INTERNATIONAL STANDARD

ISO 17367

Second edition
2013-03-01

Supply chain applications of RFID — Product tagging

Applications de chaîne d'approvisionnements de RFID — Étiquetage de produit

Reference number
ISO 17367:2013(E)

Contents

Page

Foreword v

Introduction vi

1 Scope 1

2 Conformance and performance specifications 1

3 Normative references 1

4 Terms and definitions 3

5 Concepts 3
5.1 Differentiation between this layer and the preceding layers 3
5.2 Returnable packaging item 5
5.3 Unique item identifier 5
5.4 Other identification requirements 8

6 Differentiation within this layer 8
6.1 Business processes 8
6.2 Lot/batch vs. serial number vs. product identification only 9
6.3 Consumer products vs. industrial/government 9

7 Data content 9
7.1 Introduction 9
7.2 System data elements 10
7.3 Tag structure 10
7.4 Protocol control (PC) bits 12
7.5 Data elements 13
7.6 Traceability 14
7.7 Unique item serialization 14

8 Data security 14
8.1 Confidentiality 14
8.2 Data integrity 14
8.3 Interrogator authentication 14
8.4 Non-repudiation/audit trail 14
8.5 Product authentication/anti-counterfeiting 14

9 Identification of RFID labelled material 15

10 Backup in case of RF tag failure 15
10.1 Human readable interpretation 15
10.2 Human readable translation 15
10.3 Data titles 15
10.4 Backup 16

11 Tag operation 16
11.1 Data protocol 16
11.2 Minimum performance requirements (range and rate) 16
11.3 Environmental considerations 17
11.4 Tag orientation 18
11.5 Packaging material 18
11.6 Shock loads and abrasions 18
11.7 Tag lifetime 18
11.8 Minimum system reliability 18
11.9 Air interface 18
11.10 Memory requirements for application 18
11.11 Sensor interface, if applicable 18
11.12 Real time clock option 19
11.13 Safety and regulatory considerations 19
11.14 Non-observable data 19

11.15 Tag recyclability ... 19
11.16 Tag reusability ... 19

12 Tag location and presentation ... 20
12.1 Material on which the tag is mounted or inserted ... 20
12.2 Geometry of the package/tag environment ... 20

13 Interrogator and reader requirements ... 20
13.1 Safety and regulatory considerations ... 20
13.2 Data privacy ... 20

14 Interoperability, compatibility and non-interference with other RF systems ... 20

Annex A (informative) **Proposed guidelines for the verification and qualification of design and manufacture for RFID chips and transponders for tyres ... 21**

Annex B (informative) **Table of useful data elements for product life cycle management ... 39**

Annex C (normative) **Encoding ... 40**

Bibliography ... 50

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17367 was prepared by Technical Committee ISO/TC 122, *Packaging*, Subcommittee SC , .

This second edition cancels and replaces the first edition (ISO 17367:2009), which has been technically revised.

This International Standard has three annexes: Annexes A and B, which are informative, and Annex C, which is normative.

Introduction

The 'Supply Chain' is a multi-level concept that covers all aspects of taking a product from raw materials to a final product including shipping to a final place of sale, use and maintenance and potentially disposal. Each of these levels covers many aspects of dealing with products, and the business process for each level is both unique and overlapping with other levels.

This International Standard has been created in order to ensure compatibility at the physical, command and data levels with the four other International Standards under the general title S*upply chain applications of RFID*. Where possible, this compatibility takes the form of interchangeability. Where interchangeability is not feasible, the International Standards within this suite are interoperable and non-interfering. The International Standards within the complete series of *Supply chain applications of RFID* include

— ISO 17363, *Supply chain applications of RFID — Freight containers;*

— ISO 17364, *Supply chain applications of RFID — Returnable transport items (RTIs) and returnable packaging items (RPIs);*

— ISO 17365, *Supply chain applications of RFID — Transport units;*

— ISO 17366, *Supply chain applications of RFID — Product packaging;*

— ISO 17367, *Supply chain applications of RFID — Product tagging.*

These International Standards define the technical aspects and data hierarchy of information required in each layer of the supply chain. The air-interface and communications protocol standards supported within the *Supply chain applications of RFID* International Standards are ISO/IEC 18000; commands and messages are specified by ISO/IEC 15961 and ISO/IEC 15962; semantics are defined in ISO/IEC 15418; syntax is defined in ISO/IEC 15434.

Although not pertinent to this International Standard, the following work is considered valuable:

— ISO/IEC JTC 1, *Information technology,* SC 31, *Automatic identification and data capture techniques*, in the areas of air interface, data semantic and syntax construction and conformance standards, and

— ISO/TC 104, *Freight containers*, in the area of freight container security, including electronic seals (e-seals) (i.e. ISO 18185) and container identification.

Supply chain applications of RFID — Product tagging

1 Scope

This International Standard defines the basic features of RFID for use in the supply chain when applied to product tagging. In particular it

— provides specific recommendations about the encoded identification of the product,

— makes recommendations about additional information about the product on the RF tag,

— makes recommendations about the semantics and data syntax to be used,

— makes recommendations about the data protocol to be used to interface with business applications and the RFID system, and

— makes recommendations about the air interface standards between the RF interrogator and RF tag.

This International Standard only addresses *product tagging* and does not address *product packaging*.

2 Conformance and performance specifications

All of the devices and equipment that claim conformance with this International Standard shall also conform to the appropriate sections and parameters specified in ISO/IEC 18046 for performance and ISO/IEC 18047-6 (for ISO/IEC 18000-63, Type C) and ISO/IEC 18047-3 (for the ASK interface of ISO/IEC 18000-3, Mode 3) for conformance.

NOTE Annex A gives an illustrative example of an industry-specific conformance/quality document.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 445, *Pallets for materials handling — Vocabulary*

ISO 830, *Freight containers — Vocabulary*

ISO 8601, *Data elements and interchange formats — Information interchange — Representation of dates and times*

ISO/IEC/IEEE 8802-15-4, *Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs)*

ISO/IEC 15418, *Information technology — Automatic identification and data capture techniques — GS1 Application Identifiers and ASC MH10 Data Identifiers and maintenance*

ISO/IEC 15434, *Information technology — Automatic identification and data capture techniques — Syntax for high-capacity ADC media*

ISO/IEC 15459 (all parts), *Information technology — Automatic identification and data capture techniques — Unique identification*

ISO/IEC 15961, *Information technology — Radio frequency identification (RFID) for item management — Data protocol: application interface*

ISO/IEC 15962:—[1]), *Information technology — Radio frequency identification (RFID) for item management — Data protocol: data encoding rules and logical memory functions*

ISO/IEC 15963, *Information technology — Radio frequency identification for item management — Unique identification for RF tags*

ISO/IEC 16022, *Information technology — Automatic identification and data capture techniques — Data Matrix bar code symbology specification*

ISO 17364:2013, *Supply chain applications of RFID — Returnable transport items (RTIs) and Returnable packaging items (RPIs)*

ISO/IEC 18000-3, *Information technology — Radio frequency identification for item management — Part 3: Parameters for air interface communications at 13,56 MHz*

ISO/IEC 18000-63, *Information technology — Radio frequency identification for item management — Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C*

ISO/IEC 18004, *Information technology — Automatic identification and data capture techniques — QR Code bar code symbology specification*

ISO/IEC 18046 (all parts), *Information technology — Radio frequency identification device performance test methods*

ISO/IEC 18047 (all parts), *Information technology — Radio frequency identification device conformance test methods*

ISO/IEC 19762 (all parts), *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary*

ISO 21067, *Packaging — Vocabulary*

ISO/IEC/IEEE 21451-5 [IEEE 1451.5], *Information technology — Smart Transducer Interface for Sensors and Actuators — Wireless Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats*

ISO/IEC/IEEE 21451-7, *Information technology — Smart transducer interface for sensors and actuators — Part 7: Transducer to radio frequency identification (RFID) systems communication protocols and Transducer Electronic Data Sheet (TEDS) formats*

ISO/IEC/TR 24729-1, *Information technology — Radio frequency identification for item management — Implementation guidelines — Part 1: RFID-enabled labels and packaging supporting ISO/IEC 18000-6C*

ISO/IEC 29160, *Information technology — Radio frequency identification for item management — RFID Emblem*

ANS MH10.8.2, *Data Identifiers and Application Identifiers*

GS1 EPC *Tag Data Standard Version 1.6*

GS1 *General Specifications*

ICNIRP Guidelines, *Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)*

IEEE C95-1, *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*

1) To be published.

4 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 445, ISO 830, ISO 17364, ISO/IEC 19762 (all parts), and ISO 21067 apply.

For the purposes of this document, hexadecimal characters are represented as 0xnn, where "nn" is the hexadecimal value.

5 Concepts

5.1 Differentiation between this layer and the preceding layers

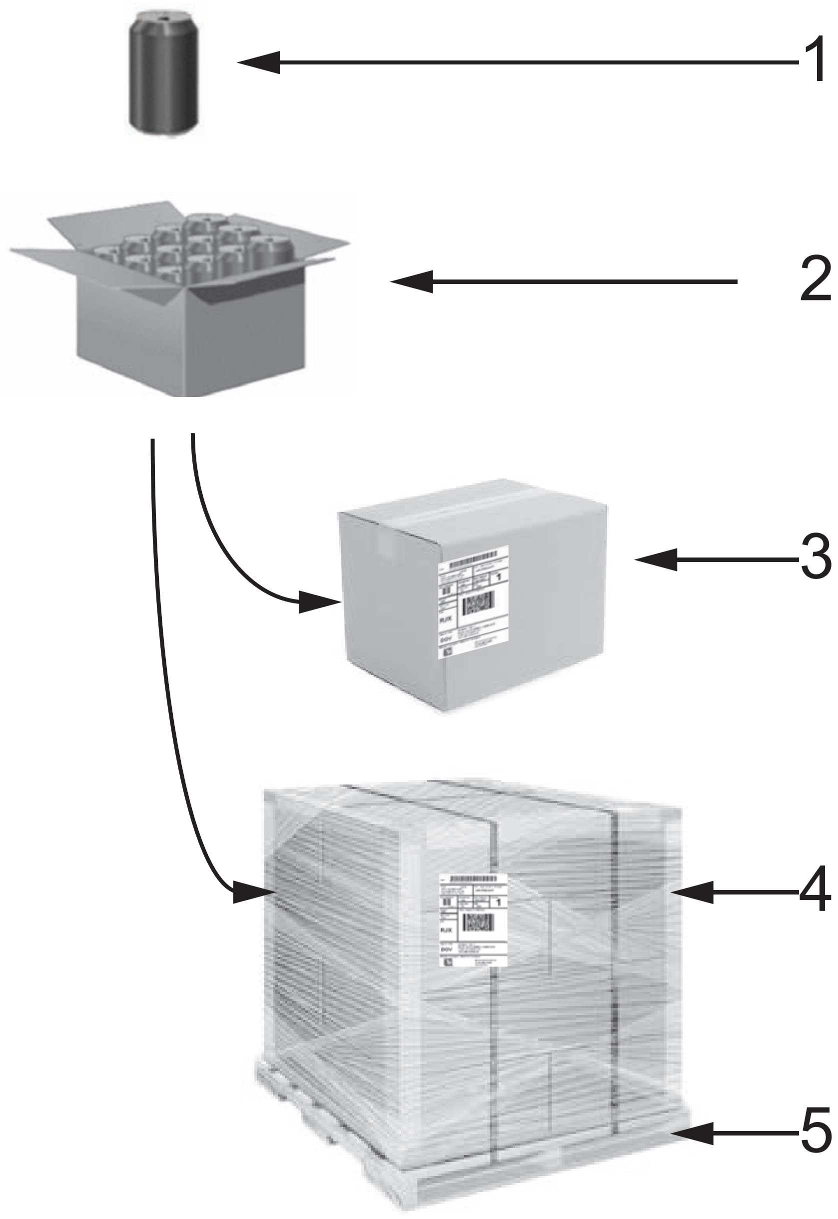
Figures 1 and 2 give a graphical representation of supply chain layers. They show a conceptual model of possible supply chain relationships, not a one-for-one representation of physical things. Although several layers in Figure 2 have clear physical counterparts, some common supply chain physical items fit in several layers depending on the use case. For example, as shown in Figure 2, a repetitively used pallet under constant ownership would be covered by ISO 17364 as an RTI; a pallet that is part of a consolidated unit load would be covered by this International Standard as a transport unit; and a pallet that is integral to a single item would be covered by ISO 17366 as product packaging.

The term "supply chain layers" is a multi-level concept that covers all aspects of taking a product from raw materials to a final product to shipping to a final place of sale, use, maintenance and potentially disposal and returned goods. Each of these levels covers many aspects of dealing with products and the business process for each level is both unique and overlapping with other levels.

The Item Level through Freight Container Level layers are addressed within the suite of standards for "supply chain applications of RFID" and are intended to enhance supply chain visibility. The Movement Vehicle Level is the purview of ISO/TC 204/WG 7.

The Item Level in Figure 2, and specifically products, (as defined in ISO 17364:2013, 4.1) is the subject of this International Standard.

Item Level tags can be distinguished from following or preceding layer tags by use of a *group select* methodology contained in the RFID interrogator/reader. This group select function allows the interrogator and supporting automated information systems (AIS) to quickly identify Item Level tags.



Key

1	primary packaging – consumer packaging – *(product)*
2	secondary packaging – outer packaging – *(product package)*
3	tertiary packaging – transport packaging – *(transport unit)*
4	tertiary packaging – unitized transport packaging – *(transport unit)*
5	pallet – *(returnable transport item – RTI)*

Figure 1 — Packaging

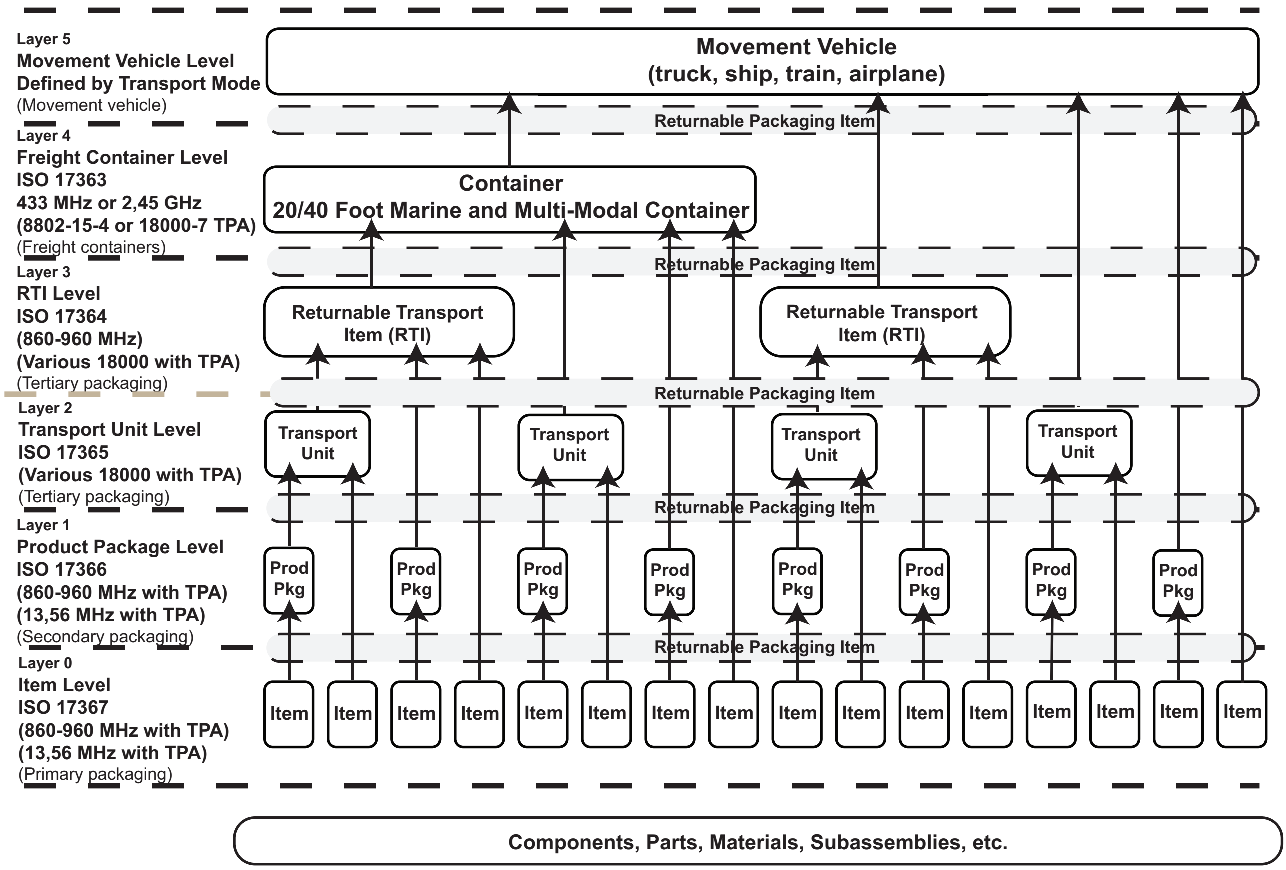


Figure 2 — Supply chain layers

5.2 Returnable packaging item

At all layers within the supply chain are devices that are shipped to a customer with full expectation that such devices will be returned to the supplier. These returnable packaging items (RPIs) are assets of value as well as potentially the physical transport unit. RPIs and their identification are well addressed in Annex A of ISO 17364:2013 and Annex A of ISO 17365:2013.

5.3 Unique item identifier

5.3.1 General

Unique item identification is a process that assigns a unique data string to an individual item, or in this case to an RFID tag that is associated to the item. The unique data string is called the unique item identifier. Unique item identification of items allows data collection and management at a granular level. The benefits of granular level data are evident in such areas as maintenance, retail warranties and enabling electronic transactions of record. This granularity is possible only if each tagged item has a unique identification. Items that are not uniquely identified would not normally be tagged at the item level. Items to which unique item identifiers have been assigned are said to be serialized items. Low cost consumable items would normally be tagged at the package level or higher as a standard assortment.

Product layer tagging can uniquely identify items, thus providing differentiation between like items and between like and unlike items. Product layer tagging can also be used to identify items by differentiating unlike items but not differentiating between like items. This is used for commodity where individualization is not practical or desired.

The unique product identifier described above shall be the unique identifier as described in ISO/IEC 15459-4. The unique item identifier (UII) provides granular discrimination between like items that are identified with RFID tags. The unique tag ID (as defined by ISO/IEC 15963) is a mechanism to uniquely identify RFID tags and is not the unique product identifier defined in this International Standard.

The minimum data elements required for unique identification are an enterprise identifier and a serial number that is unique within that enterprise identifier. Commonly, a part or model number is also required to achieve unique identification.

This International Standard uses the following identification mechanisms for unique product identification:

— Unique identifiers for supply chain items (ISO/IEC 15459-4);

— GS1 Serialized Global Trade Item Number (SGTIN).

5.3.2 International Unique Identification for Items

The unique identifier of ISO/IEC 15459 provides identification schemes for various layers of the supply chain, from layer 1 (products) up to layer 4 (returnable transport items). The unique identification of product packages shall use ISO/IEC 15459-4. Unique identification is provided contextually by three components:

a) issuing agency code (IAC),

b) company identification number (CIN),

c) serial number (SN),

preceded by an AFI and Data Identifier (DI). The AFI code assignments table in ISO/IEC 15961-3, Data Constructs Register and shown below in Table 1 permits identification of the supply chain layer, i.e. product = 0xA1, transport unit = 0xA2, returnable transport item = 0xA3, and product package = 0xA5.

The Data Identifier shall be “25S”. The ISO/IEC 15459 registration authority assigns the IAC. The CIN is assigned by the issuing agency. The company registered with the issuing agency assigns the serial number. The serial number should be no longer than 20 alphanumeric characters.

Table 1 — 1736x AFI Assignments

AFI	Assignment	ISO Standard
0xA1	17367_ISO	ISO 17367, Supply chain applications of RFID — Product tagging
0xA2	17365_ ISO	ISO 17365, Supply chain applications of RFID — Transport unit
0xA3	17364_ ISO	ISO 17364, Supply chain applications of RFID — Returnable transport item
0xA4	17367_HazMat	ISO 17367, Supply chain applications of RFID — Product tagging (HazMat)
0xA5	17366_ ISO	ISO 17366, Supply chain applications of RFID — Product packaging
0xA6	17366_HazMat	ISO 17366, Supply chain applications of RFID — Product packaging (HazMat)
0xA7	17365_HazMat	ISO 17365, Supply chain applications of RFID — Transport unit (HazMat)
0xA8	17364_HazMat	ISO 17364, Supply chain applications of RFID — Returnable transport item (HazMat)
0xA9	17363_ ISO	ISO 17363, Supply chain applications of RFID — Freight container
0xAA	17363_HazMat	ISO 17363, Supply chain applications of RFID — Freight container (HazMat)

When stored on a tag with a technology that supports AFIs, the unique identifier shall also be associated with an AFI. EPC does not use AFIs; consequently, there are no AFIs used for product tagging employed in retail applications using EPC. AFI 0xA1 may be used for products intended solely for commodities other than consumer goods. Annex C provides an in-depth discussion of the ISO approach to encoding.

To define its class (in the ISO/IEC 15459 sense), the unique identifier shall have an associated class identifier, which is the Data Identifier “25S”. For the purposes of this International Standard, a unique identifier of products should be no longer than 35 alphanumeric characters in length, excluding the Data Identifier (an3+an..35). See Table 2. With the mutual agreement of the trading partners this length can be extended to 50 characters (an3+an..50).

Table 2 — ISO UII element string

Format of the License Plate	
Data Identifier	IAC Company Identification Number (CIN) Serial Reference
25S	N_1 N_2 N_3 N_4 N_5 N_6 N_7 N_8 N_9 N_{10} N_{11} N_{12} N_{13} N_{14} N_{15} N_{16} N_{17} . . . N_{35}

5.3.3 Serialised Global Trade Identification Number (SGTIN)

The GS1 EPC Serialised Global Trade Item Number (SGTIN) is a Unique Item Identifier (UII) capable of providing unique item identification of products.

Table 3 — SGTIN-96 element string

	Header	Filter Value	Partition	Company Prefix	Item Reference	Serial Number
Number of bits	8	3	3	20 to 40	24 to 4	38
Reference	0011 0000[a]	—[b]	—[b]	999 999 to 999 999 999 999[c]	9 999 999 to 9[c]	274 877 906 943[d]

NOTE Maximum decimal value range of Company Prefix and Item Reference fields vary according to the contents of the partition field.

[a] Binary value.

[b] Refer to GS1 EPC, Tag Data Standard Version 1.6 for values

[c] Maximum decimal range.

[d] Maximum decimal value.

The SGTIN consists of the following information elements:

a) The *Header*, which is defined in GS1 EPC, *Tag Data Standard,* Version 1.6. It is eight (8) bits long and for an SGTIN-96 is the value 0x30. While the remainder of the document describes an SGTIN-96 the GS1 EPC Tag Data Standard also describes a longer version.

b) The *Filter Value*, which is defined in the *GS1 EPC Tag Data Standard Version 1.6.* The *Filter Value* is three (3) bits long and identifies whether an EPC is for a retail trade item, a standard trade item grouping, or a single shipping/consumer trade item.

c) The *Partition*, defined in the *GS1 EPC Tag Data Standard Version 1.6.* The *Partition* is three (3) bits long, carries one of seven (7) values, and identifies where the subsequent *Company Prefix* and *Item Reference* numbers are divided.

d) The *Company Prefix*, assigned by GS1 to an organization. The *Company Prefix* is the same as the *Company Prefix* digits within a GS1 GTIN decimal code. The combined *Company Prefix* and It*em Reference* are 44 bits long (13 decimal digits).

e) The *Item Reference*, assigned by the “Company” entity to a particular product. The combined *Company Prefix* and *Item Reference* are 44 bits long (13 decimal digits).

f) The *Serial Number* assigned by the managing entity to an individual object. The EPC representation is only capable of representing a subset of *Serial Numbers* allowed in the *GS1 General Specifications*.

Specifically, only those *Serial Numbers* consisting of one or more digits, with no leading zeros, are permitted. The length of the *Serial Number* is 38 bits.

5.4 Other identification requirements

This International Standard does not supersede or replace any applicable safety or regulatory marking or labelling requirements.

This International Standard is meant to satisfy the minimum product identification requirements of numerous applications and industry groups. As such, its applicability is to a wide range of industries, each of which may have specific implementation guidelines for this International Standard. This International Standard is to be applied in addition to any other mandated labelling requirements.

6 Differentiation within this layer

6.1 Business processes

Business processes such as those described below are illustrative of the applications envisioned by this International Standard.

Acquisition: ordering, including the identification of relevant specifications and requirements, can be facilitated by referencing the item's original acquisition data using the RFID tag's unique ID as a database key.

Shipping: where items can have different configurations or capabilities, such as with computer software loads that differentiate items with otherwise identical form, fit and function, such items can be issued and shipped with the tag read providing assurance that the correct item was shipped. This level of non-intrusive tracking and tracing can serve as a front end to higher level in-transit visibility RFID applications detailed in the other standards of this series.

Receiving: non-intrusive collection of receipt data can shorten data collection times, in support of automated inventory management systems and provide an electronic *transaction of record* much earlier in the process. Earlier knowledge of on-hand inventory can reduce stock outs and the need for expedited premium transportation.

Cross-docking: in addition to recording inbound receipts and outbound shipments, tagged items can be sorted. Many items will have exterior marking (tagging) that are used in lieu of reading the product tag.

Work in process: used to track individual components and the final assembly (bill of material) and to monitor any item through a fabrication or manufacturing process.

- Maintenance: related to work in progress and differentiated in that it covers functions prior to and subsequent to the actual work. This includes fault analysis, identification, preparation of packing and packaging.
- Inventory control: item level serialization yields a granularity of visibility that supports the management of individual items. This allows data collection, tracking and tracing of individual items and selection at point of issue.
- Disposal: identification of items that have recycling or other disposal requirements.
- Picking and put-away: selection of items from a package or transport unit prior to placement into shelf stock in a warehouse situation or other storage situation where a specific asset is desired or knowledge of the specific item selected is required for issue.
- Pick and place: selection of items from shelf stock in a warehouse situation or other storage situation where a specific asset is desired or knowledge of the specific item selected is required incident to the placement of the item into or onto another asset incident to a manufacturing or assembly process.

— Sortation: process that places individual items into groups based upon some selection criteria, often performed at speed.

— Identification: process that is an inherent part of each of the functions set out above. It allows the positive differentiation of an item consistent with the business process in use. Identification can be at the discrete item level for serialized products or by commodity for non-serialized products. Identification is often the underlying base process that enables the other uses of the tag.

— Network topology: can be used to identify discrete nodes or locations on a network.

— Configuration management: discrete identification of the individual component items that comprise a higher assembly. This component data can be tiered to cover each of the multiple levels of configuration (e.g. the circuit board inside the radio installed in the communications suite of an aircraft).

The multitude of different business processes circumscribed by the supply chain will employ distinctly different groupings of functions and processes outlined above. The reading, writing or erasing of data to/from a tag is intended to effect identification and data capture about the product and the process involved and shall be integrated into business processes as required by the business process owner.

6.2 Lot/batch vs. serial number vs. product identification only

Just as different business processes have varying data requirements, different items will have varying identification requirements. Use of structured or intelligent serialization schemes include additional data such as part number or lot number in the serialization scheme and should be avoided whenever possible. This means ideally that the serialization is unique within the enterprise.

The lowest level of identification would be product ID only. Lot and batch type items shall be marked with the product ID of the item and the lot or batch of that item that this particular item belongs to. Serialized items shall be marked with a unique serial number in conformance with the appropriate part of ISO/IEC 15459, which details the differing methods of serialization that provide unique identification.

The need to identify an item at each level is not absolute. Many items are manufactured, sold, and used at the commodity level. Examples are sand, coal and bulk liquids. These items may be marked at the lot level or simply as a generic commodity.

Medicines are typical of the type of item that is manufactured and managed at the lot level but sold and used at the item level. Thus, a particular dosage of medicine will require unique identification of that dose and the ability to reference that back to the original manufacturing lot. Looking up associated information on the information system may accomplish this reference.

6.3 Consumer products vs. industrial/government

Personal privacy considerations present a unique set of considerations for consumer products as opposed to products that remain exclusively in the industrial/government sectors. Consumer privacy regulations shall be considered in the design and operation of every consumer level product scenario. Encryption and data security are addressed in Clause 8.

7 Data content

7.1 Introduction

Subclauses 7.2 to 7.7 describe the data content of RFID tags for the product layer. They identify, amongst others,

— the data elements that shall or may be present on the tag,

— the way in which the data elements are identified (semantics),

— the representation of data elements in tag memory, and

— the placement of data elements in the memory of the tag.

7.2 System data elements

7.2.1 Unique product identification

The first data element on a compliant tag shall be the unique identification described in ISO/IEC 15459-4. The length and nature of this unique identification is defined in this data element. For an ISO/IEC 18000-63, Type C and ISO/IEC 18000-3, Mode 3 compliant tag, the “unique identification” data element is segregated from any additional (user data) by the memory architecture. The unique identification data element shall be stored in UII memory (Bank 01), with any additional data being stored in user memory (Bank 11). For the purposes of this International Standard, a unique identifier of product packages can be up to 35 alphanumeric characters in length, excluding the Data Identifier (an3+an..35). With the mutual agreement of the trading partners this length can be extended to 50 characters (an3+an..50). Annex C provides an in-depth analysis of encoding.

7.2.2 Data semantics

Tags that only encode the unique product identity should conform to ISO/IEC 15961. This data structure will conform to Annex C. Tags containing complex data structures or larger data sets shall include semantics that conform to ISO/IEC 15418 and Annex C of this International Standard.

7.2.3 Data syntax

Tags that encode identity only are considered to have no syntax. Tags containing complex data structures or larger data sets shall conform to Annex C of this International Standard.

For certain types of products, e.g. tyres, this International Standard also recognizes the use of Relative OIDs, as defined in ISO/IEC 15962. In such cases the DSFID employs a Format 13 (0x0D), defined in the 15961-2 Data Constructs Register. This format is a non-directory Access Method using ASC MH10.8.2 Data Identifiers and the relative OIDs found at: http://www.autoid.org/ANSI_MH10/ansi_mh10sc8_wg2.htm.

7.2.4 Tag character set

Tags using Data Identifiers shall employ characters from the character set 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, [, \,], :, ;, < , = , > , ?, @, (,), *, +, -, ., /, <GS> , <RS> , <FS> , <US> , <EOT> , and Space, as shown in Table C.1.

7.3 Tag structure

7.3.1 Unique product identifiers

Memory Bank “01” of a product tagging shall contain either an ISO/IEC defined AFI or an EPC GS1 defined EPC. The ISO/IEC 15961 AFI for product package is 0xA2, in bits 0x18 – 0x1F as described in Tables 1 and 4. Support for ISO standards (including AFIs) is indicated when bit 0x17 is set to “1”. Alternatively, support for GS1 EPC coding is indicated when bit 0x17 is set to “0” as described in the GS1 EPC Tag Data Standard.

NOTE A 96-bit SGTIN is represented by EPC header 0x30.

7.3.2 Tag memory

Figure 3 provides a graphical representation of tag memory.

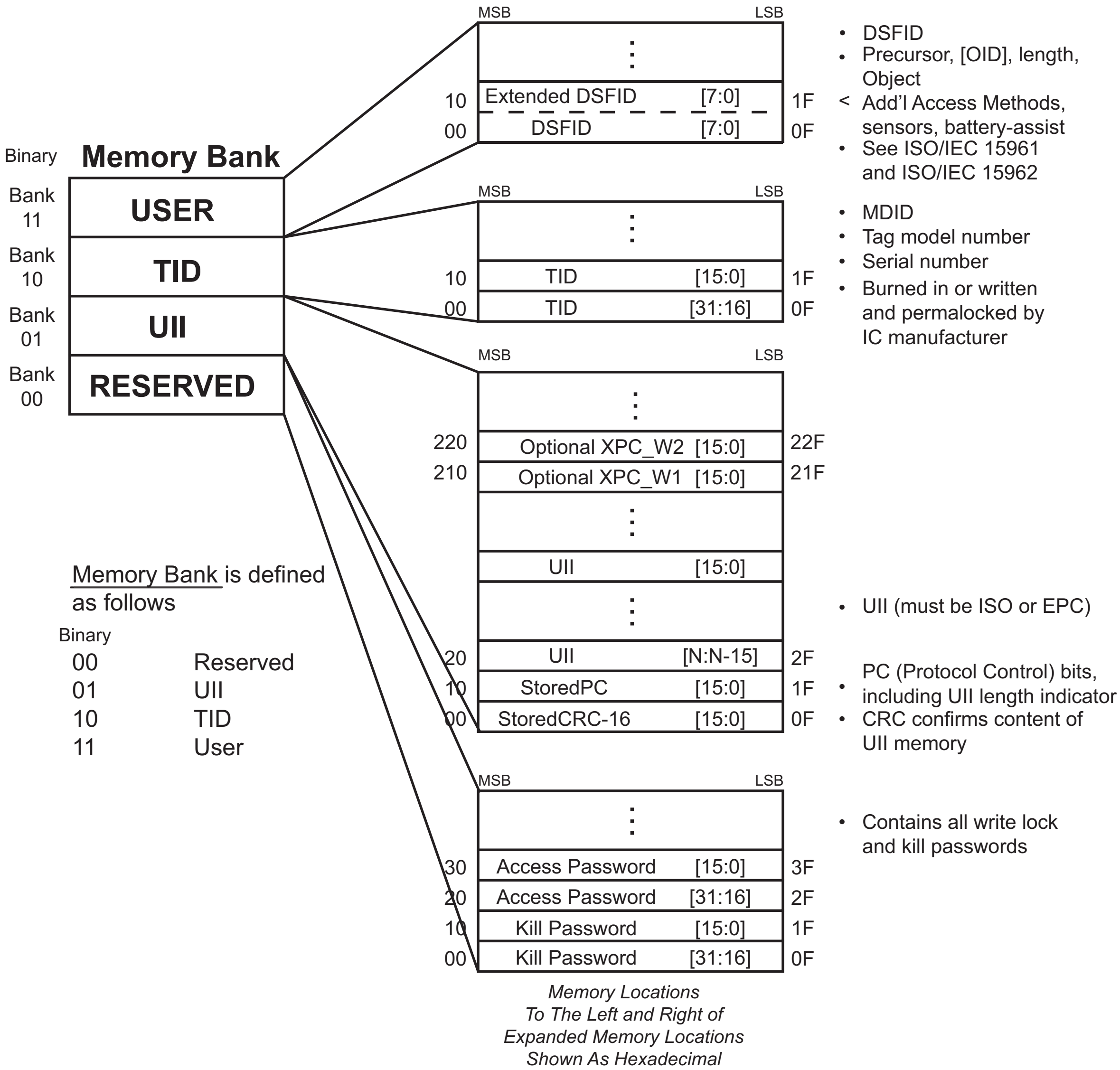


Figure 3 — Segmented memory map

7.3.3 Tag memory banks

Tag memory shall be logically separated into four distinct banks, each of which may comprise one or more memory words. A logical memory map is given in Figure 3. The memory banks are as follows.

a) Reserved memory (MB00): shall contain the kill and access passwords. The kill password shall be stored at memory addresses 0x00 to 0x1F; the access password shall be stored at memory addresses 0x20 to 0x3F. If a tag does not implement the kill and/or access password(s), the tag shall act as though it had zero-valued password(s) that are permanently read/write locked, and the corresponding memory locations in reserved memory need not exist.

b) UII memory (MB01): shall contain a CRC-16 at memory addresses 0x00 to 0x0F, Protocol-Control (PC) bits at memory addresses 0x10 to 0x1F, and a code, i.e. a UII, that identifies the object to which the tag is or will be attached beginning at address 0x20. The PC is subdivided (see Table 4 and Figure C.2). The CRC-16, PC, and UII shall be stored MSB first (the UII's MSB is stored in location 0x20).

c) TID memory (MB10): shall contain an 8-bit ISO/IEC 15963-allocation class identifier at memory locations 0x00 to 0x07. TID memory shall contain sufficient identifying information above 0x07 for an Interrogator to uniquely identify the custom commands and/or optional features that a tag supports.

d) For EPC tags whose ISO/IEC 15963-allocation class identifier is 111000102, this identifying information shall comprise a 12-bit tag mask-designer identifier at memory locations 0x08 to 0x13 and a 12-bit tag model number at memory locations 0x14 to 0x1F. Tags may contain tag- and vendor-specific data (for example, a tag serial number) in TID memory above 0x1F.

e) For ISO/IEC 15459-4 tags operating conformant to ISO/IEC 18000-63, Type C and whose ISO/IEC 15963 allocation class identifier is 11100000_2 (0xE0), this identifying information shall comprise an 8-bit IC manufacturer registration number at memory locations 0x08 to 0x0F and a 48-bit serial number allocated by the IC manufacturer from memory locations 0x10 to 0x3F.

   For ISO/IEC 15459-4 tags operating conformant to ISO/IEC 18000-3, Mode 3 and whose ISO/IEC 15963 allocation class identifier is 11100000_2 (0xE0), this identifying information shall comprise an 8-bit IC manufacturer registration number at memory locations 0x08 to 0x0F and a 48-bit serial number allocated by the IC manufacturer from memory locations 0x10 to 0x3F.

   For ISO/IEC 15459-4 tags operating conformant to ISO/IEC 18000-63, Type C and ISO/IEC 18000-3, Mode 3 and whose ISO/IEC 15963 allocation class identifier is 11100011_2 (0xE3), this identifying information shall comprise an 8-bit IC manufacturer registration number at memory locations 0x08 to 0x0F, a 16-bit user memory and size definition according to ISO/IEC 15963 from memory locations 0x10 to 0x1F, and a 48-bit serial number allocated by the IC manufacturer from memory locations 0x20 to 0x4F.

f) User memory (MB11): allows user-specific data storage. The storage format described in ISO/IEC 15961 and ISO/IEC 15962 defines the memory organization. The presence of data in user memory in MB11 shall be indicated by the presence of a “1” in the 0x15 PC-bit. A zero in the 0x15 PC-bit shall indicate that there is no user memory at MB11 or that there is no data in MB11. Further information on MB11 can be found in Annex C.

7.4 Protocol control (PC) bits

The PC bits contain physical-layer information that a tag backscatters with its UII during an inventory operation. There are 16 PC bits, stored in UII memory at addresses 0x10 to 0x1F, with bit values defined as follows:

— Bits 0x10 to 0x14: The length of the (PC + UII) that a tag backscatters, in words:

  — 000002: One word (addresses 0x10 to 0x1F in UII memory).

  — 000012: Two words (addresses 0x10 to 0x2F in UII memory).

  — 000102: Three words (addresses 0x10 to 0x3F in UII memory).

  — 111112: 32 words (addresses 0x10 to 0x20F in UII memory).

  — Bit 0x15: User Memory; shall be set to “0” for tags without data in user memory (MB “11”) or tags without User Memory and shall be set to “1” for tags with data in user memory.

  — Bit 0x16: Shall be set to “0” if there are no extended PC (XPC) bits or the XPC bits have a zero value and shall be set to “1” if the PC bits are extended by an additional 16 bits.

NOTE 1 If a tag implements XPC bits then PC bit 0x16 shall be the logical OR of the XPC bits contents. The tag computes this logical OR, and maps the result into PC bit 0x16, at power up. Readers can select on this bit, and tags will backscatter it.

NOTE 2 The XPC will be logically located at word 32 of UII memory. If a reader wants to select on the XPC bits, then it issues a Select command targeting this memory location.

— Bit 0x17: Shall be set to “0” if encoding an EPC and shall be set to “1” if encoding an ISO/IEC 15961, AFI in Bits 0x18 – 0x1F.

— Bits 0x18 – 0x1F: Attribute bits whose default value is 000000002 and which may include an AFI as defined in ISO/IEC 15961 (when encoding the tag pursuant to ISO standards). The MSB of the NSI is stored in memory location 0x18. Bit 0x1F has been designated within the GS1 EPC system to be used as an indicator that the product package contains Hazardous Materials.

The default (unprogrammed) PC value shall be 0x0000.

Table 4 summarizes the content.

Table 4 — Segmented memory: memory bank “01”

Protocol Control bits run from 0x10 to 0x1F															
					0/1	0/1	0/1								
10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
Length indicator					User memory	XPC bit	EPC/ISO bit = 1	ISO Application family identifier (AFI)							
Length indicator					User memory	XPC bit	EPC/ISO bit = 0	EPC Attribute bits							Haz Mat

7.5 Data elements

7.5.1 Unique product identifier

The UII–Product tagging shall be present on all conformant product tags. For non-retail tags, the unique product identifier shall conform to ISO/IEC 15459-4 and shall be used as described in 5.3.2. For retail tags, the unique product identifier shall conform to the *GS1 EPC Tag Data Standard* Version 1.6 for the SGTIN-96 and shall be used as described in 5.3.3.

7.5.2 Hazardous goods

RFID tags for items that are classified as hazardous for storage, transportation, or use must contain a bit reference indicating that the item is hazardous. In addition, the tag, regulations and statues may require a more detailed categorization of the hazard. The setting of this bit (“1”) directs the material handler to the included Material Safety Data Sheet. This additional categorization shall not be mandatory unless it provides an approved replacement for hazard data otherwise required by the requiring authority.

The specific hazardous goods code shall include the appropriate Data Identifier and qualifier and reflected in the user data memory. The presence of hazardous material is indicated by bit “1F” of the PC bits of memory bank MB01 as defined in ISO/IEC 18000-63, Type C and ISO/IEC 18000-3 Mode 3. The presence of hazardous material for ISO product tags is indicated by the AFI “0xA4” in bits “0x18” to “0x1F” of the PC bits of memory bank MB01 as defined in ISO/IEC 18000-63, Type C and ISO/IEC 18000-3 Mode 3.

This International Standard does not supersede or replace any applicable safety or regulatory marking or labelling requirements. This International Standard is meant to satisfy the minimum product identification requirements of numerous applications and industry groups. As such, its applicability is to a wide range of industries, each of which may have specific implementation guidelines for this International Standard. This International Standard is to be applied in addition to any other mandated labelling requirements.

7.5.3 Optional data

Dependent upon the tag type and capacity, optional data may be written to tags as required. Agreement between trading partners is not required. Optional data may be encrypted or otherwise secured at the discretion of the tag writer. Note that encrypted or secured data may not be readable by subsequent applications or users. Unless written in a read-only format or locked, optional data may be removed or changed by subsequent applications. Optional data shall be contained in Annex C.

7.6 Traceability

Unique identification enables traceability. Traceability can relate to specific items yielding the ability to differentiate between like items, and traceability can also relate to groups of like items differentiating them from unlike items.

Serialization schemes shall comply with ISO/IEC 15459-4.

Traceability of commodity items may be achieved by concatenating data elements representing the manufacturer, the part/model number and the lot or batch number assigned by the manufacturer.

7.7 Unique item serialization

Unique item identification shall be ensured by concatenating three elements of data: the Issuing Agency Code (IAC), an Enterprise Identifier (relating to the IAC), and a unique serialization as described in ISO/IEC 15459-4 using the rules of ISO/IEC 15459-3.

Product-RFID tag data formats shall utilize an AFI in bits 0x18 to 0x1F with bit 0x17 equal to "1". A listing of the valid AFIs can be found at Table 1.

8 Data security

8.1 Confidentiality

Tag users desiring to have their tags read only by authorized users shall have the ability to secure/protect data written to a tag. The tag shall be capable of having secured/protected data written to it and read from it without interference from the tag design or structure. Use of this feature shall be at the discretion of the user. The type of security/protection to be utilized shall be commensurate with the degree of risk and vulnerability associated with the tag data, and shall be agreed upon between the enterprise writing to the tag and any/all authorized readers/users of the data.

8.2 Data integrity

Tags shall have the ability to prevent the alteration or erasure of data commonly known as *locking* data. This shall be at the discretion of the user. Locking of data shall be at the discretion of the user, except for Tag ID (MB10), which shall be locked by the manufacturer. A CRC-16 is required to enhance the integrity of the data. The location of the stored CRC-16 shall be as per the memory map in Figure 3.

8.3 Interrogator authentication

Tag's data storage schemas for user memory and future data transfer protocols should provide for the user-enabled option to require authentication of the interrogator's authorization prior to reading the tag data.

8.4 Non-repudiation/audit trail

Tags shall be capable of supporting non-repudiation when programmed to provide non-forgeable evidence that a specific action occurred.

8.5 Product authentication/anti-counterfeiting

RFID devices by themselves do not prevent counterfeiting. The serialization of product and a secure chain of custody can aid in anti-counterfeiting. MB10 should be serialized and locked by the tag manufacturer. A locked serialized TID can aid in anti-counterfeiting.

9 Identification of RFID labelled material

RF tags and RF label inlays compliant with this International Standard shall include one or more of the internationally accepted RFID emblems. The accepted emblems shown in Figure 4 are examples of the RFID Emblem as described in ISO/IEC 29160 and GS1 EPC seal.

Figure 4 — ISO and GS1 EPC RFID compliance emblems

NOTE 1 The emblems above only represent the 860 – 960 MHz air interface for this application standard. Other air interface designations can be found in ISO/IEC 29160.

NOTE 2 These graphics can be scaled to the appropriate size and are available in either Dark on Light or Light on Dark.

10 Backup in case of RF tag failure

10.1 Human readable interpretation

If human readable interpretation of Unique Item Identifiers is not used then human readable translation is required.

ISO/IEC/TR 24729-1 shows how to encode within a 2D symbol everything that is in an RF tag. What is most likely needed, however, is to encode the same data in a 2D symbol and RF tag, so that a host computer receives the same information, regardless of media. This is accomplished by the means contained in Annex C.

ISO standard two-dimensional symbols, e.g., Data Matrix ECC 200, QR Code, or PDF417 encoded in conformance with ISO/IEC 15434 and ISO/IEC 15418 should be considered as a primary backup to RF tags on products. An additional level of backup of human readable interpretation may be considered.

10.2 Human readable translation

If human readable translation of Unique Item Identifiers is not used then human readable interpretation is required.

Human readable translation of the data on the tag is selected data rather than complete data and may or may not contain data semantics. Human readable translation should be used when space constraints or privacy considerations do not permit the use of human readable interpretation.

HRI of either ISO UII or EPC tags shall be the upper case alphabetic and numeric representation of the encoded data as set forth in Annex C.

10.3 Data titles

The use of data titles shall be as specified in ANS MH10.8.2 or the GS1 *General Specifications*.

10.4 Backup

Use of human readable information is strongly encouraged for data that is critical to the item's use or sale and shall function as the first backup in the event that the RFID tag is unreadable/misleading for any reason. At the product marking level trading partners shall agree upon a linear symbol such as Code 128 as described in ISO/IEC 15417 or U.P.C. as described in ISO/IEC 15420. Trading partners shall agree upon the two-dimensional symbol to be used such as Data Matrix, as described in ISO/IEC 16022 or QR Code, as described in ISO/IEC 18004.

If optically readable media is used, the International Standards shown in Figure 5 shall be used.

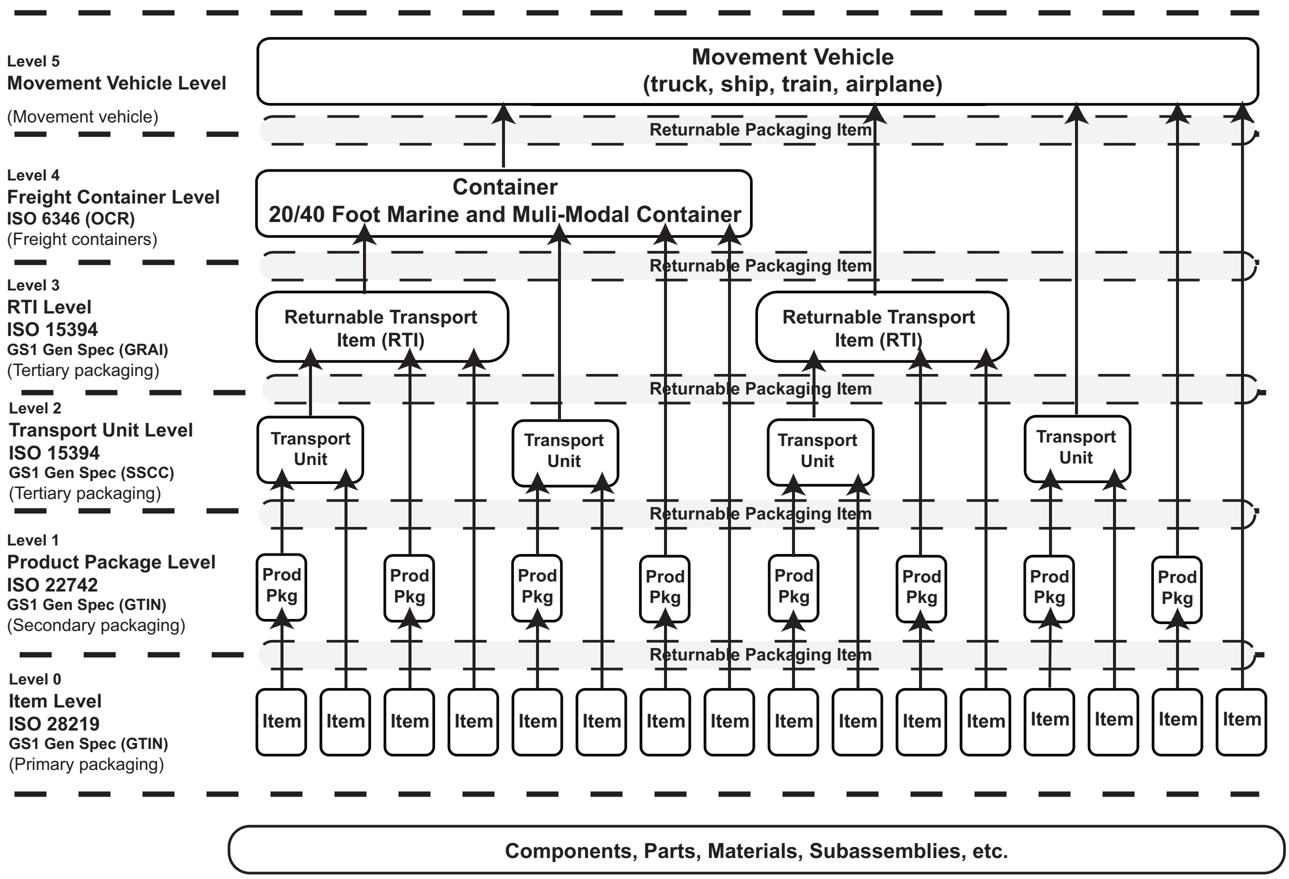


Figure 5 — Layers of supply chain standards for bar codes and two-dimensional symbols

11 Tag operation

11.1 Data protocol

The data protocol for this International Standard shall support the requirements of Annex C.

11.2 Minimum performance requirements (range and rate)

The performance for tags shall be measured in accordance with ISO/IEC 18046-3. Minimum performance requirements will vary for different functional applications of RFID. Table 5 shows the typical performance requirements for passive tags to transfer tag data of up to 256 bits. These specifications also relate to the writing of the tag. Greater distances may be achieved in reading from RF tags than writing to RF tags.[2)] The performance for interrogator shall be measured in accordance with ISO/IEC 18046-2. The performance for systems shall be measured in accordance with ISO/IEC 18046-1.

2) In case regulatory restrictions provide fewer channels than there are interrogators in the environment, this

Table 5 — Typical passive tag performance

Parameter	860 MHz to 960 MHz ISO/IEC 18000-63, Type C	13,56 MHz ISO/IEC 18000-3, Mode 3
How far? [Minimum supported read distance (in metres)]	3	0,7
How fast? [Minimum supported item speed when read (in kilometres per hour)]	16	16
How many? [Minimum supported effective measure of tag data transfer rate and ability to do anti-collision (in tags per second)]	200[a] or 500[b]	200

[a] This value corresponds to the 200 kHz bandwidth.

[b] This value corresponds to the 500 kHz bandwidth.

11.3 Environmental considerations

The operating environment will vary significantly by location. A description of various environmental factors associated with RFID can be found in ISO/IEC/TR 18001. Consideration will be given to the following general parameter set, as derived from the product user community.

— The product RFID tag must function properly in the temperature range from −40 °C to +70 °C. It must be able to endure for a specified period of time harsher conditions in the range −50 °C to +85 °C.

— Humidity 95 %.

— Warehouse construction, including racking.

— Transportation mode.

— Speed and direction of movement of tag relative to reader.

— Orientation of tag to reader (i.e. controlled or random).

— Read distance.

— Write distance (if applicable).

— Electro-magnetic interference from motors, fluorescent lights, other spectrum users.

— Electro-magnetic characteristics of the tagged item.

— Shape and size constraints on antenna, and any requirement to decouple antenna from tagged item.

— Form factor constraints in terms of size, shape, resistance to pressure, temperature, moisture, cleaning and contaminants (dust, oil [natural food, petroleum and synthetic], acids and alkalis).

— Method of attachment of form factor.

— Resistance of readers to heat, moisture, impact damage.

— Health and safety regulations.

A description of various environmental factors associated with RFID can also be found in ISO/IEC/TR 18001.

performance can only be achieved by appropriate shielding of the interrogators against other interrogators.

The performance of passive RFID (range and rate) can be adversely affected by the presence of metal and/or liquids in the container, transport unit or (packaged) product. Appropriate shielding can be used to reduce interference.

If the process requires read rates in excess of 200 tags/sec sequentially, parallel readings should be considered.

11.4 Tag orientation

It should be assumed that the handling operation is unable to predict the orientation of the individual (packed) products in higher levels of packaging and transport. This may hamper the effective use of the reading equipment on site and/or en route.

11.5 Packaging material

A wide range of materials (such as wood, metal, plastic, glass, paper and textile) is utilized in primary packaging. Also, materials for coding and identification, as well as branding and the representation of legally required information, are used. These can interfere with the RFID equipment.

11.6 Shock loads and abrasions

Typically, the various products are subject to shock loads during the physical handling process. This may result in intentional or unintentional damage to the RFID tag. Placement and insertion of the tag should be done in such a way that damage due to shocks is minimized.

11.7 Tag lifetime

Tags attached to product packaging will be continuously used throughout the life of the product package. Product packaging RFID tags shall be capable of being continuously used throughout the life of the product package, without failure.

11.8 Minimum system reliability

Systems where tags are positioned, programmed and presented to reading equipment in accordance with the provisions of 11.3 and ISO/IEC 18046 (all parts) shall have a minimum read reliability of 99,99 %, i.e. no more than one no-read event in 10 000 readings, and a read accuracy of 99,998 %, i.e. two undetected incorrect readings in 100 000 readings.

11.9 Air interface

Product RFID tags shall operate in either one of two frequencies ranges and comply with the appropriate parts of ISO/IEC 18000. With agreement between trading partners either 18000-63, Type C or the ASK air interface of 18000-3 Mode 3 may be used. It is recommended that tags supporting ISO/IEC 18000-63, Type C also be able to support ISO/IEC 18000-3 Mode 3.

11.10 Memory requirements for application

The memory requirements for product tagging RFID tags may be grouped into three basic categories: 96 bits, 256 bits, and greater than 256 bits. Industry surveys have yielded recommendations for RF chip manufacturers to provide for 2 Kbits and 4 Kbits. Use of alternative memory requirements shall not result in changes to the minimum and mandatory data elements of their format or tag data structure as otherwise specified in this International Standard. Annex B provides a listing of useful data fields for product life cycle management totalling 152 bytes (1 216 bits).

11.11 Sensor interface, if applicable

Sensors and batteries integrated into or onto a tag and their tag operations or management shall not interfere with the operation of the tag as required by this International Standard.

Sensor equipped Product Packaging RFID tags shall conform to ISO/IEC/IEEE 21451-7 for the wired or wireless interface.

The 2,45 GHz O-QPSK option of ISO/IEC/IEEE 8802-15-4 and ISO/IEC/IEEE 21451-5 shall be used for the wireless interface between the tag/access point and the sensor.

11.12 Real time clock option

A real time clock shall be included with product tagging RFID tags that are sensor equipped and where the application requires a time stamp. The accuracy of the time compared to actual Coordinated Universal Time (UTC) shall be no worse than ± five seconds per day. The representation of time shall be UTC ("Z" – Zulu) and formatted as described in ISO 8601, namely, yyyy-mm-ddThh:ssZ, for example 2012-01-01T14:55Z. When time is represented, the character "T" serves as the delimiter between "dd" and "hh".

11.13 Safety and regulatory considerations

All tags, interrogators and antennas conforming to this International Standard shall meet the safety and regulatory requirements of the country where the technology is used. The use of passive or semi-passive (battery assisted) RFID tags shall also be restricted in hazardous environments, such as near or around explosives or flammable gasses, unless these devices have been certified as safe for such use by appropriate authorities.

All tags conforming to this International Standard shall meet national safety and regulatory requirements to include power, duty cycle and electromagnetic radiation.

11.14 Non-observable data

The nature of non-observable data is such that when individual data fields within a tag are protected by an interrogator command, the command may implement whatever protection measures are chosen, provided that the protection measures do nothing to impact, interfere with or deteriorate the operation of other tags in the supply chain.

11.15 Tag recyclability

All tags attached to the product may be used to facilitate the recycling of the product and the tag itself. In this respect, it may also be feasible to reuse the tag after reprogramming, however without compromising the supply chain data structure. The exact implementation depends on cost of the tag and environmental implications of reuse/recycling. It will not be possible to use RF tags for recycling if the tags are "killed".

The recyclability of product tags described in this International Standard is dependent upon the component materials used in the individual tags. The tag manufacturer shall clearly mark product tags with recycling instructions or an appropriate logo to assist in the proper disposal of the tag. Guidelines for tag recyclability can be found in ISO/IEC/TR 24729-2.

11.16 Tag reusability

Technologically all RFID tags are theoretically reusable. Because of the unique identification aspects of product tagging, the permanent nature of the physical attachment of the tag, and the low cost of the tags themselves, product level tags are generally not reusable for commercial retail items and commodity items.

High value and mission critical items may utilize higher functionality (read/write, larger memory, and possibly sensors) tags whose cost may justify their reuse. Tags intended for reuse shall clearly be marked with appropriate human readable characters or logos to enable identification, reclamation and return. Prior to reuse, reusable tags shall have their headers checked for data integrity and user memory cleared.

12 Tag location and presentation

Guidelines for tag location and presentation can be found in ISO/IEC/TR 24729-1.

12.1 Material on which the tag is mounted or inserted

The potential disturbance of metals and other reflective materials as well as liquids and other absorptive materials on the product shall be considered in the RF tag mounting to minimize disturbance of the RF signal.

12.2 Geometry of the package/tag environment

RF tags should be affixed to the product in such a way to minimize the disturbance of the RF signal. This pertains to both the product package and the products it is containing. See ISO/IEC/TR 24729-1.

13 Interrogator and reader requirements

13.1 Safety and regulatory considerations

All RFID tags and interrogators shall comply with IEEE C95-1 and ICNIRP guidelines.

All interrogators and readers shall comply with the specific power, bandwidth and duty cycle requirements in addition to all of the local radio frequency regulations for the location in which they are used. In addition, all interrogators and readers intended for use in hazardous environments shall carry the appropriate specific information for use in hazardous environments.

13.2 Data privacy

13.2.1 Aggregated data

Security of aggregated data shall be the responsibility of the collector. Data collectors and data storage operators shall comply with all applicable personal privacy regulations and rules governing the collection, storage and dissemination of personal data. Personal data collected by or incident to the reading of an RFID tag shall be accorded the same protection and security as personal data collected by any other means.

13.2.2 Company proprietary data

Security of product data collected from or incident to the reading of a product RFID tag is the responsibility of the company collecting the data. Companies wishing to restrict the collection of company proprietary data from product RFID tags shall utilize appropriate forms of data security. As security/protection of tag data may be compromised, use of RFID product tags to carry sensitive, classified or proprietary data should be limited.

14 Interoperability, compatibility and non-interference with other RF systems

All RFID systems including tags, interrogators and readers shall operate on a strict non-interference basis with all other RF systems operating in the same spectrum. All RFID systems including tags, interrogators and readers claiming conformance with this International Standard shall be interoperable and compatible at the specific frequency designed.

Annex A
(informative)

Proposed guidelines for the verification and qualification of design and manufacture for RFID chips and transponders for tyres

A.1 General

The objective of this annex is to provide background, reference information, and practical knowledge in the selection and verification of the design and manufacturing quality for *RFID chips and transponders for tyres*.

The performance of RFID devices, particularly those operating in the UHF band (860 MHz to 960 MHz), is strongly influenced by the construction of the RFID-enabled device (from the chip to the transponder), where it is applied to the object, and the characteristics of the underlying object. In this regard, much more care has to be taken in selection and placement of the RFID-enabled device on/or in the tyre in comparison with a conventional bar code as specified in MIL-STD-129 or ISO 15394. This in turn requires the additional knowledge and practical guidelines for RFID chip and transponder selection and verification of design and manufacturing quality that are provided here. This annex targets item level tagging where the RFID tag may be present in various formats, including a label, incorporated into a patch which then becomes permanently affixed to the inner or outer surface of a tyre, or incorporated during manufacture into the structure of the tyre as an integral part of the tyre.

This annex includes chip as well as transponder design and manufacture guidelines.

A.2 General terms and definitions for initial reference design

Subclauses A.2.1 to A.2.4 give a general description of the current design of a tag for use in tyres, broadly describing the physical design for a first generation tag for this service condition.

A.2.1 Life-of-tyre application

The category of “life-of-tyre” RFID installations, where an RFID is permanently associated with a tyre and is intended to remain functional for a substantial portion of the tyre’s life. These RFID transponders can be included in the structure of a tyre as it is being built, or they can be applied as a “patch” to an interior or exterior surface of a tyre after manufacture. This International Standard addresses both types, and is orientated specifically to the case where an RFID with a dipole antenna is embedded and cured into rubber.

Temporary label RFID solutions will also be addressed only to ensure that the correct degree of testing and qualification occurs.

A.2.2 Tyre size specification

Tyres come in a variety of sizes, spanning several orders of magnitude in size, weight, and load-carrying capacity. Most of the requirements that follow are common to all tyres, but every specific application shall be examined carefully to ensure optimum performance.

A.2.3 “Rubber”

In this context, the term “rubber” refers to either natural or synthetic compounds commonly used in tyre construction.

A.2.4 Passive RFID

The term passive RFID transponder is used to describe the combination of an RFID integrated circuit (chip) bonded to an antenna, where the antenna is used for both two-way wireless communication and to draw power from the reader RF signal to operate the RFID chip.

A.3 Management systems

The ISO 9000 and ISO 14000 series of International Standards emphasize the importance of audits as a management tool for monitoring and verifying the effective implementation of an organization's quality and/or environmental policies. Specifically, manufacturers of RFID hardware (such as readers, interrogators, transponders, and tags), will benefit from well established and implemented ISO 9000 and ISO 14000 conformity programmes. The ISO 9000 certification process requires individual companies to undergo and pass an outside conformity audit and can include internal assessments.

ISO 9000 conformity requires use of documented repeatable processes that result in products that meet customer requirements. Fully conformant process outputs meet or exceed customer requirements by the use of process control and total quality management techniques. Use of specific techniques or procedures is not required for conformity.

ISO 9000 lays out the basic principles that underlay a quality management system. ISO 9001 details the specifics of the quality system at each of the organizational levels. ISO 19011 contains the actual audit guidelines. ISO 9004 contains guidelines on continual process improvement.

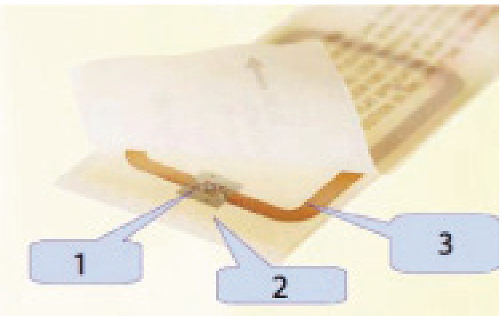
ISO 14000 utilize the same format as the ISO 9000 series and are designed to be complementary to each other. Conformity with ISO 14001 does not mean that the production processes and policies for the company are environmentally friendly, rather that the company meets regulatory requirements and has an established policy and commitment to continuous process improvement.

Conformant hardware manufacturers can be independently certified as ISO 9000 conformant and ISO 14000 conformant.

A.4 RFID chip technology and quality

Two approaches to placement of transponders are shown by way of examples in Figures A.1 and A.2. These examples do not indicate that an acceptable RFID transponder is in any way restricted to these concepts; rather they illustrate examples of working concepts available at the time of writing.

Figure A.1 depicts an RFID transponder in the form of an RFID Smart Label with the various components identified. This section is instructive for temporary RFID labels for tyres.



Key

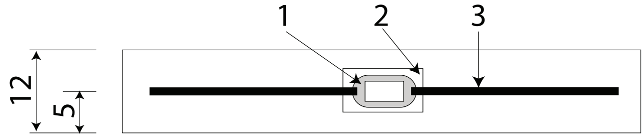
1 RFID chip

2 substrate (e.g. plastic foil)

3 antenna (printed, etched or stamped)

Figure A.1 — RFID transponder (Smart Label)

Figure A.2 is instructive for RFID transponders capable of being cured directly into or onto a tyre. The transponder consists of a UHF/SHF RFID chip packaged in a TSOP-8. The TSOP-8 is soldered to a thin FR4 circuit board, and soldered to the TSOP-8 are two helical springs forming a dipole antenna. The antenna leads have been tuned to resonate at 868 MHz and 960 MHz when cured into the tyre.



Key

1 solder

2 PC board w/IC

3 helix, 12 turns/cm, 1 mr OD

NOTE 1 Dimensions in millimetres.

NOTE 2 Overall length to be specified in purchase order.

NOTE 3 Tolerance window shown (tag is placed ± 6 mm in a straight line).

Figure A.2 — Initial reference design: RFID transponder directly cured into or onto tyre

A.4.1 RFID chip quality

The quality of any component contributes to the quality of the integrated product whether the product is a single device or a system. Practical consideration of quality results in a definition that quality of any item (or component) is represented through the characteristics that result in meeting the item's intended use (i.e. user requirements). In the case of an electronic component such as an RFID chip, the characteristics of interest are

— physical,

— electrical, and

— functional.

The physical characteristics are defined by the various mechanical qualities and interfaces involved in the manufacturing process whereby the RFID chip is attached to an antenna/substrate to produce a functioning RFID transponder. It should be noted that not all transponder assembly processes have the same requirements for the physical characteristics of RFID chips for the production of quality RFID transponders. Consideration should be given to specifying RFID performance requirements that are not peculiar (or unique) to a specific transponder manufacturing process. This is particularly important where the manufacturing process is proprietary. Applications of RFID chip and transponder technology to tyres are perhaps the most challenging with regard to mechanical endurance. In addition, for the embedded version, the transponder shall survive the moulding/curing process.

The electrical characteristics for an RFID chip are generally well defined in the product specifications of the various RFID chips. As the primary electrical interface for a passive RFID chip is through the contacts for the RFID antenna, impedance matching between the RFID chip and antenna is usually the most critical electrical interface issue. Under the rigors of the tyre applications, secondary packaging for the chip may be required. The chip may first be packaged in a standard small outline package (SOP) prior to antenna attachment. The SOP package adds the potential benefit of both mechanical and thermal isolation of the IC. This secondary packaging shall also be taken into account in the process of impedance matching of the system.

The functional characteristics of an RFID chip are completely defined by the air interface protocol to which the RFID chip is conformant. RFID conformance testing (e.g. ISO/IEC 18047) shall be used to verify the functional quality of the RFID chip. This is key to ensuring design robustness, and in avoidance of an inadequate design.

Proper conformity to the physical, electrical and functional requirements allows a wide variety of passive RFID transponders to be produced from a common RFID chip. This results in increased interoperability and reduced cost. For example, a large variety of passive RFID transponders are available with a common RFID chip, but only a few designs are capable of being an integral part of a tyre.

A.4.2 Chip packaging — Physical interface

A.4.2.1 Label-based transponders

The RFID label chip is generally connected to an antenna via a direct electrical contact, though there are other concepts in development that may afford advantages for low-cost assembly. A caution is that even an RFID label designed for tyres as a temporary attachment, such as for logistics, needs to have robust mechanical features (see 7.3). Most transponder assembly methods currently use a direct connection between the RFID chip and the tag antenna.

A.4.2.2 Pick-and-place chip

Currently, most inlet manufacturers use pick-and-place machines (robots) to pick an integrated circuit (IC) from a silicon wafer, flip it over, and carefully place it on an antenna. Two tiny metal pads on the chip have to touch the ends of the antenna to make the electrical connection (there are a variety of ways to bond the antenna to the pads). However, picking and placing chips is costly and is becoming more difficult as RFID chip sizes decrease.

A.4.2.3 Intermediate carrier

As chip size decreases, the traditional intermediate carrier process becomes more challenging, as the alignment requirement (RFID chip to antenna pad) becomes more demanding. As a result, there have been developments focused on providing a “standardized” RFID chip delivery method using an intermediate attachment mechanism. This approach calls for the semiconductor manufacturer to deliver the RFID chips attached to a standardized delivery structure (carriers, tabs, interposers, etc.). The inlay manufacturer/label converter can then handle the RFID chips (subassemblies) in a standardized manner since the connection structure to which they are attached is “fixed”, independent of the chip size. Additionally, the carriers to which they attach the antenna have a physically larger structure allowing greater flexibility and reduced precision requirements.

Such delivery mechanisms provide significant benefits, including:

— simple, flexible RFID manufacturing process, independent of IC size;

— standard delivery type, i.e. 35 mm tape reel format with four units per 4,75 mm pitch allows one package format;

— robust, well-industrialized, high volume technology, with high yields and high assembly throughput of 10 000 units per hour;

— removal of the need for transponder manufacturers/label converters to connect the RFID ICs in a clean room environment;

— allowing flexibility for inlet antenna design, as connect areas on the flip chip package are larger than the bond pads of the ICs;

— allowing many different connection strategies between the IC and the inlet antenna, such as soldering, gluing, crimping;

— better protection of the IC.

Negative aspects include:

— carriers add one unit operation to assembly;

— more connections that may fail.

See also A.4.2.4.

A.4.2.4 SOP packaging and solder bonding — Method used in baseline tyre transponder design

Two different style RFID transponders can be used. Each type uses a Mini Small Outline Package (MSOP – Ref. JEDEC MO-187E/AA) packaged chip solder attached to antennas. An MSOP is a traditional electronic package employed to protect the chip from its environment, including the ability to cure the device into rubber. Other attachment techniques such as flip chip or direct bonding have not been proven to be sufficiently robust in the tyre application. One style of an MSOP tag may be manufactured on a flexible substrate. The other style of MSOP transponder has spring wire antenna solder bonded directly to the MSOP on miniature thin board. Conformity with environmental directives (e.g. RoHS) can require process changes due to materials' characteristics. Lead-free solder reflow will likely require higher temperatures resulting in higher peak component temperatures. Care should be taken to ensure against package damage due to higher internal pressure resulting from absorbed moisture.

A.5 Assembly — Transponder

Various assembly process approaches have been explored in search of a reliable means to attach the RFID chip to the tag antenna. The intent is to make the processes as independent as possible while minimizing assembly cost.

An example is given in Figure A.3, which shows the general process chain for RFID Smart Labels. The activity depicted in the centre of Figure A.3, the transition from the RFID chip manufacturer to the inlay manufacturer/label converter, is critical to the production of cost effective RFID transponders.

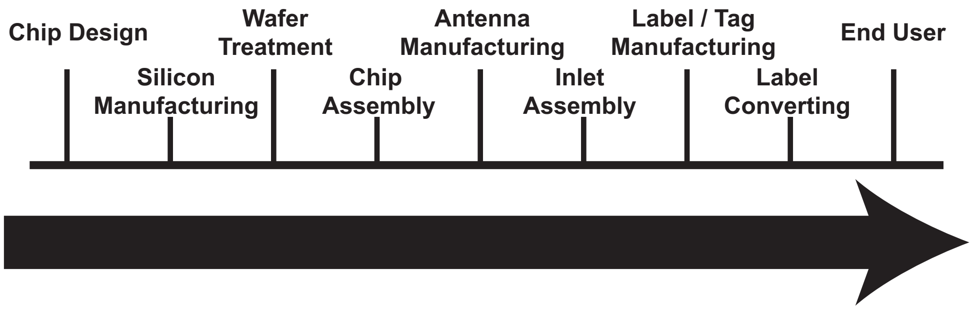


Figure A.3 — Label process chain

A.6 Chip/transponder interface

A.6.1 Physical interface

A.6.1.1 Physical interface requirements

As noted above, there are a variety of assembly methods potentially usable for establishing the mechanical interface between the RFID chip and the transponder antenna. Proper matching of chip physical characteristics to the assembly process is crucial. Requirements related to these critical physical characteristics are as follows.

— Antenna contact points shall be widely separated to minimize interaction.

— Antenna contact areas shall be maximized while maintaining physical isolation and separation.

— Flip chip assembly shall use an appropriate underfill to provide mechanical durability across specified operating environment.

— Chip design shall include a buffer region along edge boundaries.

Chip delivery structures (straps, tabs, interposers, etc.) shall survive flexure due to thermal expansion and mechanical stress transmitted through inlay substrate.

Bonding materials shall support conformity to RoHS and WEEE requirements/directives.

A.6.1.2 Attachment methods — Chip/antenna

Some examples of different chip/antenna attachment mechanisms include the following.

Direct Connection: RFID chip is directly connected to the antenna, such as with conductive epoxy, stud bumping, wire bonding, wet conductive ink, etc.

Capacitive Coupling: Antenna on tag substrate couples capacitively to RFID chip.

Inductive Coupling: Integrated coil on chip is inductively coupled to external passive resonant circuit.

A.6.2 Electromagnetic interface

The electromagnetic interface of a passive RFID chip is defined primarily through the air interface definition along with the design characteristics of the product. Performance characteristics are defined for the transponder by the application requirements. These performance characteristics include the following.

Range (identification, reading, and writing), i.e. distance (metres) from the reader antenna to the transponder.

Rate (identification, reading, and writing), i.e. speed of data transaction (tags/second).

In addition to the system level performance characteristics, transponders also have directly measurable performance characteristics that are defined through the air interface specification to which they are conformant. Some critical parameters include the following.

Delta radar cross-section (RCS): This parameter reflects the differential radio reflectivity of the tag based on the digital modulation definition (i.e. 0/1). The differential radio reflectivity is a direct and significant driver of the Signal-to-Noise-Ratio (SNR) available from the rag in the return link.

Activation power density/field strength: This parameter defines the minimum power density/field strength required to activate a passive RFID tag. This is usually the most significant parameter in defining the maximum communication range (i.e. distance) of an RFID system.

Modulation depth: This parameter represents the signal available from the RFID chip through load or impedance modulation and is a direct contributor to the Delta RCS parameter noted above. It is separate from the antenna characteristics (e.g. gain, polarization).

Bandwidth: This parameter defines the signal performance of a tag across the defined operating band. As there may be significant differences in antenna characteristics as a function of frequency, this parameter is a strong indicator of range performance for tags across the defined RF band. This is of particular interest when the defined RF band is significantly broad (e.g. 860 MHz to 960 MHz).

It should be noted that many of these defined requirements imply a matching of characteristics between the RFID chip and the antenna as represented in the transponder. As such, many electromagnetic interface characteristics of the RFID chip (e.g. impedance, bandwidth) shall be matched to the antenna/inlay design and fabrication process. Thus a less sensitive, as measured by activation power density, RFID chip can be combined with a larger and more efficient antenna structure to meet the same user performance requirement (i.e. range) as a more sensitive RFID chip matched to a smaller/less efficient antenna. Both may be completely acceptable to the user from an application performance standpoint.

RFID chip electromagnetic interface conformity shall be established through appropriate conformance tests using ISO/IEC 18047. In a similar manner, electromagnetic interface conformity relating to performance shall be verified through conformity testing using ISO/IEC 18046.

A.6.3 Functional interface

The functional interface directs relates to the RFID chip's conformity to the air interface protocol for which it is designed to implement. Functionality is defined by the various actions the RFID chip can perform in its support of the specified air interface protocol. These functions can include

wake-up,

group selection,

anti-collision,

reading,

writing,

error handling, and

locking/security.

RFID chip conformance shall be established through conformance testing using ISO/IEC 18047 for the appropriate air interface supported.

A.7 Transponder

A.7.1 General

The current AIAG B-11 Tyre and Wheel Standard for passive RFID transponder chips for tyre transponders meets ISO/IEC 18000-63, Type C. Additional transponder types may be utilized in the future, once defined. The nominal memory size is 1 024 bits, with the size of the EPC and user memory banks defined in the AIAG B-11 specification.

A.7.2 Passive UHF transponder frequency considerations

RFID readers are subject to local regulations regarding frequency and allowed reader power. For example, in North America, the nominal operating frequencies are 902 MHz to 928 MHz, conforming to FCC Part 15.247. In Europe, the nominal operating frequencies are 865 MHz to 868 MHz, conforming to EN 302 208-1 (this is a recommendation where only national countries have national regulations guided by pan-European recommendations). In Japan, the pending nominal frequencies are in the range of 950 MHz to 956 MHz, conforming to the Radio Law of Japan. Local regulations should be consulted before purchasing and deploying UHF RFID readers.

The transponder, when embedded within or applied to the inside wall of the tyre, shall be functional over the full range of UHF RFID frequencies that are approved for use in most countries, i.e. 860 MHz to 960 MHz. It is acknowledged that transponder-reading performance may differ in different regulatory environments. The mandatory minimum read range is 0,6 m for passenger tyres in a factory environment.

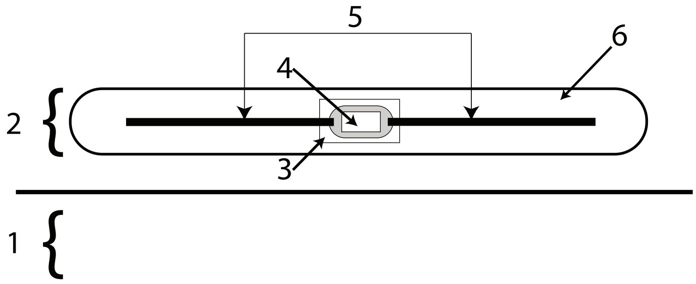
A.7.3 Transponder antenna design considerations for initial reference design

The method of transponder construction affects its technical performance, operating life, and environmental compatibility, as well as its cost. Certain special considerations apply for use in tyres.

UHF transponder antennas may be fabricated in a number of ways. Antennas produced by each process have different electrical and mechanical properties.

The antenna shall be a dipole configuration with the two radiating elements made from a spring steel coil or similar material which shall not deteriorate in conductivity or fracture over the expected tyre life and the full range environmental conditions. Antenna tuning may be optimized for the primary region of tyre sale or intended usage, but in any case the transponder shall be functional with reduced read range over 860 MHz to 960 MHz.

Figure A.4 gives the basic conceptual arrangement of parts.



Key

1 another layer of tyre

2 one layer of tyre

3 package and support

4 RFID MSOP

5 antenna

6 embedding

NOTE Both the "package and support" and the "embedding rubber" are purposely shown "cloudlike" to indicate that although performance standards do apply, no specific shape or dimensions are required by this International Standard.

Figure A.4 — The basic conceptual arrangement of parts in a tyre tag

A.7.4 RFID assembly size and shape

For passenger tyres and larger, the RFID chip with its package and support (not counting antennas) form a rigid structure that should fit within a "box" no more than 12 mm by 6 mm by 2 mm. Sharp corners are to be avoided, as they concentrate stress in the surrounding rubber. In most cases the smallest structure that can meet the other requirements for strength and interface with the antennas will be the best structure. It is also conceivable that a rigid core could be surrounded by a more flexible extended structure that is larger in one or two dimensions than the specified box.

A.7.5 Flexure of the RFID transponder and antenna

RFID transponders mounted in tyres will undergo three types of flexure:

tyre shipping, handling and mounting flexure;

— continuous, cyclical flexure as the tyre rotates;

— shock flexure caused by the tyre rolling over or being impacted by bumps, potholes or road debris.

The antenna shall be capable of sustaining repeated cycles of flexing suitable for the specific tyre application intended. "Flexing" includes extension, compression, bending, and twisting. The number and severity of the cycles depends on the particular target tyre.

Depending on the materials and methods used in production of the transponder antenna and the chip bonding method, every transponder has a minimum allowed bending radius. Flexing or bending the finished RFID transponder to a radius smaller than this during the application process to the tyre, or during usage, may result in RFID failure from fracture of antenna, chip or the chip-antenna bond.

The zone where the flexible antennas approach the rigid RFID package and support assembly is an area of particular concern for antenna fatigue failures. Suitable design features shall be employed to manage stress concentration.

A.7.6 Strength of electronic chip assemblies

It is impossible to give a single specification for mechanical strength that will be satisfactory in all cases. The RFID manufacturer shall coordinate with the customer for specific information. For example, during the rubber curing cycle, the RFID chip and its associated packaging and support components will be subjected to a combination of pressure, heat and time that is determined by the needs of the patch or tyre manufacturer. Depending on the particular application, there may be some rubber flow or deformation during curing that would tend to exert lateral forces on the surface of the assembly and may cause the antennas to tend to pull away from the package and support. In use, the RFID assemblies will be subjected to mechanical stresses arising from tyre deformation. There is a statistical component to the in-use deformations: a baseline deformation occurs on every revolution of the tyre, and more severe deformations occur when the tyre runs over a bump. It can be noted that copper component leads are not capable of sustaining even tiny amounts of repeated strain or bending without fatigue failure.

A.7.7 Antenna electrical properties

The antenna shall be configured in conjunction with the RFID chip to achieve at least the minimum read range needed for the particular application. Generally, this means the assembly shall be tuned to resonance in the target environment and shall not have significant resistive losses relative to the needs of the application. Note that the antenna will not be resonant at the operating frequency until it is placed in its target environment. The RFID supplier may ship the assemblies with antennas longer than needed, so that the customer can trim them to the specific length needed in a particular environment.

While this International Standard makes no specific prescription, it can be noted that

— a resonant antenna surrounded by a dielectric material is shorter than one in air,

— a conductor in the form of a helix has inductance, which further shortens the resonant length of an antenna,

— steel is a very poor conductor at UHF frequencies, but it can be plated with conductive metal, and

— the “skin depth” of conductive metals at UHF frequencies is measured in units of micrometres.

A.7.8 Tag insulation from tyre rubber

To work properly, a dipole antenna must be insulated from contact with conductive rubber. Most of the rubber compounds used in tyres are “conductive”, that is, their carbon black concentration exceeds the “percolation threshold.” In general, the antenna must be insulated from electrical contact with most of the normal rubber compounds used in tyres. A usual formulation for this would be to employ rubber of similar composition to the tag’s nearest neighbour only at a significantly reduced carbon loading (reduce by typically 30 % to 60 %).

Typically, provision of the insulating layer of rubber will be the responsibility of the tyre maker or patch maker who buys the RFID assemblies, and not the RFID manufacturer. An adequate insulation layer is critical to the performance of the unit, and the tyre or patch maker must understand that the RFID manufacturer is not responsible for poor results caused by inadequate insulation. Although specific compounds may vary, in general insulating rubbers can be defined as rubbers with resistivity > 10^5 ohm·cm. However, the best way to evaluate candidate rubber compounds is to measure the dielectric permittivity (ε') and dielectric loss (ε''). Successful RFID transponders have been made using materials characterized at 915 MHz to have $\varepsilon' < 5$ and $\varepsilon'' < 0,2$, although higher values might work.

A.7.9 Bonding components to rubber or elastomer

The RFID package and support assembly and the antennas shall all be bonded to the embedding rubber that surrounds them. This bonding can be accomplished with a suitable adhesive system that acts during the rubber curing cycle. One of the reasons for this requirement is that the RFID assembly shall “do no harm to the tyre”; the other reason is to achieve a long lifetime of the assembly. Either the RFID manufacturer or the patch or tyre maker may apply the adhesive system, according to their specific needs. At least one suitable adhesive system can be applied to the assembly at the point of manufacture; it dries to a paint-like film that is not tacky and is relatively stable during gentle handling.

A.7.10 Attachment of patches

If the RFID transponder is cured into a patch for later application to a tyre, the patch maker shall demonstrably master the adhesive technology for attachment of the patch to the tyre. The tyre-repair industry is able to supply candidate adhesive systems.

A.8 Transponder testing and qualification

The ultimate customer will determine the numerical criteria necessary to specify a successful product. A minimum set of criteria will include specifications for the following:

— read range, or percentage of successful reads under conditions of actual use;

— expected lifetime, expressed in distance travelled, assuming normal tyre operating conditions;

NOTE It might not be practical to test this directly, but laboratory tests or highway tests can be used as indicators.

— required minimum operational lifetime under laboratory test conditions, such as

  — low-pressure endurance (test with high flexing and high temperature conditions),

  — high-speed endurance (test with high temperature and high stresses in the tyre), and

  — endurance with cleats (test with high flexing but relatively normal temperature);

— the ability to survive recapping operations (if applicable);

— verification of manufacturability in the target application;

— verification of integrity after manufacture, including bonding of components to rubber.

NOTE Generally, a good bond is a “rubber-tearing” bond; the specific force required to separate a part from the rubber is less important than the nature of the break.

In addition, the customer may require the supplier to meet other quality-control practices such as certifications that raw materials meet specifications or controls on process steps that cannot be easily tested non-destructively on the completed product.

A.8.1 Environmental considerations

Both extreme limits and cycling of environmental conditions can reduce RFID transponder operating life. Failure modes include chip-bonding failure, antenna fracture, antenna corrosion and electrostatic discharge damage to the chip. Accelerated life testing is recommended before deployment when unusual environmental conditions are expected to determine any limitations on working life of the transponder as mounted. These conditions may include outdoor storage, desert heat, arctic cold, nuclear or electromagnetic radiation exposure, usage underwater, chemical wash-down, etc.

A.8.1.1 Temperature range

For full-range military and commercial usage, the following recommendations apply.

Reading temperature range: −40 °C to +70 °C

Storage range (non-reading): −51 °C to +95 °C

Tyre fabrication temperature range (non-reading)

A.8.1.1.1 Tyre manufacturing conditions

The transponders shall survive these conditions

— 175 °C for 20 min or

— 160 °C for 45 min

— Max. moulding pressure > 5 000 kPa

A.8.1.1.2 Tyre operational conditions

Transponder shall be operational at a temperature between −40 °C and +85 °C.

Transponder shall survive indefinitely between −40 °C and +110 °C.

Transponder shall survive up to 8 h between 110 °C and 125 °C.

Transponder shall be operational under maximum tyre inflation pressures, e.g. passenger/light truck up to 413 kPa.

A.8.1.2 Humidity, underwater usage and the like

It is assumed that the transponder is embedded in or attached to the tyre. Therefore, humidity and water or chemical contact are not anticipated to be issues. Extreme cases of heat and humidity noted to affect the tyre itself could similarly affect the electronic. However, note that the transponder may not be readable when the portion of the tyre on which it is mounted is underwater, in snow, in mud, in soft sand, in gravel, etc., due to absorption of the R reader RF signal by the intervening foreign material.

A.8.2 Electrostatic discharge (ESD) conformace

Many processes can easily generate static electricity, including tyre flexure. It is especially a problem in low-humidity environments as found in desert, winter or high-altitude conditions. Discharge of static electricity through the transponder antenna into the RFID chip can cause permanent chip failure or loss or corruption of the stored data. Antenna designs can help mitigate ESD.

The ESD resistance of the transponder in free air shall be at least 2 kV. Conformance shall be verified by a standard test such as MIL-STD-331, or simply by discharging a 500 pF capacitor charged to 2 kV DC through a 500 Ω resistor.

The 500 pF capacitor and 500 Ω resistor simulate the characteristics of a human body discharge.

During testing, circuit inductance should be limited to 5 µH.

The discharges shall be applied in both polarities at various points on the RFID-enabled label as applied to the ends of the transponder antenna.

A minimum of five RFID transponders shall be tested to provide a scientific basis for concluding that the requirement is met.

A.8.3 Dealing with defective transponders

Systems shall test each embedded transponder to verify that the transponder is both functional and the data properly encoded. Tyres with defective transponders shall have a functional transponder applied as a patch and vulcanized onto the inside side wall, not closer than 10cm to the defective transponder, and programmed with the same data that would have been programmed into the embedded transponder.

A.8.4 Temporary label transponder — Specific considerations

For the purposes of this International Standard, an RFID label is defined as an RFID inlay or transponder laminated to an adhesive based label stock attached to a release paper carrier web. Some of the important requirements of the RFID label are the following

The label is used to store tyre manufacturer's information and identification. The end receiver may also request manifest information or unique product identification (i.e. UII or EPC).

Insert will be adhered to a label, which will in turn be adhered to a tyre.

Label/tyre combination are expected to stay intact through

tyre manufacturing processes of inspection, shipping, storage, and loading onto trailers for transportation to vehicle assembly plants, tyre distributor or direct retailer,

transportation from the tyre manufacturer to the automotive manufacturer, distributor or direct retailer, and

processing in the vehicle plant or similar application facility, including but not limited to receiving inspection, tyre/wheel assembly, wheel vehicle assembly, wheel balance/rotation final assembly, and final assembly inspection and data gathering.

Tyre applications not requiring permanent tagging are expected to employ RFID labels. While these labels are not expected to be "life of tyre", they are expected to survive traditional manufacturing, logistics and tyre mounting applications. Some of these requirements of use are listed below.

A.8.5 Tyre RFID label's test requirements

a) The label shall not lose any more than 20 % of its original strength (do a 90° pull test after the label has been applied for 1 h) after being applied to a tyre and placed in an oven at 71,5 °C for 6 weeks (tyre is allowed to cool for 1 h before testing).

b) The label shall not loose any more than 20 % of its original strength (do a 90° pull test after the label has been applied for 1 h) after being applied to a tyre (cross terrains) and placed in a refrigerator at −40 °C for 1 week (tyre is allowed to warm for 1 h before testing).

c) The original strength of the label shall exceed the current 2D label employed for AIAG B-11 standard applications.

d) 99,6 % of the labels and RFID tags shall be readable after being applied to a tyre, maximized, shipped to LA, shipped back to Detroit, unloaded, mounted with an automatic tyre mounter and place through a simulator.

e) 99,6 % of the RFID labels shall be readable when applied to a tyre and placed on a conveyor (label up) moving at a speed of 0,61 mps. The tyre shall be able to be placed in any orientation on the conveyor (1 m wide) and be read with a single antenna mounted 1 m above the conveyor.

f) 99,6 % of the RFID labels shall be able to be written to (128 characters) when placed on a conveyor (label up and any orientation) moving at 0 speed within 5 sec with a single antenna mounted 1 m above the conveyor.

g) Logistics and shipping shall include as a minimum 1 000 tyres stacked in a dense packing configuration and shipped an extended distance without loss of any labels.

h) The labels on the tyres in f) shall survive wheel assembly and mounting without loss.

i) Finally, the same labels on the tyres [f) and g)] shall survive transport through the vehicle assembly facility to tyre vehicle mounting.

j) Optionally, the label should be removed at final shipping preparation of the vehicle or at the landing point of vehicle distribution.

A.8.6 Adhesive residue (label designed to be removed after mounting)

Adhesive residue on tyre after label is removed should be minimized as much as possible (goal is less than 10 %) and should be easily cleaned with a heptane solvent or citric-based cleaner.

A.8.7 Tyre RFID label placement specification

A.8.7.1 Dielectric variations

The final feature that is a key feature of this specification is the fact that the tyre has generally a very lossy dielectric value for the rubber, due to the carbon content of the tyre as well as the presence of metal in parts or most of nearly all tyres. The reading distance for tyres can vary tremendously based on carbon content as well as the proximity to metal such as tyre tread steel. For example, a label designed for a passenger tyre can read at 0,76 m, while the same label attached to an earthmover tyre would read at only 0,127 m. This example emphasizes the impact of carbon. In addition, a tyre with shallow tread results in more interference from the steel in the belts. The same drop in performance can occur in a single passenger car tyre when the identical label from the sidewall that has no steel cords is moved to the tread that has a significant number of steel cords. Finally, the fact that tread by design is a series of blocks or bands with features means that there are air spaces that would have a different dielectric and result in variability in tuning. Sidewall areas tend to lack steel or have lower density of steels cords (truck tyres), thus reducing or eliminating one source of interference. Sidewall areas inherently have lower carbon content than tread areas and therefore are more RF friendly.

A.8.7.2 Label location

The RFID label requires placement on the sidewall of the tyre. Factory automation dictates that the side read be available without the need to specially orientate the tyre. For example, as the tyre moves on a conveyor or is suspended on a hook the label would be read from the side. A tread label would cause undue cost in finding the RFIS due to specific orientation.

Wheel assembly and vehicle assembly also dictate the need for a sidewall label to allow for reading tyre, tyre/wheel assembly and tyre/vehicle while on production lines.

Tyres with sidewall tags can be read when in a retail display, provided an air space of one inch exists between tyres. This has the advantage of ensuring that the exact tyre desired is being read. The challenge with a tread label is that one cannot be ensured that a particular tyre is being read and not its direct neighbour. A sidewall label being read from the tread side ensures isolation and high quality read reliability.

A.8.7.3 Label size specification

The label size should be a minimum of 101,6 mm in length by 35,56 mm in height. The maximum should be 190,5 mm in length by 50,8 mm in height. Variations between 101,6 mm and 190,5 mm for length and between 35,56 mm and 50,8 mm for height are acceptable. The shape can be curved, rectangular, elliptical or other shape with the limits of the maximum length and height.

The transponder shall not represent more that 60 % of the area of the entire label (transponder plus over-label).

A.8.7.4 Label read distance

The label read distance is similar to that required by the AIAG B-11 standard for tyre and wheel identification which requires a minimum distance of 609,6 mm (as measured between the tyre surface and the reader antenna) for passenger tyres. Heavy truck tyres that have steel cords in the sidewall and can vary in design from one manufacturer to another shall have a minimum distance of 304,8 mm.

A.8.7.5 Insert specification

The insert should be designed to sustain the shipping and handling requirements.

An example set of guidelines is given in Table A.1.

Table A.1 — Insert specification guidelines

Substrate	The tag is printed on a PEN flexible substrate with laminate thickness of 0,050 8 mm (2 mil) (typical).
Physical characteristics	The label shall comprise an RF insert and a thin layer of solder mask as a cover layer. The RF insert will comprise an ASIC with an appropriate package and a substrate and an antenna attached to the package.
ASIC package	Wire bond glob top package.
Cover layer	Nominal thickness 0,025 4 mm (1 mil) (typical) over the plated copper, excluding chip attach area. Can be photo imagible or screen-printed and can be transparent.
Maximum package thickness	The overall package thickness is 1,27 mm (maximum).
Twist	The insert shall withstand 10 180° twists from one end to the other.

A.8.7.6 Adhesive type

Typically, pressure sensitive or heat seal adhesive is used; rubber based adhesive is preferred. If a heat seal adhesive is used, then its green tack shall be sufficient to hold the label in place while curing.

The ambient minimum application temperature for the label and the tyre surface should be at least 4,4 °C.

A.8.7.7 Bend radius

The RFID label shall be capable of withstanding without degradation a minimum bend radius of 12 mm.

A.8.7.8 ESD limits

The label shall withstand electrostatic air discharge of 2 kV.

A.8.7.9 Survival rate

The survival rate of the label through the defined process will be greater than 99,9 %.

A.8.7.10 Operating life (label on tyre)

The expected life of an RFID label applied to a tyre sidewall will be one year when stored at operating temperature and humidity.

A.8.7.11 Operating temperature

The RFID label shall operate at the temperature range −40 °C to +71,1 °C.

A.8.7.12 Operating humidity

The RFID label shall operate at a relative humidity range of 5 % to 95 % (non-condensed).

A.8.7.13 Surface interaction

Labels shall not introduce any surface cracks or damaging marks on sidewall that might impact functional performance of the tyre.

A.8.7.14 Label colour/marking

To ensure no interference by optical scanners in OE automotive factories as well as ensure visibility, the label shall be principally cyan in colour (Pantone or SWOT Process Cyan).

For labels intended for commercial tyres, the colour may be Process Black or Pantone Black 2U.

A.9 RFID transponder testing methods

While the visual inspection methods may be used to guide RFID-enabled label placement, a more quantitative method is useful in both confirming results and in determining the best transponder selection, polarization and placement on the transport package in terms of reader performance. Use of this method will help ensure that the labelled transport package or unit load will meet the minimum read range requirements.

The method described here requires a minimum of equipment and gives relative (not absolute) measurements of read range performance (not conformance) that may be easily compared between transponders and labelled packages made in the same test lab. By testing the same transponders and packages in multiple laboratories, meaningful correlations of test results between laboratories may be made.

For standardized performance measurement, the methods of ISO/IEC 18046 should be followed. Conformance measurement should be performed utilizing the methods of ISO/IEC 18047-6.

A.9.1 Equipment

A.9.1.1 Facility

An indoor or outdoor facility capable of maintaining a fixed relationship at a defined distance between an RFID reader system and the device under test is used. A range of 1 m with the device under test (DUT) on direct line to the reader transmit antenna is recommended; however, if the size of the package makes this difficult to achieve, an increase to 2 m is possible, but absorber material may be required on the floor between the DUT and reader system to suppress reflections. The centre of the transmit antenna should be located approximately 1,5 m above the floor. If indoor, the ceilings should be as high as possible, and the floor should be non-metallic. If available, an anechoic chamber can be used; if not, environmental adsorptions can be suppressed using suitable RF absorber panels.

A.9.1.2 RFID interrogator and antenna mounting

The UHF RFID reader will be of the appropriate frequency, designed for fixed-mount applications and will be used together with a fixed-mount UHF RFID antenna having a linear polarization, with a facility to rotate the antenna through 90° to measure tag devices designed to be dual polarized. The antenna used should be of a patch type and orientated so that the peak radiation direction is towards the device under test; the operator should always stay behind the antenna, or at least 4 m away from the test system, during testing.

A.9.1.3 RFID interrogator and antenna type approval

Both the reader and antenna should be types approved for use on conveyors in Defence Logistics Agency depots, and conformant with the appropriate radio regulations.

The reader shall have either programmable or manually step-adjustable output power; the power should be controllable in 0,25 dB steps or less.

Either a single port, receive and transmit on the same connector, or a dual port, separate receive and transmit, reader can be used; in the case of a dual port system, external attenuation should be placed in the transmit path, and, as noted above, the DUT should be on direct line to the transmit antenna.

Readers having integral antennas may be used.

A.9.1.4 Computer

A computer with appropriate reader driver software is connected to the reader. If the computer has a wireless LAN link, it should be disabled.

A.9.1.5 Antenna set-up

For a 1 m test range, it is suggested that the centre point of the transmit antenna be 1,5 m above the floor.

The transport package under test shall be set up on a plastic or wooden table. It shall be strong enough to support the heaviest transport package (24,6 kg). A moulded plastic or structural foam patio table is a good choice. Preferably, replace any metal fasteners with nylon fasteners.

A.9.1.6 Cabling

The set-up shall include computer and RF coaxial cabling, as required.

A.9.1.7 Facilities set-up

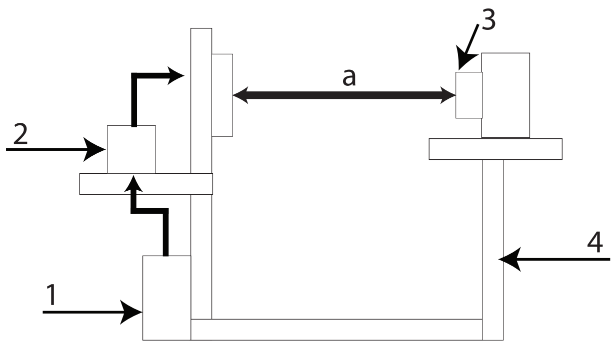
Ideal test environments are specified in ISO/IEC 18046:2006, Annex A. While such facilities are necessary for accurate absolute measurements, the simplified method described is much less costly and adequate for the purpose of guiding transponder selection and placement.

A suggested structure is shown below; more details of one implementation of this structure are currently being used for carrying out this test.

The system consists of a suitably rigid frame supporting a reader antenna at 1,5 m above the floor, a shelf mounted behind the antenna for carrying the reader equipment, external attenuator (if used) and computer system. Optionally, a layer of absorber material can be placed behind the reader antenna system to suppress reflections between the operator and computer equipment and device being tested.

A suitable low dielectric constant mount holds the device being tested.

Ensure that there are no active RFID readers within 30 m of the test in any direction, even if there are intervening walls, ceilings or floors. As a general practice, cellular telephones, cordless telephones, cordless earphones or speakers, Bluetooth-connected devices and 802.11 wireless LANs should not be used within that same 30 m radius. This is because certain transponder antennas are resonant at multiple frequencies, causing the chip to be activated by an external RF source rather than the test reader and antenna, therefore resulting in false readings of activation power threshold for the transponder under test.



Key

1 host computer system with suitable software

2 reader system with controllable output power

3 device under test (DUT) on boresight to the transmit path at 1 metre

4 low dielectric constant support

a 1 metre test path.

Figure A.5 — Nominal package test facilities layout

A.9.1.8 Equipment set-up

A.9.1.8.1 RF cabling considerations

The RF cabling used to connect the reader to the external attenuator (if used) and reader antenna should be of a good quality and the RF connectors should be tightened to a defined torque in accordance with the manufacturer's recommendations. It is recommended that the cable used be dedicated to the test system and not moved or used for other purposes to avoid inducing variations in test results.

A.9.1.8.2 Reader set-up

Ideally, the test software used should allow direct control of both reader frequency and reader output power.

If this is not available, a number of companies provide utility software for their products that can set the output power.

Ideally, power should be measured using a real time spectrum analyser for each individual channel in the output frequency range of the reader, or a calibration technique, using a calibrated tag, should be used.

If this cannot be done, an average power measurement, with a defined command sequence being executed, integrated over a large enough time to allow the reader to fully exercise all channels, can be used to indicate if the relative performance of a system has altered.

A.9.1.8.3 Empirical testing

Since tyre RFID has a specification read distance of nominally one metre or less, it is possible and convenient to establish an empirical test method and procedure.

The procedure is to find a space no less than 4,57 m by 4,57 m with no sources of interferences in proximity to the centre of the room.

Place the tyre to be tested on a spacer (a wooden table is ideal) approximately 0,61 m to 0,91 m above the ground. Rotate the tyre so that the area to be read is at 12 o'clock with the tyre facing the reader sideways sitting otherwise upright.

Hold or place the reader antenna perpendicular to the tyre with only clear space between. Only non-metallic rules shall be used for any attempts to measure read distance.

These empirical techniques can provide adequate baseline and directional information.

Annex B
(informative)

Table of useful data elements for product life cycle management

Table B.1 — Useful data elements for product life cycle management

Name	Classification	Item	Explanation	Bytes
TID	TID	TID	Tag Identification Number (ISO/IEC 15963)	(32 bits)
UII	UII	EPC	(SGTIN)	(96 bits)
	Product identification code assigned by manufacturers (ISO/IEC 15459-4)	Data Identifier	Serialized item number ("25S")	3+50
		Issuing Agency Code		
		Manufacturer code		
		Product code	Example: CF-L2M8WAXS	
		Serial number	Example: 3AKSB01019	
User memory	Internal code of manufacturers			30
	Hazardous material	Hazardous material flag	Hazardous material flag	1
		Products revision	Revision identification number of products	5
	Data for maintenance (This data is for maintenance person's use at consumer's office or home)	Maintenance contract date	Maintenance contract date between maintenance company and user (YYMMDD)	6
		Parts exchange flag	Flag that indicate some parts were exchanged for new parts	1
		Consumable supply flag	Consumable supply flag	1
		Supplies change date	Date consumable supplies put into service (YYMMDD)	6
		Durable hours	How many hours is it possible to use the supply for	1
	Data for Recycling (This data is used in a recycle phase and resale)	Recycle application date	Date that recycle application form was made (Date that user delivers recycle products to recycle company or carrier) YYMMDD	6
		Recycle application ID number	Number assigned to recycle product to identify each product.	11
		Product classification	Product classification flag (Classification example: Desktop PC, Laptop) This flag is used to pre-sort the products in recycle operation.	2
		Manufacturing date	Manufacturing date YYYYMMDD	8
		Durability period	Durable years from manufacturing date	2
		Resale date	Resale date of lease products (YYMMDD), Product no longer subject to manufacturer's guarantee.	6
		Resale dealer	Identification code of resale dealers	10
			Total	152 bytes

Annex C
(normative)

Encoding

C.1 General

This International Standard recommends three possible forms of encoding for ISO/IEC 18000-63, Type C and ISO/IEC 18000-3, Mode 3 RF tags:

a GS1 EPC compliant form for either or both the Unique Item Identifier (UII) in Memory Bank “01” and User Memory in Memory Bank “11”. The segmentation of Type C and Mode 3 tags is illustrated in Figure C.1 below. EPC encoding is detailed in EPC TDS 1.6 and higher;

a structure employing ISO/IEC 15962, Format 13 (relative OID);

a simplified structure, encoding an entire ISO/IEC 15434 message as a unit, employing a no directory, encoding six-bit defined in ISO/IEC 15962 as described in the remainder of this annex.

C.2 Basics

Each of these encoding forms can be unambiguously discerned from the other by the content of bits 0x17 through 0x1F of Memory Bank “01”, as illustrated in Figure C.2, and bits 0x00 through 0x1F of Memory Bank “11”.

When ISO/IEC 15434 was created, it was intended to support all AIDC media, including RFID. As RFID developed, a completely different set of encoding schema was developed around a set of standards, ISO/IEC 15961 and ISO/IEC 15962.

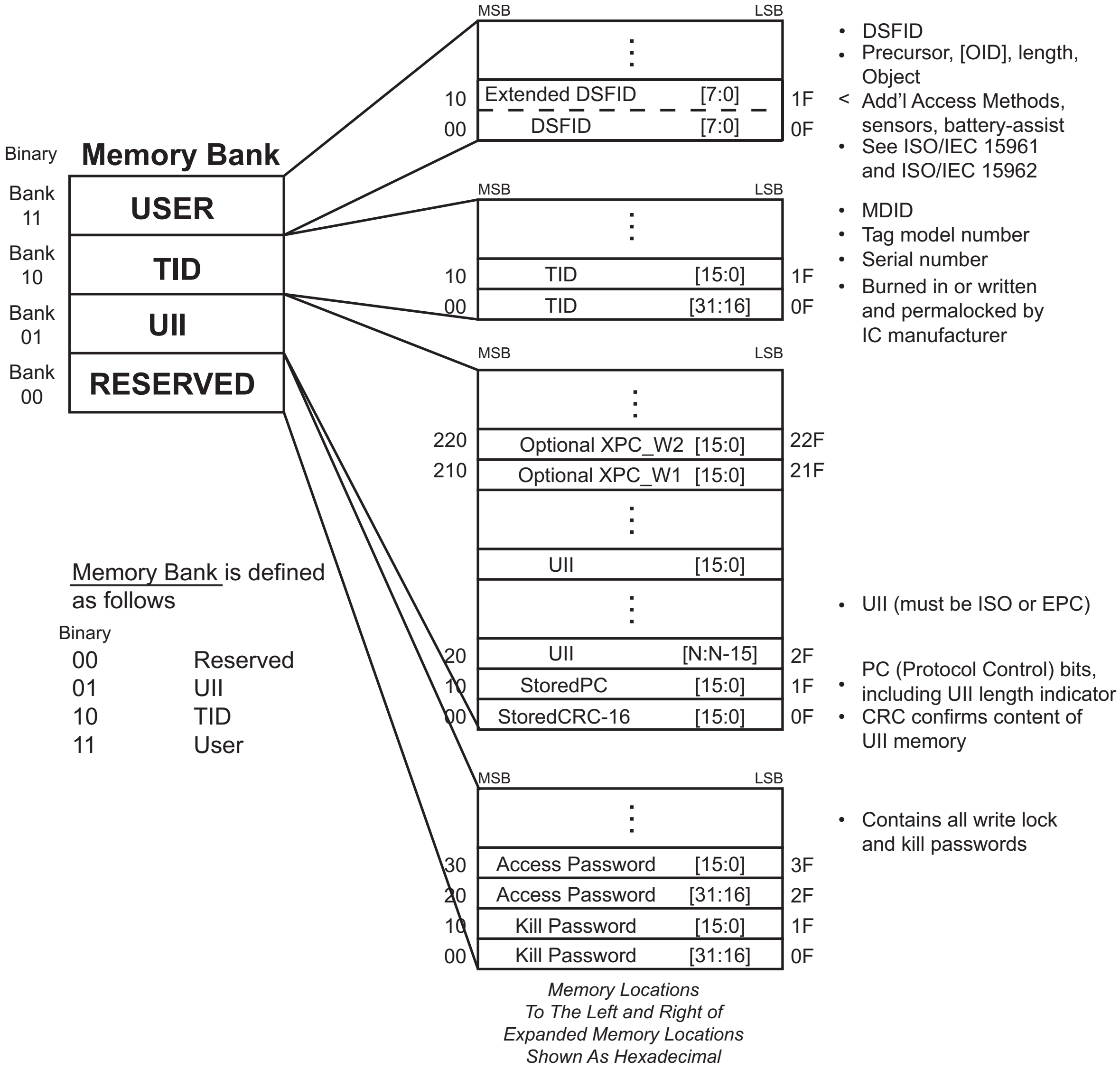


Figure C.1 — 18000-63, Type C and 18000-3, Mode 3 Logical Memory Structure

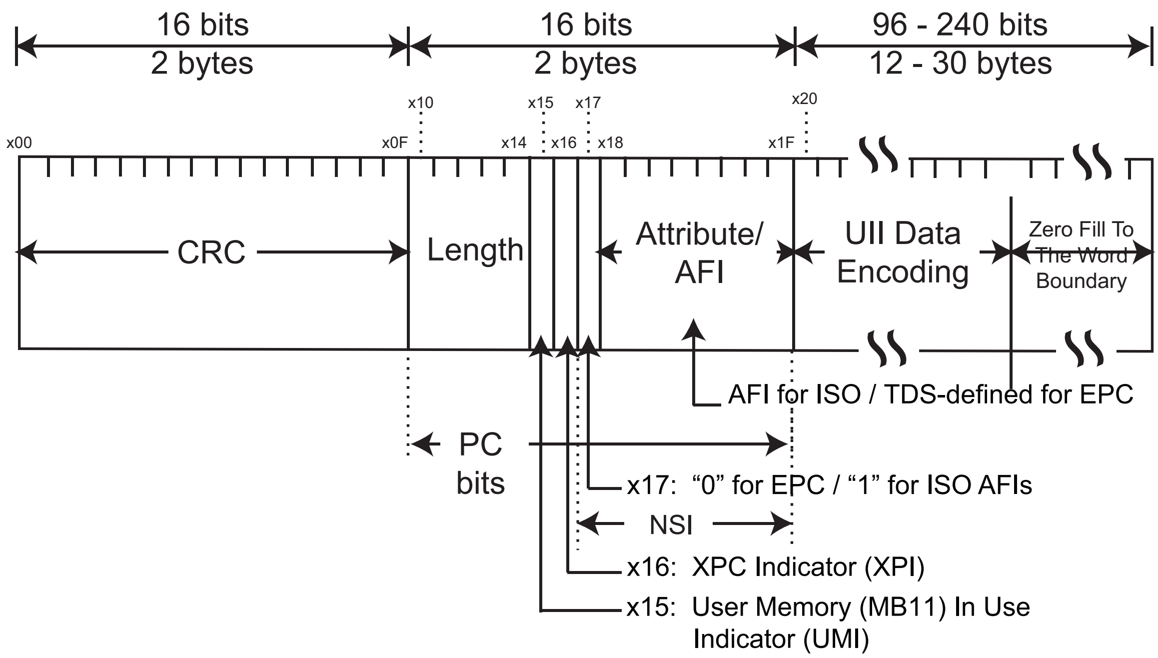
A key concept in this simplified encoding form, in both MB01 and MB11, is the use of a six-bit encoding as shown in Table C.1.

Table C.1 — Six-bit encoding

Space	100000	0	110000	@	000000	P	010000
<EOT>	100001	1	110001	A	000001	Q	010001
<Reserved>	100010	2	110010	B	000010	R	010010
<FS>	100011	3	110011	C	000011	S	010011
<US>	100100	4	110100	D	000100	T	010100
<Reserved>	100101	5	110101	E	000101	U	010101
<Reserved>	100110	6	110110	F	000110	V	010110
<Reserved>	100111	7	110111	G	000111	W	010111
(	101000	8	111000	H	001000	X	011000
)	101001	9	111001	I	001001	Y	011001
*	101010	:	111010	J	001010	Z	011010
+	101011	;	111011	K	001011	[	011011
,	101100	<	111100	L	001100	\	011100
-	101101	=	111101	M	001101	]	011101
.	101110	>	111110	N	001110	<GS>	011110
/	101111	?	111111	O	001111	<RS>	011111

NOTE Table C.1, above, is six-bit encoding created through the simple removal of the two high-order bits from the ISO 646-8-bit ASCII character set, save the shaded values. The shaded values are re-assigned, as provided, to minimize the bit count when using the ISO/IEC 15434 envelope.

The <Reserved> values in Table C.1 are not to be used without a re-issuance of this International Standard that reflects the defined values and functionality. An example would be a decision of the GS1 community to use this encoding and petitioning for the encoding of an ECI. Additionally, the presence of one or more of these characters might signal a different behaviour on the part of the decoder. While these <Reserved> values are not used in this iteration of this International Standard, they should not be used for any other purpose than defined by this International Standard.



Note 1 User Memory (MB11) in Use Indicator (UMI).

Note 2 XPC Indicator.

Note 3 "0=Binary 1=AFI+ISO/IEC 15459".

Note 4 AFI for ISO/TDS-defined for EPC/29161 defined for ISO binary.

Note 5 Last bit of AFI for ISO / Haz Mat for EPC.

Figure C.2 — Type C and Mode 3 structure of Memory Bank "01"

C.3 Encoding of Memory Bank "01" Unique Item Identifier

Bit 0x17 is the switch between ISO formats and EPC formats. When Bit 0x17 is set to a "0", the UII encoding is as per the GS1 EPC Tag Data Standard, Version 1.6. When Bit 0x17 is set to a "1", the UII encoding is as per ISO/IEC 15459 preceded by an ISO/IEC 15961, Application Family Identifier (AFI). The specific AFIs defined for the ISO 1736x series of International Standards are shown in Table C.2.

Table C.2 — 1736x Application Family Identifiers (AFIs)

AFI	Assignment	ISO Standard
0xA1	17367_ISO	ISO 17367, Supply chain applications of RFID – Product tagging
0xA2	17365_ ISO	ISO 17365, Supply chain applications of RFID – Transport unit
0xA3	17364_ ISO	ISO 17364, Supply chain applications of RFID – Returnable transport item
0xA4	17367_HazMat	ISO 17367, Supply chain applications of RFID – Product tagging (HazMat)
0xA5	17366_ ISO	ISO 17366, Supply chain applications of RFID – Product packaging
0xA6	17366_HazMat	ISO 17366, Supply chain applications of RFID – Product packaging (HazMat)
0xA7	17365_HazMat	ISO 17365, Supply chain applications of RFID – Transport unit (HazMat)
0xA8	17364_HazMat	ISO 17364, Supply chain applications of RFID – Returnable transport item (HazMat)
0xA9	17363_ ISO	ISO 17363, Supply chain applications of RFID – Freight container
0xAA	17363_HazMat	ISO 17363, Supply chain applications of RFID – Freight container (HazMat)

For the purposes of illustration, encoding of a product is shown. Transport units would be identically encoded except for the AFI and the DI. A linear bar code symbol encoding the data providing unique item identification comprises the Data Identifier (DI), Issuing Agency Code (IAC), Company Identification (CIN), and Serial Number (SN). Such a unique item identification linear bar code would be represented in Code 128 as shown in Figure C.3.

DI = 25S

IAC = UN (DUNS)

CIN = 043325711

SN = MH8031200000000001

Figure C.3 — Code 128 encoding "25SUN043325711MH8031200000000001"

Adding the AFI to the structure for RFID purposes we have

AFI = 0xA1

DI = 25S

IAC = UN (DUNS)

— CIN = 043325711

— SN = MH8031200000000001

Looking then at a completed data structure, using the encoding defined above and using DUNS as the Issuing Agency Code (IAC), we find that MB01, when encoding a Product, this data structure is 25SUN043325711MH8031200000000001 and is represented in MB01 as follows:

Table C.3 — MB01 structure of AFI and UII (DUNS) Using Six-bit Encoding

AFI = 0xA1			2	5	S	U	N	0	4	3	3	2	5	7	1
1010 0001			110010	110101	010011	010101	001110	110000	110100	110011	110011	110010	110101	110111	110001
1	**M**	**H**	**8**	**0**	**3**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
110001	001101	001000	111000	110000	110011	110001	110010	110000	110000	110000	110000	110000	110000	110000	110000
0	**0**	**1**													
110000	110000	110001													

Alternatively, looking at a completed data structure using the encoding defined above, using ODETTE as the Issuing Agency Code (IAC), we find that MB01 when encoding a Product having an:

— AFI = 0xA1

— DI = 25S

IAC = OD (ODETTE)

CIN = CIN1

SN = 0000000RTIA1B2C3DOSN12345 (This example shows the SN composed of Object Type and Object Serial Number)

. . . we have an MB01 structure as shown in Table C.4

Table C.4 — MB01 structure of AFI and UII (ODETTE) Using Six-bit Encoding

AFI = 0xA1			2	5	S	O	D	C	I	N	1	0	0	0	0
1010 0001			110010	110101	010011	001111	000100	000011	001001	001110	110001	110000	110000	110000	110000
0	**0**	**0**	**R**	**T**	**I**	**A**	**1**	**B**	**2**	**C**	**3**	**D**	**O**	**S**	**N**
110000	110000	110000	010010	010100	001001	000001	110001	000010	110010	000011	110011	000100	001111	010011	001110
1	**2**	**3**	**4**	**5**											
110001	110010	110011	110100	110101											

In both cases, once the AFI is stripped from the message, the output of the RFID reader is identical to that of the linear bar code.

C.4 Encoding of Memory Bank “11” User Memory

To indicate that data resides in MB11 (User Memory) bit 0x15 of MB01 is set to a “1”. Likewise, the presence of an AFI in MB01 cannot declare the format for MB11 because some users may choose to implement EPC encoding for MB01 and ISO encoding for MB11, in cases where MB01 is to be read by retailers and MB11 by industrial consumers. Further, it is preferable that there exists no confusion between the structures defined herein and those defined in ISO/IEC 15962. Consequently, MB11 must declare its access method and format.

C.4.1 DSFID

Data encoding starts with the DSFID (Data Storage Format Identifier) that encodes the access method and Data-Format. When using direct ISO/IEC 15434 encoding, the DSFID is “0x03”. See Figure C.4 for how this byte fits into the sequence of the first three encoded bytes.

C.4.1.1 Precursor byte

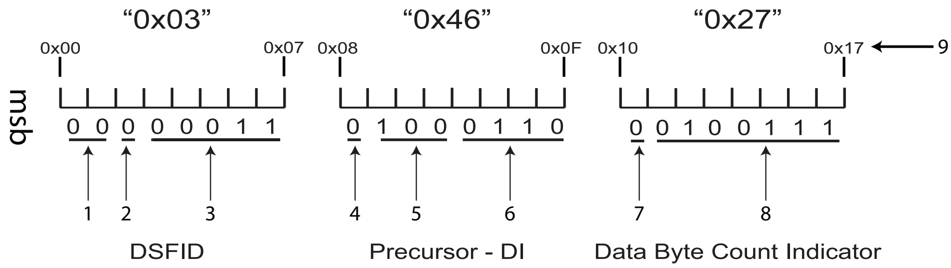
Data encoding continues with the Precursor and it encodes the extension bit in the most significant position, the compaction type (next three bits) and the ISO/IEC 15434 Format envelope (four least significant bits). For ISO/TC 122 applications the only permitted Precursor is byte “0 100 0110” or

"0x46" (i.e. extension bit is a "0" in the case of no sensors or battery assist, a compaction type 4 which indicates use of the special 6-bit table defined in this annex and an ISO/IEC 15434 format envelope "06"). See Figure C.4 for how this byte fits into the sequence of the first three encoded bytes.

C.4.1.2 Data byte-count indicator

Some air interface protocols allow for optimization in noisy environments by varying the number of bytes sent in each transmission. Therefore, it is useful to know at the beginning the number of bytes in tag memory that contain data. For many ISO/IEC 15434 DI data encoding applications, the number of bytes needed to encode the data will be a number less than 127 and therefore handled in one byte. For larger messages, two bytes are used where the first byte begins with "1" and the second byte begins with "0" as in ISO/IEC 15962:—, D.2. The number of bytes is encoded in the 14 remaining bits (e.g. 200 bytes is encoded as "10000001 01001000").

For example, if a message contains 51 6-bit characters, it will be encoded in 39 bytes (i.e. the last bit of the last character is in the 39th byte and in this case there are six un-encoded bits which require padding). Therefore, the data byte-count indicator is "0x27". See Figure C.4 for how this byte fits into the sequence of the first three encoded bytes.



NOTE 1 Access Method (#0 as listed in Table 7 of ISO/IEC 15962:—).

NOTE 2 Extended Syntax – turns on additional byte of DSFID byte (turned off in this instance).

NOTE 3 Data Format 03 (ISO/IEC 15434).

NOTE 4 Extension Bit – not specified in this example.

NOTE 5 Compaction bits (indicating 6-bit table).

NOTE 6 Format Envelope (specifically DI "06").

NOTE 7 Byte Count Indicator switch (set to "0" to signify final byte of byte count).

NOTE 8 Bit values for Byte Count Indicator (variable based on length of data).

NOTE 9 Physical memory addresses (0x00, 0x07, 0x08, 0x0F, 0x10, and 0x17).

NOTE 10 For the purpose of the above example battery-assist and sensors are shown as not present.

Figure C.4 — ISO/IEC 18000-63, Type C and ISO/IEC 18000-3, Mode 3 Structure of MB "11" 1st 24 bits

C.5 Encoding and decoding

C.5.1 Encode process

1. Starting with a valid ISO/IEC 15434 DI message, strip "[) > RS 06 GS" from the front and "<RS> <EOT>" from the end.

2. Convert every data character into its code value using Table C.1.

3. When encoding multiple “06” Format Envelopes (e.g. to represent a message containing several “records” from the same data format in order to describe the subassemblies of a complex part) reduce each internal ISO/IEC 15434 sequence “<RS> <06> <GS>” indicating a new “record” to a single < RS > character (encoded as “011111” from Table C.1).

4. Encode an <EOT> pattern after the last encoded data character.

5. Lay out the 6-bit characters as bits and then group them into 8-bit bytes.

6. Add the first 2 or 4 bits of an <EOT> character (i.e. “10” or “1000”) or the entire <EOT> character (i.e. “100001” from the 6-bit character set) to fill un-encoded bits in the last byte, if any, as padding bits.

7. Determine the byte number that contains the last bit of the <EOT> character, convert the decimal count into binary and encode explicitly as the data byte-count indicator.

8. Encode the DSFID, Precursor, data byte-count indicator, data, <EOT> and padding bits (if any) into memory.

NOTE Because only one ISO/IEC 15434 message is allowed to be encoded in a single RFID data carrier, there is no need to encode a zero byte as a terminator after the last data byte.

C.5.2 Decode process

1. Examine the DSFID and Precursor bytes and verify that they are equivalent to “0x03 0x46”.

2. Process the next 8 bits and convert the resulting data byte-count indicator to a decimal value to determine the number of bytes containing data.

3. Starting with the next bit, group the following bits into character bit-sets from the 6-bit code table and continue until the number of bytes containing data has been parsed.

4. Assign data characters according to Table C.1 and delete all complete and incomplete <EOT> characters from the end.

5. For any encoded <RS> character that is not immediately followed by “06” and a <GS> character, expand the <RS> to “RS 06 GS”.

6. Add “[) > RS 06 GS” to the beginning of the transmission and “RS EOT” at the end.

7. Transmit the entire ISO/IEC 15434 compliant message. Optionally, the receiver may wrap the ISO/IEC 15434 message in an OID format as a single data object. When using this option, the complete OID of the message is {1 0 15434 06}.

C.6 Encoding and decoding example

C.6.1 Translation and encoding procedure from ISO/IEC 15434 data to Access Method 0 Data Format 3

To prepare a typical DI input message in ISO/IEC 15434 format for encoding using ISO/IEC 15962 Access Method 0 Data-Format 3, the following steps are performed.

Verify that the input message is a valid ISO/IEC 15434 DI message.

— The DSFID indicating Access Method 0 and Data Format 3 is encoded.

The leading message envelope characters “[) > RS 06 GS” and the trailing “RS EOT” are discarded.

The data is encoded into 6-bit codewords from Table C.1.

Add an <EOT> character.

Add part or all of an <EOT> to fill the last data byte, if necessary.

Encode the DSFID, Precursor, data byte-count indicator, data, <EOT> and padding into memory.

C.6.2 Decoding and Translation procedure from Access Method 0 Data-Format 3 to ISO/IEC 15434 data

The system will see this information as ISO/IEC 15434-6-bit DI data by reading the DSFID byte.

The system discards the DSFID, Precursor and data byte-count indicator at the beginning.

The encoded bytes are parsed into 6-bit codes, discarding any pad bits and the encoded <EOT> character, and then into data according to Table C.1.

The system adds “[) > RS 06 GS” to the beginning of the transmission and “RS EOT” at the end

The system transmits the entire ISO/IEC 15434 compliant message.

Optionally, the receiver may wrap the entire ISO/IEC 15434 message in an OID format as a single data object.

C.6.3 Data encode and decode example

The following example encodes ISO/IEC 15434 DI data in an application with a mandatory <EOT> requirement.

Starting data:

[)><RS>06<GS>25SUN043325711MH8031200000000001 <GS>1T110780<GS>Q21<GS>4LUS<RS><EOT>

The data on the tag from the above message is as follows (with DIs in bold font):

25SUN043325711MH8031200000000001 <GS> **1T**110780 <GS> **Q**21 <GS> **4L**US <EOT>

Where:

UII = **25S**UN043325711MH8031200000000001

LOT = **1T**110780

QTY = **Q**21

CoO = **4L**US

Data to bit conversion:

There are 51 6-bit characters (50 plus <EOT>), which translates to 39 data-bytes. There is a need to fill six trailing bits for byte alignment so in this case an entire <EOT> character is encoded. See Table C.5.

Table C.5 — Type C and Mode 3 Structure of Memory Bank “11” 1st 16 bits

DSFID = 0x03	Precur-sor = 0x46	Data byte-count = 0x27	2	5	S	U	N	0	4	3	3	2	5
00000011	01000110	00100111	110010	110101	010011	010101	001110	110000	110100	110011	110011	110010	110101
7	**1**	**1**	**M**	**H**	**8**	**0**	**3**	**1**	**2**	**0**	**0**	**0**	**0**
110111	110001	110001	001101	001000	111000	110000	110011	110001	110010	110000	110000	110000	110000
0	**0**	**0**	**0**	**0**	**0**	**1**	**<GS>**	**1**	**T**	**1**	**1**	**0**	**7**
110000	110000	110000	110000	110000	110000	110001	011110	110001	010100	110001	110001	110000	110111
8	**0**	**<GS>**	**Q**	**2**	**1**	**<GS>**	**4**	**L**	**U**	**S**	**<EOT>**	**pad**	
111000	110000	011110	010001	110010	110001	011110	110100	001100	010101	010011	100001	100001	

C.6.3.1 Complete contents of tag memory

Using the Access Method 0 Format 3 encoding, including a DSFID, ISO/IEC 15434 Precursor byte, 39 bytes of data (compressing 51 6-bit characters including the <EOT>), and six pad bits, the final tag encodation in hexadecimal is as follows.

03 46 27 CB 54 D5 3B 0D 33 CF 2D 77 C7 13 48 E3 0C F1 CB 0C 30 C3 0C 30 C3 0C 31 7B 15 31 C7 0D F8 C1 E4 72 C5 ED 0C 55 38 61

C.6.3.2 Transmitted data

The header characters and the “<RS> <EOT>” are reinserted into the message. The following data string is transmitted from the reader.

[) > $^{R}{}_{S}$ 06 $^{G}{}_{S}$ 25SUN043325711MH8031200000000001 $^{G}{}_{S}$ 1T110780 $^{G}{}_{S}$ Q21 $^{G}{}_{S}$ 4LUS $^{R}{}_{S}$ $^{E}{}O_{T}$

C.6.3.3 Conclusion

When encoded in a 2D symbol, the output would be identical:

[[)><RS>06<GS>25SUN043325711MH8031200000000001 <GS>1T110780<GS>Q21<GS>4LUS<RS><EOT>

Figure C.5 — QR Code encoding the contents of MB01 and MB11 [)><RS>06<GS>25SUN043325711MH8031200000000001 <GS>1T110780<GS>Q21<GS>4LUS<RS><EOT>

Figure C.6 — DataMatrix encoding the contents of MB01 and MB11 [)><RS>06<GS>25SUN043325711MH8031200000000001 <GS>1T110780<GS>Q21<GS>4LUS<RS><EOT>

Bibliography

[1] ISO 3166-1, *Codes for the representation of names of countries and their subdivisions — Part 1: Country codes*

[2] ISO 4000-1, *Passenger car tyres and rims — Part 1: Tyres (metric series)*

[3] ISO 9000, *Quality management systems — Fundamentals and vocabulary*

[4] ISO 9001, *Quality management systems — Requirements*

[5] ISO 9004, *Managing for the sustained success of an organization — A quality management approach*

[6] ISO 14001, *Environmental management systems — Requirements with guidance for use*

[7] ISO 15394, *Packaging — Bar code and two-dimensional symbols for shipping, transport and receiving labels*

[8] ISO/IEC 15420, *Information technology — Automatic identification and data capture techniques — EAN/UPC bar code symbology specification*

[9] ISO/IEC 15438, *Information technology — Automatic identification and data capture techniques — PDF417 bar code symbology specification*

[10] ISO 17363, *Supply chain applications of RFID — Freight containers*

[11] ISO 17365:2013, *Supply chain applications of RFID — Transport units*

[12] ISO 17366, *Supply chain applications of RFID — Product packaging*

[13] ISO/IEC/TR 18001, *Information technology — Radio frequency identification for item management — Application requirements profiles*

[14] ISO/IEC 18000-2, *Information technology — Radio frequency identification for item management — Part 2: Parameters for air interface communications below 135 kHz*

[15] ISO 19011, *Guidelines for auditing management systems*

[16] ISO 21849, *Aircraft and space — Industrial data — Product identification and traceability*

[17] ISO/IEC/TR 24729-2, *Information technology — Radio frequency identification for item management — Implementation guidelines — Part 2: Recycling and RFID tags*

[18] ISO 28219, *Packaging — Labelling and direct product marking with linear bar code and two-dimensional symbols*

[19] EN 302 208-1, *Electromagnetic compatibility and Radio spectrum Matters (ERM); Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W; Part 1: Technical requirements and methods of measurement*

[20] IEEE 1451.7, *Smart Transducer Interface for Sensors and Actuators — Transducers to Radio Frequency Identification (RFID) Systems Communication Protocols and Transducer Electronic Data Sheet Formats*

[21] EPC™ Radio-Frequency Identity Protocols Class-1 Generation - 2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz Version 1.0.9)

[22] RoHS (2002/95/EC) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) and WEEE (2002/96/EC) On waste electrical and electronic equipment directive (WEEE)

[23] MIL-STD-331 — Department Of Defense, *Environmental and Performance Tests for Fuze and Fuze Components*

[24] AIM Global Standard for the use of the AIM RFID Emblem and index to identify RFID-enabled labels

[25] MIL-STD-129 — *Department of Defense Standard Practice Military Marking for Shipment and Storage*

[26] ASTM F538-03:—, *Standard Terminology Relating to the Characteristics and Performance of Tires*

ICS 55.020

Price based on 51 pages