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Supply chain applications of RFID — Transport units

Applications de chaîne d'approvisionnements de RFID — Unités de transport

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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 17365 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 transport units. Transport units are defined here as either a transport package or a unit load (see ISO 17364:2009, 4.12 and 4.15)

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 ISO 17364 as a *returnable transport item* or within this International Standard as a *transport unit*. If ownership title of the pallet remains with its owner then the applicable International Standard is ISO 17364. 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, then this International Standard is applicable.

Specific to transport units is the grouping of (packaged) products, in order to make these more suitable for efficient and effective transport and distribution. The transport unit provides an added value for the product being sold, mostly in terms of logistics performance. RFID tagged transport units can help further optimize the supply chain.

This International Standard is intended for use by owners and users of transport units, manufacturers and logistic services providers. It ensures the unambiguous and optimal use of transport units in the supply chain. In conjunction with the other *Supply chain applications of RFID* International Standards, a seamless application of the transport units within the total supply chain is enabled.

Supply chain applications of RFID — Transport units

1 Scope

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

— provides specifications for the identification of the transport unit,

— 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 15459-1, *Information technology — Unique identifiers — Part 1: Unique identifiers for transport units*

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 17364, *Supply chain applications of RFID — Returnable transport items (RTIs)*

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 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, *IEEE Standard for a Smart Transducer Interface for Sensors and Actuators*

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 17364, ISO/IEC 19762-1, ISO/IEC 19762-3 and ISO 21067 apply.

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 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.

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 2 in Figure 1 and transport units (as defined in the Introduction) are the subject of this International Standard.

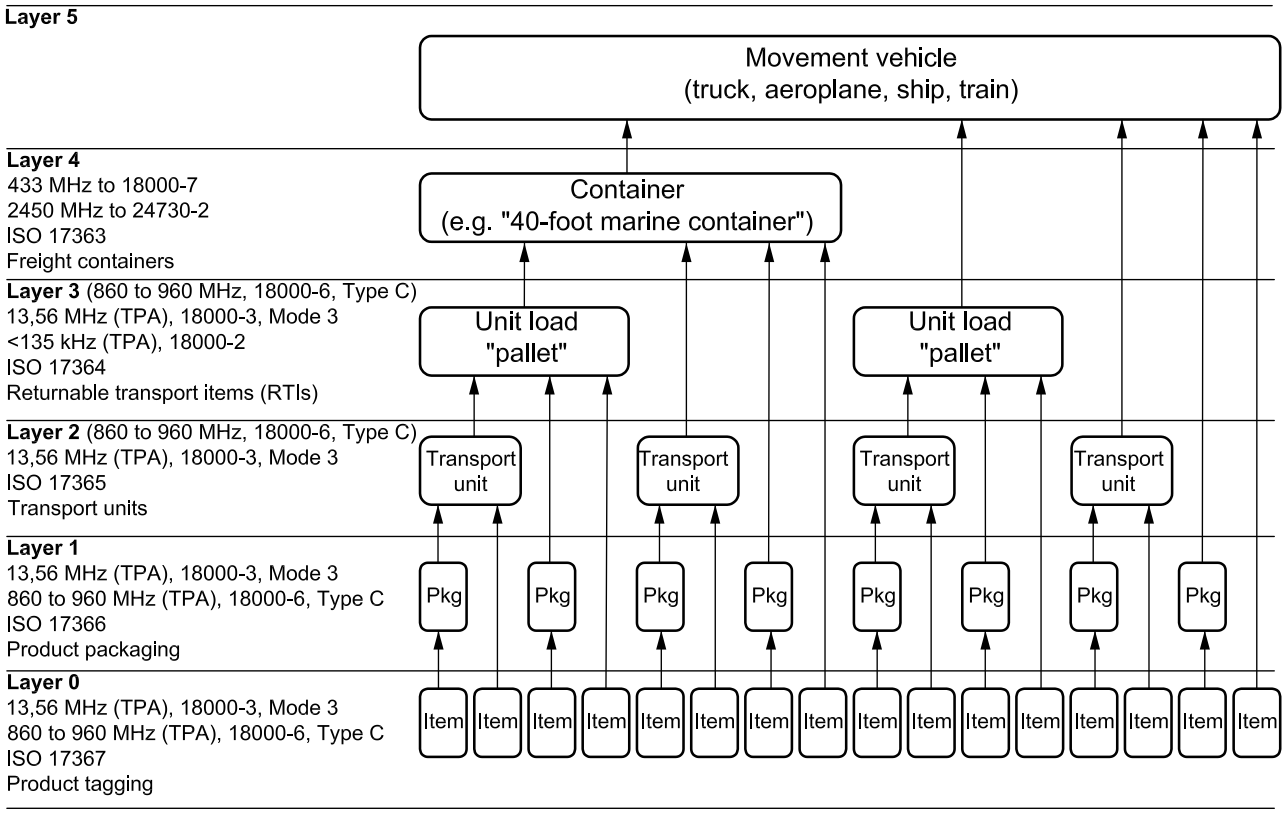

Figure 1 — Supply chain layers

Once tagged, transport unit layer 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 transport unit layer tags. As indicated in 5.2.2, the group select methodology is further elaborated in ISO/IEC 15961.

5.2 Unique identification of transport units

5.2.1 General

Unique transport unit identification is a process that assigns a unique data string to an individual transport unit, or in this case to an RFID tag that is associated to the transport unit. The unique data string is called the unique transport unit identifier. Unique item identification of transport units 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 transport unit 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 transport unit identifier defined in this International Standard.

Transport unit tagging provides unique identification of transport units. 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 transport unit identification:

— unique identifier for transport units (ISO/IEC 15459-1);

— GS1 Serial Shipping Container Code (SSCC).

5.2.2 International unique identification of transport units

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 transport units shall use ISO/IEC 15459-4. 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 transport units employed in retail applications using EPCglobal. AFI $A2_{HEX}$ may be used for transport units 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 “1J, 2J, 3J, 4J, 5J, 6J or J”. A unique identifier of transport units can be up to 20 alphanumeric characters in length (an..2+an..20). See Table 2.

Table 2 — UII element string

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

5.2.3 Serial shipping container code (SSCC)

The serial shipping container code (SSCC) is a unique item identifier (UII) capable of providing unique item identification of transport units.

To define its class, the UII shall have an associated class identifier, which is the Application Identifier “00”.

A logistic unit is an item of any composition established for transport and/or storage that needs to be managed through the supply chain. The identification and symbol marking of logistic units enables a large number of user applications. In particular, the SSCC provides a link between the physical logistic unit and information pertaining to the logistic unit that is communicated between trading partners using electronic data interchange (EDI).

The SSCC element string AI (00) is used for the identification of logistic units. Each individual logistic unit is allocated a unique number, which remains the same for the life of the logistic unit. When assigning an SSCC, the rule is that an individual SSCC number shall not be reallocated within one year of the shipment date from the SSCC assignor to a trading partner. However, prevailing regulatory or industry organization specific requirements may extend this period.

In principle, the SSCC provides a unique reference number that can be used as the key to access information regarding the logistic unit in computer files. However, attributes relating to the logistic unit (e.g. ship-to information, logistic weights) are also available as standardized element strings. See Table 3.

Table 3 — SSCC element string

Format of the element string			
SSCC			
Application Identifier	Extension digit	GS1 Company Prefix Serial Reference	Check digit
00	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_{18}

The Application Identifier (00) indicates that the data field contains an SSCC.

The extension digit is used to increase the capacity of the Serial Reference within the SSCC. The company that constructs the SSCC assigns the extension digit.

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.

The structure and content of the Serial Reference is at the discretion of the system user responsible for its assignment.

The check digit is explained in the GS1 *General Specifications.* Its verification, which shall be carried out in the application software, ensures that the number is correctly composed.

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 transport unit 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

The layer represented by the transport unit is characterized by the following unique aspects.

— Individual transport units are identified by a shipment control number (SSCC or J-series Data Identifier).

— The transport unit is the source of information about the environmental condition of the unit or package. This includes data on temperature, humidity, shock, and other physical characteristics.

The RF tag associated with the transport unit is written to or read from as part of one or more of the following business processes:

— building a transport unit;

— assembly of the next higher level in the supply chain;

— shipment;

— in transit;

— cross-docking;

— in-check/receipt;

— de-aggregation of the transport unit.

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

7 Data content

7.1 Introduction

Subclauses 7.2 to 7.8 describe the data content of RFID tags for the transport unit 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 transport unit tagging only, both write once/read many (WORM) and read-write tags are used. This is done to enable transport unit owners to assign specific and permanent UIIs to their transport units.

7.2 System data elements

7.2.1 Unique transport unit identification

The first data element on a compliant tag shall be the unique identification described in ISO/IEC 15459-1. 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 transport units can be up to 23 alphanumeric characters in length, including the Data Identifier (an3+an..20).

7.2.2 Data semantics

Tags that only encode the unique transport identifier shall conform to ISO/IEC 15961. Tags containing complex data structures or larger data sets shall include semantics that conform to ISO/IEC 15418, ISO/IEC 15961 and ISO/IEC 15962.

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 transport units, i.e. $A2_{HEX}$, 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 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 SSCC is represented by EPC header 31_{HEX}.

7.3.2 Tag memory

Figure 2 provides a graphical representation of tag memory.

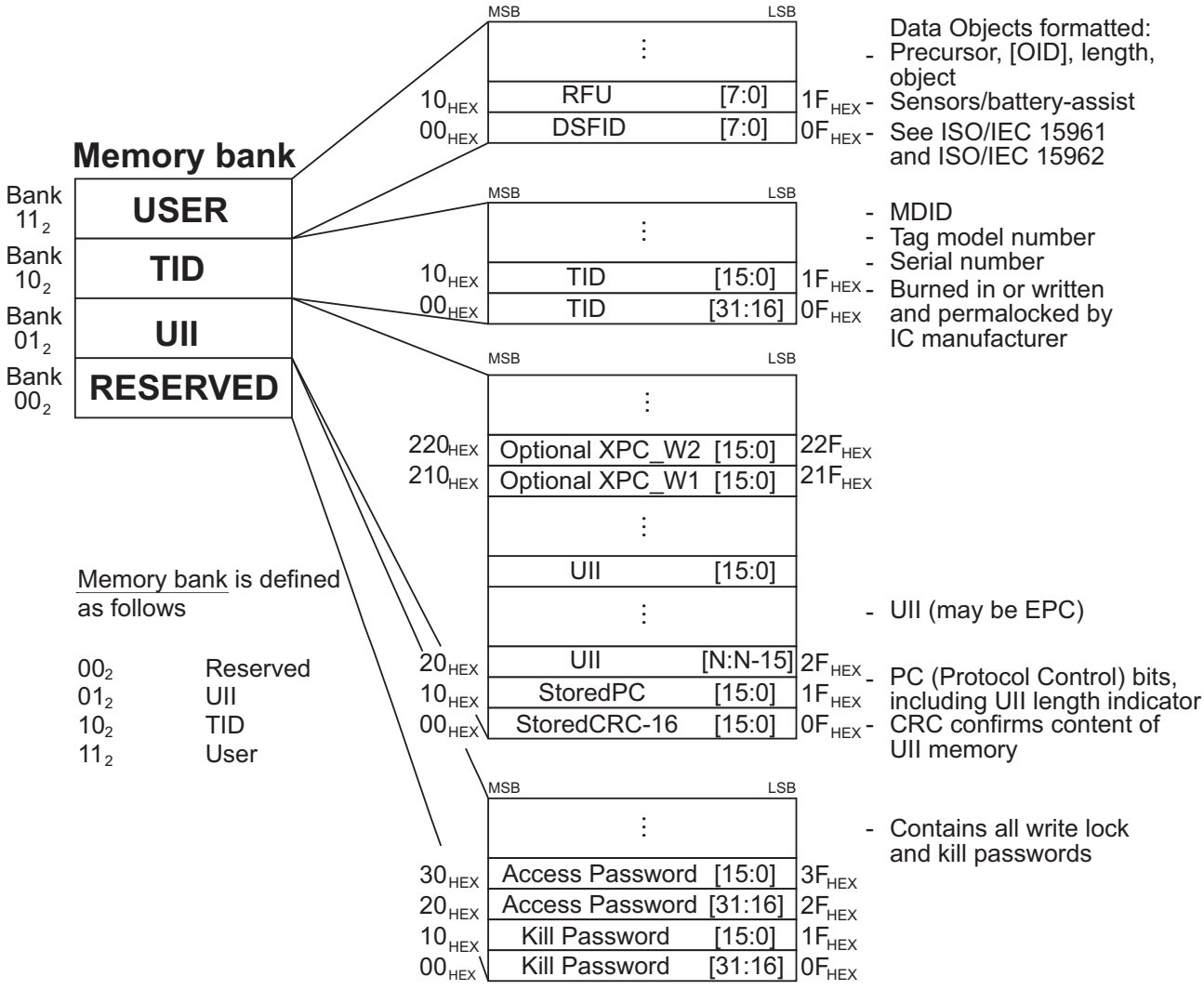

Figure 2 — Memory map for segmented memory tags

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 15459-1 tags operating conformant to ISO/IEC 18000-6, Type C and whose ISO/IEC 15963 allocation class identifier is 11100000_2 ($E0_{HEX}$), 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 15459-1 tags operating conformant to ISO/IEC 18000-3, Mode 3, and whose ISO/IEC 15963 allocation class identifier is 11100000_2 ($E0_{HEX}$), 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 $1F_{HEX}$.

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 in MB11.

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 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 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 transport unit identifier

The UII – transport unit shall be present on all conformant transport unit tags. For non-retail tags, the unique transport unit identifier shall conform to ISO/IEC 15459-1 and shall be used as described in 5.2.2. For retail tags, the unique transport unit identifier shall conform to EPCglobal, *Tag Data Standards*, Version 1.3 for the SSCC-96 and shall be used as described in 5.2.3.

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 transport units 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 transport units 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 transport unit 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 15459-1.

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 RTI identification is addressed at length in ISO 17364.

7.7.2 ISO data structures

For full read/write tags, additional tag data shall include the appropriate UII – transport unit identifier and the UII – RTI 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 practical purposes, both the UII – RTI and the UII – transport unit identifier should be encoded using ISO/IEC 15961, the syntax of ISO/IEC 15434 and the semantics of ISO/IEC 15418.

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 transport unit, that Data Identifier is the appropriate "J" Data Identifier. In the case of the RTI, that Data Identifier is "25B".

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 written 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.

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 transport unit. 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.

Transport unit-RFID tag data formats shall make a clear distinction in the leading eight bits of the tag between unique transport unit 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.

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. 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 transport units in the supply chain, it should be possible at the retail 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

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 a transport unit 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 transport unit, 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 shown 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 transport units. 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 ANSI 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.				

11.3 Environmental parameters

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 transport unit user community.

— The transport unit RFID tag shall function properly in the temperature range −40 °C to +70 °C and be able to endure, for a specified period of time, harsher conditions in the range −50 °C to +85 °C.

— An operating environment with relative humidity of 95 %.

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.

— 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).

— Electromagnetic interference from motors, fluorescent lights and other spectrum users.

— Electromagnetic characteristics of the packaging and contents 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.

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 per second sequentially, parallel readings should be envisioned.

11.4 Tag orientation

It should be assumed that the handling operation is unable to predict the orientation of the individual (packed) products in the transport unit. This may hamper the effective use of the reading equipment on site and/or *en route*. Where the transport unit also functions as an RTI, guidance can be found in ISO 17364.

11.5 Packaging material

A wide range of materials (such as wood, metal, plastic, glass, paper and textile) is utilized in primary packaging and small and large transport units. 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 transport units are subject to shock loads during the physical handling process. This can 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 the transport unit will be continuously used throughout the life of the transport unit.

All tags attached to the transport unit may be used to facilitate the recycling of the transport unit and the tag itself, e.g. by holding information on plastic type. In this respect, it may also be feasible to reuse the tag after reprogramming, provided it does not compromise the supply chain data structure. The exact implementation depends on cost of the tag and environmental implications of reuse/recycling. Transport unit RFID tags shall be capable of a minimum 100 000 read or read/write cycles, as appropriate, without failure.

11.8 Minimum reliability

Systems where tags are positioned, programmed and presented to reading equipment in accordance with the provisions of 11.3 and ISO/IEC TR 18046, 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

The air interface specification recommended by this International Standard is ISO/IEC 18000-6, Type C. ISO/IEC 18000-2, Type A, the ASK air interface of ISO/IEC 18000-3, Mode 3, and ISO/IEC 18000-7 may be used with trading partner agreement. It is recommended that tags supporting ISO/IEC 18000-6,Type C also be able to support ISO/IEC 18000-3, Mode 3.

11.10 Memory requirements for application

The memory requirements for transport unit RFID tags can 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. Memory capacities shall not alter the air interface. Use of alternate 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.

11.11 External communications

External communications (interactive as opposed to simple data transfer and read/write) shall not be required for, but may be a part of, transport unit RFID tags where the optional supporting commands meet the requirements of the optional commands in the air interface (ISO/IEC 18000). Proprietary commands should not be used.

11.12 Sensor interface, if applicable

Sensor equipped transport unit RFID tags shall conform to IEEE 1451.7 for the physical interface between the tag and the sensor.

11.13 Real time clock option

A real time clock shall be included with transport unit 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.

11.14 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.

11.15 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. Tags that are intended for use over the supply chain shall have the mandatory data elements readable.

11.16 Tag recyclability

The recyclability of RFID tags is dependent upon the component materials used in the individual tags used. Items marked with RFID tags that require recycling shall be marked with an appropriate logo or other visible symbol that indicates the required recycling. It will not be possible to use RF tags for recycling if the tags are "killed" at point-of-sale.

Tags that should be recycled but for which such recycling is not mandated by regulation, statute or operating condition, shall be marked with an appropriate recycling symbol to assist the user in the proper disposal of the tag. Tags should not be an impediment to the recycling of transport units. The tag manufacturer shall clearly mark transport unit tags with recycling instructions or appropriate logo to assist in the proper disposal of the tag. Guidelines for tag recyclability can be found in ISO/IEC TR 24729-2.

11.17 Tag reusability

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

High-value and mission critical items can utilize higher functionality (read/write, larger memory and possibly sensors) tags, the cost of which can 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.

Tag location and presentation shall allow multi-reading and omni-reading simultaneously for the transport unit and the products it contains. To minimize damage, the tag location should be recessed on the outside of the transport unit or inside the transport unit.

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 within the transport unit shall be considered in the design to minimize disturbance of the RF signal.

12.2 Geometry of the transport unit/tag environment

Products/product packages should be placed into transport units in such a way to minimize the disturbance of the RF signal. This pertains to both the transport unit 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 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 the appropriate authorities.

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 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

Company proprietary data shall be identified beforehand and companies wishing to restrict the collection of company proprietary data from transport unit RFID tags shall utilize appropriate forms of data security. As security/protection of tag data can be compromised, use of RFID transport unit 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.

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