Track & Trace in Agrochemicals
CRISTAL Standards for Marking in Europe

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1 The Argument for Agrochemical Traceability

From the first moment that primitive man noticed he could bury tiny things in the ground and wait for them to turn into larger things which he could eat, technology has played an important role in agriculture. That technology has not only contributed to advances in easier and more efficient ways to plant and raise crops, but also in advances to the protection of those crops from the various creatures who enjoy eating them without permission.

Of course, it is easy to build a fence to keep larger animals out – and even smaller animals, with finer mesh fences and the like – but insects tend to be too small to fence out. The solution, once discovered, seemed obvious: spray down plants with chemicals designed to keep insects away, usually because any insects in the area are now dead. The development of pesticides made it possible to drastically reduce the amount of a given crop lost to infestation by insects, but unfortunately, the effects of pesticides were not fully understood until much later. The negative impact that early pesticides had on the environment, once finally acknowledged, caused governments to step in and ban them.

The agrochemical industry was, fortunately, able to develop alternative pesticides which were not disastrously harmful to the environment. The problem that remained, of course, was that these new pesticides were sometimes more expensive, and not always quite as effective as the old pesticides, most likely because they were created with less of a "kill everything and let Demeter, goddess of the harvest, sort it out" mentality. Sensing the opportunity to make money, a thriving criminal enterprise of producing counterfeit or illegal pesticides sprang up, making it difficult for growers to know they had, in fact, purchased legitimate goods that would both work without causing potentially catastrophic environmental damage and not get them arrested or fined.

In other words, a system was required to ensure the authenticity (and legality) of chemical pesticides sold. Proper traceability implementation would not only ensure product authenticity, it would also naturally lead to better supply chain visibility; this would have the side-effect of protecting against grey market imports. In order to implement traceability that would work well, there needed to be a standard for manufacturers to adhere to. In Europe, the European Crop Protection Agency (ECPA) published a series of standards aimed at increasing traceability across the supply chain which is known as CRISTAL.

1.1 What is CRISTAL?

CRISTAL stands for Communicating Reliable Information and Standards to Agriculture and Logistics. It started as an initiative with the stated goal of establishing a communications framework for the European agrochemical industry, but the latest edition of the standards make it clear that CRISTAL can be applied to any agribusiness supply chain. By doing so, CRISTAL hopes to achieve complete supply chain visibility in order to allow easy electronic commerce, i.e. buying and selling agrochemicals and other agricultural products through internet-based stores. An added benefit, of course, is easier identification of counterfeit product, increased traceability throughout the supply chain through serialization and aggregation.

Rather than building new standards from the ground up, CRISTAL instead relies on pre-existing technologies and formats in order to make implementation easier for manufacturers. That these technologies are also in wide use internationally allows other non-EU countries to integrate CRISTAL’s markings into their own traceability systems. This allows for a larger goal than mere traceability for agrochemicals throughout the EU, but across the globe; a projected endpoint that will do a great deal in helping the ECPA accomplish their stated mission of ensuring a safe and sustainable food supply for Europeans.

At the time of this writing, the standards are still entirely voluntary. CRISTAL is promoted as being advantageous for reasons of efficiency and knowledge sharing. The organization is made up of representatives from numerous agrochemical companies so the CRISTAL website does claim that the industry is committed to implementing these standards, but the decision to conform is still up to the discretion of individual manufacturers. There is no penalty to declining to conform beyond pressure from other industry manufacturers. In other words, some brand
owners and manufacturers will expect their contract manufacturers (CMOs) or contract packagers (CPOs) to fulfill CRISTAL’s standards and define concrete timelines for the implementation.

2 The CRISTAL Guidelines

As previously mentioned, CRISTAL relies on pre-existing traceability standards in order to make it easier to implement Track & Trace processes. The guidelines define three core technologies as necessary for the support of electronic commerce:

- Electronic Data Interchange for Administration Commerce and Transport (EDIFACT), which facilitates the exchange of data between entities
- Identification codes, which are used to link the data exchanged to products in the system
- Barcodes, to link the physical products to the identification codes

CRISTAL leverages the standards for use of barcodes and labeling of products already defined by the GS1 system, specifically in its definition of standards for bar coding and standards for labeling of products. CRISTAL’s standards recommend the EDIFACT standard for the EDI messages, which are developed by the United Nations Center for Trade Facilitation and Electronic Business.

2.1 GS1 Standards

The GS1 standards are broken into several distinct services, which each contribute to the larger goal of allowing companies to implement traceability.

2.1.1 Identification Keys

A GS1 identification key is meant to allow access to the information about a given product from a computer file. Each number is, of course, globally unique and can be used as references to the following:

- Trade items
- Logistic units
- Locations
- Assets
- Shipments
- Consignments
- Documents
- Service relationships

These identification keys serve as a Global Trade Item Number (GTIN), and can be assigned to a single item or group of items, depending on the requirement. GTINs are 14 digits long and depending on the application CRISTAL recommends a different GTIN standard – in essence, the amount of information to be transmitted will determine the GTIN format to be used: GTIN-81, GTIN-122, GTIN-13, or GTIN-14.

2.1.2 Barcodes

The GS1 allows for use of both 1D and 2D barcodes in order to transmit GS1 identification keys into an easily readable format. This helps to ensure a smooth flow of information between points in the supply chain – the GS1 identification key is encoded into a barcode, which can be scanned into a larger eMessaging system easily. The accepted barcode standards are as follows:

- EAN/UPC
- ITF-14
- GS1 DataBar
- GS1 DataMatrix
- EPC/RFID
- GS1-128
Barcodes are generally applied during the production process and may be pre-printed on the label with other important package information which is then applied to a package, or it is printed directly onto the packaging, depending on the process.

2.1.3 eMessaging

The eMessaging component is the last link in the chain set up by the GS1 standards. It is a series of agreed-upon messaging protocols to transfer the information encoded in the barcodes between computer applications. The eMessaging component leverages the GS1 Global Data Synchronization Network (GDSN), an internet-based global registry that provides a place for companies to synchronize supply chain data with their customers and partners in the supply chain.

For companies opting for Radio Frequency Identification (RFID)-based tracking rather than barcode based tracking, CRISTAL recommends assigning RFIDs to Electronic Product Codes (EPCs). The EPCglobal framework, which combines RFID technology with EPCs, allows an RFID and its associated EPC to serve as an unique identifying number which, in concert with the GTIN, is assigned to a particular item. This framework allows faster scanning and tracking of items as they move through the supply chain.

2.2 Assigning a Number

As mentioned previously, GTINs are assigned to (as the name would suggest) trade items. Trade items are defined as any product or service "upon which there is a need to retrieve pre-defined information and that may be priced or ordered or invoiced at any point in any supply chain." (CRISTAL Standards p 10) This allows GTINs to stand for a single packaged item or a pallet made up of items (which may have GTINs of their own). Every item has its own GTIN, which is assigned to every different version of the product in question. So for example, a product that comes in two different colors will have a different GTIN for each color.

Should a trade item’s makeup change, such as a different weight or size due to a change in design or makeup – a new GTIN may need to be assigned. The GS1’s website (http://www.gs1.org) provides a handy reference guide for GTIN allocation rules to help determine whether or not a new GTIN is necessary. Trade items which are pulled off the market and are no longer sold can have their GTIN reassigned to a new trade item but only after a minimum of four years have elapsed from either the expiration date of the last of the original trade item, or the last date which the item was supplied to a customer. It is important to remember, however, that even if four years have passed records for the retired trade items will most likely still be kept for longer than four years – so care should be taken when making the decision to reuse an old GTIN.

2.3 GTIN Format

The amount of information to be transmitted will determine the GTIN format. CRISTAL uses GTIN-13 for Consumer Units. Consumer Units are defined as "the lowest level of packaging as sold at retail level" (CRISTAL Standards p 12) and can be anything from a single item through a multi-pack or twin pack item, depending on what is being sold to the consumer.

![Figure 1: Structure of a GTIN](image-url)
A GTIN-13 number is broken down into three parts, and can be displayed as a 1D EAN-13 barcode or as a 2D GS1 DataMatrix code:

- Company Prefix: These are allocated by the GS1 Member Organizations and are usually between seven and nine digits long.
- Item Reference: A unique, non-significant number which is generally issued sequentially for each variant on the product
- Check Digit: This is used to validate the accuracy of the number using a mathematical formula

The next level up from the Consumer Unit is the Shipper. Shippers are defined as “the lowest grouping of consumer units traded between manufacturers and distributors” (CRISTAL p 13) and include cartons and cases – anything made to facilitate handling, storage and order preparation for shipment. This covers multiple levels of packaging, from intermediate packaging up to (but not including) the pallet – CRISTAL has different requirements for pallets and shipping containers that will be addressed in the following section.

Shippers also use GTIN-13, but if all units on a pallet or in a case are the same trade item, then manufacturers have the option of using a GTIN-14 code instead. Generating a GTIN-14 uses an indicator digit which is followed by the first twelve digits of the GTIN-13 code belonging to the items contained within the shipper, along with a recalculated check digit, which can be determined by using the Check Digit Calculator program on the GS1 Germany website (www.gs1-germany.de). GTIN-14 codes must be encoded as 2D DataMatrix codes.

It is also important to note that should manufacturers wish to have the GTIN included along with any other information, such as lot number or expiration date, they must use a 2D DataMatrix code, as 1D barcodes can only provide the number. For point of sale applications, it is recommended to include both a 1D barcode alongside a 2D DataMatrix code, as not all retail scanners have the ability to read 2D codes.

### 2.3.1 Numbering of Logistic Units

Logistic units, defined as “an item of any composition established for transport and/or storage” (CRISTAL p 20), do not use GTINs. This is because the function of a GTIN is to identify a single unit, whereas a shipping container or pallet of products will vary in composition and are generally not settled until a customer order comes in – so assigning a GTIN would be meaningless.

At the same time, it is still critical to trace the movement of logistic units, so rather than using a GTIN, CRISTAL uses a Serial Shipping Container Code (SSCC). This is generated at the moment the logistic unit is created and serves a reference number to identify logistic units. The SSCC can be encoded as a GS1-128 barcode or using EPC/RFID, allowing it to be traced throughout the entire supply chain, from supplier through distributor to customer. The SSCC should be used as the reference number to pull up the contents of a given logistic unit, which would include GTINs for the items therein.

The structure of an SSCC is an eighteen digit number which begins with an extension digit, followed by, as in a GTIN, the GS1 company prefix and a serial reference number followed by a check digit. The SSCC is then applied to the logistic unit in question.

### 3 Logistics Label Design

While it is true that CRISTAL’s ultimate goal is a fully-automated Track & Trace system, that future is still far off. This means there needs to be a way for facilities without fully automated communications channels to obtain relevant information visually. The GS1 Logistics Label is meant to address this by providing clear and concise information in human and machine-readable form. The required information on a logistics label is as follows:

- To and from addresses, basic description of contents – this can be made up of both text and graphics
- Bar codes, which provide the same information in a machine readable format
While the precise information provided on the label can vary, the SSCC must be present in both text and barcode formats, to allow it to function as a reference point for information. In order to help ensure that labels are easy to read, the design of the logistics label should be broken down into three sections:

- **Supplier Section:** This part of the label is where the SSCC and GTIN are found, as well as product-related information such as batch/lot number, expiration date and product variant or container contents.
- **Customer Section:** The customer section gives the information specifically related to the customer, such as ship to location, purchase order number and routing and handling information.
- **Carrier Section:** This final section gives the information relating to transportation of the shipment.

These sections can be added at separate points in time as the information becomes available to fill out the section. Each section should have its information encoded in a barcode as well as in a human-readable format. The barcode should be placed below the human readable information, with sufficient space between the two formats in order to ensure automatic data capture.

All labels should be either in A6 format (105mm x 148mm) or A5 format (148mm x 210mm). A6 sized labels should only be used if the decision has been made to only encode the SSCC and limited additional information rather than everything. Barcodes should be encoded as GS1-128 barcodes and displayed with bars and spaces perpendicular to the base upon which the logistics unit stands. The SSCC should be displayed on the lowest portion of the label.

### 3.1 Logistics Label Information Requirements in the Agro Industry

While the GS1 standards give flexibility in the type and amount of information allowed on a logistics label, the CRISTAL guidelines outline a minimum data requirement for labels depending on the composition of the pallet in question.

#### 3.1.1 Standard Pallet Containing the Same Trade Items

This composition actually breaks down into two separate types: pallets made up of products homogenous in batch and product, and pallets homogenous in product, but not batch. Both pallet compositions require the display of SSCC and GTIN. When pallets are homogenous in both batch and product, the standard requires the production/release date and batch number as well. The expiration date (if the product in question has one) can be added to the label as well, but this is optional. For products which are only homogenous in product, the production date (or dates) and expiration dates are optional – and obviously, batch number is not included.

#### 3.1.2 Non-standard Pallet Containing the Same Trade Items

Non-standard pallets have the same label composition as standard pallets – they require the SSCC, GTIN, production/release date and batch number, with the option of including the expiration date if it is available. The assumption with non-standard pallets is that all products on the pallet will share batch number, so the standards have no requirements for products which do not share batch numbers.

#### 3.1.3 Pallet Containing Mixed Trade Items

For many distributors, pallets with mixed trade items are likely to comprise the majority of shipments. It does not make sense to list the separate GTINs of each product variety and keep the label to a reasonable size, so the only mandatory information that must appear on the label is the SSCC. However, the standards also stress that “full use of eMessaging is required,” as in truth the SSCC requires eMessaging to serve as the key to all relevant information about the logistic unit.
3.2 Label Placement

Barcodes should be placed on the sides of the unit. There must be at least one barcode present, but CRISTAL recommends at least two for redundancy purposes. If, for some reason, only one label will be applied it is important that it is placed on whatever side it will be facing outward (or on the ‘pick side’) of the unit so as to ensure visibility of the label at all times. In addition, it is required that no part of any barcode (including the Quiet Zone surrounding the barcode) come within 19mm of any vertical edge of the logistics unit.

On pallets in particular, CRISTAL recommends barcodes be placed at a height between 400 and 800mm from the base of the unit, with the edge of the codes (again, including Quiet Zones) at least 50mm from any vertical edge as a way of protecting the label from possible damage. Should a pallet be shorter than 400mm, then it is recommended that labels are placed as high as possible while still maintaining protection from possible damage.

4 The Future of Crop Science and Traceability

The CRISTAL standards represent much more than traceability for pesticides. These same standards can serve as a blueprint for implementing traceability throughout the agricultural supply chain. As crop science continues to make advances in technology, particularly on the genetic level, the need for greater transparency of the supply chain becomes more important. A growing consumer anxiety centered around so-called Genetically Modified Organisms (GMOs) has resulted in EU regulations that limit the allowable presence of GMOs without declaration to a mere 0.9%, making the identification of GMOs in the food/feed supply chain more important – not only does it help to prevent cross-contamination, it helps to find the source of cross-contamination when it happens.

Other initiatives aimed at stopping so-called food fraud (e.g. watering down wine and milk) are also underway, and part of addressing these concerns will also involve greater security along the supply chain. It is very likely that more industry and government organizations will make recommendations for the implementation of similar traceability standards across the agricultural sector.

At the same time, traceability providers are continually looking for ways to provide greater granularity when it comes to tracking products and materials through the supply chain, as well as more efficient ways of surfacing product information. The march toward global connectivity continues to be a factor in traceability improvements – crop science is far from the only industry with an interest in traceability, and the use of common standards, e.g. the GS1 standards, across industries allows companies with broader product portfolios to implement Track & Trace across their entire operation. Providers of Track & Trace technology are similarly providing offerings that have the flexibility required to make such an implementation as easy as possible.

Automated vision inspection systems can help to ensure the required codes are present and readable, while Track & Trace software can provide the necessary printing and database connectivity needed for a successful serialization program. METTLER TOLEDO vision inspection and Track & Trace systems are designed by experts in serialization and vision technology and are well-suited for the precise sort of applications required for the implementation of the CRISTAL standards, as well as future standards to come.
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