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Barcode Symbologies and Machine Vision

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A Certified GS1 Standards Professional, Barbie LaBine has provided training to global medical device manufacturers on UDI compliance and UDI code and label verification for the past two years. LaBine comes to Microscan from the industry-leading barcode verification systems manufacturer Label Vision Systems, Inc., (acquired by Microscan in August 2015), and now offers a range of training on LVS® brand barcode verification and other Microscan technology and applications.

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  - Consulting Services
  - Barcode Verification analysis services
  - Information on regulatory compliances
  - Standards specifications
  - And more….

What are Barcodes?

- *Optical, machine readable, representation of data.*

- Typically contain a number
  - Index to a look-up
  - Identification number
- Can contain text
- There are many types of Data Carriers
- Called *Symbologies*

Who uses Barcodes?

- Industrial Commercial
- Distribution & Transportation
- Government
- Healthcare and Pharmaceutical
- Grocery & Food Service
- General Merchandise and Apparel
- Hardware and Office Products
- Publishing

What Is The Ideal Barcode?

The “Ideal Barcode” has been described as:

“The right barcode in the right place which scans first time every time”

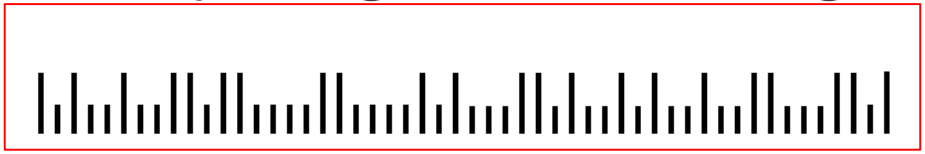
How Do I Know That My Barcode Is “Ideal”

- The “Right Barcode”:
  - Correct symbology and correct size.
- The “Right Place”:
  - Location of the barcode is also important – especially for automated systems.
- “Scans First Time Every Time”:
  - Print quality must be satisfactory.

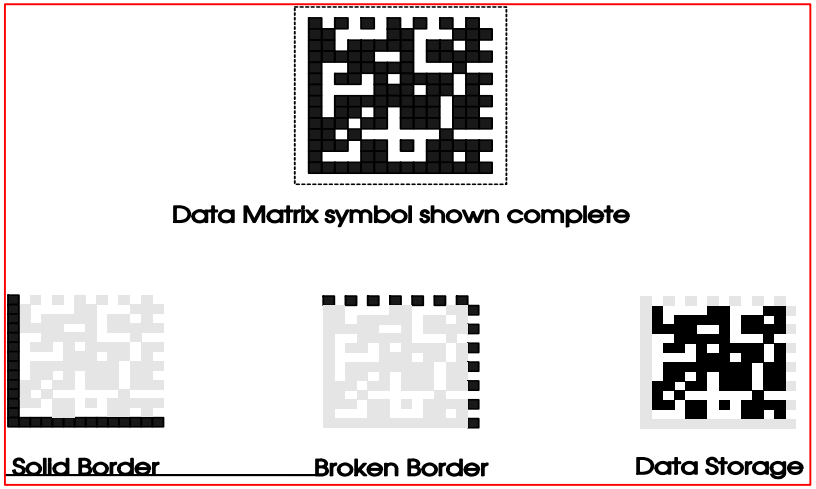
Barcode Symbologies Are Not Created Equally

- Data carriers or Barcode symbologies even though similar, have different attributes.
- Typical Linear codes have
  - Bars
  - Spaces
  - Quiet Zones

A few symbologies encode with height



- While 2D Symbols have 4 Physical Components
  - Solid border
  - Broken border/Clock pattern
  - Data storage
  - Quiet zone



Pain Points Identified

- Unreadable Codes

Incorrect Code or Text Format/Content

Remember: Your symbol is allowing for an electronic exchange of your data providing traceability for your product as it travels through the supply chain.
When a label is scanned and is unreadable, or contains Incorrect code or text format/ data this slows down the process of the ease of the electronic exchange of data and requires manual support.
If the symbol is not performing as it should, it is the equivalent of taking a can of food from your pantry without a label. "Electronically", the product cannot be quickly and properly identified.

Imagine A Barcode Not Scanning In These Processes?

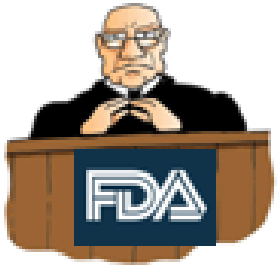
Pain Points Can Result In Larger Issues

Loss of Identity or Traceability

Vendor Compliance Penalties

Process Downtime

Regulatory Issues



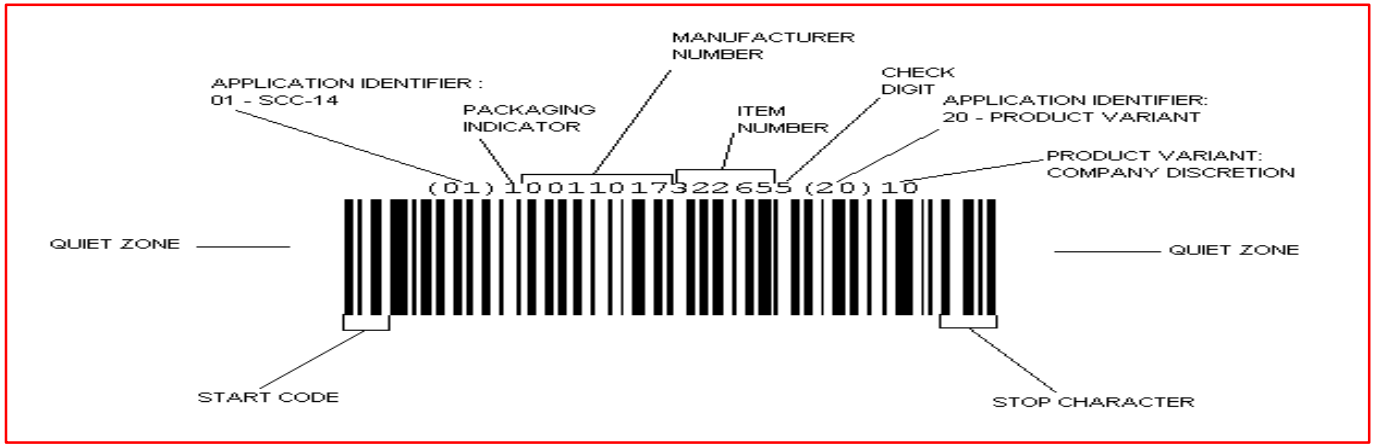
Upset or Confused Customers

The Right Barcode

- Factors to consider in selecting the right barcode symbology for your application:
  - Will the product be scanned at the point of sale in retail stores?
  - Which character set needs to be supported?
    - ✓ Numeric?
    - ✓ Alphanumeric?
  - How much space is available on the product packaging?
  - Which material will you print the barcode on?
  - Which barcode type supports the largest amounts of data?
  - Do you have issuing agency specifications, such as GS1?

Start Your Plan With Compliance And Quality In Mind

- The previous factors should be considered from the *beginning* to create the most efficient quality plan for your labelling process.
- Example: If you have a small area on your label for your symbol, but require large strings of alphanumeric data, a Code 128 may not be ideal for your needs (the more data, the larger the symbol).



Issuing Agencies

- If you are an Industry that has an FDA Accredited Issuing agency, such as:

  - ✓ GS1
  - ✓ Health Industry Business Communications Council (HIBCC)
  - ✓ ICCBBA or ISBT 128

Know The Specifications

- Barcode types, data formatting, and other UDI specifications are all agency-dependent

GS1 Specification Standards:
https://www.GS1.org

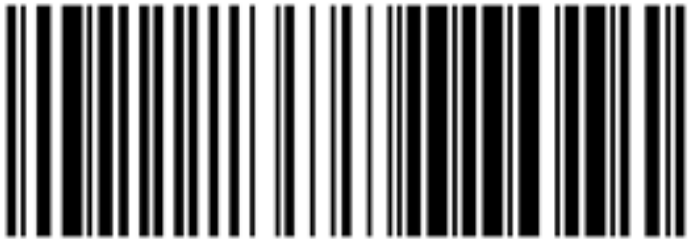
HIBC Standards:
https://www.HIBCC.org

ICCBBA Standards:
https://www.ICCBA.org

Data Carriers

Select a data carrier (barcode type) that is in compliance with your issuing agency's application standards.

Data Matrix



Code 128

Databar Stacked, Omni-directional

Code 128 CC/A

UPC-A

Data Structure

Be sure you know the approved data carriers (barcode types) for your agency's standards and properly enter the data in the format as it is specified by the agency's standards.

These three codes have the same data carrier (Code 128), but the way the data is encoded defines the barcodes as GS1, HIBCC, or ICCBBA.

GS1

HIBCC

ICCBBA-ISBT 128

GS1 Provides Symbology Specification Tables

- The GS1 Symbology Specification Tables indicate:
  - Which symbologies are allowed
  - Guidelines for the selected symbol

5.5.2.7.6. Symbol Specification Table 6 - Regulated Healthcare Non-Retail Consumer Trade Items Not Scanned in General Distribution

Figure 5.5.2.7.6-1. GS1 System Symbol Specification Table 6

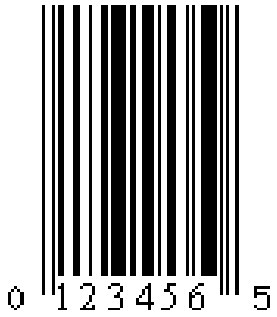
Symbol(s) Specified	X-dimension mm (inches)			Minimum Symbol Height for Given X mm (inches)			Quiet Zone		Minimum Quality Specification
	Minimum	Target	Maximum	For Minimum X-dimension	For Target X-dimension	For Maximum X-dimension	Left	Right	
GS1- 128	0.170 (0.0067")	0.495 (0.0195")	0.495 (0.0195")	12.70 (0.500")	12.70 (0.500")	12.70 (0.500")	10*X*	10*X*	1.5/06/660
GS1 DataMatrix (ECC 200) (*)	0.255 (0.0100")	0.380 (0.0150")	0.495 (0.0195")	Height is determined by X-dimension for Data that is encoded			1X on all four sides		1.5/08/660
GS1 DataBar Omnidirectional	0.170 (0.0067")	0.200 (0.0080")	0.660 (0.0260")	5.61 (0.221")	6.60 (0.260")	21.78 (0.858")	*Not Applicable*	*Not Applicable*	1.5/06/660
GS1 DataBar Truncated	0.170 (0.0067")	0.200 (0.0080")	0.660 (0.0260")	2.21 (0.087")	2.60 (0.102")	8.58 (0.338")	*Not Applicable*	*Not Applicable*	1.5/06/660

If Your Label Is scanned At Retail POS

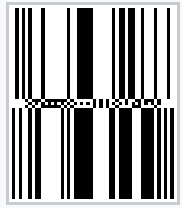
- Products scanned at Retail POS most commonly use
- A UPC or an EAN symbol
  - Produce at retail POS use:
    - ✓ GS1 DataBar Omnidirectional or a GS1 DataBar Stacked Omnidirectional

Understanding symbologies will help you make the most informed decision for your labeling requirements.

12 Numeric digits
Typically the GTIN



0 Suppressed version of the UPC-A allowing for smaller space requirements



Designed to condense the GTIN information into a more compact and square barcode suitable for use on smaller packages

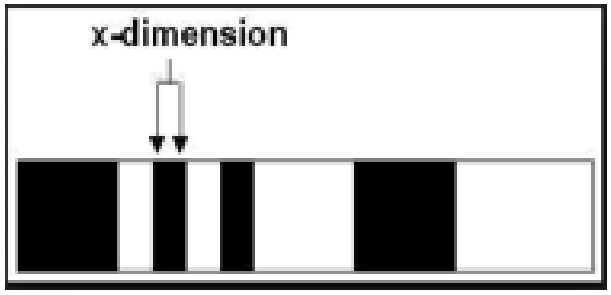
One-Dimensional (1D) (Linear Barcodes)

- One-dimensional, or 1D barcodes, systematically represent data by varying the widths and spacings of parallel lines, and may be referred to as linear or one-dimensional.
- These include some of the traditional, or most well recognized barcode types such as
  - UPC
  - EAN
  - Code 128

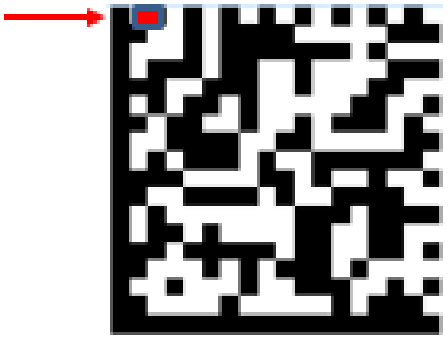
What Is The X-dimension?

- The X dimension in a 1D barcode is the width of the narrow bar. In 2D symbols, the X dimension is the module which has both width and height. In both cases X dimension is the basic building block of the 1D barcode and 2D symbol, and determines its physical size (along with the amount of encoded data, of course).

1D Example



2D Example



UPC-A Symbology

- Example: There are different “rules” for each barcode symbology. Let’s take a look at a linear UPC-A code.

1. Barcodes are made up of black and white lines. The white spaces in between the black lines are part of the code.
2. There are 4 different thicknesses to the lines. In the “Rules” or algorithm for the code, the skinniest line (X-dimension) will be referred to as “1,” the medium size line as “2,” the next largest line as “3,” and the thickest line as “4.”

Why Does It Matter?

- In UPC codes, each digit has it's own unique 4-line set.

- 0= 3211
- 1=2221
- 2= 2122
- 3= 1411
- 4= 1132
- 5= 1231
- 6= 1114
- 7= 1312
- 8= 1213
- 9= 3112

Note:
After the center line, the colors are reversed. The lines to the left are white/black/white, and on the right they are black/white/black. This provides us a way to error check and also tells us in what direction to scan the code. It is crucial that the barcode end with a bar rather than a space.

How Are Linear Symbols Measured?

- Scan with a laser and measure reflected signal
- Image with an imaging sensor
- Create a scan profile
- Detect threshold crossings
- Create a space/bar List
- Pass to a decoder
- Essentially an analog process

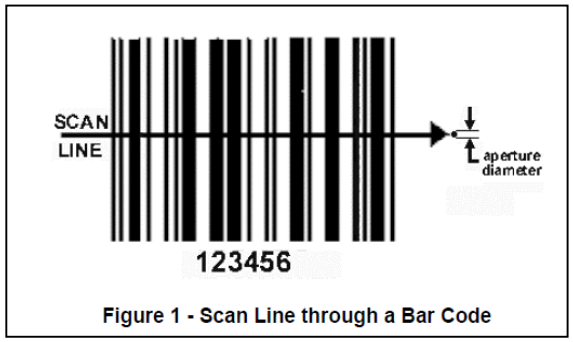
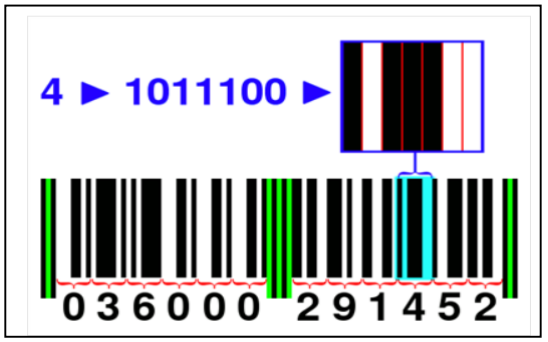
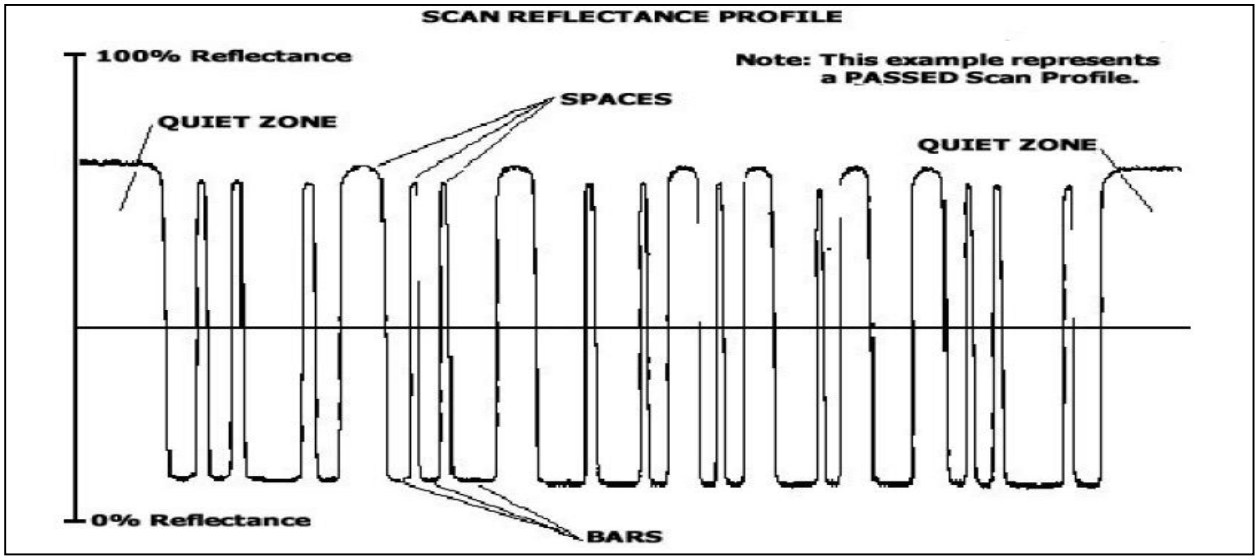


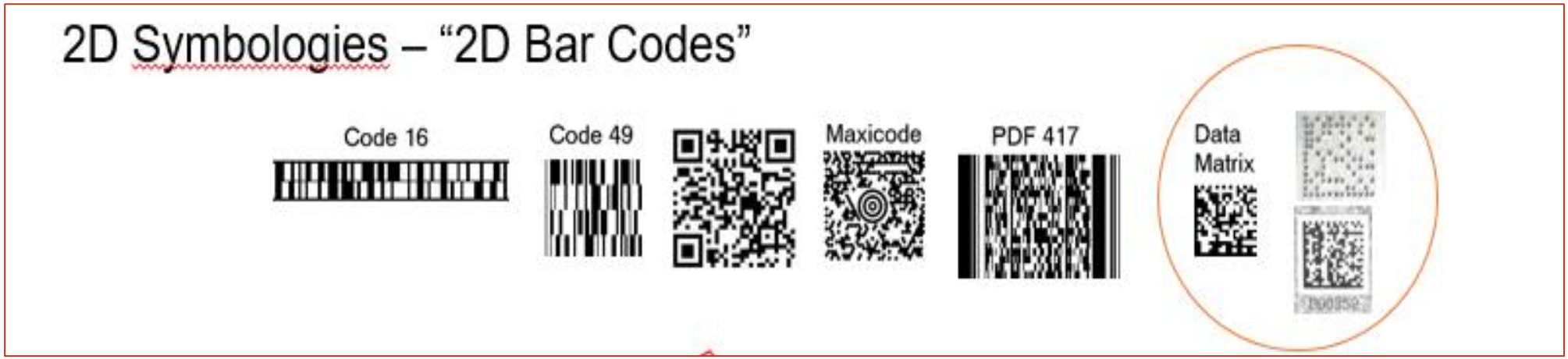
Figure 1 - Scan Line through a Bar Code





Two-Dimensional (2D) Barcode Types

- Two-dimensional, or 2D barcodes, systematically represent data using two-dimensional symbols. They are similar to a linear 1D barcode, but can encode more data per unit area. These include barcode types such as the Data matrix and QR Code code types.



Recommended for DPM

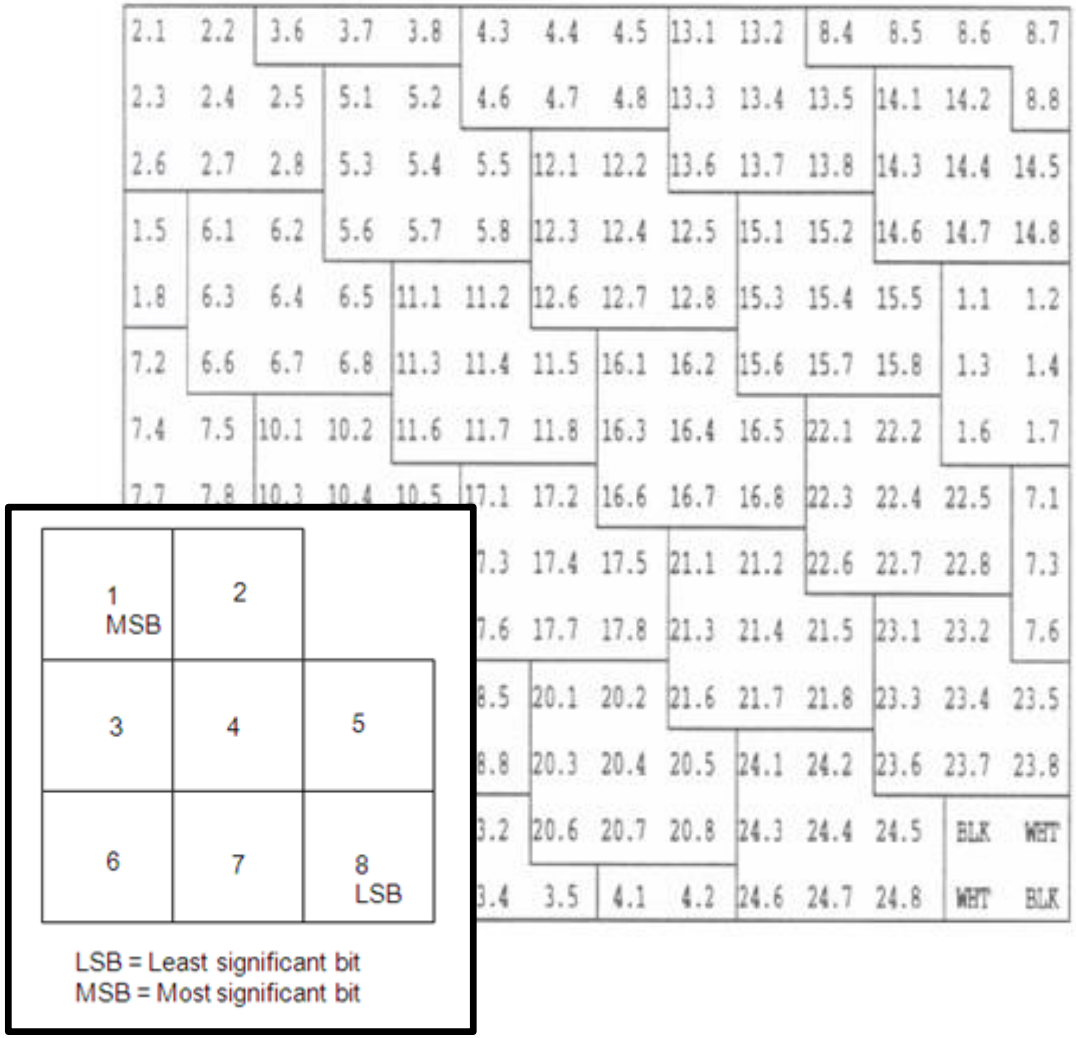
The Microscan Data Matrix Basics

- Data Matrix, owned by Microscan, is a two-dimensional matrix symbology that is normally square. The most Commonly used is the ECC 200, which uses Reed-Solomon error correction.

- Encodable character set:
  - Values 0 - 127, which also referred to as 7-bit ASCII
  - Values 128 – 255, which are referred to as extended ASCII or 8-bit ASCII
  - Symbol size in modules (not including quite zone): 10 x 10 to 144 x 144, even values only.
  - The maximum number of data characters per symbol (for maximum symbol size in ECC200):
  - Alphanumeric data: up to 2 335 characters
  - 8-bit byte data: 1 555 characters
  - Numeric data: 3 116 digits

How Does It Work?

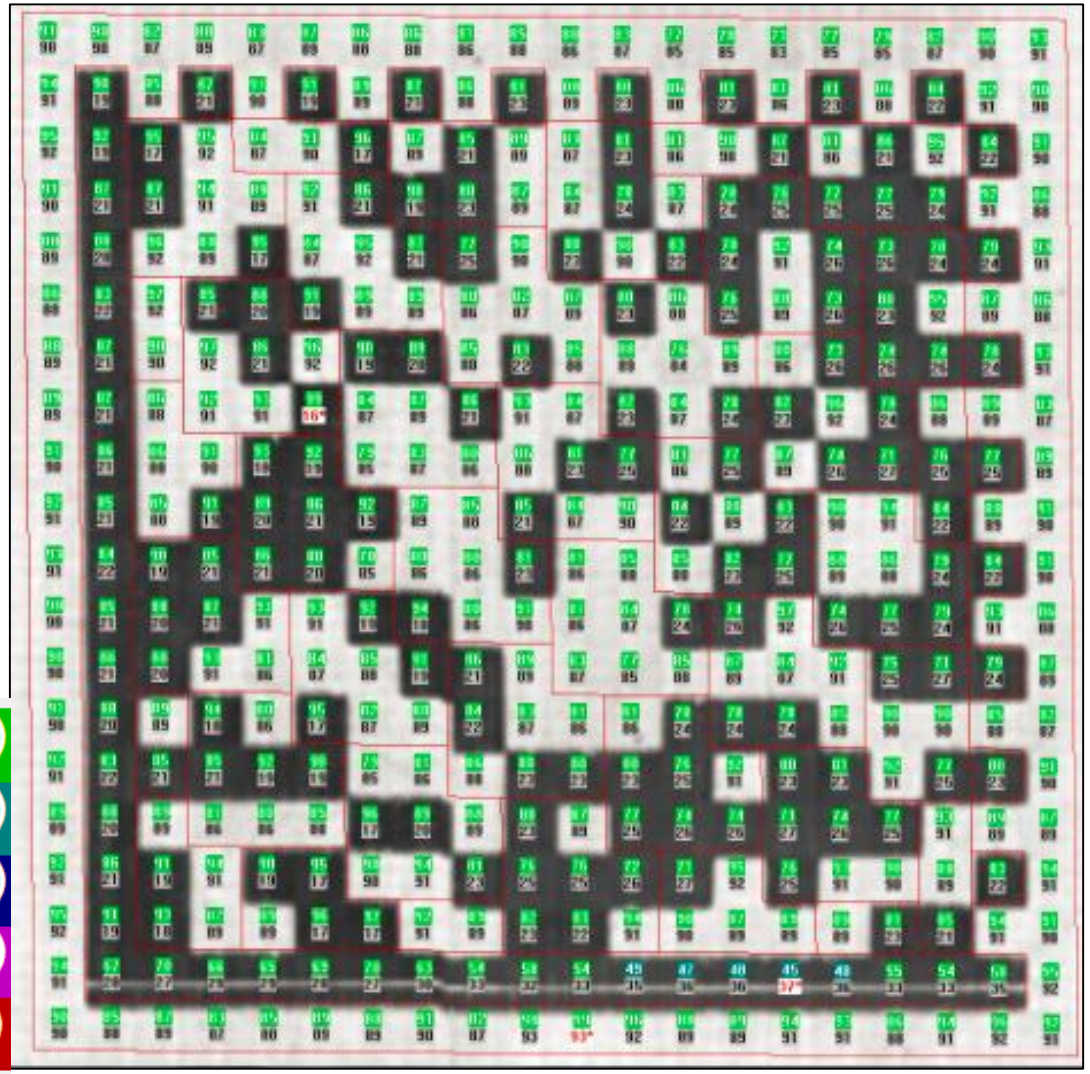
- Each symbol character (or codeword) is represented by eight modules which are nominally square in shape
- Each module represents a binary bit
- Each “Utah” shape represents a byte of data.
- A dark module is a binary one and a light module is a binary zero.
  - The figure to the right is a representation of a codeword in a symbol character for ECC 200.



A 2D Analysis Overview

The 2D Analysis in our Verification Systems offers a complete visual of the grades received for each cell.

In this example you can see the fixed pattern L2 parameter has some damage resulting in a B Grade (by Color Code)

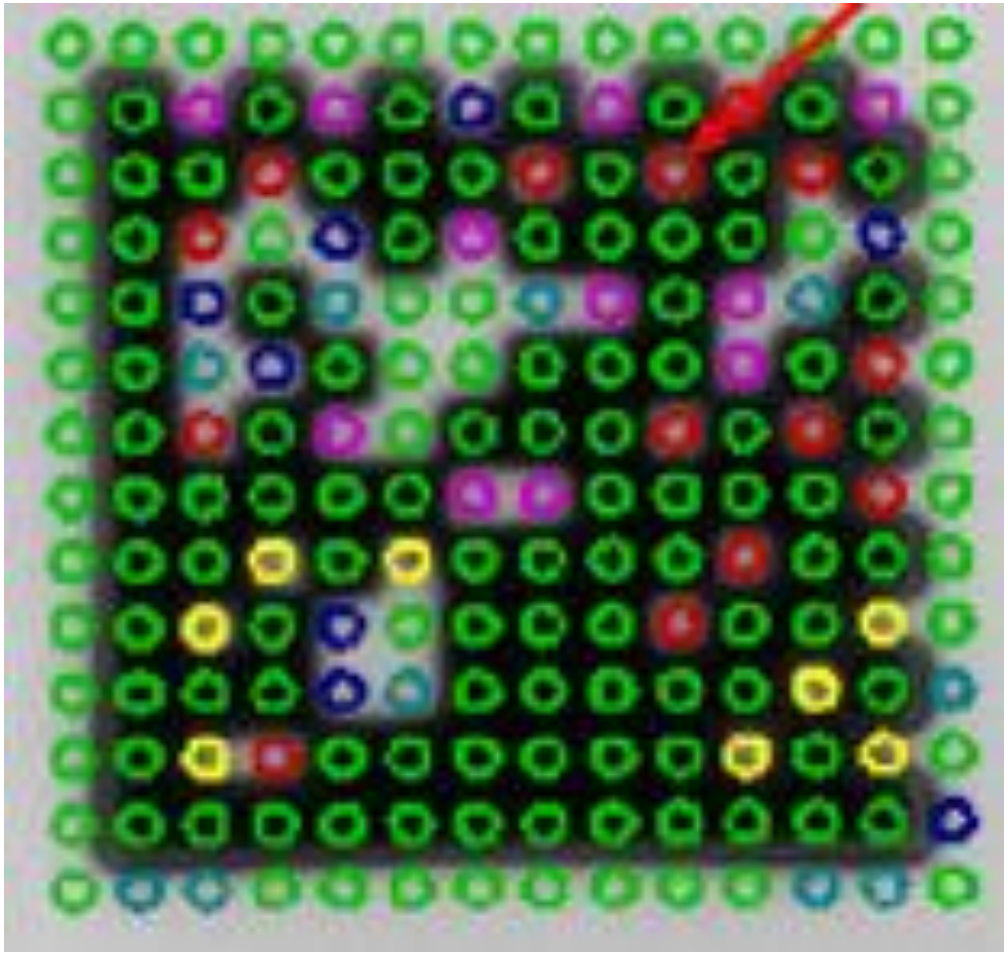


Microscan Data Matrix Has Error Correction

- One of the benefits of the Microscan Data Matrix symbology is that it has **Error Correction**.
- This allows the symbol to be more **robust** for many applications, but is a great benefit when faced with an application requiring **direct part marking.**
- Reed/Solomon Error Correction.
  - Every grid center point should fall on the correct side of the global threshold.
  - Common for some center points to fall on the wrong side. Any such cell is considered an error that requires processing through the Reed/Solomon algorithm.
  - Amount of error correction used increases with the number of errors.
  - The more error correction, the lower the Unused Error Correction score

ECC- Error Correction

The amount of Error Correction allowed is based on the amount of Encoded data and as your symbol starts with the 100% allowed, the parameter is on exhaustion, so if all of the allowed Error Correction is used, the parameter will fail resulting in an overall failing grade.



Pros And Cons

	Pros	Cons
1D Codes	• Simple readers (low cost) • Large Infrastructure in commerce • Well understood marking methods • High read rates.	• Limited content • Unidirectional • Readers can not read 2D codes • **Requires high contrast marking** • Not suitable for Direct Part Marking • Analog reading can produce error
2D Codes	• **Compact codes** • **High potential code content** • **Includes error correction** • **Omni directional reading** • Imaging readers can decode 2D codes • High end readers can do OCR etc.	• Requires imaging reader • Requires slightly higher resolution printing and imaging

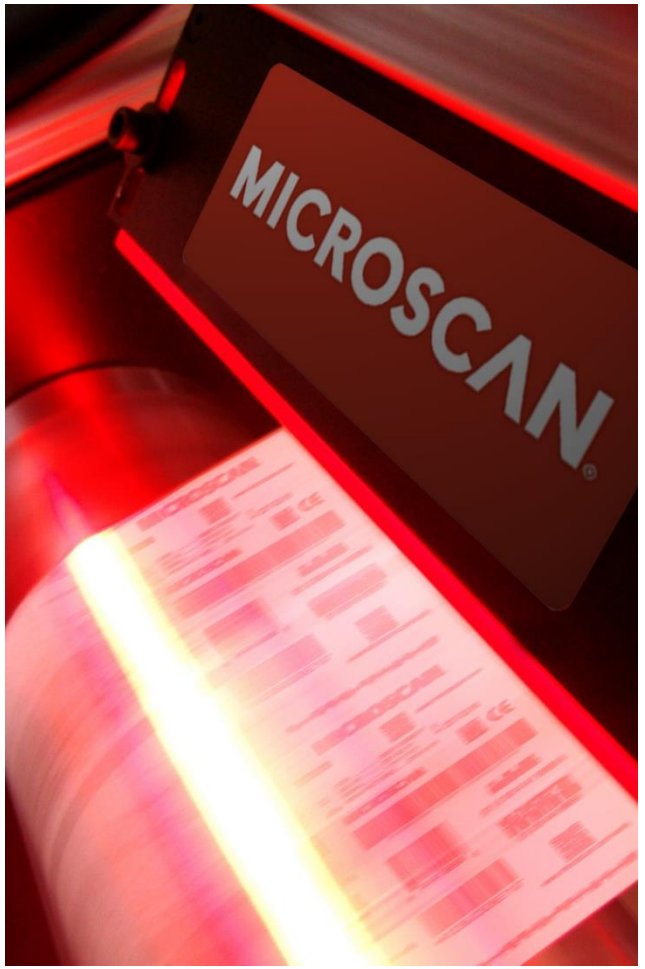
Barcode Quality Assessment

- As with many other processes the advent of Independent International standards have enabled a higher level of objectivity than ever before
- Accurately assessing which barcodes will be easily scanable and which will cause problem gives more flexibility, more opportunities – if *only* that barcode would work properly

Verification

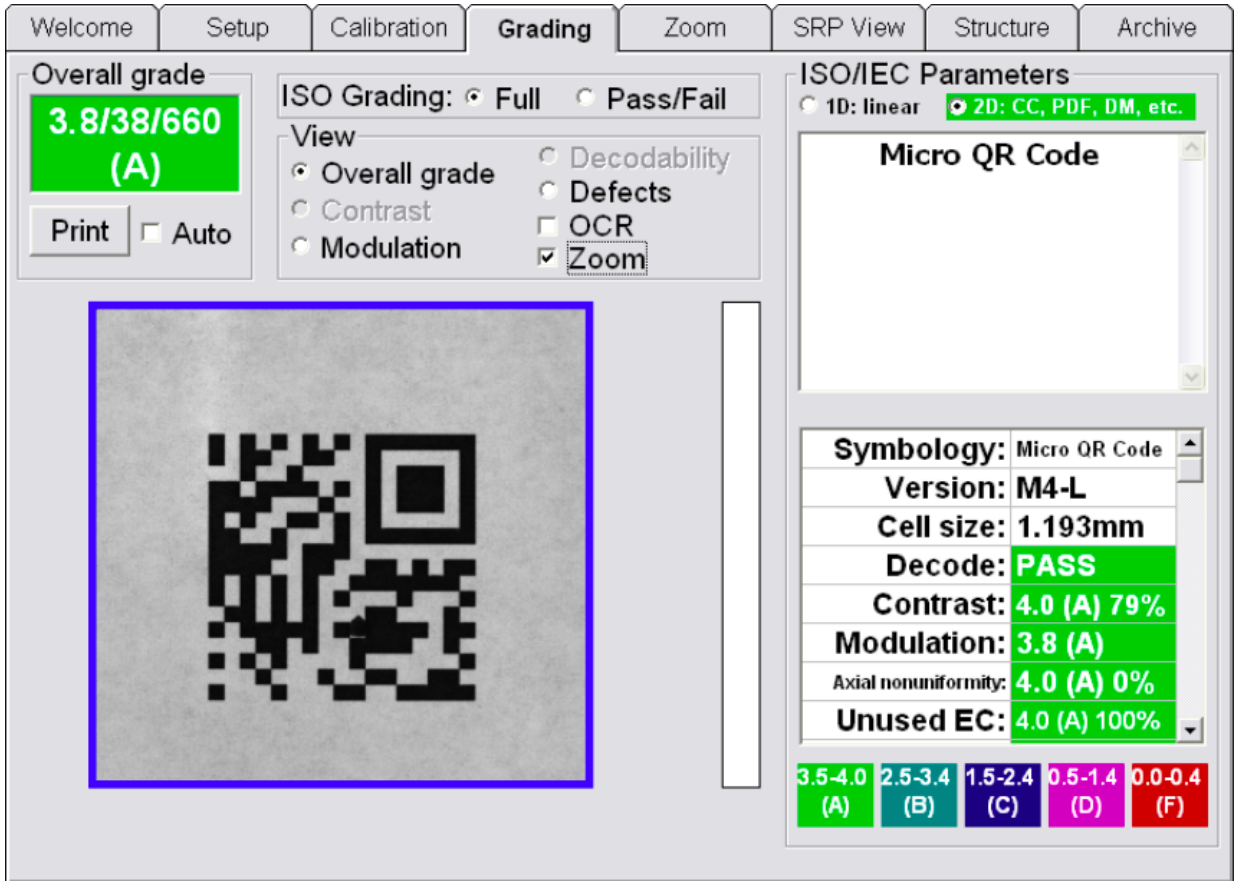
Off-Line Verification can verify Print Quality and Data Structure to the standards

In-Line verification can verify that print quality is maintained



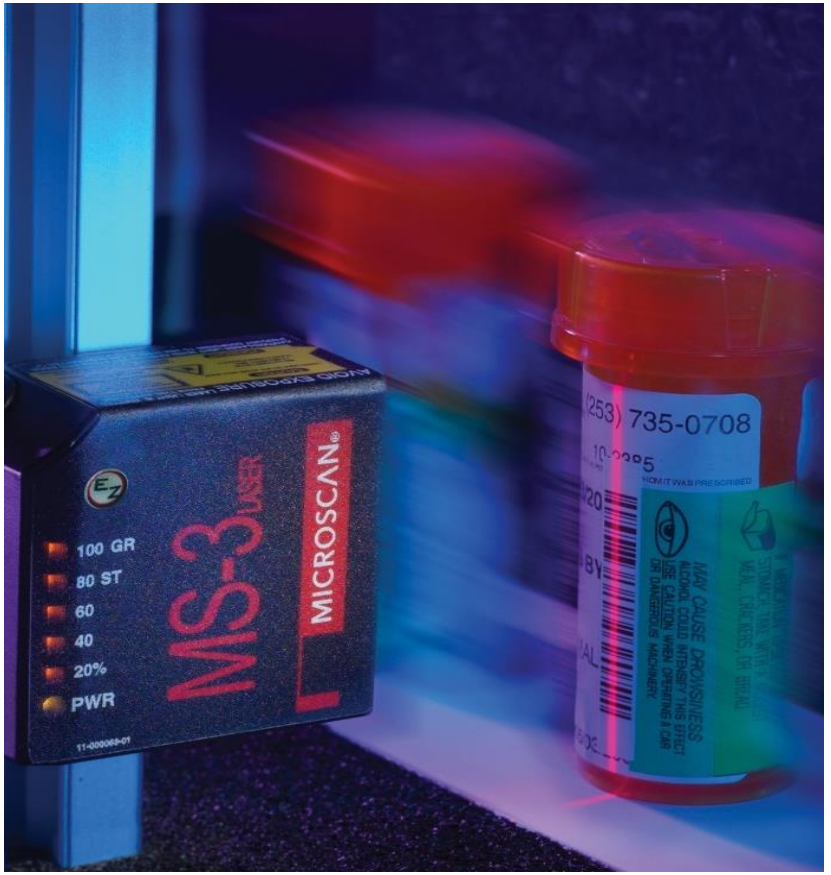
What Is Verification?

- Verification is a method of analyzing a printed code against a published specification to determine whether the barcode is compliant to specifications (IN-SPEC) and will scan properly



Can I Use A Scanner To Verify My Code?

- No
- A barcode scanner or barcode reader will report the data it sees
  - HOWEVER it does not have the ability to tell you that the data in your code is:
    - ✓ Not compliant to your selected standards
    - ✓ Whether it is formatted correctly



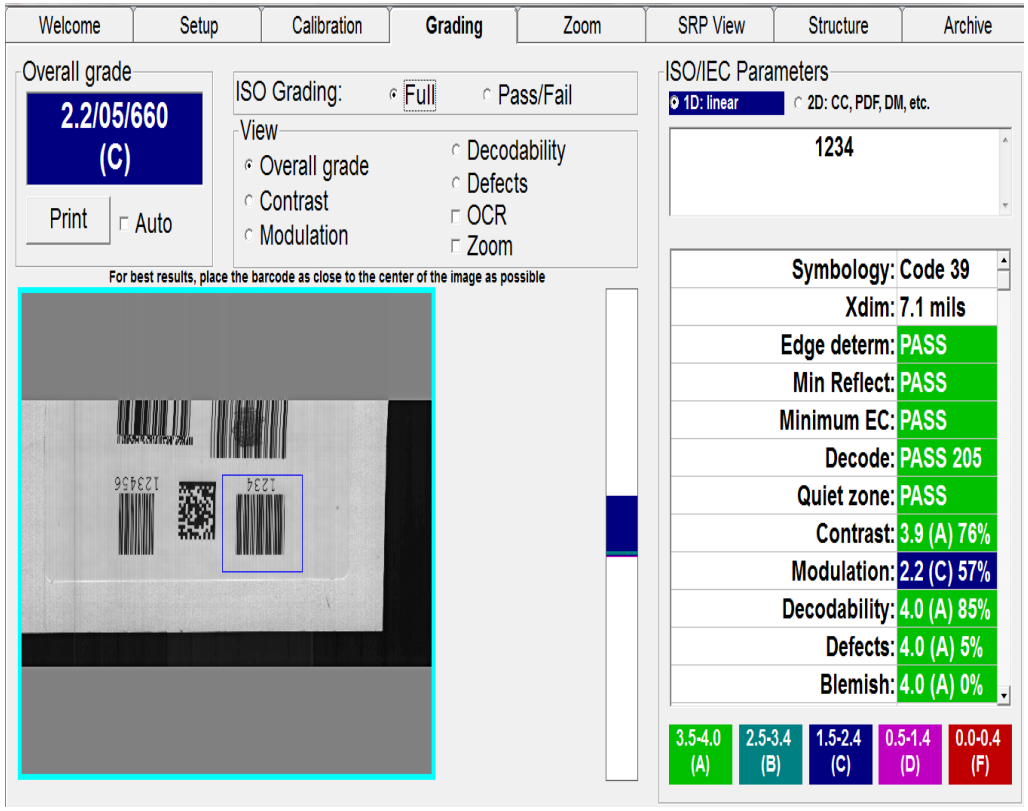
Once My Code Is Verified, Am I Good To Go?

Plan for more than one verification step

- Are you adding the code to label artwork?
  - The barcode must be exported correctly at a consistent aspect ratio and at the same DPI that it will be printing to.
  - If the barcode image is stretched or otherwise manipulated incorrectly for artwork, your symbol may fall out of compliance.
  - By verifying the barcode again after the artwork process, you can be sure that your barcode is compliant, quality, and ready to print.

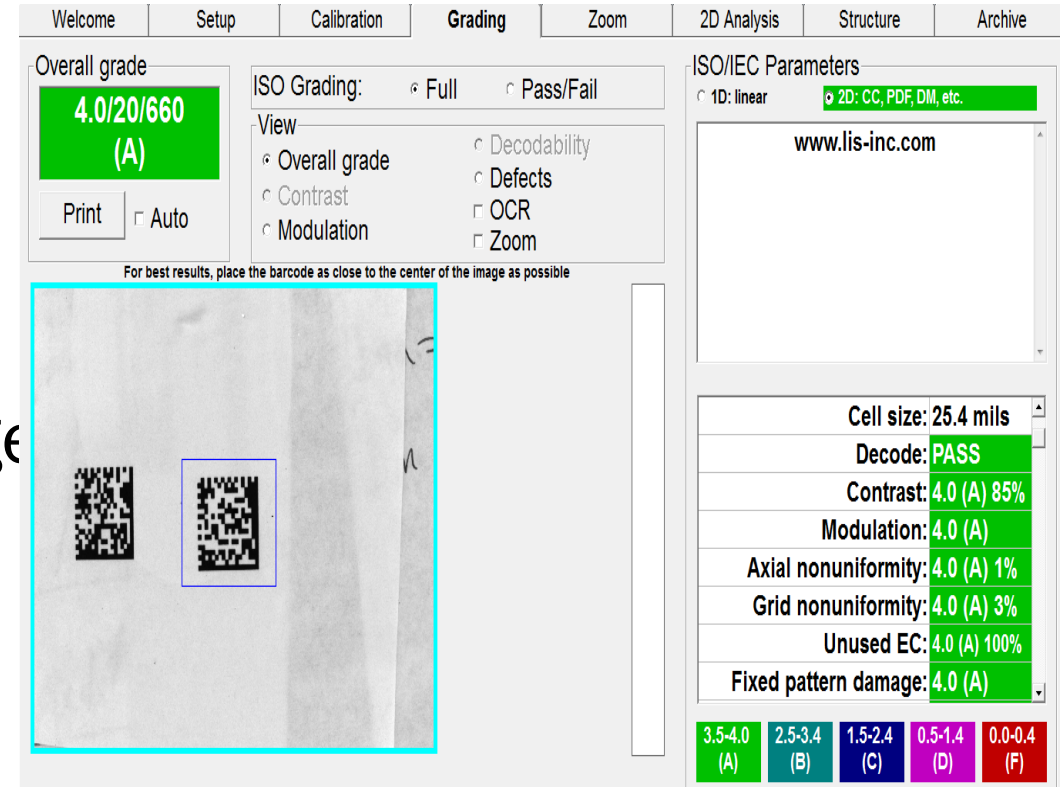
Print Quality For Linear Symbols ISO15416

- A barcode verifier works the way a reader does, but instead of simply decoding a barcode, a verifier performs a series of tests. For linear barcodes these tests are:
- Edge Determination
- Minimum Reflectance
- Symbol Contrast
- Minimum Edge Contrast
- Modulation
- Defects
- Decode
- Decodability



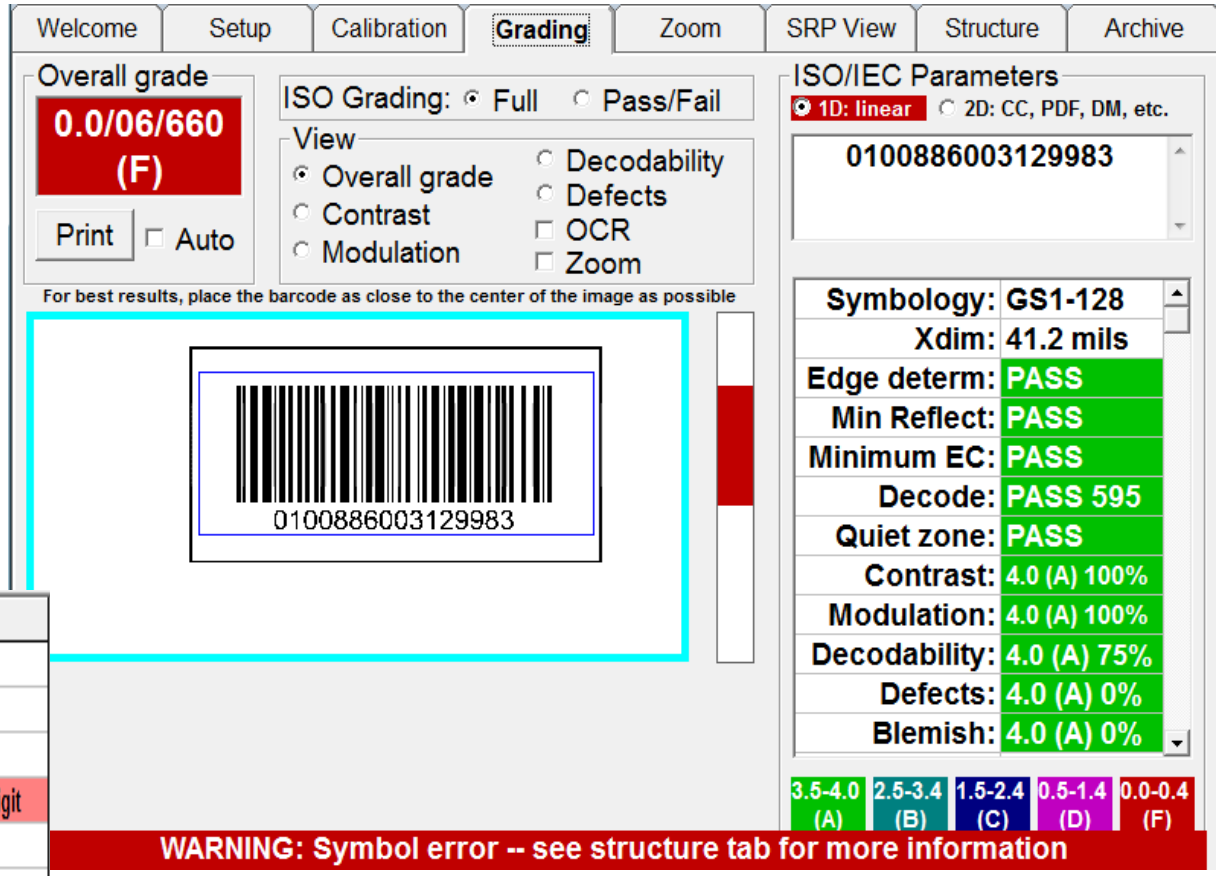
Print Quality For 2D Matrix Symbols ISO15415

- 2D matrix symbols look at the parameters:
- Symbol Contrast
- Modulation
- Decode
- Unused Error Correction
- Fixed (finder) Pattern Damage
- Grid Non-uniformity
- Axial Non-uniformity



Grading And Data Structure

- Verification systems are Grading ISO/IEC15415/15416 for the Print Quality of your symbol
  - Note that if you select an application standard such as GS1, we are still grading print quality, but now we are also verifying that the data is structured properly for GS1 requirements.



Embedded data	Description	Value
<StartC>		
<FNC1>		
01	Global Trade Item Number (GTIN)	(01)
00886003129983	Global Trade Item Number (GTIN)	Invalid check digit
<Check 30>		
<Stop>		

Verification Systems Knowledge

- Our team of Verification experts offer a training course that reviews the meaning of the grading parameters as well as possible causes and solutions for quality issues.
- Most of the issues that we see are due to
  - Poor print quality such as print growth
  - Impression pressure (Haloing)
  - Ink not adhering to the substrate
  - Modulation from using glossy substrates or laminates
- Our knowledge team can assist with barcode verification analysis and feedback on improvement.

- Questions?

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Thank You!

Any Questions?

Contact: Microscan

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www.microscan.com