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Supply chain applications of RFID — Returnable transport items (RTIs)

Applications de chaîne d'approvisionnements de RFID — Éléments restituables de transport (RTIs)

Reference number
ISO 17364:2009(E)

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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 17364 was prepared by Technical Committee ISO/TC 122, *Packaging*, in collaboration with Technical Committee ISO/TC 104, *Freight containers.*

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)*,

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

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

— 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 work of

— 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

is considered valuable.

This International Standard defines the requirements for RFID tags for returnable transport items (RTIs). RTIs are defined as all means to assemble goods for transportation, storage, handling and product protection in the supply chain which are returned for further usage, including for example pallets with and without cash deposits as well as all forms of reusable crates, trays, boxes, roll pallets, barrels, trolleys, pallet collars and lids.

An important concept here is the use cases of such things as *unitized loads*, pallets and returnable transport items. How a pallet is used can determine whether it is covered under this International Standard as a *returnable transport item* or within ISO 17365 as a *transport unit*. If ownership title of the pallet remains with its owner then this International Standard is applicable. If the ownership title of a pallet is transferred to the customer as part of a unitized load then it is considered an element of that unitized load, and the applicable International Standard is ISO 17365.

Specific to RTIs is the placement of tagged packed products and products inside the RTI.

Owners and other users of RTIs can use this International Standard. It ensures the unambiguous and optimal use of RTIs in the supply chain. In conjunction with the *Supply chain applications of RFID* International Standards, a seamless application of the RTIs within the total supply chain is enabled.

Supply chain applications of RFID — Returnable transport items (RTIs)

1 Scope

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

— provides specifications for the identification of the RTI,

— makes recommendations about additional information on the RF tag,

— specifies the semantics and data syntax to be used,

— specifies the data protocol to be used to interface with business applications and the RFID system,

— specifies the minimum performance requirements,

— specifies the air interface standards between the RF interrogator and RF tag, and

— specifies the reuse and recyclability of the RF tag.

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 TR 18046 for performance and ISO/IEC TR 18047-6 (for ISO/IEC 18000-6, Type C) and ISO/IEC TR 18047-3 (for the ASK interface of ISO/IEC 18000-3, Mode 3) for conformance.

When through trading-partner agreement, other specific ISO/IEC 18000 air interfaces are employed (i.e. ISO/IEC 18000-2, Type A and ISO/IEC 18000-7) the corresponding part of ISO/IEC 18047 shall be used.

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/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 15459-4, *Information technology — Unique identifiers — Part 4: Individual items*

ISO/IEC 15459-5, *Information technology — Unique identifiers — Part 5: Unique identifier for returnable transport items (RTIs)*

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

ISO/IEC 15962, *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 18000-2, *Information technology — Radio frequency identification for item management — Part 2: Parameters for air interface communications below 135 kHz*

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 18000-6, *Information technology — Radio frequency identification for item management — Part 6: Parameters for air interface communications at 860 MHz to 960 MHz*

ISO/IEC 18000-7, *Information technology — Radio frequency identification for item management — Part 7: Parameters for active air interface communications at 433 MHz*

ISO/IEC TR 18046, *Information technology — Automatic identification and data capture techniques — Radio frequency identification device performance test methods*

ISO/IEC TR 18047-3, *Information technology — Radio frequency identification device conformance test methods — Part 3: Test methods for air interface communications at 13,56 MHz*

ISO/IEC TR 18047-6, *Information technology — Radio frequency identification device conformance test methods — Part 6: Test methods for air interface communications at 860 MHz to 960 MHz*

ISO/IEC 19762-1, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC*

ISO/IEC 19762-3, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 3: Radio frequency identification (RFID)*

ISO 21067, *Packaging — Vocabulary*

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*

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

EPCglobal, *Tag Data Standards,* Version 1.3

GS1 *General Specifications*

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

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*

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

4 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 445, ISO 830, ISO/IEC 19762-1, ISO/IEC 19762-3, ISO 21067 and the following apply.

4.1
conveyable
item that can be moved efficiently and safely on handling devices used to move material over a fixed line of travel

NOTE Such material handling devices, or conveyors, are for the purposes of this International Standard considered to be continuous-loop belted systems moving packages or objects in a predetermined path and having fixed or selective points of loading or discharge. The width of the belt, height permitted within the facility, and weight capacity of the belt may determine whether the items are conveyable.

4.2
EPC tag
ISO/IEC 18000-6 Type C or ISO/IEC 18000-3 Mode 3 tag with Protocol Control bit 17 set at "0" indicating that what follows is an EPC header

4.3
freight containers
article of transport equipment

a) having a permanent character and accordingly strong enough to be suitable for repeated use,

b) specially designed to facilitate the carriage of goods by one or more modes of transport, without intermediate reloading,

c) fitted with devices permitting its ready handling, particularly its transfer from one mode of transport to another,

d) so designed as to be easy to fill and empty,

e) having an internal volume of 1 m^3 (approximately 35,3 ft^3) or more

[ISO 830:1999, definition 3.1]

4.4
integrity
design whereby any modification of the electronically stored information, without proper authorization, is not possible

4.5
IUI tag
international unique identification tag
ISO/IEC 18000-6 Type C or ISO/IEC 18000-3 Mode 3 tag with Protocol Control bit 17 set at "1" indicating that what follows is an Application Family Identifier (AFI)

4.6
monolithic memory structure
memory storage that is addressable by a single addressing element

4.7
non-conveyable
item of such width, height or mass to preclude its movement on conveyor systems

4.8
product
first level or higher assembly that is sold in a complete end-usable configuration

[EIA 802, 3.16]

4.9
product package
product packaging
first tie, wrap or container to a single item or quantity thereof that constitutes a complete identifiable pack

NOTE 1 A product package may be an item packaged singularly, multiple quantities of the same item packaged together or a group of parts packaged together.

NOTE 2 Adapted from ISO 22742:2005, definition 3.32.

4.10
returnable transport item
RTI
means to assemble goods for transportation, storage, handling and product protection in the supply chain which are returned for further usage, including for example pallets with and without cash deposits as well as all forms of reusable crates, trays, boxes, roll pallets, barrels, trolleys, pallet collars and lids

NOTE 1 The term returnable transport item is usually allocated to secondary packaging; however, in certain circumstances primary packaging can also be considered as a form of RTI.

NOTE 2 Freight containers, trailers and other similar enclosed modules are not covered by the term returnable transport item.

NOTE 3 The term returnable transport *equipment* is considered to have the same definition as the term returnable transport item within an electronic data interchange environment.

4.11
segmented memory structure
memory storage that is separated into more than one element and requires multiple addressing elements for access

4.12
transport package
package intended for the transportation and handling of one or more articles, smaller packages, or bulk material

NOTE See ISO 15934:2009, 4.2.

4.13
transport unit
either a transport package or a unit load

NOTE See ISO 15934:2009, 4.2.

4.14
unitized
secured together so as to be handled as an entity

4.15
unit load
one or more transport packages or other items held together by means such as pallet, slip sheet, strapping, interlocking, glue, shrink wrap, or net wrap, making them suitable for transport, stacking, and storage as a unit

NOTE See ISO 15934:2009, 4.2.

4.16
use case
detailed description of a single activity in a business process that identifies data inputs and outputs, performance/timing requirements, the handling of error conditions and interfaces with external applications

5 Concepts

5.1 Supply chain model

Figure 1 gives a graphical representation of the supply chain. It shows a conceptual model of possible supply chain relationships, not a one-for-one representation of physical things. Although several layers in Figure 1 have clear physical counterparts, some common supply chain physical items fit in several layers depending on the use case. For example, a repetitively used pallet under constant ownership would be covered by this International Standard as an RTI; a pallet that is part of a consolidated unit load would be covered by ISO 17365 as a transport unit; and a pallet that is integral to a single item would be covered by ISO 17366 as product packaging.

Layers 0 to 4 are addressed within the series of International Standards *Supply chain applications of RFID* (see Introduction). Layer 5 is addressed by the work of ISO/TC 204/WG 7.

Layer 3 in Figure 1 and RTIs (as defined in 4.10) are the subject of this International Standard.

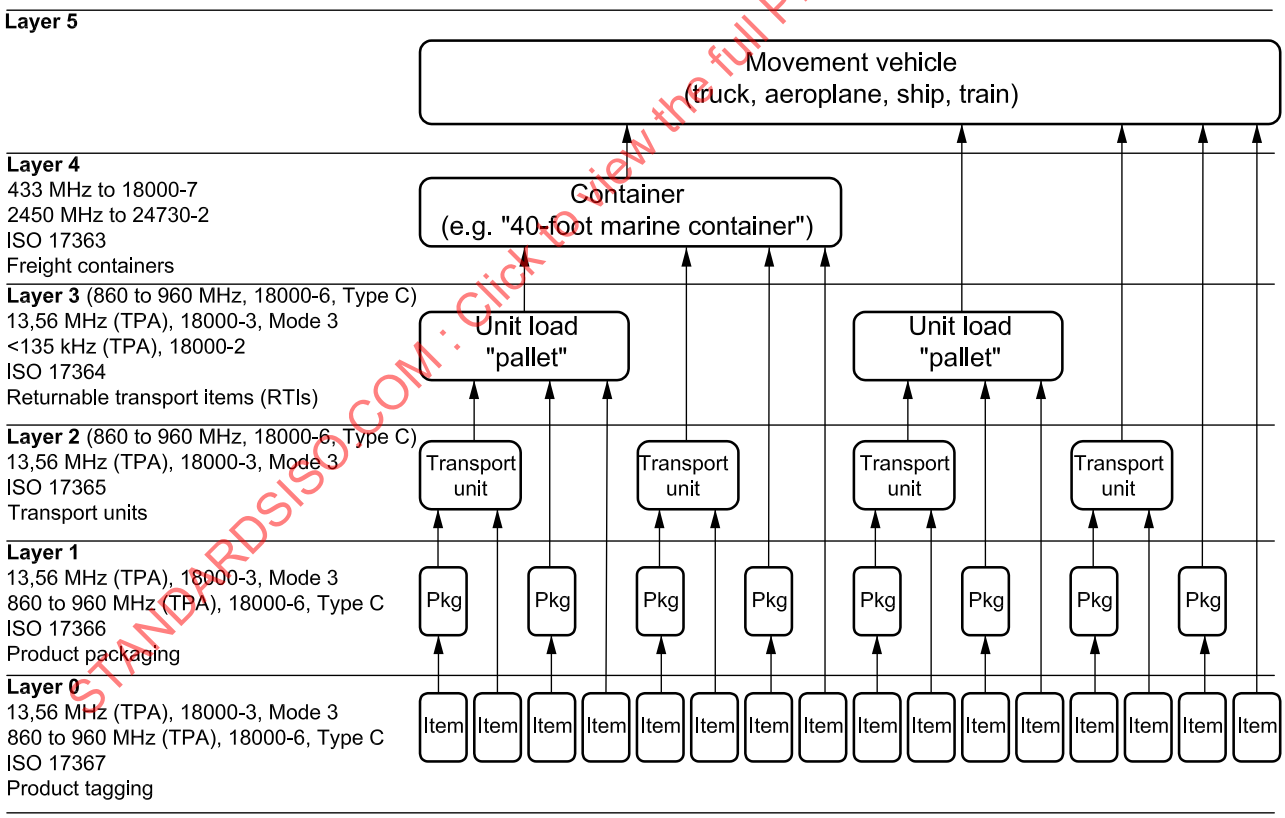

Figure 1 — Supply chain layers

RTI 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 RTI layer tags. As indicated in 5.2.2, the group select methodology is further elaborated in ISO/IEC 15961.

5.2 Unique RTI identification

5.2.1 General

Unique RTI identification is a process that assigns a unique data string to an individual RTI, or in this case to an RFID tag that is associated to the RTI. The unique data string is called the unique RTI identifier. Unique item identification of RTIs allows data collection and management at a granular level. The benefits of granular level data are evident in such areas as maintenance, warranties and enabling electronic transactions of record. This granularity is possible only if each tagged item has a unique item identifier.

The information on items in the supply chain is often held on computer systems and may be exchanged between parties involved via electronic data interchange (EDI) and extensible markup language (XML) schemas. The unique item identifier is intended to be used as a key to access this information.

The unique RTI identifier described above is a unique identifier as described in ISO/IEC 15459-5. 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 RTI identifier defined in this International Standard.

RTI tagging provides unique identification of RTIs. The minimum data elements required for unique identification are an enterprise identifier/company identification number and a serial number that is unique within that enterprise identifier.

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

— unique identifier for RTIs (ISO/IEC 15459-5);

— global returnable asset identifier (GRAI).

5.2.2 International unique identification of RTIs

The unique identifier of ISO/IEC 15459 provides identification schemes for various layers of the supply chain, from layer 0 (products) up to layer 3 (returnable transport items). The unique identification of product packages shall use ISO/IEC 15459-5. Unique identification is provided 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 15961:2004, Annex B, permits identification of the supply chain layer, i.e. product = $A1_{HEX}$, transport unit = $A2_{HEX}$, returnable transport item = $A3_{HEX}$ and product package = $A5_{HEX}$.

Table 1 — 1736*x* AFI Assignments

AFI (HEX)	Assignment	International Standard
A1	17367_Non-EPC	ISO 17367 — *Supply chain applications of RFID — Product tagging*
A2	17365_Non-EPC	ISO 17365 — *Supply chain applications of RFID — Transport units*
A3	17364_Non-EPC	ISO 17364 — *Supply chain applications of RFID — Returnable transport items (RTIs)*
A4	17367_HazMat	ISO 17367 — *Supply chain applications of RFID — Product tagging* (HazMat)
A5	17366_Non-EPC	ISO 17366 — *Supply chain applications of RFID — Product packaging*
A6	17366_HazMat	ISO 17366 — *Supply chain applications of RFID — Product packaging* (HazMat)
A7	17365_HazMat	ISO 17365 — *Supply chain applications of RFID — Transport units* (HazMat)
A8	17364_HazMat	ISO 17364 — *Supply chain applications of RFID — Returnable transport items (RTIs)* (HazMat)
A9	17363_Non-EPC	ISO 17363 — *Supply chain applications of RFID — Freight containers*
AA	17363_HazMat	ISO 17363 — *Supply chain applications of RFID — Freight containers* (HazMat)

EPC does not use AFIs; consequently, there are no AFIs used for RTIs employed in retail applications using EPCglobal. AFI $A3_{HEX}$ may be used for RTIs intended solely for commodities other than consumer goods.

To define its class (in the ISO/IEC 15459 sense), the unique identifier shall have an associated class identifier, identified with the Data Identifier “25B”. Clause 7 addresses data content for a unique identifier for returnable transport items. A unique identifier of returnable transport items can be up to 35 alphanumeric characters in length, including the Data Identifier (an3+an..32). See Table 2.

NOTE In view of current and future food safety legislation, differentiation between food and non-food applications could be beneficial, if not necessary. In particular, the risk analysis of cross-contamination would be addressed.

Table 2 — UII element string

Format of the license plate	
Data Identifier	IAC, company identification number (CIN), serial number
25B	$N_1\ N_2\ N_3\ N_4\ N_5\ N_6\ N_7\ N_8\ N_9\ N_{10}\ N_{11}\ N_{12}\ N_{13}\ N_{14}\ N_{15}\ N_{16}\ N_{17} \ldots N_{32}$

5.2.3 Global returnable asset identifier (GRAI)

The global returnable asset identifier (GRAI) is a unique item identifier (UII) capable of providing unique item identification of RTIs.

The GRAI consists of the following information elements:

— The *Company Prefix*, assigned by GS1 to a managing entity. The Company Prefix is the same as the Company Prefix digits within a GS1 GRAI decimal code.

— The *Asset Type*, assigned by the managing entity to a particular class of asset.

— 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.

See Table 3.

Table 3 — GRAI element string

Format of the element string			
Application Identifier	Global returnable asset identifier		Serial Number (optional)
	GS1 Company Prefix Asset Type	Check digit	
8003	0 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}	X_1 variable X_{16}

To define its class the unique item identifier shall have an associated class identifier, which is the Application Identifier 8003. Clause 7 addresses data content for a GRAI.

5.3 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 RTI 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 the layer

6.1 The layer represented by RTIs is characterized by the following unique aspects.

— The RTI may be used more than once.

— The same RTI can be used by different users and/or for different or multiple shipments at different moments.

— The content of the RTI may consist of tagged (packed) products and/or non-tagged (packed) products.

— The RTI has a value of its own, not directly and necessarily derived from the product that it contains.

— The possibility to have selective access to the data elements stored and/or written into the RTI RF tag is required.

— The physical handling of the RTI includes specific steps, such as cleaning, storage, repair, maintenance and transport.

A typical RTI pool system can be described as follows:

a) Manufacturer produces product.

b) Primary packing is added; this can also be the RTI, for instance in the case of drums and bags for concentrated juices, water or beer.

c) Packed products are packed in RTIs (multiple and different products can be included in one RTI). Small RTIs (crates, trays, boxes, barrels) are stored on large RTIs (pallet and/or roll container).

d) RTIs are placed in transport vehicle (truck, boat, train, aeroplane) for direct transport to end user (mostly industrial) or regrouping in distribution centre (retail).

e) RTIs are redirected and can be (partially) emptied and refilled at distribution centre.

f) RTIs are unloaded and emptied at end-user site or retail outlet.

g) Empty RTIs are stored (nested, stacked) and collected by the (pool) owner or shipped back to the manufacturer of the packed product.

h) Empty RTIs are cleaned, stored, repaired and reprogrammed for new shipment of (packed) products.

6.2 The relevant functions in RTI-management and -logistics are RTI-supplier, dispatcher, receiver and service providers:

— RTI-suppliers own the RTI, control an RTI-pool and make them available for use by dispatchers (RTI-supplier and pool-operator are used as synonymous terms).

— Dispatchers use RTIs in the distribution of their goods. Dispatchers fill empty RTIs with goods and hand over filled RTI to receivers. Dispatchers can be fillers, brand manufacturers, distribution centres, consolidation points, etc.

— Receivers receive RTIs from dispatchers and make these items available for collection by service providers. Receivers can be retailers, distribution centres, consolidation points, etc.

— Service providers collect RTI from receiver and are responsible, in the case of items subject to a deposit, for refunding this deposit, and make the sorted RTI available to RTI suppliers or dispatchers.

6.3 A company can fulfil more than one of these functions, for example:

— A beverage producer can use his own crates for bottles; in this case the producer acts as an RTI-supplier and a dispatcher.

— A retail distribution centre (RDC) sends received units to its outlets; in this case the RDC acts as a receiver as well as a dispatcher.

— An RDC can sort and collect empty crates after use; in this case the RDC acts as a receiver and a service provider.

— A pool operator collects and sorts empty crates; in this case the pool operator acts as an RTI-supplier and a service provider.

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

— Receipt: receiving goods/empty or filled RTI/unit loads for further use, e.g. transhipment, storage, selling, recording of data, collecting, sorting or reconditioning.

— Unloading: physical movement of unit loads out of a means of transport.

— Identification: systematic determination and registration (including measuring) of objects following this International Standard for numbering systems in order to distinguish them from each other. This includes the possibility of electronic identification (scanning).

— Inspection: checking completeness of goods/empty or filled RTI/unit loads; checking if goods/empty or filled RTI/unit loads fulfil specific and defined criteria for quality.

— Order picking: assembling goods to unit loads according to order (list).

— Retaining: means (e.g. straps) to guarantee safe unit loads during transport.

— Loading: physical movement of unit loads into a means of transport.

— Storage: maintaining stocks of products/empty or filled RTI/unit loads in a warehouse, including internal movement activities.

— Transhipment/cross docking: transferring goods/empty or filled RTI/unit loads from one means of transport to another during the course of one transport operation according to order.

— Dispatching: shipping of goods/empty or filled RTI/unit loads, including recording of data.

— Labelling: putting on labels/writing on tags following the recommendations of GS1, covering e.g. logistic data.

— Transport: movement of goods/empty or filled RTI/unit loads by means of transport from point-to-point.

— Warehousing: all activities of receiving, holding, handling and dispatching goods/empty or filled RTI/unit loads in a store.

— Collecting: retrieving goods/empty RTI from a location according to order, including recording of data (reverse logistics).

— Sorting: separating different kinds of RTI and making them available for further activities, including recording of data.

— Reconditioning: all physical activities which enables RTI to be reused, e.g. repairing, washing.

Different business processes within 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 RTI and the process involved and shall be integrated into business processes as required by the business process owner.

The RTI and the system in which it is used are closely intertwined. Additionally, all variations possible in different supply chains are also observed in the RTI layer of the supply chain due to the nature of the RTI and its usage.

7 Data content

7.1 Introduction

Subclauses 7.2 to 7.9 describe the data content of RFID tags for the RTI-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.

NOTE 1 As specified elsewhere in this International Standard, use is made of ISO/IEC 18000-6, Type C, and ISO/IEC 18000-3, Mode 3 tags. Where necessary, use is made of the specific (memory) terminology of those tags.

NOTE 2 For the purpose of RTI tagging, only read-write tags are used. This is done to enable RTI pool owners to assign specific and permanent UIIs to their RTIs.

7.2 System data elements

7.2.1 Unique RTI identification

The first data element on a compliant tag shall be the unique identification described in ISO/IEC 15459-5. The length and nature of this unique identification is defined in this data element. For an ISO/IEC 18000-6, Type C 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). A unique identifier of returnable transport items can be up to 35 alphanumeric characters in length, including the Data Identifier (an3+an..32).

7.2.2 Data semantics

Tags that only encode the unique RTI identity shall conform to ISO/IEC 15961. Tags containing complex data structures or larger data sets shall include semantics that conform to ISO/IEC 15418 and ISO/IEC 15961.

7.2.3 Data syntax

Tags that only encode identity are considered to have no syntax. Tags containing complex data structures or larger data sets shall conform to ISO/IEC 15434 and ISO/IEC 15962.

7.3 Tag structure (ISO/IEC 18000-6, Type C and ISO/IEC 18000-3, Mode 3)

7.3.1 Tag header

Tag headers should contain the ISO/IEC 15961 AFI for returnable transport items, i.e. $A3_{HEX}$, in bits 18_{HEX} to $1F_{HEX}$ as described in Table 1 and Table 4. Support for ISO standards (including AFIs) is indicated when bit 17_{HEX} is set to "1". Alternatively, such headers may contain an EPC header as described in the EPCglobal, *Tag Data Standards*, Version 1.3. Support for EPCglobal coding is indicated when bit 17_{HEX} is set to "0".

NOTE A 96-bit GRAI is represented by EPC header 33_{HEX}.

7.3.2 Tag memory

Figure 2 provides a graphical representation of tag memory.

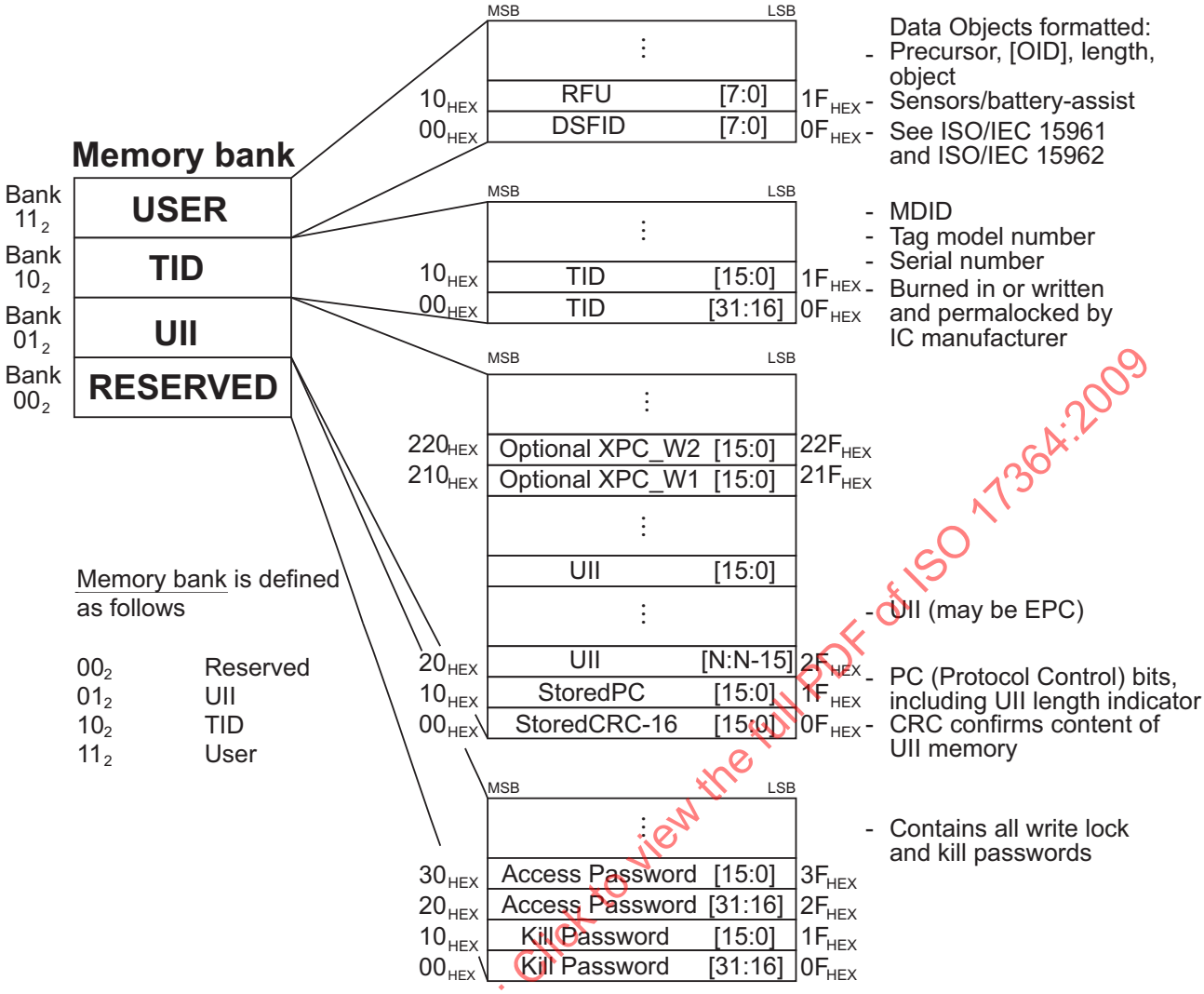

Figure 2 — Memory map for segmented memory tags

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 2. The memory banks are as follows.

a) Reserved memory: shall contain the kill and access passwords. The kill password shall be stored at memory addresses 00_{HEX} to $1F_{HEX}$; the access password shall be stored at memory addresses 20_{HEX} to $3F_{HEX}$. 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: shall contain a CRC-16 at memory addresses 00_{HEX} to $0F_{HEX}$, Protocol Control (PC) bits at memory addresses 10_{HEX} to $1F_{HEX}$ and a code, i.e. a UII, that identifies the object to which the tag is or will be attached beginning at address 20_{HEX}. The PC is subdivided into a UII length field in memory locations 10_{HEX} to 14_{HEX}, an indication of user memory bit in memory location 15_{HEX}, a PC extension indicator bit in memory location 16_{HEX}, an ISO/EPC bit in memory location 17_{HEX} and a numbering system identifier (NSI) in memory locations 18_{HEX} to $1F_{HEX}$. The CRC-16, PC and UII shall be stored MSB first (the UII's MSB is stored in location 20_{HEX}).

c) TID memory: shall contain an 8-bit ISO/IEC 15963 allocation class identifier at memory locations 00_{HEX} to 07_{HEX}. TID memory shall contain sufficient identifying information above 07_{HEX} for an interrogator to uniquely identify the custom commands and/or optional features that a tag supports.

For EPC tags whose ISO/IEC 15963 allocation class identifier is 11100010_2, this identifying information shall comprise a 12-bit tag mask-designer identifier at memory locations 08_{HEX} to 13_{HEX} and a 12-bit tag model number at memory locations 14_{HEX} to $1F_{HEX}$.

For ISO/IEC 15459-5 tags operating conformant to ISO/IEC 18000-6, Type C and whose ISO/IEC 15963 allocation class identifier is 11100000_2 (E0), this identifying information shall comprise a 12-bit tag mask-designer identifier at memory locations 08_{HEX} to 13_{HEX} and a 12-bit tag model number at memory locations 14_{HEX} to $1F_{HEX}$. Tags may contain tag- and vendor-specific data (for example, a tag serial number) in TID memory above $1F_{HEX}$.

For ISO/IEC 15459-5 tags operating conformant to ISO/IEC 18000-3, Mode 3 and whose ISO/IEC 15963 allocation class identifier is 11100000_2 (E0), this identifying information shall comprise a 12-bit tag mask-designer identifier at memory locations 08_{HEX} to 13_{HEX} and a 12-bit tag model number at memory locations 14_{HEX} to $1F_{HEX}$. Tags may contain tag- and vendor-specific data (for example, a tag serial number) in TID memory above $1F_{HEX}$.

For ISO/IEC 15459-5 tags operating conformant to ISO/IEC 18000-7 and whose ISO/IEC 15963 allocation class identifier is 00010001_2, this identifying information shall comprise an 8-bit tag mask-designer identifier at memory locations 08_{HEX} to $0F_{HEX}$ and a 32-bit tag serial number at memory locations 16_{HEX} to $1F_{HEX}$.

For ISO/IEC 15459-5 tags operating conformant to ISO/IEC 18000-2, Type A and whose ISO/IEC 15963 allocation class identifier is 11100000_2, this identifying information shall comprise an 8-bit tag manufacturer identification at memory locations 08_{HEX} to 15_{HEX} and a 48-bit tag serial number at memory locations 16_{HEX} to $3F_{HEX}$.

d) User memory: allows user-specific data storage. The StorageFormat ID 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 15_{HEX} PC bit. A zero in the 15_{HEX} PC bit shall indicate that there is no user memory at MB11 or that there is no data within existing user memory.

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 10_{HEX} to $1F_{HEX}$, with bit values defined as follows.

— Bits 10_{HEX} to 14_{HEX}: The length of the (PC + UII) that a tag backscatters, in words:

  — 00000_2: one word (addresses 10_{HEX} to $1F_{HEX}$ in UII memory).

  — 00001_2: two words (addresses 10_{HEX} to $2F_{HEX}$ in UII memory).

  — 00010_2: three words (addresses 10_{HEX} to $3F_{HEX}$ in UII memory).

  — ...11111_2: 32 words (addresses 10_{HEX} to $20F_{HEX}$ in UII memory).

— Bit 15_{HEX}: 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 16_{HEX}: Shall be set to “0” if there is no extension of the PC bits 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 16_{HEX} will be the logical OR of the XPC bits contents. The tag computes this logical OR, and maps the result into PC bit 16_{HEX}, 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 17_{HEX}: Shall be set to “0” if encoding an EPC and shall be set to “1” if encoding an ISO/IEC 15961 AFI in bits 18_{HEX} to $1F_{HEX}$.

— Bits 18_{HEX} to $1F_{HEX}$: A numbering system identifier (NSI) whose default value is 00000000_2 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 18_{HEX}.

The default (unprogrammed) PC value shall be 0000_{HEX}.

Table 4 summarizes the content.

Table 4 — Segmented memory: memory bank “01”

Protocol control bits run from 10_{HEX} to $1F_{HEX}$															
					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	Application family identifier (AFI)/ Numbering system identifier (NSI)							Haz Mat

7.5 Data elements

7.5.1 Unique RTI identifier

The UII – RTI shall be present on all conformant RTI tags. For non-retail tags, the unique RTI identifier shall conform to ISO/IEC 15459-5 and shall be used as described in 5.2.2. For retail tags, the unique RTI identifier shall conform to EPCglobal, *Tag Data Standards*, Version 1.3 for the GRAI-96 and shall be used as described in 5.2.3.

One tag represents the unique RTI identification and the second represents the shipment unique identification. Shipment unique identification is addressed at length in ISO 17365.

For full read/write tags, additional tag data shall include the appropriate ISO/IEC 15459-5 unique identifier. The mandatory data to be written to the tag shall be a function of the type of tag and the purpose of the specific tag application. For the purposes of this International Standard, the only required data element in compliant tags is the UII – RTI identifier, however, for practical purposes, both the UII – RTI and the UII – Transport Unit Identifier would be encoded using ISO/IEC 15961, the syntax of ISO/IEC 15434 and the semantics of ISO/IEC 15418 and ISO/IEC 15962.

The UII – RTI shall be locked, under password protection.

7.5.2 Hazardous goods

RFID tags for items that are classified as hazardous for storage, transportation or use shall contain a bit reference indicating that the item is hazardous. In addition, the tag, regulations and statutes 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 shall be reflected in the user data memory. The presence of hazardous material for EPC RTIs is indicated by bit "1F" of memory bank MB01 as defined in ISO/IEC 18000-6, Type C and ISO/IEC 18000-3 Mode 3. The presence of hazardous material for ISO RTIs is indicated by the AFI "A8" in bits "18" to "1F" of memory bank MB01 as defined in ISO/IEC 18000-6, 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 RTI identification requirements of numerous applications and industry groups. As such, it is applicable 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. The semantics of other user data shall conform to ISO/IEC 15961 and ISO/IEC 15418. The syntax of other user data shall conform to ISO/IEC 15962 and ISO/IEC 15434. ISO 15394 provides specific examples of other data elements using the ISO/IEC 15418 semantics and the ISO/IEC 15434 syntax.

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 15459-5.

7.7 Combined RTI and transport unit data

7.7.1 General

RFID tags are available in different formats. There are read only, write once/read many (WORM) and full read/write. All tags shall have the chip ID written to them by the manufacturers in accordance with ISO/IEC 15963. If read only or WORM tags are employed, two tags shall be used. One tag represents the unique transport unit identifier and the second represents the unique RTI. Unique transport unit identification is addressed at length in ISO 17365.

7.7.2 ISO data structures

Where there are application requirements to encode both the identity of the asset as well as a unique pointer to a database, e.g. shipment ID or license plate, it is possible to encode these unique identities in either one or two RF tags. In the case of two tags within the ISO system, each tag would include its own unique AFI, that is, "$A2_{HEX}$" for license plate (shipment identification) and "$A3_{HEX}$" for the RTI AFI. The AFIs are followed by the respective ASC MH10 Data Identifier as specified in ISO/IEC 15418. In the case of the RTI that DI is "25B". In the case of the transport unit that DI is the appropriate "J" Data Identifier.

When encoding both data structures in a single tag that has a monolithic memory structure (e.g. ISO/IEC 18000-2, Type A), the first data structure shall be the UII – RTI, preceded by the DI "25B" and shall be locked and the second data structure shall be the UII – transport unit that will change with each trip of the RTI, preceded by the "J" DI. For tags having a segmented memory structure (e.g. ISO/IEC 18000-6, Type C and ISO/IEC 18000-3 Mode 3), the UII – RTI shall be written to the UII memory and locked. The UII – transport unit shall be preceded by the "J" DI and, along with any additional data (with the appropriate DI), be

written and locked in user memory. When combining multiple data structures, the syntax of the data shall comply with ISO/IEC 15434. For 18000-7 tags, the memory segmentation will be as described in ISO/IEC 18000-7.

7.7.3 EPCglobal data structures

Where there are application requirements to encode both the identity of the asset (GRAI) as well as a unique pointer to a database, e.g. shipment ID or GS1 Serialized Shipping Container Code (SSCC), it is possible to encode these unique identities in either one or two RF tags. In the case of two tags within the EPCglobal system, each tag would include its own unique header, that is, "31" for SSCC and "33" for GRAI. In the case of encoding both data structures in a single tag, the first data structure (96 bits) shall be the GRAI and shall be locked and the second data structure (96 bits) shall be the SSCC that will change with each trip of the RTI. Since both data fields are fixed length, there is no requirement for a data element separator.

GS1 Member Organizations allocate the GS1 Company Prefix to a system user (see GS1 *General Specifications*). This makes the SSCC unique worldwide but does not identify the origin of the unit.

7.8 Unique item serialization

Unique item identification can be assured 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 15459-3.

RTI-RFID tag data formats shall make a clear distinction in the leading eight bits of the tag between unique RTI identification and its contents, in addition to a ninth bit (at seventeenth HEX position) indicating ISO (AFI) or EPCglobal.

The data structure identifying the asset shall be locked. This information shall only be changed in the case of change of ownership. For tags having a monolithic memory structure, the data structure identifying the shipment shall be appended to the asset license plate and shall be rewritable for new shipments.

For tags having a segmented memory structure, the asset license plate shall be stored in the memory segment dedicated to the item license plate (i.e. UII memory). The data structure identifying the shipment shall be stored in the memory segment dedicated to additional data (i.e. user memory) and shall be rewritable.

7.9 Ownership of and responsibility for RTIs

For RTIs in the supply chain, it shall be impossible to disable the tag, e.g. by a *kill-command*.

The ownership of the RTI and the information on its content shall be defined. This applies for the tag as well as the RTI itself.

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.

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. Tag manufacturers shall have the option of locking a portion of the tag data for identification and storage of data related to the manufacturer and not the user. A CRC-16 is required to enhance the integrity of the data. The location of the CRC-16 shall be as per the memory map in Figure 2.

8.3 Data preservation

For an RTI in the supply chain, it shall be impossible at the point-of-sale of any (packed) product to disable the tag, e.g. by a kill-command.

8.4 Interrogator authentication

A tag's data storage and transfer protocols shall provide for the user-enabled option to require authentication of the interrogator's authorization prior to reading the tag data. Reading of the tag ID alone shall not require authentication.

8.5 Non-repudiation/audit trail

Tags shall be capable of supporting non-repudiation when programmed to provide non-forgeable evidence that a specific action occurred. Nothing in this non-repudiation feature shall interfere with or degrade the performance of the tag or other tags in the field of view.

9 Identification of RFID labelled material

RTIs, 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 are given in Figure 3.

NOTE 1 The above emblems only represent the 860 MHz to 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.

Figure 3 — Examples of the RFID emblem and EPCglobal seal as described in ISO/IEC 29160

10 Human readable information

10.1 Human readable interpretation

Human readable interpretation of the data on an RTI RFID tag is optional, except when required by regulation or statute. Human readable interpretation is the literal representation of all of the data on the tag, including semantics. When human readable interpretation is used, it shall be placed on the exterior of the RTI, as required elsewhere in this section. Where used, the mandatory information (UII) contained in the binary encodations in RF tags shall be represented in their octal or hexadecimal equivalent as specified in ISO/IEC TR 24729-1. ISO standard two-dimensional symbols, for example Data Matrix ECC 200 or QR code, encoded in conformance with ISO/IEC 15418 and ISO/IEC 15434, should be considered as a primary backup to RF tags on RTIs. An additional level of backup of human readable interpretation may be considered.

10.2 Human readable information (HRI) and bar code representation of UII

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 specified in ISO/IEC TR 24729-1.

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 and shall function as the first backup in the event that the RFID tag is unreadable/misleading for any reason. If optically readable media is used, trading partners shall agree upon a linear symbol such as Code 128, as described in ISO/IEC 15417, or a two-dimensional symbol such as Data Matrix, as described in ISO/IEC 16022 or QR Code, as described in ISO/IEC 18004.

11 Tag operation

11.1 Data protocol

The data protocol for this International Standard shall support the requirements of ISO/IEC 15961 and the semantics of ISO/IEC 15418 and ISO/IEC 15962 and the syntax of ISO/IEC 15434.

11.2 Minimum performance requirements (range and rate)

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

Table 5 — Typical tag performance

Parameter	860 MHz to 960 MHz ISO/IEC 18000-6, Type C	13,56 MHz ISO/IEC 18000-3, Mode 3	<135 kHz ISO/IEC 18000-2, Type A	433,92 MHz ISO/IEC 18000-7
How far? [Minimum supported read distance (in metres)]	3	0,7	0,7	30
How fast? [Minimum supported item speed when read (in kilometres per hour)]	16	16	0	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	1	1
[a] This value corresponds to the 200 kHz bandwidth.				
[b] This value corresponds to the 500 kHz bandwidth.				

1) In case regulatory restrictions provide fewer channels than there are interrogators in the environment, this performance can only be achieved by appropriate shielding of the interrogators against other interrogators.