10 Printing and Production

10.1 Introduction

This section is for printers, film master suppliers, and anyone else interested in producing bar codes used in the GS1 System. It outlines:

- the considerations to make during the production processes
- methods that allow you to achieve acceptable quality for the authorised GS1 Symbologies: EAN/UPC, ITF-14, and GS1-128

Note: The beginning of this section contains general printing information. Specific details for each symbology are provided later in this section.

GS1 does not directly specify required dimensions and tolerances in the final printed bar code. Instead, they specify conditions to fulfil at each stage of the production process. By adhering to these conditions, scanning equipment should be capable of reading the bar code you produce.

If you do want to check that a printed bar code meets the requirements of this manual, you must use verification equipment that responds exactly in accordance with the printing requirements stated in this section. This is particularly vital in regard to the spectral range you choose.

Results you obtain from inappropriate verification equipment can be seriously misleading in both over and under estimating the acceptability of printed bar codes.

10.2General Printing and Production Information

Different Ways to Print a Bar Code

There are three ways you can print a bar code:

- at source - as part of the final film of the packaging; often called source marking
- on-line - printing directly onto the package during production
- print and apply method - a label applied to the package when required

Producing an accurate bar code on an item **at source** involves a number of separate processes, each contributing to the quality of the final result. This section describes these processes.

Producing **on-line** and **print and apply method** bar codes uses printing machines that convert data into bar codes. These processes are almost totally automated and are covered briefly in this section. In addition, "Thermal Bar Code Label Printers" on page 114 contains information regarding Thermal Transfer, Direct Thermal and General Office Printing of Bar Codes.

Production Processes for Source Marked Bar Codes

The main processes in producing a source marked bar code are:

- assessing the printing conditions
- determining the magnification factor and bar width reduction necessary to compensate for the printing conditions
- producing a film master that represents the bar code
- making printing plates
- printing the bar code on the packaging
- performing print quality checks.

These processes, except producing the film master, are normally undertaken by specialist printers. Specialist film master suppliers produce the film masters. Both specialists employ techniques at their own discretion to produce bar codes that are within GS1 specifications.

Note: Read all general information; then follow the information under the headings in this section for the type of bar code you are printing.

10.3Print Gain and Variation

When a film master with nominal (100%) X-dimensions (module widths) is converted into a printing plate and printed onto a package, the printed bars usually end up wider than the bars on the film master. The amount by which a printed bar is wider than the same bar on the film master is called print gain, and is caused by factors such as:

- plate making
- print pressure
- absorbent substrate
- ink coverage.

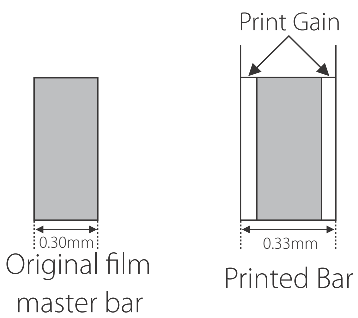


Figure 48 - Typical Print Gain for a Single Bar in an EAN-13 Bar Code

During the course of a print run, the extent of print gain usually differs between individual impressions. The difference in the amount of print gain is called variation.

Note: In preparation for printing a bar code, you must first assess the **average print gain** and **extent of variation** you encounter in the normal printing process.

Basic Assessment Method for Determining the Print Gain and Variation

Use proper sampling over a sufficient variety of production. Measure the bars directly from the printed bar codes. Determine the:

- average extremes of **print gain** (G)
- **variation** about this average (V).

The film master supplier makes compensations for both these factors when preparing the film master.

Mathematically, if print gain is G, variation is V, the original bar width on the film master is N, and the printed bar width is L, then:

$$L = N + G \pm V$$

The **extent of variation** in print gain determines the magnification factor to use.

The **extent of average print gain** determines the Bar Width Reduction (BWR). This is the amount by which the bars on the film master must be reduced in width to correct for the print gain.

10.4Print Quality Checks

If all allowances are properly made in the preparation of the film master, it may be sufficient to only carry out spot checks in the course of, and during, the print run. Spot checks carried out regularly during a print run can give a good indication if print quality is deteriorating.

Perform a spot check by:

- Verifying using a verifier which uses the ISO grading (ANSI) method.
- Taking a direct measurement of a particular bar in the printed bar code or the first two bars and spaces.

ISO/IEC 15416 describes a method for looking at the quality of a printed bar code using an ISO(ANSI) based verifier as a tool. The verifier is programmed to look at certain characteristics of the bar code the way a scanner would, provide scan grades, and after ten scans provide an ISO symbol grade.

GS1 utilises the ISO method, but specifies the minimum grade necessary for every GS1 Bar Code depending on which symbol is used, where it is used, or what identification code it is carrying. In addition to the minimum grade, GS1 also specifies the verifier aperture width and wavelength. This would be similar to a university using a standardised test to determine whether applicants qualify for admission. Several universities may utilise the same standardised test, but each sets the minimum score necessary for their applicants to be admitted.

The table below provides you with a quick reference list of the bar code quality parameters depending on their type, their application, or the identification code they are carrying.

Symbology	ISO (ANSI) Passing Grade	Aperture	Wavelength (nanometres)
EAN/UPC	1.5 (C)	6 mils (0.15mm)	670nm +/-10
ITF-14 < 62.5% Magnification (X-dimension 0.64mm)	1.5 (C)	10 mils (0.25mm)	670nm +/-10
ITF-14 ≥ 62.5% Magnification (X-dimension 0.64mm)	0.5 (D)	20 mils (0.50mm)	670nm +/-10
GS1-128	1.5 (C)	10 mils (0.25mm)	670nm +/-10
GS1 DataBar	1.5 (C)	6mils (0.15mm)	670nm +/-10
GS1 DataMatrix	1.5(C)	6mils (0.15mm)*	670nm +/-10
GS1 QR Code	1.5(C)	6mils (0.15mm)*	670nm +/-10
* The effective aperture for GS1 DataMatrix and GS1 QR Code quality measurements should be taken at 80 percent of the minimum X-dimension allowed for the application.			

TABLE 28. Required ISO Grades for GS1 Bar Code

For example a EAN/UPC Bar Code will always be verified using a 6 mils aperture, a 670nm (nanometres) +/-10 wavelength of light, and require a minimum symbol grade of 1.5 (C).

10.5Colours, Contrast, and Reflectance

Scanners recognise a bar code by "seeing" the difference between light and dark areas. Various factors can affect the recognition process. Their explanations follow.

Reflectance and Reflection Density

Light areas show high reflectance values whereas dark areas show low values.

The reflection density required for the dark bars depends on the reflection density of the light background being used.

Mathematically, when R is the reflectance and D is reflection density:

$$D = -\log_{10} R$$

Measure reflectance to ensure your bar code is acceptable. Make the measurements under the following conditions, with equipment meeting the stated specifications.

In **Geometric** conditions, centre the incident illumination 45^{o} to the normal of the sample and the reflected light collected by a receiver subtending a solid angle centred on the normal to the sample. The sampling aperture should be a circular area of a minimum 0.2 mm and maximum 0.56 mm in diameter.

In **Spectral** conditions, illuminate the sample by light having a spectral power distribution which corresponds to CIE source A, obtained using a gas filled, coiled-tungsten filament lamp operating at a correlated colour temperature of 2856K.

The photometric receiver of the reflected light should have a relative spectral sensitivity corresponding to a photomultiplier with an S-4 response as specified by the American Joint Electronic Devices Engineering Council, used with a Wratten 26 filter meeting nominal specifications.

Contrast

Print Contrast Signal (PCS) is affected by the reflectance of the light and dark bars.

Mathematically, when PCS is print contrast, RL is the reflectance of the light background, and RD is the reflectance of the dark background:

$$PCS = \frac{R_L - R_D}{R_L}$$

Figure 49 - PCS Equation

For ITF-14 and GS1-128 Bar Codes, most values of R_L require less contrast than EAN/UPC Bar Codes. However, ITF-14 and GS1-128 Bar Codes with R_L values greater than 65 have more stringent specifications than equivalent EAN/UPC Bar Codes. Refer to Table 29 and Table 30.

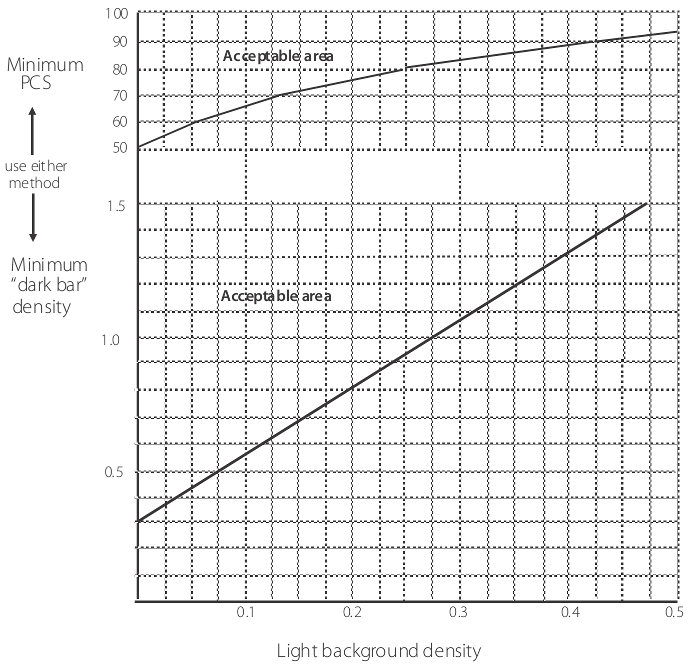


Figure 50 - EAN/UPC Bar Code Symbol Density and PCS

Light Bars		Dark Bars		Minimum PCS
D	RL	D	RD	RL –RD / RL
0	100	0.300	50.1	0.499
0.025	94.4	0.365	43.1	0.543
0.050	89.1	0.430	37.1	0.583
0.075	84.1	0.495	32.0	0.619
0.125	74.9	0.625	23.7	0.683
0.15	70.8	0.69	20.4	0.712
0.175	66.8	0.755	17.6	0.737
0.2	63.1	0.82	15.1	0.76
0.25	56.2	0.95	11.2	0.801
0.275	53.1	1.015	9.6	0.818
0.3	50.1	1.08	8.3	0.834
0.325	47.3	1.145	7.2	0.849
0.35	44.7	1.21	6.2	0.862
0.375	42.2	1.275	5.3	0.874
0.4	39.9	1.34	4.6	0.886
0.425	37.5	1.405	3.9	0.896
0.45	35.5	1.47	3.4	0.904
0.475	33.5	1.535	2.9	0.914
0.5	31.6	1.6	2.5	0.921

TABLE 29. EAN/UPC Bar Code Density, Reflectance, and PCS

Light bars		Dark bars		Minimum PCS
D	Minimum RL	D	Minimum RD	$\frac{RL - RD}{RL}$
0.97	> 80	0.699	20.00	0.75
0.125	75	0.727	18.75	0.75
0.155	70	0.757	17.50	0.75
0.187	65	0.789	16.25	0.75
0.222	60	0.824	15.00	0.75
0.26	55	0.861	13.75	0.75
0.301	50	0.903	12.50	0.75
0.347	45	0.949	11.25	0.75
0.398	40	1.000	10.00	0.75
0.456	35	1.058	8.75	0.75
0.523	30	1.125	7.50	0.75
0.602	25	1.204	6.25	0.75

TABLE 30. GS1-128 and ITF-14 Bar Codes Density, Reflectance, and PCS

Colour

Use any dark and light colour combination that conforms to the reflectance and contrast specifications stated previously. Make the background the light colour.

As a general guide to colour selection, it is the blue content of a colour that produces the dark tone when viewed through a Wratten 26 filter. Red and yellow colours correspond to the light tones.

Do not use high gloss inks or substrates for the background, because they upset the reflectance and colour combinations.

Show Through

For some items, the inside material may show through the light areas of the packaging. This may make the package colour appear dark to the scanner. In these cases, calculate the reflectance and contrast from a **finished** item, not just the outer package.

Different packaging materials reflect light differently, according to the dimensions of the bars and spaces. This is especially evident on transparent and translucent packages, where the background (that is, the spaces) is not printed.

In these cases, calculate the bar code contrast specifications from a **finished** item. Make contrast measurements using the bar code parts where the bars and spaces are at a minimum width, for example, in the centre pattern of an EAN/UPC Bar Code.

When there is the possibility of show through, it is preferable to print both the light background and the dark bars.

Transparent Wrapper

A transparent wrapper over the printed bar code tends to slightly reduce the contrast. If you use a transparent wrapper over the printed bar code, consider the transparent wrapper an integral part of the symbol. Make all reflectance measurements with the wrapper over the bar code.

Specularly Reflecting Materials

Avoid using specularly reflecting materials (those that are **very** reflective) for either light or dark areas in a bar code. If such material is the substrate for a bar code, it is advisable to overprint the substrate with two inks having sufficiently different light absorbing characteristics to meet the print contrast requirements.

If you cannot avoid using specularly reflecting materials, and the bar code surface is rigid, **print** the **spaces** in a **light** colour. **Leave** the **bars** in the **reflective substrate**, preferably the bare substrate. Otherwise, print a portion of the bar area with a transparent ink that does not significantly change the reflectance.

If the bars are not printed, it is preferable to varnish the entire bar code. In these circumstances it is not recommended to print bar codes under 100% magnification. Ensure the human readable digits are highly visible.

When using this method, the accuracy of the bar code dimensions is critical.

Film master manufacturers have to execute bar width expansion and create reverse orientation of film (positive becomes negative and vice versa). They “fatten” the human readable digits to make them more “visible.”

Obscuring Patterns

You may need to obscure bar codes in some circumstances, for example, on the individual unit packs in a multipack container that carries its own bar code.

One way to obscure a bar code is to print a solid layer of ink over the bar code. However, this is not always 100% effective. It is better to print a distraction, in the form of an obscuring pattern, over the bar code.

The obscuring pattern printed over the bar code must meet the same print contrast signal level as the bar code you are covering. See “Contrast” on page 83.

Make sure the bar width for the obscuring pattern is the “target” module width for the magnification factor of the bar code being obscured. Make sure the space width of the obscuring pattern is no more than twice its own bar width.

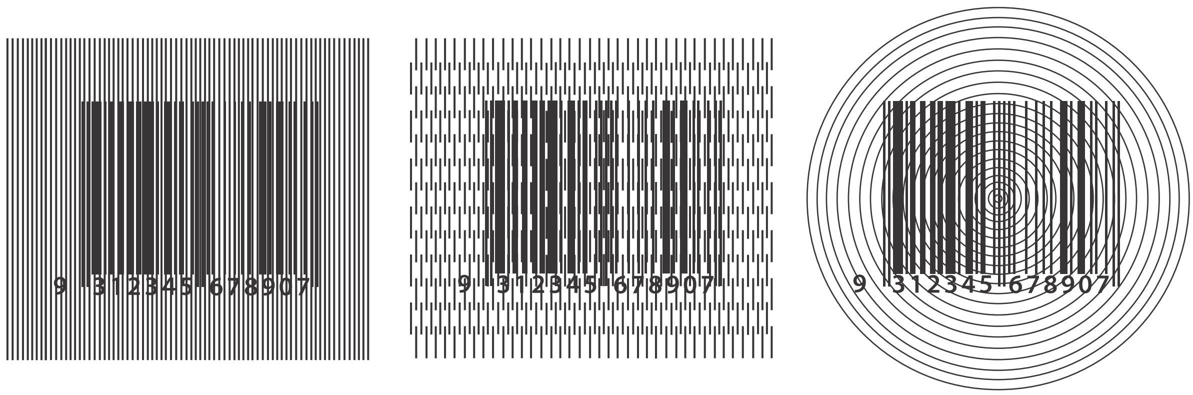


Figure 51 - Patterns that Obscure a Bar Code

10.6EAN/UPC Bar Code Specifications

10.6.1 EAN/UPC Magnification

The size of the bar code has historically been known as magnification. This technique relies upon setting a nominal size (100% magnification) that is directly related to a given X-dimension (module width). The more precise X-dimension is now also used to specify permissible bar code sizes.

The extent of variation (V) in print gain determines the magnification factor by which the bar code must be magnified (or reduced) in relation to the nominal size.

Adopt any value of magnification (M) between 80% - 200% (X-dimension 0.27mm - 0.66mm) by interpolation of Figure 52 on page 89 and Table 31 on page 90.

Note: For General Distribution Scanning the magnification range is 150% - 200% (X-dimension 0.50mm - 0.66mm).

The left column inTable 31 is based on a regular sequence of values of M. The right column is based on a regular sequence of values of V.

The finer the ink gain, the smaller the bar code; the broader the ink gain, the larger the bar code.

Note: For any magnification factor below 100% (X-dimension 0.33mm), the amount of acceptable print gain variation rapidly becomes smaller.

Determining the magnification factor determines the amount of space required on the package to accommodate the bar code.

The space required needs to accommodate the overall length and height of the bar code which is between 80% and 200% magnification (X-dimension 0.27mm - 0.66mm).

For scanning in a General Distribution Scanning Environment the magnification range 150% - 200% (X-dimension 0.46mm - 0.66mm).

Note: Wherever possible, use a magnification higher than the minimum. This greatly increases the bar code scanning reliability. If you reduce the magnification to below nominal, you may reduce its reliability.

Note: It is the print quality of the bar code and the scanning environment that determines the minimum magnification factor you must apply, **not** a predetermined space on the package.

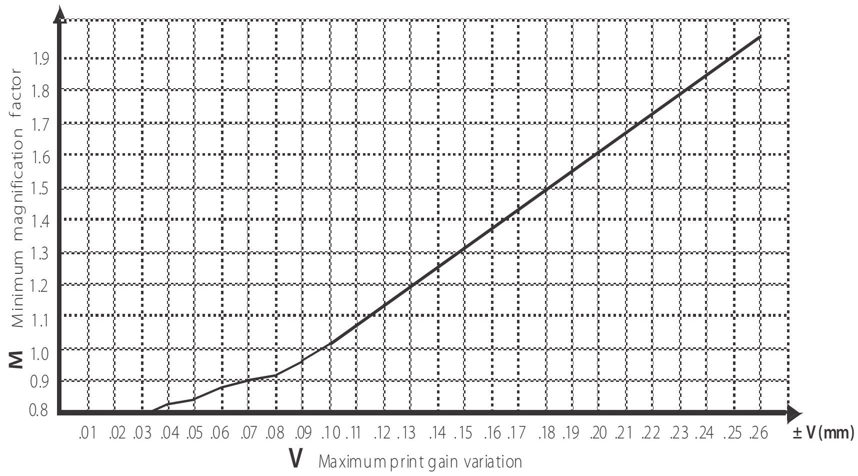


Figure 52 - Relationship between Maximum Print Gain Variation and Minimum Magnification

Continuous sequence of values of M			Continuous sequence of values of V		
Maximum print gain variation	Minimum magnification	X-dimension	Maximum print gain variation	Minimum magnification	X-dimension
±0.035	0.80	0.26	±0.04	0.82	0.27
±0.051	0.85	0.28	±0.06	0.88	0.29
±0.069	0.90	0.30	±0.08	0.94	0.31
±0.085	0.95	0.31	±0.10	1.00	0.33
±0.101	1.00	0.33	±0.12	1.14	0.38
±0.108	1.05	0.35	±0.14	1.25	0.41
±0.115	1.10	0.36	±0.16	1.39	0.46
±0.124	1.15	0.38	±0.18	1.52	0.50
±0.132	1.20	0.40	±0.20	1.65	0.55
±0.140	1.25	0.41	±0.22	1.78	0.59
±0.147	1.30	0.43	±0.24	1.90	0.63
±0.152	1.35	0.45	±0.26	2.00	0.66
±0.163	1.40	0.46	—	—	—
±0.171	1.45	0.48	—	—	—
±0.178	1.50	0.50	—	—	—
±0.184	1.55	0.51	—	—	—
±0.192	1.60	0.53	—	—	—
±0.201	1.65	0.54	—	—	—
±0.209	1.70	0.56	—	—	—
±0.216	1.75	0.58	—	—	—
±0.224	1.80	0.59	—	—	—
±0.233	1.85	0.61	—	—	—
±0.241	1.90	0.63	—	—	—
±0.250	1.95	0.64	—	—	—
±0.256	2.00	0.66	—	—	—

Note: In the heading of this table, M = magnification, V = print gain variation.
All measurements are in millimetres.

TABLE 31. Relationship between Maximum Print Gain Variations and Minimum Magnification

10.6.2 EAN/UPC Film Master Tolerances

The magnification factor compensates for variation in print gain and is the minimum magnification you apply to a bar code.

It does not take into account any further magnification required to compensate for tolerances in the preparation of the film master itself, nor does it allow any additional safety margin.

The permissible tolerances when preparing a film master are:

- ± 0.005 mm on any module width
- ± 0.013 mm on any complete symbol character or auxiliary pattern

Consult your film master supplier regarding the variation in tolerance to expect, in practice, in the film master. Add this amount to the variation value (V) you calculated in respect to the print gain. See "Print Gain and Variation" on page 79.

Generally, it is best to add the amount of the modular tolerance (0.005 mm) to the variation value (V) before looking up the required value of M in Table 31 on page 90.

10.6.3 EAN/UPC Bar Width Reduction

Film master suppliers compensate for the extent of the demonstrated print gain. They achieve this by applying Bar Width Reduction (BWR) to the film master. BWR is equal to the print gain.

Reduce the width of **every** bar by the same amount on the film master symmetrically, that is, on **both** the left and right sides, by the total amount of the print gain.

Note: Apply the bar width reduction to the film master **after** carrying out any magnification to the bar code, **not** before. The only exception is when printing by Flexography, or any other process producing a print gain in excess of 0.3mm.

The bar width reduction is equal to the average print gain in all cases and is not affected by the magnification of the bar code.

When the film master is printed with its bars reduced by the BWR, the average print gain restores the bars to their ideal width. Variation in the average print gain has already been allowed for in the choice of magnification. The tolerance of bar width reduction is ± 0.008mm.

Note: Never reduce a bar in a bar code on the printing plate below 0.13mm.

If the effect of the magnification factor and bar width reduction combined causes a single module bar to go below 0.13mm, increase the magnification factor until the bar reaches the acceptable width of 0.33 mm. Mathematically:

$$(0.33 \times M) - G \geq 0.13 \text{ mm}$$

10.6.4 On-Site Production of EAN/UPC Bar Codes

The processes described previously for source marked bar codes are not relevant for on-site printers.

In some circumstances, automatic label printing machines are used on-site to convert numerical data directly into a bar code. The performance of these machines must be specified in order to control their output. It is necessary to stipulate the tolerance permitted in the printed bar code.

The nominal EAN/UPC X-dimension (module width) is 0.33 mm. Tolerances for bar code labels are defined for various X-dimensions (module widths) corresponding to magnifications 80% - 200%.

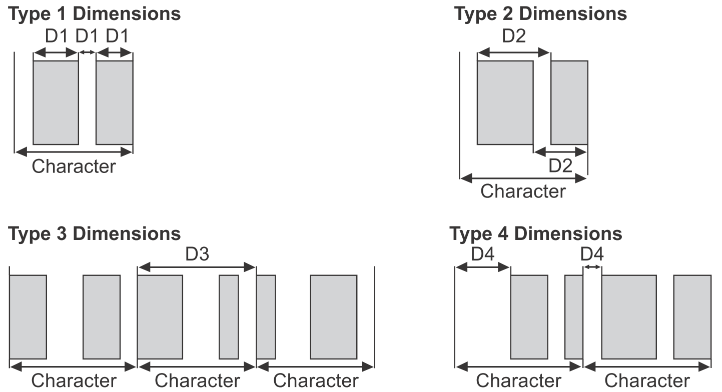
Different tolerances may apply to different types of dimensions. There are four different dimensions in an EAN/UPC Bar Code.

- The measurement of a bar (space) inside a character.
- The measurement of the width between corresponding edges of the bars inside the character.
- The measurement between corresponding edges of corresponding bars in adjacent characters.
- The measurement of the space between the last and first bars of adjacent characters.

See Table 32 on page 93.

These dimensions and tolerances may also be used by packaging manufacturers to ensure that printing is of an acceptable quality.

The dimensions given in Table 32 do not represent a standard for source marked bar codes, but can be used by film master suppliers, verification equipment, scanning equipment, and printers as a reference.



Magnification	X-dimension (Module width)	Tolerance D1	Tolerance D2	Tolerance D3
80%	0.26	±0.032	±0.038	±0.075
85%	0.28	±0.052	±0.041	±0.081
91%	0.30	±0.072	±0.044	±0.087
97%	0.32	±0.092	±0.047	±0.093
100%	0.33	±0.101	±0.049	±0.096
103%	0.34	±0.105	±0.050	±0.099
109%	0.36	±0.115	±0.053	±0.104
115%	0.38	±0.124	±0.056	±0.110
121%	0.40	±0.134	±0.059	±0.116
127%	0.42	±0.143	±0.062	±0.122
133%	0.44	±0.152	±0.065	±0.128
139%	0.46	±0.162	±0.068	±0.133
145%	0.48	±0.171	±0.071	±0.139
151%	0.50	±0.181	±0.073	±0.145
158%	0.52	±0.190	±0.076	±0.151
164%	0.54	±0.199	±0.079	±0.157
170%	0.56	±0.209	±0.082	±0.162
176%	0.58	±0.218	±0.085	±0.168
181%	0.60	±0.228	±0.088	±0.174
188%	0.62	±0.237	±0.091	±0.180
194%	0.64	±0.246	±0.094	±0.186

Note: Type 4 dimensions are not subject to explicit tolerances but must not be less than 0.2 mm.
All measurements are in millimetres.

TABLE 32. EAN/UPC Bar Code Dimensions and Tolerances for Types 1, 2, and 3 Dimensions

10.6.5 EAN/UPC Bar Code Dimensions

EAN-13 Bar Code Dimensions

Magnification	X-dimension	Width	Bar Height	Left Quiet Zone	Right Quiet Zone
80%	0.26	25.08	18.28	2.90	1.85
85%	0.28	26.65	19.42	3.09	1.96
90%	0.30	28.22	20.57	3.27	2.08
95%	0.31	29.78	21.71	3.45	2.19
100%	0.33	31.35	22.85	3.63	2.31
105%	0.35	32.92	23.99	3.81	2.43
110%	0.36	34.49	25.14	3.99	2.54
115%	0.38	36.05	26.28	4.17	2.66
120%	0.40	37.62	27.42	4.36	2.77
125%	0.41	39.19	28.56	4.54	2.89
130%	0.43	40.76	29.71	4.72	3.00
135%	0.45	42.32	30.85	4.90	3.12
140%	0.46	43.89	31.99	5.08	3.23
145%	0.48	45.46	33.13	5.26	3.35
150%	0.50	47.03	34.28	5.45	3.47
155%	0.51	48.59	35.42	5.63	3.58
160%	0.53	50.16	36.56	5.81	3.70
165%	0.54	51.73	37.70	5.99	3.81
170%	0.56	53.30	38.85	6.17	3.93
175%	0.58	54.86	39.99	6.35	4.04
180%	0.59	56.43	41.13	6.53	4.16
185%	0.61	58.00	42.27	6.72	4.27
190%	0.63	59.57	43.42	6.90	4.39
195%	0.64	61.13	44.56	7.08	4.50
200%	0.66	62.70	45.70	7.26	4.62

Note: In the heading of this table, Width = Width of bar code excluding Quiet Zones,
Bar Height = Bar Height excluding guard bar patterns.
It is recommended to always allow slightly more than the minimum required Quiet Zone to allow for any possible ink spread or registration issues.
All measurements are in millimetres.

TABLE 33. EAN-13 Bar Code Dimensions

EAN-8 Bar Code Dimensions

Magnification	X-dimension	Width	Bar Height	Left Quiet Zone	Right Quiet Zone
80%	0.26	17.69	14.58	1.85	1.85
85%	0.28	18.79	15.50	1.96	1.96
90%	0.30	19.90	16.41	2.08	2.08
95%	0.31	21.00	17.32	2.19	2.19
100%	0.33	22.11	18.23	2.31	2.31
105%	0.34	23.22	19.14	2.43	2.43
110%	0.36	24.32	20.05	2.54	2.54
115%	0.38	25.43	20.96	2.66	2.66
120%	0.40	26.53	21.88	2.77	2.77
125%	0.41	27.64	22.79	2.89	2.89
130%	0.43	28.74	23.70	3.00	3.00
135%	0.45	29.85	24.61	3.12	3.12
140%	0.46	30.95	25.52	3.23	3.23
145%	0.48	32.06	26.43	3.35	3.35
150%	0.50	33.17	27.35	3.47	3.47
155%	0.51	34.27	28.26	3.58	3.58
160%	0.53	35.38	29.17	3.70	3.70
165%	0.54	36.48	30.08	3.81	3.81
170%	0.56	37.59	30.99	3.93	3.93
175%	0.58	38.69	31.90	4.04	4.04
180%	0.59	39.80	32.81	4.16	4.16
185%	0.61	40.90	33.73	4.27	4.27
190%	0.63	42.01	34.64	4.39	4.39
195%	0.64	43.11	35.55	4.50	4.50
200%	0.66	44.22	36.46	4.62	4.62

Note: In the heading of this table, Width = Width of bar code excluding Quiet Zones,
Bar Height = Bar Height excluding guard bar patterns.
It is recommended to always allow slightly more than the minimum required Quiet Zone to allow for any possible ink spread or registration issues.
All measurements are in millimetres.

TABLE 34. EAN-8 Bar Code Dimensions

UPC-A Bar Code Dimensions

Magnification	X-dimension	Width	Bar Height	Left Quiet Zone	Right Quiet Zone
80%	0.26	25.08	18.28	2.38	2.38
85%	0.28	26.65	19.42	2.52	2.52
90%	0.30	28.22	20.57	2.67	2.67
95%	0.31	29.78	21.71	2.82	2.82
100%	0.33	31.35	22.85	2.97	2.97
105%	0.36	32.92	23.99	3.12	3.12
110%	0.36	34.49	25.14	3.27	3.27
115%	0.38	36.05	26.28	3.42	3.42
120%	0.40	37.62	27.42	3.56	3.56
125%	0.41	39.19	28.56	3.71	3.71
130%	0.43	40.76	29.71	3.86	3.86
135%	0.45	42.32	30.85	4.01	4.01
140%	0.46	43.89	31.99	4.16	4.16
145%	0.48	45.46	33.13	4.31	4.31
150%	0.50	47.03	34.28	4.46	4.46
155%	0.51	48.59	35.42	4.60	4.60
160%	0.53	50.16	36.56	4.75	4.75
165%	0.54	51.73	37.70	4.90	4.90
170%	0.56	53.30	38.85	5.05	5.05
175%	0.58	54.86	39.99	5.20	5.20
180%	0.59	56.43	41.13	5.35	5.35
185%	0.61	58.00	42.27	5.49	5.49
190%	0.63	59.57	43.42	5.64	5.64
195%	0.64	61.13	44.56	5.79	5.79
200%	0.66	62.70	45.70	5.94	5.94

Note: In the heading of this table, Width = Width of bar code excluding Quiet Zones,
Bar Height = Bar Height excluding guard bar patterns.
It is recommended to always allow slightly more than the minimum required Quiet Zone to allow for any possible ink spread or registration issues.
All measurements are in millimetres.

TABLE 35. UPC-A Bar Code Dimensions

UPC-E Bar Code Dimensions

Magnification	X-dimension	Width	Bar Height	Left Quiet Zone	Right Quiet Zone
80%	0.26	13.47	18.28	2.38	1.85
85%	0.28	14.31	19.42	2.52	1.96
90%	0.30	15.15	20.57	2.67	2.08
95%	0.31	15.99	21.71	2.82	2.19
100%	0.33	16.83	22.85	2.97	2.31
105%	0.35	17.67	23.99	3.12	2.43
110%	0.36	15.51	25.14	3.27	2.54
115%	0.38	19.36	26.28	3.42	2.66
120%	0.40	20.20	27.42	3.56	2.77
125%	0.41	21.04	28.56	3.71	2.89
130%	0.43	21.88	29.71	3.86	3.00
135%	0.45	22.72	30.85	4.01	3.12
140%	0.46	23.56	31.99	4.16	3.23
145%	0.48	24.40	33.13	4.31	3.35
150%	0.50	25.25	34.28	4.46	3.47
155%	0.51	26.09	35.42	4.60	3.58
160%	0.53	26.93	36.56	4.75	3.70
165%	0.54	27.77	37.70	4.90	3.81
170%	0.56	28.61	38.85	5.05	3.93
175%	0.58	29.45	39.99	5.20	4.04
180%	0.59	30.29	41.13	5.35	4.16
185%	0.61	31.14	42.27	5.49	4.27
190%	0.63	31.98	43.42	5.64	4.39
195%	0.64	32.82	44.56	5.79	4.50
200%	0.66	33.66	45.70	5.94	4.62

Note: In the heading of this table, Width = Width of bar code excluding Quiet Zones,
Bar Height = Bar Height excluding guard bars patterns.
It is recommended to always allow slightly more than the minimum required Quiet Zone to allow for any possible ink spread or registration issues.
All measurements are in millimetres.

TABLE 36. UPC-E Bar Code Dimensions

10.7ITF-14 Bar Code Specifications

10.7.1 ITF-14 Magnification Factor

The size of the bar code has historically been known as magnification. This technique relies upon setting a nominal size (100%) that is directly related to a given X-dimension (module width). The more precise X-dimension is now used to specify permissible bar code sizes but magnification is often included to assist in transitioning to X-dimension.

The extent of variation (V) in print gain determines the minimum magnification factor by which the entire bar code must be magnified (or reduced) in relation to the nominal size. See Table 37.

For General Distribution Scanning choose any value of magnification (M) between 48.7% and 100% (X-dimension 0.495mm - 1.02mm). For environments other than General Distribution Scanning, the minimum magnification factor is 25% (X-dimension 0.25mm).

The left column in Table 37 is based on a regular sequence of values of M. The right column is based on a regular sequence of values of V.

Note: Wherever possible, use a magnification factor higher than the minimum. This greatly increases the bar code scanning reliability. If you reduce the magnification to below nominal, you may reduce its reliability. See "Overall ITF-14 Dimensions" on page 101 for the dimensions of an ITF Bar Code at various magnification factors.

Note: It is the print quality of the bar code that determines the minimum magnification factor you must apply, not a predetermined space on the packaging.

Continuous sequence of values of M			Continuous sequence of values of V		
Maximum print gain variation	Minimum magnification	X-dimension	Maximum print gain variation	Minimum magnification	X-dimension
±0.127	62.5%	0.64	±0.15	65%	0.66
±0.203	70%	0.71	±0.18	68%	0.69
±0.244	80%	0.81	±0.21	71%	0.72
±0.274	90%	0.91	±0.24	79%	0.80
±0.305	100%	1.02	±0.27	89%	0.90
			±0.30	99%	1.01
Note: In the heading of this table M = Magnification, V = print gain variation. All measurements are in millimetres.					

TABLE 37. Relationship between variation and magnification for ITF-14 Bar Code

10.7.2 ITF Bar Width Reduction

Film master suppliers compensate for the extent of the demonstrated print gain. They achieve this by applying Bar Width Reduction (BWR) to the film master. BWR is equal to the print gain.

Reduce the width of **every** bar by the same amount on the film master symmetrically, that is, on **both** the left and right sides, by the total amount of the print gain.

Note: Apply the bar width reduction to the film master **after** carrying out any magnification to the bar code, **not** before.

The bar width reduction is equal to the average print gain in all cases and is not affected by the magnification of the bar code.

When the film master is printed with its bars reduced by the BWR, the average print gain restores the bars to their ideal width. Variation in the average print gain has already been allowed for in the choice of magnification.

10.7.3 Specification for the Dimensions of the Film Master

The dimensions for the specifications of the film master are shown in Table 38.

	Values of the dimensions	Tolerances
Width of a wide or narrow element of the bar code	Ideal nominal dimensions: • wide element 2.540 mm • narrow element 1.016 mm. To be corrected according to M and BWR	± M x 0.013 mm
Width of each pair of data characters	Ideal nominal dimensions: • 16.258 mm To be corrected according to M.	± M x 0.025 mm
Width of the start and stop patterns	Ideal nominal dimensions: • start character 4.064 mm • stop character 4.572 mm To be corrected according to M and BWR.	± M x 0.017 mm
Height of bars, thickness of Bearer Bar, minimum width of Quiet Zones	See Table 39 on page 100 and "Overall ITF-14 Dimensions" on page 101	± 0.127
Other dimensions of the bar code	See Table 39 on page 100 and "Overall ITF-14 Dimensions" on page 101	± 0.254

TABLE 38. ITF-14 Specifications for Manufacturing the Film Master

10.7.4 On-site Production of ITF-14 Bar Codes

The processes described previously for source marked bar codes are not relevant for on-site printers.

In some circumstances, automatic label printing machines are used on-site to convert numerical data directly into a bar code. The performance of these machines must be specified in order to control their output. It is necessary to stipulate the tolerance permitted in the printed bar code.

Tolerances for the ITF-14 Bar Codes are defined for various magnification factors, from 62.5% - 100% (X-dimension 0.64mm - 1.02mm).

In practice, packaging manufacturers may prefer to determine dimensions and tolerances by measurement to ensure that printing is of acceptable quality.

Table 39 shows an acceptable bar width dimensional tolerance for a given bar width for label printing equipment.

These do not represent a standard for source marked bar codes, but can be used by film master suppliers, verification equipment, scanning equipment, and printers as a reference.

	Width and tolerance wide and narrow elements			Width and tolerance digit pair (*)		Width and tolerance symbol start and stop pattern (*)		
Mag. (M)	Ideal width narrow bar (X)	Ideal width wide bar	Tolerance wide and narrow bar	Ideal width digit pair	Tolerance width digit pair	Ideal width start pattern	Ideal width stop pattern	Tolerance start and stop pattern
62.5%	0.635	1.588	±0.13	10.162	±0.36	2.54	2.858	±0.24
70%	0.711	1.778	±0.20	11.378	±0.41	2.844	3.2	±0.27
80%	0.813	2.032	±0.24	13.006	±0.46	3.252	3.658	±0.31
90%	0.914	2.286	±0.27	14.628	±0.52	3.656	4.114	±0.35
100%	1.016	2.540	±0.30	16.256	±0.58	4.064	4.572	±0.39

* The tolerances are defined for label printing equipment. In source marking, the tolerances will be met provided the film master manufacturer respects the tolerances allowed and the printer respects the specified procedures.
X = X-dimension
All measurements are in millimetres.

TABLE 39. Dimensions and Tolerances in a Printed ITF-14 Bar Code

You can interpolate these tolerances to obtain intermediate values of M greater than 0.714. For values of M less than 0.714, the tolerance is limited by the requirement that the absolute minimum bar or space width be 0.50mm.

Allow a tolerance of ±0.5 mm for the height of the bars and the height and location of the human readable digits.

10.7.5 Overall ITF-14 Dimensions

At a magnification of 100%, the X-dimension (width of a narrow element, i.e. bar) is 1.02mm and a wide element (bar) is 2.54mm.

Figure 53 - ITF Bar Code with X-dimension 1.016mm

Note: Figure reduced below 100% for presentation purposes only

ITF-14 Bar Code Dimensions

Magnification	X-Dimension	Width	Bar Height	Quiet Zones
25%	0.25	30.62	13.00	2.54
30%	0.30	36.73	13.00	3.05
35%	0.36	42.85	13.00	3.56
40%	0.41	48.97	13.00	4.05
45%	0.46	55.09	13.00	4.57
50%	0.51	61.21	32.00	5.08
55%	0.56	67.34	32.00	5.59
60%	0.61	73.46	32.00	6.10
70%	0.71	85.70	32.00	7.11
75%	0.76	91.82	32.00	7.62
80%	0.81	97.94	32.00	8.13
85%	0.86	104.05	32.00	8.64
90%	0.91	110.19	32.00	9.14
95%	0.97	116.31	32.00	9.65
100%	1.02	122.43	32.00	10.16

Note: In the heading of this table, Width = width of bar code excluding Quiet Zones and Bearer Bars, and assumes a Bar Width Ratio of 2.5:1, Bar Height = bar height excluding Bearer Bars
It is recommended to always allow slightly more than the minimum required Quiet Zone to allow for any possible ink spread or registration issues.
All measurements are in millimetres.

10.7.6 Formula for Calculating the ITF-14 Symbol Width

Mathematically, when W is width, 48 is the total number of narrow elements, 29 is total the number of wide elements, BWR is the Bar Width Ratio which is nominally 2.5, and X is X-dimension (module width), which is 1.02mm at 100% magnification.

W = (48X) +(29X)BWR (excluding Quiet Zones and Bearer Bars)

10.7.7 Human Readable Interpretation

For Human-Readable Interpretation Rules see Section 9 of the GS1 Australia User Manual Numbering and Bar Coding. For HRI Rules specific to Regulated Healthcare Retail Consumer Trade Items, see Section 4 of the GS1 Australia User Manual Numbering and Bar Coding.

10.7.8 ITF-14 Symbol Character Dimensions

At an X-dimension of 1.016mm (magnification 100%), the ideal theoretical width of the bars is:

- narrow bar 1.016 mm
- wide bar 2.540 mm (2.5 times wider than the narrow bar).

The total width of an ITF-14 Bar Code with X-dimension 1.016mm (magnification100%) excluding the Bearer Bar, Quiet Zones is 122.43mm.

The total width of an ITF-14 Bar Code with X-dimension 1.016mm (magnification100%) including the Bearer Bar, Quiet Zones, and H gauges is 158.428 mm.

Start pattern	n x digit pairs	Stop pattern
4.064 mm	n x 16.256 mm	4.572 mm

TABLE 40. ITF-14 Bar Code Total Width excluding Quiet Zones

As shown in Table 41, the bar widths of the symbol characters are:

digit pair	= 6 narrow elements and 4 wide elements = (6 x 1.016 mm) + (4 x 2.540 mm)	= 16.256 mm
start pattern	= four narrow elements	= 4.064 mm
stop pattern	= two narrow elements + 1 wide element	= 4.572 mm

These dimensions are ideal, theoretical dimensions corresponding to an X-dimension (narrow element width) of 1.016mm. They are not intended to be used directly in the preparation of bar codes.

Start pattern	7 digit pairs	Stop pattern	Total
4 narrow elements	6 narrow elements 4 wide elements x 7 pairs 42 narrow elements 28 wide elements	2 narrow elements 1 wide element	48 narrow elements 29 wide elements
4.064 mm	113.792 mm	4.572 mm	122.428 mm

TABLE 41. ITF-14 Bar Code Character Dimensions

10.8GS1-128 Bar Code Specifications

10.8.1 GS1-128 Magnification Factor

The extent of variation in print gain determines the minimum magnification factor by which the entire bar code must be magnified (or reduced) in relation to a bar code at 100% magnification (X-dimension1.016mm).

The magnification factor (X-dimension) depends on the scanning environment:

For scanning in a General Distribution Scanning Environment magnification factors are between 48.7% and 100% (X-dimension 0.495mm - 1.016mm). For GS1-128 Symbols containing the Application Identifier (00): Serial Shipping Container Code (SSCC), the minimum magnification range is 48.7% - 92.5% (X-dimension 0.495mm - 0.940mm). For other scanning environments refer to "Symbology Operational Bands" on page 4 or contact GS1 Australia.

See Table 42 and Figure 54 for more information. The left column in Table 42 is based on a regular sequence of values of M. The right column is based on a regular sequence of values of V.

The finer the ink gain, the smaller the bar code; the broader the ink gain, the larger the bar code.

Continuous sequence of values of M			Continuous sequence of values of V		
Maximum print gain variation	Minimum magnification	X-dimension	Maximum print gain variation	Minimum magnification	X-dimension
0.02	25%	0.25	0.05	28%	0.28
0.07	30%	0.31	0.10	33%	0.34
0.14	40%	0.41	0.15	41%	0.42
0.18	50%	0.51	0.20	54%	0.55
0.22	60%	0.61	0.25	66%	0.67
0.26	70%	0.71	0.30	79%	0.80
0.30	80%	0.81	0.35	91%	0.92
0.34	90%	0.91			
0.38	100%	1.02			
Note: In the heading of this table M = magnification, V = print gain variation. For any magnification below 100%, the amount of acceptable print gain variation rapidly becomes smaller. The values in this table respect the condition that no printed bars shall be less than 0.23mm in width. All measurements are in millimetres.					

TABLE 42. GS1-128 relationship between print gain variation and magnification

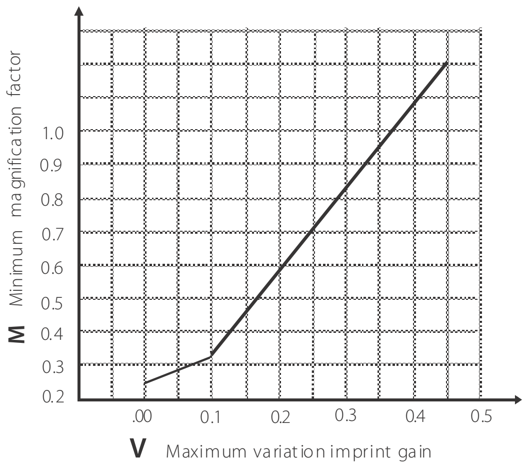


Figure 54 - GS1-128: Relationship between Maximum Print Gain Variation and Minimum Magnification Factors

The actual magnification factor you choose depends on the print quality and is derived from measuring the variation in print gain. When the GS1-128 Bar Code supplements an EAN/UPC or ITF-14 Bar Code, the magnification factor chosen must take into account the size of the EAN/UPC or ITF-14 Bar Code.

As a general rule, the GS1-128 X-dimension (module width) must not be less than 75% of the X-dimension (single module or narrow element width) in the EAN/UPC or ITF-14 main Bar Code. See Table 43 for magnification factors.

EAN-13 magnification	Minimum GS1-128 magnification	ITF-14 magnification factor	Minimum GS1-128 magnification
80%	25%	62.5%	50%
90%	25%	70%	55%
100%	25%	80%	65%
120%	30%	90%	70%
140%	35%	100%	80%
160%	40%		
180%	45%		
200%	50%		

TABLE 43. GS1-128 Magnification Factors for Various EAN-13 and ITF-14 Magnification Factors

10.8.2 GS1-128 Bar Width Reduction

Film master suppliers compensate for the extent of the demonstrated print gain. They achieve this by applying Bar Width Reduction (BWR) to the film master. BWR is equal to the print gain.

Reduce the width of **every** bar by the same amount on the film master symmetrically, that is, on **both** the left and right sides by the total amount of the print gain.

Note: Apply the bar width reduction to the film master **after** carrying out any magnification to the bar code, **not** before.

The bar width reduction is equal to the average print gain in all cases and is not affected by the magnification of the bar code.

When the film master is printed with its bars reduced by the BWR, the average print gain restores the bars to their ideal width. Variation in the average print gain has already been allowed for in the choice of magnification.

Look up the print gain variation (V) in Table 42 and Figure 54.

Note: Never print a bar less than **0.23** mm in width.

10.8.3 On-site Production of GS1-128 Bar Codes

Often the GS1-128 Bar Code is produced from equipment which produces bar codes directly from the input of data. In order to specify the performance of such printers and to control their output, it is necessary to stipulate the tolerances permitted in the printed bar code.

Tolerances are defined for various module widths corresponding to magnification factors from 25% - 100% of the nominal size (X-dimension 0.25mm - 1.016mm). Different tolerances apply to different types of dimensions.

There are three different types of dimensions in the GS1-128 Bar Code.

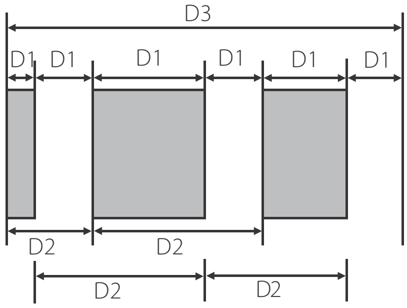
- Type 1 - measurement of a bar or space inside the bar code.
- Type 2 - measurement of the width between corresponding edges of bars within a character.
- Type 3 - measurement of the total width of a character.

Based on 100% magnification, tolerances D1, D2, and D3 apply to dimension types 1, 2, and 3:

- $D1 = \pm 0.4X - 0.013$ mm (0.0005 inches)
- $D2 = \pm 0.2X$
- $D3 = \pm 0.2X$

X is the nominal minimum dimension

.



Magnification	X-dimension	Tolerance D1*	Tolerance D2	Tolerance D3
25%	0.25	0.020	0.050	0.050
30%	0.30	0.070	0.060	0.060
35%	0.36	0.127	0.070	0.070
40%	0.41	0.147	0.080	0.080
45%	0.46	0.167	0.090	0.090
50%	0.51	0.187	0.100	0.100
55%	0.56	0.207	0.110	0.110
60%	0.61	0.227	0.120	0.120
65%	0.66	0.247	0.130	0.130
70%	0.71	0.267	0.140	0.140
75%	0.76	0.287	0.150	0.150
80%	0.81	0.307	0.160	0.160
85%	0.86	0.327	0.170	0.170
90%	0.91	0.347	0.180	0.180
95%	0.97	0.367	0.190	0.190
100%	1.02	0.387	0.200	0.200

* These values respect the condition that no printed bar shall be less than 0.23mm in width.
Note: All measurements are in millimetres.

TABLE 44. GS1-128 Bar Code Dimension Tolerances, Types 1,2, and 3

10.8.4 Overall GS1-128 Dimensions

156.46
136.14
10.16 10.16
32.00

(01)09312345678907

Figure 55 - GS1-128 Symbol at Nominal Size (not to scale)

The size of the GS1-128 Bar Code depends on:

- the X-dimension (magnification factor) chosen
- the number of characters encoded
- the number of non-numeric characters in the data.

The X-dimension (module width) at 100% magnification is 1.016mm.

Magnifications are between 25% and 100% (X-dimension 0.254mm to 1.016mm). For General Distribution Scanning, a minimum magnification of 48.7% (X-dimension 0.495mm) should be used.

Note: Magnification factors for (AI) 00 - Serial Shipping Container Code (SSCC) are between 48.7% and 92.5% (X-dimension 0.495mm - 0.940mm).

Mathematically, when W is width, 11 is the number of modules per symbol character, N is the number of symbol characters (excluding the start and stop characters and Symbol Check Character), 66 is the number of auxiliary character modules and X is the X-dimension (module width), which at 100% magnification is 1.016mm.

$W = (11N + 66)X$ (including Quiet Zones)

GS1-128 Bar Code Dimensions

Magnification	X-dimension	Width	Bar Height	Quiet Zones
25%	0.25	34.04	13.00	2.54
30%	0.30	40.84	13.00	3.05
35%	0.36	47.65	13.00	3.56
40%	0.41	54.46	13.00	4.06
45%	0.46	61.26	13.00	4.57
50%	0.51	68.07	32.00	5.08
55%	0.56	74.88	32.00	5.59
60%	0.61	81.68	32.00	6.10
65%	0.66	88.49	32.00	6.60
70%	0.71	95.30	32.00	7.11
75%	0.76	102.11	32.00	7.62
80%	0.81	108.91	32.00	8.13
85%	0.86	115.72	32.00	8.64
90%	0.91	122.53	32.00	9.14
95%	0.97	129.33	32.00	9.65
100%	1.02	136.14	32.00	10.16

Note: In the heading of this table, Width = Width of bar code excluding Quiet Zones,
It is recommended to always allow slightly more than the minimum required Quiet Zone to allow for any possible ink spread or registration issues.
All measurements are in millimetres.

These dimensions are only indicative of a GS1-128 Bar Code with one Application Identifier and a GTIN without any attribute data, e.g. (01)09312345678907.

TABLE 45. GS1-128 Bar Code Dimensions

10.8.5 GS1-128 Symbol Character Dimensions

The following calculations are based on a GS1-128 Bar Code at a magnification of 100%, (X-dimension or width of a single module **1.016 mm)**.

A GS1-128 Bar Code has a total of 11N + 66 modules (including the Quiet Zones). This is made up from all data characters plus auxiliary characters. See Table 11 on page 25 of chapter 4 .

The width of each **symbol character**, with the exception of the stop character, is **11.176 mm**, and the width of the **stop character** is **13.208 mm**.

The maximum number of encoded human readable characters for one GS1-128 Bar Code is 48. This number includes AIs and function characters when used as field separator characters, but excludes auxiliary characters and the Symbol Check Character.

The **total physical length** of a GS1-128 Bar Code depends on how many characters you encode and which character set you use. The maximum physical length, including Quiet Zones, is **165mm**.

Measure the width of each character, except the stop character, from the visually indicated edge (dark bar) to the visually indicated edge of the adjacent character. For the stop character, measure between its extreme visually indicated edges.

In character set C, two digits are encoded in one symbol character so you can encode numeric data with twice the density.

Note: All dimensions given are ideal, theoretical dimensions corresponding to an X-dimension of 1.016mm (magnification 100%). These dimensions are not intended for use directly in the preparation of bar codes.

10.8.6 Human Readable Interpretation

For Human-Readable Interpretation Rules see Section 9 of the GS1 Australia User Manual Numbering and Bar Coding. For HRI Rules specific to Regulated Healthcare Retail Consumer Trade Items, see Section 4 of the GS1 Australia User Manual Numbering and Bar Coding.

10.8.7 Concatenation

You can concatenate (combine) multiple AIs and their fields into a single bar code. See "Concatenation " on page 73

(01)09312345678907(17)060215(10)123456

GTIN AI | Data | Used By Date AI | Data | Batch/Lot Number AI | Data

Figure 56 - Concatenated GS1-128 Bar Code

Place a FNC1 character field separator after all variable-length fields to identify the end of that field. This is not necessary for the last field in the bar code.

When the first two characters of the AI correspond to a pre-defined length indicator, you do not need to use a FNC 1 field separator character to separate the fields because their length is already known. See Table 41 on page 72 of chapter 9 .

The next AI follows immediately after the last character in the data field of the previous AI.

Figure 56 and Figure 55 show various concatenations.

AI = Application Identifier,
data 1 = fixed length field
data ..2 and data ..3 = variable length fields
F1 = Function 1 Symbol Character (FNC1)

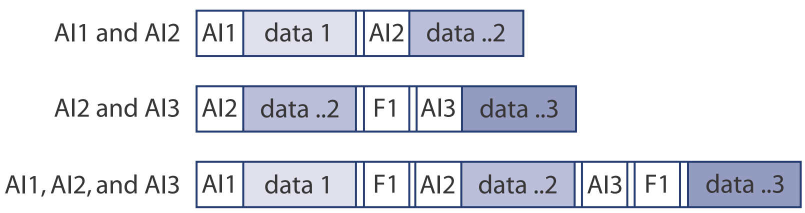


Figure 57 - Example of Concatenated Element Strings

Note: When you concatenate a number of AIs and their data fields, and only one field is of variable length, place the variable length field at the end of the bar code. This saves you from needing to include a field separator.

10.9Thermal Bar Code Label Printers

Direct thermal and thermal transfer printers are capable of generating high quality bar codes - typically ISO Grade 3 or 4. The printers may stand-alone or they may be integrated into an application such as a weighing and labelling system. In many cases the user has no control over the size or placement of the bar code. Quality printing is easily maintained by observing the following guidelines.

Symbology Design Considerations for Direct Thermal and Thermal Transfer Printers

Direct thermal and thermal transfer printers typically contain all of the low-level software required to generate bar codes. This means that various symbology formats are loaded into the firmware of the printer. The bar code design software simply sends commands to address the firmware in the printer to create the bar code. These commands typically relate to data characters, symbol size, symbol orientation and symbol placement.

The following special factors should be considered when designing the bar code for direct thermal and thermal transfer printers:

- Generate bar codes at a corrected magnification (see **Note:** below) or an X-dimension which is supported by the resolution of the specified printer. For example, the closest X-dimension (bar width) to 0.33mm a 203 DPI printer can achieve is 0.375mm. This is because each bar width is constructed with three 203 DPI dots which individually measure 0.125mm wide. Table 46 lists achievable EAN/UPC Bar Code magnifications (after correction) addressed by several resolutions of direct thermal and thermal transfer printers.

Note: A process of altering the desired dimensions of a GS1 Bar Codes to create modules consisting of a consistent integer number of addressable imaging device dots.

- Use a bar code graphic file that was designed for the resolution or the printer specified.

General Considerations for Direct Thermal Printing

Direct thermal printing should be avoided whenever the bar code may be exposed to direct sunlight, extreme temperatures, or has a shelf life exceeding one year. These labels fade very quickly in direct sunlight, and the background darkens at elevated temperatures. Some fading also occurs as labels age at room temperature under normal indoor lighting. As labels fade or darken, the contrast decreases so that at some point the bar code can no longer be scanned.

An example of good application for thermal labels is in-store marking of meat and other perishable food items. Such labels need last only days or weeks under protected indoor conditions.

General Considerations for Thermal Transfer Consumable Supplies

Consumable supplies are an important quality consideration. For best results, the correct combination of label and ribbon materials should be chosen for the printer type and application environment. Whenever a different brand or part number of labels or ribbons is loaded on the printer, the initial set-up should be repeated.

Initial Direct Thermal and Thermal Transfer Printer Set-Up

Direct thermal and thermal transfer printers require different settings for best results on different combinations of label and ribbon materials. Manufacturers' recommendations should be followed for making the necessary changes and adjustments.

After any change (e.g. printed format, ribbon type, label type, print speed, or printhead heat intensity), it is advisable to print a test symbol and verify it using an ISO (ANSI) based verifier. If you are printing a long run of identical bar codes, it would be appropriate to verify one to determine the bar code quality. If you are printing EAN/UPC Bar Codes that will vary in data content, a test EAN/UPC Bar Code containing the digits "4 12785 12783 2" is recommended for the verification process.

When you verify the test bar code, you should expect an ISO (ANSI) grade of 4 (A) or 3 (B) using the thermal transfer process. If these grades are not achieved, you are likely to have a problem with printer adjustments, cleanliness, or some other malfunction. With some direct thermal label materials, you may only be able to produce 1.5 (C) grade symbols. While such bar codes do conform to the quality specifications, you will have less margin for process variations and degradation from handling and ageing.

In addition to verification, you should examine the test bar code for adequate Quiet Zones, bar height, and the legibility of the human readable interpretation.

Maintaining Acceptable Quality

The quality of printed bar codes tends to degrade as deposits build up on the thermal print head. Regular cleaning of the print head and guide surfaces in accordance with manufacturers recommendations is strongly advised.

Thermal print heads eventually wear out to the point where one or more dot elements fail to heat properly. When this occurs, the printed bar codes may no longer be scannable. One solution to this problem is frequent verification to assure continuing quality. Some printers can be equipped with on-line verification devices that will indicate when a problem is detected. Although such on-line verifiers may not test all of the parameters for ISO, they can be very useful for monitoring the printing process. This is particularly true after supplies replacement or printer maintenance.

An alternative method for detecting dot burnout is to print a line across the width of the bar code. Any dot failure will be immediately visible to the operator as a small break in the line as shown in the figure below:

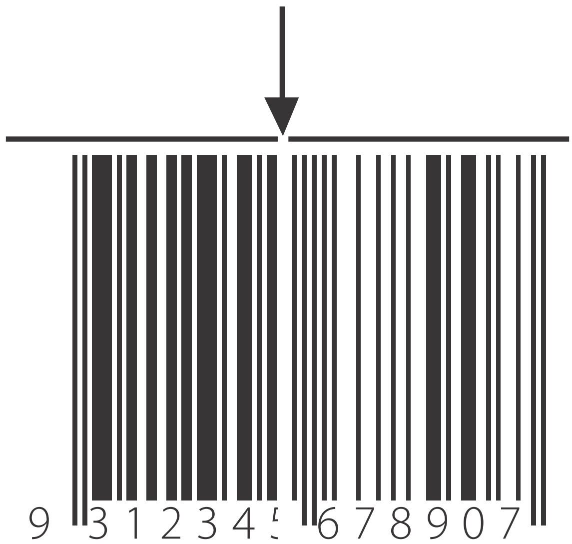


Figure 58 - Detection of Dot Burnout on Thermal/Direct Thermal Printheads

Reference DPI	Actual DPI	Dots Per Millimetre	Actual Dot Width (Centre Point to Centre Point mm)	Dots Per Module Width	MODULE WIDTH (mm)	*Corrected Magnification
200	203.2	8	0.12500	2	0.2500	**75.76%
200	203.2	8	0.12500	3	0.3750	113.64%
200	203.2	8	0.12500	4	0.5000	151.52%
200	203.2	8	0.12500	5	0.6250	189.39%
300	304.8	12	0.08333	3	0.2500	**75.76%
300	304.8	12	0.08333	4	0.3333	100.01%
300	304.8	12	0.08333	5	0.4166	126.26%
300	304.8	12	0.08333	6	0.5000	151.52%
300	304.8	12	0.08333	7	0.5833	176.77%
400	406.4	16	0.06250	4	0.2500	**75.76%
400	406.4	16	0.06250	5	0.3125	94.70%
400	406.4	16	0.06250	6	0.3750	113.64%
400	406.4	16	0.06250	7	0.4375	132.58%
400	406.4	16	0.06250	8	0.5000	151.52%
400	406.4	16	0.06250	9	0.5625	170.45%
400	406.4	16	0.06250	10	0.6250	189.39%
600	609.6	24	0.04167	6	0.2500	**75.76%
600	609.6	24	0.04167	7	0.2916	88.38%
600	609.6	24	0.04167	8	0.3333	101.01%
600	609.6	24	0.04167	9	0.3750	113.64%
600	609.6	24	0.04167	10	0.4166	126.26%
600	609.6	24	0.04167	11	0.4583	138.89%
600	609.6	24	0.04167	12	0.5000	151.52%
600	609.6	24	0.04167	13	0.5416	164.14%
600	609.6	24	0.04167	14	0.5833	176.77%
600	609.6	24	0.04167	15	0.6250	189.39%

TABLE 46. Achievable Magnifications for Thermal Printed EAN/UPC Bar Codes after correction

***Note:** The nominal EAN/UPC Bar Code can be based on a module width of either 0.013 inch or 0.33 mm. In North America, the long-standing GS1 US specifications have set the nominal module size at 0.013 inch or 13 mils. GS1 specifications and the ISO/IEC specification for EAN/UPC Symbols set the nominal module size at 0.33 mm. The international, metric nominal is 0.0606 percent smaller than the original inch-based nominal. The data in the right-most column labelled "*Corrected Magnification" are based on a nominal module width of 0.33mm.

****Note:** The allowance of magnifications 75%-80% are applicable only to on demand print processes (for example thermal or laser).

10.10General Office Printers

General-purpose printing devices are capable of printing high quality bar codes when operated by experienced GS1 members equipped with a good bar code design software product. This category includes laser, desktop, ink jet, ion deposition, and mechanical matrix office printers. These devices are designed primarily for printing full size pages of text and graphics. However, they can be used to print retail tags by using pre-cut labels on page size backing paper. Some are also equipped with a continuous feed mechanism for producing bar codes in large quantities.

It is more difficult for the user to create high quality bar codes with general-purpose printers than it is with direct thermal transfer label printers. There are two reasons for this difficulty. First, the printed dot size for general-purpose printers is appreciably larger than the pixel dimension, as shown in Figure 59 below. This will cause the bars (dark bars) to be printed wider and the spaces (light bars) narrower than nominal, unless the software driving the printer corrects for this distortion. Second, the software that constructs the bar code may itself introduce dimensional errors.

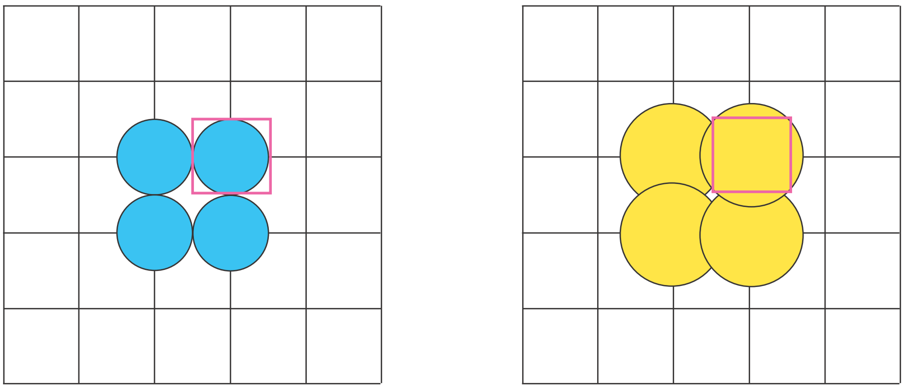


Figure 59 - Pixel-Sized Dot on the Left and Typical Size General-Purpose Printer Dot on the Right

Bar Code Design Considerations for General Purpose Printers

There are a wide variety of software packages for creating bar codes using general-purpose printers. Unfortunately, many of these packages are capable of producing bar codes with totally unacceptable quality. The following special factors should be considered when designing the bar code for general-purpose printers:

- Generate bar codes at a corrected magnification or an X-dimension which is supported by the resolution of the specified printer. For example, the closest bar width to 0.33mm a 300 DPI printer can achieve is 0.3333mm. This is because each bar width is constructed using four 300 DPI dots which individually measure 0.0833mm wide. Table 46 on page 117 lists the achievable EAN/UPC Bar Code magnifications (after correction) addressed by several different resolutions of general-purpose printers. EAN/UPC Bar Code magnifications other than those listed in this table will be printed inaccurately and may or may not achieve passing verifier grades.
- Specify one or more dots (pixels) of uniform bar width reduction to compensate for excessive bar width that is typical of general-purpose printers. For example, with a typical 300 DPI laser printer and four dots per module, best print quality is often achieved with one pixel (or dot) of bar width reduction.
- When a bar code graphic file is transferred between two parties, the printer resolution attribute should be communicated. If the printer resolution changes, the bar code file should be recreated. The bar code should be treated as a fixed design element. It should not be resized, rotated, scaled, or stretched.
- When the bar code graphic file is transferred between two parties, they should determine which bar code design attributes should be communicated. The following list should be considered as optional attributes which can be useful in assuring bar code quality:
    - printer resolution for bar width (strongly suggested)
    - "corrected magnification" factor
    - "corrected BWR" factor

These specifications should not be altered at any later stage within illustration or page layout software programs. These suggestions should provide you with quality bar codes when the output conditions match the design attributes. The most predictable results are obtained using software packages that drive the printer directly by low level software. Often, when bar code images are passed from one software application to another, the bar code may become distorted. These distorted bar codes may or may not achieve passing verifier grades.

Initial General-Purpose Printer Set-Up

Once you have the required software, hardware, and consumable materials in place, determine the bar code magnification and other parameters that you will be using to produce bar code labels or tags. Next, print two test EAN/UPC symbols in which all of the left and right hand digits are represented: for example, the following bar codes:

0 12345 01234 1

6 78912 56789 0

Verify both test EAN/UPC Bar Codes per the ISO (ANSI) method. It is desirable to achieve grade 3 (B) or better in this initial set-up. If one or both of the test bar codes are below grade 3 (B), you may be able to improve the quality by changing some of the software or printer variables. At the minimum, grade 1.5 (C) bar codes are acceptable, but they leave you with minimal margin for process variations and possible degradation from handling. In addition to verification, you should examine the test bar code for adequate Quiet Zones, bar height, and legibility of the human readable interpretation.

For small operations, the investment in a bar code verifier that conforms to the ISO (ANSI) method may not be justified. The alternative is to submit your test symbols to GS1 Australia for verification.

Finally, whenever any changes are made in software parameters, the initial set-up procedures should be repeated.

Maintaining Acceptable Quality

All printers require periodic maintenance. Laser printers, for example, not only consume toner, but also require periodic replacement of components such as drums, developers, fusers, and brushes. All of the consumable parts may be contained in a single replacement cartridge, or they may be separately installed, depending on the make and model of printer. Because bar code labels contain a higher percentage of black printing than occurs in ordinary text, fewer pages can be printed between maintenance intervals.

Printed bar codes should be checked visually for consistent appearance and verified whenever they appear doubtful. Bar code verification, whether conducted on-site or consulted, can be an effective tool for maintaining quality within a conscientiously applied program of quality assurance. Verification should be employed as a quality sampling technique, particularly after any supplies replacement or printer maintenance.

Reference DPI	Actual DPI	Dots Per Millimetre	Actual Dot Width (Centre Point to Centre Point)	Dots Per Module Width	X-dimension (module width)	*Corrected Magnification
300	304.8	12	0.0833	3	0.25000	**75.76%
300	304.8	12	0.0833	4	0.33333	100.01%
300	304.8	12	0.0833	5	0.41667	126.26%
300	304.8	12	0.0833	6	0.50000	151.52%
300	304.8	12	0.0833	7	0.58333	176.77%
300	300	11.812	0.0846	3	0.25387	76.96%
300	300	11.812	0.0846	4	0.33863	102.61%
300	300	11.812	0.0846	5	0.42329	128.27%
300	300	11.812	0.0846	6	0.50795	153.92%
300	300	11.812	0.0846	7	0.59261	179.58%

TABLE 47. General-Purpose Printer: Achievable Magnifications for EAN/UPC Bar Codes after correction

***Note:** The nominal EAN/UPC Bar Code can be based on a module width of either 0.013 inch or 0.33 mm. In North America, the long-standing UPC specifications have set the nominal module size at 0.013 inch or 13 mils. GS1 specifications and the ISO-IEC specification for EAN/UPC set the nominal module at 0.33 mm. The international, metric nominal is 0.0606 percent smaller than the original inch-based nominal. The data in the right-most column labelled "*Corrected Magnification" are based on a nominal module width of 0.33 mm.

****Note:** The allowance of magnifications 75%-80% is applicable only to on demand print processes (for example thermal or laser).