GS1 US

The Global Language of Business

Developing an RFID or 2D Barcode Serialization Plan

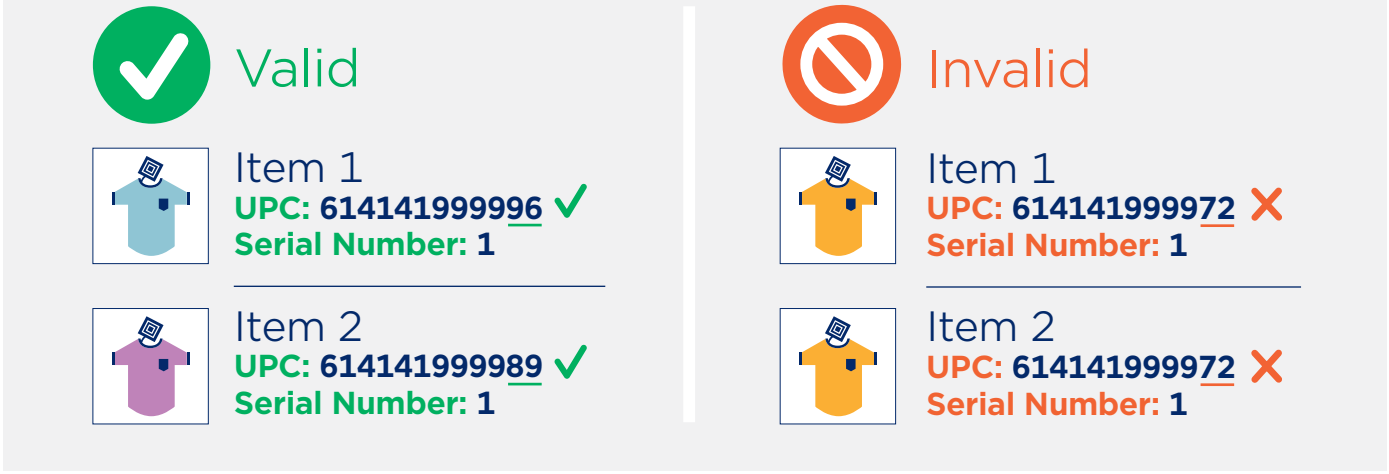
Item serialization allows you to trace individual products as they move through the supply chain and into the hands of the customer. As you ramp up your **2D barcode and/or Radio Frequency Identification (RFID)** tagging solution, you are faced with the decision of how to go about serializing the data encoded in the tags. This document outlines common serialization solution approaches and highlights key points to keep in mind.

You'll want to:

- Understand what serialization model(s) is/are being used, regardless of approach
- Ensure that a number range is explicitly excluded and reserved for future use
- Ensure that a number range is assigned for potential trading partners or customers to leverage (e.g., for in-store tagging)
- Understand any specific serialization requirements expressed by any of your customers or partners

The commonly used RFID **SGTIN-96** encoding scheme uses 38 bits to encode the serial number. That is two to the 38th power, or over 274 billion possible values! There is plenty of capacity to handle one or many serialization models.

Serialization Occurs at the Product (GTIN/UPC) Level



Note: Capturing a record of what serial numbers have been encoded is recommended, even if you do not anticipate leveraging this data in the initial phases of your project. It is helpful to know what tag was encoded on what media at what location and at what time.

Serialization Model Considerations

There are various serialization models your company can choose from when setting out on developing a serialization plan.

1. Service Bureaus

Pre-printed and pre-encoded hangtags or labels are provided by a third party that also manages serialization. Production of these tags is spread across a network of countries to optimize delivery times and lower costs.

Do you presently receive hangtags or labels (with pre-printed product data including the **Universal Product Code (UPC*)** from a third-party provider? If so, you may find that the provider can add an RFID inlay to the existing hangtags or labels. This leverages the fact that the product **Global Trade Item Number® (GTIN®)**/UPC data is already known when these products are printed and there is an existing process to properly match them with the right product in the factory.

In this case, you would rely on the service bureau (the party providing the tags) to manage the serialization of the tags. Note that you will want the service bureau to provide clear documentation regarding their serialization model, and you will want to ensure that a significant range of serial numbers is reserved for future use.

2. Centralized/IT-Based Serialization

A central solution assigns serial number values in blocks and is able to record details related to encoding.

A centralized solution assigns serial numbers or blocks of serial numbers to in-factory devices or applications. It offers the ability to capture live encoding data that could be used as a measure of factory production activity and progress-to-plan. It could also be helpful when tracking the manufacture and provenance of high-value items. It can assign serial values while tracking characteristics such as media type, label data, encoder, location, date/time, etc. If integrating with a **manufacturing execution system (MES)**, then additional transactional data can be associated with the encoded **electronic product code (EPC®).**

A centralized solution may be preferable to a distributed solution if the factory and supply chain network are notably large and therefore have a substantial number of factories and encoding devices to manage. It also may be helpful in researching or identifying counterfeit goods.

A centralized solution does require network connectivity. Is there reliable networking connectivity to all of your factory sites? If not, then a centralized solution would need to be supplemented with an on-site solution that would receive serial number blocks and would synchronize data whenever network connectivity is restored. One way of evaluating this is to see if there are any business-critical systems in the factory that require **wide area network (WAN)** connectivity.

*In this publication, the letters "UPC" are used solely as an abbreviation for the "Universal Product Code," which is a product identification system. They do not refer to the UPC, which is a federally registered certification mark of the International Association of Plumbing and Mechanical Officials (IAPMO) to certify compliance with a Uniform Plumbing Code as authorized by IAPMO.

3. Distributed Serialization

This model establishes a hierarchy of number ranges by site and device. Encoding data may or may not be captured and aggregated.

This model assigns serial number ranges or prefixes to different sites and different subranges to various encoding devices at each site. For example:

Site	Device	Serial Section
Plant 1	Device 1	101001...
Plant 1	Device 2	101002...
Plant 2	Device 1	102001...
Plant 2	Device 2	102002...
Plant 2	Device 3	102003...

Serialization parameters may be set via device configuration, network settings, or a centralized management system. Serial numbers may be incremented sequentially regardless of GTIN/UPC, which offers some degree of randomization.

Distributed solutions do not require network connectivity to work. Printer or application logs may potentially be pushed to a centralized corporate tracking system if and when network connectivity is available. The resulting structure of a population of RFID tags allows evaluation of tag data to potentially gain insights into sourcing (e.g., this tag came from Plant 1, Device 1).

4. Chip-Based Serialization

This leverages the unique Transponder ID (TID) to create a serial number.

This is a form of distributed serialization that leverages the **TID**. The TID identifies the microchip, not the product that the tag is attached to. The manufacturer of the microchip provides an algorithm for compressing the TID into an SGTIN-96 serial number value, which the encoding software implements. The chip manufacturer-recommended algorithm should be leveraged, and a best practice (as with other approaches) is to reserve a number range that is excluded from the possible values encoded. The resulting serial numbers will likely appear completely random and not have the location-device hierarchy order outlined in the prior model.

Bring It Together in a Top-Level Plan

The most important thing for brand owners to do once armed with all of the facts is to create a top-level plan to define what serialization approaches are to be used. A good top-level plan clearly specifies what approach is to be used, drawing from the variety of approaches discussed in this guideline. In constructing a top-level plan, the brand owner should gather the following information:

- What products are to be serialized? What are their GTINs?
- Where will serialization take place? Will it be in the brand owner's own manufacturing facility, in third parties contracted by the brand owner (contract manufacturers, service bureaus, etc.), or by other supply chain parties?
- How many different internal facilities and/or third parties will be used?
- What IT capabilities are available, or can be made available, to manage serialization?
- How are the answers to the above expected to change over time?
- Note that proper tag encoding requires knowing the GS1 Company Prefix length. Contact GS1 US® or a Solution Partner for assistance.

These questions will help you select among the various approaches outlined earlier. You may conclude from analyzing the available approaches and your company's requirements that more than one approach needs to be supported.

Serialization Quality Best Practices

Practical guidance for anyone managing product serialization

The importance of unique serialization

Item-level serialization is critical to inventory counting operations. Without unique GTIN + Serial combinations as illustrated on page 2, RFID or 2D barcode counting systems will potentially under-represent inventory. Supply chain use cases that depend on unique serialization include claims compliance, grey market tracking, organized retail crime detection, and product authenticity.

The growth of 2D barcode use on products further illustrates this. Absent quality controls for serialization, consumer-facing experiences may be compromised, be it from returns management to direct consumer engagement via GS1 Digital Link. An increase in the number of product-embedded 2D and RFID tags further magnifies the need for unique serialization that will span the life of the product. It is imperative that serialized values be unique, meaning there is no duplication of the GTIN + Serial combination.

Serialization and core systems

RFID technology can read many thousands of tags per minute with precision. This is enabled, in part, by the unique serialization encoded in each RFID tag. Early deployments of the technology sought to reconcile vast amounts of item-specific data with legacy systems that store product-specific data. The result was an entry-level approach that discarded

the rich serialization data to group item counts at a product level for legacy inventory systems to track.

The advent of 2D barcodes on products provides additional barcode data capacity, enabling the advantages of serialization to be extended well beyond the domain of RFID technology. The Sunrise 2027 initiative advances the use of 2D barcodes for point-of-sale. As a result, serialization use cases are being incorporated into core systems and provide advantages across the supply chain. Such advances allow for movement from the above-mentioned entry-level approach to an advanced approach that incorporates RFID and 2D serialization into a robust set of new use cases that rely on unique serialization.

Key insights for deployment

Products are increasingly likely to have more than one data carrier (such as a RAIN RFID tag, NFC tag, or 2D barcode). It is important to ensure that the data encoded in the various data carriers be aligned with the same item identification. The 2D barcode is read by the factory worker scanning items into a carton for shipment and the consumer at checkout alike, with the same data captured via RFID in between these endpoints. Trade partners can leverage the Electronic Code Product Services (EPCIS) event visibility standard to share serialized data and address several visibility opportunities. As such it is helpful to note the structural limitations of the commonly used SGTIN-96 encoding scheme, which is a numeric value (no leading zeros) less than the 38-bit capacity of 274 billion. Encoding an alpha-numeric serial number or encoding a numeric value with leading zeros into another data carrier would preclude use of the SGTIN-96 encoding scheme.

Chip-based serialization requires a read of the tag TID value, which may not be a preferred approach for high-speed encoding operations. If not using chip-based serialization, the need to ensure unique serialization requires a record of previously encoded values to ensure prior encodings are not duplicated. This can be as simple as a single "last used" value if encoding in an ascending or descending numerical order.

Here are a few common errors to avoid:

- Avoid inserting logic into serialization values (such as inserting a PO or job number), as that may inadvertently produce duplicate values if production runs are repeated.
- Tag quality control processes may occasionally remove a small number of encoded tags for destructive testing purposes. In such cases, care is needed to ensure any reprinted values do not overlap with prior encoded values.
- Where a product identifier may be created at multiple locations, coordination is required to ensure multiple locations are not duplicating serialized values.
- Brand owners should expect the inclusion of service-bureau-consumed serialization data to be communicated as a part of regular business communications. This documentation is helpful to audit service bureau compliance, inform root-cause-analysis, and enable the onboarding of additional service bureaus if needed.

Components of a healthy serialization solution

A healthy serialization solution incorporates the following across the various stakeholders:

Service Bureau	Brand Owner	Retailer
• Ensure quality controls are implemented to prevent duplicate values • Share encoding approach with brand owner • Document consumed serialization ranges and share with brand owner • Work with brand to ensure alignment with any other entities encoding the same GTINs	• Retain service bureau documentation detailing quality controls and encoding approach • Ensure processes are in place to receive serialization range data from service bureaus • Periodically review reported values to ensure non-overlapping values • Incorporate a basic automated data capture mechanism in distribution center areas to generally corroborate range consumption data and non-duplication	• Leverage data collected by various existing data capture processes to detect duplicate serialization • Ensure an open line of communication with brand owners to highlight duplicate serial values and include EPC data to be used for root-cause analysis • Communicate expectations in vendor playbook and hold suppliers accountable for duplicate serialization

Binary Value	Decimal (base 10)	Hexadecimal (base 16)
00011000010100000001110001110110100101 00	104423257748	18501C7694
00100010001101110001110001110110100101 00	146953500308	22371C7694
00110010100010010100110001110110100101 00	217051854484	32894C7694
01110111000100000000110001110110100101 00	511370360468	77100C7694

The binary value encoded into an RFID tag may be rendered in various formats such as decimal and hexadecimal. It is helpful to understand the format when performing root-cause analysis. For example, evaluating the following duplicate serial values may not be helpful when rendering in decimal format, but when rendering in hexadecimal format a pattern is clearly seen.

You Don't Have To Do This On Your Own—We're Here To Help

Solution Partner for the Retail Sector ›

If you're deploying serialized data carriers at the item-level, be it RFID or 2D barcodes, and need labels, software, hardware, or consulting services, a GS1 US Solution Partner will work with you every step of the way.

GS1 US Advisory Services ›

With a special mix of industry, technology, and standards expertise, we can provide a tailored RFID and 2D education and implementation program that is consistent with your company's specific needs.

RFID Serialization Management Guideline

To learn more about RFID serialization management, check out the GS1 US Guideline—EPC-enabled RFID Serialization Management for SGTIN-96 ›

This Guideline explains how brand owners can manage the assignment of unique serial numbers to their products. In particular, it offers several strategies that can be used when brand owners have to delegate the assignment of serial numbers to multiple parties, either internal divisions or manufacturing plants or external parties such as contract manufacturers and service bureaus.

The Guideline discusses managing serialization for 96-bit RFID tags and describes options and methods for assigning globally unique identification to individual instances of trade items using a GTIN plus a unique serial number.

- This combination is commonly referred to as a Serialized Global Trade Item Number, or SGTIN. Assigning a unique SGTIN to every instance of a trade item means that two otherwise identical units of the same product have distinct SGTINs.
- A product instance identified by an SGTIN is said to be serialized, and the process of assigning a unique SGTIN to a product and affixing a tag bearing that SGTIN in machine-readable form is called serialization.

Even if you decide to outsource serialization to a third party, the Guideline will help you understand the approaches your third-party solution provider partner may use. And it will provide you with the proper context and questions to ask of any potential vendor.

Glossary

2D Barcode: A matrix symbology that encodes information in both horizontal and vertical dimensions.

Electronic Product Code (EPC): An EPC combines a GTIN with a unique serial number to identify individual products. Used with Radio Frequency Identification (RFID) tagging, it allows you to precisely trace individual products as they move through the supply chain.

Global Trade Item Number (GTIN): A GTIN is the number you see underneath the UPC barcode symbol—and it's the same number that's encoded in the lines and spaces that the scanner reads. GTINs uniquely identify products.

Manufacturing Execution System (MES): An MES sequences, schedules, and tracks the process steps used to transform raw materials or assemblies into finished products.

Radio Frequency Identification (RFID): RFID is a wireless technology that enables product identity to be detected using an interrogator that is near a product. The RFID tag is often part of product packaging, primarily embedded in the price tag.

Serialized Global Trade Item Number (SGTIN): An SGTIN is used to uniquely identify individual instances of a product by combining a GTIN and a unique serial number.

Universal Product Code (UPC): A UPC is the barcode that uniquely identifies a product for retail checkout. It encodes the Global Trade Item Number. In this publication, the letters "UPC" are used solely as an abbreviation for the "Universal Product Code," which is a product identification system. They do not refer to the UPC, which is a federally registered certification mark of the International Association of Plumbing and Mechanical Officials (IAPMO) to certify compliance with a Uniform Plumbing Code as authorized by IAPMO.

Transponder ID (TID): A TID is a unique number that identifies the microchip embedded in the RFID tag. It is set at the time the microchip is created and cannot be changed. This should not be confused with the SGTIN serial number, which uniquely identifies the product that the tag is attached to.

Wide Area Network (WAN): A WAN connects IP-addressable devices across a large geographical area.

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