
**Information technology — Radio
frequency identification (RFID) for
item management — Data protocol:
data encoding rules and logical
memory functions**

*Technologies de l'information — Identification par radiofréquence
(RFID) pour la gestion d'objets — Protocole de données: règles
d'encodage des données et fonctions logiques de mémoire*



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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see patents.iec.ch).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This third edition cancels and replaces the second edition (ISO/IEC 15962:2013), which has been technically revised.

The main changes are as follows:

- editorial changes were made;
- references have been updated.

A list of all parts in the ISO/IEC 15962 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

The technology of radio frequency identification (RFID) is based on non-contact electronic communication across an air interface. The structure of the bits stored on the memory of the RFID tag is invisible and accessible between the RFID tag and the interrogator only by the use of an air interface protocol, as specified in the appropriate part of the ISO/IEC 18000 series. The result of the transfer of data between an application and an interrogator in open systems requires data to be encoded in a consistent manner on any RFID tag that is part of that open system. This is not only to allow equipment to be interoperable, but in the special case of data carriers, for the data to be encoded on the RFID tag in one system's implementation for it to be read at a later time in a completely different and unknown system's implementation. The data bits stored on each RFID tag must be formatted in such a way as to be reliably read at the point of use if the RFID tag is to fulfil its basic objective. This reliability is achieved through the specification of a Data Protocol using the application-defined arguments defined in ISO/IEC 15961-1 and the data encoding rules of this document. Additionally, ISO/IEC 24791-1 specifies a software system infrastructure architecture that enables RFID system operations between business applications and RFID interrogators. Specific parts of the ISO/IEC 24791 series address data management requirements (ISO/IEC 24791-2) and device interface requirements (ISO/IEC 24791-5). These support defined implementations that incorporate the encoding rules of this document and the functional rules of the commands and responses in ISO/IEC 15961-1.

Manufacturers of RFID equipment (e.g. interrogators, RFID tags) and the users of RFID technology require a standards-based Data Protocol for RFID for item management. ISO/IEC 15961-1, ISO/IEC 15961-2, ISO/IEC 15961-3, this document and the ISO/IEC 24791 series specify this protocol, which is layered above the air interface standards defined in the ISO/IEC 18000 series.

The Data Protocol used to exchange information in an RFID system for item management is specified in ISO/IEC 15961-1 and in this document. Both documents are required for a complete understanding of the Data Protocol in its entirety, but each focuses on one particular interface:

- ISO/IEC 15961-1 addresses the interface with the application system.
- This document deals with the processing of data and its presentation to the RF tag, and the initial processing of data captured from the RF tag.

The transfer of data to and from an application, supported by appropriate application commands, is the subject of ISO/IEC 15961-1. This document specifies the overall process and the methodologies developed to format the application data into a structure to store on the RFID tag.

Information technology — Radio frequency identification (RFID) for item management — Data protocol: data encoding rules and logical memory functions

1 Scope

This document focuses on encoding the transfer syntax of the application commands defined in ISO/IEC 15961-1. The encodation is in a Logical Memory as a software analogue of the physical memory of the RFID tag being addressed by the interrogator.

This document

- defines the encoded structure of object identifiers;
- specifies the data compaction rules that apply to the encoded data;
- specifies a Precursor for encoding syntax features efficiently;
- specifies formatting rules for the data, e.g. depending on whether a directory is used or not;
- defines how application commands, e.g. to lock data, are transferred to the Tag Driver;
- specifies processes associated with sensory information and the transfers to the Tag Driver;
- defines other communication to the application.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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/IEC 15961-1, *Information technology — Radio frequency identification (RFID) for item management — Data Protocol — Part 1: Application interface*

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

3 Terms and definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762 and the following apply. ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1.1

data compaction

mechanism, or algorithm, to process the original data so that it is represented efficiently in fewer bytes in a data carrier than in the original presentation

3.1.2

data processor

implementation of the processes defined in this document, including the Data Compactor, Formatter, Logical Memory, and Command/Response Unit

3.1.3

precursor

byte, sometimes a sequence of bytes, used in the Directory and No-Directory Access-Methods that acts as metadata for the subsequent Object-Identifier and Object

3.2 Abbreviated terms

FQIDV	Fully-qualified ID value
IDLPO	ID List Packed Object
IDMPO	ID Map Packed Object
PO	Packed Object
TBD	To be determined
TEI	Text element identifier
URN	uniform resource name

Since "TDS", "Type A" to "Type D" are commonly used in the industry to refer to the technology components as specified by these standards, the following designations are used in this document:

Type A	refers to ISO/IEC 18000-61
Type B	refers to ISO/IEC 18000-62
Type C	refers to ISO/IEC 18000-63
Type D	refers to ISO/IEC 18000-64
TDS	refers to GS1 EPC, <i>Tag Data Standard</i>

4 Conformance

4.1 Conformance with the air interface

A conformant implementation of this document shall support one or more air interface protocols through the Tag Drivers defined in [Annex C](#). Declarations of conformance shall refer to the specific air interface protocol(s). This applies to encoders, decoders, or more comprehensive devices.

4.2 Conformance with the application interface

4.2.1 Encoders and the application interface

Within the constraints of the air interface protocol supported, a conformant implementation of this document on an encoder shall support the application commands defined in [8.2](#) and the associated process argument, as defined in [Clause 10](#).

A conformant RFID tag shall have its encoding in a state that can be properly decoded by a conformant decoder (see [4.2.2](#)).

4.2.2 Decoders and the application interface

Within the constraints of the air interface protocol supported, a conformant implementation of this document on a decoder shall support the application commands defined in [8.3](#) and the associated process argument, as defined in [Clause 10](#).

4.2.3 Comprehensive encoder/decoder devices and the application interface

Within the constraints of the air interface protocol supported, a conformant implementation of this document on an encoder/decoder shall support the application commands defined in [8.2](#) and [8.3](#) and the associated process argument, as defined in [Clause 10](#). In addition, the Delete-Object (see [8.4.2](#)) and Modify-Object (see [8.4.3](#)) commands shall be supported. Other commands defined in [8.4](#) may be supported, and each command that is supported shall be declared.

4.3 Conformance with the Access-Method

4.3.1 Encoders and the Access-Method

A conformant implementation of this document on an encoder shall support the encoding rules and formatting rules of one or more Access-Methods as defined in [Clause 11](#) and associated Annexes. Declarations of conformance shall refer to the specific Access-Method(s) supported.

4.3.2 Decoders and the Access-Method

A conformant implementation of this document on a decoder shall support the decoding rules and formatting rules of all the Access-Methods as defined in [Clause 11](#) and associated Annexes.

An interrogator is not expected to fully support the decoding functions of all the Access-Methods, and the following shall apply to achieve conformance:

- For full conformance, the decoder process on the interrogator shall output the Object-Identifier, Object and other arguments as required in the responses to the commands.
- For partial conformance, the decoder process on the interrogator shall output the byte string that represents the encoded package (depending on the Access-Method) containing the requested Object-Identifier. The encoded package then shall be fully decoded by a decoder process, external to the interrogator that is fully in conformity with the rules defined in this document.

Declarations of conformance shall refer to the specific Access-Method(s) supported.

4.3.3 Comprehensive encoder/decoder devices and the Access-Method

A conformant implementation of this document on an encoder/decoder shall support the encoding rules and formatting rules of one or more Access-Methods as defined in [Clause 11](#) and associated Annexes. Declarations of conformance shall refer to the specific Access-Method(s) supported. The decoding function shall be as defined in [4.3.2](#).

5 Protocol model

5.1 Overview

RFID supports bit encodation in the RFID tag memory. Unlike other data carrier standards which require encodation schemes that are specific to the individual data carrier technology, the ISO/IEC 18000 series does not specify the interpretation of bits or bytes encoded on the RFID tag memory. However, as an RFID tag is a relay in a communication system, each tag used for open systems item management shall have data encoded in a consistent manner. The prime function of ISO/IEC 15961-1 is to specify a common interface between the application programs and the RFID interrogator. The prime function of this document is to specify the common encoding rules and Logical Memory functions.

RFID tags utilise electronic memory, which is typically capable of increasing data capacity as new generations of product are introduced. Differences in data capacity of each RFID tag type, whether similar or dissimilar, are recognised by the Data Protocol defined in these two documents.

Different application standards may have their own datasets or data dictionaries. Each major application standard for item management shall have its data treated in an unambiguous manner, avoiding confusion with data from other applications and even with data from closed systems. The Data Protocol specified in these documents ensures the unambiguous identification of data.

5.2 Layered protocol

5.2.1 Layers

The protocol layers of an implementation of RFID for item management are illustrated schematically in [Figure 1](#).

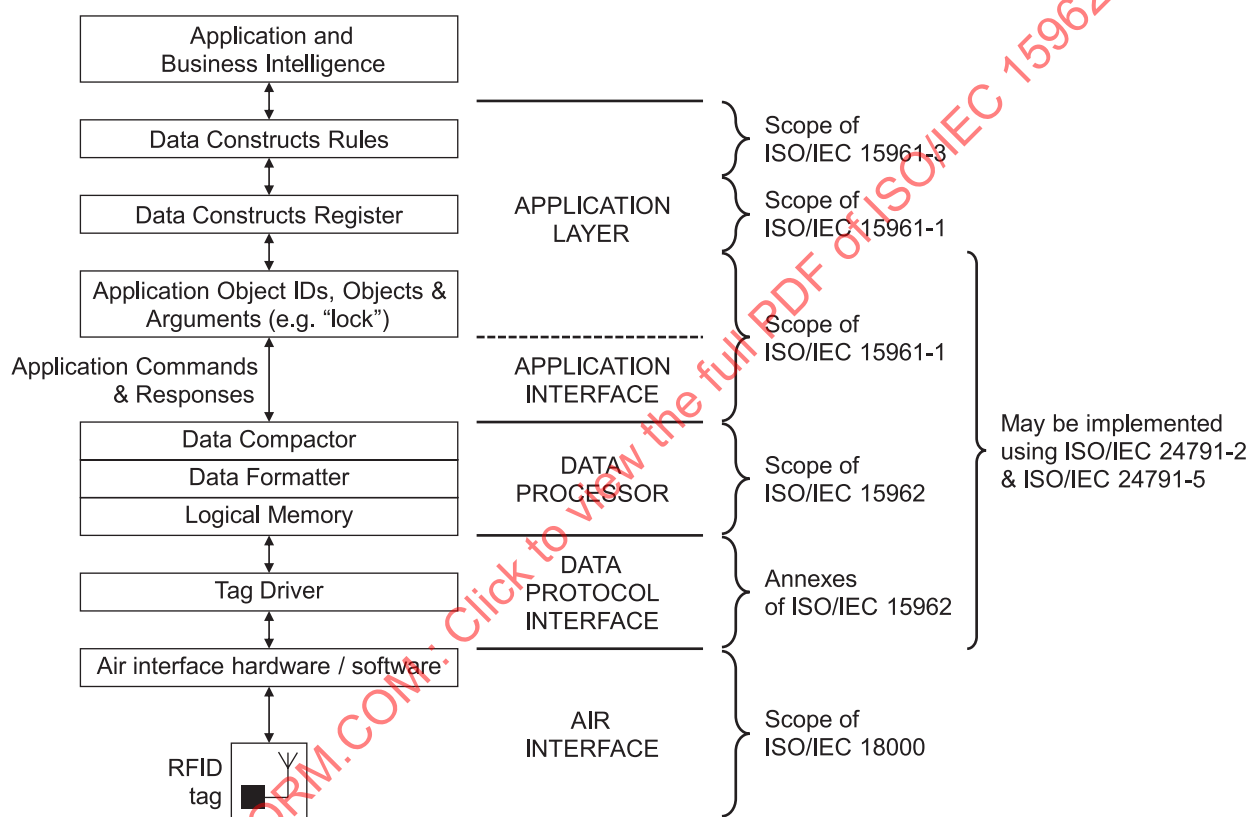


Figure 1 — Schematic of protocol layers for an implementation of RFID for item management

5.2.2 Application layer as defined in the ISO/IEC 15961 series

The RFID Data Protocol specifies how data is presented as objects, each uniquely identified with an object identifier, which are meaningful to the application and can be encoded on the RFID tag. ISO/IEC 15961-3 specifies the data construct rules for the AFI, DSFID, object identifier for the unique item identifier, and object identifier structure for other item-related data. This ensures that each piece of data can be uniquely identified, both within the scope of a particular application and between applications.

Each application shall be registered according to ISO/IEC 15961-2 so that the data constructs can be declared and used in an unambiguous manner.

The RFID Data Protocol in ISO/IEC 15961-1 defines functions and arguments used to construct application commands and responses. This is so that application programs can specify what data to

transfer to and from the RFID tag and to append, update, selectively lock, delete data, or perform other functions on the RFID tag.

NOTE To illustrate how the functions and arguments are assembled into a structured format, several commands and responses have been constructed using an abstract syntax. This is independent of the host application, operating system, and programming language and independent of the specific command structures between the interrogator and Tag Driver. The abstract syntax used in ISO/IEC 15961-1 is like that used in ISO/IEC 24791-5, and is intended to enable closer integration with that standard. The original version of ISO/IEC 15961:2004¹⁾ included commands defined using ASN.1 abstract syntax, see ISO/IEC 8825-1. For backward compatibility, the commands that were originally defined in this manner have been included in an annex of ISO/IEC 15961-1.

This RFID Data Protocol also defines arguments and codes to support responses of data that is read from an RFID tag, including error messages, which are returned to the application.

The abstract syntax may be used as a basis to prepare commands in different programme languages, supporting the functionality and arguments of the abstract commands.

5.2.3 Application interface as defined in ISO/IEC 15961-1

The application interface may be implemented in several different ways that are not explicitly defined in this document, nor in ISO/IEC 15961-1. The basic requirement is to identify data objects distinctly from all others using object identifiers, even to enable different data formats to be intermixed on the same RFID tag. The application interface also shall define command and response arguments unambiguously, so that they can be intermixed with data on the same wired or wireless network.

One major class of implementation, described as a *straight-through process*, is appropriate where the functions and arguments used to construct commands and the arguments and codes used to construct responses, as specified in this document, are directly input to the encoding processes of ISO/IEC 15962. Such input can be from computer screens or forms, or more direct transfers from host systems. The advantage of this process is that it avoids the creation of the transfer encoding (see below) but requires more rigorous adherence to the functional requirements of the commands and responses. ISO/IEC 15961-1 imposes no constraints on the application interface process to be adopted, other than the requirement that it be integrated with the encoding rules of ISO/IEC 15962.

Whichever approach is used, the encoding rules of ISO/IEC 15962 shall be followed, and the encoding on the RFID tag shall be in conformity with all the arguments in the commands specified in ISO/IEC 15961-1.

5.2.4 Data Protocol processing

The RFID Data Protocol specifies how data is encoded, compacted, and formatted on the RFID tag and how this data is retrieved from the RFID tag to be meaningful to the application.

This RFID Data Protocol provides for a set of schemes that compact the data to make more efficient use of the memory space.

This RFID Data Protocol also supports various storage formats to enable efficient use of memory and efficient access procedures.

5.2.5 Data Protocol interface

Each air interface protocol standard in the ISO/IEC 18000 series has its own specific rules for defining commands and responses. Furthermore, some air interface protocols can support different tag architectures with different memory sizes, and possibly support optional commands. The Data Protocol provides a mechanism to interface with these rules through specific Tag Drivers. These allow the basic application commands and responses of ISO/IEC 15961-1 to be applied independently of the air interface protocol and specific tag architecture.

1) Withdrawn standard. Revised by ISO/IEC 15961-1:2013, ISO/IEC 15961-2:2019, ISO/IEC 15961-3:2019, ISO/IEC 15961-4:2016.

The Tag Driver component of the Data Protocol provides the mapping rule from the generic processes to the specific tag requirements. These mapping rules are used to write data and to read data.

NOTE Additional Tag Drivers can be specified as new air interface protocols are introduced in the ISO/IEC 18000 series of standards.

5.3 Flexible implementation configurations

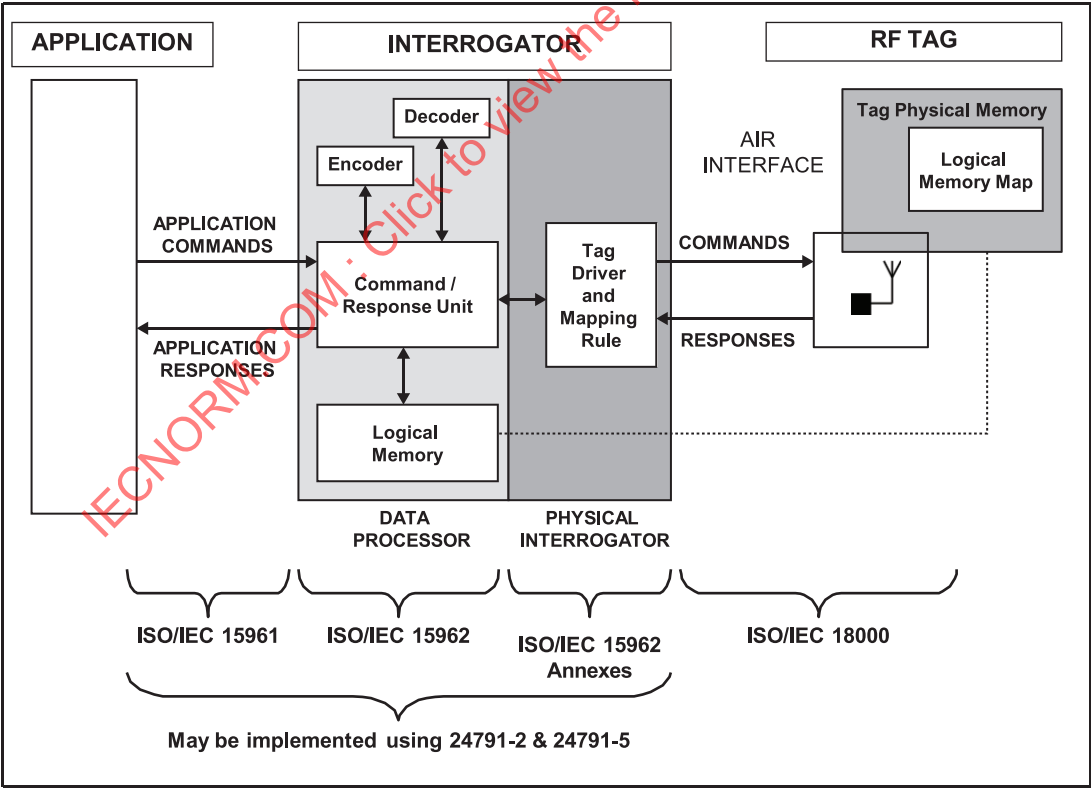
This RFID Data Protocol specifies the application level communication and the RFID tag interrogator level rules for data encoding, compaction, and storage formats. This protocol may be implemented:

- with the document incorporated into the software system infrastructure architecture defined in the ISO/IEC 24791 series. This is the recommended approach for any networked application.
- with ISO/IEC 15961-1 and this document incorporated into stand-alone software or devices that have as its output conformant encoding and/or conformant decoding with responses in conformity with the responses of ISO/IEC 15961-1.

5.4 Functional processes — Interrogator implementation

5.4.1 Logical functions and interfaces

There are various functional processes that need to take place to write data to an RFID tag and to read data from it. Figure 2 shows a schematic of an example implementation where the processing of the Data Protocol resides in the interrogator. This illustration is provided to help with the understanding of the processes, and although a typical implementation, many others are possibly in conformity with this Data Protocol.



NOTE The Logical Memory Map in the Tag Physical Memory is given by the Tag architecture and the mapping rules in the Tag Driver. All the information in the Logical Memory is represented in the Logical Memory Map.

Figure 2 — Logical functions and interfaces of ISO/IEC 15962 with other RFID system components

5.4.2 Functional processes — Application interface

The data flows between the application and the Data Processor are formatted according to this document and are not compacted. However, there are numerous established systems where data is formatted to be in conformance, for example, with a bar code related syntax. It is therefore reasonable to insert interface modules in the data flow to convert from and to existing application formats.

Careful consideration should be given to the extent that established systems need to be supported relative to the potential benefits to be gained from adopting the Data Protocol specified in this document and ISO/IEC 15961-1. This is because this protocol has been developed around the features of RFID, such as selective read/write and the ability to lock data. Older protocols are unlikely to support such features.

5.4.3 Functional processes — Interrogator

5.4.3.1 General

In the process illustrated in [Figure 2](#), the interrogator is the module in which all the basic processing of the Data Protocol takes place and there is an interface to the RFID tag. Different implementations can separate some of the functions described below and have an interface between the application and the physical interrogator.

5.4.3.2 Data processor

5.4.3.2.1 General

The Data Processor provides all the processing, which is as specified in this document and is required for handling application data. It consists of the following components, all of which are described more fully below: Command/Response Unit, Logical Memory, Encoder (which supports a Data Compactor and Formatter function) and Decoder (which supports the inverse functions of the Encoder).

The Data Processor can physically reside anywhere between the application software and the Tag Driver but shall contain all the components. Some, or all, of the Data Processor functions may be implemented using processes defined in ISO/IEC 24791-2 and ISO/IEC 24791-5.

5.4.3.2.2 Command/Response Unit

The Command/Response Unit receives the application commands from the application in a format specified in this document, acting upon these commands where appropriate and converting to the specific RFID tag lower-level command codes.

EXAMPLE An application command of *write Data Object "name"* is application related. The Data Protocol recognises this and can format the data onto the Logical Memory in the Data Processor. Information from the particular RFID tag is required to set the parameters of the Logical Memory Map (e.g. number of bytes, whether a directory is in use) on the RFID Tag. The Tag Driver converts the application command into a tag-specific command.

It can be seen from this example that there is a distinct logical boundary between the Data Processor and the Tag Driver.

5.4.3.2.3 Logical Memory

This is an array of contiguous bytes of memory acting as a common software representation of the RFID tag memory accessible by an application and to which the object identifiers and data objects are mapped in bytes. The Logical Memory considers some parameters of the real RFID tag, for example the block size, the number of blocks and the storage format. The Logical Memory ignores any detailed tag architecture.

The use of the Logical Memory means that an application can interface with an application-conformant RFID tag, but that individual RFID tags can have completely different memory capacities and architectures. This enables an implementation to benefit from new technological developments permitted within the framework of the ISO/IEC 18000 series, such as larger capacity or faster access RFID tags, without changing the application.

5.4.3.2.4 Encoder

The Encoder controls the process of writing data through the functional processes performed by the Data Compactor Module and Formatter Module.

5.4.3.2.5 Data Compactor

The Data Compactor provides the standard compaction rules to reduce the number of bytes stored on the RFID tag and transferred across the air interface. Numeric data, for example, is byte based to some coded character set for the application but can be encoded in a compact form on the RFID tag memory.

5.4.3.2.6 Formatter

The Formatter provides the processes to place the object identifier and object (data) into an appropriate and efficient format for storing on the Logical Memory.

NOTE The physical mapping of bits to conform with the RFID tag architecture is performed based on information provided by the Tag Driver.

5.4.3.2.7 Decoder

The Decoder controls the process of reading and interpreting data through the functional processes performed by the Data de-compactor Module and de-formatter Module.

5.4.3.3 Tag Driver

The Tag Driver provides two main functions:

- It provides mapping rules on the structure of the RFID tag to enable the contents of the Logical Memory in the Data Processor to be exchanged with the Logical Memory Map of the RFID tag in use.
- It provides facilities that accept the application commands of this Data Protocol and converts them to a format that results in calls to command codes supported by the particular RFID Tag. For example, an application command write Data Object "name" could result in the RFID tag related command of write (block #, data).

The description of the Tag Driver for RFID tags is provided in the annexes of this document, specifically [Annexes B](#) and [C](#). For this document, a Tag Driver is unique to a particular air interface type of RFID tag as specified in the appropriate part of the ISO/IEC 18000 series. This is a logical representation; physical implementation could combine features of different logical Tag Drivers. An interrogator may support one or many Tag Drivers.

5.4.3.4 Transfer mechanisms

The transfer mechanisms for transferring data, commands, and responses between the Data Processor (i.e. the implementation of this document) and the RFID tag shall be done through the interrogator or incorporated within the functions of the interrogator.

5.4.4 RFID tag

Although the RFID tag is beyond the scope of this document, the tag is shown in [Figure 2](#) to complete the flow of data and commands. Within the RFID tag, the Logical Memory Map represents all the data in

the Logical Memory of the Data Processor converted (or mapped) to a location structure determined by the mapping rules in the Tag Driver and the architecture of the RFID tag.

5.5 ISO/IEC 15962 and the Data Processor

This document defines all the rules for encoding data on an RFID tag. The implementation of these rules is described in this document as the Data Processor. As described in 5.4, various processes are undertaken to achieve successful encoding. The rules ensure the encoded bytes are "self-declaring" in a reading operation without any previous or independent knowledge of what is encoded on the tag. This allows the Data Protocol to be used in open systems where the organisation encoding the data on the RFID tag can be completely unaware of what organisation can eventually read the data from the RFID tag. This is achieved by:

- Having clearly defined rules for compacting data that are applied independently of the application and the type of RFID tag.
- Defining fundamental structuring rules for the encoding of data largely determined by a user-selectable feature called the Access-Method.
- Having precise structuring rules within each Access-Method, including a clearly defined syntax that allows reading systems to selectively identify data required for the application.

[Clause 11](#) provides a description and a definition of the Access-Methods currently supported. The associated processing is fully specified in annexes referred to in [Clause 11](#).

6 Data and presentation conventions

6.1 Data types in ISO/IEC 15961-1 commands and responses

The following data types are used in the commands and responses:

- BOOLEAN: An argument that can have the values TRUE or FALSE.
- BIT STRING: A sequence of bits.
- BYTE: An integer with the possible values 0 to 255, usually expressed as a hexadecimal value 00h to FFh.
- BYTE STRING: A sequence of bytes (equivalent to OCTET STRING).
- HEXADECEMAL ADDRESS: A location (on the memory of an RFID tag), expressed as a hexadecimal value
- INTEGER: An integer can take any whole number. In the context of this document, the values are all positive.
- OBJECT IDENTIFIER: An Object Identifier as defined in [6.3.1](#).

6.2 Extensible bit vector (EBV)

The EBV block structure is used as a self-declaring code to determine the length, position, or size of some characteristic. Various EBV-n structures are used in this document, where n refers to the number of bits in each block. EBV-8 is identical to the length encoding (see [9.3.11](#)), which has been used since the original edition of this document.

6.3 Object Identifier presentation in the application interface

6.3.1 Object identifier structure to ISO/IEC 8824-1

This document uses the OBJECT IDENTIFIER type as defined in ISO/IEC 8824-1 and with identifiers assigned as specified in ISO/IEC 9834-1. This uses a registration tree with a common implied root node (ISO/IEC 9834-1), a series of arcs from each node, with new arcs added as required to define a particular object. Thus, the body responsible for a particular node (see [Figure 3](#)):

- has a defined set of arcs to identify itself;
- can manage the allocation of arcs under its node, independently of other bodies;
- is assured of uniqueness from all other arcs in the registration tree.

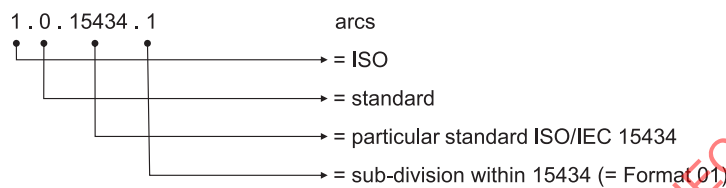


Figure 3 — Example of arcs

The only top arcs permitted for all object identifiers are shown in [Table 1](#).

Table 1 — Object Identifier top arcs

Identifier arc name	Numeric value	
itu-t	0	
iso	1	
joint-iso-itu-t	2	

The second arc is administered by the relevant organisation named for the top arc. The current list of top and second arcs is given in ISO/IEC 15961-3.

The third arc is controlled by the system or body defined for the second arc; sometimes this is a registration authority. The hierarchical structure continues until the object is identified uniquely. The procedure of naming object identifiers ensures that each object is unique within its "parent" arc and that each parent arc is unique within its previous level, right back to the top 3 arcs.

NOTE This structure enables object identifiers from different domains (e.g. open and closed systems) to be encoded unambiguously on an RFID tag memory.

Three forms of object identifier are used with the RFID Data Protocol:

- **Object-Identifier:** This full structure is used for communications between the application and the Data Processor defined by the scope of this document. The full structure is suitable for use in this document where the set of object identifiers to be encoded on the RFID tag have different higher-level arcs, or where a generic system is in place.
- **Relative-OID:** This structure is used in conjunction with the Root-OID (see below) for communication between the application and the Data Processor. These structures are applied in situations where a common root applies to the set of object identifiers to be encoded on the RFID tag. For example, if all the object identifiers have the common root 1 0 15961 12 1, encoding space can be saved on the RFID tag if this common Root-OID does not have to be encoded for each object identifier. The Relative-OID is a suffix to a common Root-OID, which is either encoded or declared in some other way.

- Root-OID: The Root-OID is the common part of a set of encoded object identifiers. It acts as a common prefix to the Relative-OID values encoded on the RFID tag. This structure is particularly important in applications that require a variety of data from a common data dictionary to be encoded on an RFID tag. The Root-OID is either explicitly encoded or declared in some other way, according to the encoding rules of this document.

6.3.2 Presenting the Object-Identifier in accordance with ISO/IEC 8824-1

When the Object-Identifier is presented in application commands and responses in accordance with ISO/IEC 8824-1, spaces are inserted between each arc as follows:

1 0 15961 12 1

6.3.3 Presenting the Object-Identifier as a Uniform Resource Name (URN)

The Object-Identifier may also be presented in the URN in the following format, based on IETF RFC 3061, with the decimal point character between each arc:

urn:oid:1.0.15961.12.1

6.4 The Object

On the interface with the application, all data that is intended to be encoded on the RFID is described as the Object in this document. The Object shall be qualified using an Object-Identifier to ensure unambiguous communication.

When the Object-Identifier is that of a unique item identifier then its combination with the Object confers domain uniqueness. Other Object-Identifier plus Object pairs (e.g. to identify a particular batch number) are not unique but represent attribute data that is associated with the unique item identifier.

6.5 8-bit byte

This document supports the encoding of data and data objects aligned as 8-bit bytes (sometimes referred to as octets to be more compatible with communications standards). Within each 8-bit byte (hereafter "byte"), the most significant bit is bit 8 and the least significant is bit 1. Accordingly, the weight allocated to each bit is defined in [Table 2](#).

Table 2 — Bit sequence in the 8-bit byte

Bit value	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1
Weight	128	64	32	16	8	4	2	1

NOTE Although other bit position conventions are possible and more common, this bit sequence is used here for backward compatibility with the original version of this document, which in turn was in conformity with ASN.1 rules (ISO/IEC 8825-1).

6.6 N-bit encoding

This document supports the encoding of bit fields that are not necessarily aligned on a byte boundary. The most significant bit is bit N and the least significant bit is bit 1. When a sequence of bit fields is defined, the first bit field occupies the most significant bits.

7 Data Processor — High level processing

The main flows of information to and from the Command/Response Unit are illustrated in [Figure 4](#), which focuses on the encoding process.

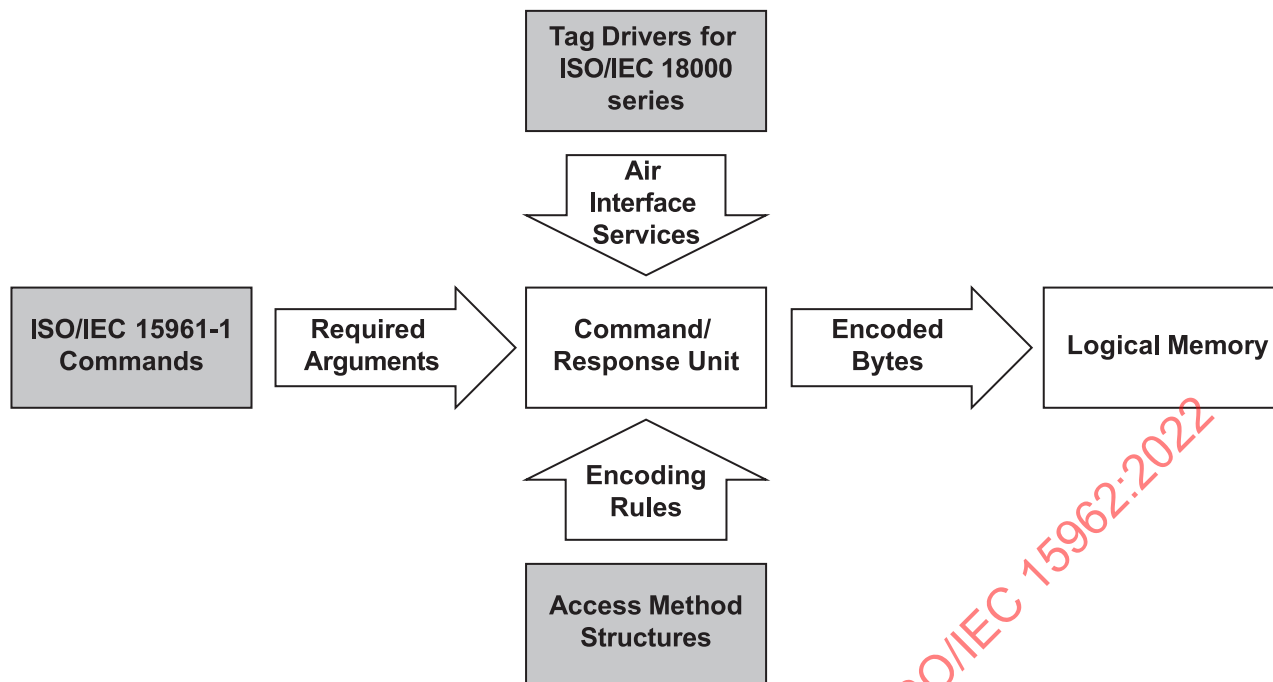


Figure 4 — High level information flows

The Data Processor is not required to support all application commands. For the commands that are supported, all the set of incorporated arguments shall be processed correctly to achieve the encoding required by the application. These requirements are defined in [Clause 8](#). The method of transferring the commands to the command response unit is not specified in this document.

Applications should define that the data is to be encoded on a particular type of RFID tag. The Tag Driver for the particular tag provides the air interface services as defined in [Clause 9](#). These are used by the Command/Response Unit to correctly encode data on, and decode data from, the type of tag required by the application. The Data Processor is not required to support all tag types but shall support the encoding and decoding capabilities of any type of tag that is supported. As some types of RFID tag that are defined in the ISO/IEC 18000 series of air interface protocols have optional components, the precise capability of the Data Processor shall be clearly defined against optional components and revisions to the ISO/IEC 18000 series.

8 Data Processor and the application interface

8.1 Application commands — Overview

ISO/IEC 15961-1 defines several commands and associated responses to provide instructions of how data is to be encoded on the RFID tag. [Table 3](#) lists these commands. The column headed "Code" identifies the final arc of the object identifier that identifies the command module and response module. These code values have been retained to provide a structure that is compatible with the previous, withdrawn edition (ISO/IEC 15961:2004).

EXAMPLE The inventory-tag command has the object identifier: 1 0 15961 126 3. Its response has the object identifier: 1 0 15961 127 3.

Table 3 — ISO/IEC 15961-1 commands

Code	Command name	Write	Read	Other
1	Configure-AFI	a		
2	Configure-DSFID	a		
3	Inventory-Tags			YES
5	Delete-Object			YES
6	Modify-Object			YES
8	ReadObject-Identifiers		YES	
10	Read-Logical-Memory-Map		YES	
12	Erase-Memory			^b
13	Get-App-based-System-Info			^c
17	Write-Objects	YES		
18	Read-Objects		YES	
19	Write-Objects-Segmented-Memory-Tag	YES		
20	Write EPC-UII	YES		
21	Inventory-ISO-UIImemory		YES	
22	Inventory-EPC-UIImemory		YES	
23	Write-Password-Segmented-Memory-Tag	YES		
24	Read-Words-Segmented-Memory-Tag		YES	
25	Kill-Segmented-Memory-Tag			YES
26	Delete-Packed-Object			YES
27	Modify-Packed-Object			YES
28	Write-Segments-6TypeD-Tag	YES		
29	Read-Segments-6TypeD-Tag		YES	
30	Write-Monomorphic-UII	YES		
31	Configure-Extended-DSFID	YES		
32	Configure-Multiple-Records-Header	YES		
33	Read-Multiple-Records		YES	
34	Delete-Multiple-Record			YES
^a The Configure-AFI and Configure-DSFID commands are implemented in different ways, depending on the air interface protocol. Some support specific air interface commands that are distinctly different from the generic write commands (e.g. ISO/IEC 18000-3 Mode 1). Others use the write command but require the data to be written into a specific location (e.g. Type B and Type C).				
^b Some air interface protocols support a specific Erase-Memory command, whereas others require the data to be overwritten with a null-byte value (typically 0016).				
^c The Get-App-based-System-Info command is one that is explicitly supported in some air interface protocols but in others is completely redundant because the information is returned as part of another command.				

[Table 3](#) has three columns: write, read, other. The write column shows the commands that are most likely to be implemented in a device such as a printer-encoder, and in an application that simply provides source marking for data capture at a later stage and at a different point. The read column identifies commands that need to be implemented in the simplest of data capture devices. The commands highlighted in the other column either require more complex processing (e.g. Modify-Object) or require a special process (e.g. Kill- Segmented-Memory-Tag).

The commands associated with code values not included in [Table 3](#) were originally specified in ISO/IEC 15961:2004. This document no longer shall support these commands, mainly because their functionality has been absorbed in other commands.

To implement the encoding rules of this document it is necessary to understand the detail of the commands and responses in ISO/IEC 15961-1. The subclauses that follow, provide a listing of commands under the three main headings of: read, write, and other. The arguments for each command are listed in the subclauses.

8.2 Application commands and responses — Write

8.2.1 Configure-AFI

8.2.1.1 Use

The AFI is a single byte code and is used as part of the selection process in an application. Depending on the air interface protocol, it may write into a particular location of memory using an explicit air interface protocol command. This application command is intended to support this process. It may also be used to support the encoding of the AFI using a generic air interface write command.

8.2.1.2 Process requirements

To correctly implement this command in the Data Processor, in addition to processing the AFI in the range 90_{16} to CF_{16} , the following process argument shall be supported:

AFI (see [10.2.3](#))

AFI-Lock (see [10.2.4](#))

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 1 AFI-Not-Configured
- 2 AFI-Not-Configured-Locked
- 3 AFI-Configured-Lock-Failed
- 8 Singulation-Id-Not-Found
- 255 Execution-Error

8.2.1.3 Conformance requirements

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- That the RFID tag(s) supported by the encoder have the AFI in a memory location requiring an explicit air interface command, or that a generic air interface write command supports writing the AFI to a specific location determined by the Tag Driver with a single byte write transaction.
- If the encoder supports writing the AFI, then it shall also support the transfer of any AFI-Lock argument so that it can be implemented in the air interface.
- The encoder shall support the associated Completion-Codes and Execution-Codes.

8.2.2 Configure-DSFID

8.2.2.1 Use

The DSFID is a single byte or multiple byte code that is used to reduce the encoding of Object-Identifiers, based on encoding rules in this document. In particular, the DSFID specifies the Access-Method and the Data-Format assigned to particular applications. Depending on the air interface protocol, the DSFID is written into a particular location of memory using an explicit air interface protocol command. This application command is intended to support this process. It may also be used to support the encoding of the DSFID using a generic air interface write command.

8.2.2.2 Process requirements

To correctly implement this command in the Data Processor, in addition to processing the DSFID, the following process argument shall be supported:

DSFID (see [10.2.11](#))

DSFID-Lock (see [10.2.12](#))

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 4 DSFID-Not-Configured
- 5 DSFID-Not-Configured-Locked
- 6 DSFID-Configured-Lock-Failed
- 8 Singulation-Id-Not-Found
- 255 Execution-Error

8.2.2.3 Conformance requirements

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- That the RFID tag(s) supported by the encoder have the DSFID in a memory location requiring an explicit air interface command, or that a generic air interface write command supports writing the DSFID to a specific location determined by the Tag Driver with a single byte write transaction.
- If the encoder supports writing the DSFID, then it shall also support the transfer of any DSFID-Lock argument so that it can be implemented in the air interface.
- The encoder shall support the associated Completion-Codes and Execution-Codes.

8.2.3 Write-Objects

8.2.3.1 Use

This command shall not be used to write a Monomorphic-UII. If the AFI on the RFID tag declares that it is registered for a Monomorphic-UII, the appropriate error shall be returned, and the encoding process aborted. The correct command to use is defined in [8.2.8](#).

The Write-Objects command is used to write one or more Object-Identifiers and associated Objects to an RFID tag. This command may be implemented to write the initial data to the RFID tag, or to add data to the tag. The command is supported by the following compound arguments, for which individual arguments are listed below:

Add-Objects-List

DSFID-Constructs

Ext-DSFID-Constructs

Multiple-Records-Constructs

Packed-Object-Constructs

8.2.3.2 Process requirements

To correctly implement this command in the Data Processor, the process arguments and compound arguments defined for the command in ISO/IEC 15961-1 shall be supported. For Multiple Records they are applied once per record, otherwise they are applied once per Logical Memory.

Data-CRC-Indicator (see [9.3.12](#))

DSFID (see [10.2.11](#))

DSFID-Lock (see [10.2.12](#))

DSFID-Pad-bytes (see [9.3.18](#))

Length-Of-Encoded-Data (see [9.3.11](#))

Memory-Capacity (see [9.3.11](#))

Tag-Data-Profile-ID-Table (see [10.2.53](#))

The main determinant for conformant encoding is the Access-Method, which is incorporated as part of the DSFID. The DSFID is provided as an optional argument for use in one of the following ways:

- If data is being written to a blank RFID tag, then the DSFID is provided as part of this command to minimise communications.
- If data is being added to the RFID tag, then the DSFID in the command should match the DSFID already encoded on the RFID tag, otherwise there is an error and the encoding process can cease before significant amounts of data have been processed.

To correctly implement this command in the Data Processor, the following process arguments shall be supported for each Object-Identifier and Object pair, irrespective of the Access-Method:

Avoid-Duplicate (see [10.2.7](#))

Compact-Parameter (see [10.2.9](#))

Object-Lock (see [10.2.38](#))

The Avoid-Duplicate, Compact-Parameter and Object-Lock arguments shall be applied in a manner consistent with the rules of the Access-Method (see [Clause 11](#)) to ensure reliable encoding. If there is an inconsistency within the application command, then it shall be in error and the encoding process shall not be implemented.

If the Access-Method = Packed-Objects, the input states are all defined in the Packed-Objects-Constructs argument specified in ISO/IEC 15961-1 and apply to a single Packed Object. That argument in turn has the following arguments, for which the processes are defined in [Annex I](#):

Block-Align-Packed-Objects

Editable-Pointer-Size

ID-Type

Object-Offsets-Multiplier

Packed-Object-Directory-Type

PO-Directory-Size

PO-ID-Table

PO-Index-Length

If the Access-Method = Tag-Data-Profiles, the input states are all defined by the Tag-Data-Profile-ID-Table and encoded as a single Tag Data Profile using the processes defined in [Annex N](#).

The following tag-related arguments, if declared by the Extended DSFID are used as follows to complete the encoding process:

- If the memory Memory-Capacity (see [9.3.11](#)) is encoded, or the air interface has its own means of providing this information, it can be used to assess if there is sufficient memory for the command to be fully implemented.
- If one or both Data-CRC-Indicators (see [9.3.12](#)) is set, then the CRC-16 shall be applied as defined in [9.3.13](#).
- If the Length-Of-Encoded-Data (see [9.3.11](#)) is signalled to be encoded, then this shall be calculated after all encoded bytes have been determined. This field is then written, or overwritten, taking into account the availability of DSFID-Pad-bytes (see [9.3.18](#)).

If the compound argument Multiple-Records-Constructs is used in the command, then the Object-Identifier structure as defined in [11.6](#) shall be used for identifying each data Object in the add-Objects-List argument. If this is not the case, then the command shall not be processed. In addition to writing the Multiple-Record itself, this command can require other areas of the Logical Memory to be encoded: The MR-header if the number of records is maintained and the directory if already encoded or called for by the command arguments. If any part of the memory required to implement the command is locked, then the command shall be aborted.

Encoding shall be as defined in [Annex Q](#) if the first four arcs are 1.0.15961.401, or as defined in [Annex R](#) if the first four arcs are 1.0.15961.402 or 1.0.15961.403. The compound argument in turn has the following arguments, for which the processes are defined in [Annex Q](#) and [Annex R](#).

Append-To-Existing-Multiple-Record (see [10.2.5](#))

Application-Defined-Record-Capacity (see [10.2.6](#))

Identifier-Of-My-Parent (see [10.2.17](#))

Lock-Directory-Entry (see [10.2.24](#))

Lock-Record-Preamble (see [10.2.26](#))

Number-In-Data-Element-List (see [10.2.36](#))

Record-Memory-Capacity (see [10.2.46](#))

Record-Type-Classification (see [10.2.48](#))

Update-Multiple-Records-Directory (see [10.2.58](#))

The following arguments shall be supported for the response:

Completion-Code (see 10.3 and below)

Execution-Code (see 10.4)

Object-Identifier (see 6.3)

The response arguments Completion-Code and Object-Identifier are associated with each data element.

The Completion-Codes for this command will vary based on the associated compound arguments. The complete list is:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 9 Object-Not-Added
- 10 Duplicate-Object
- 11 Object-Added-But-Not-Locked
- 29 Object-Not-Editable
- 31 Packed-Object-ID-Table-Not-Recognised-No-Encoding
- 32 Tag-Data-Profile-ID-Table-Not-Recognised
- 33 Insufficient-Tag-Memory
- 36 Command-Cannot-Process-Monomorphic-UII
- 37 Data-CRC-Not-Applied
- 38 Length-Not-Encoded-In-DSFID 255 Execution-Error
- 43 Data-Format-Not-Compatible-Multiple-Records-Header
- 44 Access-Method-Not-Compatible-Multiple-Records-Header
- 45 Sector-Identifier-Not-Compatible-Multiple-Records-Header
- 46 Record-Preamble-Not-Configured
- 47 Record-Preamble-Not-Locked
- 255 Execution-Error

8.2.3.3 Conformance requirements

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- The encoder supports all aspects of the Access-Method.
- The encoder supports all the processes defined by the Extended DSFID.
- The encoder supports the associated Completion-Codes and Execution-Codes.
- If any of the first two conditions are not supported, an error is signalled by returning the Execution-Code = 4 Command-Not-Supported.

8.2.3.4 Guidance for appending data

To maximize reliability when adding additional data or modifying data, it is recommended that the interrogator performs the following procedure in the order presented below:

- a) write all the new bytes except the first word or block of data (i.e. the data that will overwrite the existing 00_{16} terminator), including the new terminator at the end of the new data;
- b) optionally read all the new encoded data to ensure that it was stored correctly;
- c) write the first word/block, which overwrites the original terminator.

NOTE Writing the new data in this sequence preserves the ability to parse the pre-existing data in an event of a failure to write of the new data.

8.2.4 Write-Objects-Segmented-Memory-Tag

8.2.4.1 Use

This command shall not be used to write a Monomorphic-UII. If the AFI on the RFID tag declares that it is registered for a Monomorphic-UII, the appropriate error shall be returned, and the encoding process aborted. The correct command to use is defined in [8.2.8](#).

The Write-Objects-Segmented-Memory-Tag command is like the Write-Objects command except that it is intended to write data to a selected memory bank in a segmented memory tag. The command may be implemented to write initial data to the RFID tag, or to add data to the tag. The command is supported by the following compound arguments, for which individual arguments are listed below:

Add-Objects-List

DSFID-Constructs

Ext-DSFID-Constructs

Multiple-Records-Constructs

Packed-Object-Constructs

8.2.4.2 Process requirements

To correctly implement this command in the Data Processor, the process arguments and compound arguments defined for the command in ISO/IEC 15961-1 shall be supported. For Multiple Records they are applied once per record, otherwise they are applied once per Logical Memory.

Access-Password (see [10.2.1](#))

AFI (see [10.2.3](#))

Data-CRC-Indicator (see [9.3.12](#))

DSFID (see [10.2.11](#))

DSFID-Lock (see [10.2.12](#))

DSFID-Pad-bytes (see [9.3.18](#))

Length-Of-Encoded-Data (see [9.3.11](#))

Memory-Bank (see [10.2.29](#))

Memory-Capacity (see [9.3.11](#))

Tag-Data-Profile-ID-Table (see [10.2.53](#))

The Access-Password in the application command shall match that encoded on the RFID tag to continue processing. If there is a mismatch, then an error shall be reported.

The main determinant for conformant encoding is the Access-Method, which is incorporated as part of the DSFID. The AFI and DSFID are provided as arguments for use in one of the following ways:

- If data is being written to a blank segmented memory RFID tag, then these arguments are provided as part of this command to minimise communications.
- Depending on the memory bank concerned, if data is being added to the segmented memory RFID tag, then the AFI and DSFID in the command should match the AFI and DSFID already encoded on the RFID tag, otherwise there is an error and the encoding process can cease before significant amounts of data have been processed.

To correctly implement this command in the Data Processor, the following process arguments shall be supported for each Object-Identifier and Object pair, irrespective of the Access-Method:

Avoid-Duplicate (see [10.2.7](#))

Compact-Parameter (see [10.2.9](#))

Object-Lock (see [10.2.38](#))

The Avoid-Duplicate, Compact-Parameter and Object-Lock arguments shall be applied in a manner consistent with the rules of the Access-Method (see [Clause 11](#)) to ensure reliable encoding. If there is an inconsistency within the application command, then it shall be in error and the encoding process shall not be implemented.

If the Access-Method = Packed-Objects, the input states are all defined in the Packed-Objects-Constructs argument specified in ISO/IEC 15961-1 and apply to a single Packed Object. That argument in turn has the following arguments, for which the processes are defined in [Annex I](#):

Block-Align-Packed-Objects

Editable-Pointer-Size

ID-Type

Object-Offsets-Multiplier

Packed-Object-Directory-Type

PO-Directory-Size

PO-ID-Table

PO-Index-Length

If the Access-Method = Tag-Data-Profiles, the input states are all defined by the Tag-Data-Profile-ID-Table and encoded as a single Tag Data Profile using the processes defined in [Annex N](#).

The following tag-related arguments, if declared by the Extended DSFID are used as follows to complete the encoding process:

- If the memory Memory-Capacity (see [9.3.11](#)) is encoded, or the air interface has its own means of providing this information, it can be used to assess if there is sufficient memory for the command to be fully implemented.
- If one or both Data-CRC-Indicators (see [9.3.12](#)) are set, then the CRC-16 shall be applied as defined in [9.3.13](#).

- If the Length-Of-Encoded-Data (see [9.3.11](#)) is signalled to be encoded, then this shall be calculated after all encoded bytes have been determined. This field is then written, or overwritten, taking into account the availability of DSFID-Pad-bytes (see [9.3.18](#)).

If the compound argument Multiple-Records-Constructs is used in the command, then the Object-Identifier structure as defined in [11.6](#) shall be used for identifying each data Object in the add-Objects-List argument. If this is not the case, then the command shall not be processed. In addition to writing the Multiple-Record itself, this command can require other areas of the Logical Memory to be encoded: The MR-header if the number of records is maintained and the directory if already encoded or called for by the command arguments. If any part of the memory required to implement the command is locked, then the command shall be aborted.

Encoding shall be as defined in [Annex Q](#) if the first four arcs are 1.0.15961.401, or as defined in [Annex R](#) if the first four arcs are 1.0.15961.402 or 1.0.15961.403. The compound argument in turn has the following arguments, for which the processes are defined in [Annex Q](#) and [Annex R](#).

Append-To-Existing-Multiple-Record (see [10.2.5](#))

Application-Defined-Record-Capacity (see [10.2.6](#))

Identifier-Of-My-Parent (see [10.2.17](#))

Lock-Directory-Entry (see [10.2.24](#))

Lock-Record-Preamble (see [10.2.26](#))

Number-In-Data-Element-List (see [10.2.36](#))

Record-Memory-Capacity (see [10.2.46](#))

Record-Type-Classification (see [10.2.48](#))

Update-Multiple-Records-Directory (see [10.2.58](#))

The data shall only be encoded in memory bank 11 of the segmented memory tag.

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

Object-Identifier (see [6.3](#))

The Completion-Codes for this command will vary based on the associated compound arguments. The complete list is:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 9 Object-Not-Added
- 10 Duplicate-Object
- 11 Object-Added-But-Not-Locked
- 25 Password-Mismatch
- 26 AFI-Mismatch
- 27 DSFID-Mismatch
- 29 Object-Not-Editable

- 31 Packed-Object-ID-Table-Not-Recognised-No-Encoding
- 32 Tag-Data-Profile-ID-Table-Not-Recognised
- 33 Insufficient-Tag-Memory
- 36 Command-Cannot-Process-Monomorphic-UII
- 37 Data-CRC-Not-Applied
- 38 Length-Not-Encoded-In-DSFID
- 43 Data-Format-Not-Compatible-Multiple-Records-Header
- 44 Access-Method-Not-Compatible-Multiple-Records-Header
- 45 Sector-Identifier-Not-Compatible-Multiple-Records-Header
- 46 Record-Preamble-Not-Configured
- 47 Record-Preamble-Not-Locked
- 255 Execution-Error

8.2.4.3 Conformance requirements

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- The encoder supports all aspects of the Access-Method.
- The encoder supports encoding to a segmented memory tag.
- The encoder supports a process to match the Access-Password in the command with that encoded on the RFID tag.
- The encoder supports all the processes defined by the Extended DSFID.
- The encoder supports the associated Completion-Codes and Execution-Codes.
- If any of the first four conditions are not supported an error is signalled by returning the Execution-Code = 4 Command-Not-Supported.

8.2.4.4 Guidance for appending data

The procedure described in [8.2.3.4](#) applies to this command.

8.2.5 Write-EPC-UII

8.2.5.1 Use

The Write-EPC-UII command specifies an EPC code to be written to the UII memory of a segmented memory tag (e.g. Memory Bank 01 of a Type C tag).

8.2.5.2 Process requirements

To correctly implement this command in the Data Processor, the following process arguments shall be supported:

Access-Password (see [10.2.1](#))

EPC-Code (see [10.2.15](#))

Memory-Bank-Lock (see [10.2.30](#))

NSI-bits (see [10.2.35](#))

The Access-Password in the command is required to match that on the RFID tag to promote writing data to the RFID tag.

This command can be used to initially write the EPC-Code to the RFID tag, or to overwrite the code value. If the new code is of a shorter length, the interrogator shall ensure that bytes representing part of the older code are removed.

The interrogator shall calculate the length bits in the Protocol Control word. If the bits are provided by the application, the interrogator shall use its calculation of the length bits in preference.

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 25 Password-Mismatch
- 33 Insufficient-Tag-Memory
- 255 Execution-Error

8.2.5.3 Conformance requirements

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- The encoder supports encoding to a segmented memory tag.
- The encoder supports a process to match the Access-Password in the command with that encoded on the RFID tag.
- The encoder supports the associated Completion-Codes and Execution-Codes.

8.2.6 Write-Password-Segmented-Memory-Tag

8.2.6.1 Use

The Write-Password-Segmented-Memory-Tag command does not require any encoding, other than a transfer using the device interface (e.g. as in ISO/IEC 24791-5) to the interrogator. If it is incorporated in the Data Processor, then the output interface will simply carry through the command arguments.

8.2.6.2 Process requirements

The following process arguments shall be supported:

Password (see [10.2.40](#))

Password-Type (see [10.2.41](#))

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 26 Password-Not-Written
- 255 Execution-Error

8.2.6.3 Conformance requirements

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- The encoder supports encoding to a segmented memory tag.
- The encoder supports a process to write the password in the application command to the appropriate memory location on the RFID tag.
- The encoder supports the associated Completion-Codes and Execution-Codes.

8.2.7 Write-Segments-6TypeD-Tag

8.2.7.1 Use

This command shall not be used to write a Monomorphic-UII. If the AFI on the RFID tag declares that it is registered for a Monomorphic-UII, the appropriate error shall be returned, and the encoding process aborted. The correct command to use is defined in [8.2.8](#).

The Write-Segments-6TypeD-Tag is used to write data to the UII segment, the item-related segment or both segments. The command may be implemented to write initial data to the Type D tag, or to add data to the tag.

The Write-Segments-6TypeD-Tag command is similar to the Write-Objects-Segmented-Memory-Tag command except that it is intended to write data to the Type D tag that has its segmented memory boundaries determined dynamically by the encoder. The command is supported by the following compound arguments, for which individual arguments are listed below:

- Ext-DSFID-Constructs
- Item-Related-Add-Objects-List
- Item-Related-DSFID-Constructs
- Multiple-Records-Constructs
- Packed-Object-Constructs
- UII-Add-Objects-List
- UII-DSFID-Constructs

8.2.7.2 Process requirements

To correctly implement this command in the Data Processor, the process arguments and compound arguments defined for the command in ISO/IEC 15961-1 shall be supported. For Multiple Records they are applied once per record, otherwise they are applied once per Logical Memory.

AFI (see [10.2.3](#))

DSFID-Lock (see [10.2.12](#))

Item-Related-DSFID (see [10.2.20](#))

Lock-UII-Segment-Arguments (see [10.2.27](#))

Memory-Segment (see [10.2.31](#))

Tag-Data-Profile-ID-Table (see [10.2.53](#))

UII-DSFID (see [10.2.56](#))

The Type D does not require implementing any of the features of the Extended DSFID that have an impact on encoding processes. The tag has its own methods for declaring memory capacity and length of the encoded data. It also calculates a CRC-16 for each segment. Given these hardware features, this command defines no processes associated with the Extended DSFID. The Extended DSFID is still required to encode an Access-Method code value greater than 3.

The main determinant for conformant encoding is the Access-Method, which is incorporated as part of the DSFID. The AFI and DSFID are provided as arguments for use in one of the following ways:

- If data is being written to a blank segment, then these arguments are provided as part of this command to minimise communications.
- Depending on the memory segment concerned, if data is being added to the segmented memory, then the AFI and DSFID in the command should match the AFI and DSFID already encoded on the RFID tag, else there is an error and the encoding process can cease before significant amounts of data have been processed.

To correctly implement this command in the Data Processor, the following process arguments shall be supported for each Object-Identifier and Object pair, irrespective of the Access-Method:

Avoid-Duplicate (see [10.2.7](#))

Compact-Parameter (see [10.2.9](#))

Object-Lock (see [10.2.38](#))

The Avoid-Duplicate, Compact-Parameter and Object-Lock arguments shall be applied in a manner consistent with the rules of the Access-Method (see [Clause 11](#)) to ensure reliable encoding. If there is an inconsistency within the application command, then it shall be in error and the encoding process shall not be implemented.

If the Access-Method = Packed-Objects, the input states are all defined in the Packed-Objects-Constructs argument specified in ISO/IEC 15961-1 and apply to a single Packed Object. That argument in turn has the following arguments, for which the processes are defined in [Annex I](#):

Block-Align-Packed-Objects

Editable-Pointer-Size

ID-Type

Object-Offsets-Multiplier

Packed-Object-Directory-Type

PO-Directory-Size

PO-ID-Table

PO-Index-Length

If the Access-Method = Tag-Data-Profiles, the input states are all defined by the Tag-Data-Profile-ID-Table and encoded as a single Tag Data Profile using the processes defined in [Annex N](#).

If the compound argument Multiple-Records-Constructs is used in the command, then the Object-Identifier structure as defined in [11.6](#) shall be used for identifying each data Object in the add-Objects-List argument. If this is not the case, then the command shall not be processed. In addition to writing the Multiple-Record itself, this command can require other areas of the Logical Memory to be encoded: The MR-header if the number of records is maintained and the directory if already encoded or called for by the command arguments. If any part of the memory required to implement the command is locked, then the command shall be aborted.

Encoding shall be as defined in [Annex Q](#) if the first four arcs are 1.0.15961.401, or as defined in [Annex R](#) if the first four arcs are 1.0.15961.402 or 1.0.15961.403. The compound argument in turn has the following arguments, for which the processes are defined in [Annex Q](#) and [Annex R](#).

Append-To-Existing-Multiple-Record (see [10.2.5](#))

Application-Defined-Record-Capacity (see [10.2.6](#))

Identifier-Of-My-Parent (see [10.2.17](#))

Lock-Directory-Entry (see [10.2.24](#))

Lock-Record-Preamble (see [10.2.26](#))

Number-In-Data-Element-List (see [10.2.36](#))

Record-Memory-Capacity (see [10.2.46](#))

Record-Type-Classification (see [10.2.48](#))

Update-Multiple-Records-Directory (see [10.2.58](#))

The data shall only be encoded in the item-related segment of the tag memory.

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command will vary based on the associated compound arguments. The complete list is:

- 0 No-Error
- 7 Object-Locked-Could-Not-Modify
- 8 Singulation-Id-Not-Found
- 9 Object-Not-Added
- 10 Duplicate-Object
- 11 Object-Added-But-Not-Locked
- 13 Object-Identifier-Not-Found
- 21 Object-Not-Modified
- 22 Object-Modified-But-Not-Locked
- 26 AFI-Mismatch

27 DSFID-Mismatch
 29 Object-Not-Editable
 31 Packed-Object-ID-Table-Not-Recognised-No-Encoding
 32 Tag-Data-Profile-ID-Table-Not-Recognised
 33 Insufficient-Tag-Memory
 36 Command-Cannot-Process-Monomorphic-UII
 37 Data-CRC-Not-Applied
 38 Length-Not-Encoded-In-DSFID
 43 Data-Format-Not-Compatible-Multiple-Records-Header
 44 Access-Method-Not-Compatible-Multiple-Records-Header
 45 Sector-Identifier-Not-Compatible-Multiple-Records-Header
 46 Record-Preamble-Not-Configured
 47 Record-Preamble-Not-Locked
 255 Execution-Error

8.2.7.3 Conformance requirements

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- The encoder supports all aspects of the Access-Method.
- The encoder supports encoding to a Type D segmented memory tag.
- The encoder supports the associated Completion-Codes and Execution-Codes.
- If any of the first two conditions are not supported, an error is signalled by returning the Execution-Code = 4 Command-Not-Supported.

8.2.7.4 Guidance for appending data

The procedure described in [8.2.3.4](#) applies to this command.

8.2.8 Write-Monomorphic-UII

8.2.8.1 Use

The Write-Monomorphic-UII command instructs the Data Processor to write a Monomorphic-UII, either initially or to modify an existing Monomorphic-UII. Arguments are applied selectively depending on the type of RFID tag being addressed.

The generic encoding process calls for the Data Processor to check that the AFI in the command matches with the one for a Monomorphic-UII on the ISO/IEC 15961-2 Data Constructs register. If a match is not possible, either because the AFI is not registered for a Monomorphic-UII or that no matching AFI can be found on the register, then the encoding process is aborted.

If the AFI matches, the Object-Identifier is also checked for a match with that on the ISO/IEC 15961-2 Data Constructs register. A mismatch generates an appropriate Completion-Code, but this should only be treated as a warning about constructing the command. The process continues because the Object-

Identifier is not encoded. The Data Processor uses the explicitly defined compaction scheme associated with the AFI on the ISO/IEC 15961-2 Data Constructs register to encode the Monomorphic-UII.

8.2.8.2 Process requirements

To correctly implement this command in the Data Processor, the following process arguments shall be supported once per tag:

Access-Password (see [10.2.1](#))

AFI (see [10.2.3](#))

AFI-Lock (see [10.2.4](#))

Compact-Parameter (see [10.2.9](#))

Lock-UII-Segment-Arguments (see [10.2.27](#))

Memory-Bank-Lock (see [10.2.30](#))

Memory-Type (see [10.2.32](#))

Object-Lock (see [10.2.38](#))

The command argument Memory-Type (see [10.2.32](#)) should match the type of RFID tag being encoded. If there is a match, then one of the following processes is applied.

For a Type C tag:

- If the Access-Password is in the command it is used to match that on the RFID tag to protect against unauthorised writing of data to the RFID tag.
- Next, read the content of MB 01 to establish any existing encoding. If this is locked the process is aborted, otherwise the process continues.
- The encoding process compacts the Object, and if this results in an odd number of bytes appends the terminator byte 00₁₆.
- The Protocol Control word is constructed, incorporating the AFI and the length bits.
- If this command is used to over-write MB01 with a new Monomorphic-UII it is necessary to compare the length of the current and the new byte string. If the new code is of a shorter length, the interrogator shall ensure that bytes representing part of the older code are over-written with zero bytes.
- If the command calls for the Monomorphic-UII to be locked, the entire MB01 is locked.

For a Type D tag:

- Read the content of the UII segment to establish any existing encoding. If this is locked the process is aborted, otherwise the process continues.
- The encoding process compacts the Object, and if this results in an odd number of bytes appends the terminator byte 00₁₆.
- The Protocol Control word is constructed, incorporating the AFI and the length bits. If the tag has data encoded in the item related segment, or has a simple sensor, these characteristics shall be encoded and maintained in the Protocol control word.
- If this command is used to over-write the UII segment with a new Monomorphic-UII it is necessary to compare the length of the current and the new byte string. If the new code is of a different length (i.e. shorter or longer) to an existing Monomorphic-UII, the interrogator shall check if an item related segment is already encoded. If the encoding can still be encoded in the UII segment without re-

writing the item-related segment, the encoded bytes are transferred to the interrogator. If the UII segment shall be increased in size and none of the item-related bytes are locked, the entire memory can be re-written, otherwise the process shall be aborted.

NOTE The interrogator calculates a CRC-16 and places this at the end of the encoded words of the UII segment. Depending on the end position of the UII segment and the lock boundary, one or more pad words can be added by the interrogator to achieve alignment.

- If the command calls for the Monomorphic-UII to be locked, then the locking shall be as defined in the Lock-UII-Segment-Arguments.

If the RFID tag has a single memory for all data:

- The first requirement is to read the AFI on the RFID tag (which can be encoded in a separate memory area). If this matches, continue, otherwise report an AFI mismatch.
- Read at least 16 bytes of the content of the user memory to establish any existing encoding. If encoded bytes are found, then the process continues until a string of four zero bytes is found. If either the AFI or any part of the user memory is locked the process is aborted, otherwise the process continues.
- The encoding process compacts the Object and adds the length of the compacted Monomorphic-UII as a prefix.
- If this command is used to over-write a new Monomorphic-UII it is necessary to compare the length of the current and the new byte string. If the new code is of a shorter length, the interrogator shall ensure that bytes representing part of the older code are over-written with zero bytes.
- If the correct AFI for the Monomorphic-UII is not already encoded on the RFID tag, then this is encoded.

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 7 Object-Locked-Could-Not-Modify
- 8 Singulation-Id-Not-Found
- 22 Object-Modified-But-Not-Locked
- 25 Password-Mismatch
- 26 AFI-Mismatch
- 33 Insufficient-Tag-Memory
- 34 AFI-Not-For-Monomorphic-UII
- 35 Monomorphic-UII-OID-Mismatch
- 255 Execution-Error

8.2.8.3 Conformance requirements

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- The Monomorphic-UII shall be compacted to the rules defined for the AFI on the ISO/IEC 15961-2 Data constructs register.
- The encoding on the tag shall be as defined in the processes above for the Memory-Type defined in the command.

8.2.9 Configure-Extended-DSFID

8.2.9.1 Use

Whereas the Configure-DSFID command (see [8.2.2](#)) provides the Data Processor with the basic encoding rules to follow when encoding data, there have been additional requirements that call for an extended set of encoding instructions. These include providing the Data Processor with information about the memory capacity and length of encoded data where this cannot be provided by a mechanism in the tag architecture or air interface protocol. Information is also provided about the requirement to encode a data-related CRC, and to declare to the decoder that this process has been applied.

The Configure-Extended-DSFID command is used prior to encoding the set these encoding parameters and to also encode the base DSFID.

8.2.9.2 Process requirements

To correctly implement this command in the Data Processor, the following process arguments shall be supported once per tag:

- Battery-Assist-Indicator (see [9.3.16](#))
- Data-CRC-Indicator (see [9.3.12](#))
- DSFID-Lock (see [10.2.12](#))
- DSFID-Pad-bytes (see [9.3.18](#))
- Full-Function-Sensor-Indicator (see [9.3.17](#))
- Length-Of-Encoded-Data (see [9.3.11](#))
- Memory-Capacity (see [9.3.11](#))
- Memory-Length-Encoding (see [9.3.11](#))
- Simple-Sensor-Indicator (see [9.3.15](#))

The Extended DSFID is encoded in a slightly different ways depending on the tag architecture:

- For tags where the DSFID is encoded as the first byte of memory, the entire Extended DSFID is encoded starting at the position of the single DSFID.
- For tags that have a dedicated DSFID memory, the first byte(s) of the Extended DSFID are encoded in the dedicated memory location. The remaining bytes are then encoded from the first position of the data memory.

If there is an intention to encode some extended DSFID parameters initially and add to this later, then sufficient pad bytes shall be reserved for this purpose.

The following arguments shall be supported for the response:

Completion-Code (see 10.3 and below)

Execution-Code (see 10.4)

The Completion-Codes for this command are:

- 0 No-Error
- 4 DSFID-Not-Configured
- 5 DSFID-Not-Configured-Locked
- 6 DSFID-Configured-Lock-Failed
- 8 Singulation-Id-Not-Found
- 37 Data-CRC-Not-Applied
- 38 Length-Not-Encoded-In-DSFID
- 255 Execution-Error

8.2.9.3 Conformance requirements

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- If the RFID tag(s) supported by the encoder have the DSFID in a memory location requiring an explicit air interface command, then the Extended DSFID shall be split with the first byte(s) transported by the explicit air interface command, and the remaining bytes transferred with a single write transaction.
- If the RFID tag(s) supported by the encoder have the DSFID in a memory location requiring a generic air interface write command, then the Extended DSFID shall be written with a single write transaction to a specific location starting with the DSFID position determined by the Tag Driver.
- If the encoder supports writing the DSFID, then it shall also support the transfer of any DSFID-Lock argument so that it can be implemented in the air interface.
- The encoder shall support the associated Completion-Codes and Execution-Codes.

8.2.10 Configure-Multiple-Records-Header

8.2.10.1 Use

Encoding multiple records shall be undertaken in a precise sequence of stages. The first stage is to configure the MR-header, as defined in this clause. The Configure-Multiple-Records-Header command is used to create all the fields on the RFID tag within the MR-header that provides information about the types of record encoded on the RFID tag, including the directory. The command is supported by the following compound arguments defined in ISO/IEC 15961-1, for which additional inherent arguments are also defined.

DSFID-Constructs

Ext-DSFID-Constructs

8.2.10.2 Process requirements

To correctly implement this command in the Data Processor, the process arguments and compound arguments defined for the command in ISO/IEC 15961-1 shall be supported. The application command has the following arguments:

Access-Password (see [10.2.1](#))

Directory-Length-EBV8-Indicator (see [10.2.13](#))

Lock-Multiple-Records-Header (see [10.2.25](#))

Multiple-Records-Features-Indicator (see [10.2.34](#))

Pointer-To-Multiple-Records-Directory (see [10.2.43](#))

Sector-Identifier (see [10.2.49](#))

Singulation-Id (see [9.3.2](#))

For RFID tags with segmented memory, the multiple records shall only be encoded in the user memory. Specifically, for Type C this is Memory Bank 11 and for Type D this is the item-related segment.

The bit setting for sensors and batteries shall only be applied if the tag has no hardware means of defining that a sensor is attached. Currently, Type C and Type D are the only RFID tags that support sensors. Both use hardware mechanisms to declare the presence of sensors and batteries.

The Extended DSFID component of the header is encoded in slightly different ways depending on the tag architecture:

- For tags where the DSFID is encoded as the first byte of memory, the entire Extended DSFID is encoded starting at the position of the single DSFID.
- For tags that have a dedicated DSFID memory, the first byte(s) of the Extended DSFID are encoded in the dedicated memory location. The remaining bytes are then encoded from the first position of the data memory.

The Data Processor shall accept the address at the start of the directory provided by the command, unless the address is non-existent in the tag memory. In this case, an error shall be reported.

Because the memory length encoding on the data CRC indicator refers to the requirement of these in the directory, no processing can take place whilst creating the header record.

The header shall be locked according to the instructions provided in the command.

The response arguments, as defined for the command response in ISO/IEC 15961-1, shall be supported by the Data Processor when responding to the application.

The Completion-Codes for this command will vary based on the associated compound arguments. The complete list is:

- 0 No-Error
- 4 DSFID-Not-Configured
- 8 Singulation-Id-Not-Found
- 25 Password-Mismatch
- 37 Data-CRC-Not-Applied
- 38 Length-Not-Encoded-In-DSFID
- 39 Multiple-Records-Header-Not-Configured
- 40 Multiple-Records-Header-Not-Locked
- 41 File-Support-Indicators-Not-Configured
- 42 File-Support-Indicators-Not-Locked

255 Execution-Error

8.2.10.3 Conformance requirements**8.2.10.3.1 DSFID conformance**

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- If the RFID tag(s) supported by the encoder have the DSFID in a memory location requiring an explicit air interface command, then the Extended DSFID shall be split with the first byte(s) encoded by the explicit air interface command in the dedicated DSFID memory on the tag, and the remaining bytes encoded in the user memory.
- If the RFID tag(s) supported by the encoder have the DSFID in a memory location requiring a generic air interface write command, then the Extended DSFID shall be written to a specific location starting with the DSFID position determined by the Tag Driver.
- If the encoder supports writing the DSFID, then it shall also support the transfer of any DSFID-Lock argument so that it can be implemented in the air interface.

8.2.10.3.2 Other conformance

To conform, an encoder shall support this command and its arguments, subject to the following conditions:

- The encoder supports all aspects of encoding the header for the Multiple-Records Access-Method.
- The Data-CRC-Indicator shall be ignored for the header record itself.
- The total encoded data length (part of the Extended DSFID) refers to the size of the directory and shall be ignored for the header record itself.
- The encoder supports the associated Completion-Codes and Execution-Codes.

8.3 Application commands and responses — Read**8.3.1 Read-Object-Identifiers****8.3.1.1 Use**

The Read-Object-Identifiers command instructs the interrogator to read all the Object-Identifiers from the RFID tag. This module can be used in advance of a more selective command to read a specific Object, or to identify duplicate Object-Identifiers so that a housekeeping procedure can be invoked. A valid response, if the RFID tag Logical Memory Map has no Object-Identifiers stored, is to return an empty Object-Identifiers list. Only one RFID tag shall be programmed per command to ensure that the read process is robust.

This command is not used to read Object-Identifiers from a Multiple Record. The functionality is incorporated in the Read-Multiple-Records command (see [8.3.8](#))

8.3.1.2 Process requirements

To correctly implement this command in the Data Processor, the following points shall be considered:

- An interrogator may provide all the functionality to achieve this application command. Alternatively, the interrogator may invoke a read command to capture all the encoded bytes a transfer the decode process to a higher-level device.

- The different Access-Methods each provide a means of a faster delivery of the Object-Identifiers than reading the entire data on the tag. For example, the basic No-Directory syntax enables a decoder to "step over" the de-compaction process. Achieving this is an implementation issue for each decoder manufacturer.

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

Object-Identifier (see [6.3](#))

The Completion-Codes for this command are:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 255 Execution-Error

8.3.1.3 Conformance requirements

To conform, a decoder shall support this command and its arguments. In addition, it shall support the associated Completion-Codes and Execution-Codes.

8.3.2 Read-Logical-Memory-Map

8.3.2.1 Use

The Read-Logical-Memory-Map command is intended to read the entire memory content of the RFID tag and respond with this in a completely unstructured way (i.e. by returning the encoded byte values). No processing takes place through the Data Processor as part of this read command, so it is not possible to identify the encoding structure.

8.3.2.2 Process requirements

The command applies equally to all Access-Methods, but if a directory structure has been defined by the Access-Method, this shall be included in the response, but shall not be distinguished from other bytes in the Logical Memory Map.

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

Logical-Memory-Map (see list in [Clause 10](#))

The Completion-Codes for this command are:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 19 Read-Incomplete
- 255 Execution-Error

8.3.2.3 Conformance requirements

To conform, a decoder shall support this command. In addition, it shall support the associated Completion-Codes and Execution-Codes.

8.3.3 Read-Objects

8.3.3.1 Use

The Read-Objects command is intended to read one or more data objects from the RFID tag, as defined by their Object-Identifiers. The argument Read-Type determines whether the first, selected, or all Object-Identifier(s) are read from the RFID tag. The command also supports an argument, Max-App-Length, which enables the application to prescribe an upper address point on the RFID tag beyond which reading is discontinued.

This command is not used to read Object-Identifiers from a Multiple Record. The functionality is incorporated in the Read-Multiple-Records command (see [8.3.8](#)).

8.3.3.2 Process requirements

To correctly implement this command in the Data Processor, the following process arguments shall be supported:

Check-Duplicate (see [10.2.8](#))

Max-App-Length (see [10.2.28](#))

Read-Type (see [10.2.45](#))

The following arguments shall be supported for the response:

Compact-Parameter (see [10.2.9](#))

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

Lock-Status (see list in [Clause 10](#))

Object (see [6.4](#))

Object-Identifier (see [6.3](#))

Except for Execution-Code, the response arguments are associated with each data element.

The Completion-Codes for this command are:

0 No-Error

8 Singulation-Id-Not-Found

10 Duplicate-Object

13 Object-Identifier-Not-Found

15 Object-Not-Read

255 Execution-Error

8.3.3.3 Conformance requirements

To conform, a decoder shall support this command and its arguments, subject to the following:

- If the Check-Duplicate argument is set to TRUE, then the entire encoded data shall be read to establish that the subject Object-Identifier is not duplicated. If the Access-Method is Multiple-Records, then the Check-Duplicate argument is only applied to the specific record being accessed. As there is no requirement to decode the data Object for Object-Identifiers not called out in the application command, a process like the Read-Object-Identifiers command could be used.
- If the Max-App-Length argument is invoked, the interrogator and decoder shall only process the bytes up to the value for that argument.
- The decoder shall support the associated Completion-Codes and Execution-Codes.

8.3.4 Inventory-ISO-UIImemory

8.3.4.1 Use

The Inventory-ISO-UIImemory command is intended to return the contents of the UII memory from several segmented memory tags, given the expectation that an Object-Identifier for a non-EPC-Code is encoded. The response returns the content of the UII memory for all tags whose encoded bit string matches the arguments of the command.

8.3.4.2 Process requirements

To correctly implement this command in the Data Processor, the following arguments shall be supported:

Additional-App-bits (see [10.2.2](#))

AFI (see [10.2.3](#))

DSFID (see [10.2.11](#))

The arguments provided in the command enable a bit mask to be incorporated into appropriate air interface protocol commands to select only tags that match the bit mask. For tags with encoding based on Object-Identifier, the AFI is included as a minimum component of the mask. The DSFID may be added, particularly where its value is constant for an application. Additional bits may be added that, for example, identify the Precursor of the first (sometimes only) encoded dataset and any additional bits that a certain to create a tag selection criterion.

The Data Processor concatenates these values into a contiguous bit stream and prepends this with a bit = "1" and identifies this bit stream as beginning at bit 17h of Memory Bank 01. An error occurs if bit 17h of Memory Bank 01 = "0".

The following arguments shall be supported for the response:

Compact-Parameter (see [10.2.9](#))

Completion-Code (see [10.3](#) and below)

DSFID (see [10.2.11](#))

Execution-Code (see [10.4](#))

Lock-Status (see list in [Clause 10](#))

Object (see [6.4](#))

Object-Identifier (see [6.3](#))

Protocol-Control-Word (see list in [Clause 10](#))

If the UII memory encodes more than one Object-Identifier, then these arguments shall be returned for each data element: Compact-Parameter, Completion-Code (some values), Lock-Status, Object, and Object- Identifier.

The Completion-Codes for this command are:

- 0 No-Error
- 10 Duplicate-Object
- 13 Object-Identifier-Not-Found
- 15 Object-Not-Read
- 255 Execution-Error

8.3.4.3 Conformance requirements

To conform, a decoder shall support this command and its arguments, subject to the following conditions:

- The decoder supports decoding from a segmented memory tag.
- The decoder supports the associated Completion-Codes and Execution-Codes.

8.3.5 Inventory-EPC-UIImemory

8.3.5.1 Use

The Inventory-EPC-UIImemory command is intended to return the contents of the UII memory from several segmented memory tags, given the expectation that an EPC-Code is encoded. The response returns the content of the UII memory for all tags whose encoded bit string matches the arguments of the command.

8.3.5.2 Process requirements

To correctly implement this command in the Data Processor, the following arguments shall be supported:

- Length-of-Mask (see [10.2.23](#))
- Pointer (see [10.2.42](#))
- Tag-Mask (see [10.2.54](#))

If the value of the pointer is less than 18h, an error occurs if bit 17h of Memory Bank 01 = "1".

The following arguments shall be supported for the response:

- Completion-Code (see [10.3](#) and below)
- EPC-Code (see [10.2.15](#))
- Execution-Code (see [10.4](#))
- Protocol-Control-Word (see list in [Clause 10](#))

The Completion-Codes for this command are:

- 0 No-Error

255 Execution-Error

8.3.5.3 Conformance requirements

To conform, a decoder shall support this command and its arguments, subject to the following conditions:

- The decoder supports decoding from a segmented memory tag.
- The decoder supports the associated Completion-Codes and Execution-Codes.

8.3.6 Read-Words-Segmented-Memory-Tag

8.3.6.1 Use

The Read-Words-Segmented-Memory-Tag command instructs the interrogator to read a contiguous sequence of words from one of the memory banks of a segmented memory RFID tag. This command can be used to extract encoded bytes, which might not be object-based such as the unique Singulation-Id or a password. It can also be useful for diagnostic purposes.

8.3.6.2 Process requirements

To correctly implement this command in the Data Processor, the following arguments shall be supported:

Access-Password (see [10.2.1](#))

Memory-Bank (see [10.2.29](#))

Word-Count (see [10.2.59](#))

Word-Pointer (see [10.2.60](#))

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

Read-Data (see list in [Clause 10](#))

The Completion-Codes for this command are:

- 0 No-Error
- 25 Password-Mismatch
- 255 Execution-Error

8.3.6.3 Conformance requirements

To conform, a decoder shall support this command and its arguments, subject to the following conditions:

- The decoder supports decoding from a segmented memory tag.
- The decoder supports a process to match the Access-Password in the command with that encoded on the RFID tag.
- The decoder supports the associated Completion-Codes and Execution-Codes.

8.3.7 Read-Segments-6TypeD-Tag

8.3.7.1 Use

The Read-Segments-6TypeD-Tag command instructs the interrogator to read all the data from a Type D tag and instructs the Data Processor to provide the decoded data according to the arguments in the command. This command can be used to show the content of each segment as a raw byte string, or to provide more detailed analysis of the content of one or more segments.

This command is not used to read Objects or Object-Identifiers from a Multiple Record encoded on an RFID tag in conformance with Type D. The functionality is incorporated in the Read-Multiple-Records command (see [8.3.8](#))

8.3.7.2 Process requirements

To correctly implement this command in the Data Processor, the following argument shall be supported:

Segment-Read-Type (see [10.2.50](#))

The Type D air protocol delivers the entire data payload of the RFID. Therefore, the command argument codes specify the processes that the Data Processor undertakes, as defined in [10.2.50](#).

The following arguments shall be supported for the response, and be included depending on the command arguments:

Compact-Parameter (see [10.2.9](#)) Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

Item-Related-DSFID (see [10.2.20](#))

Item-Related-Segment-Map (see [10.2.21](#))

Lock-Status (see list in [Clause 10](#))

Object (see [6.4](#))

Object-Identifier (see [6.3](#))

Simple-Sensor-Data-Block (see [10.2.51](#))

TID-Segment-Map (see [10.2.55](#))

UII-Segment-Map (see [10.2.57](#))

The Completion-Codes for this command are:

0 No-Error

19 Read-Incomplete

255 Execution-Error

8.3.7.3 Conformance requirements

To conform, a decoder shall support this command and its arguments, subject to the following conditions:

- The decoder supports decoding from to a segmented memory tag in conformance with Type D.
- The decoder supports the processing into segments and further into the constituent parts of the UII segment and the Item-related segment

- The decoder supports the associated Completion-Codes and Execution-Codes.

8.3.8 Read-Multiple-Records

8.3.8.1 Use

The Read-Multiple-Records command instructs the interrogator to read various logically structured components from an RFID tag configured to encode multiple records. This includes performing relevant functions defined in [8.3.1](#) to read a set of one or more Object-Identifiers; and performing the relevant functions defined in [8.3.3](#) to read data Objects from an individual record.

The command is applied to memory bank 11 of the Type C tag, and to the Item-related data segment of the Type D tag. Only one RFID tag shall be programmed per command to ensure that the reading process is robust.

The command is supported by the following compound argument defined in ISO/IEC 15961-1, for which the additional inherent Read-Objects argument is also defined.

8.3.8.2 Process requirements

To correctly implement this command in the Data Processor, the process arguments and compound arguments defined for the command in ISO/IEC 15961-1 shall be supported. The application command has the following arguments:

- Check-Duplicate (see [10.2.8](#))
- Max-App-Length (see [10.2.28](#))
- Object-Identifier (see [6.3](#))
- Read-Record-Type (see [10.2.44](#))
- Singulation-Id (see [9.3.2](#))

The Read-Record-Type codes 3 to 9 (as defined in [10.2.44](#)) require the use of one or more Object-Identifiers in the command for the Data Processor to invoke the relevant processes. Three very specific formats of Object-Identifier are applied to multiple records:

- For a multiple record that is not part of a hierarchy, the structure is: 1.0.15961.401."Data-Format"."sector identifier"."record type"."instance-of"."Relative-OID of data element"
- For a multiple record that is part of a hierarchy, but not a data element list, the structure is: 1.0.15961.402."Data-Format"."sector identifier"."record type"."hierarchical id"."Relative-OID of data element"
- For a multiple record that is a data element list, the structure is: 1.0.15961.403."Data-Format"."sector identifier"."record type"."hierarchical id"."Relative-OID of data element"

NOTE This object identifier calls for response to include all the list element numbers.

The first two Object-Identifier structures apply to Read-Record-Type codes 3 to 8. The third listed Object- Identifier structure only applies to Read-Record-Type codes 3, 4 and 9.

If Read-Multiple-Records-Header (Read-Record-Type code 0) is selected, the Data Processor returns the interpretation of the MR-header in the Multiple-Records-Header-Structure argument. The response contains the following compound arguments, for which individual arguments are listed below:

- DSFID-Constructs with the following inherent arguments:
 - Access-Method (see [Clause 11](#))
 - Data-Format (see [9.3.6](#))

— Ext-DSFID-Constructs with the following inherent arguments:

- Battery-Assist-Indicator (see [9.3.16](#))
- Data-CRC-Indicator (see [9.3.12](#))
- DSFID-Pad-bytes (see [9.3.18](#))
- Full-Function-Sensor-Indicator (see [9.3.17](#))
- Length-Of-Encoded-Data (see [9.3.11](#))
- Memory-Capacity (see [9.3.11](#))
- Memory-Length-Encoding (see [9.3.11](#))
- Simple-Sensor-Indicator (see [9.3.15](#))

The following arguments are also in the Multiple-Records-Header-Structure argument:

- Multiple-Records-Directory-Length (see [10.2.33](#))
- Multiple-Records-Features-Indicator (see [10.2.34](#))
- Number-Of-Records (see [10.2.37](#))
- Pointer-To-Multiple-Records-Directory (see [10.2.43](#))
- Sector-Identifier (see [10.2.49](#))

If Read-Multiple-Records-Header-Plus-1st-Preamble (Read-Record-Type code 1) is selected, the Data Processor returns the interpretation of the MR-header in the Multiple-Records-Header-Structure argument and the interpretation of the first record's preamble in the Multiple-Records-Preamble-Structure argument.

The response is a combination of the responses for Read-Record-Type code 0 and 3. It contains the specific responses for the compound arguments DSFID-Constructs, Ext-DSFID-Constructs and Multiple-Records-Header-Structure that are all listed above, and the specific responses for the compound argument Multiple-Records-Header-Structure that are listed for the Read-Preamble-Specific-Multiple-Record (below).

If Read-Multiple-Records-Directory (Read-Record-Type code 2) is selected, the Data Processor returns the interpretation of the multiple records directories in the Multiple-Records-Directory-Structure argument. The response contains the following compound arguments, for which individual arguments are listed below.

- DSFID-Constructs with the inherent arguments as defined for the Read-Multiple-Records-Header.
- Ext-DSFID-Constructs with the inherent arguments as defined for the Read-Multiple-Records-Header.

The following arguments are also in the Multiple-Records-Directory-Structure argument:

- Hierarchical-Identifier-Arc (see [10.2.16](#))
- Identifier-Of-My-Parent (see [10.2.17](#))
- Instance-Of-Arc (see [10.2.19](#))
- Record-Type-Arc (see [10.2.47](#))
- Record-Type-Classification (see [10.2.48](#))
- Sector-Identifier (see [10.2.49](#))

Start-Address-Of-Record (see [10.2.52](#))

If Read-Preamble-Specific-Multiple-Record (Read-Record-Type code 3) is selected, the command shall include a single Object-Identifier in the Read-Objects list that is certainly defined down to the record type arc, and the instance-of arc (if applicable) or the hierarchical id arc (if applicable). The Data Processor returns the interpretation of the record's preamble in the Multiple-Records-Preamble-Structure argument. The response contains the following compound arguments, for which individual arguments are listed below:

- DSFID-Constructs with the inherent arguments as defined for the Read-Multiple-Records-Header
- Ext-DSFID-Constructs with the inherent arguments as defined for the Read-Multiple-Records-Header

The following arguments are also in the Multiple-Records-Preamble-Structure argument:

Data-Length-Of-Record (see [10.2.10](#))

Encoded-Memory-Capacity (see [10.2.13](#))

Hierarchical-Identifier-Arc (see [10.2.16](#))

Identifier-Of-My-Parent (see [10.2.17](#))

Instance-Of-Arc (see [10.2.19](#))

Record-Type-Arc (see [10.2.47](#))

Record-Type-Classification (see [10.2.48](#))

Sector-Identifier (see [10.2.49](#))

Start-Address-Of-Record (see [10.2.52](#))

The Read-All-Record-OIDs-Specific-Record-Type (Read-Record-Type code 4) is used for identifying a series of history records of the same type or a set of records in a hierarchy of the same type. The command shall include a single Object-Identifier in the Read-Objects list that is only defined down to the record type arc. The Data Processor returns the list of Object-Identifiers one layer lower in the Read-OIDs-Response-List, i.e. either with the set of instance-of arcs or with the set of hierarchical id arcs. To achieve this, the Data Processor shall parse the entire Multiple Records directory; or if this is not encoded, the Data Processor read and parse the preamble of each Multiple Record. During this procedure, the Data Processor shall only retain and report on records whose record type arc matches that in the Object-Identifier in the command.

If Read-OIDs-Specific-Multiple-Record (Read-Record-Type code 5) is selected, the command shall include a single Object-Identifier in the Read-Objects list that is certainly defined down to the record type arc, and the instance-of arc (if applicable) or the hierarchical id arc (if applicable). The Data Processor returns the list of Object-Identifiers encoded within the record in the Read-OIDs-Response-List. This does not apply to Data Element lists.

If Read-All-Objects-Specific-Multiple-Record (Read-Record-Type code 6) is selected, the command shall include a single Object-Identifier in the Read-Objects list that is certainly defined down to the record type arc, and the instance-of arc (if applicable) or the hierarchical id arc (if applicable). The Data Processor returns the list of Object-Identifiers and Objects encoded within the record in the Read-Objects-Response-List. This does not apply to Data Element lists.

If Read-Multiple-Objects-Specific-Multiple-Record (Read-Record-Type code 7) is selected, the command shall include the nominated Object-Identifiers that are defined down to the specific data element in the Read- Objects list. The Data Processor returns the list of nominated Object-Identifiers and Objects encoded within the record in the Read-Objects-Response-List. This does not apply to Data Element lists.

If Read-1st-Objects-Specific-Multiple-Record (Read-Record-Type code 8) is selected, the command shall include the nominated Object-Identifier(s) that are defined down to the specific data element(s) in the Read- Objects list. The Data Processor returns the list of nominated Object-Identifiers and Objects encoded up to the Max-App-Length within the record in the Read-Objects-Response-List. This does not apply to Data Element lists.

If Read-Data-Element-List-Specific-Multiple-Record (Read-Record-Type code 9) is selected, the command shall include a single Object-Identifier in the Read-Objects list that is defined down to the data element. The Data Processor first checks that the record is a Data Element list. If so, it uses the rules of the Access-Method to re-construct the Object-Identifier down to the list element number as encoded in the data element list and returns this and associated Objects encoded within the record in the Read-Objects-Response-List. The first four arcs of the root-OID for the application command and response is 1.0.15961.403. If this is not in the command, then the Data Processor shall not implement the command.

The Completion-Codes for this command will vary based on the Read-Record-Type code value set in the command. The complete list is:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 10 Duplicate-Object
- 13 Object-Identifier-Not-found
- 15 Object-Not-Read
- 35 Monomorphic-UII-OID-Mismatch
- 48 Multiple-Records-Directory-Not-Present
- 255 Execution-Error

8.3.8.3 Conformance requirements

To conform, a decoder shall support this command and its arguments. In addition, it shall support the associated Completion-Codes and Execution-Codes.

To conform, a decoder shall support this command and its arguments, subject to the following conditions:

- All the Read-Record-Types shall be supported.
- For Read-Record-Type codes 5, 6, 7 and 8, if the Check-Duplicate argument is set to TRUE, then the entire record shall be read to establish that the subject Object-Identifier is not duplicated.
- For Read-Record-Type codes 4 and 9, if the Check-Duplicate argument is set to TRUE, then the argument shall be ignored, because the intention is to identify multiple occurrences of the Object-Identifier in the command and return any additional arc.
- If the Max-App-Length argument is invoked, the interrogator and decoder shall only process the bytes up to the value for that argument.
- The decoder shall support the associated Completion-Codes and Execution-Codes.

The decoder shall support the following, depending on the requirements of the application:

- At least one of the Access-Methods defined in this document.
- The decoding from a segmented memory tag in conformance with Type C.
- The decoding from to a segmented memory tag in conformance with Type D.

8.4 Application commands and responses — Other

8.4.1 Inventory-Tags

8.4.1.1 Use

The Inventory-Tags command is intended to read a set of Singulation-Ids from RFID tags that have a particular AFI. It is only applicable where an air interface command supports an inventory process using the AFI as a named argument and, generally, where a unique chip identifier is used in the arbitration process.

8.4.1.2 Process requirements

To correctly implement this command in the Data Processor, the following arguments shall be supported:

Identify-Method (see [10.2.18](#))

Number-Of-Tags (see [10.2.18](#))

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

Identities (see list in [Clause 10](#))

Number-of-Tags-Found (see list in [Clause 10](#))

Typically, the response should include the argument Identities, which is a list of Singulation-Ids each of which has met the selection criteria.

The Completion-Codes for this command are:

- 0 No-Error
- 23 Failed-To-Read-Minimum-Number-Of-Tags
- 24 Failed-To-Read-Exact-Number-Of-Tags
- 255 Execution-Error

8.4.1.3 Conformance requirements

To conform, a decoder shall support this command and its arguments, subject to the following conditions:

- That the RFID tag(s) supported by the decoder are capable of being selected using an explicitly declared AFI and that the response Singulation-Id is used in the arbitration process.
- The decoder shall support the associated Completion-Codes and Execution-Codes.

8.4.2 Delete-Object

8.4.2.1 Use

The Delete-Object command is intended to remove an Object-Identifier and its associated data Object from the memory of the RFID tag. Invoking this command depends on the Access-Method declared for the RFID tag. Each of the cases is discussed under the appropriate Access-Method (see [Clause 11](#)).

8.4.2.2 Process requirements

To correctly implement this command in the Data Processor, the following arguments shall be supported:

Check-Duplicate (see [10.2.8](#))

The way the Delete-Object command is implemented in the Logical Memory is dependent on the Access-Method:

- For the No-Directory and Directory Access-Methods if other encoding follows the deleted Object-Identifier, the Data Processor may replace the deleted bytes with a null dataset (see [D.7.5](#)). This procedure is invoked automatically by the Data Processor.
- For Packed-Objects the Delete-Object command is supported in one of two ways:
 - If the Packed Object contains an Addendum section then the rules defined in [1.5.7](#) are applied.
 - Otherwise the entire Packed Object shall be re-written.
- For Tag-Data-Profiles the Data Processor shall replace the deleted bytes with a null dataset (see [D.7.5](#)).
- For the Records-Directory Access-Method, the target Object-Identifier is identified according to the rules defined in [11.6.3](#). Within the record, the rules of the record-specific Access-Method shall be followed.

If any of the bytes associated with the Object-Identifier is locked, then the Data Processor shall return an error.

If the Check-Duplicate flag is set to TRUE, the interrogator shall verify, before deleting the requested Object, that there is only a single instance of the requested Object-Identifier. If the interrogator detects that the RFID tag is encoding more than one instance of the referenced Object-Identifier, it shall not perform the Delete-Object function and shall return the appropriate Completion-Code.

If the Check-Duplicate flag is set to FALSE, the interrogator shall delete the first occurrence of the dataset specified by its Object-Identifier.

This is an argument that effectively provides no protection against duplicate Object-Identifiers. It should only be used when there is a high expectation of no duplicates.

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 10 Duplicate-Object
- 12 Object-Not-Deleted
- 13 Object-Identifier-Not-Found
- 14 Object-Locked-Could-Not-Delete
- 255 Execution-Error

8.4.2.3 Conformance requirements

To conform, a device shall support encoding and decoding to support this command and its arguments, subject to the following conditions:

- The device supports a delete function as defined for the Access-Methods that it supports
- If the Check-Duplicate argument is set to TRUE, then the entire encoded data shall be read to establish that the subject Object-Identifier is not duplicated prior to invoking the delete process.
- The device supports the associated Completion-Codes and Execution-Codes.

If the Access-Method is Multiple-Records, then the Check-Duplicate argument is only applied to the specific record being accessed.

8.4.3 Modify-Object

8.4.3.1 Use

The Modify-Object command is intended to change the value of a data Object associated with an Object-Identifier already encoded on the memory of the RFID tag. The complete memory shall be read to ensure that the Object-Identifier is not duplicated. If so, the command is aborted. Invoking this command depends on the Access-Method declared for the RFID tag. In addition, the procedure is different if the resultant encoding length of the modified object is different from the original length. Each of the cases is discussed under the appropriate Access-Method (see [Clause 11](#)).

If the data object is part of a multiple record (identified with the basic root-OID of 1.0.15961.401) or a hierarchical multiple record (identified with the basic root-OID of 1.0.15961.402), then the process to modify a data object shall be that of the declared Access-Method. A data object cannot be modified on a data element list (identified with the basic root-OID of 1.0.15961.403). If a command carries the instructions to modify a data element list, the Data Processor shall not implement the command and report an error.

8.4.3.2 Process requirements

The Modify-Object command instructs the Data Processor to carry out three related processes:

- a) Read the complete Logical Memory Map from the RFID tag. If the command is being applied to a Multiple Record, then only that record shall be read.
- b) Identify the encoded packet specified by the Object-Identifier. If duplicated instances are found, the process is aborted.
- c) Over-write with the modified encoded packet, or, depending on the Access-Method,
 - invoking a combination of a writing a null dataset where the original bytes were encoded and writing a new dataset; or
 - invoking a combination of a deleting and writing a new encoded packet.

If any of the bytes associated with the Object-Identifier is locked, then the Data Processor shall abort the process and return the appropriate completion code.

To correctly implement this command in the Data Processor, the following arguments shall be supported:

Compact-Parameter (see [10.2.9](#))

Object-Lock (see [10.2.38](#))

The way the Modify-Object command is implemented in the Logical Memory is dependent on the Access-Method:

For the Multiple-Records Access-Method the Modify-Object command is supported as follows:

- a) The target Object-Identifier is identified according to the rules defined in [11.6.3](#).
- b) Within the record, the rules of the record-specific Access-Method shall be followed (as defined below).

For the No-Directory and Directory Access-Methods:

- If the byte string, that represents the modified data when prepared for encoding in the Logical Memory Map, is the same length as its previous encoded byte string, the modified value is generally written to the same positions.
- If the byte string is shorter than the previous encoded byte string, then the Data Processor automatically encodes an offset to re-align the modified encoding with the original.
- If the byte string is longer than the previous encoded byte string, then it shall be in a different area of the Logical Memory Map with this process controlled by the Data Processor. A similar situation can arise if the Object-Lock argument is set to TRUE in the command. Alternatively, the Data Processor may apply a procedure that automatically replaces the modified bytes with one or more Null-bytes (see [D.7.5](#)) and writes the longer dataset at the end of encoded memory.

For the Directory Access-Method, in addition to modifying the dataset itself (as defined above), additional processing can be necessary to update the directory.

For Packed-Objects the Modify-Object command is supported in one of two ways:

- a) If the Packed Object contains an Addendum section then the rules defined in [1.5.7](#) are applied.
- b) Otherwise the entire Packed Object shall be re-written.

For Tag-Data-Profiles the following rules apply:

- If the byte string, that represents the modified data when prepared for encoding in the Logical Memory Map, is the same length as its previous encoded byte string, the modified value is written to the same positions.
- If the byte string is shorter than the previous encoded byte string, then the Data Processor automatically encodes an offset to re-align the modified encoding with the original.
- If the byte string is longer than the previous encoded byte string, then there is an error and the process shall cease.

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 7 Object-Locked-Could-Not-Modify
- 8 Singulation-Id-Not-Found
- 10 Duplicate-Object
- 13 Object-Identifier-Not-Found

- 21 Object-Not-Modified
- 22 Object-Modified-But-Not-Locked
- 255 Execution-Error

8.4.3.3 Conformance requirements

To conform, a device shall support encoding and decoding to support this command and its arguments, subject to the following conditions:

- The device supports a modify function as defined for the Access-Methods that it supports.
- The device supports the associated Completion-Codes and Execution-Codes.

8.4.3.4 Guidance for appending modified data

If the modified data is longer than the original data and requires being appended, the procedure described in [8.2.3.4](#) applies to this command.

8.4.4 Erase-Memory

8.4.4.1 Use

The Erase-Memory command is intended to reset to zero the entire Logical-Memory-Map of a particular RFID tag. This includes the directory if this is defined by the Access-Method.

8.4.4.2 Process requirements

To correctly implement this command in the Data Processor, all bytes shall be reset, except those that are locked. In this case, the Completion-Code Blocks-Locked (17) shall be returned.

The following arguments shall be supported for the response:

- Completion-Code (see [10.3](#) and below)
- Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 17 Blocks-Locked
- 18 Erase-Incomplete
- 255 Execution-Error

8.4.4.3 Conformance requirements

To conform, a device shall support encoding and decoding to support this command and its arguments.

8.4.5 Get-App-based-System-Info

8.4.5.1 Use

The Get-App-based-System-Info command is used to return the AFI and DSFID from the RFID tag. In some air interface protocols, the equivalent air interface command is the only way in which this information can be retrieved.

8.4.5.2 Process requirements

To correctly implement this command the Data Processor shall call up the equivalent air interface command and transfer the Singulation-Id to that command.

The following arguments shall be supported for the response:

AFI (see [10.2.3](#))

Completion-Code (see [10.3](#) and below)

DSFID (see [10.2.11](#))

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 20 System-Info-Not-Read
- 255 Execution-Error

8.4.5.3 Conformance requirements

To conform, a decoder shall support this command and its arguments, subject to the following conditions:

- The air interface supported by the decoder shall have the equivalent command (e.g. ISO/IEC 18000-3 Mode 1).
- The decoder shall support the associated Completion-Codes and Execution-Codes.

8.4.6 Kill-Segmented-Memory-Tag

8.4.6.1 Use

The Kill-Segmented-Memory-Tag command instructs the interrogator to apply appropriate air interface protocols to render the RFID tag unreadable in future. The Kill-Password in the command shall match the Password encoded on the RFID tag.

8.4.6.2 Process requirements

The Kill-Segmented-Memory-Tag command does not require any processing through the Data Processor, other than a transfer using the device interface (e.g. as in ISO/IEC 24791-5) to the interrogator. If it is incorporated in the Data Processor, then the output interface will simply carry through the command arguments.

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 27 Zero-Kill-Password-Error
- 28 Kill-Failed
- 255 Execution-Error

8.4.6.3 Conformance requirements

To conform, a device shall support this command and its arguments, subject to the following conditions:

- The device supports processing with a segmented memory tag.
- The device shall support the associated Completion-Codes and Execution-Codes.

8.4.7 Delete-Packed-Object

8.4.7.1 Use

The purpose of the Delete-Packed-Object command is to delete a complete Packed Object, by using an encoded Object-Identifier as an alias for the Packed Object.

8.4.7.2 Process requirements

The Delete-Packed-Object command instructs the Data Processor to:

- a) Identify the Packed Object using the Object-Identifier.
- b) Establish the memory location on the entire Packed Object.
- c) Erase the complete memory typically by over-writing with the default byte value of the RFID tag.

If any part of the Packed Object is locked, then the command cannot be invoked, and the process shall be aborted, and the appropriate completion code returned.

To correctly implement this command in the Data Processor, the following arguments shall be supported:

Check-Duplicate (see [10.2.8](#))

Object-Identifier (see [6.3](#))

Singulation-Id (see [9.3.2](#))

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 8 Singulation-Id-Not-Found

- 10 Duplicate-Object
- 12 Object-Not-Deleted
- 13 Object-Identifier-Not-Found
- 14 Object-Locked-Could-Not-Delete
- 255 Execution-Error

8.4.7.3 Conformance requirements

To conform, a device shall support this command and its arguments, subject to the following conditions:

- The device supports processing of Access-Method Packed-Objects.
- The device shall support the associated Completion-Codes and Execution-Codes.

8.4.8 Modify-Packed-Object-Structure

8.4.8.1 Use

The Modify-Packed-Object-Structure command is used to change the structure of a Packed Object, for example to introduce a directory structure. An encoded Object-Identifier is used as an alias for the particular Packed Object.

8.4.8.2 Process requirements

The Modify-Packed-Object-Structure command instructs the Data Processor to:

- a) Identify the Packed Object using the Object-Identifier.
- b) Check the status of any directory or capability to add a directory.
- c) Modify the Packed Object as necessary
- d) If necessary, based on the command arguments, write an additional Packed Object directory.

If it is not possible to add the directory structure, or one is already in place, then the process shall be aborted, and the appropriate completion code returned.

To correctly implement this command in the Data Processor, the following arguments shall be supported:

Check-Duplicate (see [10.2.8](#))

Object-Identifier (see [6.3](#))

Packed-Object-Directory-Type (see [10.2.39](#))

Singulation-Id (see [9.3.2](#))

The following arguments shall be supported for the response:

Completion-Code (see [10.3](#) and below)

Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 7 Object-Locked-Could-Not-Modify

- 8 Singulation-Id-Not-Found
- 10 Duplicate-Object
- 13 Object-Identifier-Not-Found
- 30 Directory-Already-Defined
- 255 Execution-Error

8.4.8.3 Conformance requirements

To conform, a device shall support this command and its arguments, subject to the following conditions:

- The device supports processing of Access-Method Packed-Objects.
- The device shall support the associated Completion-Codes and Execution-Codes.

8.4.9 Delete-Multiple-Record

8.4.9.1 Use

The Delete-Multiple-Record command instructs the interrogator to mark a Multiple Record as deleted. The bytes that make up the record are not actually deleted, but the subject record and its entry in the directory (if present) have code values set to indicate that the record is no longer to be treated as valid.

8.4.9.2 Process requirements

The Object-Identifier is to the level where the final arc is that of the instance-of or hierarchical identifier. Multiple-Records are identified with one of the following basic root-OIDs:

- 1.0.15961.401
- 1.0.15961.402
- 1.0.15961.403

If the Object-Identifier has a different root, the command shall not be processed.

If either the record preamble or the directory is locked, then the command cannot be invoked. If the record is part of a hierarchical structure with the root-OID 1.0.15961.402, then all the child(ren) records and in turn their children shall be deleted first. If any of these record preambles, or the associated directory entry, is locked then none of the records can be deleted. This requires the hierarchy to be established and the lock status of each record in that hierarchy to have an unlocked status in the preambles and the directory (if present).

To correctly implement this command in the Data Processor, the following arguments shall be supported:

- Access-Password (see [10.2.1](#))
- Object-Identifier (see [6.3](#))
- Singulation-Id (see [9.3.2](#))

The following arguments shall be supported for the response:

- Completion-Code (see [10.3](#) and below)
- Execution-Code (see [10.4](#))

The Completion-Codes for this command are:

- 0 No-Error
- 8 Singulation-Id-Not-Found
- 13 Object-Identifier-Not-Found
- 25 Password-Mismatch
- 49 Record-Not-Deleted-Preamble-Locked
- 50 Record-Not-Deleted-Directory-Locked
- 51 Record-Not-Deleted-Lower-Level-Preamble-Locked
- 255 Execution-Error

8.4.9.3 Conformance requirements

To conform, a device shall support this command and its arguments, subject to the following conditions:

- The device supports processing of Access-Method Multiple-Records.
- The device shall support the associated Completion-Codes and Execution-Codes.

8.5 Air interface support for application commands

Different air interface protocols can support some, but not all, of the application commands. For a specific air interface protocol, an application command:

- Can be supported as included in this document, whether this is because there is a directly equivalent air interface command, or by invoking a series of air interface commands.
- Is unable to be supported, because features are not supported on the air interface protocol, even in an optional manner.
- Can be supported, but another application command achieves the same results probably in a better way.

[Annex A](#) provides this information in more detail for specific air interface protocols.

9 Data Processor and the air interface

9.1 Use

The Data Processor receives communications across the air interface, via the Tag Driver. This clause defines the basic requirements that enable the Data Processor and RFID tag to transfer and share information.

9.2 Air interface services

This document is open-ended with respect to the fact that new types of RFID tag may be added to the ISO/IEC 18000 series that require some interface with the Data Processor. To achieve this, some basic presumptions are made about the types of RFID tag in the ISO/IEC 18000 series.

- Application memory is an integer number of bytes.
- Application memory shall be organised in blocks. These shall be fixed size and be of one or more bytes.

NOTE 1 The term "block" is used in this document in a manner consistent with its definition in [Clause 3](#), because this aligns with the most common usage of the term in air interface protocols. In Type C the term "word" has a similar function.

- The individual blocks shall each be accessible by read and/or write. This applies to the basic function, additional features may be used to restrict access to authorised users.
- In addition to the requirements (above) relating to the memory, there shall be a reliable mechanism for writing and reading to and from the application memory.

Each type of RFID tag in the ISO/IEC 18000 series shall provide the following air interface services of the physical characteristics and data capabilities of the RFID tag:

- a) Provide a byte location addressing mechanism from the beginning to the end of the application memory, starting from byte 0. This shall map to the Logical Memory.
- b) Provide a mechanism to address a specific RFID tag using a permanent or virtual tag identifier.
- c) Provide the block size (in bytes).
- d) Provide the value of the number of blocks in the application memory.
- e) Optionally support selection and/or addressing of groups of RFID tags using to the AFI as part of the selection mechanism.
- f) Provide a mechanism to write and read the DSFID.
- g) Return a positive or negative acknowledgement (error code) to read and to write commands.
- h) Optionally provide the writing capabilities supported by the RFID tag.
- i) Optionally provide the locking capabilities supported by the RFID tag.
- j) Support the ability to query the status (locked or not locked) of the memory blocks.

These air interface services should be provided by the Tag Driver. A description of a generic Tag Driver is provided in [Annex B](#). Details of specific Tag Drivers are provided in [Annex C](#).

9.3 Defining the system information

9.3.1 System information elements

The system information is a set of elements that is encoded, or provided by other means, from the RF tag to the Data Processor when communications are established. The systems information shall consist of the elements listed in [Table 4](#) with the length of each element and shall be as defined in the following subclasses.

Table 4 — System information elements

Element	Length
Singulation-Id	up to 255 bytes
physical block size (in bytes)	1 byte (hexadecimal value of block size)
number of blocks	1 or more bytes (hexadecimal value of number of blocks)
AFI	1 byte
DSFID	1 byte

9.3.2 Singulation-Id

The Singulation-Id is the means of ensuring reliable communication between the application and the RFID tag throughout the transaction process via the Data Processor. It is communicated across the air

interface and the application interface. The Singulation-Id may be up to 256 bytes long, depending on the rules of the air interface protocol or the way that the interrogator maintains a register of RFID tags with which it communicates.

NOTE In the 2004 edition of this document the Singulation-Id was called the "Tag-Id". Apart from the change of name all functions remain the same.

The format of the Singulation-Id shall be as defined for each Tag Driver (see [Annex C](#)) and shall be based on one of the following:

- a) A completely unique identifier programmed in the RFID tag, as specified in the ISO/IEC 18000 series).
- b) A data related identifier (e.g. like the unique identifier of transport units as specified in ISO/IEC 15459-1), that provides for uniqueness within the domain of item management or logistics. This requires the data to be read to establish the Singulation-Id.
- c) A virtual or session ID based on a time slot or other feature managed by the air interface protocol.
- d) Combinations of (b) and (c), e.g. a virtual identifier across the air interface, but requiring the data related identifier to be returned as a response.

9.3.3 Physical block size

The physical block size is defined as the minimum number of 8-bit bytes that are capable of being written to, read from, on the particular RFID tag. If the minimum number of bytes differs for read and write operations, for the purposes of this document the block size shall be the smaller value. The value is constrained to between 1 and 256 bytes.

NOTE The block size relates to memory units on the RFID tag and not necessarily to any constraint, such as a frame, on the air interface.

The physical block size shall be identified by any reasonable means using the Tag Driver and air interface features and is communicated to the Data Processor. The physical block size is not communicated across the application interface.

9.3.4 Number of blocks

The number of blocks is defined as the number of physical blocks in the user memory of the particular RFID tag. For RFID tags with segmented memory structures, the number of blocks is required for each memory bank to which the application has access for a read or write command.

The number of blocks shall be identified by any reasonable means using the Tag Driver and air interface features and is communicated to the Data Processor. The number of blocks is not communicated across the application interface.

9.3.5 AFI

The AFI is defined by the application as a single byte value and is used as an air interface selection mechanism to separate RFID tags with a given AFI from tags with different AFI values. The AFI is defined by the application as a single byte value in conformity with ISO/IEC 15961-3 and the register maintained as part of ISO/IEC 15961-2.

9.3.6 DSFID

The DSFID is defined by the application as a single byte value with the following structure:

- | | |
|--------------|--|
| Bits 8 and 7 | Determine the Access-Method (see Clause 11). |
| Bit 6 | Is the extended syntax indicator bit (see 9.3.8). |

Bits 5 to 1 Identify the Data-Format, as defined in ISO/IEC 15961-3 and registered to ISO/IEC 15961-2.

Once a Data-Format has been specified for an RFID tag (or a specific bank of a segmented memory RFID tag), all subsequent additional data shall be encoded in a conformant manner. Once an Access-Method has been specified for an RFID tag (or a specific bank of a segmented memory RFID tag), all subsequent additional data shall be encoded in a conformant manner, with one exception. It is possible to convert a No-Directory structure to a directory structure. These points are discussed in greater detail for the specific Access-Methods (see [Clause 11](#) and associated annexes).

The only alternative process to change the Data-Format and / or Access-Method is to invoke an erase command and then overwrite all the new data. This process can fundamentally change the original function of the application data on the RFID tag.

The single byte DSFID can support up to four Access-Methods and up to 30 Data-Formats. Extension mechanisms that can be applied independently to each are possible as defined in the rules of the following subclauses. These subclauses also define support for other functions that are not directly supported by air interface features.

9.3.7 Encoding the Extended-Data-Format

When the ISO/IEC 15961-1 specifies a Data-Format value greater than 31_{10} , the Extended-Data-Format byte is required to encode the value of the Data-Format. bits 5 to 1 of the single (primary) DSFID are set to the value 11111 to indicate that an Extended-Data-Format byte follows. The value of the Extended-Data-Format byte is the value of the Data-Format provided by the application command less 32_{10} . For example, Data-Format 69_{10} requires the Extended-Data-Format byte to have the value 00100101_2 .

9.3.8 Other extensions using the Extended Syntax indicator bit

If the Extended Syntax indicator bit = 0, then all the information about the Access-Method is encoded in the single byte DSFID and no other functions are indicated as present. If the Extended Syntax indicator bit = 1, then an Extended Syntax flag byte 1 is used (see [9.3.9](#)).

9.3.9 Extended Syntax flag byte 1

The Extended Syntax flag byte 1 is defined by the application and/or by processes of the Data Processor, as will be described in various subclauses. The initial structure is as a single byte value with the following structure:

- Bit 8 Extended Syntax flag byte 2 indicator (see [9.3.14](#))
- Bits 7 & 6 Extensions to Access-Method (see [Clause 11](#))
- Bits 5 & 4 Memory length indicator (see [9.3.10](#))
- Bits 3 & 2 Data CRC indicator (see [9.3.12](#))
- Bit 1 Reserved

9.3.10 Memory length indicator bits

9.3.10.1 Values

The memory length indicator bits are determined by arguments in an application command that recommends its use where the relevant memory is greater than 256 bits, taking into account the information provided by the air interface (see [9.3.10.2](#)). There are a number of conditions that apply to particular Access-Methods that are discussed in [9.3.10.3](#). The 2-bit code values for the memory length indicator are:

- 00₂ No encoding of the total length of data or memory capacity, as these are small (i.e. not more than 256 bits)
- 01₂ Memory capacity is declared
- 10₂ The total length of encoded data is declared
- 11₂ Both memory capacity and total length of encoded data are declared

Irrespective of the capability of the air interface to provide a hardware solution for encoding the total length of encoded data, if the indicator bits are set, then the Data Processor shall update the encoded length each time that data is written to the RFID tag.

9.3.10.2 Air interface exceptions

The following air interface protocol shall make use of memory length encoding, as qualified by the Access-Method as follows:

- ISO/IEC 18000-3 Mode 1: The memory capacity does not need to be encoded, because this is provided by other means in the services from the air interface, particularly through part of the code value of the Singulation-Id. The length of the encoded data over 256 bits should be encoded unless this is supported by the Access-Method. The length shall be expressed in blocks, which can vary between conformant RFID tags.
- Type C: Length encoding shall not be used either for the memory capacity or the encoded length for Memory Banks 00₂, 01₂, and 10₂. The total length of the encoded data over 256 bits in Memory Bank 11₂ should be encoded unless this is supported by the Access-Method. The length shall be expressed in blocks as defined in this document and expressed as 16-bit words in this air interface protocol.
- Type D: The memory capacity does not need to be encoded because this is declared by the number of available pages of memory. The total length of encoded data is not required for the UII segment and the Item-related segment because these lengths are encoded on the tag using hardware processes.

9.3.10.3 Access-Method requirements and exceptions

Encoding the memory capacity and the total length of encoded data is applied to the Access-Methods in the following way:

- No-Directory

Unless the Tag Driver has another means of declaring the memory capacity, this should be declared and encoded if this is greater than 256 bits. The total length of the encoded data should also be declared and encoded if this is greater than 256 bits.

- Directory

The memory capacity should be encoded if greater than 256 bits unless the Tag Driver has another means of declaring the memory capacity. The total length of the encoded data should apply to the directory only, irrespective of its length.

If the directory is added at some later stage over an existing No-Directory structure the original length of data encoding will not only be different but will refer to different bytes. The length of encoded directory shall be overwritten at the time that the directory is first prepared.

- Packed Objects

Unless the Tag Driver has another means of declaring the memory capacity, this should be declared and encoded if this is greater than 256 bits. As each Packed Object declares its length, if only one Packed Object is encoded there is no need to encode the total length of encoded data. The total length of the encoded data should be declared and encoded if there are two or more Packed Objects and the total length of all the encoded data is greater than 256 bits.

— Tag Data Profile

The length of the encoding is declared in the encoded header record, so there is no requirement to encode length.

— Multiple-Records

The memory capacity is encoded for each Multiple-Record in its preamble.

9.3.11 Procedure for length encoding

The procedure for encoding the memory capacity or total length of encoded data shall be based on the length encoding rules defined in [D.3](#).

9.3.12 Data CRC indicators

The data CRC indicator bits are generated by the Data Processor, as defined in this subclause. The use of a data CRC is determined by arguments in an application command.

The 2-bit code values for the data CRC indicator are:

00 ₂	No data CRC
01 ₂	Data CRC applied to each individual dataset
10 ₂	Data CRC applied only to the entire encoded data
11 ₂	Data CRC applied to each dataset and to the entire encoded data

9.3.13 Data CRC

9.3.13.1 Algorithm

The data CRC is calculated using the polynomial defined in ISO/IEC 13239 (CRC-16-CCITT, commonly known as CRC-CCITT): $x^{16} + x^{12} + x^5 + 1$. The 16-bit register shall be preloaded with FFFF₁₆ prior to calculating the CRC-16.

9.3.13.2 Data CRC applied to a dataset

The CRC-16 shall be applied to the entire dataset and encoded immediately after the dataset. If there is a requirement to block align after the CRC-16, then padding in conformance with the Access Method shall be used. The CRC-16 shall be applied to all the datasets encoded on the RFID tag.

9.3.13.3 Data CRC applied to the entire encoded bytes

The CRC-16 shall be applied to the entire encoded data plus the terminator byte (00₁₆) and shall be encoded immediately after the terminator byte.

9.3.14 Extended Syntax flag byte 2

The Extended Syntax flag byte 2 is defined by the application and/or by processes of the Data Processor, as will be described in various subclauses. The initial structure has the following structure:

Bit 8	Extended Syntax flag byte 3 indicator - an extension for future special features
Bit 7	Simple sensor indicator (see 9.3.15)
Bit 6	Battery-Assist indicator (see 9.3.16)
Bit 5	Full-function sensor indicator (see 9.3.17)

Bits 4 to 1 Reserved

9.3.15 Simple Sensor indicator

Simple Sensors have limited configuration capabilities and can be factory programmed, so provide resultant observations based on their pre-designed functionality. The Simple Sensor indicator is used when one such sensor is added to an RFID tag. The indicator is only used where the functionality, if supported on the RFID tag, is not declared by some air interface mechanism. The indicator is set to "1" if the RFID tag supports a Simple Sensor.

The information is transmitted in any response that contains the Extended Syntax flag byte, but any follow-up action by the interrogator or the application is beyond the scope of this document.

9.3.16 Battery Assist indicator

The Battery Assist indicator is used when a battery is added to a passive tag to assist with improving the communication capability of the RFID tag. The indicator is only used where the functionality, if supported on the RFID tag, is not declared by some air interface mechanism. The indicator is set to "1" if the RFID tag employs battery-assist power.

The information is transmitted in any response that contains the Extended Syntax flag byte 2, but any follow-up action by the interrogator or the application is beyond the scope of this document.

9.3.17 Full-Function Sensor indicator

The Full-Function Sensor indicator is used when one or more such sensors are added to an RFID tag. The indicator is only used where the functionality, if supported on the RFID tag, is not declared by some air interface mechanism. The indicator is set to "1" if the RFID tag supports one or more Full-Function Sensors.

The information is transmitted in any response that contains the Extended Syntax flag byte 2, but any follow-up action by the interrogator or the application is beyond the scope of this document.

9.3.18 DSFID and Extended Syntax

This syntax depends on the value of the Data-Format and Extended Syntax indicator bit. The following sequence of elements shall be used, with elements omitted if not signalled by earlier bytes:

The term "shall follow" by each element depends on how the DSFID is encoded, and whether all the preceding elements are declared to be present. All the elements shall precede any encoding of data in conformance with the declared Access-Method.

- DSFID: This shall be encoded according to the rules of the air interface protocol, which could be in a separate memory location or with other user-related data.
- Extended-Data-Format: If bits 5 to 1 have the value 11111, then this shall follow the DSFID.
- Extended Syntax Flag byte 1: If the Extended Syntax flag byte 2 indicator bit is set in the Extended Syntax flag byte 1, then this byte shall be the next logical element. In turn, it determines which of the following optional elements are encoded, which depend on the air interface and Access-Method constraints as discussed above.

- **Extended Syntax Flag byte 2:** If the Extended Syntax flag byte 3 indicator bit is set in the Extended Syntax flag byte 2, then this byte shall be the next logical element. In turn, it determines which of the following optional elements are encoded, which depend on the air interface and Access-Method constraints as discussed above.
- **Syntax Extension (provisional):** If future editions of this document specify and support this element, then it will appear in this logical sequence in the structure.
- **Memory capacity:** This is a single byte or multiple bytes indicating the size of the memory in terms of the block size definition provided by the Tag Driver for the particular tag. It is not required if the memory capacity is 256 bits or less.
- **Total Encoded Data length:** This is a single byte or multiple bytes indicating the length of the encoded bytes in terms of the block size definition provided by the Tag Driver for the particular tag. It is not required if the total length of encoded data is 256 bits or less.
- **Pad byte(s):** If there is a requirement to lock this extended system information, or for example to provide memory for length encoding to be added at a later time, it can be necessary to align to a block boundary. The Null-byte mechanism, encoding a sequence of byte 8016 shall be used (see [D.7.5](#)).

[Table 5](#) shows all the syntax structures that are possible, including how future extensions will be addressed. The table only shows bytes that are encoded under the different conditions and shows these in the sequence in which they would appear to a decoder. Bytes that signal a feature that is invoked beyond the extended DSFID (e.g. a data CRC) are shown with "x" in the relevant bit position. The presence of these is only relevant to the byte in which they are encoded and does not affect the structure of the remaining bytes in the Extended DSFID.

Table 5 — DSFID extension syntax

DSFID	Extended-Data-Format	Extended Syntax flag byte 1	Extended Syntax flag byte 2	Syntax extension	Memory capacity	Encoded length	Pad bytes
bb000000 to bb011110	Not present	Not present	Not present	Reserved	Not present	Not present	Not present
bb011111	Present	Not present	Not present	Reserved	Not present	Not present	Conditional
bb100000 to bb111110	Not present	0bb00000 Access- Method only	Not present	Reserved	Not present	Not present	Conditional
bb100000 to bb111110	Not present	0xx00xxx	Not present	Reserved	Not present	Not present	Conditional
bb100000 to bb111110	Not present	0xx01xxx	Not present	Reserved	Present	Not present	Conditional
bb100000 to bb111110	Not present	0xx10xxx	Not present	Reserved	Not present	Present	Conditional
bb100000 to bb111110	Not present	0xx11xxx	Not present	Reserved	Present	Present	Conditional
bb100000 to bb111110	Not present	1xx00xxx	Present	Reserved	Not present	Not present	Conditional
bb100000 to bb111110	Not present	1xx01xxx	Present	Reserved	Present	Not present	Conditional
b indicates any value.							
x indicates that the value is not relevant to the subsequent structure.							

Table 5 (continued)

DSFID	Extended Data-Format	Extended Syntax flag byte 1	Extended Syntax flag byte 2	Syntax extension	Memory capacity	Encoded length	Pad bytes
bb100000 to bb111110	Not present	1xx10xxx	Present	Reserved	Not present	Present	Conditional
bb100000 to bb111110	Not present	1xx11xxx	Present	Reserved	Present	Present	Conditional
bb111111	Present	0bb00000 Access- Method only	Not present	Reserved	Not present	Not present	Conditional
bb111111	Present	0xx00xxx	Not present	Reserved	Not present	Not present	Conditional
bb111111	Present	0xx01xxx	Not present	Reserved	Present	Not present	Conditional
bb111111	Present	0xx10xxx	Not present	Reserved	Not present	Present	Conditional
bb111111	Present	0xx11xxx	Not present	Reserved	Present	Present	Conditional
bb111111	Present	1xx00xxx	Present	Reserved	Not present	Not present	Conditional
bb111111	Present	1xx01xxx	Present	Reserved	Present	Not present	Conditional
bb111111	Present	1xx10xxx	Present	Reserved	Not present	Present	Conditional
bb111111	Present	1xx11xxx	Present	Reserved	Present	Present	Conditional
b indicates any value.							
x indicates that the value is not relevant to the subsequent structure.							

The "conditional" state for pad bytes depends on the air interface support for selective locking, the call by the application to lock this syntax sequence, or alternatively to leave it unlocked but to lock the encoded data.

The following hypothetical example illustrates various aspects of encoding the DSFID and other features. The data to be encoded is as follows:

Access Method = 5

Data format = 69

Memory capacity = 128 blocks

Length of encoded data = 37 blocks

Data CRC applied to all the data

A simple sensor is on the tag

Any pad bytes to enable the length of the encode data to be the same size as the memory capacity.

The Data format = 69 is encoded to the rules defined in 9.3.7. The calculation determines the value of the byte that immediately follows the DSFID byte:

$$69 - 32 = 37 = 00100101_2$$

The Access Method = 5 is encoded to rules defined in Table 7. Four bits shall be encoded 0010_2 spread over different bytes. The lead bits of the DSFID are encoded with 00_2 and the next bit is set = 1_2 to signal that the Extended Syntax flag byte 1 shall be encoded. The value of the first two bytes can be fully determined and contain the DSFID byte and Extended data format byte:

$$00111111_2$$

$$00100101_2 = 3F25_{16}$$

The Extended Syntax flag byte 1 has the following initial structure to encode the other two bits of the Access Method (see 9.3.9):

$$\text{x10xxxxx}_2$$

Encoding the indicators for memory capacity and length of the encoded data determines two more bits:

$$\text{x1011xxx}_2$$

Encoding that a Data CRC is applied to the entire data but not to the individual datasets determines two more bits:

$$\text{x101110x}_2$$

The final bit is reserved, so has the default value 02. As this tag has a simple sensor that is not declared by an air interface mechanism, the Extended Syntax flag byte 2 is required, so the lead bit of this flag shall be set = 12. The complete encoding of the Extended Syntax flag byte 1 is:

$$11011100_2 = \text{DC}_{16}$$

This byte follows immediately after the encoded bytes that have already been determined, resulting in the following string:

$$3\text{F}25\text{DC}_{16}$$

The Extended Syntax flag byte 2 has the following initial structure to encode the fact that there is a simple sensor encoded on the RFID tag (see 9.3.14):

$$\text{x1xxxxxx}_2$$

There is no indicator for battery assist and full function sensors, so the structure is set as follows:

$$\text{x100xxxx}_2$$

As there are no further extensions defined, the lead bit = 0₂ and the trailing bits are = 0000₂ to indicate that they are reserved, resulting in this encoding:

$$01000000_2 = 40_{16}$$

The byte string is now extended to:

$$3\text{F}25\text{DC}40_{16}$$

The encoding for the memory capacity follows the rules defined in 9.3.11, resulting in these two bytes:

$$10000001_2 \qquad 00000000_2 = 8100_{16}$$

The length of the encoded data is 37 blocks, encoded as 25₁₆. These three bytes are appended to the four already determined:

$$3\text{F}25\text{DC}40810025_{16}$$

Finally, as the memory capacity requires two bytes but the length of the current encoded data only requires one byte, it is necessary to provide a single pad byte, as described in 9.3.18. The complete encoded DSFID byte string comprises: 3F25DC4081002580₁₆.

9.4 Configuring the Logical Memory

The Logical Memory is assumed to be empty at the beginning of the process of any application read or write command. This enables the Data Processor to populate the Logical Memory with encoded bytes using the encoding rules of this document. It also enables transfers across the air interface (usually in blocks) to partially populate the Logical Memory, to enable decoding by the rules of this document.

The size of the Logical Memory is defined using the physical block size and number of blocks from the system information (see 9.3.3 and 9.3.4). This can be perceived as a matrix with the physical block size determining the X-axis and the number of blocks determining the Y-axis. This matrix concept is used in the remainder of this document. However other structures such as arrays and byte streams are also likely to be used in implementations.

The Access-Method determines additional structuring rules (see [Clause 11](#) for a detailed definition).

10 Command/Response Unit — Processing of command and response arguments

10.1 Function

The Command/Response Unit is responsible for processing application commands and providing responses to the application system from the RFID tag(s) with which it is communicating. This unit can be considered conceptually as some form of executive software that receives application commands as defined in ISO/IEC 15961-1 and illustrated in [Figure 4](#). It takes account of the support for application commands by the air interface protocol; this information being delivered by the Tag Driver. It then calls for the rules for encoding (or decoding) and formatting functions as defined by the Access-Method.

Additionally, certain command arguments result in the processing of the tag memory (e.g. lock functions, conditional selections) which requires a set of air interface commands of the particular ISO/IEC 18000 series to achieve. Throughout this process, the Command/Response Unit is continually monitoring and updating the Logical Memory of each RFID tag with which it is maintaining a logical association.

The arguments used in the application commands are classified as:

- process arguments, which determine that some action is required by the Data Processor or the interrogator to achieve successful encoding or decoding of the bytes on the RFID tag. These are defined in [10.2](#).
- Completion-Codes, which are command-related error or pass codes. These are described in [10.3](#).
- Execution-Codes, which are system-related error or pass codes. These are described in [10.4](#).
- command-related and response-related field names, which distinguish a particular type of data, and for this document simply act as descriptors for data which is input to the encode process or is output from the decode process. These are listed below and defined in ISO/IEC 15961-1.

Dataset

Identities

Lock-Status

Logical-Memory-Map

Number-of-Tags-Found

Protocol-Control-Word

Read-Data

10.2 Process arguments

10.2.1 Access-Password

The Access-Password is a 32-bit (4 byte) code that provides permission to access data on the RFID tag either to read or to write. Of the Tag Drivers currently supported, the Access-Password argument only applies to Type C tags.

The Access-Password is included as an argument in the following ISO/IEC 15961-1 application commands: Write-Objects-Segmented-Memory-Tag, Write-EPC-UII, and Read-Words-Segmented-Memory-Tag. If the Access-Password is a non-zero value, then this 32-bit code shall match with that on the RFID tag to gain access for subsequent secure transactions. The interrogator processes this according to the rules of the air interface protocol, with the password separated into two 16-bit strings and processed according to the rules of Type C. If a perfect match is achieved of the 32-bit code, then the other arguments in the application commands can be processed.

Type C indicates that the Access-Password itself is optional, as is support for the Access air interface command both on interrogators and RFID tags. If any of these optional features are not present, then the Completion-Code (25) Password-Mismatch is returned.

10.2.2 Additional-App-bits

The Inventory-ISO-UIImemory command enables a search on a Type C tag to match a bit pattern on the command with that on one or more RFID tags in the field. The application command supports selection on the AFI and DSFID. The Additional-App-bits field allows the bit pattern to be extended to enable a search to a finer resolution. For example, it could include the value of the Precursor and the Relative-OID. If this field is included in an application command, it is concatenated to the AFI and DSFID and incorporated directly into the associated Type C Inventory air interface command.

This argument is used with Type C when accessing Object-Identifier related data.

10.2.3 AFI

The application command argument AFI is used as parameter in the construction of an air interface command. Processing this argument maps the value of the AFI into bit positions in the air interface command. There is a possibility that the AFI will not be explicitly called out in the command, but its location within the encoded memory is specified in the relevant part of ISO/IEC 18000.

This argument is used with Type C.

10.2.4 AFI-Lock

The application command argument AFI-Lock is BOOLEAN. If set to TRUE, the AFI shall be written to the RFID tag's system information and be permanently locked. If set to FALSE it shall be written but not locked.

The AFI-Lock argument is part of the Configure-AFI command, which is not directly supported by Type C (see [A.3.2](#)).

Possible failures to complete the command argument result in the following error, represented by the Completion-Codes (more fully defined in [10.3](#)):

- 1 AFI-Not-Configured
- 2 AFI-Not-Configured-Locked
- 3 AFI-Configured-Lock-Failed

10.2.5 Append-To-Existing-Multiple-Record

The application command argument Append-To-Existing-Multiple-Record is a BOOLEAN argument. If TRUE, the data objects are to be appended to an existing multiple record, subject to various checks by the Data Processor. If FALSE, then a new multiple record shall be created.

10.2.6 Application-Defined-Record-Capacity

The application command argument Application-Defined-Record-Capacity is a BOOLEAN argument that applies to a multiple record. If FALSE, the Data Processor automatically determines that the capacity for the given multiple record is simply based on the encoded data and then increased to be block aligned. If set to TRUE, then the application sets the size of memory assigned to the record using the Record-Memory-Capacity argument. This is the value used by the Data Processor.

10.2.7 Avoid-Duplicate

The application command argument Avoid-Duplicate is used in a write command to ensure that the Object-Identifier is not already encoded on the RFID tag.

This is a BOOLEAN argument. If set to TRUE, sufficient content of the memory is read into the Logical Memory until a duplicate Object-Identifier is found, or until the end of the encoding. Variant processes based on the Access-Methods are as follows:

- No-Directory: sufficient content of each dataset shall be read to identify the Object-Identifier.
- Directory: the directory can be read to establish the presence of the candidate Object-Identifier.
- Packed-Objects: the index of each Packed-Object is read to establish whether the candidate Object-Identifier is present.
- Tag-Data-Profile: sufficient content of each dataset shall be read to identify the Object-Identifier.
- Multiple-Records: The specific Object-Identifier structure (see [11.6.3](#)) identifies a data element within a specific record. The final arc identifies the data element, which shall be used to apply this argument within the record using the processes (above) for the Access-Method of the record.

If a duplicate of the specified Object-Identifier is found, the write process is aborted, and the appropriate Completion-Code is used to indicate the error.

If the BOOLEAN argument is set to FALSE, no attempt shall be made to check for duplicates.

Possible failures to complete the command argument result in the following errors, represented by the Completion-Codes:

- 9 Object-Not-Added
- 10 Duplicate-Object

10.2.8 Check-Duplicate

The application command argument Check-Duplicate is used in a read command to ensure that the Object-Identifier is not already encoded on the RFID tag. This is a check of encoded data that is either not in conformity with this document, or where the Avoid-Duplicate argument was set to FALSE in the original write command, possibly by a trading partner.

This is a BOOLEAN argument. If set to TRUE, sufficient content of the memory is read into the Logical Memory until a duplicate Object-Identifier is found, or until the end of the encoding. The variant processes based on the Access-Method are as defined in [10.2.7](#) for the Avoid-Duplicate argument. If a duplicate of the specified Object-Identifier is found, the Completion-Code (10) is used to indicate the error, and neither Object-Identifier nor associated Object is returned as a response, because there is no

way to ascertain which is valid. Other housekeeping commands such as Read-Logical-Memory-Map can then be used to identify errors on the tag.

If the BOOLEAN argument is set to FALSE, no attempt shall be made to check for duplicates.

Possible failures to complete the command argument result in the following errors, represented by the Completion-Codes:

- 10 Duplicate-Object
- 13 Object-Identifier-Not-Found

10.2.9 Compact-Parameter

The application command argument Compact-Parameter determines what compaction scheme is applied to the data Object, based on the following integer code values:

- 0 Application-Defined - The Object shall not be processed through the data compaction rules of ISO/IEC 15962 and remains unaltered when stored in the Logical Memory Map of the RFID tag. This compaction applies to the No-Directory and Directory Access-Methods.
- 1 Compact - This requires using the basic ISO/IEC 15962 compaction rules to compact the Object as efficiently as possible to reduce the number of bytes required on the Logical Memory Map. This compaction applies to the No-Directory and Directory Access-Methods.
- 2 UTF8-Data - This identifies that the Object has been externally transformed from the ISO/IEC 10646 coded character set to UTF-8 encoding. The Object shall not be processed through the data compaction rules of ISO/IEC 15962 and remains unaltered for transfer to the Logical Memory Map. This compaction applies to the No-Directory and Directory Access-Methods.
- 3 Pack-Objects - This identifies that a set of Objects is to be encoded using the Packed-Object encoding scheme and identified with the associated Access-Method. If any of the set is defined with a different Compact-Parameter an error occurred in the command and encoding shall be aborted. The set of Objects shall be compacted using the Packed-Object encoding rules.
- 4 Tag-Data-Profile - This identifies that a set of Objects is to be encoded using the Tag Data Profile encoding scheme and identified with the associated Access-Method. Although the set of compaction schemes is identical to the basic ISO/IEC 15962 compaction rules, the Profile IDTable can call for a specific compaction scheme.
- 5 to 14 reserved for future definition.
- 15 De-Compacted-Data - This identifies that the Object in a response has been de-compacted using rules in ISO/IEC 15962 and restored to its original application input format. This code applies to any de-compacted data from Access-Methods: No-Directory, Directory, and Packed- Objects. It does not apply to Objects that were originally encoded as Application-Defined or UTF8-Data, because these codes are carried throughout the command arguments encoded on the tag, and response to the application.

The Packed-Object encoding scheme may only be applied if the application administrators choose to adopt the scheme by creating an index table to which source references should be provided in the register of data constructs (associated with ISO/IEC 15961-2).

10.2.10 Data-Length-Of-Record

This application response argument provides the size of the encoded Multiple Record in terms of the write block size, as encoded in EBV-8 format in the record preamble. The Data Processor returns this in EBV-8 format.

10.2.11 DSFID

The application command argument DSFID is used as parameter in the construction of an air interface command. Processing this argument basically maps the value of the DSFID into bit positions in the air interface command. There is a possibility that the DSFID will not be explicitly called out in the command, but its location within the encoded memory is specified in the relevant part of ISO/IEC 18000.

This argument is used with Types C and D.

10.2.12 DSFID-Lock

The application command argument DSFID-Lock is BOOLEAN. If set to TRUE, the DSFID shall be written to the RFID tag's system information and be permanently locked. If set to FALSE it shall be written but not locked.

The DSFID-Lock argument is part of the Configure-DSFID command, which is not directly supported by Type C (see [A.3.3](#)).

Possible failures to complete the command argument result in the following error, represented by the Completion-Codes (more fully defined in [10.3](#)):

- 4 DSFID-Not-Configured
- 5 DSFID-Not-Configured-Locked
- 6 DSFID-Configured-Lock-Failed

10.2.13 Directory-Length-EBV8-Indicator

This application command argument is used to determine the size of the EBV-8 field in the MR-header that encodes the size of the directory. The following codes apply:

- 1 Single byte EBV-8
- 2 Double byte EBV-8, even if the length is less than 128 blocks

The value 2 is used for a directory that is originally small in size but is expected to increase in size at some future time. The Data Processor shall encode the EBV-8 using the length defined by the application command.

10.2.14 Encoded-Memory-Capacity

This application response argument provides the size reserved for a Multiple Record in terms of the write block size, as encoded in EBV-8 format in the record preamble. The Data Processor returns this in EBV-8 format.

10.2.15 EPC-Code

The application command argument EPC-Code provides a unique code defined by TDS. Because some of the codes do not align on an 8-bit boundary, these shall be rounded to 8-bit bytes for processing through the Data Processor and be rounded to 16-bit words for encoding on the associated RFID tag. No other processing is required.

10.2.16 Hierarchical-Identifier-Arc

The application response argument Hierarchical-Identifier-Arc is an integer value, converted by the Data Processor from the EBV-8 value encoded in the Multiple Record's preamble from a hierarchical record.

10.2.17 Identifier-Of-My-Parent

The command and response argument Identifier-Of-My-Parent is used for a multiple record that is part of a hierarchy and has the value of the hierarchical code of that record. The Data Processor shall check that the associated parent record exists by establishing that the hierarchical code exists. In addition, it shall check that it can be a parent from bits 8 to 6 of the Multiple-Records intermediate arcs indicator having the values 010 or 011. If the hierarchical code exists and the fact that the record can be a parent is proven, then the record can be written. Otherwise, the encoding process is discontinued, and an error reported.

10.2.18 Identify-Method and Number-Of-Tags

The application command argument Identify-Method is used to define whether all or some of the RFID tags belonging to the selected AFI in the operating area shall be identified. It shall be used in conjunction with the command argument Number-Of-Tags (defined later in this subclause). The value of Identify-Method is an integer, and the following codes apply:

- | | | |
|---|------------------------|--|
| 0 | Inventory-All-Tags | - This call for the Singulation-Id of all RFID tags in the operating field to be identified, probably with the additional system constraint of a time limit. |
| 1 | Inventory-At-Least | - This call for the Singulation-Id of all RFID tags in the operating field to be identified but differs from (1) in that an error occurs if the minimum number is not found. The minimum quantity should reflect some value relevant to the application. |
| 2 | Inventory-No-More-Than | - This call for the Singulation-Id of a maximum number of RFID tags in the operating field to be identified. This could be used for sampling purposes. |
| 3 | Inventory-Exactly | - This call for the Singulation-Id of a specific number of RFID tags in the operating field to be identified. This argument can be used to confirm that items are present in the operating field (e.g. within a container). |

The application command argument Number-Of-Tags is a conditional qualifier to the basis argument Identify-Method. This numeric selection is defined by the application to confirm by an actual count, or a partial count, of which RFID tags are in the operating field. The Data Processor and the Tag Driver do not need to be concerned with the application logic of this command. However, there are some systems applications to consider:

- If the Identify-Method is set to Inventory-All-Tags (0) the Number-Of-Tags should be set to 0 in the application argument.
- If the Identify-Method is set to Inventory-At-Least (1) and the Number-Of-Tags is set to 1, the RFID interrogator is effectively being set to wait for an RFID tag to enter the operating field. It then responds with the Singulation-Id of the first RFID tag that it detects, and others that are in the operating area at the same time. If the Number-Of-Tags is set to greater than 1, it is possible that the argument will need to support with an additional system constraint of a time limit.
- Some of the identify arguments can result in an open-ended loop and an indefinite wait. Additional systems constraints may be required to respond with an appropriate Completion-Code.

10.2.19 Instance-Of-Arc

The application response argument Instance-Of-Arc is an integer value, converted by the data Processor from the EBV-8 value encoded in the Multiple Record's preamble.

10.2.20 Item-Related-DSFID

The application argument Item-Related-DSFID is used as parameter to identify the DSFID encoded with the Item-Related segment of a Type D tag.

10.2.21 Item-Related-Segment-Map

The application response argument Item-Related-Segment-Map is used as parameter to identify the raw byte string encoded within the Item-Related segment of a Type D tag.

10.2.22 Kill-Password

The application command argument Kill-Password requires the Data Processor to pass this to the interrogator so that the Kill-Password in the command is matched with that on the RFID tag. A match results in the RFID tag function being permanently disabled. A mismatch results in the air interface rejecting the command.

10.2.23 Length-Of-Mask

The application command argument Length-Of-Mask represents the number of bits in the Tag-Mask and is used as a parameter in the associated Type C *Inventory* air interface command.

This argument is used with Type C when accessing TDS data.

10.2.24 Lock-Directory-Entry

The application command argument Lock-Directory-Entry is BOOLEAN and if set to TRUE the interrogator shall lock the directory entry for the record.

10.2.25 Lock-Multiple-Records-Header

The application command argument Lock-Multiple-Records-Header is used to determine if all, some, or none of the MR-header is locked. This command argument is presented as an integer value and the following codes apply:

- 0 Not locked
- 1 Completely locked
- 2 The Number of Record's field remains unlocked; the preceding fields are locked.
- 3 The Data Length of the directory field remains unlocked, all other fields including the Number of Record's field are locked.
- 4 The Data Length of the directory field and the Number of Record's field remain unlocked; all other fields are locked.

The Data Processor shall ensure block alignment. The interrogator shall lock the memory as instructed by the command.

10.2.26 Lock-Record-Preamble

The application command argument Lock-Record-Preamble is BOOLEAN and if set to TRUE the interrogator shall lock the fields in the preamble.

The Data Processor shall ensure block alignment. The interrogator shall lock the memory as instructed by the command.

10.2.27 Lock-UII-Segment-Arguments

The application command argument Lock-UII-Segment-Arguments defines which component parts of the UII segment of a Type D tag to lock. The size of the lock block is determined by the tag model declared by the TID-S page(s) of the tag.

10.2.28 Max-App-Length

The application command argument Max-App-Length is provided as a numeric value equivalent to the number of bytes to be read starting from the first location on the RFID tag. This shall be converted into blocks, by dividing the value of the Max-App-Length by the block size and rounding up to a whole block, as necessary.

The number of blocks is then transferred to the interrogator for the air interface protocol to read and return this number of blocks, which should provide the application with the first dataset(s) encoded on the RFID tag.

The Max-App-Length argument is only applicable to the Access-Method No-Directory and Directory. It should be applicable to all single bank memory structures, and to Memory Bank 11₂ of the Type C tag and other segmented memory structures.

10.2.29 Memory-Bank

The application command argument Memory-Bank represents a 2-bit code used to distinguish which memory bank shall be accessed to invoke the following commands:

- Read-Words-Segmented-Memory-Tag, with possible values (01₂ to 11₂)
- Write-Objects-Segmented-Memory-Tag, with possible values (01₂ or 11₂)

These bit values are incorporated directly into the associated Type C air interface commands.

10.2.30 Memory-Bank-Lock

The application command argument Memory-Bank-Lock is BOOLEAN. If set to TRUE, the selected memory of the Type C tag shall be permanently locked. If set to FALSE, any data written to the tag shall not be locked in the specified memory bank.

The Memory-Bank-Lock argument is part of the Write-EPC-UII command, which is only supported by Type C.

NOTE For the Write-ISO-UII and other ISO-related data to be encoded in a Type C tag, different rules apply.

10.2.31 Memory-Segment

The application command argument Memory-Segment is used to distinguish which memory segments of a Type D are addressed.

10.2.32 Memory-Type

The command argument Memory-Type is used to define which memory structure is intended for encoding a Monomorphic-UII, effectively instructing the Data Processor which of the optional and conditional arguments and processes to apply to the encoding process.

10.2.33 Multiple-Records-Directory-Length

The application response argument Multiple-Records-Directory-Length is an EBV-8 value. If the data length of directory is not encoded in the MR-header, then a zero value is returned.

10.2.34 Multiple-Records-Features-Indicator

The application command and response argument Multiple-Records-Features-Indicator is a bit map. The 8-bit value in the command shall be encoded as submitted in the MR-Header. As currently defined in [Q.2.8](#) some of the values for bits 7 to 4 are either not permitted or are reserved. Bit 1 is also currently reserved.

The Data Processor shall abort processing the Configure-Multiple-Records-Header command if any of the bits that are not permitted or are reserved are included in the application command for this argument.

10.2.35 NSI-bits

The application command argument NSI-bits defines a 9-bit code defined by TDS used as a prefix to the EPC-Code when encoded on the associated RFID tag. The NSI-bits are encoded in bit locations 17h to 1Fh of memory bank 01₂ of a Type C tag, only when encoding TDS data.

10.2.36 Number-In-Data-Element-List

The application command argument Number-In-Data-Element-List is only used in a hierarchical record that is a data element list. The value is the count of the number of instances of the data element being encoded. The Data Processor should use this as an aid to ensure that the number of data elements matches this value. A mismatch is not treated as an error, so the encoding process continues.

10.2.37 Number-Of-Records

The response argument Number-Of-Records is used in one of two ways. If bit 2 of the Multiple-Records-Features-Indicator equals:

- 1 then this field is fully maintained as new records are added. A zero value is encoded when the MR-header is created. In this case the Data Processor returns the EBV-8 value as encoded in the MR-header.
- 0 then this field is not maintained, and the value should be zero, but any other value should be ignored, e.g. if some record count was initially maintained but later this function was decided to be stopped. In this case the Data Processor returns the EBV-8 value of zero, irrespective of the value encoded in the MR-header.

10.2.38 Object-Lock

The application command argument Object-Lock is BOOLEAN. If set to TRUE, the selected Object and Object-Identifier (as presented in the ISO/IEC 15961-1 commands) shall be locked according to the rules that apply for the Tag Drivers. If set to FALSE, neither the Object, nor its associated Object-Identifier, shall be locked.

The sequence of bytes that need to be locked will vary according to the Access-Method, and further discussions about locking Objects and associated Object-Identifiers is included in [Clause 11](#).

Additional rules apply to Type C tags (see [A.3.8](#)) for details.

10.2.39 Packed-Object-Directory-Type

The application command argument Packed-Object-Directory-Type is used in write and modify commands to either indicate whether the Pack Object is treated as a directory Packed Object or to change the status to be a directory. The following codes apply:

- 0 This Packed-Object is not a directory and does not require one
- 1 Packed-Object Presence/Absence

- 2 Packed-Object index field
- 3 Packed-Object offset
- 4 Packed-Object pointer-allocation only expecting a future command to set the directory type

Code "0" is used in a write command to identify that the Packed Object is not a directory Packed Object. Code "5" is used to indicate that a directory will be set at some future time. The other three codes define different types of directory.

10.2.40 Password

The application command argument Password defines the byte string that represents a code value, qualified by the Password-Type, in a command that writes the password to the RFID tag. The Password-Type determines the structure of the Password, and if wrong the command shall be rejected. The Password-Type also determines the location to which the Password is written for the particular air interface protocol.

10.2.41 Password-Type

The application command argument Password-Type determines which location a password is written to in the specified memory bank of an RFID tag with a segmented memory. This argument qualifies the type of Password with the following code values.

- 0 Kill-Password
- 1 Access-Password

Processing this argument requires the password defined by the Password-Type to be specified to be written to the appropriate address location in the correct memory bank using a generic air interface *Write* command.

This argument is used with Type C.

10.2.42 Pointer

The application command argument pointer identifies the hexadecimal address of the first bit against which to apply the Tag-Mask in the Inventory-EPC-UIMemory command. This field is incorporated directly into an associated Type C air interface command. It is also used in conjunction with Length-Of-Mask.

This argument is used with Type C when accessing TDS data.

10.2.43 Pointer-To-Multiple-Records-Directory

The application command and response argument Pointer-To-Multiple-Records-Directory is used to define the highest block number at the start address of the directory. This is defined as an EBV-8 value. If a directory is not initially encoded, then a fixed length EBV-8 string of the same length as required for the start point shall be encoded with a value zero. The start of the directory is not necessarily the highest address in Logical Memory, because other hardware features of the tag can be specified to be located there.

The Data Processor shall encode the value provided by the application command unless the value is greater than the highest addressable memory location. In this case the command processing shall be aborted, and the MR-header not encoded.

10.2.44 Read-Record-Type

The application command argument Read-Record-Type is used to identify various logical structures from the RFID tag. This command argument is presented as an integer value and the following codes apply:

- 0 Read-Multiple-Records-Header
 - 1 Read-Multiple-Records-Header-Plus-1st-Preamble
 - 2 Read-Multiple-Records-Directory
 - 3 Read-Preamble-Specific-Multiple-Record
 - 4 Read-All-Record-OIDs-Specific-Record-Type
 - 5 Read-OIDs-Specific-Multiple-Record
 - 6 Read-All-Objects-Specific-Multiple-Record
 - 7 Read-Multiple-Objects-Specific-Multiple-Record
 - 8 Read-1st-Objects-Specific-Multiple-Record
 - 9 Read-Data-Element-List-Specific-Multiple-Record
- The process rules are defined in [8.3.8.2](#).

10.2.45 Read-Type

The application command argument Read-Type defines which Object-Identifier is to read from the RFID tag. There are three Read-Type codes:

- 0 Read-First-Objects
- 1 Read-Multiple-Objects
- 2 Read-All-Objects

The Read-First-Objects argument is restricted to the No-Directory and directory Access-Methods. If this Read-Type is selected, then the command shall include the list of Object-Identifiers together with a value for the Max-App-Length (see [10.2.28](#)).

The Read-Multiple-Objects argument requires a list of Object-Identifiers to be provided and can be applied to any of the Access-Methods. If the Check-Duplicate argument is set to FALSE for all the Object-Identifiers, the read process may cease once all the Object-Identifiers on the read list have been identified. If any of the Object-Identifiers have the Check-Duplicate argument set to TRUE, then reading continues to the end of the memory or until a duplicate Object-Identifier is found at which point the read process is aborted and an error is returned.

The Read-All-Objects argument does not require a list of Object-Identifiers. If any Object-Identifier is found to be duplicated, then the Completion-Code 10 should be returned, and the reading process aborted. An appropriate "housekeeping" command should then be used to read the bytes from the RFID tag.

10.2.46 Record-Memory-Capacity

The application command argument Record-Memory-Capacity is used in commands to write a multiple record to indicate the amount of memory (in terms of write blocks) to assign, usually to enable the record to have additional data elements added. It is only used if the application shall over-ride the automatic sizing by the Data Processor when the Application-Defined-Record-Capacity argument is set to TRUE.

10.2.47 Record-Type-Arc

The application response argument Record-Type-Arc is an integer value, converted by the Data Processor from the EBv-8 value encoded in the Multiple Record's preamble.

10.2.48 Record-Type-Classification

The application command and response argument Record-Type-Classification is a bit string that identifies the class of record being encoded. The code values are as defined in [Q.3.5](#).

The Data Processor shall check that the value for this argument in the command aligns with the Object-Identifier in the command (particularly the value of the fourth arc and the value of the instance-of or hierarchical-id). For hierarchical records there also shall be a logical agreement with the presence of a parent code. Any discrepancy points to an ambiguous error in the construction of the command, in which case the Data Processor shall not proceed with the command.

10.2.49 Sector-Identifier

The Sector-Identifier is used in the MR-header either to indicate the true Sector-Identifier for all records in the Logical Memory, or to signal that the true value varies between records and the true value is encoded in the record. This application command and response argument is presented as an integer value. The Data Processor accepts the integer value provided in the command and converts this to EBv-8 format before encoding in the MR-header.

In commands to write, read, modify, or delete, the Sector-Identifier is provided as part of the Object-Identifier and is already in EBv-8 format. The Data Processor shall compare the value in the MR-header with the value in the command. If the MR-header value is:

0, then the command value shall be any value >2

1, then the command value shall be = 1

2, then the command value shall be = 2

>2, then the command value shall be the same

All other states are in error and the command shall not be invoked.

10.2.50 Segment-Read-Type

The application command argument Segment-Read-Type defines which segment, and to what detail, segments from a Type D are to be read. There are four Segment-Read-Type codes:

0 Read-Segments

1 Read-All-Segment-Details

2 Read-UII-Segment-Details

3 Read-Item-Related-Segment-Details

Read-Segments requires the Data Processor to parse the payload into a set of byte strings that represent: the TID segment, the UII segment, the Item-Related segment (if present), and the Simple Sensor Data Block (if present).

Read-UII-Segment-Details requires the Data Processor to provide in the response: the AFI, DSFID, Object Identifier, and data object.

Read-Item-Related-Segment-Details requires the Data Processor to provide in the response: the DSFID and list of object identifiers.

Read-All-Segment-Details requires the Data Processor to provide: the TID segment, the UII segment to the detail of the Read-UII-Segment-Details argument, the Item-Related segment to the detail of the Read-Item-Related-Segment-Details argument, and the Simple Sensor Data Block.

10.2.51 Simple-Sensor-Data-Block

The application response argument Simple-Sensor-Data-Block is used as parameter to identify the raw byte string encoded for simple sensors on a Type D tag.

10.2.52 Start-Address-Of-Record

This application response argument provides the address of first byte of the encoded Multiple Record in terms of the write block size, as encoded in EBV-8 format in the multiple record's directory.

10.2.53 Tag-Data-Profile-ID-Table

The application command argument Tag-Data-Profile-ID-Table identifies the table that shall be used as a reference for the sequence of Object-Identifiers and the compaction scheme to apply to the data Object.

10.2.54 Tag-Mask

The application command argument Tag-Mask represents a bit pattern in the Inventory-EPC-UIImemory command to enable tags with this bit pattern from the pointer to be identified and returned. This field is incorporated directly into the associated Type C Inventory air interface command. It is also used in conjunction with Length-Of-Mask.

This argument is used with Type C when accessing TDS data.

10.2.55 TID-Segment-Map

The application response argument TID-Segment-Map is used as parameter to identify the raw byte string encoded as the TID, or Singulation-Id, on a Type D tag.

10.2.56 UII-DSFID

The application argument UII-DSFID is used as parameter to identify the DSFID encoded with the UII segment of a Type D tag.

10.2.57 UII-Segment-Map

The application response argument UII-Segment-Map is used as parameter to identify the raw byte string encoded within the UII segment of a Type D tag.

10.2.58 Update-Multiple-Records-Directory

The application command argument Update-Multiple-Records-Directory is BOOLEAN, but the processing on the Logical Memory by the Data Processor shall consider whether a directory already exists. The following states and processes apply:

- If a directory pre-exists and the command argument is set to TRUE, the directory is fully updated, including any previously missed directory entries.
- If a directory pre-exists and the command argument is set to FALSE, the argument is ignored and the directory is fully updated, including any previously missed directory entries.
- If no directory exists and the command argument is set to TRUE, the directory is created and fully updated, including any previously missed directory entries.

— If no directory exists and the command argument is set to FALSE, no directory is created.

10.2.59 Word-Count

The application command argument Word-Count identifies the number of words, counting from the Word-Pointer, that are to be read from a Type C tag using the application command Read-Words-Segmented-Memory-Tag. This field is incorporated directly into associated Type C air interface commands.

10.2.60 Word-Pointer

The application command argument Word-Pointer identifies the first word to be read in a Read-Words-Segmented-Memory-Tag that returns an un-interpreted sequence of bytes on a Type C tag. This field is used in conjunction with the Word-Count field, and it is incorporated directly into an associated Type C air interface command.

10.3 Completion-Codes

If a command fails to be properly executed and an error is identified, the response to the application shall include this information. This is achieved by means of the appropriate Completion-Code, as specified in [Table 6](#). If errors occur, at least one Completion-Code shall be returned per response. Addressing multiple errors is beyond the scope of this document, but multiple Completion-Codes may be provided depending on the design of the interface. Additionally, the "housekeeping" commands such as Read-Logical-Memory-Map and Read-Words-Segmented-Memory-Tag can be used for diagnostic purposes.

Table 6 — List of Completion-Codes

0	No-Error
1	AFI-Not-Configured For some reason, possibly because of a prior configure action, the command was not completed.
2	AFI-Not-Configured-Locked As (1) but responding that the existing AFI was also found to be locked.
3	AFI-Configured-Lock-Failed Successfully configured but not locked as required
4	DSFID-Not-Configured For some reason, possibly because of a prior configure action, the command was not completed.
5	DSFID-Not-Configured-Locked As (4) but responding that a pre-existing DSFID was found to be locked
6	DSFID-Configured-Lock-Failed Successfully configured but not locked as required.
7	Object-Locked-Could-Not-Modify The previous encodation on the RFID tag was locked, and as a result the attempt to update the Object value could not be completed.
8	Singulation-Id-Not-Found The RFID tag, specified by the Singulation-Id, could not be found in the operating area.
9	Object-Not-Added The Object and Object-Identifier plus associated syntax bytes could not be added to the Logical Memory Map (e.g. because there was insufficient memory space). This response also applies if the RFID tag supports a lock function that failed.

Table 6 (continued)

10	Duplicate-Object An Object-Identifier with the same value as the one to be processed (added, modified, or deleted) was found. The process was aborted.
11	Object-Added-But-Not-Locked The Object and Object-Identifier plus associated syntax bytes was added to the RFID tag that did not support a lock feature in the memory.
11	Object-Not-Deleted The Object and Object-Identifier plus associated syntax bytes could not be deleted from the Logical Memory Map (e.g. because the delete function is not supported by the particular RFID interrogator).
12	Object-Not-Deleted The Object and Object-Identifier plus associated syntax bytes could not be deleted from the Logical Memory Map (e.g. because the delete function is not supported by the particular RFID interrogator).
13	Object-Identifier-Not-Found The Object-Identifier intended to be processed was not actually encoded on the RFID tag.
14	Object-Locked-Could-Not-Delete The Object and Object-Identifier plus associated syntax bytes is locked and could not be deleted.
15	Object-Not-Read The intention to read the specified Object failed.
16	Reserved
17	Blocks-Locked This indicates that the intended action to erase encoded bytes from one or more blocks could not be actioned.
18	Erase-Incomplete This indicates that the intended action to erase encoded bytes from one or more blocks was interrupted and that not all blocks have been processed. The command can be re-invoked to complete the process.
19	Read-Incomplete The intention to read the complete contents of the Logical Memory Map failed, because not all blocks from the RFID tag were transferred to the Logical Memory.
20	System-Info-Not-Read The intention to read the system information failed.
21	Object-Not-Modified The Object and Object-Identifier plus associated syntax bytes could not be modified on the Logical Memory Map (e.g. because the modify function is not supported by the particular RFID interrogator).
22	Object-Modified-But-Not-Locked The Object was modified in the RFID tag that did not support a lock feature in the memory.
23	Failed-To-Read-Minimum-Number-Of-Tags The minimum number of RFID tags was not identified with the specified selection criterion, possibly because of a time-out.
24	Failed-To-Read-Exact-Number-Of-Tags The pre-defined exact number of RFID tags was not identified with the specified selection criterion, possibly because of a time-out.
25	Password-Mismatch The Password in the command failed to match the Password encoded on the RFID tag.

Table 6 (continued)

26	Password-Not-Written The Password in the command was not written to the RFID (e.g. this writing feature was not supported on the interrogator or RFID tag).
27	Zero-Kill-Password-Error The Kill operation was not executed because the Kill password has a zero value.
28	Kill-Failed The intended air interface <i>Kill</i> command failed (e.g. There was insufficient power to perform the kill operation).
29	Object-Not-Editable The Object, encoded as part of a Packed-Object, was not modified because it is not editable.
30	Directory-Already-Defined A Packed-Object already has a directory type defined.
31	Packed-Object-ID-Table-Not-Recognised The ID-Table called for in the command was not supported by the encoder or interrogator, and encoding is impossible to achieve.
32	Tag-Data-Profile-ID-Table-Not-Recognised The ID-Table called for in the command was not supported by the encoder or interrogator, and encoding is impossible to achieve.
33	Insufficient-Tag-Memory The operation failed because there was insufficient memory on the tag to satisfy the requested operation.
34	AFI-Not-For-Monomorphic-UII The operation failed because the AFI called for in the command is not registered for Monomorphic-UIIs.
35	Monomorphic-UII-OID-Mismatch The Object-Identifier defined in the command does not match that on the ISO/IEC 15961-2 Data Constructs register for this AFI.
36	Command-Cannot-Process-Monomorphic-UII A Monomorphic-UII was presented as an Object to command that does support this type of UII.
37	Data-CRC-Not-Applied At least one of the Data-CRCs requested in the Extended-DSFID was not applied to the data.
38	Length-Not-Encoded-In-DSFID At least one of the requested lengths was not encoded in the Extended-DSFID.
39	Multiple-Records-Header-Not-Configured Some of the processes required to configure the Multiple-Records-Header could not be processed by the Data Processor, resulting in an incomplete record.
40	Multiple-Records-Header-Not-Locked The Multiple-Records-Header was added to an RFID tag that did not support a selective lock feature in the memory.
41	File-Support-Indicators-Not-Configured Some of the processes required to configure the File-Support-Indicators could not be processed by the Data Processor, resulting in an incomplete encoding.
42	File-Support-Indicators-Not-Locked The File-Support-Indicators field was added to an RFID tag that did not support a selective lock feature in the memory.

Table 6 (continued)

43	Data-Format-Not-Compatible-Multiple-Records-Header The Data-Format in the command is at variance with the controlling Data-Format rules defined in the MR-header. The record was not encoded.
44	Access-Method-Not-Compatible-Multiple-Records-Header The Access-Method in the command is at variance with the controlling Access-Method rules defined in the MR-header. The record was not encoded.
45	Sector-Identifier-Not-Compatible-Multiple-Records-Header The sector identifier in the Object-Identifier in the command is at variance with the controlling sector identifier rules defined in the MR-header. The record was not encoded.
46	Record-Preamble-Not-Configured Some of the processes required to configure the record preamble could not be processed by the Data Processor, resulting in an incomplete encoding.
47	Record-Preamble-Not-Locked The record preamble was added to an RFID tag that did not support a selective lock feature in the memory.
48	Multiple-Records-Directory-Not-Present The command to read this directory could not be invoked because of the absence of the directory.
49	Record-Not-Deleted-Preamble-Locked The command could not be invoked because the record's preamble is locked.
50	Record-Not-Deleted-Directory-Locked The command could not be invoked because the record's entry in the directory is locked.
51	Record-Not-Deleted-Lower-Level-Preamble-Locked: The command could not be invoked because the preamble of a lower-level record is locked.
52	Record-Not-Deleted-Encoding-Locked: The command could not be invoked because part of the record is locked
53 to 252	Unassigned
253	ISO/IEC 24791-5 Result-Code This Completion-Code may be used to pass through the Result code from an ISO/IEC 24791-5 response in the form of "message code" "result value".
254	Undefined-Command-Error An error occurred in a command, not defined by another code.
255	Execution-Error A system error occurred which made it impossible to action the command. The appropriate Execution-Code is returned in the response.

10.4 Execution-Codes

If a command fails to be completely executed because of a systems error, the response to the application shall include this information. This is achieved by means of the appropriate Execution-Code, as specified below. If systems errors occur, at least one Execution-Code shall be returned per response. Addressing multiple errors is beyond the scope of this document, but multiple Execution-Codes may be provided depending on the design of the interface.

The following Execution-Codes apply and are equivalent to those defined in ISO/IEC 15961-1.

- 0 No-Error: The command was executed without error

- 1 No-Response-From-Tag: No response was received from the RF tag
- 2 Tag-Communication-Error: The response(s) from the RFID tag(s) was corrupted (e.g. there was an aborted frame)
- 3 Tag-CRC-Error: A CRC error was detected in the RFID tag's response
- 4 Command-Not-Supported: The interrogator or RFID tag does not support the command.
- 5 Invalid-Parameter: The command parameter(s) are invalid
- 6 Interrogator-Communication-Error: An error occurred in the communication between the application and in the interrogator
- 7 Internal-Error: An error occurred in the application software
- 255 Undefined-Error: An error occurred, not defined by another code

11 Access-Method

11.1 Methods

The Access-Method, as defined by the application, is the most significant determinant of how data is encoded on the RFID tag. The value of Access-Method should be stored on the RFID tag, or may be defined by the air interface services, if this can be done unambiguously. The Access-Method is defined as an integer value in the application command and encoded as a compound bit value in the DSFID and the SFF (Special Features flag) byte on the RFID tag.

[Table 7](#) defines the code structure.

Table 7 — Assigned and reserved Access-Methods

15961-1 integer code	15962 DSFID bit code	15962 SFF bit code	Name	Description
0	00	00	No-Directory	This structure supports the contiguous abutting of all the datasets
1	01	00	Directory	The data is encoded exactly as for No-Directory but the RFID tag supports an additional directory, which is first read to point to the address of the relevant object identifier.
2	10	00	Packed-Objects	This is an integrated compaction and encoding scheme that formats data in an indexed structure as defined by the application administrator (see ISO/IEC 15961-2)
3	11	00	Tag-Data-Profile	This is an integrated compaction and encoding scheme for a fixed set of data elements, each of a defined length
4	00	01	Multiple-Records	This encoding scheme enables multiple instances of No-Directory, Packed-Objects, and Tag-Data-Profile to be encoded on the same Logical Memory
5	00	10		reserved for future revisions of ISO/IEC 15962
6	00	11		reserved for future revisions of ISO/IEC 15962
7	01	01		reserved for future revisions of ISO/IEC 15962
8	01	10		reserved for future revisions of ISO/IEC 15962
9	01	11		reserved for future revisions of ISO/IEC 15962
10	10	01		reserved for future revisions of ISO/IEC 15962
11	10	10		reserved for future revisions of ISO/IEC 15962

Table 7 (continued)

15961-1 integer code	15962 DSFID bit code	15962 SFF bit code	Name	Description
12	10	11		reserved for future revisions of ISO/IEC 15962
13	11	01		reserved for future revisions of ISO/IEC 15962
14	11	10		reserved for future revisions of ISO/IEC 15962
15	11	11		reserved for future revisions of ISO/IEC 15962

NOTE In addition to the encoding schemes declared by the Access-Method, the Monomorphic-UII is an additional encoding scheme that is declared directly by the AFI (see 9.3.5).

The Extended Syntax flag byte 1 is required for all Access-Methods 4 to 15. It is only required for Access-Methods 0 to 3 to signal other functions supported by the RFID tag.

Each of the Access-Methods defines specific encoding rules for the Object-Identifier and for the data Object. The subclauses that follow describe each of the Access-Methods and define specific rules for encoding Object-Identifiers and data Objects.

Any of the Access-Methods may be applied to the user memory of a single memory structure RFID tag, subject to that Access-Method being supported by the application standard.

For segmented memory structures, only some of the Access-Methods can be applied to memory banks. Details are provided in the following subclauses.

11.2 No-Directory structure

11.2.1 Structure

The Access-Method = No-Directory is designed to achieve a combination of flexibility and efficiency for the bytes that are encoded on the RFID tag. In particular:

- Data Objects are compacted efficiently using a defined set of compaction techniques that reduce the encoding of data objects on the RFID tag across the air interface.
- Data formatting minimises the encoding of the Object-Identifiers on the RFID tag and on the air interface, but still provides complete flexibility for identifying specific data.

The encoding consists of a repeating cycle of datasets (see 11.2.3), with each additional dataset abutted to the previous dataset as illustrated in Figure 5.

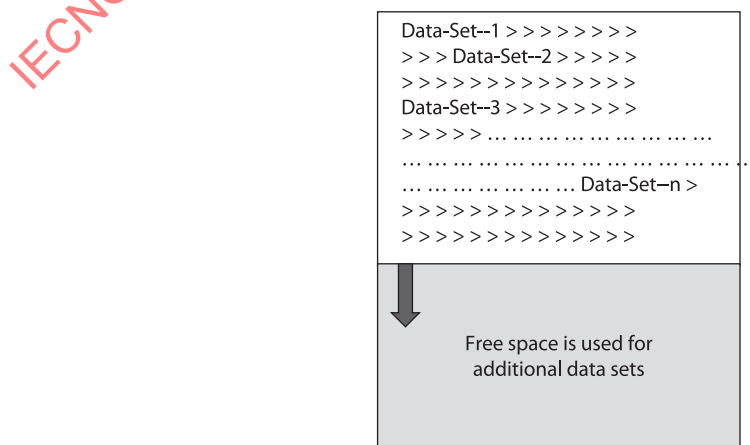


Figure 5 — Logical Memory Schematic — No-Directory structure

The first dataset is encoded in the lowest block, subject to any requirements to encode the AFI and DSFID in the same encoding space.

11.2.2 Restrictions to air interfaces

This Access-Method may be used to encode ISO-related data in any memory area where applications are able to write a UII and/or item-related data, including the relevant memory banks in a segmented memory tag.

11.2.3 The dataset

Each dataset comprises the following component parts some of which are conditional on the value of the Object-Identifier:

- Precursor - This is typically 1 byte long and provides a bit-based meta-data structure of the encoded Object-Identifier and Object.
- Offset - This is only present when the dataset shall be aligned on a block boundary, for example to ensure that the dataset is locked or not locked relative to adjacent datasets.
- The length of the Object-Identifier.
- Object-Identifier - This is a formatted Object-Identifier that may be encoded as a Relative-OID, using the Data-Format to identify the Root-OID and reduce the number of encoded bytes, but still requires only a simple process to reconstruct the complete Object-Identifier.
- The length of the Object.
- Object - This is the compacted object.

This is a general description and there are some variations to this defined in [Table 8](#).

Table 8 — Dataset structures

Description	Structure of byte String for an encoded dataset						
Single Relative-OID 1 -14	Precursor	Length of data	Data ~~				
Single Relative-OID 15 -127	Precursor	Relative-OID	Length of data	Data ~~			
Other OID	Precursor	Length of OID	OID ~~	Length of data	Data ~~		
Single Relative-OID 1 -14 with Offset	Precursor	Offset	Length of data	Data ~~	Pad ~~		
Single Relative-OID 15 -127 with Offset	Precursor	Offset	Relative-OID	Length of data	Data ~~	Pad ~~	
Other OID with Offset	Precursor	Offset	Length of OID	OID ~~	Length of data	Data ~~	Pad ~~
~~ indicates that this component typically can be multiple bytes.							
The number of pad bytes can be 0 to 254, depending on the block size and lock block alignment.							

11.2.4 Encoding rules

The encoding rules for this Access-Method are defined in [Annex D](#), with the following annexes providing additional details:

- [Annex E](#) provides detailed rules for the data compaction schemes.
- [Annex F](#) provides details of the characters supported in each compaction scheme.

11.3.3 Directory structure for Data-Format = "3 ...287"

The directory has the following structure of a repeating cycle for each dataset consisting of:

- The Precursor for the dataset.
- The length of the Object-Identifier (conditional).
- The Object-Identifier (conditional).
- The address as a byte value of the start of the precursor in the associated dataset within the No-Directory area.

The length of the Object-Identifier is conditional because it is only required for Relative-OIDs greater than 127 or for full Object-Identifiers. The Object-Identifier is conditional because Relative-OID values in the range 1 to 14 are directly encoded in the Precursor.

The end of the directory is signalled by the terminator byte, value 00_{16} , as defined in [D.4](#).

11.3.4 Directory structure for Data-Format = 2

This directory structure is identical to that as described in [11.3.3](#) except for the fact that the first element to be encoded refers to the Root-OID as follows:

- Precursor of the Root-OID.
- The length of the Root-OID (in bytes).
- The Root-OID.

There is no need to define the address of the Root-OID because this is encoded in the first dataset with the first byte being at the lowest address in the No-Directory structure.

11.3.5 Encoding the address of the dataset

The address of the Precursor of each dataset in the No-Directory section of the Logical Memory is encoded in the directory using the length encoding rules defined in [Annex O](#). The address shall be based on the byte address of the memory, with the first byte in the first block being defined as byte value 00_{16} .

NOTE The byte address is used because a dataset can begin or end at other than a block boundary.

11.3.6 Encoding example

An example of the encoding with a directory is provided in [Annex H](#).

11.4 Packed-Objects structure

The Packed-Objects encoding scheme has been developed since the first edition of this document. It uses a rules-based table, defined by the application administrator, and registered according to ISO/IEC 15961-2. This encoding scheme specifies common compaction schemes which are significantly more efficient than those defined for the No-Directory structure, and a compaction scheme can be specified for each Relative-OID value in the table. In addition, the Packed-Objects encoding scheme may specify the use of the same compaction schemes as of the No-Directory Access-Method. This enables a simpler implementation, but still with encoding efficiencies over the basic No-Directory Access-Method. The basic process is illustrated in [Figure 7](#).

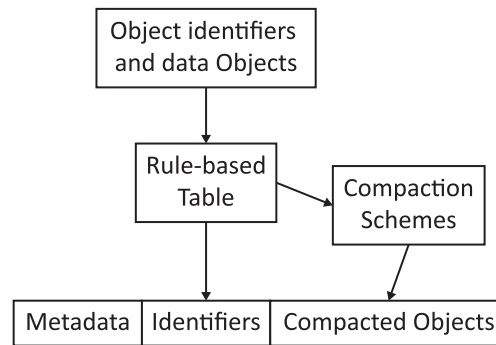


Figure 7 — Packed-Objects encoding process

The Object-Identifiers and data Objects are input into the rules-based table, where the Object-Identifiers are separated from the Objects. The Object-Identifiers are encoded in a group, and the data is compacted in a group. The encoding sequence consists of metadata, an index of identifiers, followed by the compacted Objects. The index allows for all Object-Identifiers encoded within the Packed-Object to be identified, which enables a search for a particular Object-Identifier to be undertaken efficiently. If the required Object-Identifier is not present, then the search can continue in a subsequent Packed-Object structure, if any are encoded on the RFID tag.

The details of Packed-Objects are provided in the following annexes:

- [Annex I](#) defines fully comprehensive Packed Object structure detailing all the mandatory and optional features.
- [Annex J](#) defines the ID tables.
- [Annex K](#) provides details of the encoding tables.
- [Annex L](#) provides encoding examples.
- [Annex M](#) provides decoding guidelines.

Not all features are mandatory, and a distinction will be made in relevant parts of the text of the annexes where optional components exist, and how the option is invoked.

This Access-Method may be used to encode ISO-related data in any memory area where applications are able to write a UI and/or item-related data, including the relevant memory banks in a segmented memory tag.

11.5 Tag Data Profile

11.5.1 Use

The Access-Method = Tag-Data-Profile is designed to support applications that can define all the encoded data as mandatory and of a fixed or maximum length. It is possible to apply encoding rules that achieve an efficient encoding of the bytes on the RFID tag. In particular:

- The Tag-Data-Profile table, if accessed by the interrogator, provides a rapid access to any data on the RFID tag.
- Data Objects are compacted efficiently using a defined set of compaction techniques that reduce the encoding of data objects on the RFID tag across the air interface.
- The Precursor and other syntax on the No-Directory Access-Method are retained to enable interrogators with no access to the Tag-Data-Profile to decode the data.

The encoding consists of some meta-data that uniquely identifies the Tag-Data-Profile plus encoded datasets that are the same as if encoded using the No-Directory Access-Method, except that all the data has a predetermined length and compaction.

11.5.2 Restrictions to air interfaces

This Access-Method may be used to encode ISO-related data in any memory area where applications are able to write a UII and/or item-related data, including the relevant memory.

11.5.3 Defining the Tag-Data-Profile

A Tag-Data-Profile is identified by a rules-based table, defined by the application administrator, and registered according to ISO/IEC 15961-2. The table enables the encoder to convert the Object-Identifiers, as defined by the application, to a byte-mapped position on the Logical Memory. The table also specifies length, formats, compaction scheme and whether the Data Object is locked.

11.5.4 Encoding Rules

The ID table and encoding rules for this Access-Method are defined in [Annex N](#), with the following annexes providing additional details:

- [Annex O](#) provides details of the structure of the Profile table.
- [Annex E](#) provides detailed rules for the data compaction schemes.
- [Annex F](#) provides details of the characters supported in each compaction scheme.
- [Annex P](#) provides an encoding example.

11.6 Multiple-Records

11.6.1 Structure

The Multiple-Records Access-Method is designed to enable an application to encode more than one record in the same memory area of the RFID tag. For precision, the term Logical Memory is used in this clause and associated annexes to define the bounds of the memory that is being addressed. Logical Memory can therefore be applied to the entire encoding space of a tag with a single addressable memory, to a partitioned memory such as an addressable memory bank, or to a memory that is partitioned into files.

The first edition of this document placed a restriction on having more than one instance of the same Relative-OID encoded in the same Logical Memory. The rules of the Multiple-Records Access-Method overcame this restriction, but also enables distinct records, which use the encoding rules of other Access-Methods, to be distinguished one from another. The records may be all the same type or of different types.

The basic structure is illustrated in [Figure 8](#).



Figure 8 — Basic structure for multiple records

The Access-Method = Multiple-Records has a three-part structure in the Logical Memory:

- A Multiple-Records header (hereafter MR-header) that is encoded from the lowest address in the memory. The MR-header shall be of a sufficient size to support the number of initial and future records.

- One or more individual records, where each record fully complies with one of the following Access-Methods: No-Directory, Packed-Objects, and Tag-Data-Profile. The constraint is that the Multiple-Records Access-Method shall not contain the directory Access-Method (1) or the Multiple-Records Access-Method (4) itself.

NOTE Future revisions to this document can have the capability to support additional yet-to-be defined Access-Methods of the individual records.

- The higher blocks contain the directory of all these records, as a series of directory entries, which may be added later. The directory entries are stored in reverse block sequence starting from the highest addressable (last) block, but each block is encoded from the lowest byte address to the highest byte address. This is like the ordering defined in 11.2 for the directory Access-Method. Structuring the directory in this reverse sequence of blocks leaves unused blocks available either to encode additional records or directory until there are too few blocks remaining to encode new data.

As additional records are added, they are encoded in the next available memory block higher than the end of the previous record. The directory entries are made in the next available memory block lower than the previous end of the directory.

11.6.2 Categories of multiple records

11.6.2.1 Homogeneous Multiple-Records

For this document, a homogeneous Multiple-Records encoding is one where all the records have the same Data-Format. This is illustrated schematically in Figure 9.

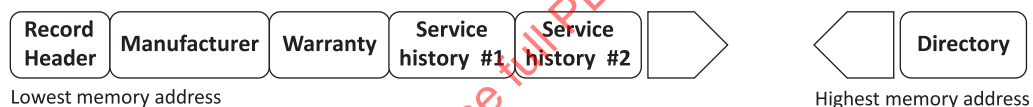


Figure 9 — Example of a homogeneous Multiple-Records encoding, with the same domain

Figure 8 illustrates a Logical Memory where data is associated with the same domain, but with the service history records being created by different individuals, even by different organisations, within the framework of that domain. This results in the same Data-Format for each record.

11.6.2.2 Heterogeneous Multiple-Records

For this document, a heterogeneous Multiple-Records encoding is one where at least two records have a different Data-Format. This is illustrated schematically in Figure 10.



Figure 10 — Example of a heterogeneous Multiple-Records encoding, with different domains

Figure 9 illustrates a Logical Memory where data is encoded by organisations from three different domains. This results in different Data-Formats for some of the records.

11.6.2.3 Hierarchical records

This is a subset of the Multiple-Records Access-Method where hierarchical levels of data are logically dependent across the levels in the hierarchy, using a parent-child link between the records. The top-level records in the hierarchy may be either homogeneous or heterogeneous, but all lower-level records shall use homogeneous encoding.

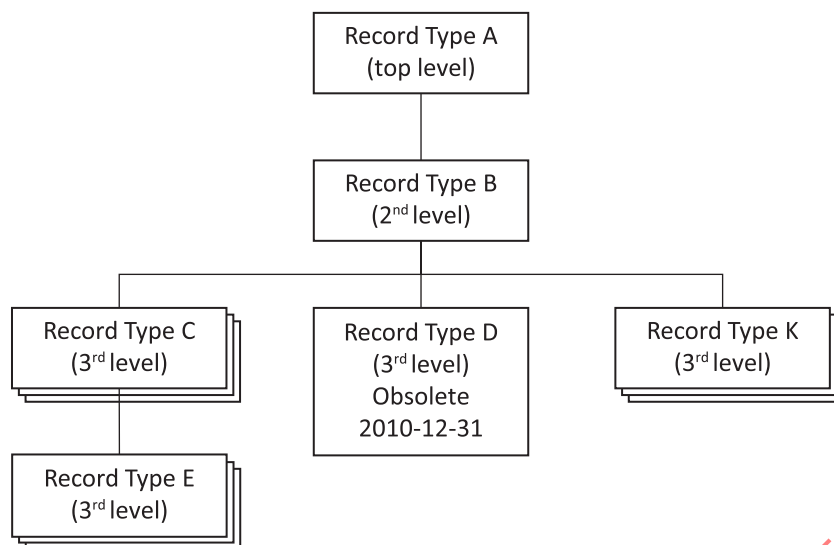


Figure 11 — Example of a hierarchy of records

The example in [Figure 11](#) illustrates a set of hierarchical records schematically and a suggested style for the overview to be presented in an application standard. A hierarchical structure may have any number of levels greater than 1. There can only be one instance of the top-level record type. This example shows a second level record where there is only one instance, simply to illustrate that it is possible, for example to have an order record below a shipping record. The third layer in the example shows three different record types that are possible below the second level and depending on the application some of these may be optional and not present in each hierarchical structure. The example shows that record types C and K can be included several times, but that record type D at this level can only occur once if included. The example shows that record type E is at the lowest (fourth) level and that each instance of record type C may in turn have only one instance of record type E (illustrated graphically by having no additional boxes).

The presence of record type K in the structure also illustrates that the application administrators may update the basic hierarchical structure by adding a completely new type of record at a later date. The reverse is also permitted (as illustrated with record type D), but such a record should be shown as "obsolete" on the hierarchical structure, because tags with the structure will still be in circulation after the final record of that type has been encoded.

This document places the following constraints and freedoms in structuring a hierarchical record structure:

- Each record shall have a different hierarchical record number.
- The top-level record shall have the lowest number in the set.
- There are no constraints on the sequence for adding lower level records.
- There are no constraints on the number of record types in a hierarchy, or the number of records of each type.
- Each record type in the hierarchy may comprise of mandatory and optional data elements.
- No relative-OID may be encoded more than once in a record.
- Records may be subsequently added to an existing hierarchy, but reference shall be made to its parent record.

The structuring rules for multiple records enable many different hierarchical structures to be developed in application standards. Application administrators should define permitted structures to provide useful information to those encoding and decoding the records. Because the parent-child link

is encoded, receiving systems can always reconstruct the intended without knowing the application standard, but knowledge of what records can establish such a relationship will ensure more efficient generation of commands and efficient responses.

11.6.2.4 Data element lists

A data element list contains a loop of several instances of the same single data element (e.g. the product codes of items in a container). Special encoding rules are used to enable what appears to be the encoding of multiple instances of the same Object-Identifier within the same record.

Having multiple instances of the same Relative-OID is not generally permitted in Access-Methods 0 to 3, but the mechanisms defined for a data element list enable this to be achieved.

EXAMPLE An airline container has 27 individual items of baggage. The data element has rules that enable each of these to be uniquely identified.

11.6.3 Object-Identifier structure

11.6.3.1 Use

To support the processing of Multiple-Records on the interrogator, an implementation of the Data Processor, or at the application layer, the Object-Identifier shall follow one of three standardised structures. This also ensures that older implementations that cannot support Multiple-Records can carry out some basic processing.

11.6.3.2 The non-hierarchical Multiple-Record

The full Object-Identifier for a non-hierarchical record is:

1.0.15961.401. "data format = dictionary"."sector identifier"."record type"."instance-of".
"Relative-OID of data element"

The arcs shown in bold text identify the root-OID. The following example describes the structure:

- The arc 401 identifies this as a Multiple-Record that is not part of a hierarchical structure.
- The arc for the data format = dictionary shall be the same as that for an existing registration for a Data-Format. For example, the arc =13 identifies the data dictionary for the mapping table for Data Identifiers.

NOTE This means that even if the registered data format has a root other than 1.0.15961 that the root defined in this clause applies for multiple records.

- The administrators of the data dictionary should assign a sector identifier to an administration that will define record types for a particular sector, e.g. a manufacturing sector using Data Identifiers. Further details are provided in [11.6.4](#).
- Thereafter, the sector administrators will be responsible for the assignment of a value for the arc for the record type for each defined record. The records shall be defined in a sector application standard, but do not need to be registered under ISO/IEC 15961-2 procedures.
- The instance-of arc is assigned by the user at the time that the record is created. Non-zero values indicate the encoding of the same record type (e.g. a maintenance record) at different points in time. A zero-value instance-of arc in the OID structure is used to mean that there can be only one instance of this record in the Logical Memory.
- The Relative-OID of the data element arc is identical to that of the data element in the data dictionary, e.g. when using Data-Format 13, Relative-OID = 16 = Data Identifier 1P (Item Identification Code assigned by Supplier).

11.6.3.3 Hierarchical Multiple-Record

The full Object-Identifier for a hierarchical record is:

1.0.15961.402."data format = dictionary"."sector identifier"."record type"."hierarchical id".
"Relative-OID of data element"

NOTE See [11.6.3.4](#) for the data element list, which is a subset of the hierarchical record structure.

The arcs shown in bold text identify the root-OID. The following example describes the structure:

- The arc 402 identifies this as a Multiple-Record that is part of a hierarchical record structure.
- The arc for the data format = dictionary is in conformity with the rules defined in [11.6.3.2](#) for data format = dictionary.
- The administrators of the data dictionary should assign a sector identifier to an administration that will define record types.
- Thereafter, the sector administrators will be responsible for assigning a value to the arc for the record type for each defined record. The records shall be defined in a sector application standard, but do not need to be registered under ISO/IEC 15961-2 procedures.
- In addition, the hierarchical parent-child relation as illustrated in [Figure 11](#) shall be defined in the application standard.
- The hierarchical identifier arc is assigned by the user at the time that the record is created. The value 0 shall not be used to avoid ambiguity with a non-hierarchical record that has zero value instance-of arc.
- The value of the data element arc is in conformity with the rules defined in [11.6.3.2](#) for the Relative-OID of the data element.

11.6.3.4 The data element list

This is a hierarchical record that lists the same data element repeatedly. The full Object-Identifier for a data element list is:

1.0.15961.403."data format = dictionary"."sector identifier"."record type".
"hierarchical id"."Relative-OID of data element"."list element number"

The arcs shown in bold text identify the root-OID. The following example describes the structure:

- The arc 403 identifies this as a Multiple-Record that is a data element list and part of a hierarchical record structure.
- The arc for the data format = dictionary is in conformity with the rules defined in [11.6.3.2](#) for data format = dictionary.
- The administrators of the data dictionary should assign a sector identifier to an administration that will define record types.
- Thereafter, the sector administrators will be responsible for the assignment of a value for the arc for the record type for each defined record. The records shall be defined in a sector application standard, but do not need to be registered under ISO/IEC 15961-2 procedures.
- In addition, the hierarchical parent-child relation as illustrated in [Figure 11](#) shall be defined in the application standard.

- The hierarchical identifier arc is assigned by the user at the time that the record is created. The value 0 shall not be used to avoid ambiguity with a non-hierarchical record that has zero value instance-of arc.
- The value of the data element arc is in conformity with the rules defined in [11.6.3.2](#) for the Relative-OID of the data element.
- The list element number is a sequentially assigned number to each data element encoded in the record.

11.6.4 Sector identifier

Three sector identifiers have specific meanings. The sector identifier = 0 is not used in the Object-Identifier structure because it is used in the encoding of the MR-header to indicate that the true sector identifiers defined in each record.

A sector identifier with the value = 1 shall be used to declare that the record types are for a closed system application. The data elements shall be in conformance with the data dictionary.

A Sector identifier with the value = 2 shall be used in the following manner. Many data dictionaries have one or more primary keys identified by Relative-OID value(s). Typically, such primary keys are encoded in the first position in a record, for example the Relative-OID = 19 in the Data Identifier data dictionary is for a CLEI code for telecommunications equipment. Other data elements are encoded that identify associated attributes of the CLEI coded item. To signal that the record contains a particular primary key data element, the record type following sector identifier= 2 shall have the same value as the first data element of the record, i.e. the same value as the record's primary key, so, in the example, the following full Object-Identifier identifies that the CLEI code is the primary key:

1.0.15961.402. "data dictionary"."sector identifier = 2"."record type =19".

Therefore, the administrators of the data dictionary shall assign sector identifiers incrementally starting with the value 3.

11.6.5 Restrictions to air interfaces

This Access-Method may be applied to any tag that has sufficient memory to support what is likely to be a larger requirement for encoding capacity. Specific additional constraints apply to tags with segmented memory. For the Type C tags, the Multiple-Records Access-Method shall only be applied to Memory Bank 11₂. For the Type D tag, this Access-Method shall only be applied to the item-related data segment.

11.6.6 Encoding rules

The details of Multiple-Records defined in the following annexes:

- [Annex Q](#) defines all the basic rules for homogeneous or heterogeneous Multiple-Records encoding.
- [Annex R](#) defines the additional rules for hierarchical records.
- An example of the encoding with a directory is provided in [Annex S](#).

12 ISO/IEC 15434 direct encoding and transmission method using Access-Method 0 and Data-Format 3

12.1 Use

The ISO/IEC 15434 direct encoding and transmission method is designed to support the encodation and transmission of a complete ISO/IEC 15434 message in a compatible manner with similar messages

in 2-D bar code symbols. This enables ISO/IEC 15434 messages to be used independently of the data carrier technology being selected.

Developers of application standards shall be aware this method requires the entire message to be read and parsed to extract a particular data element. There are alternative encoding schemes supported by the document that support the encoding of individual data elements defined with an Object-Identifier that enable selective reading and writing between the application and the RFID tag.

12.2 General rules for ISO/IEC 15434 direct encoding

ISO/IEC 15434 specifies a syntax for high-capacity ADC media for a message envelope consisting of:

- a message header,
- one or more format envelope(s),
- a message trailer (when required).

Each format envelope within the message envelope consists of:

- a format header,
- data, formatted according to the rules defined for that format,
- a format trailer (when required).

An ISO/IEC 15434 message always starts with the following four-character string for the message header:

[] > ^{Rs}

The direct encoding method has rules to simplify the encoding, often enabling a specific 6-bit compaction scheme to be used. This code set includes the ISO/IEC 15434 control characters <RS>, <GS>, and <EOT>. Also encoding "shorthand" techniques are employed, for example to eliminate the need to encode the message header, yet still re-create this on the output transmission from the decoder.

[Annex T](#) defines the detailed encoding rules for ISO/IEC 15434 direct encoding and transmission method using Access-Method 0 and Data-Format 3.

12.3 Specific support for ISO 17364, ISO 17365, ISO 17366 and ISO 17367

The character set and encoding rules for ISO 17364, ISO 17365, ISO 17366 and ISO 17367 applications are a subset of the general rules for ISO/IEC 15434 direct encoding. As a result, the same encoder and decoder processes are used.

Annex U describes ISO/IEC 15434 direct DI encoding and Transmission for ISO 17364, ISO 17365, ISO 17366 and ISO 17367.

13 Monomorphic-UII encoding

13.1 Use

The Monomorphic-UII encoding scheme is designed to achieve a simple encoding of a Unique Item Identifier when encoded in a memory area dedicated to this function, and where no additional data is encoded in the same memory area. All the features can be self-declaring through the registration of the particular AFI code values according to ISO/IEC 15961-2. The following conditions apply:

- An AFI assigned to a particular Monomorphic-UII shall not support the encoding of any additional item-related data. If item-related data is required for the application, then this shall use an entirely different AFI and Data-Format.

- The Monomorphic-UII is therefore only capable of being encoded in a tag memory architecture that supports the separate encoding of a UII or as a single data object in a monolithic structured memory tag.
- The AFI fully defines all the arcs of the Object-Identifier for communications in the commands of ISO/IEC 15961-1 and in the ISO/IEC 24791 series.
- The Monomorphic-UII does not require the encoding of a DSFID.

Each AFI shall declare which of the encoding schemes, as defined in the following subclauses, is used. In addition, the registration of the AFI in conformity with ISO/IEC 15961-2 shall define all the necessary additional parameters, including: The Object-identifier for the UII, whether the UII is fixed length or variable length, and the length in bytes. If the tag architecture does not support a method of declaring the length of the encoded UII then the fact that this is required as a preamble to the encoded UII shall be part of the registration.

13.2 6-bit encoding

If the AFI declares that 6-bit encoding is used for the particular UII, the character set shall be limited to characters 20_{16} to $5F_{16}$ as defined in [Annex F](#). The UII shall be encoded using the 6-bit encoding scheme as defined in [E.5](#).

If the tag architecture supports a method to declare the size of encoding of the UII memory, there is no requirement to encode any length indicator on the RFID tag, even if the UII may be of different lengths. If the tag architecture does not support a method to declare the size of encoding of the UII memory, then the compacted UII shall be preceded by a single byte indicating the length, in bytes, of the compacted UII.

The end of the encoding is defined by the 6-bit encoding rules, with one minor variation. If the tag architecture supports an encoding unit of more than an 8-bit byte (e.g. Type C uses a 16-bit word) then of the pad string "100000" is repeated as necessary in full and then truncated to fill the encoding space. Using the example of encoding on a 16-bit word structure, the following are the eight end conditions:

- Exactly on the boundary – no action
- Requiring two pad bits – encode 10_2
- Requiring four pad bits – encode 1000_2
- Requiring six pad bits – encode 100000_2
- Requiring eight pad bits – encode 10000010_2
- Requiring ten pad bits – encode 1000001000_2
- Requiring twelve pad bits – encode 100000100000_2
- Requiring fourteen pad bits – encode 10000010000010_2

The decoding rules as defined in [E.5](#) apply so that if pad strings " 10_2 ", " 1000_2 " or " 100000_2 " are present at the end of the encoded bit string, they are discarded. For a Monomorphic-UII there can be repeated patterns, as shown above, that need to be discarded.

13.3 7-bit encoding

If the AFI declares that 7-bit encoding is used for the particular UII, the character set shall be limited to characters 20_{16} to $7E_{16}$ as defined in [Annex F](#). The UII shall be encoded using the 7-bit encoding scheme as defined in [E.6](#).

If the tag architecture supports a method to declare the size of encoding of the UII memory, there is no requirement to encode any length indicator on the RFID tag, even if the UII may be of different lengths.

If the tag architecture does not support a method to declare the size of encoding of the UII memory, then the compacted UII shall be preceded by a single byte indicating the length, in bytes, of the compacted UII.

The end of the ending is defined by the 7-bit encoding rules, with as many 1 bit as necessary to complete the encoding space. For example, if a 16-bit encoding structure is being used and only the first bit of the final word is part of the encoding, this shall be followed by the bit string "11111111111111₂". During the decode process this will be identified as two complete pad characters followed by a single 1 bit. All of which are discarded.

13.4 URN Code 40 encoding

This encoding is designed to support the encoding of a hierarchical URN with the appropriate separators being the hierarchical components. Therefore, when the URN is decoded from the RFID tag it is presented in a structure that is compatible with that required for resolving on the Internet.

If the AFI declares that URN Code 40 encoding is used for the particular UII, the character set shall be as defined in [Annex V](#), including any required UTF-8 character codes. The UII shall be encoded using the URN Code 40 encoding defined in [Annex V](#).

13.5 8859-1 octet encoding

If the AFI declares that 8-bit encoding is used for the UII, the character set shall be any ISO/IEC 8859-1 character, including control characters, in the range 00₁₆ to FF₁₆.

If the tag architecture supports a method to declare the size of encoding of the UII memory, there is no requirement to encode any length indicator on the RFID tag, even if the UII may be of different lengths. Any additional bytes required to meet the air interface length (e.g. the length of a word) shall comprise the necessary number of bytes 00₁₆, the first of which is processed as a terminator.

If the tag architecture does not support a method to declare the size of encoding of the UII memory, then the compacted UII shall be preceded by a single byte indicating the length, in bytes, of the compacted UII.

13.6 Application-defined 8-bit coding

If 8-bit encoding is used, including any variable length 8-bit encodings (e.g. UTF-8) or any external compaction that is different from an ISO/IEC 8859-1 interpretation shall be declared as application-defined. In this case, the character set, encoding scheme and decoded interpretation are defined by the application and beyond the scope on this document.

NOTE The output from the decoder transfers the byte string and declares this as Application-Defined.

Annex A (informative)

Air interface support for application commands

A.1 Overview

As indicated in 8.5, different air interface protocols have different degrees of compatibility with individual application commands. Details are set out below for some of the air interface protocols. If an air interface protocol is not covered, then some of the remainder of this annex, in combination with the air interface protocol standard, can still be helpful to implementers developing solutions.

A.2 ISO/IEC 18000-3 Mode 1 support

ISO/IEC 18000-3 Mode 1 Rev 1 provides mandatory and optional commands (some of which are defined as requirements for RFID for Item Management) that support the application command as detailed in Table A.1.

Table A.1 — ISO/IEC 18000-3 Mode 1 support for application commands

Code	Application command name	Supported	Qualified support
1	Configure-AFI	YES	
2	Configure-DSFID	YES	
3	Inventory-Tags	YES	
5	Delete-Object	YES	
6	Modify-Object	YES	
8	Read-Object-Identifiers	YES	
10	Read-Logical-Memory-Map	YES	
12	Erase-Memory	YES	
13	Get-App-based-System-Info	YES	
17	Write-Objects	YES	
18	Read-Objects	YES	
19	Write-Objects-Segmented-Memory-Tag	NO	
20	Write-EPC-UII	NO	
21	Inventory-ISO-UIImemory	NO	
22	Inventory-EPC-UIImemory	NO	
23	Write-Password-Segmented-Memory-Tag	NO	
24	Read-Words-Segmented-Memory-Tag	NO	
25	Kill-Segmented-Memory-Tag	NO	
26	Delete-Packed-Object	YES	
27	Modify-Packed-Object-Structure	YES	
28	Write-Segments-6TypeD-Tag	NO	
29	Read-Segments-6TypeD-Tag	NO	
30	Write-Monomorphic-UII	YES	
31	Configure-Extended-DSFID	YES	

Table A.1 (continued)

Code	Application command name	Supported	Qualified support
32	Configure-Multiple-Records-Header	YES	
33	Read-Multiple-Records	YES	
34	Delete-Multiple-Record	YES	

[Table A.1](#) indicates that application commands are either supported, or not supported. Therefore, there is no requirement to create an additional interface mechanism to support the application commands that have "NO" in the supported column.

A.3 Type C support

A.3.1 Application commands

[Table A.2](#) lists whether an application command can be supported or not and identifies those that can be supported in a qualified manner. Details of this qualified support, or alternative solutions, are provided in the following subclauses.

Table A.2 — Type C support for application commands

Code	Command name	Supported	Qualified support
1	Configure-AFI	NO	YES
2	Configure-DSFID	NO	YES
3	Inventory-Tags	NO	YES
5	Delete-Object	YES	
6	Modify-Object	YES	
8	Read-Object-Identifiers	YES	
10	Read-Logical-Memory-Map	NO	YES
12	Erase-Memory	YES	
13	Get-App-based-System-Info	NO	YES
17	Write-Objects	NO	YES
18	Read-Objects	YES	
19	Write-Objects-Segmented-Memory-Tag	YES	
20	Write-EPC-UII	YES	
21	Inventory-ISO-UIImemory	YES	
22	Inventory-EPC-UIImemory	YES	
23	Write-Password-Segmented-Memory-Tag	YES	
24	Read-Words-Segmented-Memory-Tag	YES	
25	Kill-Segmented-Memory-Tag	YES	
26	Delete-Packed-Object	YES	
27	Modify-Packed-Object-Structure	YES	
28	Write-Segments-6TypeD-Tag	NO	
29	Read-Segments-6TypeD-Tag	NO	
30	Write-Monomorphic-UII	YES	
31	Configure-Extended-DSFID	YES	
32	Configure-Multiple-Records-Header	YES	
33	Read-Multiple-Records	YES	

Table A.2 (continued)

Code	Command name	Supported	Qualified support
34	Delete-Multiple-Record	YES	

A.3.2 Configure-AFI

The preferred means of encoding the AFI for this air interface is to use the Write-Objects-Segmented-Memory-Tag command, which incorporates the AFI as part of the sequence of bytes to be encoded in the RFID tag. This is because the AFI is a single byte, and the minimum communication across the Type C air interface is a 16-bit word. Invoking the Configure-AFI command on its own will require the 16-bit word in memory to be overwritten at some subsequent stage.

A.3.3 Configure-DSFID

The preferred means of encoding the DSFID for this air interface is to use the Write-Objects-Segmented-Memory-Tag command, which incorporates the DSFID as part of the sequence of bytes to be encoded in the RFID tag. This is because the DSFID is generally a single byte, and the minimum communication across the Type C air interface is a 16-bit word. Invoking the Configure-DSFID command on its own will require the 16-bit word in memory to be overwritten at some subsequent stage.

A.3.4 Inventory-Tags

The Inventory-Tags command is intended to return a unique Singulation-Id to enable ongoing communications with the RFID tag. For many air interface protocols, this is a permanently encoded code in a dedicated part of memory on the RFID tag. Type C uses different methods to maintain communication, a dynamically created value.

If there is a requirement to read the optional unique Singulation-Id encoded on a Type C tag, then the Read-Words-Segmented-Memory-Tag command may be used instead, with the Memory-Bank argument set = 10.

If the requirement is to read a unique item identifier, then the Inventory-ISO-UIImemory or Inventory-EPC-UIImemory command may be used, depending on the domain of the application. These commands return the content of the UII memory, which is required to be unique.

A.3.5 Read-Object-Identifiers

The Read-Object-Identifiers command returns a set of Object-Identifiers encoded on the RFID tag.

Because Type C does not support an air interface command to read the content of different memory banks simultaneously, one way to invoke this application command is to apply it only using the Memory-Bank argument = 11. If there is an additional requirement to read any Object-Identifier(S) from Memory Bank 01, then the Inventory-ISO-UIImemory command should be used.

A.3.6 Read-Logical-Memory-Map

The Read-Logical-Memory-Map command was designed to read the encoded bytes from a single flat file memory on an RFID tag, and not a segmented memory as used with Type C tags. The Read-Words-Segmented-Memory-Tag command should be used in preference, setting the selected Memory-Bank argument for which information is required.

A.3.7 Get-App-based-System-Info

The Get-App-based-System-Info command is primarily intended to support tags where there is a directly equivalent air interface command. The information that is returned is the AFI and DSFID. An alternative way to obtain this information (possibly with other data) is to use the Inventory-

ISO-UIImemory command to return the AFI and DSFID from memory bank = 01. The Read-Words-Segmented-Memory-Tag command can be used to read the DSFID for memory bank = 11.

NOTE No AFI code value is encoded in memory bank = 11.

A.3.8 Write-Objects

The Write-Objects command may be implemented with Type C if it is restricted to memory bank = 11. The Write-Objects-Segmented-Memory-Tag command should be used in preference because this contains all the relevant arguments needed to interface with a Type C tag.

If the Object-Lock argument (see [10.2.38](#)) is invoked for any data element, the implementation depends on the capability of the individual RFID tag, ranging for selective locking of part of memory bank 11 to only being able to lock a complete memory bank. The capability to lock data on a Type C tag is defined in [C.8.5](#).

The following rules apply to locking memory:

- a) If the tag is in conformance with Type C, locking is only allowed for the complete memory bank. Therefore, if the Write-Objects-Segmented-Memory-Tag command contains one or more object-lock arguments that are contradictory (i.e. some TRUE and some FALSE arguments), or if the command specifies a lock status that differs from the lock status of encoding on the memory bank, then the entire command shall be considered in error.
- b) If the tag is in conformance with a version of Type C then selective locking is an optional feature, which is declared by each tag model. There are sub-rules for encoding as follows in MB11:
 - 1) If the feature is supported, and the encoding is for MB11, then selective locking shall be applied as determined by the object-lock arguments for each data element.
 - 2) If the feature is not supported on the RFID tag for MB11, but locking is called for when only a single data element is to be encoded, or for all data elements in a consistent manner, then the entire memory bank shall be locked.
 - 3) If the feature is not supported on the RFID tag for MB11, and the object-lock arguments are inconsistent, then the entire command shall be considered in error.
- c) The selective locking feature is not supported for MB01, so the following rules apply:
 - 1) If a single data element is to be encoded in MB01, then the object-lock argument shall be applied to all of MB01.
 - 2) If multiple data elements are to be encoded and all have the same object-lock argument, then this shall be applied to all of MB01.
 - 3) If multiple data elements are to be encoded and these have different object-lock arguments the entire command shall be considered in error.

A.4 Type D support

A.4.1 Application commands

The support by Type D for the application commands is based on ISO/IEC 18000-64. This air interface differs from others in that it uses a modified tag-talks-first protocol. To avoid interference with other air interface protocols no forward link is specified in that standard. This means that any encoding of data shall be achieved using custom air interface commands, and in turn there are no application commands specified in this document for writing data to the tag. [Table A.3](#) lists whether an application command can be supported or not and identifies those that can be supported in a qualified manner. Details of this qualified support, or alternative solutions, are provided in the following subclauses.

Table A.3 — Type D support for application commands

Code	Command name	Supported	Qualified support
1	Configure-AFI	NO	
2	Configure-DSFID	NO	
3	Inventory-Tags	YES	
5	Delete-Object	NO ^a	
6	Modify-Object	NO ^a	
8	Read-Object-Identifiers	YES	
10	Read-Logical-Memory-Map	YES	
12	Erase-Memory	NO ^a	
13	Get-App-based-System-Info	NO	YES
17	Write-Objects	NO ^a	
18	Read-Objects	YES	
19	Write-Objects-Segmented-Memory-Tag	NO ^a	
20	Write EPC-UII	NO	
21	Inventory-ISO-UIImemory	YES	
22	Inventory-EPC-UIImemory	NO	
23	Write-Password-Segmented-Memory-Tag	NO	
24	Read-Words-Segmented-Memory-Tag	NO	
25	Kill-Segmented-Memory-Tag	NO	
26	Delete-Packed-Object	NO ^a	
27	Modify-Packed-Object-Structure	NO ^a	
28	Write-Segments-6TypeD-Tag	NO ^a	
29	Read-Segments-6TypeD-Tag	YES	
30	Write-Monomorphic-UII	NO ^a	
31	Configure-Extended-DSFID	NO ^a	
32	Configure-Multiple-Records-Header	NO ^a	
33	Read-Multiple-Records	YES	
34	Delete-Multiple-Record	NO ^a	

^a Commands 5, 6, 12, 17, 19, 26, 27, 28, 30, 31, 32 and 33 shall be supported by custom air interface commands provided by the vendors of Type D tags. These application commands may be used as a model for defining data to be encoded on a Type D tag. This is a realistic approach if the Type D air interface commands for the forward linked are modelled on the Type C forward link commands.

A.4.2 Configure-AFI

A customs method of encoding the AFI for this air interface is to base it on the Write-Objects-Segmented-Memory-Tag command, which incorporates the AFI as part of the sequence of bytes to be encoded in the RFID tag. This is because the AFI is a single byte, and the minimum communication across the Type D air interface is a 16-bit word. Invoking the Configure-AFI command on its own will require the 16-bit word in memory to be overwritten at some subsequent stage.

A.4.3 Configure-DSFID

A customs method of encoding the DSFID for this air interface is to base it on the Write-Objects-Segmented-Memory-Tag command, which incorporates the DSFID as part of the sequence of bytes to be encoded in the RFID tag. This is because the DSFID is generally a single byte, and the minimum communication across the Type D air interface is a 16-bit word. Invoking the Configure-DSFID command on its own will require the 16-bit word in memory to be overwritten at some subsequent stage.

A.4.4 Inventory-Tags

The Inventory-Tags command is intended to return a unique Singulation-Id (known as a TID-S and defined in [C.9.1](#)) to enable ongoing communications with the RFID tag or to determine a population of tags within the reading zone. The Type D unique Singulation-Id is always encoded from the first page of memory.

Because the Singulation-Id structure is pre-defined and based on the value of the lead byte, it is possible to carry out an inventory of Type D tags with any mixture of Singulation-Id structures.

A.4.5 Get-App-based-System-Info

The Get-App-based-System-Info command is primarily intended to support tags where there is a directly equivalent air interface command. The information that is returned is the AFI and DSFID. An alternative way to obtain this information (possibly with other data) is to use the Inventory-ISO-UIImemory command to return

the AFI and DSFID from the UII segment. The Read-Segments-6TypeD-Tag command can be used to read the DSFID from the item-related segment and the AFI and DSFID from the UII segment.

NOTE No AFI code value is encoded in the Item-related data segment.

A.4.6 Read-Segments-6TypeD-Tag

The Read-Segments-6TypeD-Tag command is used to subdivide the encoding from a Type D into its segments and further subdivisions. This is possible because the air interface protocol delivers the complete encoding from the tag in a single transaction.

As this command is currently only specific to this tag details are specified in [8.3.7](#).

Annex B (normative)

Pro forma description for the Tag Driver

B.1 General

This annex provides the structure for defining a Tag Driver description for a class of RFID tags in conformity with a mode of the ISO/IEC 18000 series. The details in [Annex C](#) provide more specific examples of the type of definition required.

B.2 Defining the Singulation-Id

The Singulation-Id is the device in the Data Protocol to link the RFID tag to the Logical Memory. [9.3.2](#) identifies some of the possible methods that can be invoked on the RFID tag, the air interface, or even using unique encoded data to achieve this.

The Tag Driver shall define the technique that the RFID tag uses to create the Singulation-Id.

B.3 System information — AFI

The AFI (see [9.3.5](#)) is a prime selection mechanism for specifying a relevant subset of RFID tags that could be in the operating area of the interrogator. Its coded value is one byte long and its value shall be defined by the application.

The Tag Driver shall define whether the RFID tags supports the AFI feature, not just as a provision for encoding the value, but also for it to be used as a selection tool. The Tag Driver shall also specify whether the code value, once encoded, can be locked and if this locking facility is mandatory or optional.

B.4 System information — DSFID

The DSFID (see [9.3.6](#)) incorporates the Access-Method to define the structure of the bytes on the RFID tag's Logical Memory Map and incorporates the Data-Format to define particular sets of encoded application data. It is a key to the Data Processor on how to organise selective transactions defined by the application commands and how to condense the Object-Identifiers during encoding and to expand it during decoding. The DSFID is one byte long and its value shall be defined by the application.

The Tag Driver shall define how the RFID tags support the DSFID feature, not just as a provision for encoding the value, but also for it to be used as an organisational tool, particularly for how the different Access-Methods are supported. The Tag Driver shall also specify whether the code value, once encoded, can be locked and if this locking facility is mandatory or optional.

An extension mechanism for the Data-Format is defined in [9.3.7](#) and a separate extension mechanism for the Access-Method and other tag functions is defined in [9.3.8](#). If these extension mechanisms are supported, they shall be encoded as defined for the individual Tag Drivers in [Annex C](#).

B.5 Memory-related parameters

B.5.1 Block size

The Tag Driver shall specify the size of a block in terms of number of bytes and the means of transferring this information to the Data Processor.

B.5.2 Locking feature

The Tag Driver shall specify whether any, all, or some of the blocks can be selectively locked to render it impossible (or at least extremely difficult) to change the encoded bytes in a block.

B.5.3 Number of blocks

The Tag Driver shall specify the number of blocks on the RFID tag and the means of transferring this information to the Data Processor.

B.5.4 Memory mapping

The Tag Driver shall specify:

- a) Whether the memory is structured as a single "flat" file or is organised in multiple, separately addressable, partitioned zones (or memory banks).
- b) The location within the memory (as defined in the ISO/IEC 18000 series) where the Logical Memory Map begins. This requires additional rules for addressing partitioned zones.
- c) The byte sequence in the block - the Data Protocol presumes Most Significant byte in the first position, so a different order can require a conversion process.
- d) The bit sequence in the byte - the Data Protocol presumes most significant bit in the first position, so a different ordering requires a conversion process.
- e) Any other structuring rules within the ISO/IEC 18000 series, definition of user memory (e.g. error correction bits or bytes) that impact on the structure of the Logical Memory Map.

NOTE If error correction consumes bit or byte capacity outside the block size defined for user data, then this can be ignored for the purposes of the Data Processor.

B.6 Support for commands

The way the application commands are presented in ISO/IEC 15961-1 is likely to be at a higher level than the coded commands communicated across the air interface. Each application command shall be supported in one of the following ways:

- a) Fully support (i.e. action) the functionality across the air interface.
- b) Fully support the functionality of some of the command arguments and responses but return appropriate error codes for those arguments not supported. For example, there is a possibility that a command argument of Object-Lock will not be supported by the RFID tag command calls; therefore, the appropriate Completion-Codes shall be used.
- c) Be unable to support the functionality of a complete application command, for example to modify or delete an Object-Identifier and Object on an RFID tag that is One Time Programmable (or that uses Write Once Read Many technology).

The Tag Driver shall identify in broad terms how the two levels of command (application command and RFID tag command) are linked. Precise coding rules are not required and are to be resolved at the implementation level.

NOTE [Annex A](#) provides an overview of the relevance of an application command to particular air interface protocols, but does not address the detail of air interface commands that are optional either in the RFID tag or the interrogator.

Annex C (normative)

ISO/IEC 18000 Series Tag Driver Descriptions

C.1 Tag Driver for ISO/IEC 18000-2: Parameters for air interface communications below 135 kHz

C.1.1 Defining the Singulation-Id

Tags are identified by a 64-bit Unique Identifier (UID). The UID is used during arbitration and for addressing each tag individually.

ISO/IEC 18000-2 supports commands that can ignore the UID, such that all tags in the ready state shall execute the command.

C.1.2 System information — AFI

The AFI represents the type of air interface application targeted by the Interrogator and is used to extract only those tags meeting the required selection criterion from all the tags present. The AFI may be programmed and locked by the respective commands. The AFI is coded on one byte.

The support of AFI by the tag is optional. If the AFI is not supported by the RFID tag and if the AFI flag is set in a command, the tag shall not respond whatever the AFI value is in the request.

If the AFI mechanism is supported by the tag, it shall respond when the AFI on the tag matches the AFI in the request; or if the command specifies AFI 00₁₆ irrespective of the AFI value on the tag. The tag shall also respond if the AFI flag is not set in the command.

C.1.3 System information — DSFID

The DSFID is supported in ISO/IEC 18000-2 through the DSFID mechanism. The DSFID is on one byte. DSFID is returned during the Inventory process. The DSFID can be programmed and locked by specific commands. If the tag does not support DSFID programming, the tag shall return DSFID = "00".

C.1.4 Memory-related parameters

The physical tag memory is divided into two logical sections. The first Logical Memory section contains the system data. The second Logical Memory section contains the user data and is referred to as the application memory.

The user data or application memory is organised in blocks of a fixed number of bytes. Up to 64 blocks can be addressed, starting from block 0. Block sizes can be 4, 8, 12 or 16 bytes. Each block may be locked independently of the others, using a bitwise one time programmable 64-bit field in the system data. Information on the number of blocks and the size of the blocks is returned by the Get System Information command.

C.1.5 Support for commands

Not all commands are mandatory. If a tag does not support a command, the tag shall answer with an error code as specified in ISO/IEC 18000-2. This allows the application and/or the interrogator to know that they cannot use the requested feature on this tag.

C.2 Tag Driver for Mode 1 of ISO/IEC 18000-3 — Parameters for air interface communications at 13,56 MHz

C.2.1 Defining the Singulation-Id

Each tag is identified uniquely by a Singulation-Id (also known as UID) on 64 bits. Each tag returns its Singulation-Id during the inventory process. The Singulation-Id can be further used to selectively address a tag. The Singulation-Id format is specified in ISO/IEC 18000-3 Mode 1.

C.2.2 System information — AFI

The AFI is supported in ISO/IEC 18000-3 Mode 1 through the AFI mechanism, which is a separate register in the tag memory. The AFI can be programmed and locked by specific commands. The Inventory process then uses it. The AFI is on 8 bits.

If the tag does not support AFI programming (see [C.2.5](#)), the RFID tag shall participate to the Inventory process as if it had received AFI = "00", meaning that the tag will always respond to an Inventory command, whatever the AFI value.

C.2.3 System information — DSFID

C.2.3.1 Mechanisms

The DSFID is an 8-bit code and is supported in ISO/IEC 18000-3 Mode 1 through one of these mechanisms:

- a) the DSFID air interface mechanism, which is a separate register in the tag memory (see [C.2.3.2](#)); or
- b) the DSFID encoding rule, which requires the DSFID to be encoded and read using general air interface write and read commands (see [C.2.3.3](#)).

C.2.3.2 The DSFID air interface mechanism

The DSFID is supported in some ISO/IEC 18000-3 Mode 1 RFID tags through the DSFID air interface mechanism, which is a separate register in the tag memory supported by specific commands. DSFID is returned during the Inventory process. The DSFID can be programmed and locked by specific commands.

If the tag does not support DSFID programming (see [C.2.3.3](#)), the tag shall return DSFID = "00" in response to the air interface Inventory command.

C.2.3.3 DSFID encoding rule

If the DSFID air interface mechanism is not available, then the DSFID shall be encoded as part of the encoded byte stream in the first byte of the user memory. Used in this way, the DSFID cannot be returned during the air interface inventory process and cannot be programmed and locked by specific air interface commands. The only way the DSFID can be locked is by locking the first block, but this has implications for locking of encoded data.

The manufacturer and models of tags supported by this mechanism are defined in the Standing Document, mentioned above.

C.2.3.4 Extensions mechanisms for the Data-Format, Access-Method and other tag functions

If the RFID tag supports the DSFID air interface mechanism, then all of the required extension bytes defined in [9.3.7](#) to [9.3.18](#) shall be encoded starting from the first byte of user memory and precede any encoded packets of data.

If the RFID tag supports the DSFID encoding rule, then all of the required extension bytes defined in 9.3.7 to 9.3.18 shall be encoded starting from the second byte of user memory and precede any encoded packets of data.

C.2.4 Memory-related parameters

The System Information is stored in a memory area that is logically distinct from the user memory and that can be accessed only by specific commands. Information on the number of blocks and the size of the blocks can be returned by the air interface Get System Information command.

The user memory is organised in blocks, starting at block 0. The Logical Memory mapping shall start at block 0. Bits and bytes ordering shall be the same.

ISO/IEC 18000-3 Mode 1 supports the selective locking of blocks. The hardware implementation is determined by the manufacturer of the chip.

C.2.5 Support for commands

Only two air interface commands are mandatory, the Inventory command and the Quiet command. All other commands are optional. Some tag products may therefore not have implemented them. If a tag does not support a command, the tag shall answer with an error code as specified in ISO/IEC 18000-3 Mode 1. This allows the application and/or the interrogator to know that they cannot use the requested feature on this tag.

ISO/IEC 18000-3 Rev 1 now includes a new class of air interface command status, indicating that a command is "required for item management". The details of this status are included in ISO/IEC 18000-3:2010, Annex G. Table C.1 provides a summary of the required commands.

Table C.1 — Required commands and their codes

Command code	ISO/IEC 18000-3 Mode 1 BasicType	Function	Item management requirement
"01"	Mandatory	Inventory	The AFI is a requirement in the command, and the DSFID is required as part of the response
"02"	Mandatory	Stay quiet	No change
"20"	Optional	Read single block	The interrogator shall support this command. The RFID tag shall support this command if the <i>Read multiple blocks</i> command is not supported
"21"	Optional	Write single block	The interrogator shall support this command. The RFID tag shall support this command if the <i>Write multiple blocks</i> command is not supported
"22"	Optional	Lock block	Required for the interrogator and for the RFID tag.
"23"	Optional	Read multiple blocks	The interrogator shall support this command. The RFID tag shall support this command if the <i>Read single block</i> command is not supported
"24"	Optional	Write multiple blocks	The interrogator shall support this command. The RFID tag shall support this command if the <i>Write single block</i> command is not supported
"25"	Optional	Select	This command shall be supported in interrogators and should be supported in tags
"26"	Optional	Reset to ready	This command shall be supported in interrogators and should be supported in tags
"27"	Optional	Write Afi	Required for the interrogator and for the RFID tag.
"28"	Optional	Lock Afi	Required for the interrogator and for the RFID tag.

Table C.1 (continued)

Command code	ISO/IEC 18000-3 Mode 1 BasicType	Function	Item management requirement
"29"	Optional	Write DSFID	Required for the interrogator and for the RFID tag.
"2A"	Optional	Lock DSFID	Required for the interrogator and for the RFID tag.
"2B"	Optional	Get system information	Required for the interrogator and for the RFID tag.
"2C"	Optional	Get multiple block security status	Required for the interrogator and for the RFID tag.

C.2.6 Performance optimisation

If the application and/or the interrogator plan to have a continuous sequence of commands with a given tag, they can use the Select command. The Select command is addressed to a specific tag and deselects all other tags. It contains the Singulation-Id of the tag to be selected. All further commands shall have their Select flag set, but do not contain the Singulation-Id, therefore saving transmission time. Individual commands with other Singulation-Ids can be sent to specific tags during the sequence. See ISO/IEC 18000-3 Mode 1 for details.

C.3 Tag Driver for Mode 2 of ISO/IEC 18000-3 — Parameters for air interface communications at 13,56 MHz

C.3.1 Defining the Singulation-Id

Each tag is identified uniquely by a Specific Identifier (SID). Each tag returns its SID during the Application Group Identifier command. Subsequent commands may include the SID to address a specific tag.

C.3.2 System information: AFI

The AFI is supported in ISO/IEC 18000-3 Mode 2 through the Application Group Identifier (GID) command. Tags will respond to valid commands if the GID in the command is equal to the GID stored in the tag memory. The tags will also respond if the GID in the command is set to FFFF₁₆.

C.3.3 System information — DSFID

The protocol describes Hardcode fields that provide a function like system information and include the DSFID. If requested by reader command the Hardcode fields are included in Tag replies. The protocol describes the Hardcode in virtual terms only. Thus, the Hardcode may be realised by mask or memory. If mask is chosen, the Hardcode is set at the chip design. If memory is chosen, the Hardcode is written using a special write to memory.

C.3.4 Memory-related parameters

The RFID tag memory is organised and addressed as 16-bit words. ISO/IEC 18000-3 Mode 2 supports tag types with varying block sizes, where a block is one or more 16-bit words. The total memory capacity is defined in words, so the number of blocks can be derived from this.

The user memory is addressed from Word 0 upwards. Read commands address the memory on word boundaries. Write commands address the memory on block boundaries. The protocol allows commands to address user memory using 8-bit address and 8-bit length or 16-bit address and 16-bit length.

The user memory may be locked by using a locked pointer. All memory addresses less than the value stored in the lock pointer are locked addresses. The lock pointer value can only be incremented. The lock pointer is updated using a special write command.

C.3.5 Support for commands

The RFID tag will respond to valid commands. No response is sent for an invalid command. Invalid commands include commands with invalid command types, invalid identifiers, invalid address ranges, attempts to write to locked memory or invalid CRCs.

Tags respond to valid read commands by providing the requested data. Tags respond to valid write commands by writing the data included in the command to the tag memory and then responding to the write command. The write response can include read data if requested by the write command (read/write command).

C.4 Tag Driver for ISO/IEC 18000-4 — Parameters for air interface communications at 2,45 GHz — Mode 1

C.4.1 Defining the Singulation-Id

Each tag is identified uniquely by a UID of 64 bits. Each tag returns its UID during the inventory process. The UID can be further used to address selectively a tag for subsequent transactions.

C.4.2 System information — AFI

The AFI is supported in ISO/IEC 18000-4 Mode 1 through the AFI mechanism. bytes 12 through 17 of tag system information are reserved for tag memory system information. byte 12 represents the Embedded Application Code (EAC) field. This information field defines the data architecture system represented in application memory (bytes 17 and above). The remaining five (5) bytes define the memory architecture and usage within the data architecture system defined in byte 12. If this byte is set to the value $0A_{16}$ the tag data architecture is in conformity with this document. The data field termed Application Family Identifier (AFI) is represented in the next byte (byte 13) of the reserved tag memory system information.

If the tag does not support AFI programming, the tag shall participate to the Inventory process as if it had received AFI = "00", meaning that the tag will always respond to an Inventory command, whatever the AFI value.

C.4.3 System information — DSFID

The DSFID is supported in ISO/IEC 18000-4 Mode 1 through the DSFID mechanism. The DSFID indicates how the application data is structured in the tag application memory. As defined in [C.4.2](#), bytes 12 through 17 are reserved in tag system memory for representation of tag memory system information. byte 12 with the value $0A_{16}$ defines a tag in conformity with this document. Byte 14 is designated to store the DSFID information. As this information can be stored in tag system memory, read (READ) and write (WRITE) commands may be used to program and retrieve this information.

If the tag does not support DSFID programming, the tag shall return DSFID = "00".

C.4.4 Memory-related parameters

The first 18 bytes (bytes 0 through 17) are reserved for system information. The Identification process provides information about the tag from reserved memory locations. Upon tag segregation (the anti-collision process), the tag state is moved from the "Identify" state to the "Data Exchange" state with the retrieval of such relevant tag system information.

Bytes 12, 13, and 14 are as defined above. Bytes 10 and 11 are reserved for "Hardware Tag Type". This two-byte field provides information about the hardware (physical) tag, which includes the total number of blocks and block size (bytes per block).

The application memory (user data storage) begins in byte 18 (or the first addressable block after system data). This is treated as the first byte of block 0 of the Logical Memory map for user memory.

bits and bytes ordering shall be the same, i.e. the msb and MSB shall match in both the Logical Memory and in the tag memory.

As noted in the response to question three above, unique, and unambiguous addressing of all data transactions is provided through the Tag UID (bytes 0 through 7 of system memory). All data transactions are uniquely addressed with this mechanism. The submission provides ISO/IEC 18000-4 Mode 1 supports writing and locking of data with two commands: (WRITE) and (LOCK). These commands operate at the block level. The locking mechanism is physical (fusible link) and protects data from any change permanently. Once the data block is "locked" it cannot be "unlocked". All data that is locked cannot be changed through the air interface.

C.4.5 Support for commands

Not all ISO/IEC 18000-4 Mode 1 commands are mandatory. If a tag does not support a command, the tag shall answer with an error code as specified in ISO/IEC 18000-4 Mode 1. This allows the application and/or the interrogator to know that they cannot use the requested feature on this tag.

C.5 Tag Driver for ISO/IEC 18000-4 — Parameters for air interface communications at 2,45 GHz — Mode 2

C.5.1 General

This mode supports different user interfaces and the following subclauses are based on the implementation using the "real image" user interface.

C.5.2 Defining the Singulation-Id

Each tag is identified uniquely by a tag ID of 32 bits. The tag ID is used to address selectively a tag for subsequent transactions.

C.5.3 System information: AFI

ISO/IEC 18000-4 Mode 2 does not support the functionality of AFI. As the Mode does not support AFI programming, the tag shall participate in any application command that specifies AFI as if it had received AFI = "00", meaning that the tag will always respond to an AFI argument in an application command, whatever the AFI value.

C.5.4 System information: DSFID

ISO/IEC 18000-4 Mode 2 does not support the functionality of DSFID. This has the effect of reducing support for this document to:

- Access-Method = No-Directory;
- Data-Format = Full-Feature.

C.5.5 Memory-related parameters

The tag ID provides supplementary information about the size of the user memory. Blocks are always one byte in length, irrespective of the size of memory. Read or write functions address memory by using a 2-byte position that identifies the beginning of the required data string, and a single byte value to determine its length. The maximum length of the data string is 246 bytes.

C.5.6 Support for commands

ISO/IEC 18000-4 Mode 2 supports several commands including read and write. The response to the command includes specific error codes where the command cannot be executed.

C.6 Tag Driver for Type A — Parameters for air Interface Communications at 860 MHz to 960 MHz

C.6.1 Defining the Singulation-Id

Type A is a tag based on ISO/IEC 18000-61. Each tag is identified uniquely by a UID of 64 bits or an SUID of 40 bits. Each tag returns its UID (or SUID) during the inventory process. The UID/SUID can be further used to address selectively a tag for subsequent transactions.

C.6.2 System information — AFI

The AFI is supported in Type A tags through the AFI mechanism.

The AFI can be programmed and locked by specific commands. The Inventory process then uses these commands to retrieve the AFI data. The AFI is on 8 bits.

If the tag does not support AFI programming (see [C.6.5](#)), the tag shall participate to the Inventory process as if it had received AFI = "00", meaning that the tag will always respond to an Inventory command, whatever the AFI value.

C.6.3 System information — DSFID

The DSFID is supported in Type A tags through the DSFID mechanism.

The DSFID is returned during the Inventory process. The DSFID can be programmed and locked by specific commands. The DSFID is defined on 8 bits.

If the tag does not support DSFID programming (see [C.6.5](#)), the tag shall return DSFID = "00".

C.6.4 Memory-related parameters

The System Information is stored in a memory area that is logically distinct from the user memory and that can be accessed only by specific commands. Information on the number of blocks and the size of the blocks is returned by the Get System Information command.

The Logical Memory mapping for user memory shall start at block 0. Bits and bytes ordering shall be the same.

C.6.5 Support for commands

Type A provides for both mandatory and optional commands. Mandatory commands provide the minimum functionality for activation and identification (e.g. inventory) of conformant tags in a population. All other commands (reading and writing) are optional. Some tag products may therefore not have implemented them. If a tag does not support a command, the tag shall answer with an error code as specified in Type A. This allows the application and/or the interrogator to know that they cannot use the requested feature on this tag.

C.6.6 Performance optimisation

If the application and/or the interrogator requires a continuous dialogue with a specific tag, Type A provides a mechanism for "selection" through the command set. The Select command is addressed to a specific tag and deselects all other tags. It contains the UID of the tag to be selected. All further commands shall have their Select flag set, but do not contain the tag UID, therefore saving transmission time. Individual commands with other UIDs can be sent to specific tags during the sequence.

C.7 Tag Driver for Type B — Parameters for air Interface Communications at 860 MHz to 960 MHz

C.7.1 Defining the Singulation-Id

Type B is a tag based on ISO/IEC 18000-62. Each tag is identified uniquely by a UID of 64 bits. Each tag returns its UID during the inventory process. The UID can be further used to address selectively a tag for subsequent transactions.

C.7.2 System information — AFI

The AFI is supported in Type B tags through the AFI mechanism.

Bytes 12 through 17 of tag system information are reserved for tag memory system information. Byte 12 represents the Embedded Application Code (EAC) field. This information field defines the data architecture system represented in application memory (bytes 17 and above). The remaining five (5) bytes define the memory architecture and usage within the data architecture system defined in byte 12. If this byte is set to the value $0A_{16}$ the tag data architecture is in conformity with this document. The data field termed Application Family Identifier (AFI) is represented in the next byte (byte 13) of the reserved tag memory system information.

If the tag does not support AFI programming (see [C.7.5](#)), the tag shall participate to the Inventory process as if it had received AFI = "00", i.e. the tag will always respond to an Inventory command, whatever the AFI value.

C.7.3 System information — DSFID

The DSFID is supported in Type B tags through the DSFID mechanism.

The DSFID indicates how the application data is structured in the tag application memory. As defined in [C.7.2](#), bytes 12 through 17 are reserved in tag system memory for representation of tag memory system information. byte 12 with the value $0A_{16}$ defines a tag in conformity with this document. Byte 14 is designated to store the DSFID information. As this information can be stored in tag system memory, read (READ) and write (WRITE) commands may be used to program and retrieve this information.

If the tag does not support DSFID programming (see [C.7.5](#)), the tag shall return DSFID = "00".

C.7.4 Memory-related parameters

The first 18 bytes (bytes 0 through 17) are reserved for system information. The Identification process provides information about the tag from reserved memory locations. Upon tag segregation (the anti-collision process), the tag state is moved from the "Identify" state to the "Data Exchange" state with the retrieval of such relevant tag system information.

Bytes 12, 13, and 14 are as defined above. Bytes 10 and 11 are reserved for "Hardware Tag Type". This two-byte field provides information about the hardware (physical) tag, which includes the total number of blocks and block size (bytes per block).

The application memory (user data storage) begins in byte 18 (or the first addressable block after system data). This is treated as the first byte of block 0 of the Logical Memory map for user memory. Bits and bytes ordering shall be the same.

C.7.5 Support for commands

Type B provides for both mandatory and optional commands. Mandatory commands provide the minimum functionality for activation and identification (e.g. inventory) of conformant tags in a population. All other commands (reading and writing) are optional. Some tag products may therefore not have implemented them. If a tag does not support a command, the tag shall answer with an error code as specified in Type B. This allows the application and/or the interrogator to know that they cannot use the requested feature on this tag.

C.7.6 Performance optimisation

If the application and/or the interrogator requires a continuous dialogue with a specific tag, Type B provides a mechanism for "selection" through the command set. The group selection commands (GROUP_SELECT_XX) provide an efficient means to logically query the contents of either system memory (e.g. UID, AFI, DSFID) or user memory as a means to for selecting a subset of tags for data transactions. Only the tags logically queried as TRUE based on the contents of the selected memory (system and/or user) would thus be activated and participate in subsequent data transactions.

C.8 Tag Driver for Type C — Parameters for air Interface Communications at 860 MHz to 960 MHz

C.8.1 Defining the Singulation-Id

Type C is a tag based on ISO/IEC 18000-63. Each RFID tag is defined uniquely by a dynamic 16-bit code, the RN-16. The value of the RN-16 is returned during selection processes and is used to maintain communications with the RFID tag while in the operating field. In addition, access to Memory Bank 01 returns a Unique Item Identifier, which does provide a unique identifier at the application level.

C.8.2 System information — AFI

The AFI is supported in Type C as an optional element in the protocol control word in Memory Bank 01. The AFI is encoded in bits 18_{16} to $1F_{16}$. To identify that the encoding of the tag is in conformance with AFI and DSFID rules, bit 17_{16} shall have the value = 1, to distinguish this from encoding in conformity with the TDS EPC scheme.

The AFI only requires to be encoded in Memory Bank 01 to fulfil its function with the RFID tag selection process.

C.8.3 System information — DSFID

C.8.3.1 General

The DSFID is supported in Type C tag in the manner described in the following subclauses, which may be implemented independently.

C.8.3.2 DSFID in Memory Bank 01

A DSFID is used in Memory Bank 01 when this is called for by an AFI. In this case, Memory Bank 01 shall encode the DSFID in position 20_{16} to 27_{16} . The encoding that follows shall be in conformity with this document for encoding a UII based on an Object-Identifier structure.

When the AFI declares a Monomorphic-UII, the DSFID shall not be encoded in Memory Bank 01.

C.8.3.3 DSFID in Memory Bank 11

If Memory Bank 11 is present on the Type C tag and encodes data based on Object-Identifier structures, then the DSFID shall be encoded in the first byte position of this memory bank (i.e. bits 00_{16} to 07_{16}).

C.8.3.4 Extensions mechanisms for the Data-Format, Access-Method and other tag functions

If any of the extension mechanisms defined in [9.3.7](#) to [9.3.18](#) are required, then all of the extension bytes shall be encoded starting immediately after the encoded DSFID. All the extension bytes shall precede any encoded packets of data.

C.8.4 Memory-related parameters

The memory of a Type C tag is organised into four logical sectors known as Memory Bank 00₂, 01₂, 10₂, 11₂. All read and write processes are based on transactions in multiples of 16-bit words.

Memory Bank 00₂ contains passwords that are used to provide permission to access other memory, and to carry out the kill function.

Memory Bank 01₂ contains the Unique Item Identifier, either this is a GS1 specified number or an ISO specified number. Processes on the RFID tag calculate the length of the encoding. This length (in words) encoded in bits 00₁₆ to 04₁₆, which is part of the Protocol Control word.

Memory Bank 10₂ contains tag identification details, which may be based on a code structure managed by TDS, or a Unique Tag ID in conformity with ISO/IEC 15693. There is no simple way to determine whether a tag uses one of the code structures or the other without reading this Memory Bank.

Memory Bank 11₂ contains the encoding of application data beyond the basic Unique Item Identifier and the encoding capacity of Memory Bank 01₂. There are no air interface rules to determine the size of this memory (i.e. the equivalent of the number of words or blocks), without an understanding of the IC manufacturer's specification or looking up information based on the encoded values in Memory Bank 10₂.

C.8.5 Memory locking

If the tag is in conformance with Type C, locking is only allowed for the complete memory bank for MBs other than MB11. Selective locking of MB11 is an optional feature which is declared by each tag model.

NOTE There are no currently defined rules in the air interface protocol to identify whether a particular RFID supports selective locking to the rules defined above. Until such rules are defined this remains as a vendor specific solution for the RFID tag to declare its capability and a vendor specific solution for interrogator manufacturers to implement.

C.8.6 Support for commands

Type C supports several commands including read and write. Some commands and associated functions are optional. The response to any command includes specific error codes where the command could not be executed.

C.9 Tag Driver for Type D — Parameters for air Interface Communications at 860 MHz to 960 MHz

C.9.1 Defining the Singulation-Id

Type D is a tag based on ISO/IEC 18000-64. Each tag is identified uniquely by a Singulation-Id (also known as TID-S), which can have one of three lengths. The Singulation-Id format is specified in Type D. The TID-S is in conformity with ISO/IEC 15963-1 and can therefore begin with one of the following byte values and having a pre-defined length:

- E0₁₆, with a total length of 64 bits;
- E2₁₆, with a total length of up to 192 bits;
- E3₁₆, with a total length of 96 bits.

Each structure has an internal rule that enables the total length of the TID-S to be self-declaring. Each scheme also supports an IC manufacture plus model number that makes it possible to identify the functions supported by a particular tag.

Each tag returns its Singulation-Id during the tag communication process and is at the beginning of the transmitted message.

C.9.2 System information — AFI

Bit positions 63 to 48 of the first data page shall encode the Protocol Control word. The AFI is an element in the Protocol Control word in the UII segment of memory. The AFI is encoded in bits 55₁₀ to 48₁₀. To identify that the encoding of the tag is in conformance with AFI and DSFID rules, bit 56₁₀ shall have the value = 1, to distinguish this.

The AFI only requires to be encoded in the UII segment of memory to fulfil its function with the RFID tag selection process.

C.9.3 System information — DSFID

C.9.3.1 Support

The DSFID is supported in a Type D tag in the manner described in the following subclauses, which may be implemented independently.

C.9.3.2 DSFID in UII memory segment

C.9.3.2.1 DSFID when the AFI declares a Monomorphic-UII

When the AFI declares a Monomorphic-UII, the DSFID shall not be encoded in the UII memory segment.

C.9.3.2.2 DSFID for other AFI types

If the UII segment is in conformity with encoding rules defined in this document, then in addition to the AFI, the UII segment shall encode a single byte DSFID in position 47₁₀ to 40₁₀ of the UII segment, or a multiple byte DSFID starting at position 47₁₀. The encoding that follows shall be in conformity with this document for encoding a UII based on an Object-Identifier structure.

C.9.3.3 DSFID in the item-related data segment

If the item-related data segment is present on the Type D tag and encodes data based on Object-Identifier structures, then the DSFID shall be encoded in the second byte position of this memory bank. This position varies depending on the end point of the UII segment.

The preceding byte is the length-lock byte that in the leading five bits encodes the encoded length of the Item-related segment (in words) from the beginning of the length-lock byte to the end of the CRC. The trailing three bits provide an indication of the pages that are locked.

C.9.3.4 Extension mechanisms for the Data-Format, Access-Method and other tag functions

If any of the extension mechanisms defined in [9.3.7](#) to [9.3.18](#) are required, then all of the extension bytes shall be encoded starting immediately after the encoded DSFID. All the extension bytes shall precede any encoded packets of data.

C.9.4 Memory-related parameters

When used in conformity with this document, the memory of a Type D tag is organised into four logical sectors known as:

- The TID segment;
- the UII segment, which begins on the first data page of the Type D tag;
- the item-related data segment (optional);
- the simple sensor encoding segment (optional), always 64 bits if present.

All read and write processes are based on transactions in multiples of 16-bit words, organised in 64-bit pages.

C.9.5 Memory locking

C.9.5.1 General

Memory locking is applied in a consistent manner for any one Type D tag, with locking over 16-bits, 32-bits, or 64-bits as specified by the tag manufacturer.

NOTE There are no currently defined rules in the air interface protocol to identify whether a particular RFID supports selective locking to the rules defined above. Until such rules are defined this remains as a vendor specific solution for the RFID tag to declare its capability and a vendor specific solution for interrogator manufacturers to implement.

C.9.5.2 Encoding and locking the UII segment

The UII segment begins immediately after the locked TID-S segment, and therefore begins on a 64-bit page boundary.

The UII segment may end on any 16-bit word unless there is an application requirement for it to be locked. If the UII segment requires locking and the UII does not end on a lock boundary, then pad lock bytes (value 00₁₆) are included until the end of the lock boundary.

C.9.5.3 Encoding and locking the item-related data segment

The optional item-related data segment is encoded if the Protocol Control word bit 5810 is set = 1. This segment begins immediately after the end of the UII segment, and therefore begins on a 16-bit word boundary, which does not have to be on a page boundary.

The first byte (bit positions n to "n-7" of the item-related data segment) is the length-lock indicator, which provides precise information about the number of words in the segment and basic information on whether pages in the segment are locked.

The second byte (bit positions "n-8" to "n-15" of the item-related data segment) is the DSFID for this segment, which may be different from the DSFID of the UII segment.

The item-related data is encoded from bit "n-16" of the item-related data segment until the end of the segment, using the rules of this document. Datasets within the encoded sequence may be selectively locked. Any dataset, or contiguous datasets that are to be locked, shall be on lock boundaries.

C.9.6 Support for commands

Type D communicates its data payload without the need for air interface commands. As currently specified, there are no encoding commands defined. Therefore, encoding is achieved in a vendor specific manner across the air interface, but which need to support the encoding as defined by the functional write commands as described in [A.4](#).

Annex D (normative)

Encoding rules for No-Directory Access-Method

D.1 General

This annex, and associated referenced annexes, specifies the encoding rules for the Access-Method No-Directory, which is the basic encoding scheme for this document. The process described in the following subclauses builds up the structure of a dataset in a logical process starting with: compacting the Object, encoding the length of the compacted Object, processing the Object-Identifier, formatting this into a Relative-OID wherever possible, encoding the length of the Object-Identifier or the Relative-OID, and encoding the Precursor and Offset byte (if required).

D.2 Object processing

D.2.1 Use

Data compaction is applied as a transformation to the data Objects to reduce the number of bits that are transferred across the air interface and that are required to encode data in memory. The compaction shall be done according to the Compact-Parameter (defined in [10.2.9](#)) received in the ISO/IEC 15961-1 application commands. Only Compact-Parameters 0, 1, 2 apply to the encoding of this Access-Method, and Compact-Parameters 0, 2, and 15 apply to the decoding.

The interpretation of the source data Objects (e.g. conforming to character sets) can be ignored by the interrogator and while encoded on the RFID tag. This is because the decode process is the inverse of the encode process, and the compacted data Objects are restructured to their original forms when the tag is read.

Data compaction performs all the processes necessary to compact a data Object and to determine the Compaction Type, which is encoded on the RFID tag as part of the Precursor. The Object-Identifier remains unchanged and is not subject to any form of compaction, to enable it to be directly identifiable by the application and the Logical Memory. The command argument Object-Lock remains unchanged and is passed through to the next stage of processing: data formatting.

D.2.2 Compaction process

The command argument Compact-Parameter determines whether the Object is subject to the compaction process or not, based on the following integer values:

- 0 Application-Defined: The data object is read by and passed through the data compaction process without any compaction being applied but is assigned the Compaction Type Code 000₂.
- 1 Compact: The data object is read by and passed through the data compaction process to be compacted as efficiently as possible and assigned the appropriate Compaction Type Code in the range 001₂ to 110₂.
- 2 UTF8-Data: The data object is read by and passed through the data compaction process without any compaction being applied, but is assigned the Compaction Type Code 111₂ to indicate that it is in conformity with the UTF-8 transformation of ISO/IEC 10646.

The Object is read by and passed through the data compaction process:

1. The data Object itself is transformed to its compacted form. If the command argument Compact-Parameter:

is set to 1 (Compact) the data Object input string is compacted (see [D.2.3](#) and [Annex E](#) for the detailed processes).

is set to 0 (Application-Defined), or to 2 (UTF8-Data) the input string is not compacted but the data Object is still processed through step 2 and step 3.

2. The 3-bit Compaction Type Code is assigned (see [D.2.4](#)).
3. The length of the compacted data Object is defined.

D.2.3 Compaction schemes

Data compaction shall be applied to each entire data Object. When compaction is requested by the Compact-Parameter, the selection of the particular data compaction scheme is determined by parsing the bytes in the data Object and analysing their values as defined in [Table D.1](#), which shows the Compaction Schemes in sequence of preferred application, starting with the most efficient. The compaction rules for all the compaction Schemes are defined in [Annex E](#).

Table D.1 — Determining the data compaction scheme

All bytes in the range (HEX)	Secondary conditions	Use compaction scheme	Refer to Annex
30 to 39	1. Leading byte(s) $\neq 30_{16}$ 2. Length of object > 1 byte 3. Length of object ≤ 19 bytes	integer	E.2
30 to 39	Length of object > 1 byte	numeric	E.3
41 to 5F	Length of object > 2 bytes	5-bit code	E.4
20 to 5F	Length of object > 3 bytes	6-bit code	E.5
00 to 7E	Length of object > 7 bytes	7-bit code	E.6
00 to FF	N/A	octet string	E.7

If the original character string is too short to satisfy the secondary condition for length, the octet string scheme shall be used. If the other secondary conditions for integer compaction cannot be met, then numeric compaction shall be used.

For illustration, the compaction types refer to character representations of ISO/IEC 646 (see [Annex F](#)) for values 00 to 7E. However, the compaction schemes apply to the string of byte values, irrespective of their interpretation. The precise interpretation is defined by the definition of the Object-Identifier given externally in the application.

D.2.4 Compaction Type codes

The codes for the Compaction Type are defined in [Table D.2](#). One of these is applied to the data Object after it has been through the data compaction process. On subsequent reading from the RFID tag, this is used to identify how the data object shall be de-compacted.

Table D.2 — Compaction Type codes

Code value		Name	Description
Decimal	Binary		
0	000	application defined	as presented by the application
1	001	integer	Integer

Table D.2 (continued)

Code value		Name	Description
Decimal	Binary		
2	010	numeric	Numeric String (from "0"..."9")
3	011	5-bit code	Uppercase alphabetic
4	100	6-bit code	Uppercase, numeric, etc.
5	101	7-bit code	ISO/IEC 646 character
6	110	octet string	unaltered 8-bit
7	111	UTF-8 string	External compaction of ISO/IEC 10646

D.3 Encoding the length of the compacted Object

The length of all Objects on output from the compaction process (including the Objects not intended for compaction, or not achieving a compacted state) shall be determined and encoded as follows:

1. If the length is between 0 and 127 bytes, the length is encoded in one byte with the lead bit = 0
0bbbbbbb
where bbbbbbb = length in bytes
2. If the length is between 128 and 16383 bytes, the length is encoded in two bytes as follows:
 - a. Set the first bit of the lead byte = 1 and the first bit of the second byte = 0.
1bbbbbbb 0bbbbbbb
 - b. Convert the length (in bytes) to its binary value.
 - c. Encode the value in the bits 7 to 1 of each byte of the length encoding.
3. If the length is between 16384 and 2097151, the length is encoded in three bytes as follows:
 - a. Set the first bit of the lead byte = 1 and the first bit of the last byte = 0 and the first bit of all intervening bytes = 1.
1bbbbbbb 1bbbbbbb 0bbbbbbb
 - b. Convert the length (in bytes) to its binary value.
 - c. Encode the value in the bits 7 to 1 of each byte of the length encoding.

NOTE Although probably an unrealistic requirement, the rule (in step 3.a) can be extended to cover any length.

D.4 Processing the Object-Identifier

D.4.1 Object-Identifier

The Object-Identifier in the application commands is in conformity with ISO/IEC 8824-1 and may be presented in a style in conformity with that standard (see 6.3.1) or as a Uniform Resource Name (see 6.3.3). It may also be presented in a truncated form as a Relative-OID, and this structure is discussed in D.5.

The Object-Identifier value is encoded as a series of byte-aligned values as follows:

1. The first two arcs of the registration tree are encoded as a single integer using the formula:
 $40f + s$
 where f is the value of the first arc;
 s is the value of the second arc.
2. The value "n" of each additional arc is encoded into a byte-aligned-bit-field. This is done as follows for values of "n":
 - a. For $n < 128$:
 the decimal value is converted to binary and encoded in a single byte; thus bit 8 is set to zero
 - b. For $128 \leq n < 16384$:
 the decimal value is converted to binary and subdivided into two 7-bit strings: bit 7 to bit 1, bit 14 to bit 8. Each of these new bit strings is encoded in a byte; with bit 8 of the first byte set to 1, bit 8 of the last byte set to 0.
 - c. For $n \geq 16384$:
 the decimal value is converted to binary and subdivided into 7-bit strings: bit 7 to bit 1, bit 14 to bit 8, bit 21 to bit 15, and so on. Each of these new bit strings is encoded in a byte; with bit 8 of the first byte set to 1, bit 8 of the last byte set to 0 and bit 8 of the intervening byte(s) set to 1. The example below shows the process.

EXAMPLE

1. Value = $91234_{10} = 1_2 01100100_2 01100010_2$
2. Split into 7-bit strings
 $0000101_2 1001000_2 1100010_2$
3. Add prefix bits 0 for last byte
 1 for preceding byte(s)
 $10000101_2 11001000_2 01100010_2$

Using this technique, the length of each component arc of the Object-Identifier is self-declaring. The first byte always defines the first two arcs. Each subsequent arc is defined by one byte if the lead bit of that byte is 0; and multiple bytes if the lead bit is 1, the group of bytes ends with the byte with its lead bit equal 0. The arc value is encoded in the sequence of 7-bit values.

EXAMPLE

$[00101000]_2$	$1[1111000]_2$	$0[1001010]_2$	$0[0000001]_2$
$(1 \times 40) + 0$	15434		1
1 0	15434		1

Although the number of arcs allows for an Object-Identifier of any length, this document limits the length of the encoded value to be no more than 127 bytes. This is a constraint placed to meet encoding requirements on the RFID tag and the structure of the Logical Memory.

The constraint is on the encoded length of the Object-Identifier and not the number of arcs. It should also be understood that an Object-Identifier encoded in 127 bytes is highly unlikely.

D.4.2 Encoding the Object-Identifier

The need to encode the full Object-Identifier is rare, because the formatting rules enable it to be truncated in most cases. In those situations where the Object-Identifier shall be encoded, then the structure, as described above, represents the bytes that shall be encoded.

The Object-Identifier is preceded by a length code as defined in [D.6](#).

D.4.3 The dataset structure when the Object-Identifier is encoded

In the situations where a full Object-Identifier shall be encoded, the dataset is structured as defined in [Table D.3](#), which clearly identifies that the length of the Object-Identifier shall be calculated and precede the encoded value of the Object-Identifier.

Table D.3 — Dataset structures for Object-Identifiers

Description	Structure of byte String for an encoded dataset						
Object-Identifier	Precursor	Length of Object-Identifier	Object-Identifier ~~	Length of data	Data ~~		
Object-Identifier with Offset	Precursor	Offset	Length of Object-Identifier	Object-Identifier	Length of data	Data ~~	Pad ~~
~~ indicates that this component typically can be multiple bytes. The number of pad bytes can be 0 to 254, depending on the block size and lock block alignment.							

D.5 Processing the Relative-OID

D.5.1 General

In some circumstances, a truncated form of the Object-Identifier, the Relative-OID, can be incorporated into application commands.

As the first arc(s) of the Object-Identifier is declared by some other means (e.g. the Data-Format), the remaining arcs that are presented shall be encoded according to the rules of Step 2 in the encoding rules defined in [D.4](#).

In some cases, the application will only provide the single final arc, and, for most practical examples, this is likely to be a value either less than 128 or less than 16384.

D.5.2 Formatting the Object-Identifier based on the Data-Format

The Data-Format provides a shorthand method to achieve efficient encoding of the Object-Identifier. This is done by the Data-Format declaring a specific common Root-OID that is used to truncate the full Object-Identifier into a Relative-OID. For encoding, the byte values representing the Root-OID are deleted from the beginning of the full Object-Identifier to create the Relative-OID. For decoding, the Root-OID is concatenated as a prefix to the Relative-OID to re-create an Object-Identifier in conformity with ISO/IEC 8824-1.

The processes described below are based on a typical write application command being processed by the Data Processor for encoding on an RFID tag. Where there are significant variants these are described.

A. If Data-Format = Not-Formatted (0), Closed-System (30), or Extension (31)

An error has occurred, and formatting is not possible.

B. If Data-Format = Full-Featured (1)

Each Object-Identifier shall be encoded as a full Object-Identifier, as defined in [D.4.2](#). If a Relative-OID is presented, the application command is in error and formatting is not possible

C. If Data-Format = Root-OID-Encoded (2)

1. Parse the set of Object-Identifier values to identify any common Root-OID that has at least two arcs. If the RFID tag already has an encoded Root-OID, establish whether this can be applied to the new Object-Identifiers. Once a common Root-OID has been identified, any other Object-Identifier value with a different root shall be encoded as a full Object-Identifier.
2. Create the common Root-OID if one is not already encoded on the RFID tag.
3. Strip out the common Root-OID from each Object-Identifier to create a Relative-OID from the remaining arcs.
4. If Steps 2 and 3 are not possible, an error has occurred, and formatting is not possible.
5. Each other Object-Identifier that cannot have the Root-OID stripped remains unchanged and is encoded as an Object-Identifier.

An example of the input as shown in [Annex G](#), subsequently processed with a Data-Format = Root-OID-Encoded is illustrated in [G.6.2](#).

D. If Data-Format = Any code value 3 to 29, as defined in the register of data constructs to the rules of ISO/IEC 15961-2, with some examples illustrated in [Table D.4](#).

Table D.4 — Example mappings of Data-Format to Root-OID

Data-Format	Application	common Root-OID	
3	ISO/IEC 15434	"1 0 15434"	"28 F8 4A ₁₆ "
4	ISO/IEC 6523	"1 0 6523"	"28 B2 7B ₁₆ "
5	ISO/IEC 15459	"1 0 15459"	"28 F8 63 ₁₆ "
6	Library-Loan-Items	"1 0 15961 8"	"28 FC 59 08 ₁₆ "
8	ISO15961-Combined	"1 0 15961"	"28 FC 59 ₁₆ "
10	Data-Identifier-Algorithm	"1 0 15961 10"	"28 FC 59 0A ₁₆ "
12	IATA-Baggage	"1 0 15961 12"	"28 FC 59 0C ₁₆ "

NOTE The example of the library items clearly indicates that there is no requirement for a one-to-one relationship between the Data-Format and the final arc of the Root-OID.

1. Parse the set of Object-Identifier values to identify the common Root-OID, as defined on the register of data constructs (with illustrated examples in [Table D.4](#)).
2. If Step 1 is not possible, an error has occurred, and formatting is not possible.
3. Strip out the common Root-OID from Step 1 from each Object-Identifier to create a Relative-OID from the remaining arcs.

NOTE The Root-OID is not encoded, but implied by the Data-Format.

4. Every other Object-Identifier that cannot have the Root-OID stripped remains unchanged and is encoded as an Object-Identifier.

An example of the input as shown in [Annex G](#), subsequently processed with a Data-format = Data-Identifier-Algorithm is illustrated in [G.6.3](#).

D.5.3 Encoding the Root-OID for Data-Format = Root-OID-Encoded (2)

A Root-OID up to 126 bytes long can be encoded. The value of the length is directly encoded in the Precursor (see D.6.2), so the Root-OID immediately follows the Precursor. The value of the Root-OID is exactly as the byte string derived from process C defined in D.5.2. It shall be encoded at the start of the Logical Memory.

As the Root-OID has no associated data Object, the length of the data shall be set to zero.

D.5.4 Dataset structure when the Root-OID is encoded

In the situations where a Root-OID shall be encoded, the dataset is structured as defined in Table D.5. This identifies that a length value 00_{16} shall be encoded, to enable the beginning of the next dataset to be identified. If the Offset is required for block alignment, then the appropriate number of pad bytes shall be encoded.

Table D.5 — Dataset structures for Root-OID

Description	Structure of byte String for an encoded dataset						
Root-OID	Precursor	Length of Root-OID	Root-OID ~~	Length of data = 00_{16}			
Root-OID with Offset	Precursor	Offset	Length of Root-OID	Root-OID ~~	Length of data = 00_{16}	Pad ~~	
~~ indicates that this component typically can be multiple bytes.							
The number of pad bytes can be 0 to 254, depending on the block size and lock block alignment.							

D.5.5 Encoding the Relative-OID

D.5.5.1 Method

If the Relative-OID is provided by the application, then it is already in a form for encoding in the rules defined in this subclause. If the application provides the full Object-Identifier, then the Relative-OID shall be derived using the truncation rules described in D.5.2.

The rules for encoding a Relative-OID depend on the number of arcs and the value of the final arc, as defined below.

D.5.5.2 Single arc Relative-OID value 1 to 14

The final byte of the Object-Identifier (representing the single arc value 1 to 14) transferred from the application interface has a value 01 to $0E_{16}$. This single arc value shall be encoded in bits 4 to 1 of the Precursor as defined in D.7. No additional bytes are encoded in the Logical Memory for this Object-Identifier value and its length.

D.5.5.3 Single arc Relative-OID value 15 to 127

The final arc of the Object-Identifier (representing the single arc value 15 to 127) transferred from the application interface has a value $0F$ to $7F_{16}$. The single arc shall be encoded in a single byte as follows:

$$0\text{bbbbbbb}_2$$

Where bbbbbbb = arc value -15

EXAMPLE

$$\begin{aligned}
 \text{RELATIVE-OID} &= 23 \\
 \text{bbbbbbb} &= 23 - 15 = 8 \\
 &= 00001000_2 \\
 &08_{16}
 \end{aligned}$$

No additional bytes are required to encode the length of the Relative-OID with this range of values.

D.5.5.4 Other Relative-OID values

Irrespective of the number of arcs and the value of those arcs, other Relative-OID values shall be encoded with the byte values presented in the application command or as derived from processing the Data-Format to strip off the Root-OID.

The Relative-OID is preceded by a length code as defined in [D.6](#).

D.5.6 The dataset structure when the Relative-OID is encoded

In the situations where a Relative-OID shall be encoded, the dataset is structured as defined in [Table D.6](#). This identifies that if the Relative-OID is other than a single arc with the value 1 to 127, then the length of the OID shall be calculated and precede the encoded value of the Relative-OID.

Table D.6 — Dataset structures for Relative-OIDs

Description	Structure of byte String for an encoded dataset						
Single Relative-OID 1 -14	Precursor	Length of data	Data ~~				
Single Relative-OID 1 -14 with Offset	Precursor	Offset	Length of data	Data ~~	Pad ~~		
Single Relative-OID 15 -127	Precursor	Relative-OID	Length of data	Data ~~			
Single Relative-OID 15 -127 with Offset	Precursor	Offset	Relative-OID	Length of data	Data ~~	Pad ~~	
Other Relative-OID	Precursor	Length of OID	OID ~~	Length of data	Data ~~		
Other Relative-OID with Offset	Precursor	Offset	Length of OID	OID ~~	Length of data	Data ~~	Pad ~~

~~ indicates that this component typically can be multiple bytes.

The number of pad bytes can be 0 to 254, depending on the block size and lock block alignment.

D.6 Encoding the length and Object-Identifier or Relative-OID

The process to encode the length of the Object-Identifier or Relative-OID is as follows:

1. Record the byte string that represents the Object-Identifier or Relative-OID value.
2. Count the number of bytes in the Object-Identifier or Relative-OID.
3. If the length is between 1 to 16 bytes, continue, otherwise go to step 4.
 - a. Assign 1 byte for length encoding.
 - b. Assign value 100 for bits 8 to 6 to act as an indicator.

- c. Encode the length (in bytes) of the Object-Identifier or Relative-OID in the remaining 5 bits:
length + 1 = bbbbb
- d. Encode the Object-Identifier or Relative-OID in the subsequent bytes.

NOTE This procedure allows a Relative-OID with a single arc value 0 (presented as 00₁₆) to be encoded.

4. If the length is between 17 to 126 bytes:

- a. Assign 2 bytes for length encoding.
- b. Assign value 101 for bits 8 to 6 of the first byte to act as an indicator.
- c. Encode the length (in bytes) in bits 7 to 1 of the second byte.

10100000 0bbbbbbb

- d. Encode the Object-Identifier or Relative-OID in the subsequent bytes.

EXAMPLE

RELATIVE-OID = "1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9"

From application = 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34
(29 bytes long) 35 36 37 38 39₁₆

Encoding = **A0 1D** 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32
33 34 35 36 37 38 39₁₆

The first two bytes define the length, but all the other bytes are as provided by the application command, or the process to strip off the Root-OID based on the Data-Format.

D.7 Precursor

D.7.1 Definition

The Precursor is a single metadata byte that is always the first byte of the dataset and provides information about:

- The Compaction Scheme applied to the encoded Object.
- The Object-Identifier.
- Whether any block alignment has been necessary (e.g. for locked data).

There are also some values of the Precursor that are used for different functions, as described in the subclauses below.

D.7.2 Precursor for Data-Format not equal to 2

The Precursor is a single byte that positioned at the beginning of each dataset. The structure of the Precursor is bit based from bit 8 to bit 1, as follows:

Bit 8: the offset and expansion bit
if bit 8 = 0 no offset is present

if bit 8 = 1 an additional byte follows as part of the Precursor

Bits 7 to 5: the Compaction Type Code (see [D.2.4](#))

Bits 4 to 1: used to directly encode some Relative-OID values

values 0001 to 1110₂ shall encode a Relative-OID that has only one arc and that arc has a value 1 to 14

value 1111 indicates that the Relative-OID, Object-Identifier or Root-OID is directly encoded in subsequent bytes

D.7.3 The Precursor for the Root-OID for Data-Format = 2

The Data-Format = Root-OID-Encoded (2) requires the Root-OID to be directly encoded. The Precursor for the Root-OID only shall be 1 byte that precedes the Root-OID; there is no associated compacted Object. This Precursor structure applies to the Root-OID being encoded in the directory and in the dataset area.

The structure of the Precursor is bit based from bit 8 to bit 1:

Bit 8: the offset and expansion bit

if bit 8 = 0 no offset is present

if bit 8 = 1 an additional byte follows as part of the Precursor

Bits 7 to 1: the length of the Root-OID (in bytes) between 1 to 126

bbbbbbb = length of the Root-OID

The Precursor for all other datasets in Logical Memory structures with Data-Format =2 shall be as defined in [D.7.2](#).

D.7.4 Precursor value 00₁₆ as a terminator

The Precursor with the value 00₁₆ acts as a terminator of the dataset list of No-Directory structure. It also acts as a terminator of the directory in a directory structure on the Logical Memory.

D.7.5 Precursor value 80₁₆ for the Null byte

The Precursor with the value 80₁₆ signals a Null byte that is inserted in a sequence of datasets when one has been modified or deleted.

In the case of the Modify command (see [8.4.3](#)), if the encoded length of the modified dataset is longer than the previously encoded dataset, there can be a requirement to re-organise all subsequent data on the RFID tag. An alternative solution is to encode the required number of Null bytes in the existing space and encode the modified dataset at the end of all existing datasets. This solution of using the Null byte, might not be possible in the situation where the modified dataset, placed at the end of the encoding, causes the encoding to overflow the memory capacity.

A similar option is available for the Delete command, which simply requires the deleted dataset to be overwritten with a series of Null bytes. The Null-byte should not be used as the last dataset, because this is consuming encoding capacity for no logical advantage.

During the decoding process, if the byte value 80₁₆ occurs as a valid Precursor, then all contiguously encoded bytes with the same value shall be ignored. The first byte that has a different value shall be processed as the Precursor of the next dataset.

D.8 Offset byte

The Offset byte is required if the block(s) containing the dataset shall be block aligned. This can be necessary because the dataset or an adjacent dataset is required to be locked.

The Offset byte shall encode the value of the number of pad bytes (byte value 80_{16}) required to follow the end of the Object to place the next Precursor or terminator at the beginning of the next block.

NOTE As the maximum block size is 256 bytes (see 9.3.3), and the Precursor plus offset require two bytes, the maximum value for the Offset is FE_{16} .

The Offset value 00_{16} is valid. It is used when the Offset itself provides the padding feature, i.e. when the dataset without the Offset is one byte short of reaching a block boundary.

The Offset value FF_{16} shall be used to indicate that the Offset is followed by a Precursor expansion byte (see D.9).

D.9 Precursor expansion byte

If the Offset byte has the value FF_{16} , it shall be followed by the Precursor expansion byte. At present, this only has a limited specification. Bit 7 to 1 are reserved for future expansion of the Precursor. Until this document is amended or revised, the Precursor expansion byte shall not be used.

When it is more fully specified, if bit 8 = 0, there is no Offset byte to follow. If bit 8 = 1, then an additional Offset byte shall follow and values 00 to FE_{16} shall be used to indicate the value of the Offset.

NOTE This subclause is included to show that the Precursor feature has scope for expansion if required in the future.

D.10 Decoding the Logical Memory

D.10.1 General

The following sub clauses provide advice and rules to decode components of the Logical Memory. The simpler decode functions that can easily be determined from the encoding rules are not covered.

D.10.2 Overall decode strategy

The DSFID is the prime key to decoding. Particular values determine whether a directory structure is used, which enables a three-stage search to be undertaken:

1. to read the entire directory.
2. to parse the directory to locate the address of the required dataset.
3. to read the dataset starting from that address.

In contrast, a No-Directory structure requires continual processing of the dataset area until the desired Object- Identifier is found.

The DSFID also provides information about the Root-OID, particularly whether this is implicitly or explicitly encoded.

The parsing process is continually looking forward, whether this is for reading the directory, the datasets in a No-Directory structure, or a particular dataset.

If the Object-Identifier is not required, the value for length of Object can be used to skip forward to the next Precursor. A similar, but slightly more complex process is possible to invoke to skip over the Object-Identifier. In this case, the first byte(s) of the encoded Object-Identifier shall be parsed to determine the length and type of Object-Identifier. These points are more fully described below.

D.10.3 Decoding the DSFID

The following DSFID values are in the format m, n where m = Access-Method (0-1) and n = Data-Format (0-31). This advice only applies to those values already assigned in this document and in ISO/IEC 15961.

The following values indicate structures and processes:

- 0,1 -- No-Directory, with each Object-Identifier presented in full.
- 0,2 -- No-Directory with an explicitly encoded Root-OID in the first logical position. All subsequent Relative-OID values are prefixed by the Root-OID when decoded. Full Object-Identifiers may appear in the encodation.
- 0,n (n = 3...287) -- No-Directory with the Root-OID defined by the Data-Format. All subsequent Relative-OID values are prefixed by the Root-OID when decoded. Full Object-Identifiers may appear in the encodation.
- 1,1 -- Directory with each Object-Identifier presented as in full in both the directory and the dataset area.
- 1,2 -- Directory with an explicitly encoded Root-OID in the first logical position of the directory and in the dataset area. All subsequent Relative-OID values are prefixed by the Root-OID when decoded. Full Object-Identifiers may appear in the encodation.
- 1,n (n = 3...287) -- Directory with the Root-OID defined by the DSFID. All subsequent Relative-OID values are prefixed by the Root-OID when decoded. Full Object-Identifiers may appear in the encodation.

These rules do not necessarily apply to different Access-Methods and the detailed specification of other Access-Methods should be used as the correct reference.

D.10.4 Decoding the Precursor

D.10.4.1 Precursor

The following bit-based structure applies to the Precursor, with three exceptions defined in the following sub clauses.

bits

- 8 If = 0 There is no expansion nor offset byte to follow.
 - If = 1 There is an expansion byte (see [D.9](#)) which may be followed by a second offset byte.
 - 7 to 5 Defines the Compaction Type Code (see [D.2.4](#)). Decompaaction is only required if the command calls for the particular Object to be returned.
 - 4 to 1 Values 0001 to 1110 represent the value of the single Relative-OID arc value 1 to 14. In this case, the Precursor is followed by the byte(s) defining the length of the Object. The Object-Identifier is treated as a Null field.
- Value 1111 indicates that the Precursor is followed by an encoded Object-Identifier (of any permitted type).

D.10.4.2 Terminator byte

If the Precursor has the value 00₁₆ it acts as a terminator to signal the end of the directory and/or the end of the encoding of the datasets.

D.10.4.3 Null-byte

If the Precursor has the value 80_{16} it signals that this and contiguous bytes with the same value have been used to deal with the encoding space following a delete or modify command. The first byte that has a different value shall be treated as the valid Precursor of the next dataset.

D.10.4.4 Precursor for the explicitly encoded Root-OID

If the DSFID is 0,2 the Precursor in the first logical byte position shall have the following structure:

bits

8 If = 0 There is no expansion nor offset byte to follow.

If = 1 There is an expansion byte (see [D.9](#)) which may be followed by a second offset byte.

7 to 1 Defines the length (in bytes) of the Root-OID.

If the DSFID is 1,2 the Precursor in the first logical byte position of the directory and of the dataset area shall have the structure as above.

D.10.5 Decoding the leading byte(s) of the encoded Object-Identifier

Generally, the encoding of the Object-Identifier immediately follows the Precursor. The only exceptions to this are when the Precursor itself encodes the Object-Identifier (i.e. as for a low value single arc Relative-OID), and where an offset byte is inserted after the Precursor.

The first byte(s) of the encoded Object-Identifier identify the type of Object-Identifier and the length, and sometimes the value of this, as defined below:

First byte value
(HEX)

00 to 70 This encodes the value of a Relative-OID that has a single arc. To calculate the value of the arc for the application interface add $0F_{16}$ to that in the Logical Memory.

This byte is followed by the byte(s) encoding the length of the encoded Object.

80 to 9F This encodes the length of a Relative-OID (see [D.6](#)) for lengths between 1 to 16 bytes. bits 5 to 1 encode this, and the length = $bbbbbb - 1$.

This byte is followed by the Relative-OID.

A0 This encodes the length of a Relative-OID using this lead byte and the next byte for lengths between 17 to 126 bytes. bits 7 to 1 of the second byte directly encode the length.

This pair of bytes is followed by the Relative-OID.

C0 to DF This encodes the length of an Object-Identifier for lengths between 1 to 32 bytes. bits 5 to 1 encode this; and the length = $bbbbbb - 1$.

This byte is followed by the Object-Identifier.

E0 This encodes the length of an Object-Identifier using this lead byte and the next byte for lengths between 33 to 127 bytes. bits 7 to 1 of the second byte directly encode the length.

This pair of bytes is followed by the Object-Identifier.

Annex E (normative)

Basic data compaction schemes

E.1 General

The basic data compaction schemes were first introduced in the 2004 version of this document for the No-Directory Access-Method. They are also called out in the Packed-Objects and Tag-Data-Profile Access-Methods. Annexes associated with the other Access-Methods make specific reference to subclauses below.

The basic data compaction schemes are applicable to data Objects to reduce the amount of encoding space required to store that data on the RFID tag. The schemes shall apply to entire data Object, i.e. it is not possible to switch schemes in the middle of a data Object. Nor shall a compaction scheme straddle two, or more, data Objects. By applying data compaction to a complete Object, it can be extracted in its compacted form as part of a read or write command.

The schemes are defined below in sequence of greatest potential compaction to no compaction. If a character string is too short to compact under any one compaction scheme, the character string shall be encoded using octets.

E.2 Integer compaction

Integer compaction is designed to compact decimal integers from the value 10 to 9999999999999999999 (i.e. any 2-digit to 19-digit value) to a binary format. All input bytes shall be in the range 30 to 39₁₆; and the leading byte(s) shall not be 30₁₆.

If the decimal integer value is less than 10, use octet encodation. If the decimal integer is longer than 19 digits, or the leading byte(s) are 30₁₆, numeric compaction shall be applied.

The rules for integer compaction are:

- a) If the decimal numeric value is 10 to 9999999999999999999, convert to a binary value.

This allows for conversion within a 64-bit value (or 8 bytes). Some program languages can support a simple data type conversion to an integer value (different names are used). If the particular language does not support a data type conversion of a decimal value of 19 digits, then a two-stage process should be used:

- 1) Use the data type conversion up to the limit of the program language.
 - 2) Use a Modulo 256 conversion for higher values.
- b) Align to a byte boundary, by padding with leading zero bits if required. Depending on the conversion procedure used, it could be necessary to strip off any leading bytes with the value 00₁₆ to achieve the minimum encoded length. The encoded byte string should not include Encode as integer, code value 001 in the Precursor.

E.3 Numeric compaction

Numeric compaction is designed to encode any decimal numeric character string, including leading zeros. The character string shall be 2 or more characters long. Numeric compaction preserves the

original character string length so that, once decoded, leading zeros, if present, are output. All input bytes shall be in the range 30 to 39₁₆.

The rules for numeric compaction are:

- a) Convert each decimal digit to its 4-bit binary equivalent (Binary Coded Decimal).
- b) If the numeric character string has an odd number of digits, append an additional 4-bit string "1111" to align the compaction to byte boundaries.
- c) Encode each 4-bit pair as a byte. Define the compacted sequence as numeric, code value 010 in the Precursor.

During the decode process, if the last byte has the value "xF", the last four bits "1111" are discarded to re-create the numeric character string of an odd number of decimal digits.

E.4 5-bit compaction

5-bit compaction is designed to encode uppercase Latin characters and some punctuation. All input bytes shall be in the range 41 to 5F₁₆. The character string shall be 3 or more characters long. Up to 37 % of memory space can be saved using this scheme. Annex F shows the ISO/IEC 646 characters that can be encoded.

The rules for 5-bit compaction are:

- a) For each character:
 - 1) Confirm that the byte value is in the range 41 to 5F₁₆.
 - 2) Convert the byte value to its 8-bit binary equivalent.
 - 3) Strip off the lead 3 bits "010".
 - 4) Write the remaining 5-bits to a bit string.
- b) Once all the characters have been converted to 5-bit values and concatenated, divide the resultant bit string into 8-bit segments starting with the most significant bit. If the last segment contains less than 8 bits, pad with "0" bits.
- c) Convert the 8-bit segments to hexadecimal values.
- d) Encode the converted byte sequence as 5-bit code, code value 011 in the Precursor.

During the decode process, each 5-bit segment of the compacted bit string has "010" added as a prefix to re-create the 8-bit value of the source data. If "0" pad bits are present at the end of the compaction bit string, they are discarded.

If 5, 6 or 7 pad bits are present, the decoder could attempt to convert the first 5-bits to the source data. However, this results in character 40₁₆, which is not supported in 5-bit compaction and shall be discarded.

E.5 6-bit compaction

6-bit compaction is designed to encode uppercase Latin characters, numeric digits, and some punctuation. All input bytes shall be in the range 20 to 5F₁₆. If the trailing byte(s) are 20₁₆, 7-bit compaction shall be used. The character string shall be 4 or more characters long. Up to 25 % of memory space can be saved using this scheme. Annex F shows the ISO/IEC 646 characters that can be encoded.

The rules for 6-bit compaction are:

- a) Check for byte 20_{16} in the final position(s). If found, go to 7-bit compaction, otherwise continue steps 2 to 5.
- b) For each character:
 - 1) Confirm that the byte value is in the range 20 to $5F_{16}$.
 - 2) Convert the byte value to its 8-bit binary equivalent.
 - 3) Strip off the leading 2 bits: "00₂" for bytes 20 to $3F_{16}$ or "01₂" for bytes 40 to $5F_{16}$.
 - 4) Concatenate the remaining 6-bits to a bit string.
- c) Divide the resultant bit string into 8-bit segments starting from the most significant bit. If the last segment contains less than 8 bits pad, as appropriate, with the first two, four or all bits of the pad string "100000₂".
- d) Convert the 8-bit segments to hexadecimal values.
- e) Encode the converted byte sequence as 6-bit code, code value "100₂" in the Precursor.

During the decode process, each 6-bit segment of the compacted bit string is analysed.

If the first bit is "1₂", the bits "00" are added as a prefix before converting to values 20 to $3F_{16}$.

If the first bit is "0₂", the bits "01" are added as a prefix before converting to values 40 to $5F_{16}$.

If pad strings "10", "1000" or "100000" are present at the end of the encoded bit string, they are discarded.

If 6 pad bits are present, the decoder can attempt to convert this to source data. This results in character 20_{16} that is not supported in this final position and shall be discarded.

Using the example in 8.1.2, the example below shows the effect of processing the Object through the data compaction process.

EXAMPLE

The **Object** content "ABC123456" converts to HEX as 41 42 43 31 32 33 34 35 36. Analysing this byte stream shows that all values are in the range 20 to $5F_{16}$, enabling 6-bit compaction to be used. The Object byte stream converts as follows:

HEX:	41	42	43	31	32	33	34	35	36
Binary:	10000001	10000010	10000011	00110001	0011001				
	00110011	00110100	00110101	00110110					
Remove bits 8 & 7:	000001	000010	000011	110001	110010	110011			
	110100	110101	110110						

As this is only 54 bits, the first two bits of the pad string "10" are appended and the 56-bit string is divided into a sequence of 8-bit values:

	000001 00	0010 0000	11 110001	110010 11	0011 1101
	00 110101	110110 10			
Convert to HEX:	04	20	F1	CB	3D 35 DA

E.6 7-bit compaction

7-bit compaction is designed to encode all ISO/IEC 646 characters including control characters except for DELETE. All input characters shall be in the range 00 to 7E₁₆. The character string shall be 8 or more characters long. Up to 12 % of memory space can be saved using this scheme. Annex F shows the ISO/IEC 646 characters that can be encoded.

The rules for 7-bit compaction are:

- a) For each character:
 - 1) Confirm that the byte value is in the range 00 to 7E₁₆.
 - 2) Convert the byte value to its 8-bit binary equivalent.
 - 3) Strip off the lead bit "0".
 - 4) Concatenate the remaining 7-bits to a bit string.
- b) Once all the characters have been converted to 7-bit values, divide the resultant bit string into 8-bit segments starting with the most significant bit. If the last segment contains less than 8-bits, pad with "1₂" bits.
- c) Convert the 8-bit segments to hexadecimal values.
- d) Encode the converted byte sequence as 7-bit code, code value "101₂" in the Precursor.

EXAMPLE

The **Object** content "Ace#123451337" converts to HEX as 41 63 65 23 31 32 33 34 35 31 33 33 37. Analysing this byte stream shows that all values are in the range 00 to 7E₁₆, enabling 7-bit compaction to be used. The Object byte stream converts as follows:

HEX: 41 63 65 23 31 32 33 34 35 31 33 33 37

Binary: 01000001 01100011 01100101 00100011 00110001 00110010 00110011
00110100 00110101 00110001 00110011 00110011 00110111

Remove bit 8: 1000001 1100011 1100101 0100011 0110001 0110010 0110011 0110100
0110101 0110001 0110011 0110011 0110111

As this is only 91 bits, the first five bits of the pad string "11111" are appended and the 96-bit string is divided into a sequence of 8-bit values:

10000011 10001111 00101010 00110110 00101100 10011001 10110100
01101010 11000101 10011011 00110110 11111111

Convert to HEX: 83 8F 2A 36 2C 99 B4 6A C5 9B 36 FF

NOTE Although the last encoded byte contains all "1₂"s, decoding from the first byte in 7-bit steps ensures that the pad bits are correctly recognised and discarded.

During the decode process, each 7-bit segment of the compacted bit string has bit "02" added as a prefix to recreate the 8-bit value of the source data. If "12" pad bits are present at the end of the encoded bit string, they are discarded.

If 7 pad bits are present, the decoder can attempt to convert these to source data. However, this results in character 7F₁₆, which is not supported in 7-bit compaction and shall be discarded.

EXAMPLE

The encoded string " AF CB 0E EC FB 32 F2 40 BE 0C 28 71 22 FF " is presented to the decoder, and processed as follows:

Convert to 8 bits: 10101111 11001011 00001110 11101100 11111011 00110010 11110010
01000000 10111110 00001100 00101000 01110001 00100010 11111111

Concatenate & split to 7 bits: 1010111 1110010 1100001 1101110 1100111 1101100 1100101 1110010
0100000 0101111 1000001 1000010 1000011 1000100 1000101 1111111

Add lead 0 to each 7 bits: 01010111 01110010 01100001 01101110 01100111 01101100 01100101
01110010 00100000 00101111 01000001 01000010 01000011 01000100
01000101 01111111

Convert to HEX: 57 72 61 6E 67 6C 65 72 20 2F 41 42 43 44 45 7F

Convert to ISO/IEC 646 characters: W r a n g l e / A B
C D E

NOTE The HEX byte 7F at the end of the encoding appears to be a valid character, except that 7F is not a supported character for the 7-bit compaction scheme. The apparent ambiguity is caused by the fact that the 15-character string "Wrangler /ABCDE" encodes over 105 bits and requires 7 pad bits at the end to encode on a byte aligned basis. During the decode process the 14 encoded bytes (112 bits) are concatenated and split into sixteen 7-bit sequences each of which is prefixed by a leading 0 bit. The last 7-bit sequence "11111112" indicates a pad sequence. When this has the 02 prefix this appears as a legitimate byte, except for the fact that 7F is an invalid character, and so is discarded. This occurs for character strings of 15, 23, 31 and so forth in length.

E.7 Octet encodation

Octet encodation is used when none of the above compaction schemes can be invoked. It encodes all bytes in the range 00 to FF.

The encoded byte string is identical to the source byte string. Encode as octet string, code value 110 in the Precursor. No decode processing is required.

Annex F (normative)

ISO/IEC 646 characters supported by the compaction schemes

ISO/IEC 646 character	Character value (HEX)	Included in compaction type			
		7-bit	6-bit	5-bit	Numeric
NUL	00	•			
SOH	01	•			
STX	02	•			
ETX	03	•			
EOT	04	•			
ENQ	05	•			
ACK	06	•			
BEL	07	•			
BS	08	•			
HT	09	•			
LF	0A	•			
VT	0B	•			
FF	0C	•			
CR	0D	•			
SO	0E	•			
SI	0F	•			
DLE	10	•			
DC1	11	•			
DC2	12	•			
DC3	13	•			
DC4	14	•			
NAK	15	•			
SYN	16	•			
ETB	17	•			
CAN	18	•			
EM	19	•			
SUB	1A	•			
ESC	1B	•			
FS	1C	•			
GS	1D	•			
RS	1E	•			
US	1F	•			
SPACE	20	•	•		
!	21	•	•		
"	22	•	•		
#	23	•	•		
\$	24	•	•		

ISO/IEC 646 character	Character value (HEX)	Included in compaction type			
		7-bit	6-bit	5-bit	Numeric
%	25	•	•		
&	26	•	•		
"	27	•	•		
(	28	•	•		
)	29	•	•		
*	2A	•	•		
+	2B	•	•		
,	2C	•	•		
-	2D	•	•		
.	2E	•	•		
/	2F	•	•		
0	30	•	•		•
1	31	•	•		•
2	32	•	•		•
3	33	•	•		•
4	34	•	•		•
5	35	•	•		•
6	36	•	•		•
7	37	•	•		•
8	38	•	•		•
9	39	•	•		•
:	3A	•	•		
;	3B	•	•		
<	3C	•	•		
=	3D	•	•		
>	3E	•	•		
?	3F	•	•		
@	40	•	•		
A	41	•	•	•	
B	42	•	•	•	
C	43	•	•	•	
D	44	•	•	•	
E	45	•	•	•	
F	46	•	•	•	
G	47	•	•	•	
H	48	•	•	•	
I	49	•	•	•	
J	4A	•	•	•	
K	4B	•	•	•	
L	4C	•	•	•	
M	4D	•	•	•	
N	4E	•	•	•	
O	4F	•	•	•	
P	50	•	•	•	

ISO/IEC 646 character	Character value (HEX)	Included in compaction type			
		7-bit	6-bit	5-bit	Numeric
Q	51	•	•	•	
R	52	•	•	•	
S	53	•	•	•	
T	54	•	•	•	
U	55	•	•	•	
V	56	•	•	•	
W	57	•	•	•	
X	58	•	•	•	
Y	59	•	•	•	
Z	5A	•	•	•	
[	5B	•	•	•	
\	5C	•	•	•	
]	5D	•	•	•	
^	5E	•	•	•	
_	5F	•	•	•	
`	60	•			
a	61	•			
b	62	•			
c	63	•			
d	64	•			
e	65	•			
f	66	•			
g	67	•			
h	68	•			
i	69	•			
j	6A	•			
k	6B	•			
l	6C	•			
m	6D	•			
n	6E	•			
o	6F	•			
p	70	•			
q	71	•			
r	72	•			
s	73	•			
t	74	•			
u	75	•			
v	76	•			
w	77	•			
x	78	•			
y	79	•			
z	7A	•			
"	7B	•			
	7C	•			

ISO/IEC 646 character	Character value (HEX)	Included in compaction type			
		7-bit	6-bit	5-bit	Numeric
"	7D	•			
~	7E	•			

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Annex G (informative)

Encoding example for No-Directory structure

G.1 General

The encoding example shown below is based on the processes specified in this document. The relevant clause is referred to at each stage of the illustrated example. Specific implementations are likely to be more efficient, but the detailed steps are shown to aid readers with an understanding of the process.

G.2 Starting position

This stage is based on the transfer of the Object-Identifiers and Objects in application commands. This example uses two hypothetical Object-Identifiers and Objects, but not considering any additional arguments such as locking the dataset.

EXAMPLE

Using the urn form (see [6.3.3](#)) for the Object-Identifier and printable characters for the Object, the input values are:

urn:oid: 1.0.15691.27.48 with the nine-character data "ABC123456"

urn:oid:1.0.15961.27.13 with the two-character data "50"

The data is probably transferred as the hexadecimal strings "41 42 43 31 32 33 34 35 36" and "35 30", respectively.

G.3 Encoding the Object-Identifiers

For this illustration, assume that the full Object-Identifier is first created in the correct format before any truncation to remove the common Root-OID. This is a procedure that can be used with Data-Format = 2, but for other Data-Formats it is possible to identify the Root-OID and only encode the Relative-OID.

Using the rules defined in [D.3](#):

urn:oid: 1.0.15691.27.48 encodes as "28 FC 59 1B 30"

urn:oid:1.0.15961.27.13 encodes as "28 FC 59 1B 0D"

G.4 Initial state of the entry for the Logical Memory

Using the example in [G.3](#), the bytes can be mapped to create the initial encoding as illustrated in [Table G.1](#). The Precursor bits are set to NULL. All the other encoding is of bytes.

NOTE The contents of [Table G.1](#) will be updated as additional processes are applied.

Table G.1 — Initial encoding example of application data

Precursor (bits)								Offset	L of Object-Id	Object-Identifier	Length of Object	Object
b8	b7	b6	b5	b4	b3	b2	b1					
									05	28 FC 59 1B 30	09	41 42 43 31 32 33 34 35 36
									05	28 FC 59 1B 0D	02	35 30

G.5 Logical Memory after data compaction

After processing through the Data Compactor, the data Object and its length can be redefined, but the Object-Identifier remains unchanged.

The compaction process (as defined in [D.2](#) and [Annex E](#)) can be applied to the two data objects in [Table G.1](#).

- The data Object 41 42 43 31 32 33 34 35 36 is compacted to 7 bytes, using the 6-bit code Type, to become 04 20 F1 CB 3D 35 DA (see [E.5](#) for the detailed conversion).
- The data Object 35 30 is compacted to 1 byte "32" using the integer Type (see [E.2](#) for the detailed conversion).

The first data Object has the following changes:

- Compaction Type in the Precursor bits 7 to 5 = 100BIN
- Length of data Object = 07
- data Object: 04 20 F1 CB 3D 35 DA

The second data Object has the following changes:

- Compaction Type in the Precursor bits 7 to 5 = 001BIN
- Length of data Object = 01
- data Object: 32

The results are shown in [Table G.2](#).

Table G.2 — Encoding example after data compaction

Precursor (bits)								Offset	L of Object-Id	Object-Identifier	Length of Object	Object
b8	b7	b6	b5	b4	b3	b2	b1					
	1	0	0						05	28 FC 59 1B 30	07	04 20 F1 CB 3D 35 DA
	0	0	1						05	28 FC 59 1B 0D	01	32

G.6 Logical Memory after formatting for a No-Directory Access-Method

G.6.1 General

The format rules have a different effect depending on the Data-Format values. The following subclauses illustrate this using the same input with different Data-Formats.

G.6.2 Logical Memory after formatting for Data-Format = 2 (Root-OID-Encoded)

Table G.3 shows the result of formatting the input of Table G.2 with Data-Format = 2 (Root-OID-Encoded):

- The Root-OID 28 FC 59 1B is created, and its length of 4 bytes encoded in the Precursor.
- The first Relative-OID is created. As it is a single arc it is a potential candidate for encoding in the Precursor, but as its value is greater than OE, the Relative-OID shall be directly encoded in subsequent bytes and the Precursor bits 4 to 1 = 1111_2
- The Type of Object-Identifier and its length are encoded, as follows:
 - The Type is encoded in the first 3 bits; Relative-OID = 100_2
 - The length is less than 16 bytes, so is encoded in bits 5 to 1 with length = 50000_2 ; length of 1 is encoded as 00010_2
 - The bit stream $10000010_2 = 82_{16}$
- The second Relative-OID is created. As it is a single arc it is a potential candidate for encoding in the Precursor, and as its value is no greater than OE, the Relative-OID is encoded in the Precursor. Relative- OID = 0D encoded in Precursor bits 4 to 1 = 1101_2
- No length, nor value, needs to be encoded for this Relative-OID, because it is bit encoded in the Precursor, saving two bytes.

Table G.3 — Encoding example for Data-Format = 2

Precursor (bits)								Offset	Object-Id type & length	Object-Identi- fier	Length of Ob- ject	Object
b8	b7	b6	b5	b4	b3	b2	b1					
	0	0	0	0	1	0	0			28 FC 59 1B	00	
	1	0	0	1	1	1	1		82	30	07	04 20 F1 CB 3D 35 DA
	0	0	1	1	1	0	1				01	32

G.6.3 Logical Memory after formatting for Data-Format not equal to 2

Table G.4 shows the result of formatting the input of Table G.2 with Data-Format not equal to 2. This clearly shows that the Root-OID is not encoded, because it is directly indicated by the Data-Format. In all other respects, the encodation is as in Table G.3, because the same procedures are used to create the precursor for each Object-Identifier/Object pair.

Table G.4 — Encoding example of Data-Format not equal to 2

Precursor (bits)								Offset	Object-Id type & length	Object-Identi- fier	Length of Ob- ject	Object
b8	b7	b6	b5	b4	b3	b2	b1					
	1	0	0	1	1	1	1		82	30	07	04 20 F1 CB 3D 35 DA
	0	0	1	1	1	0	1				01	32

Annex H (informative)

Encoding example for a directory structure

H.1 Base data

Table H.1 shows 64 bytes of encoding for nine datasets, with the shaded cells indicating compacted data. The byte values in white cells therefore represent the Precursor, the encoding of the Object-Identifier and length bytes.

Table H.1 — Example encoded bytes without a directory

		2 nd nibble of HEX Address															
		x0	x1	x2	x3	x4	x5	x6	x7	x8	x9	xA	xB	xC	xD	xE	xF
1 st nibble of HEX Address	0x	4F	82	32	07	04	20	F1	CB	3D	35	DA	1D	01	32	11	06
	1x	0B	3A	73	CE	2F	F2	02	01	F8	43	0A	38	CB	71	CB	3D
	2x	35	DB	7E	39	C2	44	05	38	CB	79	E7	98	15	02	04	C0
	3x	16	05	02	4C	B0	16	EA	17	06	70	48	86	0D	DF	79	00

H.2 Encoding the first directory entry

Each directory entry takes leading bytes of the dataset as follows:

- The Precursor for the dataset.
- The length of the Object-Identifier (conditional).
- The Object-Identifier (conditional)

As the first dataset has the Relative-OID value 4810, each of these components shall be encoded. In hexadecimal, the byte sequence is:

$4F_{16}$ = the Precursor
 82_{16} = the length of the Object-Identifier
 30_{16} = the Object-Identifier

The address of the Precursor for this dataset is 00_{16} . This address applies irrespective of the block size of the Logical Memory. The complete sequence is encoded, starting from the highest addressed block in the memory. For this example, assume that the block size is 8 bytes. The bytes are encoded in the highest block, but still with the normal read direction as shown in Table H.2.

Table H.2 — Start of the directory

		2 nd nibble (HEX) of block							
		x0	x1	x2	x3	x4	x5	x6	x7
1 st nibble (HEX) of block	(n-3)x								
	(n-2)x								
	(n-1)x								
	(n)x	4F	82	32	00				

H.3 Encoding the second directory entry

The second dataset has its Relative-OID encoded in the Precursor, so only the value ($1D_{16}$) of the Precursor is encoded in the directory. This is followed by the byte address ($1D_{16}$) of the Precursor. These bytes are encoded immediately after the previous directory entry, as shown in [Table H.3](#).

Table H.3 — Second directory entry

		2 nd nibble (HEX) of block							
		x0	x1	x2	x3	x4	x5	x6	x7
1 st nibble (HEX) of block	(n-3)x								
	(n-2)x								
	(n-1)x								
	(n)x	4F	82	32	00	1D	0B		

H.4 Encoding the remaining directory entries

The remaining datasets are processed to add the Object-Identifier and location to the directory, as follows:

- The third dataset only requires the Precursor and its location to be encoded, and this is entered at the end of the highest block (based on this example of an 8-byte block).
- The fourth dataset only requires the Precursor and its location to be encoded, and this is entered at the beginning of the next highest block (based on this example of an 8-byte block).
- The fifth dataset only requires the Precursor and its location to be encoded, and this is entered in the block (n-1), based on this example of an 8-byte block.
- The sixth dataset only requires the Precursor and its location to be encoded, and this is entered in the block (n-1), based on this example of an 8-byte block.
- The seventh dataset only requires the Precursor and its location to be encoded, and this is entered in the block (n-1), based on this example of an 8-byte block.
- The eighth dataset only requires the Precursor and its location to be encoded, and this is entered in the block (n-2), based on this example of an 8-byte block.
- The ninth dataset only requires the Precursor and its location to be encoded, and this is entered in the block (n-1), based on this example of an 8-byte block.
- The terminator is encoded in the next byte location of the directory.

The complete encoded directory is shown in [Table H.4](#) and is encoded in blocks (n-2) to block n, where "n" is the value of the highest block.

Table H.4 — Complete directory entries

		2 nd nibble (HEX) of block							
		x0	x1	x2	x3	x4	x5	x6	x7
1 st nibble (HEX) of block	(n-3)x								
	(n-2)x	16	30	17	37	00			
	(n-1)x	02	17	43	1A	44	26	15	2C
	(n)x	4F	82	32	00	1D	0B	11	0E

In this example, all the directory blocks are located at higher block address than the encoded data, otherwise it is not possible to encode a directory. As block (n-3) has not been used for the directory, subsequent encoding of data or directory may be placed in this block.

H.5 Decoding the directory and reading the target Object-Identifier

The directory is decoded from the highest block address. The first byte is the Precursor of the first dataset and the structure to the end of the Object-identifier is self-declaring and is decoded as defined in [D.10.4](#) and [D.10.5](#). As the location address of the target Precursor is encoded to the length encoding rules defined in [D.3](#), it too has a self-declaring structure. If the location is below position 128, 1 byte is required; for locations at addresses up to 16383, two bytes are required; and additional bytes can be used for any size of address.

With these structuring rules it is possible to parse and decode the directory until the target Object-Identifier and its location are found.

Using the block size, it is possible to identify the block containing the Precursor of the target Object-Identifier and to invoke a selective read transaction across the air interface.

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Annex I (normative)

Packed-Objects structure

I.1 Overview

The Packed Objects format provides for efficient encoding and access of user data. The Packed Objects format offers increased encoding efficiency compared to the No-Directory and Directory Access-Methods, partly by utilizing sophisticated compaction methods, partly by defining an inherent directory structure at the front of each Packed Object (before any of its data is encoded) that supports random access while reducing the fixed overhead of some prior methods, and partly by utilizing data-system-specific information (such as the GS1 definitions of fixed-length Application Identifiers).

I.2 Overview of associated Annexes

The formal description of Packed Objects is presented in this annex and in the annexes defined as follows:

- The overall structure of Packed Objects is described in [I.3](#).
- The individual sections of a Packed Object are described in [I.4](#) to [I.9](#).
- The structure and features of ID tables (utilized by Packed Objects to represent various data system identifiers) are described in [Annex J](#).
- The numerical bases and character sets used in Packed Objects are described in [Annex K](#).
- An encoding algorithm and worked example are described in [Annex L](#).
- The decoding algorithm for Packed Objects is described in [Annex M](#).

In addition, note that all descriptions of specific ID tables for use with Packed Objects are registered separately, under the procedures of ISO/IEC 15961-2, as is the complete formal description of the machine-readable format for registered ID tables.

I.3 High-level Packed-Objects format design

I.3.1 Overview

The Packed Objects memory format consists of a sequence in memory of one or more Packed Objects data structures. Each Packed Object may contain either encoded data or directory information, but not both. The DSFID associated with a particular memory or memory bank indicates the use of Packed Objects as the memory's Access Method and indicates the registered Data-Format that is the default format for every Packed Object in that memory. Every Packed Object may be optionally preceded or followed by padding patterns (if needed for alignment on word or block boundaries). In addition, at most one Packed Object in memory may optionally be preceded by a pointer to a directory Packed Object (this pointer may itself be optionally followed by padding). This series of Packed Objects is terminated by optional padding followed by one or more zero-valued octets aligned on byte boundaries. See [Table I.1](#), which shows this sequence when appearing in an RFID tag.

NOTE Because the data structures within an encoded Packed object are bit-aligned rather than byte-aligned, this annex uses the term "octet" instead of "byte" except in cases where an eight-bit quantity must be aligned on a byte boundary.

Table I.1 — Overall memory structure when using Packed-Objects

DSFID ^a	Optional Pointer ^b And/Or Padding	First Packed-Object	Optional Pointer ^b And/Or Padding	Optional Second Packed-Object	...	Optional Packed-Object	Optional Pointer ^b And/Or Padding	Zero Octet(s)
^a For many tag architectures the DSFID is encoded separately in a predefined area of memory, and not as illustrated here.								
^b The optional pointer to a directory Packed Object may appear at most only once in memory.								

Every Packed Object represents a sequence of one or more data system Identifiers, each specified by reference to an entry within a base ID table from a registered data format. The entry is referenced by its relative position within the base table; this relative position or base table index is referred to throughout this specification as an "ID value." There are two different Packed Objects methods available for representing a sequence of Identifiers by reference to their ID values:

- An ID List Packed Object (IDLPO) encodes a series of ID values as a list, whose length depends on the number of data items being represented;
- An ID Map Packed Object (IDMPO) instead encodes a fixed-length bit array, whose length depends on the total number of entries defined in the registered base table. Each bit in the array is "1" if the corresponding table entry is represented by the Packed Object and is "0" otherwise.

An ID List is the default Packed Objects format, because it uses fewer bits than an ID Map, if the list contains only a small percentage of the data system's defined ID values. However, if the Packed Object includes more than about one-quarter of the defined entries, then an ID Map requires fewer bits. For example, if a data system has sixteen entries, then each ID value (table index) is a four-bit quantity, and a list of four ID values takes as many bits as would the complete ID Map. An ID Map's fixed-length characteristic makes it especially suitable for use in a directory Packed Object, which lists all of the Identifiers in all of the Packed Objects in memory (see I.9). The overall structure of a Packed Object is the same, whether an IDLPO or an IDMPO, as shown in Table I.2, and as described in the next subsection.

Table I.2 — Packed Object structure

Optional Format Flags	Object Info section (IDLPO or IDMPO)	Secondary ID section (if needed)	Aux format section (if needed)	Data section (if needed)
-----------------------	--------------------------------------	----------------------------------	--------------------------------	--------------------------

Packed Objects may be made "editable", by adding an optional Addendum subsection to the end of the Object Info section, which includes a pointer to an "Addendum Packed Object" where additions and/or deletions have been made. One or more such "chains" of editable "parent" and "child" Packed Objects may be present within the overall sequence of Packed Objects in memory, but no more than one chain of directory Packed Objects may be present.

I.3.2 Descriptions of each section of a Packed Object's structure

Each Packed Object consists of several bit-aligned sections (i.e. no pad bits between sections are used), carried in a variable number of octets. All required and optional Packed Objects formats are encompassed by the following ordered list of Packed Objects sections. Following this list, each Packed Objects section is introduced, and later sections of this annex describe each Packed Objects section in detail.

A Packed Object may optionally begin with the pattern "0000", which is reserved to introduce one or more format flags, as described in I.4.3. These flags may indicate use of the non-default ID Map format. If the format flags are not present, then the Packed Object defaults to the ID List format:

- Certain flag patterns indicate an inter-Object pattern (Directory pointer or padding).
- Other flag patterns indicate the Packed Object's type (Map or List) and may indicate the presence of an optional Addendum subsection that enables data to be edited.

All Packed Objects contain an Object Info section that includes Object length information and ID value Information:

- Object length information includes an Object length field (indicating the overall length of the Packed Object in octets) followed by pad indicator bit, so that the number of significant bits in the Packed Object can be determined.
- ID value Information indicates which Identifiers are present and in what order, and (if an IDLPO) also includes a leading NumberOfIDs field, indicating how many ID values are encoded in the ID List.

The Object Info section is encoded in one of the following formats:

- ID List (IDLPO) Object Info format (Table I.3 and Table I.4):
 - Object length (EBV-6) plus pad indicator bit,
 - A single ID List or an ID Lists section (depending on format flags),
- ID Map (IDMPO) Object Info format (Table I.5):
 - One or more ID Map sections,
 - Object length (EBV-6) plus pad indicator bit.

For either of these Object Info formats, an optional Addendum subsection may be present at the end of the Object Info section.

Table I.3 — IDLPO Default ID List Object Info structure

Object Info, in a Default ID List PO			
Object length	Number of IDs	ID list	Optional addendum

Table I.4 — IDLPO Non-default ID List Object Info structure

Object Info, in a Non-default ID List PO		
Object length	ID Lists section (one or more lists)	Optional addendum

Table I.5 — IDMPO Object Info structure

Object Info, in an ID Map PO		
ID Map section (one or more maps)	Object length	Optional addendum

A Packed Object may include a secondary ID section, if needed to encode additional bits that are defined for some classes of IDs (these bits complete the definition of the ID).

A data Packed Object may include an Aux format section, which if present encodes one or more bits that are defined to support data compression, but do not contribute to defining the ID.

A data Packed Object includes a data section, representing the compressed data associated with each of the identifiers listed within the Packed Object. This section is omitted in a directory Packed Object, and in a Packed Object that uses No-directory compaction (see 1.7.2). Depending on the declaration of data format in the relevant ID table, the data section will contain either or both of two subsections:

- Known-Length Numerics subsection: this subsection compacts and concatenates all the non-empty data strings that are known a priori to be numeric.
- AlphaNumeric subsection: this subsection concatenates and compacts all the non-empty data strings that are not a priori known to be all-numeric.

I.4 Format flags section

I.4.1 Flags

This subclause defines the valid format flags patterns that may appear at the expected start of a Packed Object to override the default layout if desired. For example, a format flag can change the Packed Object's format or signal the insertion of padding patterns to align the next Packed Object on a word or block boundary). The set of defined patterns is shown in [Table I.6](#).

Table I.6 — Format flags

Bit pattern	Description	Additional Info	See Annex
0000 0000	Termination pattern	No more packed objects follow	I.4.2
0000 0001	Invalid pattern		
0000 0010	Invalid pattern		
0000 0011	Invalid pattern		
LLLLLL xx	First octet of an IDLPO	For any LLLLLL > 3	I.5
0000	Format flags starting pattern	(if the full EBV-6 is non-zero)	I.4.3
0000 10NA	IDLPO with: N = 1: non-default Info A = 1: Addendum present	If N = 1: allows multiple ID tables If A = 1: Addendum pointer(s) at end of Object Info section	I.4.4
0000 01xx	Inter-Packed Object pattern	A directory pointer, or padding	I.4.5
0000 0100	Signifies a padding byte	No padding length indicator follows	I.4.5
0000 0101	Signifies run-length padding	An EBV-8 padding length follows	I.4.5
0000 0110	RFU		I.4.5
0000 0111	Directory pointer	Followed by EBV-8 pattern	I.4.5
0000 11xx	ID Map Packed Object		I.4.3

I.4.2 Data terminating flag pattern

A pattern of eight or more "0" bits at the expected start of a Packed Object denotes that no more Packed Objects are present in the remainder of memory.

NOTE Six successive "0" bits at the expected start of a Packed Object can (if interpreted as a Packed Object) indicate an ID List Packed Object of length zero.

I.4.3 Format flags section starting bit patterns

A non-zero EBV-6 with a leading pattern of "0000₂" is used as a format flags section indicating pattern. The additional bits following an initial "0000₂" format flag indicating pattern are defined as follows:

- A following two-bit pattern of "10₂" (creating an initial pattern of "000010₂") indicates an IDLPO with at least one non-default optional feature (see [I.4.4](#)).
- A following two-bit pattern of "11₂" indicates an IDMPPO, which is a Packed Object using an ID Map format instead of ID List format. The ID Map section (see [I.9](#)) immediately follows this two-bit pattern.
- A following two-bit pattern of "012" signifies an External pattern (Padding pattern or pointer) prior to the start of the next Packed Object (see [I.4.5](#)).

A leading EBV-6 ObjectLength of less than four is invalid as a Packed Objects length.

The shortest possible Packed Object is an IDLPO, for a data system using four bits per ID value, encoding a single ID value. This Packed Object has a total of 14 fixed bits. Therefore, a two-octet Packed Object would only contain two data bits and is invalid. A three-octet Packed Object would be able to encode

a single data item up to three digits long. In order to preserve "3" as an invalid length in this scenario, the Packed Objects encoder shall encode a leading format flags section (with all options set to zero, if desired) in order to increase the object length to four.

I.4.4 IDLPO format flags

The presence of the bit pattern "000010₂" at the expected start of a Packed Object is followed by two additional bits, to form a complete IDLPO format flag of "000010NA", where:

- If the first additional bit "N" is "0₂", then the default IDLPO format is employed for the IDLPO Object Info section. This allows for only a single ID List (utilizing the registration's default base ID table).
- If the first additional bit "N" is "1₂", then a non-default format is employed for the IDLPO Object Info section. The optional non-default IDLPO Object Info format supports a sequence of one or more ID Lists, and each such list begins with identifying information as to which registered table it represents (see [I.5.2](#)).
- If the second additional bit "A" is "1₂", then an Addendum subsection is present at the end of the Object Info section (see [I.5.7](#)).
- If the second additional bit "A" is "0₂", then no Addendum subsection is present.

I.4.5 Patterns for use between Packed Objects

The presence of "000001₂" at the expected start of a Packed Object is used to indicate either padding or a directory pointer, as follows:

A following two-bit pattern of "11₂" indicates that a directory Packed Object pointer follows the pattern. The pointer is one or more octets in length, in EBV-8 format. This pointer may be Null (a value of zero), but if non-zero, indicates the number of octets from the start of the pointer to the start of a directory Packed Object (which if editable, shall be the first in its "chain"). For example, if the format flag byte for a directory pointer is encoded at byte offset 1, the pointer itself occupies bytes beginning at offset 2, and the directory starts at byte offset 9, then the Dir Ptr encodes the value "7" in EBV-8 format. A directory Packed Object pointer may appear before the first Packed Object in memory, or at any other position where a Packed Object may begin, but may only appear once in a given data carrier memory, and (if non-null) must be at a lower address than the directory it points to. The first octet after this pointer may be padding (as defined immediately below), a new set of format flag patterns, or the start of an ID List Packed Object.

- A following two-bit pattern of "00₂" indicates that the full eight-bit pattern of "00000100₂" pattern serves as a padding byte, so that the next Packed Object may begin on a desired word or block boundary. This pattern may repeat as necessary to achieve the desired alignment.
- A following two-bit pattern of "01₂" indicates as a run-length padding indicator, and shall be immediately followed by an EBV-8 indicating the number of octets from the start of the EBV-8 itself to the start of the next Packed Object (for example, if the next Packed Object follows immediately, the EBV-8 has a value of one). This mechanism eliminates the need to write many words of memory to pad out a large memory block.
- A following two-bit pattern of "10₂" is Reserved.

I.5 Object Info section

I.5.1 General

Each Packed Object's Object Info section contains both length information (the size of the Packed Object, in bits and in octets), and ID values information. A Packed Object encodes representations of one or more data system Identifiers and (if a data Packed Object) also encodes their associated data elements [Application Identifier (AI) strings, Data Identifier (DI) strings]. The ID values information

encodes a complete listing of all the Identifiers (e.g. AIs, DIs) encoded in the Packed Object, or (in a directory Packed Object) all the Identifiers encoded anywhere in memory.

To conserve encoded and transmitted bits, data system Identifiers (each typically represented in data systems by either two, three, or four ISO/IEC 646 characters) is represented within a Packed Object by an ID value, representing an index denoting an entry in a registered base table of ID values. A single ID value may represent a single Object Identifier or may represent a commonly used sequence of Object Identifiers. In some cases, the ID value represents a "class" of related Object Identifiers, or an Object Identifier sequence in which one or more Object Identifiers are optionally encoded; in these cases, secondary ID bits (see [1.6](#)) are encoded in order to specify which selection or option was chosen when the Packed Object was encoded. A "fully-qualified ID value" (FQIDV) is an ID value, plus a particular choice of associated secondary ID bits (if any are invoked by the ID value's table entry). Only one instance of a particular fully-qualified ID value may appear in a data carrier's data Packed Objects, but a particular ID value may appear more than once, if each time it is "qualified" by different secondary ID bits. If an ID value does appear more than once, all occurrences shall be in a single Packed Object (or within a single "chain" of a Packed Object plus its Addenda).

There are two methods defined for encoding ID values: an ID List Packed Object uses a variable-length list of ID value bit fields, whereas an ID Map Packed Object uses a fixed-length bit array. Unless a Packed Object's format is modified by an initial format flags pattern, the Packed Object's format defaults to that of an ID List Packed Object (IDLPO), containing a single ID List, whose ID values correspond to the default base ID table of the registered data format. Optional format flags can change the format of the ID section to either an IDMPPO format, or to an IDLPO format encoding an ID Lists section (which supports multiple ID tables, including non-default data systems).

Although the ordering of information within the Object Info section varies with the chosen format (see [1.5.2](#)), the Object Info section of every Packed Object shall provide length information as defined in [1.5.3](#), and ID values information (see [1.5.4](#)) as defined in [1.5.5](#) or [1.5.6](#). The Object Info section (of either an IDLPO or an IDMPPO) may conclude with an optional Addendum subsection (see [1.5.7](#)).

1.5.2 Object Info formats

1.5.2.1 IDLPO default Object Info format

The default IDLPO Object Info format is used for a Packed Object either without a leading format flags section, or with a format flags section indicating an IDLPO with a possible addendum and a default Object Info section. The default IDLPO Object Info section contains a single ID List (optionally followed by an Addendum subsection if so indicated by the format flags). The format of the default IDLPO Object Info section is shown in [Table 1.7](#).

Table 1.7 — Default IDLPO Object Info format

Field name:	Length information	NumberOfIDs	ID listing	Addendum subsection
Usage:	The number of octets in this Object, plus a last-octet pad indicator	Number of ID values in this Object (minus one)	A single list of ID values; value size depends on registered data format	Optional pointer(s) to other Objects containing edit information
Structure:	Variable: see 1.5.3	Variable: EBV-3	See 1.5.5	See 1.5.7.2

In an IDLPO's Object Info section, the NumberOfIDs field is an EBV-3 Extensible bit Vector, consisting of one or more repetitions of an Extension bit followed by 2 value bits. This EBV-3 encodes one less than the number of ID values on the associated ID Listing. For example, an EBV-3 of "101₂ 000₂" indicates $(4 + 0 + 1) = 5$ IDs values. The length information is as described in [1.5.3](#) for all Packed Objects. The next fields are an ID Listing (see [1.5.5](#)) and an optional Addendum subsection (see [1.5.7](#)).

I.5.2.2 IDLPO non-default Object Info format

Leading format flags may modify the Object Info structure of an IDLPO, so that it may contain more than one ID Listing, in an ID Lists section (which also allows non-default ID tables to be employed). The non-default IDLPO Object Info structure is shown in [Table I.8](#).

Table I.8 — Non-Default IDLPO Object Info format

Field name:	Length info	ID Lists section, first list			Optional ID list section(s)	Null App indicator (single zero bit)	Addendum subsection
		Application indicator	Number of IDs	ID listing			
Usage:	The number of octets in this Object, plus a last-octet pad indicator	Indicates the selected ID table and the size of each entry	Number of ID values on the list	Listing of ID values, then one F/R use bit	Repeated lists, each for a different ID table	Zero or more repeated lists, each for a different ID table, followed by a null application indicator (single zero bit)	Optional pointer(s) to other Objects containing edit information
Structure:	See I.5.3	See I.5.4.2	See I.5.2.1	See I.5.5 and I.5.4.3	References in previous columns	See I.5.4.2	See I.5.7

I.5.2.3 IDMPO Object Info format

Leading format flags may define the Object Info structure to be an IDMPO in which the length information (and optional Addendum subsection) follow an ID Map section (see [I.5.6](#)). This arrangement ensures that the ID Map is in a fixed location for a given application, of benefit when used as a directory. The IDMPO Object Info structure is shown in [Table I.9](#).

Table I.9 — IDMPO Object Info format

Field name:	ID Map section	Length information	Addendum
Usage:	One or more ID Map structures, each using a different ID table	The number of octets in this Object, plus a last-octet pad indicator	Optional pointer(s) to other Objects containing Edit information
Structure:	See I.9.2	See I.5.3	See I.5.7

I.5.3 Length information

The format of the length information, always present in the Object Info section of any Packed Object, is shown in [Table I.10](#).

Table I.10 — Packed Object length information

Field name:	ObjectLength	Pad indicator
Usage:	The number of 8-bit bytes in this Object. This includes the 1st byte of this Packed Object, including its IDLPO/IDMPO format flags if present. It excludes patterns for use between packed objects, as specified in I.4.5 .	If "1", then Object's last byte contains at least 1 pad bit
Structure:	Variable: EBV-6	Fixed: 1 bit

The first field, ObjectLength, is an EBV-6 Extensible bit Vector, consisting of one or more repetitions of an Extension bit and 5 value bits. An EBV-6 of "000100₂" (value of 4) indicates a four-byte Packed Object. An EBV-6 of "100001₂ 000000₂" (value of 32) indicates a 32-byte Object, etc.

The pad indicator bit immediately follows the end of the EBV-6 ObjectLength. This bit is set to "0" if there are no padding bits in the last byte of the Packed Object. If set to "1", then bitwise padding begins with the least- significant or rightmost "1" bit of the last byte, and the padding consists of this rightmost "1" bit, plus any "0" bits to the right of that bit. This method effectively uses a *single* bit to indicate a *three*-bit quantity (i.e. the number of trailing pad bits). When a receiving system wants to determine the total number of bits (rather than bytes) in a Packed Object, it would examine the ObjectLength field of the Packed Object (to determine the number of bytes) and multiply the result by eight, and (if the pad indicator bit is set) examine the last byte of the Packed Object and decrement the bit count by (1 plus the number of "0" bits following the rightmost "1" bit of that final byte).

I.5.4 General description of ID values

I.5.4.1 Base table

A registered data format defines (at a minimum) a primary base ID table (a detailed specification for registered ID tables can be found in [Annex J](#)). This base table defines the data system Identifier(s) represented by each row of the table, any secondary ID bits or Aux format bits invoked by each table entry, and various implicit rules (taken from a predefined rule set) that decoding systems shall use when interpreting data encoded according to each entry. When a data item is encoded in a Packed Object, its associated table entry is identified by the entry's relative position in the base table. This table position or index is the ID value that is represented in Packed Objects.

A base table containing a given number of entries inherently specifies the number of bits needed to encode a table index (i.e. an ID value) in an ID List Packed Object (as the Log (base 2) of the number of entries). Since current and future data system ID tables will vary in unpredictable ways in terms of their numbers of table entries, there is a need to pre-define an ID value size mechanism that allows for future extensibility to accommodate new tables, while minimizing decoder complexity and minimizing the need to upgrade decoding software (other than the addition of new tables). Therefore, regardless of the exact number of base table entries defined, each base table definition shall utilize one of the predefined sizes for ID value encodings defined in [Table I.11](#) (any unused entries shall be labelled as reserved, as provided in [Annex J](#)). The ID Size bit pattern is encoded in a Packed Object only when it uses a non-default base ID table. Some entries in the table indicate a size that is not an integral power of two. When encoding (into an IDLPO) ID values from tables that utilize such sizes, each pair of ID values is encoded by multiplying the earlier ID of the pair by the base specified in the fourth column of [Table I.11](#) and adding the later ID of the pair, and encoding the result in the number of bits specified in the fourth column. If there is a trailing single ID value for this ID table, it is encoded in the number of bits specified in the third column of [Table I.11](#).

Table I.11 — Defined ID value sizes

ID size bit pattern	Maximum number of table entries	Number of bits per single or trailing ID value, and how encoded	Number of bits per pair of ID values, and how encoded
000	Up to 16	4, as 1 base 16 value	8, as 2 base 16 values
001	Up to 22	5, as 1 base 22 value	9, as 2 base 22 values
010	Up to 32	5, as 1 base 32 value	10, as 2 base 32 values
011	Up to 45	6, as 1 base 45 value	11, as 2 base 45 values
100	Up to 64	6, as 1 base 64 value	12, as 2 base 64 values
101	Up to 90	7, as 1 base 90 value	13, as 2 base 90 values
110	Up to 128	7, as 1 base 128 value	14, as 2 base 128 values
1110	Up to 256	8, as 1 base 256 value	16, as 2 base 256 values
111100	Up to 512	9, as 1 base 512 value	18, as 2 base 512 values
111101	Up to 1024	10, as 1 base 1024 value	20, as 2 base 1024 values
111110	Up to 2048	11, as 1 base 2048 value	22, as 2 base 2048 values
111111	Up to 4096	12, as 1 base 4096 value	24, as 2 base 4096 values

I.5.4.2 Application indicator subsection

An application indicator subsection can be utilised to indicate use of ID values from a default or non-default ID table. This subsection is required in every IDMPO but is only required in an IDLPO that uses the non-default format supporting multiple ID Lists.

An application indicator consists of the following components:

- A single AppIndicatorPresent bit, which if "0" means that no additional ID List or Map follows. Note that this bit is always omitted for the first List or Map in an Object Info section. When this bit is present and "0", then none of the following bit fields are encoded.
- A single ExternalReg bit that, if "1", indicates use of an ID table from a registration other than the memory's default. If "1", this bit is immediately followed by a 9-bit representation of a data format registered under ISO/IEC 15961.
- An ID Size pattern which denotes a table size (and therefore an ID Map bit length, when used in an IDMPO), which shall be one of the patterns defined by [Table I.11](#). The table size indicated in this field must be less than or equal to the table size indicated in the selected ID table. The purpose of this field is so that the decoder can parse past the ID List or ID Map, even if the ID table is not available to the decoder.
- A three-bit ID Subset pattern. The registered data format's primary base ID table, if used by the current Packed Object, shall always be indicated by an encoded ID Subset pattern of "000". However, up to seven alternate base tables may also be defined in the registration (with varying ID sizes), and a choice from among these can be indicated by the encoded Subset pattern. This feature can be useful to define smaller sector-specific or application-specific subsets of a full data system, thus substantially reducing the size of the encoded ID Map.

I.5.4.3 Full/Restricted use bits

When contemplating the use of new ID table registrations, or registrations for external data systems, application designers may utilise a "restricted use" encoding option that adds some overhead to a Packed Object but in exchange results in a format that can be fully decoded by receiving systems not in possession of the new or external ID table. With the exception of an IDLPO using the default Object Info format, one full/restricted use bit is encoded immediately after each ID table is represented in the ID Map section or ID Lists section of a data or directory Packed Object. In a directory Packed object, this bit shall always be set to "0" and its value ignored. If an encoder wishes to utilise the "restricted use" option in an IDLPO, it shall preface the IDLPO with a format flags section invoking the non-default Object Info format.

If a "Full/Restricted use" bit is "0", then the encoding of data strings from the corresponding registered ID table makes full use of the ID table's IDstring and FormatString information. If the bit is "1", then this signifies that some encoding overhead was added to the secondary ID section and (in the case of Packed-Object compaction) the Aux format section, so that a decoder without access to the table can nonetheless output OIDs and data from the Packed Object according to the scheme specified in [I.5.2](#). Specifically, a full/restricted use bit set to "1" indicates that:

- for each encoded ID value, the encoder added an EBV-3 indicator to the secondary ID section, to indicate how many secondary ID bits were invoked by that ID value. If the EBV-3 is nonzero, then the secondary ID bits (as indicated by the table entry) immediately follow, followed in turn by another EBV-3, until the entire list of ID values has been represented.
- the encoder did not take advantage of the information from the referenced table's FormatString column. Instead, corresponding to each ID value, the encoder inserted an EBV-3 into the Aux format section, indicating the number of discrete data string lengths invoked by the ID value (which could be more than one due to combinations and/or optional components), followed by the indicated number of string lengths, each length encoded as though there were no FormatString in the ID table. All data items were encoded in the A/N subsection of the data section.

I.5.5 ID values representation, in an ID List Packed Object

Each ID value is represented within an IDLPO on a list of bit fields; the number of bit fields on the list is determined from the NumberOfIDs field (see [Table I.7](#)). Each ID value bit field's length is in the range of four to eleven bits, depending on the size of the base table index it represents. In the optional non-default format for an IDLPO's Object Info section, a single Packed Object may contain multiple ID List subsections, each referencing a different ID table. In this non-default format, each ID List subsection consists of an application indicator subsection (which terminates the ID Lists, if it begins with a "0" bit), followed by an EBV-3 NumberOfIDs, an ID List, and a full/restricted use flag.

I.5.6 ID values representation, in an ID Map Packed Object

Encoding an ID Map can be more efficient than encoding a list of ID values, when representing a relatively large number of ID values (constituting more than about 10 percent of a large base table's entries, or about 25 % of a small base table's entries). When encoded in an ID Map, each ID value is represented by its relative position within the map (for example, the first ID Map bit represents ID value "0", the third bit represents ID value "2", and the last bit represents ID value "n" (corresponding to the last entry of a base table with (n+1) entries). The value of each bit within an ID Map indicates whether the corresponding ID value is present (if the bit is "1₂") or absent (if "0₂"). An ID Map is always encoded as part of an ID Map section structure (see [I.9.2](#)).

I.5.7 Optional Addendum subsection of the Object Info section

I.5.7.1 Definition bits

The Packed Object Addendum feature supports basic editing operations, specifically the ability to add, delete, or replace individual data items in a previously written Packed Object, without a need to rewrite the entire Packed Object. A Packed Object that does not contain an Addendum subsection cannot be edited in this fashion and must be completely rewritten if changes are required.

An Addendum subsection consists of a Reverse Links bit, followed by a Child bit, followed by either one or two EBV-6 links. Links from a data Packed Object shall only go to other data Packed Objects as addenda; links from a directory Packed Object shall only go to other directory Packed Objects as addenda. The standard Packed Object structure rules apply, with some restrictions that are described in [I.5.7.3](#).

The Reverse Links bit shall be set identically in every Packed Object of the same "chain." The Reverse Links bit is defined as follows:

- If the Reverse Links bit is "0₂", then each child in this chain of Packed Objects is at a higher memory location than its parent. The link to a Child is encoded as the number of octets (plus one) that are in between the last octet of the current Packed Object and the first octet of the Child. The link to the parent is encoded as the number of octets (plus one) that are in between the first octet of the parent Packed Object and the first octet of the current Packed Object.
- If the Reverse Links bit is "1₂", then each child in this chain of Packed Objects is at a lower memory location than its parent. The link to a Child is encoded as the number of octets (plus one) that are in between the first octet of the current Packed Object and the first octet of the Child. The link to the parent is encoded as the number of octets (plus one) that are in between the last octet of the current Packed Object and the first octet of the parent.

The Child bit is defined as follows:

- If the Child bit is a "0", then this Packed Object is an editable "Parentless" Packed Object (i.e. the first of a chain), and in this case the Child bit is immediately followed by a single EBV-6 link to the first "child" Packed Object that contains editing addenda for the parent.
- If the Child bit is a "1", then this Packed Object is an editable "child" of an edited "parent," and the bit is immediately followed by one EBV-6 link to the "parent" and a second EBV-6 line to the next "child" Packed Object that contains editing addenda for the parent.

A link value of zero is a Null pointer (no child exists), and in a Packed Object whose Child bit is "0", this indicates that the Packed Object is editable, but has not yet been edited. A link to the Parent is provided, so that a directory may indicate the presence and location of an ID value in an Addendum Packed Object, while still providing an interrogator with the ability to efficiently locate the other ID values that are logically associated with the original "parent" Packed Object. A link value of zero is invalid as a pointer towards a Parent.

In order to allow room for a sufficiently-large link, when the future location of the next "child" is unknown at the time the parent is encoded, it is permissible to use the "redundant" form of the EBV-6 (for example using "100000₂ 000000₂" to represent a link value of zero).

I.5.7.2 Addendum "EditingOP" list (only in ID List Packed Objects)

In an IDLPO only, each Addendum section of a "child" ID List Packed Object contains a set of "EditingOp" bits encoded immediately after its last EBV-6 link. The number of such bits is determined from the number of entries on the Addendum Packed Object's ID list. For each ID value on this list, the corresponding EditingOp bit or bits are defined as follows:

- "1₂" means that the corresponding Fully-Qualified ID value (FQIDV) is Replaced. A Replace operation has the effect that the data originally associated with the FQIDV matching the FQIDV in this Addendum Packed Object shall be ignored, and logically replaced by the Aux format bits and data encoded in this Addendum Packed Object).
- "00₂" means that the corresponding FQIDV is Deleted but not replaced. In this case, neither the Aux format bits nor the data associated with this ID value are encoded in the Addendum Packed Object.
- "01₂" means that the corresponding FQIDV is Added (either this FQIDV was not previously encoded, or it was previously deleted without replacement). In this case, the associated Aux format bits and data shall be encoded in the Addendum Packed Object.

NOTE If an application requests several "edit" operations at once (including some Delete or Replace operations as well as Adds) then implementations can achieve more efficient encoding if the Adds share the Addendum overhead, rather than being implemented in a new Packed Object.

I.5.7.3 Packed Objects containing an Addendum subsection

A Packed Object containing an Addendum subsection is otherwise identical in structure to other Packed Objects. However, the following observations apply:

- A "parentless" Packed Object (the first in a chain) may be either an ID List Packed Object or an ID Map Packed Object (and a parentless IDMPPO may be either a data or directory IDMPPO). When a "parentless" PO is a directory, only directory IDMPPOs may be used as addenda. A directory IDMPPO's Map bits shall be updated to correctly reflect the end state of the chain of additions and deletions to the memory bank; an Addendum to the directory is not utilized to perform this maintenance (a directory addendum may only add new structural components, as described later in this section). In contrast, when the edited parentless object is an ID List Packed Object or ID Map Packed Object, its ID List or ID Map cannot be updated to reflect the end state of the aggregate Object (parents plus children).
- Although a "child" may be either an ID List or an ID Map Packed Object, only an IDLPO can indicate deletions or changes to the current set of fully-qualified ID values and associated data that is embodied in the chain.
- When a child is an IDMPPO, it shall only be utilized to add (not delete or modify) structural information and shall not be used to modify existing information. In a directory chain, a child IDMPPO may add new ID tables, or may add a new AuxMap section or subsections, or may extend an existing PO Index table or ObjectOffsets list. In a data chain, an IDMPPO shall not be used as an Addendum, except to add new ID tables.

- When a child is an IDLPO, its ID list (followed by "EditingOp" bits) lists only those FQIDVs that have been deleted, added, or replaced, relative to the cumulative ID list from the prior Objects linked to it.

I.6 Secondary ID bits section

The Packed Objects design requirements include a requirement that all of the data system Identifiers (e.g. AI"s, DI"s) encoded in a Packed Object can be fully recognised without expanding the compressed data, even though some ID values provide only a partially-qualified Identifier. As a result, if any of the ID values invoke secondary ID bits, the Object Info section shall be followed by a secondary ID bits section. Examples include a four-bit field to identify the third digit of a group of related Logistics AIs.

Secondary ID bits can be invoked for several reasons, as needed to fully specify Identifiers. For example, a single ID table entry's ID value may specify a choice between two similar identifiers (requiring one encoded bit to select one of the two IDs at the time of encoding), or may specify a combination of required and optional identifiers (requiring one encoded bit to enable or disable each option). The available mechanisms are described in [Annex J](#). All resulting secondary ID bit fields are concatenated in this secondary ID bits section, in the same order as the ID values that invoked them were listed within the Packed Object. Note that the secondary ID bits section is identically defined, whether the Packed Object is an IDLPO or an IDMPO but is not present in a directory IDMPO.

I.7 Aux format section

I.7.1 Definition bits

The Aux format section of a data Packed Object encodes auxiliary information for the decoding process. A directory Packed Object does not contain an Aux format section. In a data Packed Object, the Aux format section begins with "Compact-Parameter" bits as defined in [Table I.12](#).

Table I.12 — Compact-Parameter bit patterns

Bit pattern	Compaction method used in this Packed Object	Reference
"1"	"Packed-Object" compaction	I.7.3
"000"	"Application-Defined", as defined for the No-Directory access method	I.7.2
"001"	"Compact", as defined for the No-Directory access method	I.7.2
"010"	"UTF-8", as defined for the No-Directory access method	I.7.2
"011bbbb"	("bbbb" shall be in the range of 4 to 14): reserved for future definition	I.7.2

If the Compact-Parameter bit pattern is "1", then the remainder of the Aux format section is encoded as described in [I.7.3](#). Otherwise, the remainder of the Aux format section is encoded as described in [I.7.2](#).

I.7.2 Support for No-Directory compaction methods

If any of the No-Directory compaction methods were selected by the Compact-Parameter bits, then the Compact-Parameter bits are followed by a byte-alignment padding pattern consisting of zero or more "0" bits followed by a single "1" bit, so that the next bit after the "1" is aligned as the most-significant bit of the next byte.

This next byte is defined as the first octet of a "No-Directory data section", which is used in place of the data section described in [I.8](#). The data strings of this Packed Object are encoded in the order indicated by the Object Info section of the Packed Object, compacted exactly as described in [Annex D](#) (Encoding rules for No- Directory Access-Method), with the following two exceptions:

- The Object-Identifier is not encoded in the "No-Directory data section", because it has already been encoded into the Object Info and secondary ID sections.

- The Precursor is modified in that only the three Compaction Type Code bits are significant, and the other bits in the Precursor are set to "0".

Therefore, each of the data strings invoked by the ID table entry are separately encoded in a modified dataset structure as:

<modified precursor> <length of compacted object> <compacted object octets>

The <compacted object octets> are determined and encoded as described in [D.2.2](#) and [D.2.3](#), and the <length of compacted object> is determined and encoded as described in [D.3](#).

Following the last dataset, a terminating precursor value of zero shall not be encoded (the decoding system recognises the end of the data using the encoded ObjectLength of the Packed Object).

1.7.3 Support for the Packed-Object compaction method

If the Packed-Object compaction method was selected by the Compact-Parameter bits, then the Compact-Parameter bits are followed by zero or more Aux format bits, as may be invoked by the ID table entries used in this Packed Object. The Aux format bits are then immediately followed by a data section that uses the Packed-Object compaction method described in [1.8](#).

An ID table entry that was designed for use with the Packed-Object compaction method can call for various types of auxiliary information beyond the complete indication of the ID itself (such as bit fields to indicate a variable data length, to aid the data compaction process). All such bit fields are concatenated in this portion, in the order called for by the ID List or Map. Note that the Aux format section is identically defined, whether the Packed Object is an IDLPO or an IDMPO.

An ID table entry invokes Aux format length bits for all entries that are not specified as fixed-length in the table (however, these length bits are not actually encoded if they correspond to the last data item encoded in the A/N subsection of a Packed Object). This information allows the decoding system to parse the decoded data into strings of the appropriate lengths. An encoded Aux format length entry utilizes a variable number of bits, determined from the specified range between the shortest and longest data strings allowed for the data item, as follows:

- If a maximum length is specified, and the specified range (defined as the maximum length minus the minimum length) is less than eight, or greater than 44, then lengths in this range are encoded in the fewest number of bits that can express lengths within that range, and an encoded value of zero represents the minimum length specified in the format string. For example, if the range is specified as from three to six characters, then lengths are encoded using two bits, and "00" represents a length of three.
- Otherwise (including the case of an unspecified maximum length), the value (actual length–specified minimum) is encoded in a variable number of bits, as follows:
 - Values from 0 to 14 (representing lengths from 1 to 15, if the specified minimum length is one character, for example) are encoded in four bits
 - Values from 15 to 29 are encoded in eight bits (a prefix of "1111" followed by four bits representing values from 15 ("0000") to 29 ("1110"))
 - Values from 30 to 44 are encoded in twelve bits (a prefix of "1111 1111" followed by four bits representing values from 30 ("0000") to 44 ("1110"))
 - Values greater than 44 are encoded as a twelve-bit prefix of all "1"s, followed by an EBV-6 indication of (value – 44).

NOTE 1 If a range is specified with identical upper and lower bounds (i.e. a range of zero), this is treated as a fixed length, not a variable length, and no Aux format bits are invoked.

NOTE 2 If a range is unspecified, or has unspecified upper or lower bounds, then this is treated as a default lower bound of one, and/or an unlimited upper bound.

I.8 Data section

I.8.1 Structure

A data section is always present in a Packed Object, except in the case of a directory Packed Object or directory Addendum Packed Object (which encode no data elements), the case of a data Addendum Packed Object containing only Delete operations, and the case of a Packed Object that uses No-directory compaction (see [I.7.2](#)). When a data section is present, it follows the Object Info section (and the secondary ID and Aux format sections, if present). Depending on the characteristics of the encoded IDs and data strings, the data section may include one or both of two subsections in the following order: a Known-Length Numerics subsection, and an AlphaNumerics subsection. The following paragraphs provide detailed descriptions of each of these data section subsections. If all of the subsections of the data section are utilised in a Packed Object, then the layout of the data section is as shown in [Table I.13](#).

Table I.13 — Maximum structure of a Packed Objects data section

Known-Length Numeric subsection				AlphaNumeric subsection							
				A/N header bits				Binary data segments			
1st KLN Binary	2nd KLN Binary	...	Last KLN Binary	Non-Num base Bit(s)	Prefix bit, Prefix Run(s)	Suffix bit, Suffix Run(s)	Char Map	Ext'd. Num Binary	Ext'd Non- Num Binary	base 10 Binary	Non- Num Binary

I.8.2 Known-length-Numerics subsection of the data section

For always-numeric data strings, the ID table may indicate a fixed number of digits (this fixed-length information is not encoded in the Packed Object) and/or a variable number of digits (in which case the string's length was encoded in the Aux format section, as described above). When a single data item is specified in the FormatString column (see [I.3.4](#)) as containing a fixed-length numeric string followed by a variable-length alphanumeric string, the numeric string is encoded in the Known-length-numerics subsection and the alphanumeric string in the alphanumeric subsection.

The summation of fixed-length information (derived directly from the ID table) plus variable-length information (derived from encoded bits as just described) results in a "known-length entry" for each of the always-numeric strings encoded in the current Packed Object. Each all-numeric data string in a Packed Object (if described as all-numeric in the ID table) is encoded by converting the digit string into a single binary number (up to 160 bits, representing a binary value between 0 and $(10^{48} - 1)$). [Table K.1](#) shows the number of bits required to represent a given number of digits. If an all-numeric string contains more than 48 digits, then the first 48 are encoded as one 160-bit group, followed by the next group of up to 48 digits, and so on. Finally, the binary values for each all-numeric data string in the Object are themselves concatenated to form the Known-length-Numerics subsection.

I.8.3 Alphanumeric subsection of the data section

I.8.3.1 General

The Alphanumeric (A/N) subsection, if present, encodes all the Packed Object's data from any data strings that were not already encoded in the Known-length Numerics subsection. If there are no alphanumeric characters to encode, the entire A/N subsection is omitted. The Alphanumeric subsection can encode any mix of digits and non-digit ISO/IEC 646 characters, or eight-bit data. The digit characters within this data are encoded separately, at an average efficiency of 4.322 bits per digit or better, depending on the character sequence. The non-digit characters are independently encoded at an average efficiency that varies between 5.91 bits per character or better (all uppercase letters), to a worst-case limit of 9 bits per character (if the character mix requires base 256 encoding of non-numeric characters).

An Alphanumeric subsection consists of a series of A/N header bits (see [1.8.3.2](#)), followed by from one to four binary segments (each segment representing data encoded in a single numerical base, such as base 10 or base 30, see [1.8.3.5](#)), padded if necessary to complete the final byte (see [1.8.3.6](#)).

1.8.3.2 A/N header bits

The A/N header bits are defined as follows:

- One or two Non-Numeric base bits, as follows:
 - "0₂" indicates that base 30 was chosen for the non-numeric base;
 - "10₂" indicates that base 74 was chosen for the non-numeric base;
 - "11₂" indicates that base 256 was chosen for the non-numeric base;
- Either a single "0₂" bit (indicating that no Character Map Prefix is encoded), or a "1₂" bit followed by one or more "Runs" of six Prefix bits as defined in [1.8.3.4](#).
- Either a single "0₂" bit (indicating that no Character Map Suffix is encoded), or a "1₂" bit followed by one or more "Runs" of six Suffix bits as defined in [1.8.3.4](#).
- A variable-length "Character Map" bit pattern (see [1.8.3.3](#)), representing the base of each of the data characters, if any, that were not accounted for by a Prefix or Suffix.

1.8.3.3 Dual-base Character-map encoding

Compaction of the ordered list of alphanumeric data strings (excluding those data strings already encoded in the Known-Length Numerics subsection) is achieved by first concatenating the data characters into a single data string (the individual string lengths have already been recorded in the Aux format section). Each of the data characters is classified as either base 10 (for numeric digits), base 30 non-numerics (primarily uppercase A-Z), base 74 non-numerics (which includes both uppercase and lowercase alphas, and other ISO/IEC 646 characters), or base 256 characters. These character sets are fully defined in [Annex K](#). All characters from the base 74 set are also accessible from base 30 via the use of an extra "shift" value (as are most of the lower 128 characters in the base 256 set). Depending on the relative percentage of "native" base 30 values vs. other values in the data string, one of those bases is selected as the more efficient choice for a non-numeric base.

Next, the precise sequence of numeric and non-numeric characters is recorded and encoded, using a variable-length bit pattern, called a "character map," where each "0" represents a base 10 value (encoding a digit) and each "1₂" represents a value for a non-numeric character (in the selected base). Note that, if (for example) base 30 encoding was selected, each data character (other than uppercase letters and the space character) shall be represented by a pair of base 30 values, and thus each such data character is represented by a *pair* of "1₂" bits in the character map.

1.8.3.4 Prefix and Suffix Run-Length encoding

For improved efficiency in cases where the concatenated sequence includes runs of six or more values from the same base, provision is made for optional run-length representations of one or more Prefix or Suffix "Runs" (single-base character sequences), which can replace the first and/or last portions of the character map. The encoder shall not create a Run that separates a Shift value from its next (shifted) value, and thus a Run always represents an integral number of source characters.

An optional Prefix Representation, if present, consists of one or more occurrences of a Prefix Run. Each Prefix Run consists of one Run Position bit, followed by two Basis bits, then followed by three Run Length bits, defined as follows:

- The Run Position bit, if "0₂", indicates that at least one more Prefix Run is encoded following this one (representing another set of source-characters to the right of the current set). The Run Position bit, if "1₂", indicates that the current Prefix Run is the last (rightmost) Prefix Run of the A/N subsection.

- The first basis bit indicates a choice of numeric vs. non-numeric base, and the second basis bit, if "1₂", indicates that the chosen base is extended to include characters from the "opposite" base. Thus, "00₂" indicates a run-length-encoded sequence of base 10 values; "01₂" indicates a sequence that is primarily (but not entirely) digits, encoded in base 13; "10₂" indicates a sequence a sequence of values from the non-numeric base that was selected earlier in the A/N header, and "11₂" indicates a sequence of values primarily from that non-numeric base, but extended to include digit characters as well. Note an exception: if the non-numeric base that was selected in the A/N header is base 256, then the "extended" version is defined to be base 40.
- The 3-bit Run Length value assumes a minimum useable run of six same-base characters, and the length value is further divided by 2. Thus, the possible 3-bit Run Length values of 0, 1, 2, ... 7 indicate a Run of 6, 8, 10, ... 20 characters from the same base. Note that a trailing "odd" character value at the end of a same-base sequence must be represented by adding a bit to the Character Map.

An optional Suffix Representation, if present, is a series of one or more Suffix Runs, each identical in format to the Prefix Run just described. Consistent with that description, note that the Run Position bit, if "1", indicates that the current Suffix Run is the last (rightmost) Suffix Run of the A/N subsection, and thus any preceding Suffix Runs represented source characters to the left of this final Suffix Run.

1.8.3.5 Encoding into binary segments

Immediately after the last bit of the Character Map, up to four binary numbers are encoded, each representing all of the characters that were encoded in a single base system. First, a base 13-bit sequence is encoded (if one or more Prefix or Suffix Runs called for base 13 encoding). If present, this bit sequence directly represents the binary number resulting from encoding the combined sequence of all Prefix and Suffix characters (in that order) classified as base 13 (ignoring any intervening characters not thus classified) as a single value, or in other words, applying a base 13 to binary conversion. The number of bits to encode in this sequence is directly determined from the number of base 13 values being represented, as called for by the sum of the Prefix and Suffix Run lengths for base 13 sequences. The number of bits, for a given number of base 13 values, is determined from the [Table K.1](#). Next, an Extended-NonNumeric base segment (either base 40 or base 84) is similarly encoded (if any Prefix or Suffix Runs called for Extended-NonNumeric encoding).

Next, a base 10 binary segment is encoded that directly represents the binary number resulting from encoding the sequence of the digits in the Prefix and/or character map and/or Suffix (ignoring any intervening non-digit characters) as a single value, or in other words, applying a base 10 to binary conversion. The number of bits to encode in this sequence is directly determined from the number of digits being represented, as shown in [Annex K](#).

Immediately after the last bit of the base 10-bit sequence (if any), a non-numeric (base 30, base 74, or base 256) bit sequence is encoded (if the character map indicates at least one non-numeric character). This bit sequence represents the binary number resulting from a base 30 to binary conversion (or a base 74 to binary conversion, or a direct transfer of base 256 values) of the sequence of non-digit characters in the data (ignoring any intervening digits). Again, the number of encoded bits is directly determined from the number of non-numeric values being represented, as shown in [Annex K](#). Note that if base 256 was selected as the non-numeric base, then the encoder is free to classify and encode each digit either as base 10 or as base 256 (base 10 will be more efficient, unless outweighed by the ability to take advantage of a long Prefix or Suffix).

Note that an alphanumeric subsection ends with several variable-length bit fields (the character map, and one or more binary sections representing the numeric and non-numeric binary values). Note further that none of the lengths of these three variable-length bit fields are explicitly encoded (although one or two Extended-base binary segments may also be present, these have known lengths determined from Prefix and/or Suffix runs). In order to determine the boundaries between these three variable-length fields, the decoder shall implement a procedure, using knowledge of the remaining number of data bits, in order to correctly parse the alphanumeric subsection. An example of such a procedure is described in [Annex M](#).

I.8.3.6 Padding the last byte

The last (least-significant) bit of the final binary segment is also the last significant bit of the Packed Object. If there are any remaining bit positions in the last byte to be filled with pad bits, then the most significant pad bit shall be set to "1₂", and any remaining less-significant pad bits shall be set to "0₂". The decoder can determine the total number of non-pad bits in a Packed Object by examining the Length section of the Packed Object (and if the pad indicator bit of that section is "1₂", by also examining the last byte of the Packed Object).

I.9 ID Map and directory encoding options

I.9.1 General

An ID Map can be more efficient than a list of ID values, when encoding a relatively large number of ID values. Additionally, an ID Map representation is advantageous for use in a directory Packed Object. The ID Map itself (the first major subsection of every ID Map section) is structured identically whether in a data or directory IDMPPO, but a directory IDMPPO's ID Map section contains additional optional subsections. The structure of an ID Map section, containing one or more ID Maps, is described in [I.9.2](#), explained in terms of its usage in a data IDMPPO; subsequent sections explain the added structural elements in a directory IDMPPO.

I.9.2 ID Map section structure

I.9.2.1 Values

An IDMPPO represents ID values using a structure called an ID Map section, containing one or more ID Maps. Each ID value encoded in a data IDMPPO is represented as a "1₂" bit within an ID Map bit field, whose fixed length is equal to the number of entries in the corresponding base table. Conversely, each "0₂" in the ID Map field indicates the absence of the corresponding ID value. Since the total number of "1₂" bits within the ID Map field equals the number of ID values being represented, no explicit NumberOfIDs field is encoded. To implement the range of functionality made possible by this representation, the ID Map section contains elements other than the ID Map itself. If present, the optional ID Map section immediately follows the leading pattern indicating an IDMPPO (as was described in [I.4.3](#)), and contains the following elements in the order listed below:

- An application indicator subsection (see [I.5.4.2](#));
- an ID Map bit field (whose length is determined from the ID Size in the application indicator);
- a full/restricted use bit (see [I.5.4.3](#));
- (the above sequence forms an ID Map, which may optionally repeat multiple times);
- a data/Directory indicator bit;
- an optional AuxMap section (never present in a data IDMPPO);
- Closing flag(s), consisting of an "Addendum flag" bit. If "1₂", then an Addendum subsection is present at the end of the Object Info section (after the Object length information).

These elements, shown in [Table I.14](#) as a maximum structure (every element is present), are described in each of the next subsections.

Table I.14 — ID Map section

First ID Map		Optional additional ID Map(s)		Null App indicator (single zero bit)	Data/ directory indicator bit	(if directory) Optional AuxMap section	Closing flag bit(s)
App indicator	ID Map bit field (ends with F/R bit)	App indicator	ID Map field (ends with F/R bit)				
See I.5.4.2	See I.9.2.2 and I.5.4.3	As previous	As previous	See I.5.4.2		See Table I.15	Addendum flag bit

When an ID Map section is encoded, it is always followed by an Object Length and pad indicator, and optionally followed by an Addendum subsection (all as have been previously defined), and then may be followed by any of the other sections defined for Packed Objects, except that a directory IDMP shall not include a data section.

I.9.2.2 ID Map and ID Map bit field

An ID Map usually consists of an application indicator followed by an ID Map bit field, ending with a full/restricted use bit. An ID Map bit field consists of a single "MapPresent" flag bit, then (if MapPresent is "1₂") a number of bits equal to the length determined from the ID Size pattern within the application indicator, plus one (the full/restricted use bit). The ID Map bit field indicates the presence/absence of encoded data items corresponding to entries in a specific registered primary or alternate base table. The choice of base table is indicated by the encoded combination of DSFID and application indicator pattern that precedes the ID Map bit field. The MSB of the ID Map bit field corresponds to ID value 0 in the base table, the next bit corresponds to ID value 1, and so on.

In a data Packed Object's ID Map bit field, each "1₂" bit indicates that this Packed Object contains an encoded occurrence of the data item corresponding to an entry in the registered base table associated with this ID Map. Note that the valid encoded entry may be found either in the first ("parentless") Packed Object of the chain (the one containing the ID Map) or in an Addendum IDLPO of that chain. Note further that one or more data entries may be encoded in an IDMP but marked "invalid" (by a Delete entry in an Addendum IDLPO).

An ID Map shall not correspond to a secondary ID table instead of a base ID table. Note that data items encoded in a "parentless" data IDMP shall appear in the same relative order in which they are listed in the associated base table. However, additional "out of order" data items may be added to an existing data IDMP by appending an Addendum IDLPO to the Object.

An ID Map cannot indicate a specific number of instances (greater than one) of the same ID value, and this would seemingly imply that only one data instance using a given ID value can be encoded in a data IDMP. However, the ID Map method shall support the case where more two or more encoded data items are from the same identifier "class" (and thus share the same ID value). The following mechanisms address this need:

- Another data item of the same class can be encoded in an Addendum IDLPO of the IDMP. Multiple occurrences of the same ID value can appear on an ID List, each associated with different encoded values of the secondary ID bits.
- A series of two or more encoded instances of the same "class" can be efficiently indicated by a single instance of an ID value (or equivalently by a single ID Map bit), if the corresponding base table entry defines a "Repeat" bit (see [I.3.3](#)).

An ID Map section may contain multiple ID Maps; a null application indicator section (with its AppIndicatorPresent bit set to "0") terminates the list of ID Maps.

I.9.2.3 Data/Directory and AuxMap indicator bits

A data/Directory indicator bit is always encoded immediately following the last ID Map. By definition, a data IDMP has its data/Directory bit set to "0₂", and a directory IDMP has its data/Directory bit

set to "1₂". If the data/Directory bit is set to "1₂", it is immediately followed by an AuxMap indicator bit which, if "1₂", indicates that an optional AuxMap section immediately follows.

I.9.2.4 Closing flags bit(s)

The ID Map section ends with a single Closing flag. The final bit of the Closing flags is an addendum flag bit which, if "1₂", indicates that there is an optional Addendum subsection encoded at the end of the Object Info section of the Packed Object. If present, the Addendum subsection is as described in [I.5.7](#).

I.9.3 Directory Packed Objects

I.9.3.1 General

A directory Packed Object is an IDMPO whose directory bit is set to "1". Its only inherent difference from a data IDMPO is that it does not contain any encoded data items. However, additional mechanisms and usage considerations apply only to a directory Packed Object, and these are described in the following subsections.

I.9.3.2 ID Maps in a directory IDMPO

Although the structure of an ID Map is identical whether in a data or directory IDMPO, the semantics of the structure are somewhat different. In a directory Packed Object's ID Map bit field, each "1" bit indicates that a data Packed Object in the same data carrier memory bank contains a valid data item associated with the corresponding entry in the specified base table for this ID Map. Optionally, a directory Packed Object may further indicate *which* Packed Object contains each data item (see the description of the optional AuxMap section below).

Note that, in contrast to a data IDMPO, there is no required correlation between the order of bits in a directory's ID Map and the order in which these data items are subsequently encoded in memory within a sequence of data Packed Objects.

I.9.3.3 Optional AuxMap section (Directory IDMPOs only)

An AuxMap section optionally allows a directory IDMPO's ID Map to indicate not only presence/absence of all the data items in this memory bank of the tag, but also which Packed Object encodes each data item. If the AuxMap indicator bit is "1₂", then an AuxMap section shall be encoded immediately after this bit. If encoded, the AuxMap section shall contain one PO Index field for each of the ID Maps that precede this section. After the last PO Index field, the AuxMap section may optionally encode an ObjectOffsets list, where each ObjectOffset generally indicates the number of bytes from the start of the previous Packed Object to the start of the next Packed Object. This AuxMap structure is shown (for an example IDMPO with two ID Maps) in [Table I.15](#).

Table I.15 — Compact-Parameter bit patterns

PO Index field for first ID Map		PO Index field for second ID Map		Object Offsets Present bit	Optional ObjectOffsets subsection				
POindex Length	POindex Table	POindex Length	POindex Table		Object Offsets Multiplier	Object1 offset (EBV6)	Object2 offset (EBV6)	...	ObjectN offset (EBV6)

Each PO Index field has the following structure and semantics:

- A three-bit POindexLength field, indicating the number of index bits encoded for each entry in the PO index table that immediately follows this field (unless the POindex length is "000", which means that no PO index table follows).
- A PO index table, consisting of an array of bits, one bit (or group of bits, depending on the POindexLength) for every bit in the corresponding ID Map of this directory packed object. A PO index table entry (i.e. a "PO Index") indicates (by relative order) which Packed Object contains the data

item indicated by the corresponding "1" bit in the ID Map. If an ID Map bit is "0", the corresponding PO index table entry is present, but its contents are ignored.

- Every Packed Object is assigned an index value in sequence, without regard as to whether it is a "parentless" Packed Object or a "child" of another Packed Object, or whether it is a data or directory Packed Object.
- If the PO Index is within the first PO index table (for the associated ID Map) of the directory "chain", then:
 - a PO Index of zero refers to the first Packed Object in memory,
 - a value of one refers to the next Packed Object in memory, etc,
 - a value of m , where m is the largest value that can be encoded in the PO Index (given the number of bits per index that was set in the POindexLength), indicates a Packed Object whose relative index (position in memory) is m or higher. This definition allows Packed Objects higher than m to be indexed in an Addendum directory Packed Object, as described immediately below. If no addendum exists, then the precise position is either m or some indeterminate position greater than m .
- If the PO Index is not within the first PO index table of the directory chain for the associated ID Map (i.e. it is in an Addendum IDMPO), then:
 - a PO Index of zero indicates that a prior PO index table of the chain provided the index information,
 - a PO Index of n ($n > 0$) refers to the n th Packed Object above the highest index value available in the immediate parent directory PO; e.g. if the maximum index value in the immediate parent directory PO refers to PO number "3 or greater," then a PO index of 1 in this addendum refers to PO number 4,
 - a PO Index of m (as defined above) similarly indicates a Packed Object whose position is the m th position, or higher, than the limit of the previous table in the chain,
- If the valid instance of an ID value is in an Addendum Packed Object, an implementation may choose to set a PO Index to point directly to that addendum, or may instead continue to point to the Packed Object in the chain that originally contained the ID value.

NOTE The first approach sometimes leads to faster searching; the second sometimes leads to faster directory updates.

After the last PO Index field, the AuxMap section ends with (at minimum) a single "ObjectOffsets Present" bit. A "0" value of this bit indicates that no ObjectOffsets subsection is encoded. If instead this bit is a "1", it is immediately followed by an ObjectOffsets subsection, which holds a list of EBV-6 "offsets" (the number of octets between the start of a Packed Object and the start of the next Packed Object). If present, the ObjectOffsets subsection consists of an ObjectOffsetsMultiplier followed by an ObjectOffsets list, defined as follows:

- An EBV-6 ObjectOffsetsMultiplier, whose value, when multiplied by 6, sets the total number of bits reserved for the entire ObjectOffsets list. The value of this multiplier should be selected to ideally result in sufficient storage to hold the offsets for the maximum number of Packed Objects that can be indexed by this directory Packed Object's PO index table (given the value in the POindexLength field, and given some estimated average size for those Packed Objects).
- a fixed-sized field containing a list of EBV-6 ObjectOffsets. The size of this field is exactly the number of bits as calculated from the ObjectOffsetsMultiplier. The first ObjectOffset represents the start of the second Packed Object in memory, relative to the first octet of memory (there would be little benefit in reserving extra space to store the offset of the *first* Packed Object). Each succeeding ObjectOffset indicates the start of the next Packed Object (relative to the previous ObjectOffset on the list), and the final ObjectOffset on the list points to the all-zero termination pattern where the

next Packed Object may be written. An invalid offset of zero (EBV-6 pattern "000000") shall be used to terminate the ObjectOffset list. If the reserved storage space is fully occupied, it shall not include this terminating pattern.

- In applications where the average Packed Object length is difficult to predict, the reserved ObjectOffset storage space may sometimes prove to be insufficient. In this case, an Addendum Packed Object can be appended to the directory Packed Object. This Addendum directory Packed Object may contain null subsections for all but its ObjectOffsets subsection. Alternately, if it is anticipated that the capacity of the PO index table will also eventually be exceeded, then the Addendum Packed Object may also contain one or more non-null PO Index fields. Note that in a given instance of an AuxMap section, either a PO index table or an ObjectOffsets subsection may be the first to exceed its capacity. Therefore, the first position referenced by an ObjectOffsets list in an Addendum Packed Object need not coincide with the first position referenced by the PO index table of that same Addendum. Specifically, in an Addendum Packed Object, the first ObjectOffset listed is an offset referenced to the last ObjectOffset on the list of the "parent" directory Packed Object.

I.9.3.4 Usage as a Presence/Absence directory

In many applications, an Interrogator may choose to read the entire contents of any data carrier containing one or more "target" data items of interest. In such applications, the positional information of those data items within the memory is not needed during the initial reading operations; only a presence/absence indication is needed at this processing stage. An ID Map can form a particularly efficient Presence/Absence directory for denoting the contents of a data carrier in such applications. A full directory structure encodes the offset or address (memory location) of every data element within the data carrier, which requires the writing of many bits (typically 32 bits or more per data item). Inevitably, such an approach also requires reading many bits over the air, just to determine whether an identifier of interest is present on a particular tag. In contrast, when only presence/absence information is needed, using an ID Map conveys the same information using only one bit per data item defined in the data system. The entire ID Map can be typically represented in 128 bits or less and stays the same size as more data items are written to the tag.

A "Presence/Absence directory" Packed Object is defined as a directory IDMPPO that does not contain a PO Index, and therefore provides no encoded information as to where individual data items reside within the data carrier. A Presence/Absence directory can be converted to an "Indexed directory" Packed Object (see [I.9.3.5](#)) by adding a PO Index in an Addendum Packed Object, as a "child" of the Presence/Absence Packed Object.

I.9.3.5 Usage as an Indexed directory

In many applications involving large memories, an Interrogator may choose to read a directory section covering the entire memory's contents, and then issue subsequent Reads to fetch the "target" data items of interest. In such applications, the positional information of those data items within the memory is important, but if many data items are added to a large memory over time, the directory itself can grow to an undesirable size.

An ID Map, used in conjunction with an AuxMap containing a PO Index, can form a particularly efficient "Indexed directory" for denoting the contents of an RFID tag, and their approximate locations as well. Unlike a full tag directory structure, which encodes the offset or address (memory location) of every data element within the data carrier, an Indexed directory encodes a small relative position or index indicating which Packed Object contains each data element. An application designer may choose to also encode the locations of each Packed Object in an optional ObjectOffsets subsection as described above, so that a decoding system, upon reading the Indexed directory alone, can calculate the start addresses of all Packed Objects in memory.

The utility of an ID Map used in this way is enhanced by the rule of most data systems that a given identifier may only appear once within a single data carrier. This rule, when an Indexed directory is utilized with Packed Object encoding of the data in subsequent objects, can provide nearly complete random access to reading data using relatively few directory bits. As an example, an ID Map directory (one bit per defined ID) can be associated with an additional AuxMap "PO Index" array (using, for

example, three bits per defined ID). Using this arrangement, an interrogator would read the directory Packed Object, and examine its ID Map to determine if the desired data item were present on the tag. If so, it would examine the 3 "PO Index" bits corresponding to that data item, to determine which of the first 8 Packed Objects on the tag contain the desired data item. If an optional ObjectOffsets subsection was encoded, then the Interrogator can calculate the starting address of the desired Packed Object directly; otherwise, the interrogator may perform successive read operations to fetch the desired Packed Object.

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Annex J (normative)

Packed Objects ID tables

J.1 General

This annex defines the Packed Objects ID table format definition, to be used by all registered ID tables. These ID tables, customised for each data system, will be registered with the Registration Authority denoted by ISO/IEC 15961-2.

J.2 Packed Objects data format registration file structure

J.2.1 Format

A Packed Objects registered data format file consists of a series of "Keyword lines" and one or more ID tables. Blank lines may occur anywhere within a data format File and are ignored. Also, any line may end with extra blank columns, which are also ignored.

- A keyword line consists of a keyword (which always starts with "K-") followed by an equal sign and a character string, which assigns a value to that keyword. Zero or more space characters may be present on either side of the equal sign. Some keyword lines shall appear only once, at the top of the registration file, and others may appear multiple times, once for each ID table in the file.
- An ID table lists a series of ID values (as defined in [I.5.4](#)). Each row of an ID table contains a single ID value (in a required "IDvalue" column), and additional columns may associate Object IDs (OIDs), ID strings, format strings, and other information with that ID value. A registration file always includes a single "Primary" base ID table, zero or more alternate base ID tables, and may also include one or more secondary ID tables (that are referenced by one or more base ID table entries).

To illustrate the file format, a hypothetical data system registration is shown in [Table J.1](#). In this hypothetical data system, each ID value is associated with one or more OIDs and corresponding ID strings. The following subsections explain the syntax shown in [Table J.1](#).

J.2.2 File header section

Keyword lines in the file header (the first portion of every registration file) may occur in any order, and are as follows:

- (Mandatory) K-Version = nn.nn, which the registering body assigns, to ensure that any future revisions to their registration are clearly labelled.
- (Optional) K-Interpretation = string, where the "string" argument shall be one of the following: "ISO-646", "UTF-8", "ECI-nnnnnn" (where nnnnnn is a registered six-digit ECI number), ISO-8859-nn, or "UNSPECIFIED". The Default interpretation is "UNSPECIFIED". This keyword line allows non-default interpretations to be placed on the octets of data strings that are decoded from Packed Objects.
- (Optional) K-ISO15434=nn, where "nn" represents a format indicator (a two-digit numeric identifier) as defined in ISO/IEC 15434. This keyword line allows receiving systems to optionally represent a decoded Packed Object as a fully conformant ISO/IEC 15434 message. There is no default value for this keyword line.

- (Optional) K-AppPunc = nn, where nn represents (in decimal) the octet value of an ISO/IEC 646 character that is commonly used for punctuation in this application. If this keyword line is not present, the default application punctuation character is the hyphen.

In addition, comments may be included using the optional keyword assignment line "K-text = string" and may appear zero or more times within a file header or table header, but not in an ID table body.

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Table J.1 — Hypothetical data format registration file

K-Text = Hypothetical data format 100				
K-Version = 1.0				
K-TableID = F100B0				
K-RootOID = urn:oid:1.0.12345.100				
K-IDsize = 16				
IDvalue	OIDs	IDstring	Explanation	FormatString
0	99	1Z	Legacy ID "1Z" corresponds to OID 99, is assigned IDval 0	14n
1	9 %x30-33	7 %x42-45	An OID in the range 90 to 93, Corresponding to ID 7B..7E	1*8an
2	(10)(20)(25)(37)	(A)(B)(C)(D)	a commonly used set of IDs	(1n)(2n)(3n)(4n)
3	26/27	1A/2B	Either 1A or 2B is encoded, but not both	10n / 20n
4	(30) [31]	(2A) [3B]	2A is always encoded, optionally followed by 3B	(11n) [1*20n]
5	(40/41/42) (53) [55]	(4A/4B/4C) (5D) [5E]	One of A/B/C is encoded, then D, and optionally E	(1n/2n/3n) (4n) [5n]
6	(60/61/ (64)[66])	(6A /6B / (6C) [6D])	Selections, one of which includes an Option	(1n / 2n / ([3n][4n])
K-TableEnd = F100B0				

J.2.3 Table header section

One or more table header sections (each introducing an ID table) follow the file header section. Each table header begins with a K-TableID keyword line, followed by a series of additional required and optional keyword lines, (which may occur in any order) as follows:

- (Mandatory) K-TableID = FnnXnn, where Fnn represents the ISO-assigned data format number (where "nn" represents one or more decimal digits), and Xnn (where "X" is either "B" or "S") is a registrant-assigned table ID for each ID table in the file. The first ID table shall always be the primary base ID table of the registration, with a table ID of "B0". As many as seven additional alternate base ID tables may be included, with higher sequential "Bnn" table IDs. Secondary ID tables may be included, with sequential table IDs of the form "Snn".
- (Mandatory) K-IDsize = nn: For a base ID table, the value nn shall be one of the values from the "Maximum number of table entries" column of [Table I.6](#). For a secondary ID table, the value nn shall be a power of two (even if not present in [Table I.6](#)).
- (Optional) K-RootOID = urn:oid:i.j.k.ff where:
 - I, j, and k are the leading arcs of the OID (as many arcs as required);

- ff is the last arc of the Root OID (typically, the registered data format number). If the K-RootOID keyword is not present, then the default Root OID is urn:oid:1.0.15961.ff, where "ff" is the registered data format number.
- Other optional keyword lines: to override the file-level defaults (to set different values for a particular table), a table header may invoke one or more of the optional keyword lines listed in for the file header section.

The end of the table header section is the first non-blank line that does not begin with a keyword. This first non-blank line shall list the titles for every column in the ID table that immediately follows this line; column titles are case-sensitive.

An alternate base ID table, if present, is identical in format to the primary base ID table (but usually represents a smaller choice of identifiers, targeted for a specific application).

A secondary ID table can be invoked by a keyword in a base table's OIDs column. A secondary ID table is equivalent to a single Selection list (see [J.4](#)) for a single ID value of a base ID table (except that a secondary table uses K-Idsize to explicitly define the number of secondary ID bits per ID); the IDvalue column of a secondary table lists the value of the corresponding secondary ID bits pattern for each row in the secondary table. An OIDs entry in a secondary ID table shall not itself contain a Selection list nor invoke another secondary ID table.

J.2.4 ID table section

Each ID table consists of a series of one or more rows, each row including a mandatory "IDvalue" column, several defined optional columns (such as "OIDs", "IDstring", and "FormatString"), and any number of informative columns (such as the "Explanation" column in the hypothetical example shown above).

Each ID table ends with a required keyword line of the form:

K-TableEnd = FnnXnn, where FnnXnn shall match the preceding K-TableID keyword line that introduced the table.

The syntax and requirements of all Mandatory and optional columns shall be as described [J.3](#).

J.3 Mandatory and optional ID table columns

J.3.1 Format

Each ID Table in a Packed Objects registration shall include an IDvalue column and may include other columns that are defined in this specification as optional, and/or Informative columns (whose column heading is not defined in this specification).

J.3.2 IDvalue column (Mandatory)

Each ID table in a Packed Objects registration shall include an IDvalue column. The ID values on successive rows shall increase monotonically. However, the table may terminate before reaching the full number of rows indicated by the keyword line containing K-IDsize. In this case, a receiving system will assume that all remaining ID values are reserved for future assignment (as if the OIDs column contained the keyword "K-RFA"). If a registered base ID table does not include the optional OIDs column described below, then the IDvalue shall be used as the last arc of the OID.

J.3.3 OIDs and IDstring columns (Optional)

A Packed Objects registration always assigns a final OID arc to each identifier (either a number assigned in the "OIDs" column as will be described below, or if that column is absent, the IDvalue is assigned as the default final arc). The OIDs column is required rather than optional, if a single IDvalue is intended to represent either a combination of OIDs or a choice between OIDs (one or more secondary ID bits are invoked by any entry that presents a choice of OIDs).

A Packed Objects registration may include an IDString column, which if present assigns an ISO/IEC 646-string name for each OID. If no name is provided, systems must refer to the identifier by its OID (see J.5). However, many registrations will be based on data systems that do have an ISO/IEC 646 representation for each defined Identifier and receiving systems may optionally output a representation based on those strings. If so, the ID table may contain a column indicating the IDstring that corresponds to each OID. An empty IDstring cell means that there is no corresponding ISO/IEC 646 string associated with the OID. A non-empty IDstring shall provide a "name" for every OID invoked by the OIDs column of that row (or a single name, if no OIDs column is present). Therefore, the sequence of combination and selection operations in an IDstring shall exactly match those in the row's OIDs column.

A non-empty OIDs cell may contain either a keyword, an ISO/IEC 646 string representing (in decimal) a single OID value, or a compound string (in ABNF notation) that defines a choice and/or a combination of OIDs. The detailed syntax for compound OID strings in this column (which also applies to the IDstring column) is as defined in J.4. Instead of containing a simple or compound OID representation, an OIDs entry may contain one of the following keywords:

- K-Verbatim = OIDddBnn, where "dd" represents the chosen penultimate arc of the OID, and "Bnn" indicates one of the base 10, base 40, or base 74 encoding tables. This entry invokes several secondary ID bits that serve two purposes:
 - They encode an ISO/IEC 646 identifier "name" that might not have existed at the time the table was registered. The name is encoded in the secondary ID bits section as a series of base n values representing the ISO/IEC 646 characters of the name, preceded by a four-bit field indicating the number of base n values that follow (zero is permissible, in order to support RFA entries as described below).
 - The cumulative value of these secondary ID bits, considered as a single unsigned binary integer and converted to decimal, is the final "arc" of the OID for this "verbatim-encoded" identifier.
- K-Secondary = Snn, where "Snn" represents the Table ID of a secondary ID table in the same registration file. This is equivalent to a base ID table row OID entry that contains a single Selection list (with no other components at the top level), but instead of listing these components in the base ID table, each component is listed as a separate row in the secondary ID table, where each may be assigned a unique OID, IDString, and FormatString.
- K-Proprietary=OIDddPnn, where nn represents a fixed number of secondary ID bits that encode an optional Enterprise Identifier indicating who wrote the proprietary data (an entry of K-Proprietary=OIDddP0 indicates an "anonymous" proprietary data item).
- K-RFA = OIDddBnn, where "Bnn" is as defined above for Verbatim encoding, except that "B0" is a valid assignment (meaning that no secondary ID bits are invoked). This keyword represents a Reserved for Future Assignment entry, with an option for Verbatim encoding of the Identifier "name" once a name is assigned by the entity who registered this data format. Encoders may use this entry, with a four-bit "verbatim" length of zero, until an Identifier "name" is assigned. A specific FormatString may be assigned to K-RFA entries, or the default a/n encoding may be utilized.

Finally, any OIDs entry may end with a single "R" character (preceded by one or more space characters), to indicate that a "Repeat" bit shall be encoded as the last secondary ID bit invoked by the entry. If "1", this bit indicates that another instance of this class of identifier is also encoded (that is, this bit acts as if a repeat of the ID value were encoded on an ID list). If "1", then this bit is followed by another series of secondary ID bits, to represent the particulars of this additional instance of the ID value.

An IDstring column shall not contain any of the above-listed keyword entries, and an IDstring entry shall be empty when the corresponding OIDs entry contains a keyword.

J.3.4 FormatString column (Optional)

An ID table may optionally define the data characteristics of the data associated with a particular identifier, in order to facilitate data compaction. If present, the FormatString entry specifies whether a data item is all-numeric or alphanumeric (i.e. may contain characters other than the decimal digits) and

specifies either a fixed length or a variable length. If no FormatString entry is present, then the default data characteristic is alphanumeric. If no FormatString entry is present, or if the entry does not specify a length, then any length ≥ 1 is permitted. Unless a single fixed length is specified, the length of each encoded data item is encoded in the Aux format section of the Packed Object, as specified in [I.7](#).

If a given IDstring entry defines more than a single identifier, then the corresponding FormatString column shall show a format string for each such identifier, using the same sequence of punctuation characters (disregarding concatenation) as was used in the corresponding IDstring.

The format string for a single identifier shall be one of the following:

- A length qualifier followed by "n" (for always-numeric data);
- A length qualifier followed by "an" (for data that may contain non-digits); or
- A fixed-length qualifier, followed by "n", followed by one or more space characters, followed by a variable-length qualifier, followed by "an".

A length qualifier shall be either null (that is, no qualifier present, indicating that any length ≥ 1 is legal), a single decimal number (indicating a fixed length) or a length range of the form "i*j", where "i" represents the minimum allowed length of the data item, "j" represents the maximum allowed length, and $i \leq j$. In the latter case, if "j" is omitted, it means the maximum length is unlimited.

Data corresponding to an "n" in the FormatString are encoded in the KLN subsection; data corresponding to an "an" in the FormatString are encoded in the A/N subsection.

When a given instance of the data item is encoded in a Packed Object, its length is encoded in the Aux format section as specified in [I.7.3](#).

The format string for a single identifier shall consist of either the letter "n" (for always-numeric data) or "an" (for data that may contain non-digits), optionally preceded by a length range of the form "i*j", where "i" represents the minimum allowed length of the data item, and "j" represents the maximum allowed length. When a given instance of the data item is encoded in a Packed Object, its length is encoded in the Aux format section, using the minimum number of bits that can express the range. The minimum value of the range is not itself encoded but is specified in the ID table's FormatString column.

EXAMPLE

A FormatString entry of "3*6n" indicates an all-numeric data item whose length is always between three and six digits inclusive. A given length is encoded in two bits, where "00" would indicate a string of digits whose length is "3", and "11" would indicate a string length of six digits.

J.3.5 Interp column (Optional)

Some registrations can specify information needed for output representations of the Packed Object's contents, other than the default OID representation of the arcs of each encoded identifier. If this information is invariant for a particular table, the registration file may include keyword lines as previously defined. If the interpretation varies from row to row within a table, then an Interp column may be added to the ID table. This column entry, if present, may contain one or more of the following keyword assignments (separated by semicolons), as were previously defined (see [I.2.2](#) and [I.2.3](#)):

- K-RootOID = urn:oid:i.j.k.l...
- K-Interpretation = string
- K-ISO15434=nn

If used, these override (for a particular Identifier) the default file-level values and/or those specified in the table header section.

J.4 Syntax of OIDs, IDString, and FormatString columns

J.4.1 General

In each ID table entry, the OIDs, IDString, and FormatString column may indicate one or more mechanisms described in this clause. [J.4.2](#) specifies the semantics of the mechanism and [J.4.3](#) specifies the formal grammar for the ID table columns.

J.4.2 Semantics for OIDs, IDString, and FormatString columns

In the descriptions below, the word "Identifier" means either an OID final arc (in the context of the OIDs column) or an IDString name (in the context of the IDstring column). If both columns are present, only the OIDs column invokes secondary ID bits.

- A single component resolving to a single Identifier, in which case no additional secondary ID bits are invoked.
- (For OIDs and IDString columns only) A single component resolving to one of a series of closely related Identifiers, where the Identifier's string representation varies only at one or more character positions. This is indicated using the Concatenation operator "%" to introduce a range of ISO/IEC 646 characters at a specified position. For example, an OID whose final arc is defined as "391n", where the fourth digit "n" can be any digit from "0" to "6" (ISO/IEC 646 characters 30₁₆ to 36₁₆ inclusive) is represented by the component 391 %x30-36 (note that no spaces are allowed). A Concatenation invokes the minimum number of secondary ID digits needed to indicate the specified range. When both an OIDs column and an IDstring column are populated for a given row, both shall contain the same number of concatenations, with the same ranges (so that the numbers and values of secondary ID bits invoked are consistent). However, the minimum value listed for the two ranges can differ, so that (for example) the OID's digit can range from 0 to 3, while the corresponding IDstring character can range from "B" to "E" if so desired. Note that the use of Concatenation inherently constrains the relationship between OID and legacy ID, and so Concatenation may not be useable under all circumstances (the Selection operation described below usually provides an alternative).
- A *Combination* of two or more identifier components in an ordered sequence, indicated by surrounding each component of the sequence with parentheses. For example, an IDstring entry (A) (%x30-37B)(2C) indicates that the associated ID value represents a sequence of the following three identifiers:
 - Identifier "A", then
 - An identifier within the range "0B" to "7B" (invoking three secondary ID bits to represent the choice of leading character), then
 - Identifier "2C".

NOTE A Combination does not itself invoke any secondary ID bits (unless one or more of its components do).

- An optional component is indicated by surrounding the component in brackets, which may be viewed as a "conditional combination." For example, the entry (A) [B][C][D] indicates that the ID value represents identifier A, optionally followed by B, C, and/or D. A list of Options invokes one secondary ID bit for each component in brackets, wherein a "1" indicates that the optional component was encoded.
- A selection between several mutually exclusive components is indicated by separating the components by forward slash characters. For example, the IDstring entry (A/B/C/(D)(E)) indicates that the fully qualified ID value represents a single choice from a list of four choices (the fourth of which is a Combination). A Selection invokes the minimum number of secondary ID bits needed to indicate a choice from a list of the specified number of components.

In general, a "compound" OIDs or IDstring entry may contain any or all of the above operations. However, to ensure that a single left-to-right parsing of an OIDs entry results in a deterministic set of secondary

ID bits (which are encoded in the same left-to-right order in which they are invoked by the OIDs entry), the following restrictions are applied:

- A given Identifier may only appear once in an OIDs entry, e.g. the entry (A)(B/A) is invalid.
- A OIDs entry may contain at most a single Selection list.
- There is no restriction on the number of Combinations (because they invoke no secondary ID bits).
- There is no restriction on the total number of Concatenations in an OIDs entry, but no single Component may contain more than two Concatenation operators.
- An optional component may be a component of a Selection list, but an optional component may not be a compound component, and therefore shall not include a Selection list nor a Combination nor Concatenation.
- A OIDs or IDstring entry may not include the characters "(", ")", "[", "]", "%", "-", or "/", unless used as an Operator as described above. If one of these characters is part of a defined data system Identifier "name", then it shall be represented as a single literal Concatenated character.

J.4.3 Formal Grammar for OIDs, IDString, and FormatString Columns

In each ID table entry, the contents of the OIDs, IDString, and FormatString columns shall conform to the following grammar for `Expr`, unless the column is empty or (in the case of the OIDs column) it contains a keyword as specified in J.3.3. All three columns share the same grammar, except that the syntax for `COMPONENT` is different for each column as specified below. In a given ID table Entry, the contents of the OIDs, IDString, and FormatString column (except if empty) shall have identical parse trees according to this grammar, except that the `COMPONENTS` may be different. Space characters are permitted (and ignored) anywhere in an `Expr`, except that in the interior of a `COMPONENT` spaces are only permitted where explicitly specified below.

```
Expr ::= SelectionExpr | "(" SelectionExpr ")" | SelectionSubexpr
SelectionExpr ::= SelectionSubexpr ( "/" SelectionSubexpr )+
SelectionSubexpr ::= COMPONENT | ComboExpr
ComboExpr ::= ComboSubexpr+
ComboSubexpr ::= "(" COMPONENT ")" | "[" COMPONENT "]"
```

For the OIDs column, `COMPONENT` shall conform to the following grammar:

```
COMPONENT_OIDs ::= (COMPONENT_OIDs_Char | Concat)+
COMPONENT_OIDs_Char ::= ("0".."9")+
```

For the IDString column, `COMPONENT` shall conform to the following grammar:

```
COMPONENT_IDString ::= UnquotedIDString | QuotedIDString
UnquotedIDString ::= (UnquotedIDStringChar | Concat)+
UnquotedIDStringChar ::=
    "0".."9" | "A".."Z" | "a".."z" | "_"
QuotedIDString ::= QUOTE QuotedIDStringConstituent+ QUOTE
QuotedIDStringConstituent ::=
    " " | "!" | "#".."~" | (QUOTE QUOTE)
```

`QUOTE` refers to ISO/IEC 646 character 34 (decimal), the double quote character.

When the `QuotedIDString` form for `COMPONENT_IDString` is used, the beginning and ending `QUOTE` characters shall *not* be considered part of the IDString. Between the beginning and ending `QUOTE`, all ISO/IEC 646 characters in the range 32 (decimal) through 126 (decimal), inclusive, are allowed, except that two `QUOTE` characters in a row shall denote a single double-quote character to be included in the IDString.

In the `QuotedIDString` form, a % character does not denote the concatenation operator, but instead is just a percent character included literally in the IDString. To use the concatenation operator, the `UnquotedIDString` form must be used. In that case, a degenerate concatenation operator (where the

start character equals the end character) may be used to include a character into the IDString that is not one of the characters listed for UnquotedIDStringChar.

For the FormatString column, COMPONENT shall conform to the following grammar:

```
COMPONENT_FormatString ::= Range? ("an" | "n")
                           | FixedRange "n" " " "+" VarRange "an"
Range ::= FixedRange | VarRange
FixedRange ::= Number
VarRange ::= Number "*" Number?
Number ::= ("0".."9")+
```

The syntax for COMPONENT for the OIDs and IDString columns makes reference to Concat, whose syntax is specified as follows:

```
Concat ::= "%" "x" HexChar HexChar "-" HexChar HexChar
HexChar ::= ("0".."9" | "A".."F")
```

The hex value following the hyphen shall be greater than or equal to the hex value preceding the hyphen. In the OIDs column, each hex value shall be in the range 30₁₆ to 39₁₆, inclusive. In the IDString column, each hex value shall be in the range 20₁₆ to 7E₁₆, inclusive.

J.5 OID input/output representation

J.5.1 Default method

The default method for representing the contents of a Packed Object to a receiving system is as a series of name/value pairs, where the name is an OID, and the value is the decoded data string associated with that OID. Unless otherwise specified by a K-RootOID keyword line, the default root OID is urn:oid:1.0.15961.ff, where ff is the data format encoded in the DSFID. The final arc of the OID is (by default) the IDvalue, but this is typically overridden by an entry in the OIDs column. Note that an encoded application indicator (see [1.5.4.2](#)) may change ff from the value indicated by the DSFID.

If supported by information in the ID table's IDstring column, a receiving system shall translate the OID output into various alternative formats, based on the ID String representation of the OIDs. One such format, as described in ISO/IEC 15434, requires as additional information a two-digit format identifier; a table registration may provide this information using the K-ISO15434 keyword as described above.

The combination of the K-RootOID keyword and the OIDs column provides the registering entity an ability to assign OIDs to data system identifiers without regard to how they are actually encoded, and therefore the same OID assignment can apply regardless of the access method.

J.5.2 "ID value OID" output representation

If the receiving system does not have access to the relevant ID table (possibly because it is newly-registered), the Packed Objects decoder will not have sufficient information to convert the IDvalue (plus secondary ID bits) to the intended OID. In order to ease the introduction of new or external tables, encoders have an option to follow "restricted use" rules (see [1.5.4.3](#)).

When a receiving system has decoded a Packed Object encoded following "restricted use" rules, but does not have access to the indicated ID table, it shall construct an "ID value OID" in the following format:

```
urn:oid:1.0.15961.300.ff.bb.idval.secbits
```

where 1.0.15961.300 is a Root OID with a reserved data format of "300" that is never encoded in a DSFID, but is used to distinguish an "ID value OID" from a true OID (as would have been used if the ID table were available). The reserved value of 300 is followed by the encoded table's data format (ff) (which may be different from the DSFID's default), the table ID (bb) (always "0", unless otherwise indicated via an encoded application indicator), the encoded ID value, and the decimal representation of the invoked secondary ID bits. This process creates a unique OID for each unique fully-qualified ID

value. For example, using the hypothetical ID table shown in [Annex L](#) (but assuming, for illustration purposes, that the table's specified Root OID is urn:oid:1.0.12345.9, then an "AMOUNT" ID with a fourth digit of "2" has a true OID of:

urn:oid:1.0.12345.9.3912

and an "ID value OID" of

urn:oid:1.0.15961.300.9.0.51.2

When a single ID value represents multiple component identifiers via combinations or optional components, their multiple OIDs and data strings shall be represented separately, each using the same "ID value OID" (up through and including the secondary ID bits arc), but adding as a final arc the component number (starting with "1" for the first component decoded under that IDvalue).

If the decoding system encounters a Packed Object that references an ID table that is unavailable to the decoder, but the encoder chose not to set the "Restricted use" bit in the application indicator, then the decoder shall either discard the Packed Object, or relay the entire Packed Object to the receiving system as a single undecoded binary entity, a sequence of octets of the length specified in the ObjectLength field of the Packed Object. The OID for an undecoded Packed Object shall be urn:oid:1.0.15961.301.ff.n, where "301" is a data format reserved to indicate an undecoded Packed Object, "ff" shall be the data format encoded in the DSFID at the start of memory, and an optional final arc "n" may be incremented sequentially to distinguish between multiple undecoded Packed Objects in the same data carrier memory.

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Annex K (normative)

Packed Objects Encoding tables

Packed Objects primarily utilise two encoding bases:

- base 10, which encodes each of the digits "0" through "9" in one base 10 value.
- base 30, which encodes the capital letters and selectable punctuation in one base 30 value and encodes punctuation and control characters from the remainder of the ISO/IEC 646 character set in two base 30 values (using a Shift mechanism) (see [Table K.2](#)).

For situations where a high percentage of the input data's non-numeric characters would require pairs of base-30 values, two alternative bases, base 74 (see [Table K.5](#)) and base 256, are also defined:

- The values in the base 74 set correspond to the invariant subset of ISO/IEC 646 (which includes the GS1 character set), but with the digits eliminated, and with the addition of GS and <space> (GS is supported for uses other than as a data delimiter).
- The values in the base 256 set may convey octets with no graphical-character interpretation, or "extended ISO/IEC 646 values" as defined in ISO/IEC 8859-1 (which is the default character set for this document), or UTF-8 (the interpretation may be set in the registered ID table for an application). The characters "0" through "9" (ISO/IEC 646 decimal values 48 through 57) are supported, and an encoder may therefore encode the digits either by using a prefix or suffix (in base 256) or by using a character map (in base 10). Note that in GS1 data, FNC1 is represented by ISO/IEC 646 <GS> (octet decimal value 29₁₀).

Finally, there are situations where compaction efficiency can be enhanced by run-length encoding of base indicators, rather than by character map bits, when a long run of characters can be classified into a single base. To facilitate that classification, additional "extension" bases are added, only for use in Prefix and Suffix Runs.

- To support run-length encoding of a primarily numeric string with a few interspersed letters, a base 13 is defined (see [Table K.3](#)).
- Two of these extension bases (base 40 (see [Table K.4](#)) and base 84 (see [Table K.6](#))) are simply defined, in that they extend the corresponding non-numeric bases (base 30 and base 74, respectively) to also include the ten decimal digits. The additional entries, for characters "0" through "9", are added as the next ten sequential values (values 30 through 39 for base 40, and values 74 through 83 for base 84).
- The "extended" version of base 256 is defined as base 40. This allows an encoder the option of encoding a few ISO/IEC 646 control or uppercase ISO/IEC 646 characters in base 256, while using a Prefix and/or Suffix to encode the remaining non-numeric characters more efficiently.

The number of bits required to encode various numbers of base 10, base 16, base 30, base 40, base 74, and base 84 characters are shown in [Table K.1](#). In all cases, a limit is placed on the size of a single input group, selected to output a group no larger than 20 octets.

Table K.1 — Required number of bits for a given number of base "N" values

Base10 encoding accepts up to 48 input values per group	
	static const unsigned char bitsForNumbase10[] =
0 to 9	0, 4, 7, 10, 14, 17, 20, 24, 27, 30,
10 to 19	34, 37, 40, 44, 47, 50, 54, 57, 60, 64,
20 to 29	67, 70, 74, 77, 80, 84, 87, 90, 94, 97,
30 to 39	100, 103, 107, 110, 113, 117, 120, 123, 127, 130,
40 to 48	133, 137, 140, 143, 147, 150, 153, 157, 160
Base13 encoding accepts up to 43 input values per group	
	static const unsigned char bitsForNumbase13[] =
0 to 9	0, 4, 8, 12, 15, 19, 23, 26, 30, 34,
10 to 19	38, 41, 45, 49, 52, 56, 60, 63, 67, 71,
20 to 29	75, 78, 82, 86, 89, 93, 97, 100, 104, 108,
30 to 39	112, 115, 119, 123, 126, 130, 134, 137, 141, 145,
40 to 43	149, 152, 156, 160
Base30 encoding accepts up to 32 input values per group	
	static const unsigned char bitsForNumbase30[] =
0 to 9	0, 5, 10, 15, 20, 25, 30, 35, 40, 45,
10 to 19	50, 54, 59, 64, 69, 74, 79, 84, 89, 94,
20 to 29	99, 104, 108, 113, 118, 123, 128, 133, 138, 143,
30 to 32	148, 153, 158
Base40 encoding accepts up to 30 input values per group	
	static const unsigned char bitsForNumbase40[] =
0 to 9	0, 6, 11, 16, 22, 27, 32, 38, 43, 48,
10 to 19	54, 59, 64, 70, 75, 80, 86, 91, 96, 102,
20 to 29	107, 112, 118, 123, 128, 134, 139, 144, 150, 155,
30	160
Base74 encoding accepts up to 25 input values per group	
	static const unsigned char bitsForNumbase74[] =
0 to 9	0, 7, 13, 19, 25, 32, 38, 44, 50, 56,
10 to 19	63, 69, 75, 81, 87, 94, 100, 106, 112, 118,
20 to 25	125, 131, 137, 143, 150, 156
Base84 encoding accepts up to 25 input values per group	
	static const unsigned char bitsForNumbase84[] =
0 to 9	0, 7, 13, 20, 26, 32, 39, 45, 52, 58,
10 to 19	64, 71, 77, 84, 90, 96, 103, 109, 116, 122,
20 to 25	128, 135, 141, 148, 154, 160

Table K.2 — Base 30 Character set

Val	Basic set		Shift 1 set		Shift 2 set	
	Char	Decimal	Char	Decimal	Char	Decimal
0	A-Punc ^a	N/A	NUL	0	space	32
1	A	65	SOH	1	!	33
2	B	66	STX	2	"	34
3	C	67	ETX	3	#	35
4	D	68	EOT	4	\$	36
5	E	69	ENQ	5	%	37
6	F	70	ACK	6	&	38
7	G	71	BEL	7	"	39
8	H	72	BS	8	(	40
9	I	73	HT	9	)	41
10	J	74	LF	10	*	42
11	K	75	VT	11	+	43
12	L	76	FF	12	,	44
13	M	77	CR	13	-	45
14	N	78	SO	14	.	46
15	O	79	SI	15	/	47
16	P	80	DLE	16	:	58
17	Q	81	ETB	23	;	59
18	R	82	ESC	27	<	60
19	S	83	FS	28	=	61
20	T	84	GS	29	>	62
21	U	85	RS	30	?	63
22	V	86	US	31	@	64
23	W	87	invalid	N/A	\	92
24	X	88	invalid	N/A	^	94
25	Y	89	invalid	N/A	_	95
26	Z	90	[	91	"	96
27	Shift 1	N/A	]	93		124
28	Shift 2	N/A	"	123	~	126
29	P-Punc ^b	N/A	"	125	invalid	N/A

a Application-Specified Punctuation character (Value 0 of the Basic set) is defined by default as the ISO/IEC 646 hyphen character (45dec) but may be redefined by a registered data format.

b Programmable Punctuation character (Value 29 of the Basic set): the first appearance of P-Punc in the alphanumeric data for a packed object, whether that first appearance is compacted into the base 30 segment or the base 40 segment, acts as a <Shift 2>, and also "programs" the character to be represented by second and subsequent appearances of P-Punc (in either segment) for the remainder of the alphanumeric data in that packed object. The base 30 or base 40 value immediately following that first appearance is interpreted using the Shift 2 column (Punctuation) and assigned to subsequent instances of P-Punc for the packed object.

Table K.3 — Base 13 Character set

Value	Basic set		Shift 1 set		Shift 2 set		Shift 3 set	
	Char	Decimal	Char	Decimal	Char	Decimal	Char	Decimal
0	0	48	A	65	N	78	space	32
1	1	49	B	66	O	79	\$	36
2	2	50	C	67	P	80	%	37
3	3	51	D	68	Q	81	&	38
4	4	52	E	69	R	82	*	42
5	5	53	F	70	S	83	+	43
6	6	54	G	71	T	84	,	44
7	7	55	H	72	U	85	-	45
8	8	56	I	73	V	86	.	46
9	9	57	J	74	W	87	/	47
10	Shift1	N/A	K	75	X	88	?	63
11	Shift2	N/A	L	76	Y	89	-	95
12	Shift3	N/A	M	77	Z	90	<GS>	29

Table K.4 — Base 40 Character set

Val	Basic set		Shift 1 set		Shift 2 set	
	Char	Decimal	Char	Decimal	Char	Decimal
0	See base 30 Table					
...	...					
29	See base 30 Table					
30	0	48				
31	1	49				
32	2	50				
33	3	51				
34	4	52				
35	5	53				
36	6	54				
37	7	55				
38	8	56				
39	9	57				

Table K.5 — Base 74 Character Set

Val	Char	Decimal	Val	Char	Decimal	Val	Char	Decimal
0	GS	29	25	F	70	50	d	100
1	!	33	26	G	71	51	e	101
2	"	34	27	H	72	52	f	102
3	%	37	28	I	73	53	g	103
4	&	38	29	J	74	54	h	104
5	"	39	30	K	75	55	i	105
6	(	40	31	L	76	56	j	106
7	)	41	32	M	77	57	k	107
8	*	42	33	N	78	58	l	108

Table K.5 (continued)

Val	Char	Decimal	Val	Char	Decimal	Val	Char	Decimal
9	+	43	34	O	79	59	m	109
10	,	44	35	P	80	60	n	110
11	-	45	36	Q	81	61	o	111
12	.	46	37	R	82	62	p	112
13	/	47	38	S	83	63	q	113
14	:	58	39	T	84	64	r	114
15	;	59	40	U	85	65	s	115
16	<	60	41	V	86	66	t	116
17	=	61	42	W	87	67	u	117
18	>	62	43	X	88	68	v	118
19	?	63	44	Y	89	69	w	119
20	A	65	45	Z	90	70	x	120
21	B	66	46	_	95	71	y	121
22	C	67	47	a	97	72	z	122
23	D	68	48	b	98	73	Space	32
24	E	69	49	c	99			

Table K.6 — Base 84 Character Set

Val	Char	Decimal	Val	Char	Decimal	Val	Char	Decimal
0	FNC1	N/A	25	F		50	d	
1-73	See base 74 Table							
74	0	48	78	4	52	82	8	56
75	1	49	79	5	53	83	9	57
76	2	50	80	6	54			
77	3	51	81	7	55			

Annex L (informative)

Encoding example for Packed Objects

A number of the techniques that can be invoked when encoding a Packed Object are illustrated with the following sample input data which consists of data elements from a hypothetical data system. This data represents:

- An Expiration date (OID 7) of October 31, 2006, represented as a six-digit number 061031.
- An Amount Payable (OID 3n) of 1234.56 Euros, represented as a digit string 978123456 ("978" is the ISO Country Code which will indicate that the amount payable is in Euros). As shown in Table L, this data element is all-numeric, with at least 4 digits and at most 18 digits. In this example, the OID "3n" will be "32", where the "2" in the data element name indicates the decimal point is located two digits from the right.
- A Lot Number (OID 1) of 1A23B456CD.

The application will present the above input to the encoder as a list of OID/Value pairs. The resulting input data, represented below as a single data string (wherein each OID final arc is shown in parentheses) is:

(7)061031(32)978123456(1)1A23B456CD

The example uses a hypothetical ID table based on GS1 Application Identifiers. In this hypothetical table, each ID value is a seven-bit index into the base ID table; the entries relevant to this example are shown in [Table L.1](#), for the example in this annex ([Annex L](#)).

Table L.1 — Hypothetical base ID table, for the example in Annex L

K-Version = 1.0				
K-TableID = F99B0				
K-RootOID = urn:oid:1.0.15961.99				
K-IDsize = 128				
IDvalue	OIDs	Data Title	FormatString	
3	1	BATCH/LOT	1*20an	
8	7	USE BY OR EXPIRY	6n	
51	3 %x30-39	AMOUNT	4*18n	
125	(7) (1)	EXPIRY + BATCH/LOT	(6n) (1*20an)	
K-TableEnd = F99B0				

Encoding is performed in the following steps:

- Three data elements are to be encoded, using [Table L.1](#).
- As shown in the table's IDstring column, the combination of OID 7 and OID 1 is efficiently supported (because it is commonly seen in applications), and thus the encoder re-orders the input so that 7 and 1 are adjacent and in the order indicated in the OIDs column:

(7)061031(1)1A23B456CD(32)978123456

Now, this OID pair can be assigned a single ID value of 125 (decimal). The FormatString column for this entry shows that the encoded data will always consist of a fixed-length 6-digit string, followed by a variable-length alphanumeric string.

- Also as shown in [Table L.1](#), for the example in this annex ([Annex L](#)), OID 3n has an ID value of 51(decimal). The OIDs column for this entry shows that the OID is formed by concatenating "3" with a suffix consisting of a single character in the range 30₁₆ to 39₁₆ (i.e. a decimal digit). Since that is a range of ten possibilities, a four-bit number shall be encoded in the secondary ID section to indicate which suffix character was chosen. The FormatString column for this entry shows that its data is variable-length numeric; the variable length information will require four bits to be encoded in the Aux format section.
- Since only a small percentage of the 128-entry ID table is utilised in this Packed Object, the encoder chooses an ID List format, rather than an ID Map format. As this is the default format, no format flags section is required.
- This results in the following Object Info section:
 - EBV-6 (ObjectLength): the value is TBD at this stage of the encoding process
 - Pad indicator bit: TBD at this stage
 - EBV-3 (numberOfIDs) of 001 (meaning two ID values will follow)
 - An ID List, including:
 - First ID value: 125 (decimal) in 7 bits, representing OID 7 followed by OID 1
 - Second ID value: 51(decimal) in 7 bits, representing OID 3n
- A secondary ID section is encoded as "0010", indicating the trailing "2" of the 3n OID. It so happens this "2" means that two digits follow the implied decimal point, but that information is not needed to encode or decode the Packed Object.
- Next, an Aux format section is encoded. An initial "1" bit is encoded, invoking the Packed-Object compaction method. Of the three OIDs, only OID (3n) requires encoded Aux format information:

a four-bit pattern of "0101" (representing "six" variable-length digits – as "one" is the first allowed choice, a pattern of "0101" denotes "six").

- Next, the encoder encodes the first data item, for OID 7, which is defined as a fixed-length six-digit data item. The six digits of the source data string are "061031", which are converted to a sequence of six base 10 values by subtracting 30₁₆ from each character of the string (the resulting values are denoted as values v₅ through v₀ in the formula below). These are then converted to a single binary value, using the following formula:

$$10^5 * v_5 + 10^4 * v_4 + 10^3 * v_3 + 10^2 * v_2 + 10^1 * v_1 + 10^0 * v_0$$

According to [Table K.1](#), a six-digit number is always encoded into 20 bits (regardless of any leading zero's in the input), resulting in a binary string of:

"0000₂ 11101110₂ 01100111₂"

- The next data item is for OID 1, but since the table indicates that this OID's data is alphanumeric, encoding into the Packed Object is deferred until after all the known-length numeric data is encoded.
- Next, the encoder finds that OID 3n, is defined by [Table L.1](#) for the example in [Annex L](#) as all-numeric, whose length of 9 (in this example) was encoded as (9 – 4 = 5) into four bits within the Aux format subsection. Thus, a Known-Length-Numeric subsection is encoded for this data item, consisting of a binary value bit-pattern encoding 9 digits. Using [Table K.1](#), the encoder determines that 30 bits shall be encoded to represent a 9-digit number as a binary value. In this example, the binary value equivalent of "978123456" is the 30-bit binary sequence:

"111010010011001111101011000000₂"

- At this point, encoding of the Known-Length Numeric subsection of the data section is complete.

Note that, so far, the total number of encoded bits is (3 + 6 + 1 + 7 + 7 + 4 + 5 + 20 + 30) or 83 bits, representing the IDLPO Length section (assuming that a single EBV-6 vector remains sufficient to encode the Packed Object's length), two 7-bit ID values, the secondary ID and Aux format sections, and two Known- Length-Numeric compacted binary fields.

At this stage, only one non-numeric data string (for OID 1) remains to be encoded in the alphanumeric subsection. The 10-character source data string is "1A23B456CD". This string contains no characters requiring a base 30 Shift out of the basic base 30 character set, and so base 30 is selected for the non-numeric base (and so the first bit of the Alphanumeric subsection is set to "0" accordingly). The data string has no substrings with six or more successive characters from the same base, and so the next two bits are set to "00" (indicating that neither a Prefix nor a Suffix is run-length encoded). Thus, a full 10-bit Character Map shall be encoded next. Its specific bit pattern is "0100100011", indicating the specific sequence of digits and non-digits in the source data string "1A23B456CD".

Up to this point, the alphanumeric subsection contains the 13-bit sequence "0000100100011". From [Annex K](#), it can be determined that lengths of the two final bit sequences (encoding the base 10 and base 30 components of the source data string) are 20 bits (for the six digits) and 20 bits (for the four uppercase letters using base 30). The six digits of the source data string "1A23B456CD" are "123456", which encodes to a 20-bit sequence of:

"00011110001001000000₂"

which is appended to the end of the 13-bit sequence cited at the start of this paragraph.

The four non-digits of the source data string are "ABCD", which are converted (using Table K) to a sequence of four base 30 values 1, 2, 3, and 4 (denoted as values v₃ through v₀ in the formula below). These are then converted to a single binary value, using the following formula:

$$30^3 * v_3 + 30^2 * v_2 + 30^1 * v_1 + 30^0 * v_0$$

In this example, the formula calculates as $(27000 * 1 + 900 * 2 + 30 * 3 + 1 * 4)$ which is equal to 070DE (hexadecimal) encoded as the 20-bit sequence "00000111000011011110" which is appended to the end of the previous 20-bit sequence. Thus, the alphaNumeric section contains a total of $(13 + 20 + 20)$ or 53 bits, appended immediately after the previous 83 bits, for a grand total of 136 significant bits in the Packed Object.

The final encoding step is to calculate the full length of the Packed Object (to encode the EBV-6 within the Length section) and to pad-out the last byte (if necessary). Dividing 136 by eight shows that a total of 17 bytes are required to hold the Packed Object, and that no pad bits are required in the last byte. Thus, the EBV-6 portion of the Length section is "010001", where this EBV-6 value indicates 17 bytes in the Object. Following that, the pad indicator bit is set to "0" indicating that no padding bits are present in the last data byte.

The complete encoding process may be summarised as follows:

Original input: (7)061031(32)978123456(1)1A23B456CD Re-ordered as: (7)061031(1)1A23B456CD(32)978123456

FORMAT FLAGS SECTION: (empty)

OBJECT INFO SECTION:

ebvObjectLen: 010001₂

paddingPresent: 0₂

ebvNumIDs: 00₁₂

IDvals: 1111101₂ 0110011₂

SECONDARY ID SECTION:

IDbits: 0010₂

AUX FORMAT SECTION:

auxFormatbits: 1₂ 0101₂

DATA SECTION:

KLnumeric: 0000₂ 11101110₂ 01100111₂ 111010₂ 01001100₂ 11111010₂ 11000000₂

ANheader: 0₂

ANprefix: 0₂

ANsuffix: 0₂

ANmap: 01₂ 00100011₂

ANdigitVal: 0001₂ 11100010₂ 01000000₂

ANnonDigitsVal: 0000₂ 01110000₂ 11011110₂

Padding: none

Total bits in Packed Object: 136; when byte aligned: 136

Output as: 44 7E B3 2A 87 73 3F 49 9F 58 01 23 1E 24 00 70 DE

[Table L.1](#) shows the relevant subset of a hypothetical ID table for a hypothetical ISO-registered data format 99.

Annex M (informative)

Decoding Packed Objects

M.1 Overview

The decode process begins by decoding the DSFID. If the leading two bits indicate the Packed Objects Access Method, then the remainder of this annex applies. From the remainder of the DSFID, determine the data format, which shall be applied as the default data format for all the Packed Objects in this memory. From the data format, determine the default ID table that shall be used to process the ID values in each Packed Object.

Typically, the decoder takes a first pass through the initial ID values list, as described earlier, to complete the list of identifiers. If the decoder finds any identifiers of interest in a Packed Object (or if it has been asked to report back all the data strings from a tag's memory), then it shall record the implied fixed lengths (from the ID table) and the encoded variable lengths (from the Aux format subsection), in order to parse the Packed Object's compressed data. The decoder, when recording any variable-length bit patterns, must first convert them to variable string lengths per the table (for example, a three-bit pattern may indicate a variable string length in the range of two to nine).

Starting at the first byte-aligned position after the end of the DSFID, parse the remaining memory contents until the end of encoded data, repeating the remainder of this section until a terminating pattern is reached.

Determine from the leading bit pattern (see [L.4](#)) which one of the following conditions applies:

- a) There are no further Packed Objects in memory (if the leading 8-bit pattern is all zeroes, this indicates the terminating pattern).
- b) One or more padding bytes are present. If padding is present, skip the padding bytes, which are as described in [Annex I](#), and examine the first non-pad byte.
- c) A directory pointer is encoded. If present, record the offset indicated by the following bytes, and then continue examining from the next byte in memory.
- d) A format flags section is present, in which case process this section according to the format described in [Annex I](#).
- e) A default-format Packed Object begins at this location.

If the Packed Object has a format flags section, then this section may indicate that the Packed Object is of the ID Map format, otherwise it is of the ID List format. According to the indicated format, parse the Object Information section to determine the Object Length and ID information contained in the Packed Object. See [Annex I](#) for the details of the two formats. Regardless of the format, this step results in a known Object length (in bits) and an ordered list of the ID values encoded in the Packed Object. From the governing ID table, determine the list of characteristics for each ID (such as the presence and number of secondary ID bits).

Parse the secondary ID section of the Object, based on the number of secondary ID bits invoked by each ID value in sequence. From this information, create a list of the fully qualified ID values (FQIDVs) that are encoded in the Packed Object.

Parse the Aux format section of the Object, based on the number of Aux format bits invoked by each FQIDV in sequence.

Parse the data section of the Packed Object:

- a) If one or more of the FQIDVs indicate all-numeric data, then the Packed Object's data section contains a Known-Length Numeric subsection, wherein the digit strings of these all-numeric items have been encoded as a series of binary quantities. Using the known length of each of these all-numeric data items, parse the correct numbers of bits for each data item, and convert each set of bits to a string of decimal digits.
- b) If (after parsing the preceding sections) one or more of the FQIDVs indicate alphanumeric data of nonzero length, then the Packed Object's data section contains an AlphaNumeric subsection, wherein the character strings of these alphanumeric items have been concatenated and encoded into the structure defined in [Annex I](#). Decode this data using the "Decoding Alphanumeric data" procedure outlined below.

For each FQIDV in the decoded sequence:

- c) convert the FQIDV to an OID, by appending the OID string defined in the registered format's ID table to the root OID string defined in that ID table (or to the default Root OID, if none is defined in the table);
- d) complete the OID/Value pair by parsing out the next sequence of decoded characters. The length of this sequence is determined directly from the ID table (if the FQIDV is specified as fixed length) or from a corresponding entry encoded within the Aux format Section.

M.2 Decoding Alphanumeric data

Within the Alphanumeric subsection of a Packed Object, the total number of data characters is not encoded, nor is the bit length of the character map, nor are the bit lengths of the succeeding binary sections (representing the numeric and non-numeric binary values). As a result, the decoder shall implement a procedure using knowledge of the remaining number of data bits, to correctly parse the alphaNumeric section. An example of an appropriate procedure is described in this subclause.

When decoding the A/N subsection using this procedure, the decoder will first count the number of non-bitmapped values in each base (as indicated by the various Prefix and Suffix Runs), and (from that count) will determine the number of bits required to encode these numbers of values in these bases. The procedure can then calculate, from the remaining number of bits, the number of explicitly encoded character map bits. After separately decoding the various binary fields (one field for each base that was used), the decoder "re-interleaves" the decoded ISO/IEC 646 characters in the correct order.

The A/N subsection decoding procedure is as follows:

Determine the total number of non-pad bits in the Packed Object, as described in [I.8.3](#).

- Keep a count of the total number of bits parsed thus far, as each of the subsections prior to the Alphanumeric subsection is processed.
- Parse the initial header bits of the alphanumeric subsection, up to but not including the Character Map, and add this number to previous value of TotalBitsParsed.
- Initialize a DigitsCount to the total number of base 10 values indicated by the Prefix and Suffix (which may be zero).
- Initialize an ExtDigitsCount to the total number of base 13 values indicated by the Prefix and Suffix (which may be zero).
- Initialize a NonDigitsCount to the total number of base 30, base 74, or base 256 values indicated by the Prefix and Suffix (which may be zero).
- Initialize an ExtNonDigitsCount to the total number of base 40 or base 84 values indicated by the Prefix and Suffix (which may be zero).

- Calculate Extended-base bit counts: Using the tables in [Annex K](#), calculate two numbers:
 - ExtDigitBits, the number of bits required to encode the number of base 13 values indicated by ExtDigitsCount, and
 - ExtNonDigitBits, the number of bits required to encode the number of base 40 (or base 84) values indicated by ExtNonDigitsCount.
 - Add ExtDigitBits and ExtNonDigitBits to TotalBitsParsed.
- Create a PrefixCharacterMap bit string, a sequence of zero or more quad-base character-map pairs, as indicated by the Prefix bits just parsed. Use quad-base bit pairs defined as follows:
 - "00₂" indicates a base 10 value;
 - "01₂" indicates a character encoded in base 13;
 - "10₂" indicates the non-numeric base that was selected earlier in the A/N header;
 - "11₂" indicates the Extended version of the non-numeric base that was selected earlier;
- Create a SuffixCharacterMap bit string, a sequence of zero or more quad-base character-map pairs, as indicated by the Suffix bits just parsed.
- Initialize the FinalCharacterMap bit string and the MainCharacterMap bit string to an empty string.
- Calculate running bit counts: Using the tables in [Annex B](#), calculate two numbers:
 - DigitBits, the number of bits required to encode the number of base 10 values currently indicated by DigitsCount,
 - NonDigitBits, the number of bits required to encode the number of base 30 (or base 74 or base 256) values currently indicated by NonDigitsCount,
- set AlnumBits equal to the sum of DigitBits plus NonDigitBits.
- if the sum of TotalBitsParsed and AlnumBits equals the total number of non-pad bits in the Packed Object, then no more bits remain to be parsed from the character map, and so the remaining bit patterns, representing binary values, are ready to be converted back to extended base values and/or base 10/base 30/base 74/base 256 values (skip to the Final Decoding steps below). Otherwise, get the next encoded bit from the encoded Character map, convert the bit to a quad-base bit-pair by converting each "0₂" to "00₂" and each "1₂" to "10₂", append the pair to the end of the MainCharacterMap bit string, and:
 - If the encoded map bit was "0₂", increment DigitsCount,
 - Else if "1₂", increment NonDigitsCount,
 - Loop back to the Calculate running bit counts step above and continue,
- Final Decoding steps: once the encoded Character Map bits have been fully parsed:
 - Fetch the next set of zero or more bits, whose length is indicated by ExtDigitBits. Convert this number of bits from binary values to a series of base 13 values and store the resulting array of values as ExtDigitVals.
 - Fetch the next set of zero or more bits, whose length is indicated by ExtNonDigitBits. Convert this number of bits from binary values to a series of base 40, base 84, or base 30 values (depending on the selection indicated in the A/N header) and store the resulting array of values as ExtNonDigitVals.
 - Fetch the next set of bits, whose length is indicated by DigitBits. Convert this number of bits from binary values to a series of base 10 values and store the resulting array of values as DigitVals.

- Fetch the final set of bits, whose length is indicated by NonDigitBits. Convert this number of bits from binary values to a series of base 30 or base 74 or base 256 values (depending on the value of the first bits of the Alphanumeric subsection) and store the resulting array of values as NonDigitVals.
- Create the FinalCharacterMap bit string by copying to it, in this order, the previously created PrefixCharacterMap bit string, then the MainCharacterMap string, and finally append the previously- created SuffixCharacterMap bit string to the end of the FinalCharacterMap string.
- Create an interleaved character string, representing the concatenated data strings from all of the non-numeric data strings of the Packed Object, by parsing through the FinalCharacterMap, and
 - For each "00₂" bit-pair encountered in the FinalCharacterMap, copy the next value from DigitVals to InterleavedString (add 48 to each value to convert to ISO/IEC 646 characters);
 - For each "01₂" bit-pair encountered in the FinalCharacterMap, fetch the next value from ExtDigitVals, and use Table K-2 to convert that value to ISO/IEC 646 (or, if the value is a base 13 shift, then increment past the next "01" pair in the FinalCharacterMap, and use that base 13 shift value plus the next base 13 value from ExtDigitVals to convert the pair of values to ISO/IEC 646). Store the result to InterleavedString;
 - For each "10₂" bit-pair encountered in the FinalCharacterMap, get the next character from NonDigitVals, convert its base value to an ISO/IEC 646 value using [Annex K](#), and store the resulting ISO/IEC 646 value into InterleavedString. Fetch and process an additional base 30 value for every base 30 Shift values encountered, to create and store a single ISO/IEC 646 character.
 - For each "11₂" bit-pair encountered in the FinalCharacterMap, get the next character from ExtNonDigitVals, convert its base value to an ISO/IEC 646 value using [Annex K](#), and store the resulting ISO/IEC 646 value into InterleavedString, processing any Shifts as previously described.

Once the full FinalCharacterMap has been parsed, the InterleavedString is completely populated. Starting from the first AlphaNumeric entry on the ID list, copy characters from the InterleavedString to each such entry, ending each copy operation after the number of characters indicated by the corresponding Aux format length bits, or at the end of the InterleavedString, whichever comes first.

Annex N (normative)

Tag Data Profile encoding

N.1 General

This annex defines the encoding rules for Tag Data Profiles. Because this Access-Method uses what is, in effect, an external "directory" as represented by the Tag Data Profile Table, header information shall be encoded on the RFID tag so that the relevant table can be called for encoding and decoding purposes.

N.2 Encoding

The encoding scheme is designed to support the encoding of any type of application data using existing or newly registered Data-Formats, as follows:

- The data format may be any one of the registered data formats.
- It may be a new registration, subject to the rules of ISO/IEC 15961-2.
- In the case of small applications that do not justify their own data format, then Data-Format = 2 shall be used.

Each Tag Data Profile scheme shall be registered with the Registration Authority of ISO/IEC 15961-2, with the data profile number being a detailed qualifier to the Access-Method.

The Access-Method and Data-Format shall be encoded in the DSFID in the normal manner as defined in [9.3.6](#) and [9.3.7](#) (if applicable) and based on the rules of the particular Tag Driver.

N.3 Registered Table

A Tag Data Profile table, specified in detail in [Annex O](#), shall be registered with the Registration Authority for ISO/IEC 15961-2. If the Tag Data Profile table is for a data element list in a multiple record (see [R.5.4](#)), then the assigned table number shall begin with "9".

The table is designed to be machine readable and is in two parts. The table header identifies:

- A version number for the table;
- Information to enable interpretation of the input string of data;
- The Data-Format;
- The Tag-Data-Profile registration number (which also acts as a unique table ID);
- The Root-OID for external communication through ISO/IEC 15961-1 and ISO/IEC 24791-2 and ISO/IEC 24791-5;
- The number of Relative-OIDs encoded as part of the Tag-Data-Profile scheme.

The url for the table does not need to be on the table but shall be part of the registration process.

The main part of the table has an entry for each data element with the following column headings:

- The sequence number of the data element encoded on the tag, starting from zero.

- The Relative-OID associated with that data element. By having the two columns, the organisation of data elements can be in pre-determined groups, for example the more important ones in the first positions, or to group locked and unlocked data elements together.
- A lock data element indicator.
- A block align indicator.
- The length and format of the user data.
- The code for the ISO/IEC 15962 basic compaction scheme that is applied to the user data, including UTF-8 and application-defined.
- The compacted length (in bytes).

N.4 Encoding the Tag Data Profile on the RFID tag

N.4.1 Segments

The encoding on the tag consists of two segments: a header segment and the data encoding segment. It is more effective to carry out a preliminary encoding of the compacted data, then determine the encoding for the header segment and concatenate these two segments.

N.4.2 Header segment

The header segment shall be encoded on the RFID tag and precede any data encoding, and immediately follow the DSFID, if this is encoded as part of the used memory.

NOTE 1 For some tag types, the DSFID is encoded in a separate memory area.

The structure of the header segment shall consist (in sequence) of:

- The registered Tag-Data-Profile scheme number, using the same structure as used for length encoding as defined in [9.3.11](#).

NOTE 2 This means that the number of Tag-Data-Profile schemes can be extended to over 16,000 in two bytes but could even extend beyond this point.

- One byte to indicate the length of the encoded header. This includes any padding bytes to align the header on a boundary relevant to the type of tag, for example to a word or block boundary.
- One byte to indicate the number of bytes per block. The term block in this case is defined as the minimum size that can be locked in the tag.

For some tag types this is a different value to the one generally used in the document, which is defined as the minimum unit that can be read or written. These different values shall be considered during the encoding process.

- The encoded length of the entire Tag-Data-Profile using the method defined in [9.3.11](#).
- The root-OID when Data-Format = 2. This shall be encoded as defined in [D.5.3](#). This field is only encoded if Data-Format = 2.

NOTE 3 Because the presence of this component is declared by the **Data-Format** and because the size of the **root-OID** is self-declaring it can be encoded in this sequence in the structure and subsequently decoded.

- Any padding to the end of the header, using byte 80₁₆. This field is only encoded to achieve some alignment (e.g. for achieving a block boundary between the tag header and the encoded data).

This structure for the header information enables the Tag-Data-Profile ID table to be logical in structure and for tags with different block sizes to be used with the same Tag-Data-Profile.

N.4.3 Encoded data segment

N.4.3.1 Description

This segment simply consists of a contiguous byte string representing the compacted bytes supported by any necessary pad bytes (byte 80_{16}) for block alignment. There are two main reasons for aligning to a block boundary:

- to ensure that all the bytes of a dataset that is intended to be locked are properly aligned with adjacent datasets, and/or
- to align a dataset to begin on a block boundary for faster read access to that data.

ISO/IEC 15961-1 commands and ISO/IEC 24791-2 messages provide information about object identifiers in their processes. These are used to communicate to the encoding process, which shall follow the rules defined in the table with each data element encoded in the sequence defined by the registered Tag-Data-Profile scheme table. If any data element is missing in the initial command or its length is longer, then the entire process shall be an error.

N.4.3.2 Basic compaction

Each data Object shall be compacted according to the declared compaction code. If the character set is supported, the compaction shall over-ride any optimisation rules for the No-Directory Access-Method for selecting between compaction schemes. For example, an all-numeric string may be defined as requiring integer compaction, even if this begins with a leading zero. This deterministic approach is to ensure a constant size of compacted data for each data Object.

As the encoded length is required to be declared for the Tag-Data-Profile, the following additional rules shall apply:

- If the declared compaction scheme is integer (code 001) leading zeros shall be inserted to make up the length.
- If the declared compaction scheme is any other, then the compaction shall satisfy the required length, otherwise there is an error.

N.4.3.3 Encoding to the Logical Memory

The first encoded compacted dataset always begins on a block boundary.

A three-step process is required to establish the starting position of the next and subsequent compacted datasets:

- a) Considering the lock-block size of the tag being encoded, determine whether the previous data dataset ends on a lock-block boundary.
 - If so mark-up for the previous dataset all the blocks to be locked or unlocked as specified by the profile. Compact the current Object and evaluate as from the beginning of this step.
 - Otherwise continue at Step b).
- b) Consider the BOOLEAN arguments for locking this dataset and the previous dataset.
 - If they are different, invoke the Offset (see [D.8](#)) and insert, if necessary the required number of pad bytes (80_{16}) after the previous Object to reach a lock-block boundary. Compact this Object and evaluate as from the beginning of step a).
 - If they are the same, continue at step c).

- c) Consider the BOOLEAN argument for write-block aligning this dataset.
 - If TRUE, invoke the Offset and any necessary pad bytes to the previous dataset to reach a write-block boundary. Compact this Object and evaluate as from the beginning of step a).
 - If FALSE, compact this Object and evaluate as from the beginning of step a).

In practice, because the number of lock-block and write-block sizes are likely to be few for a particular tag, a set of basic pro forma structures can be established for encoding to a particular Tag-Data-Profile. Furthermore, for those tag types where the lock-block and the write-block are identical, the process is even more deterministic and simpler to implement.

N.5 Decoding the Tag Data Profile

N.5.1 Decoding Tag Data Profiles with an ID table

Various strategies can be used to decode the Tag-Data-Profile. In a system that only expects the Tag-Data-Profile, many of the steps discussed below can be omitted. In a more general situation where the encoding can or cannot be based on a Tag-Data-Profile, the following process is considered appropriate:

- a) If the RFID tag supports the encoding and reading of the DSFID from a separate memory, then the Access-Method "11" will clearly indicate encoding in conformance with Tag-Data-Profiles. If the DSFID is not encoded and read as part of a separate process, it shall be captured as a preamble to the header segment.
- b) Read a limited amount of the user data to establish the Access-Method, Data-Format and other information from the header segment. Effectively the generic reading process shall capture the complete header segment before decoding can begin.

NOTE Unless the Data-Format = 2, where the length of the root-OID can vary, reading 8 bytes should return the header segment in most cases.
- c) Identify the length of encoding, and if this is capable of being read by the application with one air interface transaction, read the appropriate number of blocks using the most efficient air interface transfer option.
- d) If the encoding is large and only selected data is required, use the Tag-Data-Profile scheme to identify the block(s) that contain the appropriate data elements and return these. The sequence and number of compacted bytes is specified in the ID table. To determine the actual location, account shall be taken of the block size and any alignment for locked and block-aligned data. Such calculations can be achieved using information in the ID table and the block size information and end point of the header segment from the header segment in the tag. This process may be implemented in the interrogator or in application software.
- e) Use the EncodeLength data (from the ID table) to select the relevant compacted bytes.
- f) De-compact these using the ISO/IEC 15962 basic de-compaction rule as declared by the CompactCode (from the ID table).
- g) Associate the de-compacted data element to the object identifier and process any response.

N.5.2 Decoding Tag Data Profiles without an ID table

Because the structure of the encoded header segment is self-declaring, it is possible to read all the encoded blocks on the RFID tag (i.e. those where at least one byte is non-zero) and carry out some basic processing.

If Data format = 2, then the root-OID is encoded. The encoding ensures that the structure and length are self-declaring.

Once the details of the header segment have been decoded, the datasets are decoded in the same manner as for bytes encoded to a No-Directory structure. It is possible to partially decode datasets that are not requested by the application command by only processing the Precursor and length of encoded data until the target Relative-OID is found.

N.6 Modifying data

If the Tag-Data-Profile scheme supports the ability for the application to modify data, then this can be achieved, so long as the encoded data remains the same encoded length. Additional pad bytes, as used in the tag header, cannot be used because the decoder is always expecting a fixed number of encoded bytes.

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Annex O (normative)

Tag Data Profile ID tables

0.1 General

This annex defines the Tag-Data-Profile ID table format definition, to be used by all registered ID tables. These ID tables, customised for each data system, will be registered with the Registration Authority denoted by ISO/IEC 15961-2.

0.2 Tag-Data-Profile Data-Format registration file structure

A Tag-Data-Profile registered Data-Format file consists of a series of "Keyword lines" and one ID table.

A keyword line consists of a keyword (which always starts with "K") followed by an equal sign and a character string, which assigns a value to that keyword. Some keyword lines shall appear only once, at the top of the registration file, and others may appear multiple times, once for each ID table in the file.

An ID table lists a series of ID values. Each row of an ID table contains a set of columns that identify the input data and the encoded structure:

- IDValue;
- OID (defining the Relative-OID);
- LockData, a BOOLEAN argument and if TRUE indicating that the data, when encoded, shall be locked;
- BlockAlign, a BOOLEAN argument and if TRUE indicating that the encoded data shall begin on a block boundary;
- FormatString to define the input data;
- CompactCode to define the ISO/IEC 15962 basic compaction schemes;
- EncodeLength.

To illustrate the file format, a hypothetical data system registration is shown in [Table 0.1](#). In this hypothetical data system, each ID value is associated with one OID and other features. This example includes five OIDs with the following constraints:

- "1" for 18-digit serialised traceability code that shall be locked;
- "7" for a 6-character batch number;
- "9" for an expiry date 8-digit format YYYYMMDD that shall be write block aligned;
- "17" for the manufacturing plant as a 3-alpha code;
- "14" for a 5-byte hex code.

Table 0.1 — Hypothetical data format registration file

K-Version = 1.0						
K-Interpretation = ISO-8859-1						
K-ProfileID = F150P123						
K-Root-OID = urn:oid:1.0.12345						
K-Idsize = 5						
IDvalue	OID	LockData	BlockAlign	FormatString	CompactCode	En-codeLength
00	1	T	T	18 DIGITS	001	8
01	7	F	F	6 CHARS	100	5
02	9	F	T	8 DIGITS	001	4
03	17	F	F	3 ALPHAS	011	2
04	14	F	F	6 HEXES	110	3
K-TableEnd = F150P123						

The following subclauses explain the syntax shown in the figure.

0.3 File header section

The defined keyword lines in the file header (the first portion of every registration file) are:

- (Mandatory) K-Version = nn.nn, which the registering body assigns, to ensure that any future revisions to their registration are clearly labelled.
- K-Interpretation = string, where the "string" argument shall be one of the following: "ISO-646", "ISO-8859-1", "UTF-8". The default is ISO-8859-1 to align the basic processes of this document.

0.4 Table header section

One or more Table header sections (each introducing an ID table) follow the file header section. Each Table header begins with a K-TableID keyword line, followed by a series of additional required and optional keyword lines, as follows:

- (Mandatory) K-ProfileID = FnnPnn, where Fnn represents the ISO-assigned data format number, and Pnn is the ISO assigned Table ID for each ProfileID.
- (Mandatory) K-RootOID = urn:oid:i.j.k.ff where:
 - i, j, and k are the leading arcs of the OID (as many arcs as required) and ff is the last arc of the Root OID (which can be the registered data format number);
 - (Mandatory) K-IDsize = nn, where nn represents the number of OIDs in the encoded Tag Data Profile.

The end of the table header section is the first non-blank line that does not begin with a keyword. This first non-blank line shall list the titles for every column in the ID table that immediately follows this line.

0.5 Table trailer section

Each ID table ends with a required keyword line of the form:

K-TableEnd = FnnPnn, where FnnPnn shall match the K-ProfileID keyword line that introduced the table.

The syntax and requirements of all Mandatory columns shall be as described [0.6](#).

0.6 Mandatory ID table columns

0.6.1 General

Each ID table in a Tag Data Profile registration shall include several columns as defined in the following subclauses.

0.6.2 IDvalue column

Each ID table in a Tag Data Profile registration shall include an IDvalue column. The first row shall define the ID value zero, and successive rows shall increment monotonically until the size defined by the keyword line containing K-IDsize. This column defines the sequence of encoding on the RFID tag.

0.6.3 OID column

Each ID table in a Tag Data Profile registration shall include an OID column. The OID value may be any Relative-OID specified for the Root-OID.

0.6.4 LockData column

Each ID table in a Tag Data Profile registration shall include a LockData column. Using a BOOLEAN argument this declares the application requirements to lock the encoded bytes that are derived from the input data.

0.6.5 BlockAlign column

In addition to any block alignment to achieve the correct locking of data, there may be an additional requirement to begin the encoding of a compacted data Object on a block boundary, for example to enable air interface commands to call specifically for a particular encoded Object.

0.6.6 FormatString column

Each ID table in a Tag Data Profile registration shall include a FormatString column to define the data characteristics and fixed length of the data associated with a particular identifier, to facilitate data compaction. The input characters shall be in conformity with IETF RFC 4234. [Table 0.2](#) shows the input data format and the possible ISO/IEC 15962 compaction schemes. For any given data element, one compaction scheme shall be selected and specified in the ID table.

Table 0.2 — DataFormats and ISO/IEC 15962 Compactions

Input data format	Char value (HEX)	Description	CompactCode
DIGIT	%x30-39	0-9	001 (integer) for numeric strings ≥ 2 digits and with leading digit $\neq 0$ 010 (numeric) for numeric strings ≥ 2 digits and with leading digit = 0 110 (octet) for single digit string
HEXDIG	DIGIT / "A" / "B" / "C" / "D" / "E" / "F"		110 (octet)
ALPHA	%x45-5A / %x61-7A	A-Z / a-z	011 (5-bit) for A-Z strings ≥ 3 chars 101 (7-bit) for a-z strings ≥ 8 chars 110 (octet) for other shorter strings

Table O.2 (continued)

Input data format	Char value (HEX)	Description	CompactCode
VCHAR	%x21-7E	visible (printing) characters	100 (6-bit) for char 20 to 5F ₁₆ ≥ 6 chars 101 (7-bit) for strings ≥ 8 chars 110 (octet) for other shorter strings
CHAR	%x01-7F	any 7-bit ISO/IEC 646 character, excluding NULL	100 (6-bit) for char 20 to 5F ₁₆ ≥ 6 chars 101 (7-bit) for strings ≥ 8 chars 110 (octet) for other shorter strings
OCTET	%x00-FF	8 bits of data	110 (octet) for other shorter strings

0.6.7 CompactCode

Each ID table in a Tag Data Profile registration shall include a CompactCode column. This defines the ISO/IEC 15962 compaction scheme that shall be applied to the data string, rather than leave this as an automatic choice by the encoder. The table shows logical choices that should be followed, but there are process rules that differ from the No-Directory encoding. For example, because the ID table shows the length of the application data it is possible for the integer compaction to be used with numeric strings beginning with 0.

This code is also relevant to decode the encoded bytes.

0.6.8 EncodeLength

Each ID table in a Tag Data Profile registration shall include an EncodeLength column. This defines the number of bytes required to encode the application data. It is used to parse the encoded bytes to identify the byte string for de-compaction into the application data.

Annex P (informative)

Encoding example for Tag Data Profile

P.1 Overview

Several of the techniques that can be invoked when encoding a Tag-Data-Profile in the following example is based on the Profile structure as illustrated in [Table O.1](#), with the following additional inputs:

- The lock-block size is 8 bytes
- The write-block size is 2 bytes
- The DSFID is encoded in user memory
- The five data elements have the following values:
 - Relative-OID 1 = 0123456789121345678
 - Relative-OID 7 = AB12XY
 - Relative-OID 9 = 20091231
 - Relative-OID 17 = JPN
 - Relative-OID 14 = A2B380

P.2 Encoded data segment

P.2.1 Encoding the first dataset

The first dataset requires a Precursor that identifies the compaction scheme used and the Relative-OID, followed by the length of the compacted data.

The data associated with Relative-OID 1 compacts as 00 2B DC 54 5E 14 D6 4E. It is 8 bytes long, and it is required to be locked. Adding the Precursor and length byte makes for a total length of 10 bytes, which is not block aligned. The Precursor shall be set to indicate that it is followed by an Offset byte, so has the bit sequence:

- 1_2 to indicate that an Offset follows;
- 001_2 to indicate the compaction scheme;
- 0001_2 to indicate the Relative-OID.

The Precursor has the hexadecimal value 91 and is followed by the Offset byte with the value 05 indicating five pad bytes after the compacted data to align on the boundary of an 8-byte lock block. So, the first dataset of 16 bytes has the byte string of:

91 05 08 00 2B DC 54 5E 14 D6 4E 80 80 80 80 80

The **dataset** is marked-up as requiring locking.

P.2.2 Encoding the second dataset

The second dataset requires a Precursor that identifies the compaction scheme used and the Relative-OID, followed by the length of the compacted data.

The data associated with Relative-OID 7 compacts as 04 2C 72 61 98. It is 5 bytes long and does not require to be locked. Adding the Precursor and length byte makes for a total length of 7 bytes, which is not block aligned. As the next dataset shall remain unlocked, no pad pads are required for lock-block purposes. However, the next dataset shall begin on a write-lock boundary, so some re-alignment is required comprising one byte. The Precursor shall be set to indicate that it is followed by an Offset byte, so has the bit sequence:

- 1_2 to indicate that an Offset follows;
- 100_2 to indicate the compaction scheme;
- 0111_2 to indicate the Relative-OID.

The Precursor has the hexadecimal value C7 and is followed by the Offset byte with the value 00 indicating that of itself it provides sufficient pad bytes. So, the second dataset of 8 bytes has the byte string of:

C7 00 05 04 2C 72 61 98

The dataset is marked-up as not requiring locking.

P.2.3 Encoding the third dataset

The third dataset requires a Precursor that identifies the compaction scheme used and the Relative-OID, followed by the length of the compacted data.

The data associated with Relative-OID 9 compacts as 01 32 91 5F. It is 4 bytes long and does not require to be locked, but it does require to be aligned for reading and writing. The previous dataset required block alignment, so this dataset is encoded from the beginning of a block boundary. Adding the Precursor and length byte makes for a total length of 6 bytes. As this is block aligned on the 2-byte boundary, no Offset and no pad bytes are required. The Precursor so has the bit sequence:

- 0_2 to indicate that no Offset follows;
- 001_2 to indicate the compaction scheme;
- 1001_2 to indicate the Relative-OID.

The Precursor has the hexadecimal value 19 and is followed by the length byte. So, the third dataset of 8 bytes has the byte string of:

19 04 01 32 91 5F

The dataset is marked-up as not requiring locking.

P.2.4 Encoding the fourth dataset

The fourth dataset requires a Precursor that identifies the compaction scheme used. As the Relative-OID value is greater than 14, the Precursor cannot directly encode this value and signals that the Relative-OID is encoded separately as defined in [D.5.5.3](#) with the value 02_{16} . This is then followed by the length of the compacted data.

The data associated with Relative-OID 17 compacts as 54 1C. This 2-byte string is neither locked nor shall be block aligned. It can be encoded as output from the encoder. Adding the Precursor, the Relative-

OID and length byte makes for a total length of 5 bytes. The Precursor shall be set to indicate that it is followed by a directly encoded Relative-OID, so has the bit sequence:

- 0_2 to indicate that no Offset follows;
- 011_2 to indicate the compaction scheme;
- 1111_2 to indicate that the Relative-OID is separately encoded.

The Precursor has the hexadecimal value 7F and is followed by the byte with the value 02 indicating the Relative-OID = 17. So, the fourth dataset of 5 bytes has the byte string of:

7F 02 02 54 1C

The dataset is marked-up as not requiring locking.

P.2.5 Encoding the fifth dataset

Relative-OID 14 was presented with the six hexadecimal characters "A2B3C4", so these are to be encoded as the three bytes A2 B3 80.

The fifth dataset requires a Precursor that identifies the compaction scheme used and the Relative-OID, followed by the length of the compacted data. The previous dataset and this one requires no block alignment, so this dataset is abutted at the end of the previous encoding. Adding the Precursor and length byte makes for a total length of 5 bytes. The Precursor has the bit sequence:

- 0_2 to indicate that no Offset follows;
- 110_2 to indicate the compaction scheme;
- 1110_2 to indicate the Relative-OID.

The Precursor has the hexadecimal value 6E and is followed by the length byte. So, the fifth dataset of 5 bytes has the byte string of:

6E 03 A2 B3 80

The dataset is marked-up as not requiring locking.

P.2.6 The complete data segment

The complete encoding is shown in [Table P.1](#), with the locked bytes shown in bold and alternate datasets shaded for illustration purposes.

Table P.1 — Complete data segment

91	01
08	00
2B	DC
54	5E
14	D6
4E	80
80	80
80	80
C7	00
05	04
2C	72
61	98
19	04

Table P.1 (continued)

01	32
91	5F
7F	02
02	54
1C	6E
03	A2
B3	80

P.3 Encoding the header segment

Account shall be taken that the DSFID is encoded in user memory, and as this has the Data-Format value 150 two bytes are required for the DSFID. For information and completeness of this example:

- The Access-Method = 11_2 , encoded in the leading bits of the first byte;
- As the only extension is for the Data-Format, the next bit is 0;
- The last five bits are set = 11111_2 to indicate an extended Data-Format;
- Therefore, the first byte = $1101111_2 = DF_{16}$;
- The second byte encodes the value of the $(Data-Format - 32) = 150_{10} - 32_{10} = 118_{10} = 76_{16}$.

These two bytes shall be considered for block alignment of the header segment. The following can be determined:

- a) The ProfileID = 123, which can be encoded in a single byte = 7B;
- b) The header size cannot be determined until other component values are established;
- c) The lock-block size is 8 bytes, encoded as 08₁₆;
- d) The length of the complete Tag Data Profile is "header segment + data segment" = ?? + 24, and still undetermined, but certain to only require one byte;
- e) As the size of (a + c + d) is only 3 bytes, it is clear the (b) will only require one byte;
- f) As the DSFID already takes up two bytes of the 8-byte block, b = 6 and is encoded 06₁₆;
- g) The value of (d) can be determined as $6 + 24 = 30$, which is encoded as 1E₁₆;
- h) Two pad bytes are required.

The complete encoding of the header segment is: 7B 06 08 1E 80 80.

Annex Q (normative)

Basic encoding rules for Multiple-Records Access-Method

Q.1 Overview

The basic encoding rules defined in this annex support the encoding of homogeneous or heterogeneous Multiple-Records. These rules also cover generic aspects for encoding hierarchical records, as defined in [Annex R](#).

The Multiple-Records Access-Method comprises the following components:

- A MR-header (see [Q.2](#)) shall be encoded as the first entry in the Logical Memory and precede all individual records. The MR-header may be locked or unlocked, or selectively locked.
- A series of records that can support single records, multiple instances of the same type of record, hierarchical records, and data element lists. Each record comprises a preamble followed by the encoding of the data in the record, which complies with the encoding rules of the nominated Access-Method.
- Optionally, a directory, which should be encoded for larger logical memories.

The MR-header, all the records, data element lists, and entries in the directory shall be block aligned. The MR-header may be locked, or unlocked, or selectively locked.

EXAMPLES

Encoding on a Type C tag shall begin and end on a word boundary.

Encoding on an ISO/IEC 18000-3 Mode 1 tag shall begin and end on a block boundary.

The MR-header and individual records may have an assigned memory capacity that is greater than required for the initial encoding. This is to enable additional data to be correctly encoded within the boundaries defined for the record. This mechanism is also useful to align records, or the MR-header, to some hardware feature such as a lock block boundary, or some file access mechanism.

Q.2 Encoding the Multiple-Records header

Q.2.1 Byte structure of the Multiple-Records header

The MR-header for the Multiple-Records Access-Method shall begin in the lowest addressable block in memory. The MR-header shall comprise several mandatory and conditional components defined in the following subclauses. The structure is illustrated in [Table Q.1](#).