TECHNICAL REPORT

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Information technology — Radio frequency identification for item management — Application requirements profiles

Technologies de l'information — Identification par radiofréquence (RFID) pour la gestion d'objets — Profils de conditions d'application

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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. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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

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

In exceptional circumstances, the joint technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard (“state of the art”, for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

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.

ISO/IEC TR 18001, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

Introduction

The Air Interface Standards of ISO/IEC JTC 1/SC 31 are contained in the various Parts of ISO/IEC 18000, under the general title *Information technology — Radio frequency identification for item management*:

Part 1: Reference architecture and definition of parameters to be standardized

Part 2: Parameters for air interface communications below 135 kHz

Part 3: Parameters for air interface communications at 13,56 MHz

Part 4: Parameters for air interface communications at 2,45 GHz

Part 6: Parameters for air interface communications at 860 MHz to 960 MHz

Part 7: Parameters for active air interface communications at 433 MHz

If antenna design, power levels, and the active/passive nature of the implementation design are held equal, each of these technologies have differing performance and operating parameters, including the distance achievable between tag and interrogator.

Specific implementations of the various Parts above may result in different performance and operating parameter trade-offs. Such trade-offs may include the ability to operate as intended under adverse environmental conditions such as noise or interference or other physical environment variations.

To understand the applicability of each frequency or technology it is necessary to understand the applications within which this technology will be used. A profile of the application requirements must be developed.

This Technical Report addresses these Application Requirements Profiles, providing the application detail from which one should be able to assess the applicability of the various technologies.

Seven distinct and separate efforts are included within this Technical Report.

AIM circulated a questionnaire in late 1998 to which 29 responses were received. These responses serve as the primary basis for this Technical Report.

In early 1999, a United States application standards committee, ANSI MH 10/SC 8, circulated another questionnaire to which 19 responses were received. These responses are included as validation of the AIM survey.

— In 1999, a German University study was released covering RFID in the retail supply chain from manufacturer to transporter to retailer, involving 82 responses. These responses are consolidated in this ARP report.

— In early 2000, Japan's contribution on RFID tags study.

— In 2000, Sweden's contribution on 2,45 GHz RFID tags study.

— In 2001, Australia's contribution on UHF.

— In 2001, AIM's contribution on UHF.

Information technology — Radio frequency identification for item management — Application requirements profiles

1 Scope

This Technical Report provides:

— The result of three surveys identifying the applications for radio frequency identification (RFID) in an item management environment, and the resultant classification of these applications based on various operational parameters, including operating range and memory size.

— An explanation of some of the issues associated with the parameters of distance and number of tags within an RFID interrogator's field-of-view.

— A means by which classification of RF tags may be accomplished based on the application requirements defined in the survey results.

— Recommendations for areas of standardization to the parent committee (ISO/IEC JTC 1/SC 31/WG 4) based on the results of these surveys.

2 Normative references

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

ISO/IEC 19762 (all parts), *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary*[1)]

3 Terms and definitions

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

4 Symbols and abbreviated terms

ARP	Application Requirements Profile
EAS	Electronic Article Surveillance
FA	Fixed Asset
RFID	Radio Frequency Identification
WORM	Write Once Read Many

1) To be published.

5 ARP survey and questionnaire

In the preparation of this Technical Report three surveys were conducted: one by AIM, one by the U.S. Accredited Standards Committee (ASC) ANSI MH 10/SC 8, and one by Dortmund University, Germany.

5.1 AIM Survey

The AIM Survey was circulated through ISO/IEC JTC 1/SC 31 national bodies asking potential respondents to access the survey form at the web site: http://www.rfid.org. The survey that was circulated (SC 31/WG 4 N0046) is attached as Annex A to this Technical Report.

To define the application requirements for standardization, the questionnaire that was circulated by AIM consisted of three categories:

5.1.1 Application selection

a. Baggage Handling (includes airline)

b. Factory Automation

c. Warehouse Logistics / Inventory Control

d. Distribution

e. Security / Article Surveillance

f. Asset Tracking

g. Container Control

h. Pallet Control

i. Door to door delivery services

j. Others

5.1.2 Tag characteristics

a. Are tags re-usable or disposable?

b. What is the tag's memory size?

c. Is there a requirement for a unique tag ID?

d. Is the memory requirement read only, write once read many, or read and write?

e. Is there a requirement for physical size or thickness?

5.1.3 Application characteristics

a. Does the application employ a single antenna or multiple antennae?

b. Does the application use hand-held or fixed position reader / writer / antenna?

c. What are the required maximum read and write distances?

d. What is the maximum speed in front of reader / writer?

e. What amount data is transferred during read and write operations?

f. What is the minimum separation distance between tags?

g. Does the packaging or container have metallic materials?

h. Is the tag orientation controlled or not controlled?

i. Will one or multiple tags be in the field of view at one time; is an anti-collision protocol required?

j. Does the application require the encryption, authentication, or another security system?

k. What are the environmental requirements, e.g., temperature, vibration, water proof, chemical.

The results of the AIM Survey are included as Annex A.

5.2 ANSI MH 10/SC 8

The ANSI MH 10/SC 8 Survey was circulated to ANSI MH 10 members asking potential respondents to complete the survey and returning it to the administrator of ANSI MH 10/SC 8. The survey that was circulated is attached as Annex B to this Technical Report. Annex D provides a summary of the responses to the ANSI MH 10/SC 8 Survey.

5.3 Dortmund University

The Dortmund University Survey was circulated to a select group of German companies involved in the retail trade as either retail goods manufacturers, transporters, or retailers. Annex F provides a summary of the responses to the Dortmund University Survey.

6 ARP survey results and its analysis

From the circulation of the AIM ARP Survey, 29 responses were received from 8 countries. These results are shown in Annex C. Figure 1 shows an application table relating memory size and operating range based on the response Questionnaire. Eight key items were selected from 27 items in the Questionnaire (N0046).

The 8 items are

a. Application,

b. Memory size,

c. Read/Write,

d. Reuse/Disposal,

e. Tag Frequency,

f. Operating Range,

g. Multiple Tag Read (Anti-collision), and

h. Encryption.

6.1 Classification of application

For the RFID tag system, tag memory size and operating range are key factors. Figure 1 shows the summary of the applications assembled by read range and tag memory requirements. Figure 2 shows the classification of the two parameters in 3 categories.

6.2 Operating range

The operating ranges are different in each application, ranging from 0.1 m and up to 100 m. See Annex A and Tables 1 and 2. Even in applications named identically, it may be difficult to find identical operating ranges.

The operating range is a key factor for users when implementing RFID systems. For users, it is helpful that the operating range is classified in three ranges, e.g., short range, medium range and long range.

There are different approaches to propose the operating ranges. One aspect is the take into account the desired compatibility with the application requirements of contactless IC cards, the ARP group proposed the ranges within ISO/IEC 14443 and ISO/IEC 15693. The ARP Rapporteur Group has therefore defined operating ranges as follows.

Table 1 — Operating Range Classifications

	short range	≤ 0.1 m
0.1 m ≤	**medium range**	≤ 0.7 m
0.7 m ≤	**long range**	

Table 2 — Typical Operating Range Requirements by Application

		< 10 cm		**10 – 70 cm**		**70 cm – 5 m**	
	11	Pallet ID (FA)	3	Asset Tracking	25	Vehicle Management	
					30	Pallet Control	
1 kbyte							
			23	FA Auto Warehouse	2	Toll Collection	
			24	FA Logistics Pallet	4	Warehouse/Logistics	*
					8	Pallet Control	*
					10	Asset Tracking	*
					16	Gasoline	
Memory Size					21	Waste Management	
					22	Inventory Control	
					5	Log Tracking	
					6	Log Tracking	
						MR TAG	
128 byte							
			7	Access Control	9	Access & Tracking	
			14	Library	12	Baggage Handling	*
			26	Pallet Control	13	Baggage Handling	*
					15	Waste Management	*
					18	Video Tape Rental	*
					27	Container Control	*
					28	Luggage	*
					29	Asset Tracking	
					31	EAS	

Note – * is the target application. The numbers of Figure 1 correspond to the numbers in the table of Annex C.

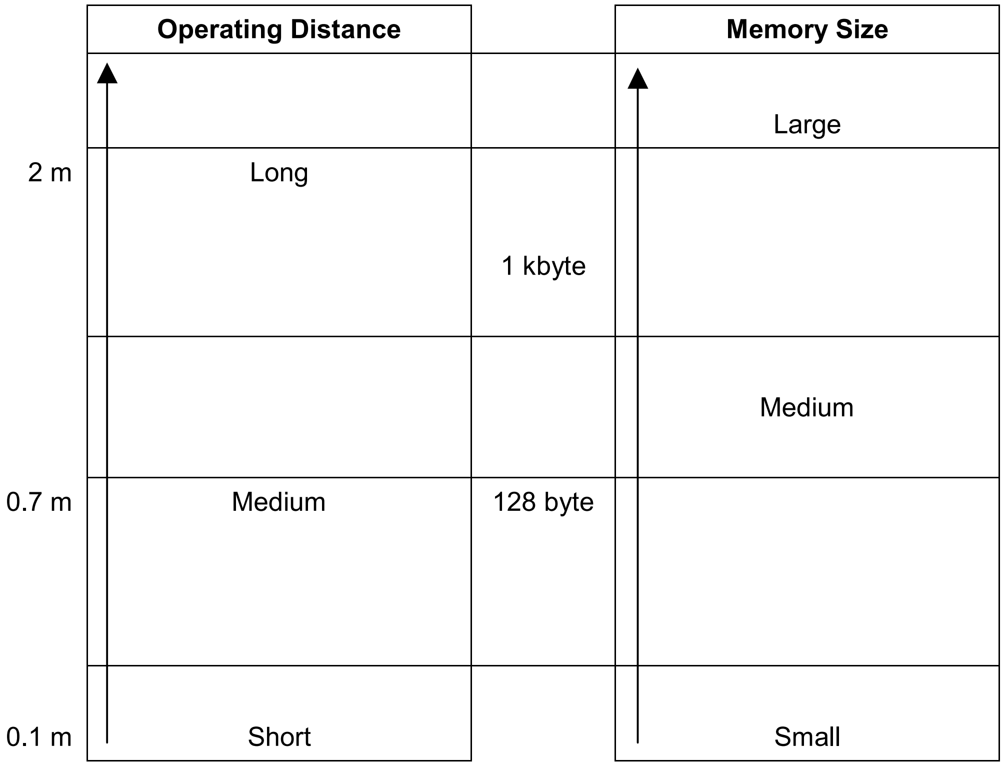


Figure 1 – Definition of Operation Distance and Memory Size

6.3 Memory size

The memory size of RF tags (see Annex A and Tables 2 and 3) differs in each application. They extend from 8 byte to 128 kbyte. This report provides classification to three sizes: small, medium, and large. They are defined as follows.

Table 3 — Classification of Memory Size

	small size	≤ 128 byte
128 byte ≤	**medium size**	≤ 1 kbyte
1 kbyte ≤	**large size**	

6.4 Initial work for the first target application

Based on the responses received, the ARP Rapporteur Group has determined that the initial application focus work should be based on the pallet and /or a container (crate, returnable plastic container etc), and not the contents of containers.

The work should concentrate in two specific areas of the matrix (Operating Range – Memory size – Application) in Table 2.

6.4.1 Memory size < 128 byte

Operating range > 70 cm
WORM
Application:
  Waste (domestic),
  Baggage Handling
  Books / Videos (libraries)
  Container Control

6.4.2 128 byte < memory size < 1 kbyte

Operating range > 70 cm
Read / Write
Application:
  Warehouse Logistics.
  Pallet Control (returnable plastic container)
  Asset tracking

7 Technical subjects for standardization (Common items for applications)

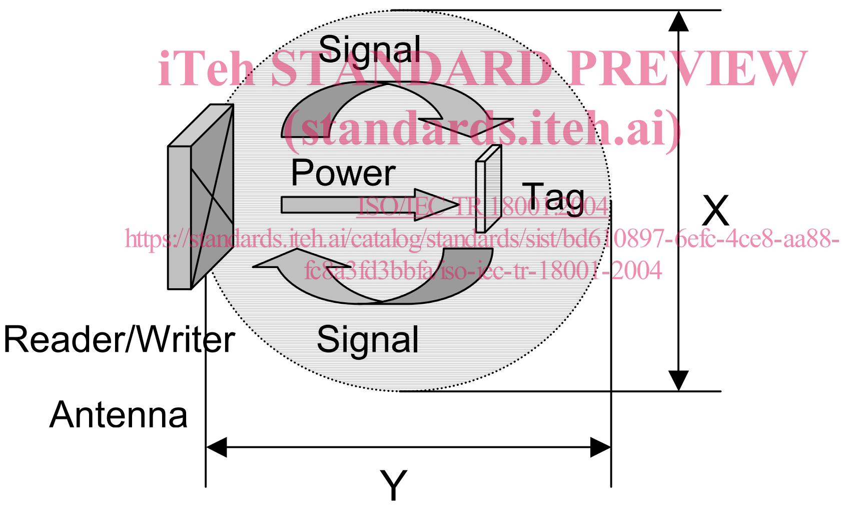


Figure 2 – The Principal of RF Tag Communications

7.1 The variation of operating range

The reader/writer antenna transmits power and signals to the tags by propagated electromagnetic waves or inductive coupling, and tags emit the response signal to the reader/writer antenna. At inductive frequencies, the operating range (X, Y, Z directions) is affected to a greater extent by the antenna size of the reader/writer and the antenna size of the tag, than are systems operating at UHF or microwave frequencies.

The operating range when writing is less than reading due to current dissipation. The tags with battery cell have a greater operating range than tags without a battery cell.

In general, an extended operating range requires a significantly larger antenna for both the reader/writer and the tag. The interference level in the environment can also have a significant effect on operating range.

Further, there are many factors that affect the operating range including tag orientation, overlap with other tags environmental noise, absorption, reflection, shadowing and the effects caused by the presence of metallic material etc.

7.1.1 Influence of tag orientation

Contrasted to bar codes systems, RFID systems have an advantage of a wider operating range. Like bar codes, the RFID tags can be attached to various surfaces, e.g., the side of the container.

When the orientation (polarization) of tag is changed, the operating range is changed. For example, the 90-degree change of orientation may cause the 20-100% deterioration of the operating range. These are shown in Figure 3.

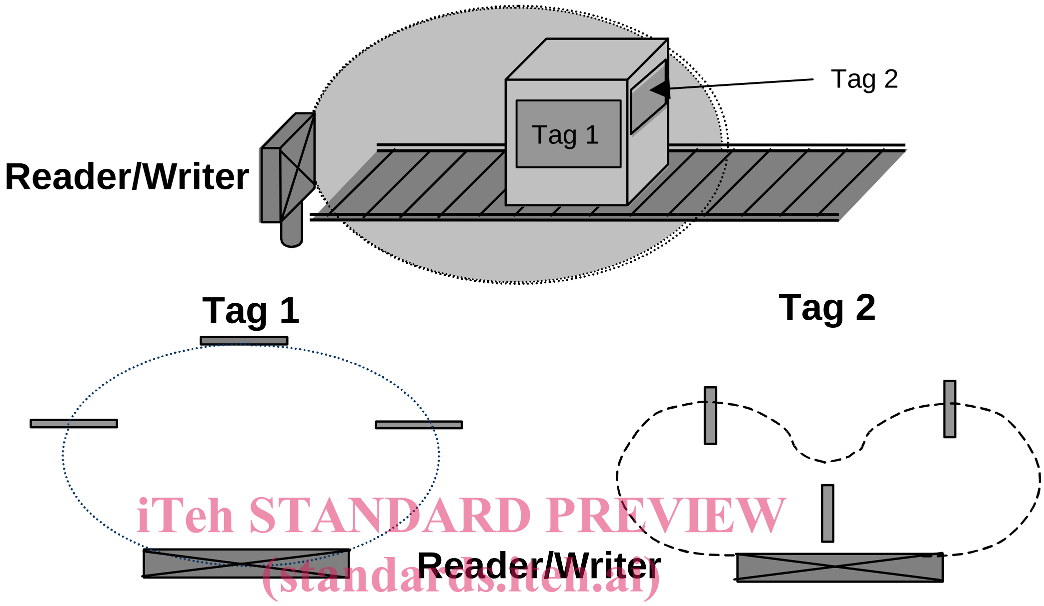


Figure 3 – The Influence of Tag Orientation

Tags can be read from one side or from both sides, where the former type gives better reading range at a certain output power. If the tag cannot be oriented during the reading process, dual-sided reading adds value to the application.

The tag can be freely oriented around the interrogator's radiation axis if circular polarization is used in the system. It is possible to read the tag horizontally as well as vertically, without consideration of how the interrogators are installed.

The tag can be freely oriented in relation to the interrogator if circular polarization is used and if the tag is designed for omni-directional reading. This configuration is of value if the objects are completely unaligned, such as various items on a conveyor belt or where people use the tag for personal access and find it difficult to orient the tag in a special way.

7.1.2 Influence of overlap of inductive tags

When the RFID tags are attached to the smaller size items, such as books or letters, the distance between tag to tag may become very short. For example, at inductive frequencies when the two tags are overlapped at 50% of the tag size, the operating range may be reduced by about 30% compared to the case of one tag. The degree of reduction is different in each tag system, particularly for different carrier frequencies and tag size. The influence is caused by the variation of resonance frequency f_0 that expressed in formula below,

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

L [H]:Inductance of tag antenna coil

C [F]: Capacity of tag's tuning capacitor

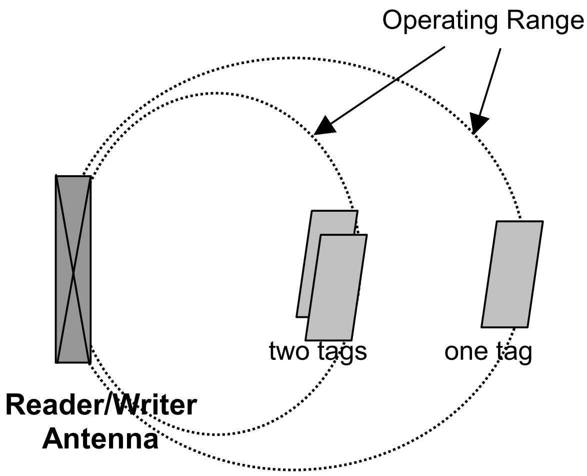


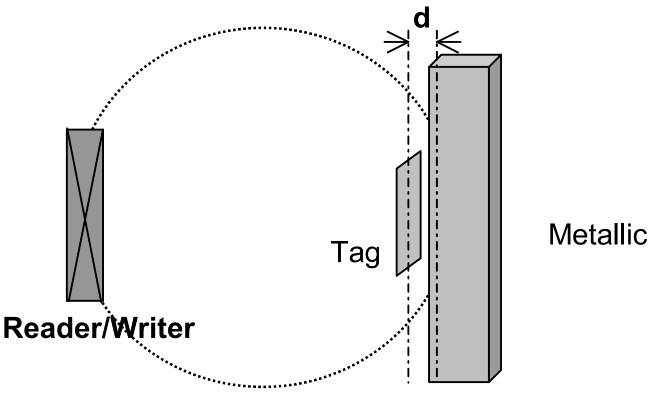
Figure 4 – The Influence of Tag Orientation

7.1.3 Influence of metallic materials

In the RFID tags system, if the tags are attached to the surface of metallic material, particularly ferrous material, the operating range is affected and in worst case tags cannot be accessed by reader/writer.

The presence of liquids, which include ions in solution, affects operating range as well as metal. The influence of liquid presence increases with the frequency.

The minimum distance between tag and metallic material should be required to ensure the access of tag.



Note: "d" is the gap between tag and the metallic material

Figure 5 – The Influence of Metallic Material

7.2 Determining the access time of RFID tags

In RFID systems, the reader/writer antenna may need to access moving tags. The communication time "T_C" between reader/writer and tags can be estimated, not considering the internal processing time of both the reader/writer and tag, as follows,

$$Tc = \frac{Dc}{Dr} \times A_{CN}$$

The tag moves distance “L” at the velocity Vtag, in the operating range of the reader/writer. T_R is the time that the tag remains within the operating range of the reader/writer antenna field, would be estimated:

$$T_R = \frac{L}{Vtag}$$

For successful communications,

T_R = (TC + Tdct) is required

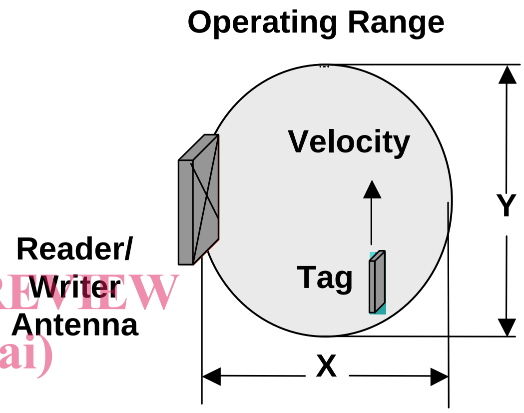


Figure 6 – Access Time Variation

If multiple tag access is required, and the number of tags is " Ntag", then

$$T_R > (T_C + T_{dct}) \times N_{tag}$$

TR (sec):	time within the operating range
TC (sec):	communication time between reader/writer and tag
Dr (bps):	data transmission rate where reading rate = writing rate
DC (bit):	data capacity of communications
ACN (times):	average communication time between reader/writer and tag
Vtag (m/sec):	velocity of tag
L (m):	distance the tag moves through the operating range
N_{tag}:	number of tags
Tdct (sec):	maximum time to detect a tag

The access time of each tag is a function of the capacity of data for communication. The total access time for all tags within the operating range is a function of the number of tags within the operating range and the data capacity of communications.