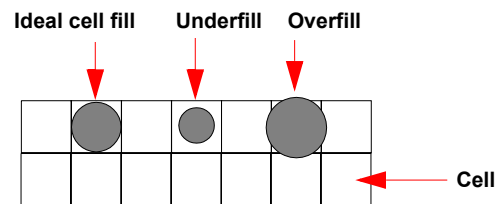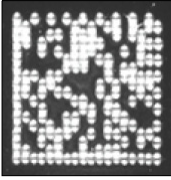
Actual dot center
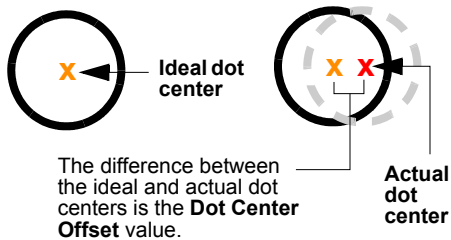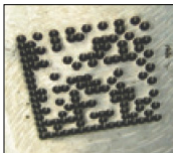
Cell Fill

Cell Fill is the percentage of the ideal cell size that the module or element fills. The range of acceptable Cell Fill is from 60% to 105%.
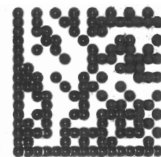
This example shows dot peen elements that overfill the ideal cell size. The elements of the dots exceed the cell boundaries.

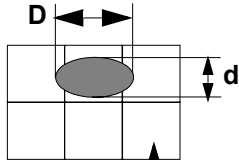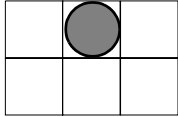**Ideal cell fill   Underfill   Overfill**

Cell

Dot Ovality

Dot Ovality is the extent to which round elements deviate from a perfect circle.

The example at left shows a symbol that would receive an unfavorable Dot Ovality evaluation.
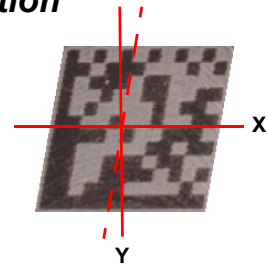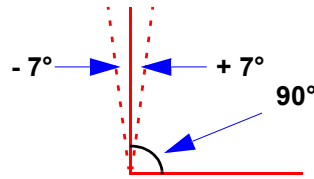
Ideal dot shape

If *D - d > 20% of nominal module size*, then dot ovality is out of spec with AS9132 requirements.

Module

Angle of Distortion

Angle of Distortion is the symbol's deviation from a 90° relation between row and column.
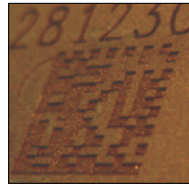
Acceptable angle deviation is ± 7°.

- 7°   + 7°

90°

Symbol Contrast

Symbol Contrast is the value difference between light and dark symbol elements, including 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.

Quiet Zone

The **Quiet Zone** is an unmarked space of at least one element in width around the symbol, required for symbol readability.
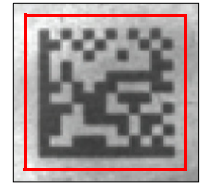
The red box in the example represents the outer perimeter of the *minimum* Quiet Zone requirement. The Quiet Zone can be any amount greater than one element in width, but any Quiet Zone width less than one element will make the symbol difficult or impossible to read.

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