ID TECHNOLOGY®

Introduction to GS1 Barcodes

L&C
LABELING & CODING

Contents

In order to use barcodes as a reference number for retail products and in the international supply chain, it is important to have consistent standards - imagine the mess if every manufacturer had to produce different barcodes for Target, Wal-Mart, Kroger, etc.

GS1 is the global entity that sets standards for barcodes and data just about everywhere to keep supply chains working.

While we tend to think of GS1 in terms of barcodes, the whole GS1 concept is really built around the data - barcodes are just a convenient way of keeping the data where it needs to be and to provide a way it can be captured automatically, when needed - RFID is another way of carrying GS1 data.

Consequently, this isn't going to be a technical document about barcode structures - no x-dimensions, contrast, quiet zones (well, not much!)- we are going to discuss how GS1 data is encoded into barcodes for some industry applications and how those barcodes are used as part of a compliant labeling and marking system.

If you need help with your GS1 barcoding, or with any other aspect of your labeling and coding operations, please contact ID Technology. We'll be happy to help.

When it comes to barcoding for the GS1 system, the definitive source of information is GS1 itself. When implementing a GS1 compliant system, it is always wise to check everything against the actual specifications.

Starting Point - GTIN

GS1 standards provide a way to generate number that identify items. In some cases, this can be a group of items, in others individual items.

A good starting point, and fundamental to many GS1 applications is the Global Trade Item Number or GTIN.

The GTIN came about when Europe's EAN system and the US UPC merged some years ago. Here in North America we often continue to refer to a barcoded GTIN as a UPC code.

A GTIN is a number that is unique to a distinct type of item or SKU (Stock Keeping Unit) and is encoded in the familiar barcodes we see on items we buy in the store.

All the bottles of soft drink in the photo on the right would have the same GTIN - the diet version would have its own GTIN, as would other sizes or types.

The type of barcode most usually found on products such as these, that are sold at retail is the UPC-A, which has the data encoded in GTIN -12 format.

UPC-A (GTIN-12) Barcode

The UPC-A barcode is very familiar to anyone who ever shops in a retail store - it is the barcode printed onto just about everything we buy. There are four pieces of data encoded into the barcode, with a fixed length of 12 digits:

Indicator Digit (Number System Digit) - This is usually 0 in a base GTIN, but can also be used to be designate the level of packaging; 0 for individual item, 1 for inner case, 2 for shipping case, 3 for pallet etc. This digit can be set by the manufacturer of the product.

GS1 Company Prefix (Manufacturer's ID Number) - This is a unique ID number for the manufacturer that is provided by GS1. The GS1 Company Prefix varies in length - shorter ones (leaving more room in the data for item numbers) are considerably more expensive.

Item Reference (Item Number) - the part of the GTIN that is available to assign a unique number for each item (SKU) that the company sells. The number of possible items varies depending on the number of characters used by the GS1 Company Prefix.

Check Digit - an algorithm digit to check for data input errors. GS1 has a nifty check digit calculator on their website that might be helpful. When designing barcodes in label software, the software can calculate check digits as well.

GTIN Compliance Rules

GS1 provides some good information in their "Introduction to the Global Trade Item Number" which you can download here. I'm going to summarize just a few of the key points.

Type of GTIN	GTIN Digit													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GTIN-8	0	0	0	0	0	0	N	N	N	N	N	N	N	C
GTIN-12	0	0	N	N	N	N	N	N	N	N	N	N	N	C
GTIN-13	0	N	N	N	N	N	N	N	N	N	N	N	N	C
GTIN-14	N	N	N	N	N	N	N	N	N	N	N	N	N	C

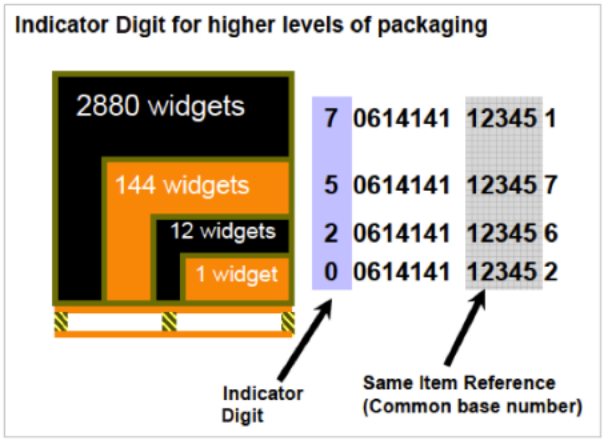
The Four GTIN Structures

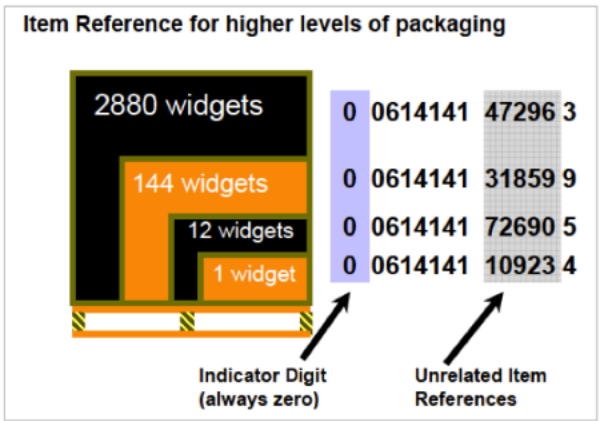
Depending on your application (and country), your GTIN might be 8, 12, 13 or 14 digits long. GS1 recommends (well, insists in many cases) that when used in software applications, the GTIN always be represented by 14 digits. Any GTIN can be converted to the full 14 digits by right justifying and padding on the left with zeros.

Each Item and Level of Packaging Needs a Unique GTIN

While it is intuitive that every item a company sells should have it's own unique GTIN, GS1 compliance also requires a unique GTIN be assigned for each level of packaging that might be tracked through the supply chain.

There are two ways this can be achieved (well, actually, 3 because a combination approach is allowed as well), as shown in the example on the right. This shows a widget that is packed 12 to a carton, 12 cartons to a shipping case and 20 shipping cases to a pallet. Each widget, carton, case and pallet needs its own unique GTIN.





Managing Packaging Hierarchy Within GTIN

As the example shows, it is possible to keep the same Item Reference Number and use the Indicator Digit for the packaging level (1-8 are available for this), or to keep the Indicator Digit at zero and add a new Item Reference Number for each level.

GS1 doesn't care, as long as the goal for a unique GTIN for each packaging level is achieved.

Indicator Digit Rules

Keep the Indicator Digit as Zero Unless Using in a Packaging Hierarchy

Always use zero for the Indicator digit for a mixed case. If (for example, a case consists of two items, that each has an assigned GTIN, the case needs to have its own GTIN-14, with a new Item Reference Number)

Indicator Digit 9. While 0-8 can be used for levels of packaging, Indicator Digit 9 is reserved for items that vary in weight or size. Items at a supermarket such as meats where the UPC barcode is printed at the counter are a good example.

GTIN Labels for Cases - ITF-14

When a GTIN needs to be labeled onto a shipping case, GS1 allows the use of the Interleaved 2 of 5 (ITF-14) barcode.

In the GS1 System, this barcode is only use to encode a GTIN and is always 14 digits.

The other GTIN structures; GTIN-8, GTIN-12 and GTIN-13 can be encoded by right justifying and padding on the left with zeros to make up the 14 digits.

ITF-14, being a relatively low density barcode can be printed on a wide range of printers, including inkjet, laser and low resolution thermal transfer printers.

When specifying printing equipment for ITF-14 applications, it might be useful to assume that higher density barcodes, such as Code 128, might need to be printed in the future and should be considered in the purchasing process.

Type of GTIN	GTIN Digit													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GTIN-8	0	0	0	0	0	0	N	N	N	N	N	N	N	C
GTIN-12	0	0	N	N	N	N	N	N	N	N	N	N	N	C
GTIN-13	0	N	N	N	N	N	N	N	N	N	N	N	N	C
GTIN-14	N	N	N	N	N	N	N	N	N	N	N	N	N	C

The Four GTIN Structures

ITF-14 barcode symbol

Printing GTIN ITF-14 barcodes using a FoxJet system from ID Technology

Adding More Data - GS1 128

Printing & Applying Produce Traceability Initiative (PTI) Labels with GS1 128 Barcodes - ID Technology

GS1 128 Barcode

Code 128 is a well proven barcode for encoding data in alpha-numeric format (it gets its name from the fact it can encode the 128 characters in the ASCII character set) and it is often used within the GS1 system.

GS1's encoding of the 128 barcode was developed in conjunction with AIM (Association for Automatic Identification and Mobility) and is a subset of the general Code 128.

A GS1 128 barcode always starts with the Function 1 Symbol Character (FCN1) - a non printable character that alerts the barcode scanner that it is being presented with a GS1 version of the barcode.

The barcode on the right is a typical GS1 128 barcode, encoded with GTIN and Lot Number. Note that (01) is the Application Identifier for GTIN and (10) the Application Identifier for Batch/Lot Number.

After I designed my GS1 128 using my BarTender label software, I scanned it a couple of times with a scanning app on my phone (yes, I have access to a lot of commercial scanners and nearly always use my phone) and here are the results.

The top result is the default scan - it is correctly identified as GS1 128 and the data is displayed correctly. (the parentheses and spaces in the barcode human readable are just for ease of reading - they are not encoded in the barcode. The FNC1 symbol can't be printed so doesn't show on my phone).

The second scan was with GS1 data parsing enabled. This lets me see that my data is all correctly encoded into the barcode.

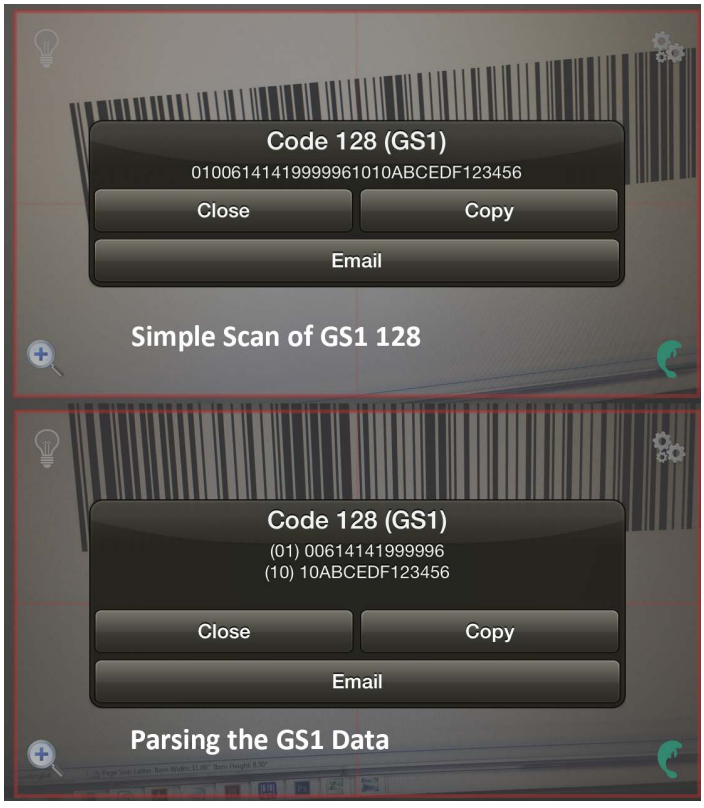
The GTIN concept has proven to be an excellent global standard for identifying SKU and other items, but does have its limitations.

It isn't able to identify an individual shipping case, a unique medical device, a range of items made with the same lot number, a single unique pallet.

To get to this enhanced level of detail, often needed for compliance and traceability reasons, more data needs to be added to the barcode.

To achieve this, GS1 uses Application Identifiers (AIs) to identify the various pieces of information that can be embedded in a GS1 barcode.

GS1 128 Barcode with GTIN and Lot Number Encoded



Barcode Scanner Output - normal on top, parsed at bottom

GS1 Application Identifiers

As we saw on the previous page, the GS1 system uses Application Identifiers to identify the data fields (GS1 calls them Element Strings) encoded within the barcode.

There are an awful lot of these AIs, but the most common are listed in the table below, along with how their data (Element String) is structured:

Common Application Identifiers

AI	Data Content	Format (*)	FNC1 Required (****)	Data Title
00	Serial Shipping Container Code (SSCC)	N2+N18		SSCC
01	Global Trade Item Number (GTIN)	N2+N14		GTIN
02	GTIN of Contained Trade Items	N2+N14		CONTENT
10	Batch or Lot Number	N2+X..20	(FNC1)	BATCH/LOT
11 (**)	Production Date (YYMMDD)	N2+N6		PROD DATE
12 (**)	Due Date (YYMMDD)	N2+N6		DUE DATE
13 (**)	Packaging Date (YYMMDD)	N2+N6		PACK DATE
15 (**)	Best Before Date (YYMMDD)	N2+N6		BEST BEFORE or BEST BY
16 (**)	Sell By Date (YYMMDD)	N2+N6		SELL BY
17 (**)	Expiration Date (YYMMDD)	N2+N6		USE BY OR EXPIRY
20	Variant Number	N2+N2		VARIANT
21	Serial Number	N2+X..20	(FNC1)	SERIAL

Notes:

(*) The first position indicated the number of digits in the GS1 Application Identifier (all 2 in this table). The following value is the format of the data content, using these conventions:

N	numeric digit
X	any character (well, most, anyway)
N14	14 numeric digits, fixed length
N..6	up to 6 numeric digits
X..20	up to 20 characters

(**) If the date consists of only a year and month, DD should be filled as two zeros

(****) These Application Identifiers are for Element Strings of variable length, which (unless this is the last Element String encoded in the barcode) need to be delimited with a FNC1 symbol to separate the data from the follow AI.

Best Practice for the Order of AIs

7) **Application Identifier Positioning:** When creating a GS1-128 barcode, best practice is to order the Application Identifiers (AIs) in the following order: First is the GS1 Identifier, GTIN AI (01), next include any fixed length Application Identifiers, such as the Pack Date AI (13) or Sell-By Date AI (15), then last is the variable length fields, such as the Batch/Lot Number, AI (10) or Serial Number, AI (21). These AIs are used as examples and following the best practice can help ensure proper barcode encoding. Please note the Function Code 1 (FNC1) character is also used to separate multiple variable length AIs and must be encoded within the barcode. Therefore, if you chose to encode a Batch/Lot Number ***AND*** a Serial Number, the Function Code 1 is needed to separate the two. This is needed for all Variable length AIs.

Much more information on Application Identifiers and their associated Element Strings is to be found in Section 3 of the GS1 General Specification

Logistics Units - SSCC

A Logistics Unit is an item that is shipped through the supply chain. This includes pallets, cases, skids and just about anything else.

In the GS1 system (and a lot of EDI systems), the data used for tracking logistics units is the SSCC (Serial Shipping Container Code)

The SSCC is a license plate for the logistics unit and is encoded as a GS1 128 barcode using AI (00).

The SSCC consists of the 2 digit AI, plus 18 additional numeric characters as follows:

(00)	SSCC Application Identifier
N_1	Extension Digit
N_2 - N_{17}	GS1 Company Prefix + unique serial number
N_{18}	check digit

Note, that because GS1 Company Prefix's have variable numbers of digits, the total number of serial numbers available is not the same for every organization.

When the available serial numbers have been used, it is permitted to increment the Extension Digit to the next number in order to start with a new set of serial numbers.

When sending shipments to trading partners, the SSCC number is usually part of the Advance Ship Notice (ASN) that is sent electronically to the recipient.

For Limited Space - GS1 DataMatrix

A lot of applications for GS1 labeling involve products that are too small to use a GS1 128 barcode.

Examples of these would include many medical devices, pharmaceutical products and small electronics items.

GS1's solution to this has been to develop a GS1 version of the industrial DataMatrix code.

GS1 DataMatrix can use the usual set of Application Identifiers and Element Strings and is encoded in the same way as GS1 128, FNC1 symbol is encoded at the beginning of the data and also be used as a group separator for variable length Element Strings.

GS1 DataMatrix also encode the same character set as GS1 128.

To produce a compliant GS1 DataMatrix, the barcode needs to meet the ISO/IEC 16022 specification. Only the ECC 200 version of DataMatrix (which uses Reed-Solomon error correction) is permitted for GS1 applications.

DataMatrix barcodes can be produced by many methods, including thermal printing on labels, flexo printing, inkjet, chemical etch, laser marking.

GS1 DataMatrix Code

GS1 DataMatrix barcode as part of an FDA UDI mark for medical devices

Laser - Direct Part Laser Marking

Citronix Continuous Inkjet Coding

Durable Thermal Transfer Labels

Thank You!

Thank you for taking the time to check out our GS1 Introduction.

If you need more detailed information on any aspect of the GS1 System, the GS1 US website is a great place to start.

GS1 has a lot of valuable reference material, including the GS1 General Specifications document, which is a great resource for just about anything related to GS1 data and barcodes.

Here at ID Technology, we have helped hundreds of companies to become compliant with many standards, such as Produce Traceability Initiative, FDA UDI labeling, pharmaceutical traceability, SSCC labeling. We've also completed many projects to help our clients meet customer mandates, such as the Department of Defense standards.

New! Wipe-on Labeling System for GS1 Labels

Digital Overprinter for Flexible Packaging

Please be sure to contact ID Technology if you need help with any aspect of your GS1 labeling applications.

With sales and service coverage throughout North America, as well as six label manufacturing plants, ID Technology is the national company that can help you right in your area.

Contact us today to get started!

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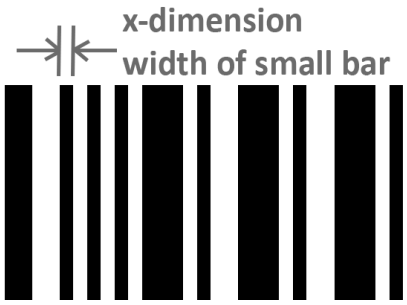
Appendix 1 - Barcode Sizes

Yes, I do remember that I said I wouldn't discuss technical barcode specs. However, thinking about this, there is not much point in the correct data for the barcode if you can't print it the correct size.

When talking about the size of a barcode, a key factor is the X-dimension. On a linear barcode (UPC-A, GS1 128) this is defined as the width of the small bar in thousandths of an inch (mils).



In the GS1 General Specification, minimum and maximum allowable x-dimensions are noted for a number of different applications.

Barcode Symbol Sizes - for General Distribution

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	
EAN-13	0.495 (0.0195")	0.660 (0.0260")	0.660 (0.0260")	34.28 (1.350")	45.70 (1.800")	45.70 (1.800")	11*X*	7*X*	1.5/10/660
EAN-8	0.495 (0.0195")	0.660 (0.0260")	0.660 (0.0260")	27.35 (1.077")	36.46 (1.435")	36.46 (1.435")	7*X*	7*X*	1.5/10/660
UPC-A	0.495 (0.0195")	0.660 (0.0260")	0.660 (0.0260")	34.28 (1.350")	45.70 (1.800")	45.70 (1.800")	9*X*	9*X*	1.5/10/660
UPC-E	0.495 (0.0195")	0.660 (0.0260")	0.660 (0.0260")	34.28 (1.350")	45.70 (1.800")	45.70 (1.800")	9*X*	7*X*	1.5/10/660
ITF-14	0.495 (0.0195")	0.495 (0.0195")	1.016 (0.0400")	31.75 (1.250")	31.75 (1.250")	31.75 (1.250")	10*X*	10*X*	1.5/10/660
GS1-128	0.495 (0.0195")	0.495 (0.0195")	1.016 (0.0400")	31.75 (1.250")	31.75 (1.250")	31.75 (1.250")	10*X*	10*X*	1.5/10/660

Notes:

(*) UPC-E & EAN-8 Symbols are intended for use on small packages only. Wherever there is space, UPC-A, EAN-13, ITF-14 or GS1 128 should be used.

(**) For general distribution scanning, the minimum symbol height is always 1.250 inches. This is the bar heights only and does not include the bearer bars on ITF-14 or the human readable text.

(***) See Appendix II for more information on quality standards and verification

Quiet Zone is the area at either end of the symbol that is clear of any other print.

When printing barcodes on a thermal printer, the barcode x-dimension sizes that can be printed, depend on the printer resolution (using multiples of adjacent dots (pixels) on the printhead. This table shows the possibilities:

Barcode X-Dimensions
Thermal Printers

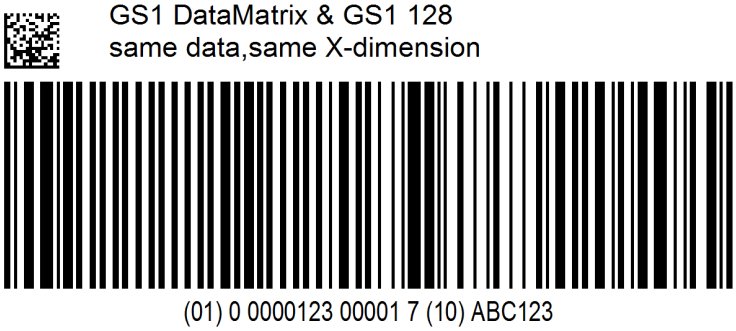
Printer	203 dpi	300 dpi	406 dpi	600 dpi
Dots -1	0.00493	0.00333	0.00246	0.00167
2	0.00985	0.00667	0.00493	0.00333
3	0.01478	0.01000	0.00739	0.00500
4	0.01970	0.01333	0.00985	0.00667
5	0.02463	0.01667	0.01232	0.00833

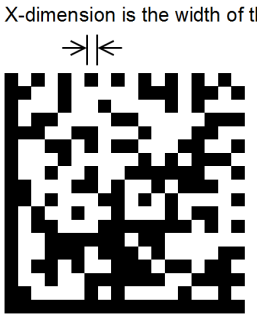
For more information, check out this Labeling News Article.

2D DataMatrix Barcodes

The GS1 DataMatrix barcode brings the GS1 system to smaller items.

As this comparison shows, for the same X-dimension, the GS1 DataMatrix takes up a lot less space than the linear GS1 128.





Barcode Sizes GS1 DataMatrix - General Distribution Applications

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	Surrounding Symbol	
GS1 DataMatrix (ECC 200) (*)	0.396 (0.0150")	0.495 (0.0195")	0.743 (0.0293")	Height is determined by X-dimension for Data that is encoded			1X on all four sides	1.5/12/660

Appendix 2 - Validation vs. Verification

So you've designed your barcode and printed it, how do you know it is correct and that it will scan every time?

To determine this, the techniques of Validation and Verification can be applied.

Validation or Verification?

VALIDATION is like "spelling"	VERIFICATION is like "penmanship"
Is the Content correct, data correct and in an acceptable structure?	Are the individual bars, cells and the symbol formed correctly? Size, shape, contrast, distortion, consistency
"Syntax rules based"	"Standards Rules Based"
Does the barcode scan? Is the data encoded using the correct syntax to meet the appropriate GS1 Specification?	Verification ensures that a barcode complies with published barcode quality standards, such as ISO 15415, ISO 15416, and AIM DPM.

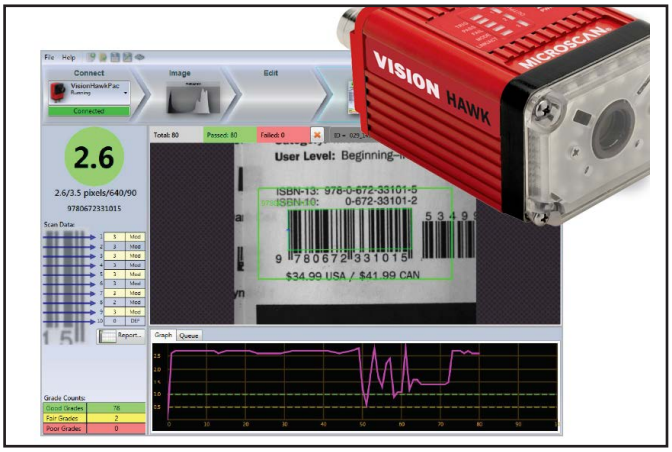
Validation of a barcode can be carried out using a number of barcode devices - even n app on a mobile phone.

Validating the barcode ensures that:

It can be read by that particular device
The data has been encoded correctly to the required GS1 (or other) specification
The encoded data is correct - this might be checked manually by inspecting the barcode data or automatically by comparing the scanned data against a database.

Validation of barcodes can be carried out in real-time by mounting a suitable scanner right after the labeling equipment. Modern industrial scanners can also carry our a level of quality check - although not true verification.

RJS Mobile Verifier



Microscan on-line Vision Based Verifier System

Barcode verification, checks the quality of the printed barcode against the appropriate ISO or ANSI specification.

Verification is the only way to ensure that a printed code meets the quality requirements and to make sure if will successfully scan with any compliant barcode scanner.

Verification systems are available in both off-line and on-line versions, depending on your needs.

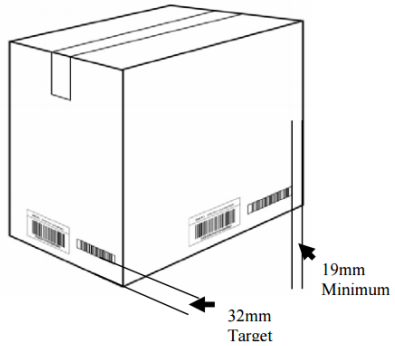
Please contact ID Technology if you need help with any barcode validation or verification issues.

Appendix 3 - Barcode Location

Where should the barcode be positioned when labeling shipping cases and pallets - can we just put the barcodes anywhere? Obviously not - in many applications the barcodes are scanned by fixed mount industrial scanners, so consistency of placement is important.

GS1 is quite clear on this, here is the information straight from the General Specification:

Figure 6.7.1.2-1. Symbol placement on cartons and outer cases



GS1 barcode location for cases and cartons

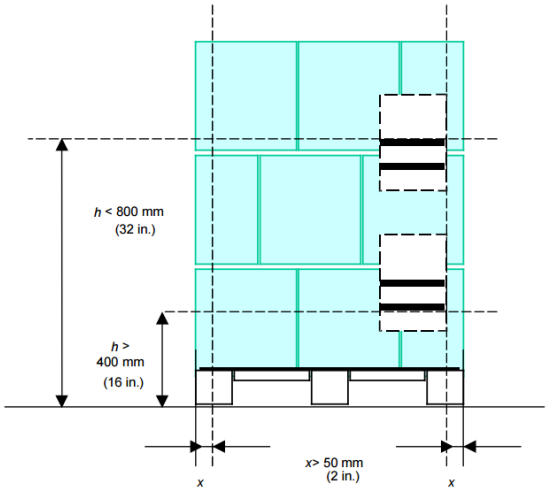
Cartons and Cases
The barcode symbol should be located 32 mm (1.25 inches) from the base of the item. In addition, the barcode symbol (including its quiet zone) needs to be at least 19 mm (0.75 inches) from any vertical edge.

Pallets
The GS1 specification asks for barcodes on pallets to be placed between 400 mm (16 inches) and 800 mm (32 inches) from the base of the pallet. The bacodes need to be 50 mm (2 inches) from any vertical edge.

If a pallet is less than 400 mm (16 inches) in height, the barcode must be positioned as high as possible on the pallet.

Number of Barcodes
GS1 recommends that for best results, barcodes are placed on two (at a minimum) sides of the carton or pallet. This ensures that at least one barcode should be visible during handing and storage.

Figure 6.7.1.1-1. Symbol placement on pallets



GS1 barcode location for pallets

Shipping cases with GS1 compliant barcode labels

Appendix 4 - Print Technology

GS1 barcodes are used extensively for identifying shipping cases and trays.

There are four main technologies used for printing the barcodes:

Pre-printed barcodes- usually printed using flexographic techniques.

Labels- either pre-printed, or printed at the time of application to the product.

High-resolution inkjet printers, such as Foxjet's Pro-Series

Laser marking- this usually needs the application of a laser receptive ink patch (such as Reveel from International Paper to produce sufficient print contrast.

What does GS1 say?

The folks at GS1 want you to be able to produce high quality barcodes that can be verified against the ISO/ANSI standard. In general GS1 doesn't comment on print technology and leaves the choice to the user.

Having said that, a recent GS1 document on the use of GS1 128 barcodes makes this suggestion:

2) **Direct Print on Corrugate**: Printing a GS1-128 barcode directly on craft (brown corrugate) does not deliver the same performance as an ITF-14 barcode. There are different print quality grades differentiating between the GS1-128 and ITF-14, therefore a GS1-128 may not scan accurately if directly printed on this type of corrugate. Please see Best Practices on Barcode Printing Directly on Corrugate Cases in the "Tools and Resources" section of this document.

You can download the GS1 document here: http://djh.cc/GS1-CaseBarcodes

As you can see, the suggestion is that while printing directly to corrugate material is fine for the low density ITF-14 barcode, it is not recommended to use direct print techniques (laser, inkjet, flexo) when barcoding brown corrugate.

This is essentially due to the lower print contrast when printing on a dark background. We wrote more on this topic here: http://www.labelingnews.com/2016/05/the-best-barcode-quality/