ISO verification

Fact Sheet

Introduction

To maintain scanning efficiency, barcodes need to be printed correctly and be of a high quality. Verification equipment can assist in providing an indication of the print quality of barcodes.

GS1 Australia's verification service has adopted the globally used ISO/IEC 15416 method for the quality analysis of barcodes, which takes into account seven main parameters covering various aspects of print quality. The ISO method is fully compatible with the ANSI standards that were released by the American National Standards Institute (ANSI). This verification method can provide a standard means of reporting between printers, brand owners and trading partners.

The ISO method of verification looks at a barcode in a similar way to the way a scanner sees it. It assesses the quality of the symbol compared to a perfect symbol and grades the symbol with a grade ranging from 4-0 (A-F), based on how closely the symbol is to perfect. The ISO grade is intended to provide an indication, based on the print quality, of the likely scanning performance of the barcode in the market place. The lower the ISO grade, the higher the possibility of scanning difficulties.

Please note that the use of a verifier should be supplemented with other appropriate checks such as visual checks in order to perform a total verification process.

When interpreting the results from a verifier it is also important to remember that:

- Verifiers do not measure bar height.
- Without additional software linking the decoded data to a database, it cannot be confirmed that the data content of a barcode is what it should be.
- Verifiers cannot confirm the barcode's dimensions are what are intended.
- A verifier cannot check that the Human Readable Interpretation corresponds to the encoded data.
- Even a perfect barcode at the time of production can be damaged or otherwise affected in its passage through the supply chain.
- A Verifier cannot confirm whether the correct barcode symbology has been used for the intended scanning environment.

Testing to the ISO method

GS1 utilise the ISO method of verification, and specify the minimum grade necessary for every barcode, as well as specifying the verifier aperture width (size of hole in the testing equipment) and wavelength of the light source.

For example, an EAN-13 barcode scanned at Point-of-Sale will always be verified using a 6 mils aperture (0.15mm), a 660nm +/- 10 wavelength of light, and require a minimum ISO grade of 1.5 (C). This is typically expressed on a verification report as 1.5/06/660.

Verifiers have a menu to adjust the aperture and wavelength according to the type of barcode being assessed and the X-dimension (magnification) of the symbol.

The table below provides you with a quick reference guide to the minimum grades for each barcode type, and the appropriate aperture sizes and wavelengths that should be used.

Table 1: Required ISO grades for GS1 barcode symbols

Symbology	ISO (ANSI) Passing Grade	Aperture	Wavelength (nanometres)
EAN/UPC	1.5 (C)	6 mils (0.15mm)	660nm +/-10
ITF-14 < 62.5% Magnification (X-dimension 0.64mm)	1.5 (C)	10 mils (0.25mm)	660nm +/-10
ITF-14 ≥ 62.5% Magnification (X-dimension 0.64mm)	0.5 (D)	20 mils (0.50mm)	660nm +/-10
GS1-128	1.5 (C)	10 mils (0.25mm)	660nm +/-10
GS1 DataBar	1.5 (C)	6mils (0.15mm)	660nm +/-10
GS1 DataMatrix	1.5 (C)	Depends on the application	660nm +/-10
GS1 QR Code	1.5 (C)	Depends on the application	660nm +/-10

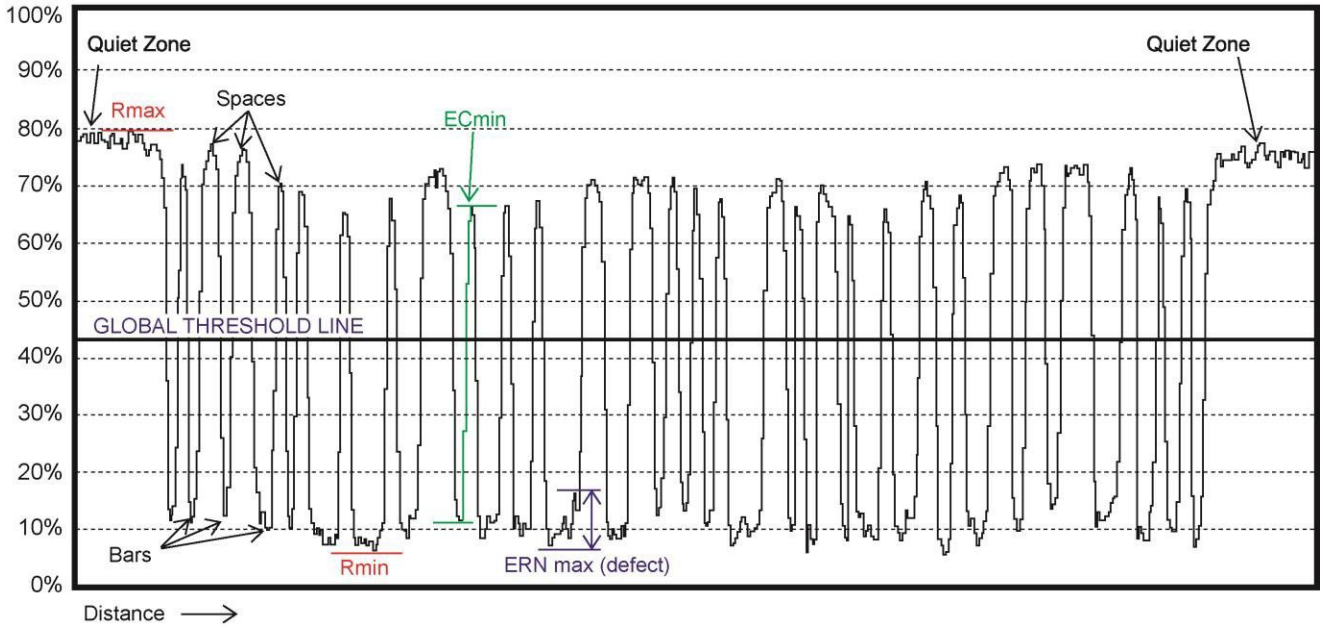
There are several steps involved in arriving at an overall symbol grade.

The ISO verification process involves the barcode being assessed based on number of scans in both directions evenly throughout the entire height of the symbol.

The requirement is for 10 scans to be taken. However, if the first 3 scans are in excess of the pass grade required and there is general consistency in the results, it is not necessary to complete the full 10 scans.

For each scan across the barcode a Scan Reflectance Profile is obtained. This is simply an analogue plot of the reflectance values measured along a single line across the entire width of the barcode. The x-axis of the plot shows linear distance across the symbol, while the y-axis shows the reflectance values. Light areas show as high reflectance values; dark areas show low values. The profile therefore consists of a series of peaks and valleys, the widths of which are proportional to those of the bars and spaces.

Figure 1: Scan Reflectance Profile



The Scan Reflectance Profile is then used to measure and grade the following parameters:

Decode, Symbol Contrast, Minimum Reflectance, Edge Contrast, Modulation, Defects and Decodability.

Firstly, an edge determination test is performed, which is basically whether the correct number of bars and spaces have been encountered in the Scan Reflectance Profile for the type of barcode being assessed (for example an EAN-13 barcode should have 30 bars and 29 spaces or a total of 59 elements).

In order for all the ISO parameters to pass, all the elements need to cross an imaginary line called the global threshold. This is half way between the highest reflectance value and the lowest reflectance value. This can be seen in the above example of a Scan Reflectance Profile, Figure 1.

Parameters assessed using ISO method

Decode - (Pass 4 or Fail 0)

Decode uses the algorithm for decoding the barcode. If the symbol can be decoded the parameter is given a pass (4). If it cannot be decoded it is given a fail (0). This parameter also assesses whether or not the correct number of elements cross the global threshold. If the correct number of elements is found a 4 is given, if not then a global threshold failure has occurred and the parameter receives a 0 grade.

Table 2: Decode grades and thresholds

Grade	Threshold
4	Passes
0	Fails

Possible causes of a Decode failure and possible remedies are:

- Symbol incorrectly encoded: Re-originate symbol; over-label with correctly encoded symbol.
- Bars and spaces being out of specification due to excessive print gain or loss: Apply correct bar width reduction (BWR) when originating symbol; adjust press or printer settings.
- One or more elements did not cross the global threshold: If global threshold failure occurs, this also results in a Decodability grade of 0.
- Too many elements detected due to defect: Correct cause of defect; adjust press (relief printing processes) to reduce haloing (a double line impression where there should only be a single line impression); replace or clean the print head (thermal/ink-jet printing).
- Incorrect Check Digit: Correct software error in origination system; re-originate symbol; over-label with correctly calculated symbol.
- Quiet Zone infringement that crosses the global threshold: Enlarge box surrounding barcode; ensure symbol registration to other print allows adequate Quiet Zones; reposition symbol farther from edge of label; use larger size label.

Symbol Contrast - (4, 3, 2, 1 or 0)

This is a measure of the contrast between the bar and background colours. A barcode printed in black ink on white paper will achieve the best result. Coloured backgrounds or coloured inks will affect the result. Highly glossy materials may also appear to have a lower background reflectance than expected.

The formula for calculating this measure is:

Symbol Contrast = Reflectance Max (R_{max}) – Reflectance Min (R_{min})

Table 3: Symbol Contrast grades and thresholds

Grade	Threshold
4	≥ 70%
3	≥ 55%
2	≥ 40%
1	≥ 20%
0	< 20%

Possible causes of low or failed symbol contrast and possible remedies are:

- Background too dark: Use lighter or less glossy material or change background colour (if printed) to a lighter colour which will provide higher reflectance.
- Show through from contents: Use more opaque material for package or print opaque white underlay prior to printing symbol.
- Bars too light: Change bar colour for a darker colour with lower reflectance and increase ink weight or print head temperature (thermal printing). Watch for consequential increase in bar widths.

Minimum Reflectance - (Pass 4 or Fail 0)

In this assessment the reflectance value for at least one bar must be half or less than the highest reflectance value for a space. For example, if the highest reflectance value is 80%, then at least one bar must register a reflectance value of 40% or less.

The formula for calculating this is:

Reflectance Min (R_{min}) ≤ 0.5 Reflectance Max (R_{max})

Table 4: Minimum Reflectance grades and thresholds

Grade	Threshold
4	$\leq 0.5\ R_{max}$
0	$> 0.5\ R_{max}$

The cause and solution for failed Minimum Reflectance is:

- The bar colour is too light: Change bar colour to a darker colour with lower reflectance and increase ink weight or print head temperature (thermal printing). Watch for consequential increase in bar widths.

Minimum Edge Contrast - (Pass 4 or Fail 0)

This is the measure of the contrast between adjacent bars and spaces. The reflectance value of the bar is deducted from the reflectance value of the space. If any of these measurements is less than 15%, this parameter fails. While this grade may be acceptable, low edge contrast values may still cause low Modulation grades.

Minimum Edge Contrast is calculated according to the following formula:

Space Reflectance (min) – Bar Reflectance (max) of the worst pair.

Table 5: Minimum Edge Contrast grades and thresholds

Grade	Threshold
4	$\geq 15\%$
0	$< 15\%$

Possible causes of failed Minimum Edge Contrast and possible remedies are:

- Variations in ink weight in different parts of a symbol (uniformity of ink spread, ink viscosity): Adjust press settings to ensure even inking.
- Show through of contents: Use more opaque material for package or print white underlay prior to printing symbol.
- Fluctuations in the background reflectance (for example areas of darker material in recycled corrugated substrates): Use a more consistent substrate or one with higher reflectance.
- Excessive ink spread: Apply correct bar width reduction (BWR) when originating symbol.

Modulation - (4, 3, 2, 1 or 0)

Modulation is a measure of Edge Contrast as a proportion of Symbol Contrast. The closer the Edge Contrast is to the overall Symbol Contrast the better as this implies that overall the differences between the bar and space reflectance values are consistent.

The formula for assessing this is: Minimum Edge Contrast / Symbol Contrast

Table 6: Modulation grades and thresholds

Grade	Threshold
4	≥ 0.70
3	≥ 0.60
2	≥ 0.50
1	≥ 0.40
0	< 0.40

Modulation will be reduced for the same reasons as when Minimum Edge Contrast is low. A scanner will tend to see spaces as narrower than bars and also see narrow elements as less distinct than wider ones.

Consequently, if there is significant bar gain, Modulation will be reduced. Measuring with an aperture that is larger than specified will also reduce Modulation.

Possible causes of low or failed Modulation and the possible remedies are:

- Fluctuations in the background reflectance (for example areas of darker material in recycled corrugated substrates): Use a more consistent substrate or one with higher reflectance.
- Show through of contents: Use more opaque material for package or print white underlay prior to printing symbol.
- Excessive ink spread: Apply correct bar width reduction (BWR) when originating symbol.

Defects - (4, 3, 2, 1 or 0)

In this instance the equipment is looking for defects in the barcode, either in the form of flaws in the substrate being printed onto or in the barcode printing.

The verifier looks at the uniformity of the reflectance throughout each individual element of the barcode. If this varies significantly then there is some defect within the symbol.

The formula for assessing this is:

Element Reflectance Non-Uniformity (ERN) / Symbol Contrast

Table 7: Defects grades and thresholds

Grade	Threshold
4	≤ 0.15
3	≤ 0.20
2	≤ 0.25
1	≤ 0.30
0	> 0.30

Possible causes of low or failed Defects and possible remedies are:

- Defective print head elements (thermal printing or ink-jet printing), which will tend to produce an unprinted line running through the symbol in the direction of printing: Clean or replace print head.
- Satellite (ink droplets in the white area surrounding the printed bars): Clean head; change ink formulation.
- Haloing (e.g. a double line impression where there should only be a single line impression): Adjust impression pressure and/or ink viscosity.
- Incorrect matching of thermal transfer ribbons and substrate (poor adhesion of ink to surface): Use correct ribbon for substrate; use smoother substrate.
- Insufficient Quiet Zones where the infringement does not cross the global threshold: Enlarge box surrounding barcode; ensure symbol registration to other print allows adequate Quiet Zones; reposition symbol farther from edge of label; use larger size label.

Decodability - (4, 3, 2, 1 or 0)

This parameter is the measure of how close the Scan Reflectance Profile is to approaching Decode failure. Each symbology has published dimensions for element widths and provides margins or tolerances for errors in the printing and reading process. Decodability measures the amount of margin left within these tolerances before Decode failure will occur.

Table 8: Decodability grades and thresholds

Grade	Threshold
4	≥ 0.62
3	≥ 0.50
2	≥ 0.37
1	≥ 0.25
0	< 0.25

Decodability grades are influenced by bar gain or loss in most symbologies and by distortion of the symbol. Distortion can occur with relief printing processes, such as flexography, when the printing plate is stretched around the press cylinder with the bars parallel to the cylinder axis (e.g. at right angles to the print direction). A common reason for distortion with digitally-originated images is that they have been rescaled in graphics software, resulting in uneven addition or removal of pixels to or from the element widths. Print processes that tend to produce irregular bar edges, such as ink-jet and photogravure, will also likely give lower Decodability grades.

Possible causes of low or failed Decodability and possible remedies are:

- Excessive bar gain or loss (systematic): Apply correct bar width reduction (BWR) when originating symbol; adjust press settings.
- Element width gain or loss (non-systematic): Correct missing pixels (burnt-out print head elements, blocked ink-jet nozzles); rectify cause of defects.
- Distortion of symbol (uneven stretching of flexographic plate; non-linear disproportioning in plate-making process): Print symbol with height of bars parallel to direction of printing; do not disproportion barcode image in plate-making.
- Rescaling of digitally-originated images: Ensure symbol is created in correct size; ensure software matches module widths to integer number of pixels after all adjustments.
- Irregular element edges (ink-jet, photogravure, screen process printing): Change print technology; increase X-dimension/magnification factor; re-orient symbol relative to cylinder engraving angle/screen mesh.
- Global Threshold failure. Refer to the Decode parameter on page 4.
- Within the EAN/UPC symbology, characters 1, 2, 7 and 8 may fail this parameter as they require an additional adjustment to their bar widths.

Overall Symbol Grade

For each individual scan the lowest single grade of one of the seven assessed parameters (being the weakest link in the chain) becomes the symbol grade. After the required number of scans has been taken, the symbol grades are averaged, and this becomes the Overall Symbol Grade.

- The target measurement for all barcodes is ISO grade 4.
- The minimum acceptable measurement is ISO grade 1.5.
- The only exception is for ITF-14 barcodes with a magnification equal to or greater than 62.5% (X- dimension 0.64mm), for which it may be difficult to achieve better than a grade 0.5.
- For ITF-14 barcodes that will be scanned in an automated scanning environment (fixed mount, conveyorised) an overall symbol grade of at least 1.0 is recommended.
- The ISO grade achieved may provide a basis for acceptance of barcoded items by your trading partners. It is recommended that companies check with their trading partners for their specific minimum ISO grade requirements.

Table 9: ANSI to ISO grade conversion table

ANSI to ISO Grade Conversion Table	
A	3.5 to 4.0
B	2.5 to 3.4
C	1.5 to 2.4
D	0.5 to 1.4
F	Less than 0.5

Adherence to the GS1 guidelines outlined in this manual will aid in achieving an acceptable ISO grade.

GS1 Australia provides a Barcode Verification Service, which utilises the ISO method and provides customers with a Barcode Verification Report. Information on submitting samples for ISO verification can be obtained from www.gs1au.org.